

THE UNIVERSE OF MOTION

Volume III
of a revised and enlarged edition of
**THE STRUCTURE OF THE PHYSICAL
UNIVERSE**

By
DEWEY B. LARSON

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THE UNIVERSE OF MOTION

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Preface

This volume applies the physical laws and principles of the universe of motion to a consideration of the large-scale structure and properties of that universe, the realm of astronomy. Inasmuch as it presupposes nothing but a familiarity with physical laws and principles, it is self-contained in the same sense as any other publication in the astronomical field. However, the laws and principles applicable to the universe of motion differ in many respects from those of the conventional physical science. For the convenience of those who may wish to follow the development of thought all the way from the fundamentals, and are not familiar with the theory of the universe of motion, I am collecting the most significant portions of the previously published books and articles dealing with that theory, and incorporating them, together with the results of some further studies, into a series of volumes with the general title *The Structure of the Physical Universe*. The first volume, which develops the fundamental physical relations, has already been published as *Nothing But Motion*. This present work is designated as Volume III. Volume II, *Basic Properties of Matter*, will follow.

As stated in *Nothing But Motion*, the development of thought in these books is purely theoretical. I have formulated a set of postulates that define the physical universe, and I have derived all of my conclusions in all physical fields by developing the necessary consequences of those postulates, without introducing anything from any other source. A companion volume, *The Neglected Facts of Science*, shows that many of the theoretical conclusions, including a number of those that differ most widely from conventional scientific thought, can also be derived from purely factual premises, if some facts of observation that have heretofore been overlooked or disregarded are taken into consideration.

As explained in the introductory chapter of this volume, astronomy is the great testing ground for physical theory. Here we can ascertain whether or not the physical relations established under the relatively moderate conditions that prevail in the terrestrial environment still hold good under the extremes of temperature, pressure, size, and speed to which astronomical entities are subjected. In order to be valid, the conclusions derived from theory must agree with all facts definitely established by astronomical observation, or at least must not be inconsistent with any of them. To show that such an agreement exists, I have compared the theoretical conclusions with the astronomical evidence at each step of the development. It should be understood, however, that this comparison with observation is purely for the purpose of verifying the

conclusions; the observations play no part in the process by which these conclusions were reached.

There are substantial differences of opinion, in many instances, as to just what the observations actually do mean. Like the situation in particle physics discussed in previous publications, the “observed facts” in astronomy are often ten percent observation and ninety percent interpretation. In those cases where the astronomers are divided, the most that any theoretical work can do is to agree with one of the conflicting opinions as to what has been observed. I have therefore identified the sources of all of the astronomical information that I have used in the comparisons. Since this work is addressed to scientists in general, rather than to a purely astronomical audience, I have taken information from readily accessible sources, where possible, in preference to the original reports in the astronomical literature.

Once again, as in the preface to *Nothing But Motion*, I have to say that it is not feasible to acknowledge all of the many individual contributions that have been made toward developing the details of the theoretical system and bringing it to the attention of the scientific community, but I do want to renew my expression of appreciation of the efforts of the officers and members of the organization that has been promoting understanding and acceptance of my results. Since the earlier volume was published, this organization, founded in 1970 as New Science Advocates, has changed its name to the International Society of Unified Science, in recognition of its increased activity in foreign countries, three of which are currently represented on the Board of Trustees.

Publication of this present volume has been made possible through the efforts of Rainer Huck, who has acted as business manager of the publishing project, Jan Sammer, who handled all of the many operations involved in taking the work from the manuscript stage to the point at which it was ready for the printers, and my wife, without whose encouragement and logistic support the book could not have been written. Also participating were Eden G. Muir, who prepared the illustrations, and Ronald Blackburn, Maurice Gilroy, Frank Meyer, and Robin Sims, who assisted in the financing.

March, 1984

D. B. Larson

CHAPTER 1

Introduction

This volume is a continuation of a series which undertakes to determine the characteristics that the physical universe must necessarily have if it is composed entirely of discrete units of motion, and to show that the universe thus defined is identical, item by item, with the observed physical universe. The specific objective of this present volume is to extend the physical relations and principles developed in the earlier volumes to a description of the large scale features of the universe of motion. This is the field of astronomy, and the pages that follow will resemble an astronomical treatise. In order to avoid misunderstanding, therefore, we will begin by emphasizing that this is not an astronomical work, in the usual sense.

Astronomy and astrophysics are based on facts determined by observation. Their objective is to interpret these facts and relate them to each other in a systematic manner. The primary criterion by which the results of these interpretive activities are judged is how well they account for, and agree with, the relevant observational data. But astronomical data are relatively scarce, and often conflicting. Opinion and judgment therefore play a very large part in the decisions that are made between conflicting theories and interpretations. The question to be answered, as it is usually viewed, is Which is the best explanation? In practice this means which fits best with current interpretations in related astronomical areas.

The conclusions that are expressed in this work, on the other hand, are derived from the postulated properties of space and time in a universe of motion, and they are independent of the astronomical observations. These conclusions must, of course, be *consistent* with all that is definitely known from observation, but whatever observational information may exist, or may not exist, plays no part in the development of thought that arrives at the conclusions that are stated. Observed astronomical objects and phenomena are not being described and discussed in this work as a foundation on which to construct theory. They are introduced only for the purpose of showing that these observations are consistent with the conclusions derived from theory. Thus the present volume is not an *astronomical* work, which interprets and systematizes the information derived from astronomical observation; it is a *physical work*, which extends the development of physical theory in the two preceding volumes into the astronomical field, confirming the previously

2 *The Universe of Motion*

derived laws and principles by showing that they still apply under extreme conditions.

The availability of this accurate new physical theory, developed and verified in other fields where the facts are more readily accessible, now gives us a source of information about astronomical matters that is not subject to the limitations that are inherent in the procedures that the astronomers must necessarily employ. It gives us a unique opportunity to examine the subject matter of astronomy from an outside viewpoint completely independent of any conclusions that have been reached from the results of astronomical observation.

The record of advancement of astronomical knowledge has been largely a story of the invention and utilization of new and more powerful instruments. The optical telescope, the spectroscope, the photographic plate, the radio telescope, the x-ray telescope, the photoelectric cell—these and the major improvements that have been made in their power and accuracy are the principal landmarks of astronomical progress. It is a matter of considerable significance, therefore, that in application to astronomical phenomena, the theory of the universe of motion, the Reciprocal System of theory, as we are calling it, has the characteristics of a new instrument of exceptional power and versatility, rather than those of an ordinary theory.

Astronomy has many theories, of course, but the products of those theories are quite different from the results obtained from an instrument, inasmuch as they are determined primarily by what is already known or is believed to be known, about astronomical phenomena. This existing knowledge, or presumed knowledge, is the raw material from which the theory is constructed, and conformity with the data already accumulated, and the prevailing pattern of scientific thought, is the criterion by which the conclusions derived from the theory are tested. The results obtained from an instrument, on the other hand, are not influenced by the current state of knowledge or opinion in the area involved. (The interpretation of these results may be so influenced, but that is another matter.) If those results conflict with accepted ideas, it is the ideas that must be changed, not the information that the instrument contributes. The point now being emphasized is that the Reciprocal System, like the instrument and unlike the ordinary theory, is wholly independent of what is known or believed about the phenomena under consideration.

Stars and galaxies are found in the existing astronomical theories because they are *put into* these theories. They are aggregates of matter, they exert gravitational forces, they emit radiation, and so on, in the theoretical picture, because this information was *put into* the theories. They theoretically generate the energy that is required to maintain the radiation by converting matter to energy, because this, too, was *put into* the astronomical theories. They conform to the basic laws of physics and chemistry; they follow the principles laid down by Faraday, by Maxwell, by Newton, and by Einstein, because

these laws and principles were *put into* the theories. To this vast amount of knowledge and pseudo-knowledge drawn from the common store, the theorist adds a few assumptions of his own that bear directly on the point at issue and, after subjecting the entire mass of material to his reasoning processes, he arrives at certain conclusions. Such a theory, therefore, does not see things as they are; it sees them in the context of existing observational information and existing patterns of thought. We cannot get a quasar, for instance, *out of* such a theory until we put a quasar, or something from which, within the context of existing thought, a quasar can be derived, *into* the theory.

On the other hand, the existing concepts of the nature of astronomical objects cannot be put into an instrument. One cannot tell an instrument what it should see or what it should record, other than by limiting the scope of its application, and it therefore sees things as they are, not as the scientific community thinks that they ought to be. If there are quasars, the appropriate instrument, appropriately utilized, sees quasars. Every new instrument uncovers many errors in accepted thinking about known phenomena, while at the same time it reveals the existence of other phenomena that were not only unknown, but in many instances wholly unsuspected.

The Reciprocal System of theory is like an instrument in that it, too, is independent of existing scientific thought. Stars and galaxies composed of matter appear in this theory, but neither these objects nor the matter itself are put into the theory; they are *consequences of* the theory: results that necessarily follow from the only things that *are* put into the theory, the postulated properties of space and time. The astronomical objects that appear in the theory are subject to the basic physical laws, they exert gravitational forces, they emit radiation, and so on, not because these things were put into the theory, but because they are products of the development of the theory itself. *All* of the entities and relations that constitute the theoretical universe of motion are consequences of the fundamental postulates of the system.

While we can hardly say, *a priori*, that this system of theory sees things as they are, we can say that it sees things as they *must be* if the physical universe is a universe of motion. If there are quasars, then this theory, like an appropriate instrument, and independently of any previous theoretical or observational information, sees quasars. Indeed, it *did* see quasars, somewhat indistinctly, to be sure, but definitely, long before they were recognized by the astronomers. As will be brought out in detail in Chapter 20, this pre-discovery development of theory identified the quasars, together with some related phenomena that were not distinguished from them at this stage of the theoretical study, as high-speed products of galactic explosions (not yet discovered observationally), defined their principal properties, and described their ultimate fate.

Like the invention of the telescope, the development of this new and powerful theoretical instrument now gives the astronomer an opportunity to

widen his horizons, to get a clear view of phenomena that have hitherto been hazy and indistinct, and to extend his investigations into areas that are totally inaccessible to the instruments previously available. The picture obtained from this new instrument differs in many respects from present-day astronomical ideas—very radically in some instances—but the existence of such differences is clearly inevitable in view of the limited amount of observational information that has been available to the astronomers, and the consequent highly tentative nature of much of the astronomical theory currently in vogue. As has been demonstrated in the preceding volumes, the correct explanation of a physical situation often differs from the prevailing ideas to a surprising degree even where the current theories have been successful enough in practice to win general acceptance. In astronomy, where comparatively few issues have been definitely settled, and differences of opinion are rampant, it can hardly be expected that the correct explanations will leave the previous theoretical structure intact.

This work does not attempt to cover the entire astronomical field. Much of the attention of the astronomers is centered on *individual objects*. They determine the distance to Sirius, the atmospheric pressure on Mars, the temperature of the sun's photosphere, the density of the moon, and so on, none of which is relevant to the objectives of this present work, except to the extent that some individual fact or quantity may serve to illustrate a general proposition. Furthermore, the scope of the work, both in the number of subjects covered, and in the extent to which the examination of each subject has been carried, has been severely limited by the amount of time that could be allocated to the astronomical portion of a project equally concerned with many other fields of science. The omissions from the field of coverage, in addition to those having relevance only to individual objects, include (1) items that are not significantly affected by the new findings and are adequately covered in existing astronomical literature, and (2) subjects that the author simply has not thus far gotten around to considering. Attention is centered principally on the evolutionary patterns, and on those phenomena, such as the white dwarfs, quasars, and related objects, with which conventional theory is having serious difficulties.

One of the recalcitrant problems of major significance is the question as to the origin of the galaxies.

There are a great many things that the cosmologist not only does not know, but finds severe difficulty in envisaging a path towards finding out . . . In particular, how did the galaxies form? The encyclopaedias and popular astronomical books are full of plausible tales of condensations from vortices, turbulent gas clouds and the like, but the sad truth is that we do not know how the galaxies came into being.¹
(Laurie John)

Gerrit Verschuur foresees major changes in current views:

With what perspective will someone fifty years from now read our astronomical journals and books? . . . I feel that in the area of understanding galaxies we might well leave present ideas farther behind than in any other area of astronomy.²

Most astronomers apparently believe that the question as to the origin of the stars is closer to a solution, but when the issue is squarely faced they are forced to admit that no tenable theory of star formation has yet been devised. For example, I. S. Shklovsky (or Shklovskii), a prominent Russian astronomer whose views will be quoted frequently in these pages, concedes that the star formation process is still in “the realm of pure speculation.” He describes the situation in this manner:

It is natural to suppose that the connection [between O and B stars and dust clouds] should be a genetic one, with the stars in the associations being formed from condensing clouds of gas and dust.

Nevertheless . . . the problem [of proof] has not yet been definitively solved . . . the situation has turned out to be all too complicated.

New technological developments . . . may ultimately lift the star formation problem from the realm of pure speculation and make it an exact science.³

Our first concern in this present work will be with these two basic problems. As we saw in Volume I, the large-scale action of the universe is *cyclic*. The contents of the sector of the universe in which we live, the *material* sector, originate in a primitive, widely dispersed form, and undergo a process of aggregation into large units. Ultimately the aggregates of maximum size are explosively ejected into an inverse sector of the universe, the *cosmic* sector. A similar process takes place in that sector, culminating in an explosive ejection of the major aggregates of cosmic matter back into the material sector.

The two preceding volumes have described the aggregation process in the material sector insofar as it applies to the primary units: atoms and sub-atomic particles. The incoming matter from the cosmic sector arrives in the form of cosmic atoms. The structure of these atoms is incompatible with existence in the material sector (that is, at speeds less than that of light), and they decay into sub-atomic particles that are able to accommodate themselves to the material environment. Over a long period of time these particles combine to form simple atoms, after which the atoms absorb additional particles to form more complex atoms (heavier elements). Meanwhile the atoms are subject to a continual increase in ionization, the ultimate result of which is to bring each atom to a *destructive limit*. At this point all, or part, of the rotational motion

(mass) of the atom is converted to linear motion (kinetic energy).

This atomic aggregation process, previously described in detail, thus terminates in destruction of the atom, or a portion thereof, rather than in ejection into the cosmic sector. In order to understand how the ejection takes place we will have to examine matter from a different standpoint. Heretofore we have been looking at the behavior of the individual units, the atoms. Now we will need to turn our attention to the behavior of material *aggregates*. This is the principal subject of the present volume.

Let us begin our consideration of these aggregates with a pre-aggregate situation, a volume of extension space (the space of the conventional reference system) in which there is a nearly uniform distribution of widely separated hydrogen atoms and sub-atomic particles, the initial products derived from the incoming cosmic matter: the cosmic rays. Coexisting with this primitive material there is usually a small admixture of matter that has been scattered into space by explosive processes, mainly gas and dust, but including some larger aggregates up to stellar size. There may even be a few small groups of stars. All this material is subject to the two general forces of the universe, gravitation and the force due to the outward progression of the natural reference system. The nature of the aggregates that are formed is determined by the properties of these two forces. Three general types of aggregates can be distinguished: (1) dust particles, (2) stars and related aggregates, (3) galaxies and related aggregates.

In the diffuse matter under consideration, the progression of the natural reference system is the dominant force except at very great distances. As we saw in Volume I, the direction of this progression is outward, but the *natural* outward direction, to which this progression conforms, is *away from unity*, because the natural datum level is unity, not zero. Inside unit space, "away from unity" is *inward* as seen in the reference system. Inasmuch as the sizes of the atoms and sub-atomic particles put them into what we have called the time region, the region inside unit space, there is nothing to prevent random motion of one from bringing it within unit distance of another. When this occurs, the progression of the reference system moves these objects inward toward each other until they reach equilibrium positions where the gravitational motion and the progression are balanced. Such contacts are infrequent because of the very low densities and temperatures, but over a long period of time these infrequent contacts are sufficient to build up molecules and dust particles.

Nothing larger than a dust particle can be formed by this contact process, because as soon as the diameter of the aggregate reaches unit distance, 4.56×10^{-6} cm, the direction of the progression of the natural reference system, relative to the conventional spatial coordinate system, is reversed. Outward from unity becomes outward from each other, and the particles move apart. Inter-atomic forces of cohesion operate against this outward progression, and

permit the maximum size of relatively complex particles such as the silicates to exceed the natural unit of distance to a limited extent. The maximum attainable diameter is something less than one micron (10^{-4} cm). This is the explanation of the “surprising” fact noted by Otto Struve:

It is surprising that the particles of all clouds are of about the same size. . . There must be a mechanism that prevents the particles from growing larger than one micron.⁴

Average grain sizes are closer to the unit of distance, which is equivalent to about 0.05 micron. Simon Mitton reports average values ranging from 0.02 microns for iron to 0.15 microns for silicates.⁵

Each of the individual entities with diameters greater than unity existing in the primitive diffuse volume of matter—molecules, dust particles, and bits of debris from disintegrated larger aggregates—is far outside the gravitational limits of its neighbors, and the progression of the natural reference system therefore tends to move them apart, but this outward motion is opposed, not only by the gravitational forces of the neighbors, but also by the inward motion due to the combined gravitational effect of all masses within the effective distance.

If we start from a given point in the region of diffuse matter, and consider spheres of successively larger radius, the progression of the natural reference system is much greater than the gravitational effect originally, but the total gravitational force is directly proportional to the mass—that is, to the cube of the radius, where the density is uniform—whereas the effect of distance is a decrease proportional to the square of the radius. The net gravitational force that the mass included within the concentric spheres exerts against a particle at the outer boundary in each case therefore increases in direct proportion to the radius of the sphere. Hence, although the gravitational motion (or force) at the shorter distances is almost negligible compared to the progression of the natural reference system, equilibrium is eventually reached at some very great distance.

Beyond the point of equilibrium the particles of matter are being pulled inward toward the center of the spherical aggregate. But coincidentally, the gravitational forces acting from other similar centers are being exerted on the particles in the same region of space, and the net result is that there is a movement in both directions that leaves a relatively clear space between adjacent aggregates. The original immense volume of very diffuse matter thus separates into a number of large autonomous gravitationally bound aggregates.

Current astronomical thought regards the condensation of a cloud of dust or gas as a matter of the relative strength of the gravitational force and the opposing thermal forces. On this basis, it is difficult to account for any large-scale condensation. As expressed by Gold and Hoyle:

Attempts to explain both the expansion of the universe and the condensation of galaxies must be very largely contradictory so long as gravitation is the only force field under consideration. For if the expansive kinetic energy of matter is adequate to give universal expansion against the gravitational field it is adequate to prevent local condensation under gravity, and vice versa. That is why, essentially, the formation of galaxies is passed over with little comment in most systems of cosmology.⁶

In the universe of motion the inward and outward forces arrive at an equilibrium, as indicated in the foregoing paragraphs. No condensation would take place if this equilibrium persisted, but the continued introduction of new matter from the cosmic sector alters the situation. The added mass strengthens the gravitational force, and initiates a contraction. The decrease in the distance between particles increases the gravitational force still further. The contraction is thus a self-reinforcing process, and once it is started it accelerates.

The two processes that have been described, the gradual contraction of the very large diffuse aggregate and the consolidation of the individual atoms and sub-atomic particles into molecules and dust particles, take place coincidentally. The drastic reduction in the number of separate units in the aggregate resulting from the consolidation results in an excess of empty space within the contracting volume, and causes the contracting sphere of matter to break up into a large number of smaller aggregates separated by nearly empty space. The product is a *globular cluster*, in which a large number of sub-masses—up to a million or more—are contained within the overall gravitational limit of a large spherical aggregate. Each of the sub-masses is outside the gravitational limits of its neighbors, and is therefore moving away from them, but it is being pulled inward by the gravitational force of the entire aggregate.

Many of the internal condensations take place around the remnants of disintegrated galaxies that are scattered through the contracting material. In that case, the relatively massive core thus provided makes the mass a self-contracting unit. Where no such nuclei are available, the sub-masses are confined by the forces of the globular cluster as a whole, and the contraction continues under the influence of these external forces until the density is adequate to continue the process.

This is where the astronomers' current theories of star formation are stopped cold. They envision the formation as taking place in the galaxies, but there are no gas or dust clouds in our galaxy—or in any other, so far as we know—that have anywhere near the critical density, or have any way of increasing their density to the critical level.

Basically there does not appear to be enough matter in any of the hydrogen clouds in the Milky Way that would allow them to contract and be stable. Apparently our attempt to explain the first stages in star evolution has failed.⁷ (G. Verschuur)

If the contraction of the sub-masses contained within the globular cluster is permitted to continue without interference from outside agencies, the gravitational energy of position (the potential energy) of their constituent units—atoms, particles, etc.—is gradually transformed into kinetic energy, and the temperature of the aggregate consequently rises. At some point, the mass becomes self-luminous, and it is then recognized as a *star*. The globular cluster, as we observe it, consists of an immense number of stars, separated by great distances, and forming a nearly spherical aggregate. As the foregoing discussion brings out, however, the star cluster stage is preceded by a stage in which the constituent units, or sub-masses, of the globular cluster are pre-stellar gas clouds rather than stars. The existence of such structures has some important consequences that will be explored as we proceed.

No new assumptions or concepts have had to be introduced in order to derive this picture of the stellar condensation process in the depths of space. We have simply taken the physical principles and relations previously obtained from a development of the consequences of the basic postulates as to the nature of space and time, as described in the previous volumes of this work, and have applied them to the problems at hand. The results of this study not only give us a clear picture of how the formation of stars takes place, but also show that the formation occurs under conditions that necessarily exist throughout immense regions of space. The production of sufficient star clusters of the globular type to meet the requirements of the later phases of evolutionary development is thus shown to be a natural and inevitable consequence of the premises of the theory.

The globular clusters are actually small aggregates of the same general nature as the galaxies. “There is no absolutely sharp cutoff distinguishing galaxies from globular clusters,”⁸ says Martin Harwit. The process just described thus provides the answers for both of the major astronomical problems identified earlier: the formation of stars and the formation of galaxies. As noted earlier, present-day astronomy has no tenable theory of galaxy formation. In the words of W. H. McCrea, “We do not yet know how to tackle the problem.”⁹ The situation with respect to the formation of stars is somewhat different, in that, although it is evident that the mechanism of star formation is not yet understood, there is a general impression that the dust clouds in the galaxies *must be* the locations in which this mechanism is operating.

In such cases as this, where the general trend of thought in any field is on the wrong track, the reason almost invariably is the uncritical acceptance of some erroneous conclusion or conclusions. As will be brought out in detail in the

pages that follow, astronomy has unfortunately been the victim of two particularly far-reaching errors. The latter portion of this volume will examine a wide variety of phenomena in which the true relations have not heretofore been recognized because the general submission to Einstein's dictum that speeds in excess of that of light are impossible has diverted inquiry into unproductive channels. The theories applicable to the more familiar astronomical objects that will be discussed in the earlier chapters have been led astray by another erroneous conclusion also imported from the physicists. This costly mistake is the conclusion that the energy production process in the stars is the conversion of hydrogen to helium and successively heavier elements.

As brought out in Volume II, the development of the consequences of the postulates that define the universe of motion arrives at a totally different conclusion as to the nature of the process by which the stellar energy is produced. Inasmuch as there is no direct way of determining just what is happening in the interiors of the stars, all conclusions with respect to this energy generation process have to be based on considerations of an indirect nature. Thus far, the thinking about this subject has been dominated by the physicists' insistence that the most energetic process *known to them* must necessarily be the process whereby the stars generate their energy, regardless of any evidence to the contrary that may exist in other scientific areas. The fact that they have had to change their conclusions as to the nature of this process twice already has not altered this attitude. The most recent change, from the gravitational contraction hypothesis to the hydrogen conversion hypothesis was preceded by a long and acrimonious dispute with the geologists, whose evidence showed that geological history required a great deal more time than was allowed by the gravitational contraction process. Ultimately the physicists had to concede defeat.

It might be assumed that the embarrassing outcome of this controversy would have engendered a certain amount of caution in the claims made for the newest hypothesis, but there is no indication of it. Today there is ample astronomical evidence that the physicists' current hypothesis is wrong, just as there was ample geological evidence in the nineteenth century that their then current hypothesis was wrong. But they are no more willing to listen to the astronomical evidence today than they were to the geological evidence of the earlier era. The astronomers are less combative than the geologists, and are not inclined to challenge the physicists' dicta. So they are ignoring the evidence from their own field, and accommodating their theories to the hydrogen conversion hypothesis. Curiously enough, the only real challenge to that hypothesis at the present time comes from a rather unlikely source, an experiment whose execution is difficult, and whose interpretation is open to question. This is an experiment designed to measure the rate of emission of neutrinos by the sun. The number of neutrinos observed is far less than that

predicted on the basis of the prevailing theories. “This is a terrible puzzle,”¹⁰ says Hans Bethe.

The neutrino experiment is one of the most interesting to be carried out in astronomy in recent years, and seems to be giving the most profound and unexpected results. The least that we can conclude is that until the matter is settled, we must treat all the theoretical predictions about stellar interiors with a bit of caution.¹¹ (Jay M. Pasachoff)

The mere fact that the hydrogen conversion process can be seriously threatened by a marginal experiment of this kind emphasizes the precarious status of a hypothesis that rests almost entirely on the current absence of any superior alternative. The hypothesis of energy generation by ordinary combustion processes held sway in its day on the strength of the same argument. Then gravitational contraction was recognized as more potent, and became the physicists’ orthodoxy, defended furiously against attacks by the geologists and others. Now the hydrogen conversion process is the canonical view, resting on exactly the same grounds that crumbled in the two previous instances. In each case the contention was that there is no other tenable alternative. But in both of these earlier cases it turned out that there *was* such an alternative. Even without the contribution of the theory of the universe of motion, which shows that, in fact, there *is* a logical and rational alternative, it should be evident from past experience that the assertion that “there is no other way” is wholly unwarranted. Without this crutch, the hydrogen conversion process is no more than a questionable hypothesis, a very provisional conclusion that must stand or fall on the basis of the way that its consequences agree with physical observations.

Unfortunately the astronomers, whose observations are the ones against which the hypothesis can be tested, have taken it as an established fact, and have accorded it a status superior to their own findings, adjusting their interpretations of their own observations to agree with the physicists’ hypothesis. We need go no farther than the first deduction that is made from the assumed existence of the hydrogen conversion process to encounter a glaring example of the way in which this pure assumption is allowed to override the astronomical evidence. In application to the question of stellar ages, this hypothetical process leads to the conclusion that the hot, massive stars of the O and B classes are very young, as their output of energy is so enormous that, on the basis of this hypothesis, their supply of fuel cannot last for more than a relatively short time. It then follows that these stars must have been formed relatively recently, and somewhere near their present locations.

No theory that calls for the formation of stars within the galaxies is plausible so long as the theorists are unable to explain *how* stars can be formed in this kind of an environment. One that, in addition, requires the most massive and

most energetic of all stars to be very young, astronomically speaking, converts the implausibility into an absurdity. Even some of the astronomers find this conclusion hard to swallow. For instance, Bart J. Bok once observed that

It is no small matter to accept as proven the conclusion that some of our most conspicuous supergiants, like Rigel, were formed so very recently on the cosmic scale of time measurement.¹²

In the context of the theory of the universe of motion, the formation of single stars, or small groups of stars, by condensation from galactic dust or gas clouds is not possible. In addition to all of the other problems that have baffled those who have attempted to devise a mechanism for this purpose, the new theory discloses that there is a hitherto unrecognized force operating against such a condensation, the force due to the outward progression of the natural reference system, which makes condensation still more difficult. No known force other than gravitation is capable of condensing diffuse material into a star, and gravitation can accomplish this result only on a wholesale scale, under conditions in which an immense number of stars are formed jointly from a gas and dust medium of vast proportions.

On this basis, the globular clusters are the youngest aggregates of matter, and the stars of these clusters are the youngest of all stars. Thus the astronomers have their age sequence upside down. It may be hard to believe that the present structure of astronomical theory could contain such a major error in its basic framework. But, as we will see when we examine the various astronomical phenomena in the pages that follow, even the astronomers themselves admit that the theoretical conclusions based on the currently accepted age sequence are inconsistent with the observations all along the line. Of course, they are reluctant to make any blanket statement to this effect, but if we add up their comments concerning the individual items, this is what they amount to. In the quotations from astronomical sources that will be introduced in connection with the discussion of these various subjects we will find that the individual inconsistencies and contradictions are characterized as “puzzling,” “curious,” “confusing,” “difficult to explain,” “not yet understood,” and so on. Some of the more candid writers concede that the theoretical understanding is unsatisfactory, referring to a particular inconsistency as “an impressive challenge to theoreticians,” admitting that it “imperils” currently accepted theory, or “conflicts with current models,” reporting that “severe problems remain” in arriving at understanding, or even that the observations constitute an “apparent defiance” of modern theory.

The existence of this multitude of commonly recognized contradictions and inconsistencies is a clear indication that there is *something* radically wrong with the foundations of present-day astronomical theory. What the development of the theory of a universe of motion has done is to *identify* the

mistake that has been made. Uncritical acceptance of an assumption made by the physicists has led to a conclusion regarding the ages and evolution of stars that is upside down.

CHAPTER 2

Galaxies

From the finding that the initial product of the large-scale aggregation process in the material sector of the universe is the globular cluster, it follows that galaxies are formed by consolidation of globular clusters. This conclusion is in direct conflict with the prevailing astronomical opinion, which is described by John B. Irwin as follows:

The Milky Way system, like other galaxies, is thought to have originated from a condensation or collapse of the intergalactic medium, which event resulted in a system of stars. The reason for the collapse is not known, and the details of the process are uncertain.¹³

As might be expected where neither the antecedents of the process nor the details are in any way understood, this explanation has encountered serious difficulties, and is currently in deep trouble. As expressed by Virginia Trimble in a report of a conference at which this situation was discussed at some length, “The conventional wisdom concerning galaxy formation and evolution is beginning to leak badly at the seams.” In the concluding portion of her report she notes that “Fall, Hogan, and Rees (Cambridge) have considered the case of a galaxy assembled entirely out of pre-existing star clusters,” and she makes this comment:

The discerning reader will long since have noticed where we are headed—if there are problems making the biggest things (clusters of galaxies) first, then perhaps we should try making the smallest things (stars or clusters of stars) first.¹⁴

Such a reversal of thinking on the subject is difficult in the context of present-day astronomical theory because so much of that theory has been specifically tailored to fit the “big things first” viewpoint but, as we will see in the following pages, if the observational evidence is taken at its face value and not twisted to conform to the prevailing theories, the problems disappear. In the universe of motion the galaxies are, in fact, “assembled entirely out of pre-existing star clusters,” as the Cambridge astronomers suggested.

Unlike the individual stars, whose spheres of gravitational control meet at locations of minimum gravitational force, so that each star is outside the gravitational limits of its neighbors, the original boundaries of the aggregate that ultimately becomes a globular cluster meet those of its neighbors at locations of maximum gravitational force. The contraction of the aggregates leaves the gravitational effect at these locations unchanged, while the increase in mass due to the influx of material from the cosmic sector adds a significant increment. Each of the globular clusters is thus well within the gravitational limits of the adjoining clusters. Consequently, there is a general tendency for the clusters to move toward each other and combine. When such a combination does occur, the combined unit exerts a stronger gravitational force within wider spatial limits, and both the accretion of diffuse material and the attraction of nearby clusters are speeded up. Like the contraction of the pre-cluster aggregate, the contraction of the group of clusters leading to combination is thus a self-reinforcing process.

It should be noted in this connection that *consolidation* of two clusters is inevitable if their mutual gravitational attraction continues to act without interference from outside sources (that is, gravitational forces of other aggregates). There has been a rather general belief that because of the immense distances between the stars in a cluster, or other aggregate, two such structures could pass through each other with little or no actual contact. Fred Hoyle expresses this general opinion in this statement:

Think of the stars as ordinary household specks of dust. Then we must think of a galaxy as a collection of specks a few miles apart from each other, the whole distribution filling a volume about equal to the Earth. Evidently one such collection of specks could pass almost freely through another.¹⁵

Our finding that the stars occupy equilibrium positions throws a considerably different light on this situation. A stellar aggregate such as a cluster has the general characteristics of a viscous liquid, and collision of two such aggregates involves an inelastic impact similar to the impact of one liquid aggregate upon another. In each case there is a certain amount of penetration while the kinetic energy of the incoming mass is being absorbed, but the eventual result is consolidation. The incoming mass meets a wall, not a passageway.

This liquid-like nature of the aggregates of stars, deduced theoretically and confirmed observationally by the behavior characteristics of the galaxies and star clusters that will be examined in the subsequent pages, has a major effect on the phenomena in which these objects participate. It invalidates many of the conclusions, such as the one expressed by Hoyle in the statement just quoted, and a great many mathematical calculations that rest on the hypothesis of free movement of the constituent stars of an aggregate.

Consolidation of two globular clusters produces an aggregate which not only has double the mass of a cluster, but also, because the impact is not exactly central in the usual case, has a rotational motion that was absent in the original cluster. Instead of an oversize cluster, we may therefore regard the combination as an aggregate of a new type: a small *galaxy*. For a period of time after its formation such a galaxy has a rather confused and disorderly structure, and is therefore classified as *irregular*, but in time the disruptions due to the collision are smoothed out, and the galaxy assumes a more regular form. By reason of the rotational motion that is now present, the galactic structure deviates to some extent from the nearly spherical shape of the original clusters, and it is now classed as an *elliptical* galaxy.

If this small elliptical galaxy is not captured by some larger unit it continues growing by accretion of dust and gas, and occasionally picks up another globular cluster. In the earlier stages, each such capture of a cluster disorganizes the galactic structure and puts the galaxy back into the irregular class for a time, but as it increases in size the galaxy gradually becomes able to swallow a cluster without any major effect on its own structure. By this time, however, some combinations of small galaxies begin to take place. Here, again, a structural irregularity develops, and persists for a time. In this stage the aggregates are reported to be “several hundred times larger than the dwarf elliptical galaxies.”¹⁸

As long as the captured clusters are mature—that is, fully consolidated into stars—the amount of dust in an elliptical or small irregular galaxy is relatively minor. Eventually, however, one or more of the captives is a cluster of dust and gas clouds, an *immature globular cluster*, rather than a mature cluster of stars. The mixing of this large amount of dust and gas with the stars of the galaxy alters the dynamics of the rotation, and causes a change in the galactic structure. If the dust cloud is captured while the galaxy is still quite small, the result is likely to be a reversion to the irregular status until further growth of the galaxy takes place. Because of the relative scarcity of the immature clusters, however, most captures of these objects occur after the elliptical galaxy has grown to a substantial size. In this case the result is that the structure of the galaxy opens up and a spiral form develops.

There has been a great deal of speculation as to the nature of the forces responsible for the spiral structure, and no adequate mathematical treatment of the subject has appeared. But from a qualitative standpoint there is actually no problem, as the forces which are definitely known to exist—the rotational forces and the gravitational attraction—are sufficient in themselves to account for the observed structure. As already noted, the galactic aggregate has the general characteristics of a heterogeneous viscous liquid. A spiral structure in a rotating liquid is not unusual; on the contrary, a striated or laminar structure is almost always found in a rapidly moving heterogeneous fluid, whether the motion is rotational or translational. Objections have been raised to this

explanation, generally known as the “coffee cup” hypothesis, on the ground that the spiral in a coffee cup is not an exact replica of the galactic spiral, but it must be remembered that the coffee cup lacks one force that plays an important part in the galactic situation: the gravitational attraction toward the center of the mass. If the experiment is performed in such a manner that a force simulating gravitation is introduced, as, for instance, by replacing the coffee cup by a container that has an outlet at the bottom center, the resulting structure of the surface of the water is very similar to the galactic spiral.

In this kind of a rotational structure the spiral is the last stage, not an intermediate form. By proper adjustment of the rotational velocity and the rate of water outflow the original dispersed material on the water surface can be caused to pull in toward the center and assume a circular or elliptical shape before developing into a spiral, but the elliptic structure precedes the spiral if it appears at all. The spiral is the end product. The manner in which the growth of the galaxy takes place has a tendency to accentuate the spiral form, but the rotating liquid experiment shows that the spiral will develop in any event when the necessary conditions exist. Furthermore, this spiral is dynamically stable. We frequently find the galactic spirals characterized as unstable and inherently short-lived, but the experimental spiral does not support this view. From all indications, the spiral structure could persist indefinitely if the mass and rotational velocity remained constant.

The conclusion that the spiral arms are quasi-permanent features of the galaxies is currently contested on other grounds, as in the following quotation from an astronomy textbook:

The trouble is that this idea predicts the arms should be nearly fixed structures almost as old as the galaxy itself, whereas actually they are young regions only a few million years old.¹⁶

The assertion that the spiral arms are “young regions” is based on the presence of hot, massive stars, currently considered to be young, on the strength of the prevailing assumption as to the nature of the stellar energy generation process. The evidence that invalidates this hypothesis, which will be presented at appropriate points in the pages that follow, thus cuts the ground from under this argument.

A spiral galaxy consists of a nucleus, approximately spherical, and a system of curving arms extending outward from the nucleus. In the smaller and younger objects the nucleus is small, the arms are thick and widely separated, and the general structure can be described as loose. As these galaxies grow older and larger, the nucleus becomes more prominent, the rotational velocity increases, and the greater velocity causes the arms to thin out and wind up more tightly. Ultimately the arms disappear entirely and the nearly spherical nucleus becomes the galaxy. At this stage the shape of the galaxy is the same

as that of the smallest and youngest of the galaxies that have attained a stable form, and these giant old galaxies are generally included in the elliptical category. But putting such widely different aggregates into the same class simply on the basis of their form leads to confusion, and cannot be considered good practice. Fortunately, the term "spheroidal" is being used to some extent in this connection, and since it is quite appropriate, we will classify these oldest and largest of the stellar aggregates as *spheroidal* galaxies.

As the foregoing discussion brings out, the primary criterion of the age of galaxies is size, with shape as a secondary characteristic varying in direct relation to size. It must be realized, of course, that accidents of environment and other factors will affect this situation to some extent, so that there are some deviations from the normal pattern, but in general the ages of the various types of galactic structures stand in the the same order as their sizes. The passage of time also brings other observable results that confirm the ages indicated by the sizes of the galaxies. One of these is a decrease in abundance. In the evolutionary course as outlined, each aggregate is growing at the expense of its environment. The smaller units are feeding on atoms, small particles, and stray stars. The larger aggregates pull in not only all material of this kind in their vicinity, but also any of the small aggregates that are within reach.

As a result of this cannibalism the number of units of each size progressively decreases with age. Observations show that the existing situation is in full agreement with the theoretical expectation, as the order of abundance is the inverse of the age sequence indicated by the galactic size and shape. The giant spheroidal galaxies, the senior members of the galactic family, are relatively rare, the spirals are more common, the elliptical galaxies are abundant, and the globular clusters exist in enormous numbers.

It is true that the *observed* number of small elliptical galaxies, those in the range just above the globular clusters, is considerably lower than would be predicted from the age sequence, but it is evident that this is a matter of observational selection. When the majority of galaxies are observed at such distances that only the large types are visible, it is not at all strange that the number of small ellipticals actually identified is less than the number which, according to the theory, should exist. The many additional elliptical galaxies discovered within the Local Group in very recent years, increasing the already high ratio of elliptical to spiral in the region accessible to detailed observation, emphasizes the effect of the selection process.

Conventional astronomical theory neither requires nor excludes the existence of large numbers of these dwarf galaxies, and because they are too inconspicuous to demand attention from an observational standpoint, little notice has been taken of them until recently. Since our development leads to the conclusion that they are, next to the globular clusters, the most numerous of the astronomical aggregates, it is worth noting that the astronomers are beginning to recognize their abundance. For instance, a recent (1980)

comment suggests that these dwarfs “may be the most common type of galaxy in the universe.”¹⁷ This is what the theory of the universe of motion says that they must be.

Other observational indications of age will be examined later, after some more foundations have been laid, but these will merely supply additional confirmation. At this time it should be noted that all three of the criteria thus far discussed are in agreement that the observed galaxies and sub-galaxies can be placed in a sequence consistent with the theoretical deduction that there is a definite evolutionary path in the material sector of the universe extending from dispersed atoms and sub-atomic particles through multi-molecular dust particles, clouds of atoms and particles, stars, clusters of stars, elliptical galaxies, and spiral galaxies to the giant spheroidal galaxies which constitute the final stage of the material phase of the great cycle of the universe. It is possible, of course, that some of these units may have remained inactive from the evolutionary standpoint for long periods of time, perhaps because of a scarcity of available “food” for accretion in their particular regions of space, and such units may be chronologically older than some of the aggregates of a more advanced type. Such variations as these are, however, merely minor fluctuations in a well-defined evolutionary pattern.

“One of the continuing mysteries,” says Virginia Trimble, “is why galaxies should have the range of masses they do.”¹⁴ The foregoing explanation of the evolution of the galaxies shows why. The galaxies originate as globular clusters and grow by capture until they reach a size limit at which their existence terminates. Galaxies therefore exist in all sizes between these two limits.

Next we turn to a different kind of evidence that gives further support to the theoretical conclusions. In the preceding discussion it has been demonstrated that the deductions as to continual growth of the material aggregates by capture of matter from the surroundings are substantiated by the definite correlation between the size, shape and relative abundance of the various types of galaxies and clusters. Now we will examine some direct evidence of captures of the kind required by the theory. First we will consider evidence which indicates that certain captures are about to take place, then evidence of captures actually in progress, and finally evidence of captures that have taken place so recently that their traces are still visible.

The most abundant evidence of impending captures is provided by the observed positions and motions of the globular clusters, but the total amount of information about these clusters now available is sufficient to justify a separate chapter. The capture of clusters by galaxies will therefore be discussed in Chapter 3, in connection with the general consideration of the role of these objects.

Capture of galaxies by larger galaxies is much less common than capture of globular clusters, simply because the clusters are very much more abundant.

We may deduce, however, that there should be a few galaxies on the road to capture by each of the giant galaxies. This is confirmed by the observation that the nearer large spirals have “satellites,” which are nothing more than small galaxies that are within the gravitational range of a larger aggregate, and are being pulled in to where they can be conveniently swallowed. The Andromeda spiral, for instance, has at least eight satellites: the elliptical galaxies M 32, NGC 147, NGC 185, and NGC 205, and four small galaxies that have been named Andromeda I, II, III, and IV. The Milky Way galaxy is also accompanied by at least six fellow travelers, the largest of which are the two Magellanic Clouds and the elliptical galaxies in Sculptor and Fornax. The expression “at least” must be included in both cases, as it is by no means certain that all of the small ellipticals in the vicinity of these two large spirals have been identified.

As one report summarizes the situation, the dwarf galaxies “cluster in swarms about the giant galaxies.” The author goes on to say, “Why this should be is not yet understood; but theorists believe that it could be telling us much about the way galaxies form.”¹⁸ In the light of the information presented in the foregoing pages, it should be evident that what these observations are telling us is simply that the original products are undergoing a process of consolidation into larger aggregates.

Some of these galactic satellites not only occupy the kind of positions required by theory, and to that extent support the theoretical conclusions, but also contribute evidence of the second class: indications that the process of capture is already under way. The so-called “irregular” galaxies were not given a separate place in the age-size-shape sequence previously established, as it appears reasonably certain that these galaxies, which constitute only a small percentage of the total number of galaxies that have been observed, are merely galaxies belonging to the standard classes which have been distorted out of their normal shapes by factors related to the capture process. The Large Magellanic Cloud, for instance, is big enough to be a spiral, and it contains the high proportion of advanced type stars that is characteristic of the spirals. Why, then, is it irregular rather than spiral? The most logical conclusion is that the answer lies in the proximity of our own giant system; that the Cloud is in the process of being swallowed by our big spiral, and that it has already been greatly modified by the gravitational forces that will eventually terminate its existence as an independent unit. We can deduce that the Large Cloud was actually a small spiral at one time, and that the “rudimentary” spiral structure which is recognized in this galaxy is actually a vestigial structure.

The Small Cloud has also been greatly distorted by the same gravitational forces, and its present structure has no particular significance. From the size of this Cloud we may deduce that it was a late elliptical or early spiral galaxy before its structure was disrupted. The conclusion that it is younger than the Large Cloud, which we reach on the basis of the relative sizes, is supported by

the fact that the Small Cloud contains a mixture of the type of stars found in the globular clusters, currently called Population II, and the type found in the spiral arms, currently called Population I, whereas the stars of the Large Cloud are predominantly of Population I.

The long arm of the Large Cloud which extends far out into space on the side opposite our galaxy is a visible record of the recent history of the Cloud. The gravitational attraction of the Galaxy is exerted on each component of the Cloud individually, as well as on the structure as a whole, since the Cloud is an assembly of discrete units in which the cohesive and disruptive forces are in balance. This balance is precarious at best, and when an additional gravitational force is superimposed on the equilibrium within the Cloud some of the stars are detached from the aggregate. The difference between the forces exerted by our galaxy on the nearest stars of the Cloud and those exerted on the most distant stars was unimportant when the Cloud was far away, but as it approached the Galaxy this force differential increased to significant levels. As the main body was speeded up by the increasing gravitational pull some stragglers failed to keep up with the faster pace, and once they had fallen behind, the force differential became even greater. The Cloud therefore left a luminous trail behind it, marking the path along which it had traveled.



Fig. 1
Galactic Trails

This is no isolated phenomenon. Small galaxies may be pulled into larger units without leaving visible evidence behind, as the amount of material involved is too small to be detected at great distances, but when two large

galaxies approach each other we commonly see luminous trails of the same nature as the one that has just been discussed. Fig. 1 is a diagram of the structural details that can be seen in photographs of the galaxies NGC 4038 and 4039. Here we can see that one galaxy has come up from the lower right of the diagram and has been pulled around in a 90 degree bend. The other has moved down from the direction of the top center and has been deflected toward the first galaxy. When the action is complete there will be one large spiral moving forward to its ultimate destiny, leaving the stray stars trailing behind the galaxies to be pulled in individually, or be picked up by some other aggregate that will come along at a later time. Several thousand "bridges" that have developed from interaction between galaxies are reported to be visible in photographs taken with the 48-inch Schmidt telescope on Mount Palomar. Some of these are trailing arms similar to those in Fig. 1. Others are advance units that are rushing ahead of the main body. The greater velocity of these advance stars is also due to the gravitational differential between the different parts of the incoming galaxy, but in this case the detached stars are the closest to the source of the gravitational pull and are therefore subject to the greatest force.

Irregularities of one kind or another are relatively common in the very small galaxies, but these are not usually harbingers of coming events like the gravitational distortions of the type experienced by the Magellanic Clouds. Instead, they are relics of events that have already happened. Capture of a globular cluster by a small galaxy is a major step in the evolution of the aggregate. Consolidation with another small galaxy is a revolutionary event. Since the relatively great disturbance of the galactic structure due to either of these events is coupled with a slow return to normal because of the low rotational velocity, the structural irregularities persist for a longer time in these smaller galaxies. The number of small irregular aggregates visible at any particular time is correspondingly large.

Although the general spiral structure of the larger galaxies is regained relatively soon after a major consolidation because of the high rotational velocities that speed up the mixing process, there are features of some of these structures that seem to be correlated with recent captures. We note, for instance, that a number of spirals have semi-detached masses, or abnormal concentrations of mass within the spiral arms, that are difficult to explain as products of the recent development of the spiral itself, but could easily be the result of recent captures. The outlying mass NGC 5195 seemingly attached to one of the arms of M 51, for example, has the appearance of a recent acquisition (although there is some difference of opinion as to the true status of this object). The lumpy distribution of matter in M 83 gives this galaxy the aspect of a recent mixture which has not yet been thoroughly stirred; NGC 4631 looks as if it contains a still undigested mass; and so on.

A study of the "barred" spiral galaxies also leads to the conclusion that these

objects are galactic unions that have not yet reached the normal form. The variable factor in this case appears to be the length of time required for consolidation of the central masses of the combining galaxies. If the original lines of motion intersect, the masses are no doubt intermixed quite thoroughly at the time of contact, but an actual intersection of this kind is not required for consolidation. All that is necessary is that the directions of motion be such as to bring one galaxy into the general vicinity of the other. The gravitational force then accomplishes the change of direction that is necessary in order to bring about a contact of the two objects. Where the gap to be closed by gravitational action is relatively large, the rotational forces may establish the characteristic spiral form in the outer regions of the combination before the consolidation of the central masses is complete, and in the interim the galactic structure is that of a normal spiral with a double center.

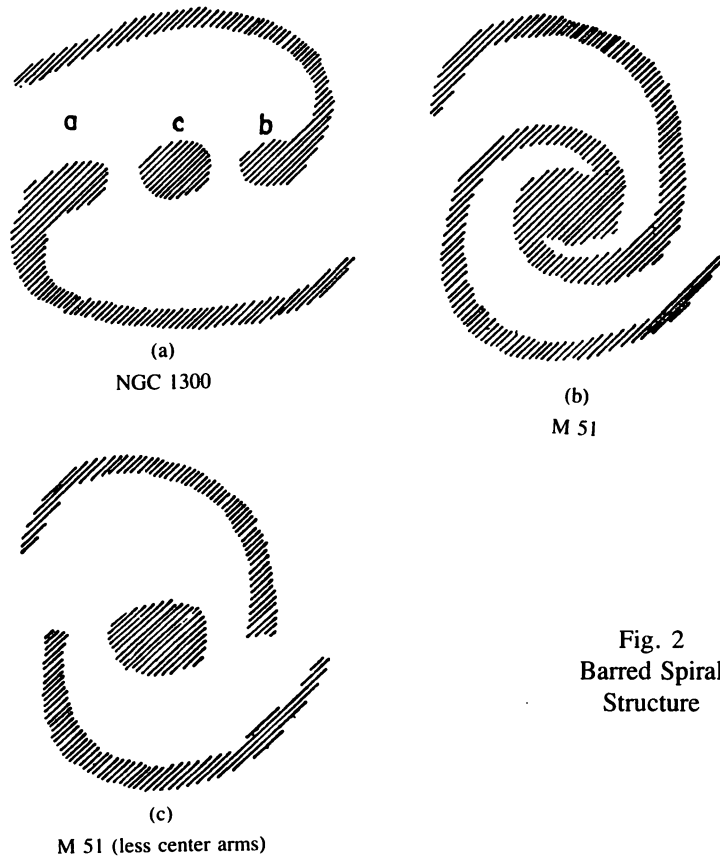


Fig. 2
Barred Spiral
Structure

Fig. 2 (a) shows the structure of the barred spiral galaxy NGC 1300. Here the

two prominent arms terminate at the mass centers a and b, each of which is connected with the galactic center c by a bridge of dense material that forms the bar. On the basis of the conclusions in the preceding paragraph, we may regard a and b as the original nuclei of galaxies A and B, the two aggregates whose consolidation produced NGC 1300. The gravitational forces between a and b are modifying the translational velocities of these masses in such a manner as to cause them to spiral in toward their common center of gravity, the new galactic nucleus, but this process is slowed considerably after the galaxy settles down to a steady rotation, as only the excess velocity above the rotational velocity of the structure as a whole is effective in moving the mass centers a and b forward in their spiral paths. In the meantime the gravitational attraction of each mass pulls individual stars out of the other mass center, and builds up a new galactic nucleus between the other two. As NGC 1300 continues on its evolutionary course, we can expect it to gradually develop into a structure such as that in Fig. 2 (b), which shows the arms of M 51. Fig. 2 (c) indicates how M 51 would look if the central portions of the arms were removed. The structural similarity to NGC 1300 is obvious.

Additional evidence of relatively recent captures will be developed in Chapter 8 after some further groundwork has been laid. Meanwhile the evolutionary pattern of the constituent stars of the clusters and galaxies will be defined, and it will be shown that the stellar evolution corresponds with the pattern of evolution of the galaxies, as described in this present chapter. All in all, the results obtained from these various lines of inquiry add up to an overwhelming mass of evidence confirming the validity of the theoretical process of galactic evolution beginning with dispersed matter and ending with the giant spheroidal galaxies.

This picture of continuous growth from globular cluster to spheroidal galaxy extending over a period of many billion years is in direct conflict with the prevailing astronomical view, which regards the galaxies as having been formed directly from dispersed matter in an early stage of an evolutionary universe, and having remained in essentially the same condition in which they were originally formed. The difference between this view and that derived from the Reciprocal System of theory is graphically illustrated by an argument offered by Shklovsky in support of the contention that a process of star formation must be operative in the Galaxy. He points out that at least one of the stars of the Galaxy "dies" each year in a supernova explosion, and then argues that "In order that the stellar tribe should not become extinct, just as many new stars, on the average, must be formed annually in our Galaxy."¹⁹ While our findings portray the Galaxy as not only pulling in single stars on a continuous basis, but also periodically swallowing a globular cluster, and even an occasional small galaxy, Shklovsky is not even willing to concede the capture of one star per year.

The same viewpoint is reflected in the current tendency to try to explain the

globular clusters detected in inter-galactic space as outgoing rather than incoming. These “intergalactic tramps,” says one text, “may actually be globular clusters that escaped from our Galaxy.”²⁰ Even the halo stars surrounding the Galaxy tend to be regarded as escapees from the original galactic system rather than as incoming matter.

In a strange juxtaposition alongside this uncompromising orthodox view, there is a widespread and growing recognition of the prevalence of galactic cannibalism. For example, Joseph Silk tells us that “It seems that the giant galaxies have grown at the expense of other galaxies in their cluster.”²¹ M. J. Rees elaborates on the same theme:

We can see many instances where galaxies seem to be colliding and merging with each other, and in rich clusters such as Coma the large central galaxies may be cannibalizing their smaller neighbors . . . Many big galaxies—particularly the so-called CD galaxies in the centers of clusters—may indeed be the result of such mergers.²²

There is also an increased willingness to recognize the observational indications of galactic collisions. After a number of years during which the collision hypothesis applied earlier to such powerful radio emitters as Cygnus A was regarded as a mistake, it has resurfaced, and is now widely accepted. We now frequently encounter unequivocal statements such as this: “Several hundred collisions or near collisions between galaxies have been photographed in the past 20 years.”²³

The concepts of galactic cannibalism, of galaxies “growing,” of “capture,” and of “collision,” are the concepts appertaining to the theory developed in this work, not to the theory currently accepted by the astronomers. Whether or not the investigators who are using these concepts realize that they are striking at the foundations of orthodox theory is not clear, but in any event, that is the effect of the present trend of thought. These present-day investigators and theorists are providing an increasing amount of significant support for the conclusions detailed in this volume.

One more question about the aggregation process remains to be considered. We have found thus far in our examination of this process that the original stellar aggregates, the globular clusters, enter into combinations which continue growing until they reach the status of giant spheroidal galaxies. The question now arises, Is this the end of the aggregation process, or do the galaxies combine into super-galactic aggregates? The existence of many definite groups of galaxies with anywhere from a dozen to a thousand members would seem to provide an immediate answer to this question, but the true status of these groups or clusters of galaxies is not as evident as that of the stars or the galaxies. Each of the stars is a definite unit, constructed according to a specific pattern from subsidiary units that are systematically related to each

other. The same can be said of the galaxies. It is by no means obvious, however, that this statement can be applied to the clusters of galaxies. So let us turn to a theoretical examination of the question.

The globular cluster, we found, originates as a contracting aggregate of diffuse matter in which numerous centrally concentrated sub-aggregates are forming. Because of their central concentration these sub-aggregates, which eventually become stars, meet their neighbors at locations of minimum gravitational effect, and their net movement is therefore outward away from each other. Dispersed aggregates of near uniform density, on the other hand, meet their neighbors at locations where the gravitational effect is at a maximum. They exist as separate entities only because of competition between the various centers, which limits each aggregate to the minimum stable size. When open space is made available by reason of contraction of the individual units, these aggregates, the globular clusters, move inward toward each other.

If we now consider a still larger volume of space, there are no large-scale aggregates corresponding to the stars; that is, centrally concentrated aggregates that are outside the gravitational limits of their neighbors. But in their original condition, the assemblage of globular clusters constitutes a dispersed aggregate similar to the dispersed aggregate of gas and dust particles, but on a larger scale. Applying the same principles as before, we can deduce that there exists a gravitationally determined limiting size of the aggregates of clusters (which we will call *groups*) corresponding to the limiting size of the aggregates of gas and dust (the globular clusters). We could continue this hierarchy of aggregates, and contemplate an aggregate of groups, but before this next level of structure has time to materialize, the life span of the constituent stars has terminated. Thus the groups of globular clusters, which eventually become groups of galaxies, are the largest structural units. The hierarchical theory, in which there are clusters, clusters of clusters, and so on indefinitely, is thus excluded. This theory has maintained a certain amount of support in astronomical circles over the years, but on the basis of the foregoing findings it is no longer tenable.

The theoretically defined groups of galaxies are not necessarily, or even usually, coincident with the currently recognized aggregates called clusters of galaxies. The members of each of the classes of aggregates that we have defined, clusters and groups, are moving inward toward each other. The inward motion of the smaller units, the clusters, is much the faster. It follows that the net motion of the outer clusters of adjoining groups carries them away from each other, even though the groups of which they are components are moving inward. Consequently, the amount of empty space between groups continually increases. Ultimately the inward motion of the groups would reverse this trend, if it continued, but before this can happen the time limit intervenes.

Inasmuch as the new groups form in the regions of space left empty by the recession or disintegration of previously existing groups of galaxies—the “holes” in space reported by the astronomers—the sizes of the resulting aggregates of galaxies are determined by the sizes of the vacant spaces. This is a matter of chance, and the individual values are no doubt distributed over a considerable range, but we can conclude that there is an average size, probably including some hundreds of visible galaxies and many hundreds of invisible dwarfs, to which most aggregates will conform approximately, with a relatively small number substantially above or below this average.

On this basis, the largest units in which gravitation is effective toward consolidation of its components are the groups of galaxies. Each such group is formed jointly with a number of adjoining groups. These groups begin separating immediately, but until the outward movement produces a clear-cut separation, their identity as distinct individuals is not apparent to observation. Here, then, is the explanation of the large “clusters” and “superclusters” of galaxies. These are not structural units in the same sense as stars or galaxies, or the groups of galaxies that we have been discussing. Each consists of a number of independent groups, formed simultaneously in the same general region of space, and separating so slowly that the processes of galaxy formation and growth are well under way before the units have moved far enough apart to be recognized as separate entities. Some of the mathematical aspects of these cluster relationships will be explored further in Chapter 15.

CHAPTER 3

Globular Clusters

In the preceding chapter we saw that galaxies (small ones, called globular clusters) condense out of diffuse material, grow by accretion and capture, and finally at an advanced age reach the limiting size, that of a giant spheroidal galaxy. This is the essence of the large-scale evolutionary process in the material sector of the universe, the subject of the first half of this volume. The next several chapters will be devoted to examining the most significant details of this process. We will first turn our attention to the galaxies, junior grade, the globular clusters.

It should be noted, in this connection, that current astronomical theory has no explanation for either the formation of the clusters or their existence in their present form. It is generally assumed that the clusters are products of the process of galaxy formation, but this provides no answer to the problem, in view of the absence of anything more than vague and tentative ideas as to how the galaxies were formed.

The clusters are spherical, or nearly spherical, aggregates containing from about 20,000 stars to a maximum that is subject to some difference of opinion, but is probably in the neighborhood of a million stars. These are contained in a space with a diameter of from about 5 to perhaps 25 parsecs. The parsec is a unit of distance equivalent to 3.26 light years. Both of these units are in common use in astronomy, and in order to conform to the language in which the information extracted from the astronomical literature is expressed, both units will be employed in the pages that follow.

The structure of these clusters has long been a mystery. The problem is that only one force of any significant magnitude, that of gravitation, has been definitely identified as operative in the clusters. Inasmuch as the gravitational force increases as the distance decreases, the force that is adequate to hold the cluster together should be more than adequate to draw the constituent stars together into one single mass, and why this does not happen has never been ascertained. Obviously some counter force is acting against gravitation, but the astronomers have been unable to find any such force. Orbital motion naturally suggests itself, in view of the prevalence of such motion among astronomical objects, but the rotations of the clusters, if they are rotating at all, are far too small to account for the outward force. For example, K. Cudworth, reporting

on a study of M 13, says that “no evidence of cluster rotation was found.”²⁴

It is recognized that this is a problem that calls for an answer. “Why then is the rotation of globular clusters so small?”²⁵ ask Freeman and Norris. Those who dislike having to concede that there is a significant gap in astronomical knowledge here are inclined to make much of the fact that a few clusters do show some signs of rotation. For instance, Omega Centauri is slightly flattened, and some indication of rotation has been found in the spectra of M 3. But a showing that *some* clusters rotate is meaningless. *All* must be rotating quite rapidly to give any substance to the hypothesis that rotational forces are counterbalancing the gravitational attraction. If even *one* cluster is not rotating, or is rotating only slowly, this is sufficient to demonstrate that rotation is *not* the answer to the problem. Thus it is clear that rotation does not provide the required counter force.

The suggestion has also been made that these clusters may be similar to aggregates of gas molecules, in which the individual units maintain a wide separation, on the average. But such an explanation requires both high stellar speeds and frequent collisions, neither of which can be substantiated by observation. Furthermore, the existence of the gaseous type of structure depends on elastic collisions, and the impact of stars upon stars, if it were possible, would certainly not be elastic. Indeed a rather large degree of fragmentation could be expected. Together with the large kinetic energies that would be required to counterbalance the weight of the overlying layers of stars, this would result in a physical condition in the central regions of the clusters very different from that existing in the outlying regions. Here, again, no such effect is observed.

The astronomers are reluctant to concede that such a conspicuous problem as that of the structure of these clusters is without an acceptable solution, and the general tendency is to assume that the possibilities mentioned in the preceding paragraphs will somehow develop into an answer at some future time. It is therefore significant that exactly the same problem exists with respect to the observed dust and gas clouds in the Galaxy, and here, where the processes suggested as possible explanations of the cluster structure clearly do *not* apply, the theorists are forced to admit that this is “a major unanswered question.” The dust cloud situation will be discussed in Chapter 9.

As in so many of the phenomena previously examined, the answer to this problem is provided by the outward progression of the natural reference system relative to the conventional stationary system of reference. Because of the way in which the cluster is formed, every constituent star is outside the gravitational limits of its neighbors, and therefore has a net outward motion away from each of them. Coincidentally, all of the stars in the cluster are subject to a motion toward the center of the aggregate by reason of the gravitational effect of the cluster as a whole. Near this center, where the gravitational effect of the aggregate is at a minimum, the net motion is

outward. But in the outer regions of the cluster, where the gravitational motion exceeds the progression of the reference system, the net motion is inward. The outer stars thus exert a force on the inner ones, confining them to a finite volume, in much the same way that the fabric of a balloon confines the gas that it encloses. The immense region of space around each star is thus reserved for that star alone, irrespective of the stellar motions. Whether or not the cluster acquires a rotation is immaterial. It is equally stable in a static condition.

This question as to the structure of the globular clusters is only one of many physical situations in which an equilibrium exists between gravitation and a hitherto unidentified counter force. Because of the lack of understanding of the nature and origin of this force, the general tendency has been to ignore it, and either to grope for some other kind of answers, as in the globular cluster case, or to evade the issue in some manner. One of the few authors who has recognized that an "antagonist" to gravitation must exist is Karl Darrow. "This essential and powerful force has no name of its own," Darrow points out in an article published in 1942. "This is because it is usually described in words not conveying directly the notion of force."²⁶ By this means, Darrow says, the physicist "manages to avoid the question." In spite of the clear exposition of the subject by Darrow (a distinguished member of the Scientific Establishment), and the continually growing number of cases in which the "antagonist" is clearly required in order to explain the existing relations, the physicists have "managed to avoid the question" for another forty years.

The development of the theory of a universe of motion has now revealed that the interaction between two oppositely directed forces plays a major role in many physical processes all the way from inter-atomic events to major astronomical phenomena. We will meet the "antagonist" to gravitation again and again in the pages that follow. Like gravitation, this counter force, which we have identified as the force due to the outward progression of the natural reference system relative to the conventional system of reference, is radial in the globular cluster, and since these two are the only forces that are operative to any significant degree during the formative period, the contraction of the original cloud of dust and gas into a cluster of stars is accomplished without introducing any appreciable amount of rotation. This is the answer to the question posed by Freeman and Norris. As noted in Chapter 2, consolidation of two or more of these clusters to form a small galaxy usually results in a rotating structure. The same result could be produced on a smaller scale if the cluster picks up a stray group of stars or a small dust cloud. Some such event, or gravitational effects during the approach to the Galaxy, probably accounts for the small amount of rotation that does exist in some clusters.

The compression of the cluster structure reduces the inter-stellar distances to some extent, but they are still immense. Current estimates put the density at the center of the cluster at about 50 stars per cubic parsec, as compared to one

star per ten cubic parsecs in the solar vicinity.²⁷ This corresponds to a reduction in separation by a factor of eight. Since the local separation exceeds 112 parsecs, or five light years, the average separation in the central regions after compression is still more than half of a light year, or 3×10^{12} miles, an enormous distance.

For general application to the inter-stellar distances, the term "star system" has to be substituted for the word "star" as used in the foregoing paragraphs, but star systems in this sense are rare in the globular clusters. The origin and nature of double and multiple systems will be discussed in Chapter 7.

In assessing the significance of the various available items of information about the globular clusters, to which we will now turn our attention, it should be kept in mind that all of the conclusions that have been reached in this work concerning these individual items are derived from the same source as the foregoing explanations of the origin and structure of the globular clusters; that is, from the postulates that define the universe of motion.

As indicated in the preceding chapter, the observations of the globular clusters add materially to the amount of evidence confirming the theoretical conclusions as to the growth of the galactic aggregates by the capture process. On the basis of this theory, each galaxy is pulling in all of the clusters within its gravitational limits. We can therefore expect all galaxies, except those that are still very young and very small, to be surrounded by a concentration of globular clusters moving gradually inward. Inasmuch as the original formation of the clusters took place practically uniformly throughout all of the space under the gravitational control of each galaxy (except for a very large-scale radial effect that will be discussed later), the concentration of clusters should theoretically continue to increase as the galaxy is approached, until the capture zone is reached. Furthermore, the number of clusters in the immediate vicinity of each galaxy should theoretically be a function of the gravitational force and the size of the region within the gravitational limit, both of which are related to the size of the galaxy.

These theoretical conclusions are confirmed by observation. A few clusters have been found accompanying such small galaxies as the member of the Local Group located in Fornax; there are several in the Small Magellanic Cloud and two dozen or more in the Large Cloud; our Milky Way galaxy has 150 to 200, when allowance is made for those which we cannot see for one reason or another; the Andromeda spiral, M 31, has the same or more; NGC 4594, the "Sombrero" galaxy, is reported to have "several hundred" associated clusters; while the number surrounding M 87 is estimated to be from one to two thousand.

These numbers of clusters are definitely in the same order as the galactic sizes indicated by observation and by criteria previously established. The Fornax—Small Cloud—Large Cloud—Milky Way sequence is not open to question. M 31 and our own galaxy are probably close to the same size, but

there are indications that M 31 is slightly larger. The dominant nucleus in NGC 4594 shows that this galaxy is still older and larger, while all of the characteristics of M 87 suggest that it is near the upper limit of galactic size.

Observation gives us only what amounts to an instantaneous picture, and to support the validity of the theoretical deductions we must rely primarily on the fact that the positions of the clusters as observed are strictly in accord with the requirements of the theory. It is significant, however, that such information as is available about the motions of the clusters of our own galaxy is also entirely consistent with the theoretical findings. In the words of Struve, we know "that the orbits of the clusters tend to be almost rectilinear, that they move much as freely falling bodies attracted by the galactic center."²⁸ According to the theory of the universe of motion, this is just exactly what they are.

We see the globular clusters as a roughly spherical halo extending out to a distance of about 100,000 light years from the galactic center. There is no definite limit to this zone. The cluster concentration gradually decreases until it reaches the cluster density of intergalactic space, and individual clusters have been located out as far as 500,000 light years. This distribution of the clusters is completely in agreement with the theoretical conclusion that the clusters do not constitute parts of the galactic structure, but are independent units that are on the way to capture by the Galaxy. Both the spherical distribution and the greater concentration in the immediate vicinity of the Galaxy are purely geometrical consequences of the fact that the gravitational forces of the Galaxy are pulling the clusters in from all directions at a relatively constant rate.

On the basis of the theoretical findings described in the preceding pages, the globular clusters are the youngest of the visible astronomical structures, and the stars of which they are composed (aside from an occasional older star or a small group of stars obtained from the environment in which the cluster condensed) are the youngest members of the stellar population. One of the observable consequences of this youth is supplied by the composition of the matter in the cluster stars. Inasmuch as the build-up of the heavier elements, according to the theoretical findings, is a continuing process, offset only to a limited extent by the destruction of those atoms that reach one or the other of the destructive limits, the proportion of heavy elements in any aggregate increases with age. It can be expected, then, that the stars of the globular clusters, with only a few exceptions, are composed of relatively young matter, in which the heavy element content is low.

The evidence concerning the stellar composition is somewhat limited, as the observations reflect only the conditions in the outer regions of the stars, and are influenced to a substantial degree by the character of the material currently being accreted from the environment. "Detailed studies of the composition of stars," says J. L. Greenstein, "can be made only in their atmospheres."²⁹ However, the differences in the reported values are too large to leave any

doubt as to the general situation. For example, the percentage of elements above helium in the average globular cluster is reported to be lower by a factor of 10 or more than the corresponding percentage in the sun.³⁰

Current astronomical theory concedes that the matter in the stars of the globular clusters is matter of a less advanced type than that in the spiral arms, but to reconcile this fact with the prevailing ideas as to the age of the clusters it invokes the assumptions (1) that the heavier elements were produced in the stellar interiors, (2) that they were ejected therefrom in supernova explosions, and (3) that the stars with the greater heavy element content were formed from this ejected material. This is an ingenious theory, but it is being called upon to explain a situation that is decidedly abnormal. The normal expectation would, of course, be that the youngest matter would be found in the youngest structures. A theory that postulates a reversal of the normal relationships is not ordinarily given serious consideration unless some strong evidence in its favor can be produced, but in this case there is no observational evidence to support any of the three assumptions. Indeed, there is some evidence to the contrary, as in the following report:

The relative abundance of these [heavy] elements in the supernova is not very different from their abundance in the sun. If the supernovae synthesize heavy elements out of lighter ones in the course of their explosion, none of that material is initially seen in the rapidly expanding debris.³¹ (Robert P. Kirshner)

This is an example of the way in which, as noted in Chapter 1, the astronomical community is disregarding or distorting the evidence from observation in order to avoid contradicting the physicists' conclusions as to the nature of the stellar energy generation process. The failure to find any evidence of the predicted increase in the concentration of heavy elements in the supernova products is, in itself, a serious blow to a theory that rests entirely on assumptions, but it is only one of a long list of similar conflicts and inconsistencies that we will encounter as we proceed with our examination of the astronomical field.

As will be demonstrated in the pages that follow, all of the relevant astronomical evidence that is available is consistent with the theoretical identification of the course of galactic evolution outlined in the preceding pages, and is more than ample to confirm its validity. In fact, the available data concerning the globular clusters are sufficient in themselves to provide a conclusive verification of the theoretical conclusions set forth in this work. The remainder of this chapter will review these globular cluster data, and will indicate their relevance to the point at issue. The various items of information that have been accumulated will be described briefly. Each description will then be followed by a short discussion, indicating the manner in which this

item is related to the point that is being demonstrated: the validity of the new conclusions with respect to the place of the clusters in the evolutionary sequence.

1. *Observation:* The globular cluster structure is stable.

Comment: The explanation of the hitherto inexplicable structure of the clusters has already been discussed, but it should be included in the present review of the evidence contributed by the observations. The fact that the explanation of the cluster structure is provided by the existence of the same hitherto unrecognized factor that accounts for the recession of the distant galaxies is particularly significant.

2. *Observation:* The proportion of heavy elements in the stars of the globular clusters is considerably lower than in the stars and interstellar material in the solar neighborhood.

Comment: Like item number 1, this fact, already discussed, is being included in the list so that it will appear in the summary of the evidence.

3. *Observation:* Some globular clusters contain appreciable numbers of hot stars.

Comment: This observed fact is very disturbing to the supporters of current theories. Struve, for example, called the presence of hot stars an "apparent defiance" of stellar evolutionary theory.³² But it is entirely in harmony with the theory of the universe of motion. Some stars, or groups of stars, are separated from the various aggregates by explosive processes, and are scattered into intergalactic space. As the globular clusters form from dispersed material they incorporate any of these strays that happen to be present. Others are captured as the clusters move through space. The presence of a small component of older and hotter stars in some of the young globular clusters is thus normal in the universe of motion. On the other hand, if the clusters have always existed in the outer regions of the galaxies, and are composed of very old stars, in accordance with conventional astronomical theory, the hot stars (which in this theory are young) should have disappeared long ago.

4. *Observation:* Some clusters also contain nebulous material.

Comment: Helen S. Hogg, writing in the *Encyclopedia Britannica*, says, "Puzzling features in some globular clusters are dark lanes of nebulous material." It is difficult, she says, "to explain the presence of distinct, separate masses of unformed material in old systems."³³ Quite true. But it is easy to explain the presence of such material in young systems, which the clusters are, according to the findings of this work.

5. *Observation:* There is an increasing amount of evidence indicating that very large dust clouds are being pulled into the Galaxy.

Comment: This observed phenomenon has not yet been fitted into conventional astronomical theory. It is part of the cannibalism that is contrary to the premises of that theory, but is not yet clearly recognized in that light. In

the universe of motion, the significance of these incoming dust clouds is clear. They are simply unconsolidated globular clusters, aggregates that have been, or are about to be, captured by the Galaxy before they have had time to complete the process of star formation. Considerable information concerning the structure of these unconsolidated clusters, and the nature of the processes that they undergo after entering the Galaxy, is now available, and will be examined in Chapter 9.

6. *Observation:* Aside from the somewhat exceptional instances where nebulous material is present, the globular clusters show little evidence of the presence of dust.

Comment: Current astronomical theory ascribes this to age, assuming that over a long period of time the original dust will have been formed into stars, or captured by stars. Our finding is that the nature of the globular cluster condensation process results in almost all of the dust and gas of which the cluster was originally composed being brought under the gravitational control of the stars. In this condition the dust is not observable as a separate phenomenon. Evidence of the existence of dust aggregates is observed only where the normal condensation process has been subject to some disturbing influence, or where a dust cloud has been captured.

7. *Observation:* Globular clusters exist in a zone surrounding our galaxy that extends out to a distance of at least 100,000 light years from the galactic center, and in similar locations around other galaxies. The existence of a substantial number of clusters in intergalactic space is also indicated.

Comment: The crucial point in this connection is the number of intergalactic clusters. According to conventional theory, the formation of the globular clusters was part of the formation of the galaxies, and there should be no clusters between the galaxies other than a few strays. In the universe of motion intergalactic space is the original zone of formation of the clusters, and the concentration around each galaxy is merely a geometric result of the gravitational motion toward the galaxy from all directions. On this basis there should be no definite limits to the cluster zone. The clusters should just thin out gradually until they reach the approximately uniform density in which they exist in space that is free of large aggregates of matter. The total number of intergalactic clusters should thus be very large. The amount of information currently available is not sufficient to provide a definitive answer to the question as to how common these intergalactic clusters actually are, but the increasing number of discoveries of distant clusters is highly favorable to the new theory.

The growing realization that dwarf galaxies, not much larger than globular clusters, may be “the most common type of galaxy in the universe” is a significant step toward recognition that intergalactic space is well populated with globular clusters. Indeed, some of the aggregates that are now being identified as dwarf galaxies may actually be globular clusters. Current

estimates of the size of these dwarf galaxies, which put the average at about one million stars, are within the range of the estimates of the sizes of the globular clusters that have been made by other observers.

8. *Observation:* The number of clusters associated with each galaxy is a function of the mass of the galaxy.

Comment: Either theory can produce a satisfactory explanation of this fact. On the basis of conventional theory the material from which the clusters are formed should constitute a fairly definite proportion of the total galactic raw material, and a larger galaxy should therefore provide material for more clusters. The Reciprocal System of theory asserts that the clusters are being drawn in from surrounding space, and that the more massive galaxies gather more clusters because they exert stronger gravitational forces throughout larger volumes of space.

9. *Observation:* The distribution of clusters around the Galaxy is nearly spherical, and there is no evidence that the cluster system participates to any substantial degree in galactic rotation.

Comment: This is difficult to reconcile with conventional theory. If the formation of the clusters was a part of the galaxy formation as a whole, it is hard to explain why one part of the structure acquired a high rotational velocity while another part of the same structure acquired little or none. B. Lindblad has suggested that the Galaxy is composed of sub-systems of different degrees of flattening, each rotating at a different rate. This, however, is simply a description, not an explanation. The Reciprocal System of theory provides a simple and straightforward explanation. According to this theory the clusters are not part of the Galaxy, but are external objects being drawn into the Galaxy by gravitational forces. On this basis the reason why the clusters do not participate in the galactic rotation is obvious. The nearly spherical distribution is also explained by the theoretically near uniform distribution of the clusters in the volume of space from which they were drawn.

10. *Observation:* Interstellar distances in the outer regions of the globular clusters are comparable to those in the solar neighborhood. Present estimates are that the distances in the central regions are less by a factor of about eight.²⁷

Comment: The significant point about the foregoing is that the variations in interstellar distance are relatively minor, and even in the locations of greatest density the distances between the stars are enormous. Conventional theory has no explanation for this state of affairs. In fact, the observed limitation on the minimum distance between stars is ignored in current astronomical thought, and close approaches of stars are features of a number of astronomical theories. The finding of this work is that the immense size of the minimum distance between stars (other than that between members of binary or multiple systems) is not accidental; it is a result of the inability of a star (or star system) to come within the gravitational limit of another. The stars *do not* approach each other more closely because they *can not* do so.

11. *Observation:* The “orbits” of the clusters are rectilinear. As expressed by Struve in the statement previously quoted, the clusters “move much as freely falling bodies attracted by the galactic center.”

Comment: Our findings are that this is exactly what they are, and that the observed motions are therefore just what we should expect. Conventional theory can explain such motions only by assuming extremely elongated elliptical orbits with relatively frequent passage of the clusters through the galactic structure. In view of the liquid-like nature of this structure, as deduced from the postulates that define the universe of motion, such passages through the galaxy are clearly impossible. Even without this information, however, it should be rather obvious that there is *some* reason why the observed minimum separation between the stars in the solar neighborhood (the only region in which we can determine the minimum) is so large. There is no justification for assuming that this reason, whatever it may be, is any less applicable to the stars of the globular clusters. The factors that determine this minimum separation bar the passage of *any* stellar aggregate through any other such aggregate, irrespective of what their nature may be. The conventional explanation of the observed inward motions of the clusters also conflicts with the following observation.

12. *Observation:* Clusters closer to the galactic center are somewhat smaller than those farther out. Studies indicate a difference of 30 percent between 10,000 parsecs and 25,000 parsecs.³⁴

Comment: If the “elongated orbit” theory were correct, the present distances from the galactic center would have no significance, as a cluster could be anywhere in its orbit. But the existence of a systematic difference between the closer and more distant clusters shows that the present positions do have a significance. Since the visible diameter of the average cluster is in the neighborhood of 100 light years, and the actual overall dimensions are undoubtedly greater, there is a substantial gravitational differential between the near and far sides of a cluster at distances within 100,000 light years. We can therefore deduce that the clusters are experiencing an increasing loss of stars as they approach the Galaxy, both by acceleration of the closest stars and by retardation of the most distant. The effect of slow losses of this kind on the shape of the aggregate is minor, and the detached stars merge with the general field of stars that is present in the same zone as the cluster. The process of attrition is therefore unobservable in any direct manner, but we can verify its existence by the comparison of sizes as noted above. From the observed differences it appears that the clusters lose more than half of their mass by the time they reach what may be regarded as the capture zone, the region in which the gravitational action on the cluster structure is relatively severe.

The loss of stars due to gravitational differentials is substantially less in the case of a cluster approaching a small elliptical galaxy. Thus we find that an elliptical galaxy in Fornax, a member of the Local Group with a mass of about

2×10^9 solar equivalents, “contains about five globulars that are bigger than those in our galaxy.”²⁰

13. *Observation:* There is also an increase in the heavy element content of the cluster stars as the distance from the galactic center decreases.

Comment: This is another systematic correlation with radial distance that contradicts the “elongated orbit” theory. It is also inconsistent with the currently prevailing assumption that the globular clusters are component parts of the Galaxy and were formed in conjunction with the rest of the galactic structure.

14. *Observation:* The globular clusters range in size from a few tens of thousands to over a million stars. No *stable* stellar aggregates have been found between this size and the multiple star systems consisting of a few stars separated by very short distances comparable to the diameters of planetary orbits.

Comment: This is a very striking situation for which present-day astronomical theory has no explanation. A study of the problem by S. Von Hoerner was able to conclude only that “the reasons must lie in the original conditions under which the clusters were formed.”³⁵ This is true, but it is not an explanation. What is needed is the information derived from theory in Chapter 2, the nature of those “conditions under which the clusters were formed.” As brought out there, no star can be formed within the gravitational limit of an existing star or multiple star system, since the gravitational pull of that star or star system prevents the accumulation of sufficient star-forming material. (Binary and multiple stars, as we will see later, are formed by division of existing stars, not by condensation of new stars.) Stars formed outside the gravitational limit of an existing star are subject to a net outward motion. The cluster is held together only by reason of the gravitational attraction that the cluster as a whole exerts on its constituent stars. A cluster must therefore exceed a certain minimum size in order to be gravitationally stable. Such clusters originate only where large numbers of stars are formed contemporaneously from dust and gas clouds of vast proportions.

The foregoing discussion has considered 14 sets of facts, derived from observation, that represent the most significant items of information about the globular clusters now available, aside from a few items that we will not be in a position to appraise until after some further background information has been developed. The deductions from the postulates of the universe of motion that have been described supply a full and detailed explanation of every one of these sets of facts. The performance of conventional astronomical theory, on the other hand, is definitely unsatisfactory, even if it is given the benefit of the doubt where definitive answers to the questions at issue are unavailable. Evaluation of the adequacy of explanations is, of course, a matter of judgment, and the exact score will differ with the appraiser, but an evaluation on the basis of the comments that were made in the preceding discussion leads to the

conclusion that conventional theory provides explanations that are tenable, on the basis of what is known from observation, for only three of the 14 items (1,6,8). It supplies no explanation at all for five items (2,7,9,10,14), and the explanation it advances is inconsistent with the observed facts in 6 cases (3,4,5,11,12,13). Five more sets of observations that are pertinent to this evaluation will be examined in Chapter 9, and with the addition of these items the total score for conventional astronomical theory is 4 items explained, 7 with no explanation, and 8 explanations inconsistent with observation. The significance of these numbers is obvious.

CHAPTER 4

The Giant Star Cycle

Thus far we have been concerned with the globular clusters and their successors as *aggregates* of stars. Now we will turn our attention to the individual stars of which these aggregates are constructed. As we saw in Chapter 1, the stars originate as dust and gas clouds. There is no clear line between dust cloud and star. Until comparatively recently stars could be detected only by means of their radiation in the visible range, and this established a low limit at about 2500 K. During the last few decades instruments of greatly extended range have been developed, and stars of normal characteristics are now being observed down to the neighborhood of 1000 K. Infrared objects of a nature not yet clearly determined, with surface temperatures as low as 300 to 700 K, have been reported.

From theoretical considerations we deduce that at some point after the interior of a contracting cloud of dust and gas has been raised to a high temperature by gravitational energy, a relatively rapid rise in the temperature of the entire aggregate occurs when the destructive limit of the heaviest element present is reached in the central regions, and conversion of mass to energy begins. As explained in Volume II, both the thermal energy of the matter in the star and its ionization energy are space displacements, and when the total of these space displacements reaches equality with one of the rotational time displacements of an atom, the opposite displacements neutralize each other, and the rotation reverts to the linear basis. In other words, both the ionization and a portion of the matter of the atoms are converted into kinetic energy. Inasmuch as all atoms are fully ionized before the temperature limit is reached, and the heavier atoms are capable of acquiring a greater degree of ionization than the lighter ones, the amount of thermal energy required to bring the total space displacement up to the limit is less for the heavier elements. The limiting temperature is therefore inversely related to the atomic mass.

Production of increasingly heavier elements is a continuing process that begins with the original entry of primitive matter from the cosmic sector. The pre-stellar dust cloud therefore contains a small proportion of newly formed heavy elements, together with whatever heavy element content there may have been in the fragments of older matter incorporated from the surroundings. Inasmuch as the entire structure of the cloud is fluid, the heavy elements make

their way to the center. As the temperature in the central regions rises, successively lighter elements reach their destructive limits and are converted to energy.

Activation of this second energy source necessitates an immediate and substantial increase in the temperature of the aggregate in order to produce enough radiation to reach equilibrium with the greater energy generation. Thus there is not a gradual rise of the surface temperature of the aggregate from the near zero of inter-stellar space up to the levels recognized as those of stars, but rather a long period of no more than minor warming, followed by a quite sudden jump to the temperature of an infrared star. The objects cooler than 1000 K generally display some peculiar characteristics that distinguish them from normal stars, and make it difficult to draw definite conclusions as to their true nature.

The most significant evolutionary changes that take place in the stars as they grow older can conveniently be shown on a graph in which the luminosity (expressed as magnitude) is plotted against some measurement representing the surface temperature. In its original form, this Hertzsprung-Russell, or H-R, diagram utilized an arbitrary spectral classification as the temperature variable, but the present tendency is to use a color index, which accomplishes the same result. The textbooks still retain the H-R diagram, probably for historical reasons, but the color-magnitude, or CM, diagram is now in general use by the observers.

The CM diagram of the globular cluster M 3 is shown in Fig. 3. In this diagram the points representing the magnitudes applicable to the individual stars fall mainly within the cross-hatched area. Identification of the locations marked O, A, B, and C has been added to the conventional diagram for purposes of this present discussion.

The mass, density, and central temperature of the globular cluster stars are related to the variables of the CM diagram, and although they are subject to modification by other factors, so that they cannot be represented accurately in this two-component diagram, they can be located approximately, and adding them to the framework of the diagram for reference purposes facilitates understanding of the theoretical development. Accurate measurements of magnitudes in the area of the diagram occupied by the globular cluster stars are difficult to obtain. S. J. Inglis points out that "There is no red giant whose mass we know with any degree of certainty."³⁶ But we can relate these magnitudes to the evolutionary pattern of the stars, and thus arrive at approximations of their values.

We know, for instance, that the line BC, the *main sequence*, is the location of gravitational equilibrium. The stars on this line are therefore at approximately the same density. The density at C is actually greater than that at B by a factor of 3 or 4, because of the compression due to the larger stellar mass, but since the equilibrium densities along the main sequence are more than a million

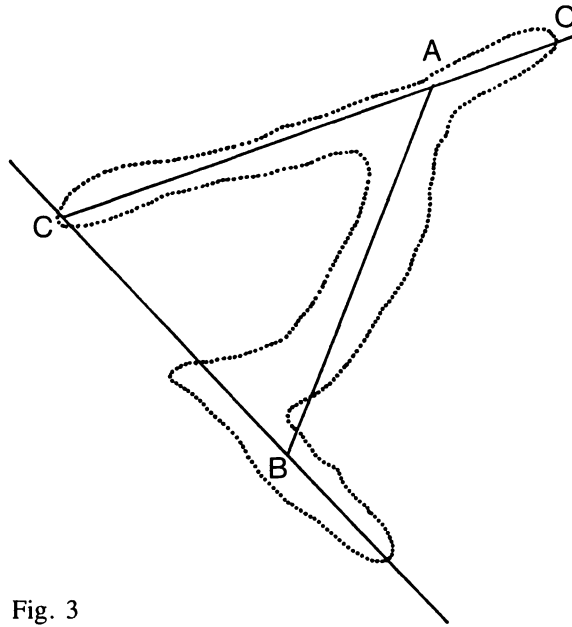


Fig. 3
CM Diagram

times greater than those in the early portions of area O, the difference between B and C is negligible on the scale of the diagram. We may therefore draw lines parallel to BC and treat them as lines of equal density for analytical purposes. Similarly, the line AB theoretically represents a condition of constant mass. The theory further indicates that the central temperatures are determined by the stellar mass. Lines parallel to AB can thus be regarded as lines of equal mass and central temperature. On the basis of the explanation of the line AC that will be developed in the following pages, this line represents a condition in which condensation of a dust cloud of nearly uniform density is proceeding at a rate determined by gravitational forces. We may call it a line of constant growth.

Fig. 4 is a reproduction of the M 3 diagram with the lines representing these other variables added. These lines provide a good indication of the way in which the several variables are related in different regions of the diagram, and reference to the pattern of this illustration will be helpful in interpreting the CM diagrams that will be introduced later. The relations represented by the auxiliary lines in Fig. 4 apply to *the stars of the globular cluster type only*. As we will see later, the corresponding relations—the lines of equal mass, for instance—are altogether different for other classes of stars. This is a fact that has not heretofore been recognized, an oversight that is responsible for many

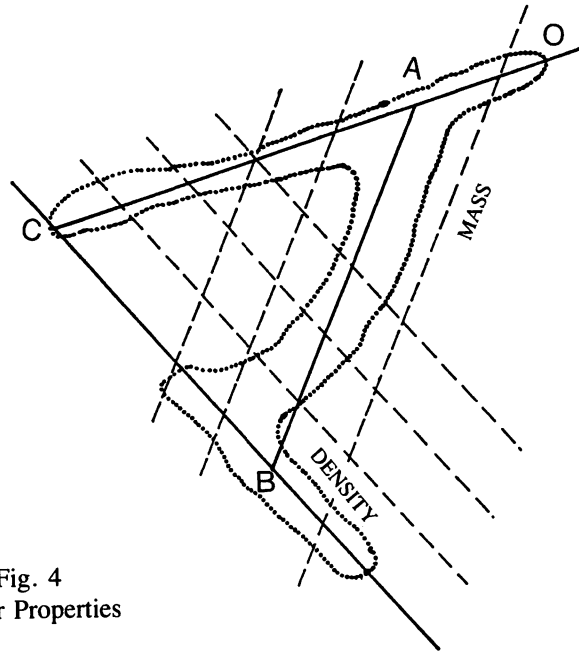


Fig. 4
Stellar Properties

errors in the orthodox interpretations of the CM diagrams.

All of the stars of a globular cluster condensed from the same dispersed aggregate of primitive material, but the conditions affecting the rate of condensation varied, and the evolutionary stages of the stars therefore differ. Consequently, the stars of a cluster such as M 3 are spread out over a range of the stellar evolutionary pattern on the CM diagram. The earliest of the visible stars are the coolest but, by reason of the immense area from which they are radiating, their luminosity is relatively high. These stars therefore occupy positions in the upper right of the diagram, in the general area marked O. The remainder of this chapter will give a general description of the paths that these stars follow when they leave this area. Further details will be added in Chapter 8, after some additional groundwork has been laid.

The stars of these globular clusters exist in two size ranges. The great majority are small, in the neighborhood of the solar mass or below. Another portion of the total consists of stars that are substantially larger. We can identify the latter as stars that had a fragment of pre-existing material as a nucleus for condensation of the pre-stellar dust and gas cloud. The smaller stars are those that did not enjoy this advantage. The fragments incorporated into the stars were usually small, as the explosions that scattered them into space were violent enough to reduce the greater part of the original structure to

dust, gas, and small aggregates. The growth of the stellar structure follows essentially the same course whether or not it contains a small fragment as a nucleus. The important difference is that it takes a very long time to build a dust particle up to an aggregate of fragment size. A pre-stellar aggregate that has a fragment to start with therefore has a big head start over those that have to build all the way from dust particles, and it is able to establish gravitational control over a larger volume of the protocluster. Thus, even though the stars of both of these groups are nearly alike at their points of origin in area O, those of one group have a much greater potential for growth.

The supply of dust and gas available for capture is, in effect, exhausted for the first group by the time they reach the vicinity of point A. These stars then cease to grow, and they no longer continue on the path OC. Instead they make a sharp turn and move downward on a relatively steep slope, reaching gravitational equilibrium on the main sequence at point B. Along the path AB the gravitational contraction continues, but because the mass is no longer increasing, the central temperature remains approximately constant. The decrease in the size of the radiating surface results in an increase in the surface temperature, but coincidentally the corresponding increase in density increases the resistance to the flow of heat from the center of the star to the surface. These two oppositely directed processes just about counterbalance each other, and the net result, including the effect of the energy contributed by the contraction, is a small increase in surface temperature. The combination of a decrease in the radiating surface and a relatively small temperature change results in a rapid decrease in the luminosity.

With the benefit of this information as to the nature of the changes that take place along the evolutionary path OAB of the small stars, it can now be seen that the stars on the path OAC are subject to the same factors, except that there is a continuous addition of more matter, and a consequent increase in the central temperature. As a result, the increase in surface temperature is much greater than that along the line AB, and the decrease in luminosity is smaller, leading to a nearly horizontal movement across the CM diagram.

Arrival at the main sequence, at either point B or point C, eliminates any further generation of energy from gravitational contraction. Each star then has to establish a thermal equilibrium on the basis of the atomic energy generation alone. For this purpose it moves up or down the main sequence to the point where the dissipation of energy by radiation is in balance with the energy production. The main sequence is the location where the stars spend most of the latter part of their lives. It has been estimated that about 95 percent of the observable stars are on this sequence (although it should be understood that the observable stars do not constitute a representative sample of the stars as a whole). For convenient reference in the subsequent discussion we will designate the stars on the evolutionary paths OAB or OAC as Class A, and those of the main sequence as Class B. The stars of Class A and Class B

coincide, in general, with those currently called Population II and Population I respectively. The reason for the reversal of the sequence is that it puts the classes into the correct evolutionary order. The younger stars are currently called Population II. The A classification is more appropriate.

In the context of the star and cluster formation process deduced from the postulates that define the universe of motion, the foregoing explanation of the CM diagram of the globular clusters is essentially self-evident, but the astronomers cannot take this simple and logical view of the situation. They did so in an earlier era, but they have changed their ideas. As one author states, "Present knowledge has forced a nearly complete reversal of this view." This "knowledge," he says, is partly observational and partly theoretical. The "observational" items that he cites are (1) "red giants are common in globular clusters and elliptical galaxies, systems which are known to be of great age . . . and in which star formation has ceased countless ages ago," and (2) "red giants do not appear in greater numbers in the nebulous regions of the Galaxy, as they would certainly do if they had been formed recently from the great gas and dust clouds of space."³⁷

As can easily be seen, these so-called "observational" items are, in fact, purely theoretical. Their application to the points at issue depends entirely on the prevailing theories of stellar formation and of stellar ages. As long as the astronomers were basing their conclusions on the evidence from their own field, they arrived at an understanding of the evolutionary course of the globular cluster stars very similar to that which we now derive from the Reciprocal System of theory. But it became evident that this conclusion is inconsistent with the physicists' contention that the stellar energy is generated by the hydrogen conversion process (this is the "present knowledge" cited in the quotation above). This pure *assumption* by the physicists is the only basis for the assertion that the globular clusters "are known to be of great age." There is no *astronomical* basis for that conclusion. But since the astronomers are unwilling to challenge the physicists' assertions, they have, as indicated in the quoted comment, "completely reversed" their own ideas, and have accommodated their theories to the requirements of the hydrogen process.

On this basis, the stars of the globular clusters are old stars. The evolutionary path obviously has to start in region O of the diagram, since the protostars are necessarily diffuse and cool. It is generally recognized that the red giant stars of the globular clusters are stars of the same type as the protostars. Shklovsky, for instance, concedes that the massive protostars in a late stage of their evolution "have all the characteristics of giant stars."³⁸ But since the astronomers now see the red giants of the globular clusters as old stars they cannot accept the conclusion that these are identical objects.

As a consequence of this inability to recognize the identity, astronomical theory first has to put the stars through the evolutionary process as protostars, and then, after a hypothetical sojourn on the main sequence, bring them back

for another experience as giant stars. These giants then have to make their way, in some, as yet unexplained, manner, directly from their position in region O of the CM diagram to the region of the early white dwarfs, which is located in the diametrically opposite corner of the diagram. As expressed by L. H. Aller in an understatement of classic proportions, "the details of its [the giant star's] evolution are uncertain."³⁹

When the stars of the globular clusters and dwarf galaxies are recognized as relatively *young* objects, only one step beyond the dense dust cloud, or protostar, stage, the necessity for these contortions in the theoretical evolutionary path is eliminated. The infrared protostars are precursors of the red giants; they are already giants and on the way to becoming red. From this cool and diffuse state they follow one or the other of the two alternate paths to gravitational equilibrium on the main sequence.

After a star has achieved both gravitational and thermal equilibrium, and has settled down to a somewhat stable condition, its subsequent course depends on the environment. If this environment is relatively free from dust and gas, the star may not be able to generate enough energy to replace that lost by radiation, because of a shortage of heavy elements. In that case it moves slowly down the main sequence to the point where the radiation has been reduced enough to balance input and output. Whether or not this movement ever continues far enough to lower the central temperature below the lowest destructive limit, so that the star loses its energy supply and ceases to be a star, is not clearly indicated at the present stage of the theoretical development. As matters now stand, however, it seems probable that any aggregate that is once able to attain the stellar status on the main sequence will remain a star.

The continual replenishment of the supply of heavy elements by means of the atomic building process described in Volume II is an important factor in this situation. It plays a major role even where there is a significant amount of accretion, as there is only a very small proportion of heavy elements in the accreted matter. Since the amount of atom building is proportional to the mass of the aggregate, the same rate of heavy element formation that maintains the stellar status of the smaller stars is sufficient to add materially to the fuel supply of a larger star.

The automatic reduction in the amount of radiation which takes place in response to a decrease in the generation of energy enables a star to adjust to a rather wide range of environmental conditions, and since changes in these conditions occur only on an extremely long time scale, many of the main sequence stars maintain approximately the same pattern of thermal behavior for extended periods of time (fortunately for the human race). But accretion from the environment plays a very important part in the general evolutionary picture. In the globular clusters the growth comes entirely, or almost entirely, from the remaining portions of the original pre-stellar dust and gas cloud. But accretion of matter also takes place from whatever environments the stars enter

after consolidation of the original dust and gas is complete. Such accretion is common in the post-globular cluster stages, and has a significant effect on many astronomical phenomena, as we will see in the pages that follow.

For reasons that will be discussed in Chapter 8, the accretion by the *average* star in the outer regions of a spiral galaxy exceeds the losses due to radiation, and this star therefore moves up the main sequence. Stars in regions of greater dust and gas concentrations evolve still more rapidly, and the process also speeds up as the stars become more massive, since the stronger gravitational forces draw material from larger regions of space.

As the stars increase in mass, the central temperatures increase accordingly, and successively higher destructive limits are reached, making additional elements available as fuel for the energy generation process. Since none of the heavy elements is present in more than a relatively small quantity in a region of minimum accretion, the availability of an additional fuel supply due to reaching the destructive limit of one more element is not sufficient to cause any significant change in the energy balance of the stars in the lower half of the main sequence. The rate of accretion increases as the stars move up the sequence, but because of the corresponding increase in mass and total energy content, they are able to absorb greater fluctuations. The main sequence stars are therefore relatively quiet and unspectacular as they gradually make their way along the evolutionary path.

The chemical composition of the stars and the distribution of elements in the stellar interiors are debatable subjects, but the deductions that have been made from the principles established in the earlier development of theory do not conflict with actual observations; they merely conflict with some interpretations of those observations. While the gravitational segregation of the stellar material which theoretically puts a high concentration of the heavier elements into the central core is not entirely in agreement with current astronomical thought, it should be emphasized that such a segregation is the normal result in a fluid medium subject to gravitational forces, and a theory which requires the existence of normal conditions is never out of order where the true situation is observationally unknown.

Furthermore, even though the conclusions that have been reached as to the amount of heavy elements present in the stellar interiors are beyond the possibility of direct verification, it will be brought out in the subsequent discussion of the solar system that some strong evidence as to the internal constitution of the stars can be obtained from collateral sources. Current ideas as to stellar composition are based almost entirely on spectroscopic information. These data are useful, but they have a limited applicability, as they only tell us what conditions prevail in the outer regions of the stars. Even from this restricted standpoint the evidence may actually be misleading, as the spectroscopic results are affected to a significant degree by the character of the material currently being picked up through the accretion process. The

observed differences in the stellar spectra that can be attributed to variations in chemical composition are probably more indicative, in many cases, of the environments in which the stars happen to exist at the moment than of the true composition of the stars themselves.

The presence of substantial amounts of elements such as technetium, for example, in the outer regions of some stars poses a formidable problem if we are to regard this as an actual indication of the composition of the stars. It is doubly difficult for present-day astronomical theory. If the technetium is manufactured in the regions of maximum temperature in the center of each star, in accordance with the majority opinion at the moment, there is a serious problem in explaining how this material gets to the surface against the density gradient. L. H. Aller makes this comment:

How the star gets the heavy elements from the core to the surface without exploding provides an impressive challenge to theoreticians.⁴⁰

Shklovsky regards this emergence from the central regions as impossible, and contends that "Only nuclear reactions in the surface layers of the stars can account for the presence of technetium lines in type S stellar spectra."⁴¹ But this merely replaces one question with another. Just how the conditions necessary for initiating atomic reactions can be attained in these surface layers is an equally difficult problem. On the other hand, the technetium content at the surface of the star is easily explained on the basis that the observed amounts of this material have been derived from the captured material. This element is stable, according to the findings detailed in Volume II, wherever the magnetic ionization level is zero, and relatively heavy concentrations could be produced in areas that are left undisturbed for long periods of time.

As indicated earlier, the gradual and uneventful progress of the growing stars up the main sequence is due to the relatively small size of the increments of energy that result from the attainment of the destructive limits of successively lighter elements. When the destructive limit of nickel is reached there is a change in the situation, as this element is present, both in the stars and in the interstellar matter, in quantities that are substantially greater than those of any heavier element. It could be expected, then, that the attainment of this temperature limit would result in some observable enhancement of the thermal activity of the stars that are involved. Such increased activity is observed in a special class of stars located near the top of the main sequence.

These *Wolf-Rayet stars* are somewhat less massive than the stars of the O class, the highest on the main sequence, but they have about the same luminosity, and they are associated with the O stars in the disk of the Galaxy. Their principal distinguishing characteristic is a very disturbed condition in their surface layers, with ejection of material that forms an expanding shell around each star. These special conditions lead to the existence of a distinctive

spectrum. It appears probable that the Wolf-Rayet star is the one whose central temperature has reached the destructive limit of nickel. We may interpret its observed characteristics as indicating that arrival at this temperature limit has resulted in an increase in the production of energy that is large enough to cause violent internal activity, and ejection of matter from the star, without being enough to initiate a full-scale explosion. On this basis, the star remains in the Wolf-Rayet condition until the greater part of the nickel is consumed. It then resumes accreting mass (probably picking up most of what was ejected) and reverts to the O status.

The foregoing comments on the Wolf-Rayet stars apply only to those known as Population I Wolf-Rayets. The Wolf-Rayet designation is also applied to some of the central stars of planetary nebulae, but there is little justification for putting these two groups of stars into the same class. This issue will be discussed in Chapter 11.

When the temperature corresponding to the destructive limit of iron is reached, the situation is more drastically changed. This element is not limited to very small quantities, or even to moderate quantities like the nickel content. It is present in concentrations which represent an appreciable fraction of the total stellar mass. The sudden arrival of this quantity of matter at its destructive limit activates a source of far more energy than the star is able to dissipate through the normal radiation mechanism. The initial release of energy from this source therefore blows the whole star apart in a tremendous explosion.

According to current estimates, iron is more than 20 times as abundant in the stars as nickel. If the amount of nickel is sufficient to bring the star to the verge of an explosion, as the behavior of the Wolf-Rayet stars appears to indicate, the amount of iron is far more than is needed in order to cause an explosion. The explosion thus takes place as soon as the first portions of this element are converted into energy. The remainder, together with the overlying lighter material, is dispersed by the explosive forces. The carry-over of material from one cycle to the next enables the amount of iron and lighter elements to continue building up as the age of the system increases, whereas the heavier elements have to start from scratch after the explosion, except for some limited quantities of the elements close to iron that have escaped destruction. This accounts for what George Gamow called the “surprising shape of the empirical curve [of abundance of the elements],”⁴² the existence of distinctly different patterns above and below iron.

The explosion that theoretically occurs at the destructive limit of iron is consistent with observation, as it can be identified with the observed phenomenon known as a *Type I supernova*. However, the characteristics of the supernova explosion, as derived from theory, conflict, in some respects, with current astronomical opinion. One of these conflicts concerns the kind of stars that are subject to becoming Type I supernovae. Inasmuch as the temperature

of a star is a function of its mass, the temperature limit at which the explosion takes place is also a mass limit. According to our theory, then, the stars that reach the destructive temperature limit and become Type I supernovae are hot massive stars, and they are all nearly alike.

The existence of a stellar mass limit is conceded by the astronomers. Since there is a recognized relation between stellar mass and temperature along the main sequence, the existence of a mass limit carries with it the existence of a temperature limit, as required by the theory of the universe of motion. Neither limit has an explanation in terms of conventional astronomical theory, and the observed cut-off in the mass distribution function was unexpected. "It is a surprise," say Jastrow and Thompson, "that there also appears to be an *upper* limit to the mass of a star."⁴³ These authors put the limit at about 60 solar masses. Other observers place it at about 100.

The astronomers also admit that all Type I supernovae are very much alike. The observations of these phenomena are thus consistent with our theoretical findings. Furthermore, the temperature limit can be reached in *any* galaxy, and Type I supernovae should therefore occur in all classes of galaxies. They are the only kind that can occur regularly, according to our findings, in elliptical and small irregular galaxies. Spirals, such as our Milky Way, and the giant spheroidals, contain both Type I and Type II supernovae, which result from a different kind of stellar explosion that we will examine in detail in Chapter 16. As we will see there, the Type II explosion is the result of reaching an *age* limit. Except where some stray old star has been picked up by a young aggregate, stars cannot reach the age limit in young galaxies. This accounts for the observed restriction of the Type II supernovae to the older and larger galaxies. All that is known about the Type I supernovae is thus entirely consistent with the theory of the universe of motion.

On the other hand, the observations are almost totally *inconsistent* with conventional astronomical theory. The astronomers have been almost completely baffled by the supernova phenomenon. Most investigators are reluctant to admit that they are up against a blank wall, and tend to describe the situation in ambiguous terms, such as the following, taken from a recent report on one aspect of the supernova problem: "The exact mechanism by which a star becomes a supernova is not yet known."⁴⁴ The insertion of the word "exact" into this statement implies that the general behavior of the supernovae is understood, and that only the details are lacking. But the truth is that the astronomers have nothing but speculations to work with, and some of the more candid observers admit this. R. P. Kirshner, for instance, concedes that the "models" thus far proposed for the origin of supernovae are no more than speculative, and adds this comment:

The train of events leading to a supernova of Type I is more mysterious than that leading to one of Type II, since a Type I supernova is expected

to be the explosion of a star about as massive as the sun. Since such a star can comfortably settle down to being a white dwarf, something unusual must happen for it to explode as a supernova.³¹

This is a good example of the problems in astronomy that have been created by the elevation of the physicists' assumption as to the nature of the stellar energy process to a status superior to that of the astronomical observations. As Kirshner brings out in his statement, the Type I supernova is mysterious not so much because little is known about it, but because that which is known from observation conflicts with two items that are "known" from deductions based on generation of energy by the hydrogen conversion process. The conclusion that a star of about one solar mass can "comfortably settle down to becoming a white dwarf" is wholly dependent on the status of the red giants as old stars. This, in turn, is based entirely on the assumption as to the nature of the energy generation process. The further conclusion that these "old" red giants develop into white dwarfs rests on the equally unsupported assumption that the white dwarfs are still older than the red giants, and that there must be some progression from one to the other. The astronomical evidence disproving these assumptions will be presented at appropriate points in the subsequent pages. The fact now being emphasized is that Kirshner's "mystery" is simply a conflict between the astronomical observations and the consequences of the physicists' assumption that the astronomers accept as gospel.

The same conflict exists with respect to the other item of "knowledge" cited by Kirshner, the identification of the Type I supernova with the explosion of a star of about one solar mass. This is another conclusion that rests entirely on the physicists' hydrogen conversion hypothesis. On the basis of this hypothesis, it has been concluded that the stars of the elliptical galaxies and small irregulars are very old. Conventional theory indicates that the more massive stars (which, according to the theory, are short-lived) would have been eliminated from these old aggregates by evolutionary processes. The deduction, then, is that "before their outburst type I supernovae were very old stars whose mass was at most only slightly (say 10 to 20 percent) greater than the mass of the sun."⁴⁵

But this does not fit into the rest of conventional astronomical theory at all. As P. Maffei puts it, "This result has caused some problems to theoreticians."⁴⁶ Kirshner points out that the supernova explosion is *not* the fate that present-day theory predicts for the small stars. Furthermore, the identification of the supernovae with the small stars, whose mass varies over a wide range, leaves the theory without any explanation for one of the few things about the Type I supernovae that definitely *is* known; that is, these explosions are all very much alike.

In the light of the points brought out in the foregoing paragraphs, it is evident that the astronomers cannot legitimately claim to have a tenable theory of

supernovae. In this case, then, as in so many of the others that have been, or will be, discussed in this volume, the deductions from the theory of the universe of motion are simply filling a vacuum, providing explanations that conventional astronomical theory has been unable to supply.

CHAPTER 5

The Later Cycles

Only a relatively small proportion of the mass of the star needs to be converted into energy in order to produce the Type I supernova explosion. The remainder, constituting the bulk of the original mass, is blown away from the explosion location at high speeds. We therefore find the site of such an explosion surrounded by a cloud of material moving rapidly outward. The prevailing view is that the entire mass is dispersed into interstellar space. As expressed by Shklovsky, “The gaseous material expelled during the outburst forever breaks its connection with the exploding star and travels out into interstellar space, interacting with the interstellar medium.”⁴⁷ In this particular case he is referring specifically to supernovae of Type II, but his subsequent comments make it clear that these remarks apply to Type I as well.

It is evident that a large part of the matter ejected into space is actually dispersed in this manner, but there is likewise a significant part of the total that does *not* escape. As we will see in Chapter 6, the matter in the central portion of the star does not participate in the expansion into space. Because the speeds generated by the explosion are distributed over a wide range, another substantial portion of the ejected mass is restricted to relatively moderate outward speeds. One factor that has a bearing on this situation is that the Type I explosion takes place in the center of the star rather than throughout the structure. Consequently, much of the ejected material does not come out in the form of finely divided debris, but consists of portions of the outer sections of the star. These are ejected in aggregates of various sizes, what we would call fragments if we were dealing with solid matter. Such quasi-fragments have lower initial velocities than the small particles or individual atoms, since the acceleration imparted by a given pressure decreases as a function of the mass, where the density is uniform. They also expand quickly from their highly compressed initial state, which reduces their temperature drastically and makes them invisible. The visible portions of the Type I supernova remnants are mainly the fastest particles.

During their outward travel, these explosion products are subject to the gravitational effect of the total mass until the fastest components reach the gravitational limit, and to a gradually decreasing effect thereafter. It follows that the slower components are subject to gravitational retardation, as well as

to some resistance from the interstellar medium, for a very long period of time. If we take the previously cited figure of 60 solar masses as the size of the exploding star, and assume that a third of the total mass goes into energy, the outer portions of the explosion products are subject to the gravitational effect of 40 solar masses. In Chapter 14 we will develop an equation for calculating the gravitational limit, and from this equation we will find that the gravitational limit of an aggregate of 40 solar masses is 23 light years, or 7 parsecs. The radii of the observed Type I supernova remnants in the Galaxy average about 5 parsecs.⁴⁸ Thus the expansion of these remnants, great as it has been, has not even taken the fastest of the explosion products beyond the gravitational limit of the aggregate as yet. Clearly, many of the slower products cease moving outward long before they reach the gravitational limit of the remaining mass.

At this stage, where the expansion ceases, there is a cloud of cold and very diffuse material occupying a tremendous expanse of space. But unlike the large dust and gas clouds in the galactic arms, this material is under gravitational control. The gravitational effect of the mass as a whole on each individual particle is small because of the huge distances involved, but a net gravitational force does exist, and once the expansion has ceased, a contraction is initiated. Another long interval must elapse while this initially minute force does its work, but ultimately the constituent particles are pulled back to where the internal temperature of the mass can rise enough to reactivate the energy generation process, and the star is reborn.

This star is now back in area O of the CM diagram, first as an infrared star, and later, as it contracts and increases in temperature, as a red giant. This red giant resembles the first generation of stars of the same type, but it is not identical with them. It has gone around the cycle and through the explosion process, and has undergone some modifications in so doing. The most significant respect in which the new stars of the second cycle differ from their counterparts of the first cycle is that the second cycle star has a gravitationally stable core. The first cycle star condensed from a practically uniform dispersed aggregate. As noted earlier, some of these stars had nuclei on which to build, but only in rare instances is this anything more than a small fragment. Thus, until it reaches the critical density, such a star is simply a contracting dust and gas cloud. On the other hand, the aggregate of matter from which the second cycle star condenses is heavily concentrated towards the center, the site of the supernova explosion. The gravitational contraction therefore proceeds much faster in this central region, and a large part of the mass of the star reaches a state of gravitational equilibrium by the time that the atomic energy process is initiated. The newly formed second cycle star is thus a two-component system, a stable core with a large contracting outer envelope.

In this combination structure, the luminosity is determined by the amount of energy generated. This, in turn, depends on the mass, which is concentrated

mainly in the core. But the surface temperature corresponding to a given luminosity depends on the volume of the star, and this is mainly the volume of the envelope. Thus the surface temperature of the early second cycle star is similar to that of an early first cycle star, while the luminosity is similar to that of a main sequence star. Instead of being concentrated in one region in the upper right of the CM diagram in the manner of the early first cycle stars, the early stars of the second cycle occupy a band along the right of the diagram similar to the upper part of the main sequence on the left. We will designate this type of star as Class C. Adding the number of the cycle, these stars of the second cycle are Class 2C stars.

After the initial movement downward from region O to a position determined by the stellar mass, the evolution of the Class 2C stars, resulting from continuation of the process of condensing the outer envelope, leaves the luminosity practically unchanged, but the surface temperature increases because of the reduction in the size of the radiating surface. This second cycle star thus moves almost horizontally across the CM diagram if it is in a region of minimum accretion. Any further accretion that takes place puts the terminal point, the location at which the star reaches gravitational equilibrium, higher on the diagram. The evolutionary paths of the Class C stars are therefore totally different from those of Class A, the stars of the first cycle.

The Class C pattern is illustrated in Figure 5. The numbers shown with the names of the prominent stars identified in the diagram are the masses in solar units. As can be seen from these values, the mass scale for the Class C stars on the right of the diagram is practically identical with that of the Class B (main sequence) stars on the left. The line XY then represents the evolutionary path of a star of about five solar masses that is accreting only the remnants of its original dispersed matter. If the star condenses within a dust cloud, or enters such a cloud before the consolidation of the diffuse matter is complete, the increase in mass by accretion from the cloud moves the star upward on the diagram, and the resulting path is similar to the line XZ.

It should be noted that although the evolutionary path of the Class C stars in the CM diagram is quite different from that of the Class A stars, and the significance of positions in the diagram, in terms of variables other than temperature and luminosity, is also quite different, the result of the evolutionary development is the same in both cases. The evolution carries the stars from a cool and very diffuse condition in region O of the diagram to a position on the main sequence that is determined by the stellar mass. And it accomplishes the movement by means of the same process in both cases, a process—gravitational contraction—that is *known* to be operative under the existing conditions.

In sharp contrast to this straightforward gravitationally powered process, conventional astronomical theory offers a bizarre succession of twists and turns that attempt to reconcile the observational data with the upside down

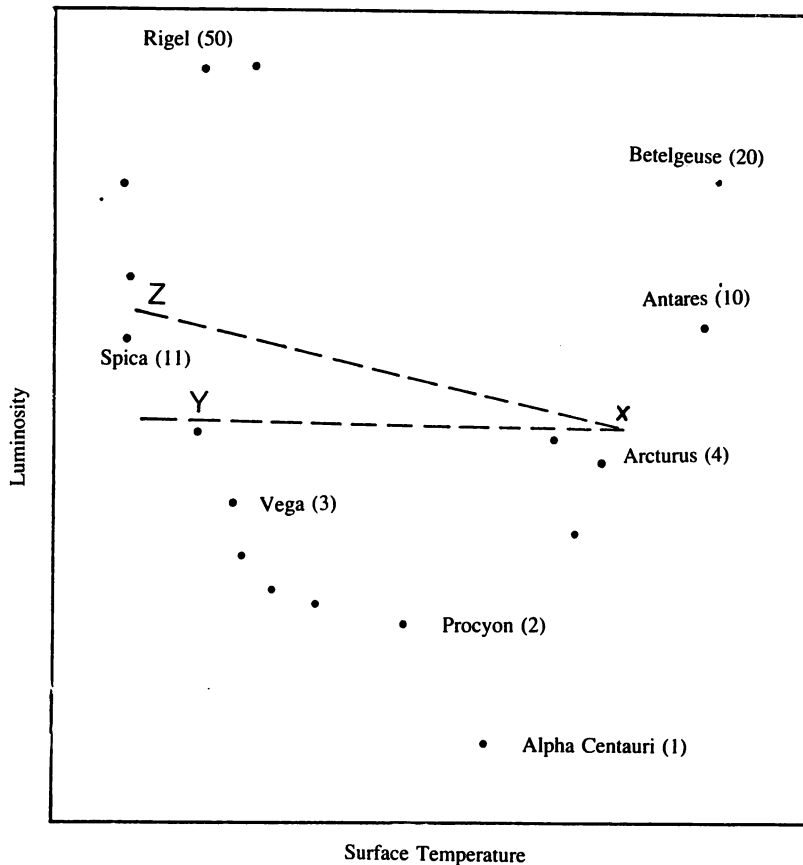


Fig. 5
Locations of Class C Stars

evolutionary sequence based on the *purely hypothetical* hydrogen conversion process as the source of stellar energy. As already noted, this theory requires a movement from region O, the red giant region, of the CM diagram, to the main sequence, but then finds it necessary to reverse the movement and bring the stars back to the red giant region again. The theorists have not been able to define this reverse movement without making the mass of the star an independent quantity. They have therefore abandoned any systematic connection between mass and position in the diagram, aside from that which exists along the main sequence. As Shklovsky puts it, the stars move on the diagram "in a rather meandering fashion."⁴⁹

This assumption that the temperature and luminosity of a star can be totally

independent of the mass is another inherently improbable hypothesis. Both of these quantities are *determined by* the mass along the main sequence, and the idea that the connection is completely severed under other conditions is unrealistic. Furthermore, it runs into an obvious difficulty when the hypothetical evolutionary line again intersects the main sequence on the road from red giant to white dwarf. If we examine the hypothetical evolutionary path without regard to its "meanderings," what we find is a "turnoff" from the main sequence at a point asserted to be determined by the mass of the star, a horizontal movement to the right, and then a turn upward that continues on a diagonal line to the red giant region. From there the path extends back to the left along a rather indefinite horizontal course. Almost all discussions of the subject in astronomical literature are accompanied by a diagram that purports to demonstrate the agreement between this theoretical pattern and the observations. This is a composite diagram, combining the CM diagrams of a number of star clusters. (See, for instance, reference 50.)

Aside from the question as to the direction of movement, which cannot be determined from observation, the hypothetical evolutionary path agrees, in general, with the CM diagram of the globular clusters. It could hardly do otherwise, since it was deliberately designed to fit the globular cluster pattern. The agreement of the composite diagram with the hypothetical evolutionary pattern is therefore significant only to the extent that there is agreement in the case of clusters *other* than those of the globular cluster type. In Chapter 10 we will find that some clusters such as M 67 and NGC 188 that are classified as open clusters are actually fragments of globular clusters that have not yet lost all of their globular characteristics. To arrive at the true significance of the composite diagram we need to eliminate the clusters of this type, as well as the normal globular clusters, and examine the extent of agreement between the remaining open clusters and the theoretical pattern. When we do this we find that there is no correlation whatever. These clusters have stars along the main sequence, and in the immediate vicinity thereof, and one of them also contains some red giants. But there is no trace of the evolutionary pattern that the diagram is supposed to corroborate. The evidence that is asserted to support the contention that the stars of the open clusters "evolve off the main sequence" simply does not exist.

A recognition of the true evolutionary pattern, as derived from the theory of the universe of motion, makes it possible to understand the real meaning of the association of certain kinds of stars with dust clouds that has led to the belief that the stars are being formed within the clouds. Two such types of association are recognized. O associations are composed of stars of the O and B types, the largest and hottest of all stars. T associations are groups of stars of the T Tauri class, much smaller and cooler than the O and B stars. "Often, but not always, the T-associations coincide with O-associations."⁵¹ The prevailing belief that the hot massive stars are young leads to the conclusion

that they were formed somewhere near their present locations. Taken together with the observed association between the O and B stars and nebulosities, this indicates that the stars of the O associations have been formed by condensation of portions of the gas and dust clouds in which they are now located. This hypothesis is currently accepted by most astronomers, but, as brought out in Chapter 1, they are unable to explain *how* stars can be formed from clouds of such low density. "This process," says Simon Mitton, "is almost a total mystery."⁵²

Development of the theory of the universe of motion does not provide any way whereby the dust and gas clouds of the Galaxy can condense into stars. On the contrary, it identifies still another force opposing such a condensation, the force due to the outward progression of the natural reference system, and it indicates that condensation cannot take place unless the clouds are either very much larger or very much denser than anything that exists in the Galaxy. However, it is clear from the information brought to light by this development that what is actually happening is accretion of matter from the dust and gas clouds by *previously existing stars*. These stars already in existence are not limited by the factor that prevents dust and gas particles from condensing into a stellar aggregate under galactic conditions; the net motion of each particle outward away from all others. All particles within the gravitational limit of an existing star have a net *inward* motion toward the star, and are on the way to capture.

The clouds of dust and gas in the Galaxy are subject to forces that tend to spread them out and dissipate them. It follows that the identifiable clouds are relatively recent acquisitions by the Galaxy. As such, they are associated mainly with the relatively recent stellar acquisitions, the Class 1A stars. As we have seen, these stars are initially divided into two groups, a large group of small stars that reach gravitational equilibrium in the lower portion of the main sequence, and a smaller group of large stars that reach equilibrium well above the midpoint of that sequence. We can therefore expect the products of accretion to existing stars from the gas and dust clouds to be of two kinds, one group of hot massive stars and one group of small and relatively cool stars. These two groups required by the theory can obviously be identified with the O associations and the T associations respectively. Both groups contain some of the Class 2 stars that have been mixed with the Class 1 population since entry of the younger stars into the Galaxy.

The positions of the O and T associations in the CM diagram are entirely consistent with the accretion explanation. The upper portion of the main sequence, in which the O stars are located, cannot be reached *without* some accretion from the environment. The largest Class 1 stars reach the main sequence considerably below this level, and the Class 2 (and later) red giants, reconstituted from *part* of the matter of the O type star that exploded, are necessarily somewhat less massive than the O stars. "There are no super red

giants which would correspond to the evolution of an O-type star.”³⁶ (S. J. Inglis) The stars of all classes therefore have to grow at the expense of their environment in order to reach the O status.

The T Tauri stars are found in a location generally described as “above” the lower portion of the main sequence. Inasmuch as this sequence runs diagonally across the diagram, it is equally correct to say that these stars are located somewhat to the right of the main sequence. As can be seen from Fig. 5, this is consistent with an ongoing accretion from the surrounding cloud of dust and gas. A star that is accreting substantial quantities of such material is in essentially the same condition as one that is consolidating the final remnants of the material dispersed by a supernova explosion. As we saw earlier, a star of this latter type (Class 2C) is moving horizontally across the CM diagram from right to left. In the latter part of this movement it occupies a position similar to that in which the T Tauri stars are found. The T Tauri position is thus in full accord with the accretion explanation. The observation that there are “erratic changes in brightness”⁵³ of these stars is also consistent with the finding that they are accreting material from the environment in substantial, and probably variable, quantities.

Let us now take a closer look at the pattern of events in the interior of an aggregate that has just become a star (of any cycle) by activating the atomic disintegration process as a source of energy. The additional energy thus released causes a rapid expansion of the star. This expansion has a cooling effect, which is most pronounced in the central regions, and as the temperature in these regions drops below the recently attained destructive limit, the energy generation process itself is shut off, accentuating the cooling effect. Eventually this cooling stops the expansion and initiates a contraction of the star, whereupon the temperature again rises, the destructive limit is once more reached, and the whole process is repeated.

A newly formed star of either Class A or Class C is therefore variable in the amount of its radiation, an *intrinsic variable*, as it is called to distinguish it from stars of the class whose variability is due to external causes. “Almost all these stars [those below 1700 K] are, as we had expected, long period variables,”⁵⁴ report Neugebauer and Leighton, pioneer investigators of the infrared stars. Not all cool stars are young, but an old cool star has had time to reach gravitational equilibrium, and it is therefore small, whereas the young stars are still very diffuse—such a star has been described as nothing but a red hot vacuum—and hence they are very large. Inasmuch as they are radiating from a much larger area, their total radiation is much greater than that of old stars of the same surface temperature. The bright infrared stars are thus the newly formed variables.

The length of the cycle, or *period*, of a variable star depends on the relation of the magnitude of the energy released by atomic disintegration to the total energy content of the star. When the star is very young, and its temperature is

barely above the stellar minimum, the rate of energy generation is large compared to the total energy of the star, and the swings from the "on" to the "off" position of the energy production mechanism are relatively large. Such stars are therefore *long-period variables*. As a star grows older, its temperature and energy content increase, because the average energy production exceeds the radiation in this stage of the evolutionary cycle. The fluctuations in the rate of energy production thus represent a constantly decreasing proportion of the total energy of the star. Both the period and the magnitude of the variation (measured in terms of percent change in radiation) therefore decrease with time.

As the average temperature of the star rises, a point is eventually reached at which the temperature in the central regions during the low phase of the cycle no longer drops below the destructive limit of the heaviest element present. But this does not put an end to the variability, because by this time, or very soon thereafter, the high point of the temperature cycle reaches the destructive limit of the next lighter element, and generation of energy by destruction of this element takes place in the same kind of an on and off cycle. The fluctuations never cease entirely, but they decrease in magnitude, and are no longer evident observationally after the temperature stabilizes, or when the total energy of the star becomes so large that the effect of the variations is negligible on the scale of the observations.

One star, the sun, is so close to us that even small variations in energy production should be detectable. This subject has not yet been studied in the context of the universe of motion, but some aspects of the sun's behavior are known to be variable. The observed fluctuations in the sunspot activity are particularly noticeable. The origin of these spots is unknown, but no doubt they are initiated in some manner by the energy production process. Hence they may be giving us an indication of the variations in the output of that process that would be expected from the periodic changes. There are also some relatively long range variations, such as the decrease in energy output that caused the Little Ice Age in the seventeenth century and the increase that is producing the gradual warming in the twentieth, which may be due to variations in the nature or amount of the material accreted from the environment. In any event these are subjects that warrant some investigation. It is possible that such an investigation can be extended to more distant stars not currently classified as variables. Some observations of "variations in activity similar to the sun's 11-year sunspot cycle" in nearby stars have already been made.⁵⁵

The theoretical explanation of the process whereby the heavier elements are built up, as set forth in Volume II, defines it as a continuous capture process that is taking place throughout the entire extent of the material sector. In the primitive aggregate of diffuse material, and in the early dust and gas clouds, the magnetic ionization level is zero, which means that there is no obstacle to

the formation of any of the 117 possible elements. The time spent in this first of the evolutionary stages is so long that all of the elements are represented in the constituent dust of the clouds by the time the protostar stage is reached. Inasmuch as the build-up of the atomic structure is a step-by-step process, the initial abundance of the elements is an inverse function of the atomic mass (with some modification by other factors), but even a small amount of the very heavy elements is sufficient to initiate the atomic disintegration that provides the increment of energy which raises the dense dust cloud to stellar status.

By the time the initial supply of heavy elements is exhausted, the stellar fuel has been replenished by accretion of material from the environment, and by the continued operation of the atomic building process. All accreted matter has some heavy element content, but the addition to the fuel supply is not limited to this amount. Any matter that adds significantly to the total mass of the star serves the purpose of activating an additional source of energy. The increase in mass increases the central temperature of the star, and it thereby makes more fuel available through reaching the destructive limits of lighter elements.

Correlation of the central temperature with the mass carries with it the implication that the principal fuel supply at any given mass level is provided by a specific element. Most of the very heavy elements are present only in small concentrations, and this makes it difficult, in most instances, to distinguish the points at which destruction of an additional element begins. There is, however, a relatively wide mass range, indicated by the cross-hatched area in Fig. 6, in which the variability is sufficiently regular to make it evident that a single element is the principal energy source. The distinctive character of the variability in this region, which we will identify as the *Cepheid zone*, extends through a wide enough range of central temperatures to indicate that the energy is being derived primarily from an element that is present in the star in a higher concentration than that reached by any element of greater atomic number. The particular element that is involved cannot be positively identified without further investigation, but since lead is not only the first moderately abundant element in the descending order of atomic mass, but also the only such element in the upper portion of the atomic series, we may, at least tentatively, correlate the destructive thermal limit of this element number 82 with the central temperature corresponding to the mass range of the Cepheid zone. It should be noted in this connection that lead is the heaviest element that is stable against radioactivity in a region of unit magnetic ionization, and it therefore occupies a preferred position somewhat similar to that of iron.

The long period variables that precede the Cepheids on the evolutionary path can be correlated with the elements above lead in the atomic series. Here the quantities of energy generated as the successive destructive limits are reached are smaller, inasmuch as these elements are relatively scarce, but each increment of energy has a greater effect on the stellar equilibrium because of the smaller heat storage capacity of these low temperature stars. This

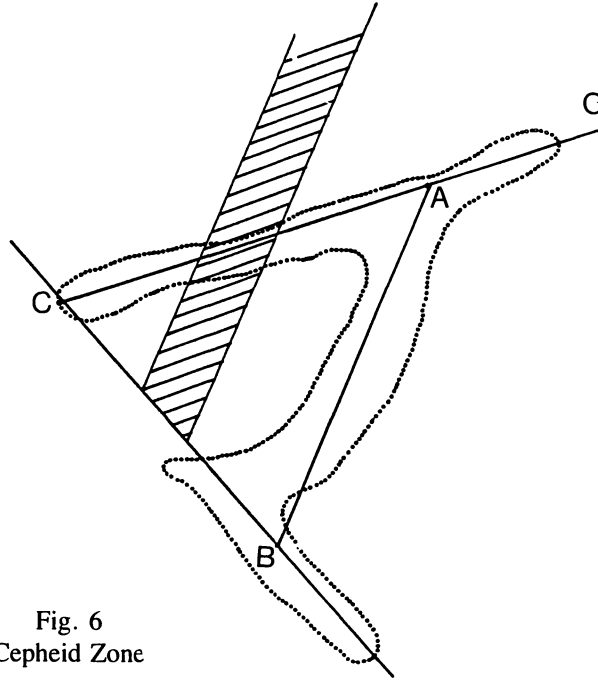


Fig. 6
Cepheid Zone

accentuates the effect of minor variations in the incoming flow of matter from the environment, and as a result these long period variables are less regular than the Cepheids. In general, these stars are not separable into easily recognizable classes on the order of the Cepheids, but some groups of a somewhat similar nature have been identified. The RV Tauri variables, for instance, are found between the red, Mira type, long period variables and the Cepheids.⁵⁶

There are 35 elements heavier than lead in the primitive material from which the globular cluster stars were formed. The destructive limit of each of these elements establishes a central temperature for a particular group of stars in the same manner that the destructive limit of lead (presumably) establishes the central temperature, and consequently the characteristic properties, of the Cepheids. Most of the Class C stars are probably at the unit magnetic ionization level, reducing the number of stable elements above lead to ten, and the RV Tauri stars account for one of these, but trying to divide all of the variables earlier than the Cepheids into groups, and to identify the elements that constitute the principal energy source for each, is clearly impractical, as matters now stand, even if only nine more groups are involved.

The stars located in the area where the Class A evolutionary line AC crosses the Cepheid zone are known as RR Lyrae stars. They are abundant in the globular clusters, and for this reason are also called cluster variables.

However, they are not the only Class A Cepheid stars in these clusters. One kind of a globular cluster star that we have not yet considered is a star that condenses on a large nucleus; either a pre-existing small star or an aggregate of planetary mass. When condensation of a star takes place on a nucleus of this size the line of evolutionary development is similar to that of the Class C giants, and is shifted upward on the CM diagram relative to the Class 1A path. This line enters the Cepheid zone at a location where the mass and central temperature are the same as in the region of the RR Lyrae stars, but the density and surface temperature are lower, while the luminosity is higher. The stars of this type are known to the astronomers as Population II Cepheids, or W Virginis stars. In our terminology they are Class 1 Cepheids.

The changes that take place in the stars during their trip around the cycle have some effect on the position that a star of a given kind occupies within its zone of the CM diagram. One such result is the existence of a third kind of Cepheid star. A giant Class C star of the second or later cycle moves through the Cepheid zone if it has a large initial mass, or is subject to heavy accretion. As would be expected, the general characteristics of this kind of Cepheid are similar to those of the Class 1 Cepheids. Indeed, it is only relatively recently that the existence of two distinct groups of these large Cepheid type stars has been recognized. But it is now known that the Class 2C (Population I) Cepheids are more massive, and are located higher (about 1½ magnitudes) on the CM diagram than those of Class 1.⁵⁷ They are also quite uniform in size and other properties. Both the large mass and the similarity in properties of these Class 2C stars are explained by our finding that they are stars reconstituted from the products of Type I supernovae, which are explosions of stars that have reached the mass limit, and are therefore both very large and very much alike. These characteristics carry over into their products.

As would also be expected, the RV Tauri variables previously mentioned are likewise separable into two distinct groups similar to the two classes of Cepheids.⁵⁶

On the other side of the Cepheid zone the controlling factors are reversed. The heat storage capacity of the star is much greater, because of the higher temperatures and greater mass. Consequently, any variations, either in the rate of accretion or in the abundance of heavy elements in the accreted matter, are, to a large extent, smoothed out.

The Cepheid stars have played an important part in the advancement of astronomical knowledge because there is a specific relation between their periods and their luminosities. This is understandable as another result of the interrelation between the different properties of the stars that has been the subject of much of the discussion in this and the preceding chapter. It probably applies to most other kinds of intrinsic variables as well as to the Cepheids, but these other types of variable stars are less common, and so far, less clearly identified. It is also doubtful if any of these other classes of stars are as

uniform as the Cepheids. The period-luminosity relation for the Cepheids, when properly calibrated, enables the absolute magnitude of a Cepheid star to be determined from the period, an observable quantity. The relation of the absolute magnitude to the observed magnitude then indicates the distance to the star, thereby providing a means of measuring distances up to millions of light years, far beyond the limits of ordinary methods of measurement.

The explanation of the pulsations of the Cepheids and other similar types of variable stars given in this work is, of course, quite different from that found in the astronomical literature. The astronomers envision this as a mechanical vibration—just like a bell, as one textbook puts it. But the observed characteristics of the pulsation contradict this hypothesis.

A peculiar fact . . . is that the maximum brightness occurs near the time of most rapid expansion, while minimum brightness coincides with the most rapid contraction. This is contrary to any theory which assumes a simple pulsation of the entire stellar body. It might indeed seem that the star should be brightest and hottest shortly after the contraction has brought it to a state of highest density and pressure.⁵⁸ (R. Burnham)

Like so many of the other “peculiar facts” that are noted, but disregarded, in current practice, this one is giving us a message. It is telling us that the prevailing theory of the pulsation is wrong. The theory of the universe of motion now reveals just what it is that is wrong. The pulsation is not a mechanical vibration; it is thermally powered. The interplay between two processes—expansion and energy generation—is the cause of the periodicity. The maximum brightness occurs near the time of maximum expansion because this is the point at which the generation of energy at the maximum rate has persisted for the longest time.

Except for some portions of the stellar content of nickel and other elements close to iron that escape because of local variations in the conditions in the central regions of a star, the elements heavier than iron are destroyed in the production of energy during the life of the star, and in the Type I supernova explosion which terminates that life if the star arrives at the temperature limit of iron. The building up of these elements has to start approximately from scratch again, but the period of expansion and re-aggregation of the explosion products is long enough to bring the heavy element concentration in the second generation protostars back somewhere near that in the protostars of the first cycle. Meanwhile the concentration of iron and the elements of lower atomic mass has been increasing without interruption, and the *total* heavy element content of the class 2C stars (usually expressed as the percentage of elements above hydrogen or above helium, or as the ratio of the heavier elements to hydrogen) is substantially greater than that of the Class 1A stars.

The same atom building processes are effective in the environment of the

stars, the interstellar space. The heavy element content is determined by the age of the *matter*, irrespective of whether that matter is in the form of dust and gas or is incorporated into stars. As noted in Chapter 3, the current view of the astronomers is that the heavy elements are formed in the interiors of the stars and are scattered into the environment by supernova explosions. On this basis, the heavy element content of young stars is greater than that of old stars because the proportion of heavy elements in the “raw material” available for star building increases as the galaxy ages.

Although this view currently enjoys quite general acceptance, more and more anomalies are appearing as evidence from observation continues to accumulate. In addition to the many items of evidence contradicting this hypothesis that have been discussed in the previous pages of this volume, we may now note that there is evidence indicating that the heavy element content in the interstellar matter of the local environment is *not* increasing. Martin Harwit has considered this situation at some length. He observes that the “similarity in abundances” (that is, in chemical composition, as indicated by the spectra) of different classes of stars in the Galaxy—B stars, red giants, planetary nebulae, etc.—is “somewhat puzzling.”⁵⁹ These similarities lead him to this conclusion: “These analyses show that throughout the lifetime of the Galaxy the interstellar matter has had an almost unchanged composition.” This is definitely in conflict with the basic premise underlying the currently accepted explanation of the difference in composition between the “old” and “young” stars: the assumption that the interstellar medium is continually enriched with heavy elements “cooked” in the stars and scattered into the environment.

Of course, our findings also require the heavy element content of any given quantity of matter to increase with age, but the existing interstellar matter is not the *same* matter that occupied this region of space in earlier times. All galaxies are pulling in diffuse material from their surroundings, material which, according to our findings, is relatively young. For example, Harwit refers to “a recently discovered, apparently continuous, infall of gas from outside the Galaxy.” As noted in Chapter 2, the larger galaxies are also capturing some immature globular clusters in which the constituent dust clouds have not yet consolidated into stars. Meanwhile, the older interstellar matter is being accreted by the stars. It is quite likely that these two processes come near enough offsetting each other to leave the average composition of the interstellar material in the local environment nearly constant. Harwit’s conclusion as to the constancy of composition is therefore consistent with the theory of the universe of motion insofar as it applies to the situation in the outer regions of spiral galaxies. The proportion of heavy elements should theoretically be greater in the older regions of the galaxies, but these are not accessible to detailed observation, as matters now stand.

CHAPTER 6

The Dwarf Star Cycle

At the very high temperatures prevailing in the interiors of the stars at the upper end of the main sequence the thermal velocities are approaching the unit level, and when these already high velocities are further increased by the energy released in the supernova explosion the speeds of many of the interior atoms rise above unity. The results of speeds above the unit level were discussed briefly in Volume I, but a more detailed consideration will now be required, as these greater-than-unit speeds, which play no part in the physical activity of our terrestrial environment, are involved in a wide variety of astronomical phenomena.

The discovery of the existence of speeds greater than that of light is one of the most significant results of the development of the theory of the universe of motion. It has opened the door to an understanding of many previously obscure or puzzling phenomena and relations. But some of the concepts that are involved in dealing with these very high speeds are new and unfamiliar. For that reason many persons find them hard to accept on the strength of theoretical reasoning alone, regardless of how solid a base that reasoning may have. The results of recent research reported in *The Neglected Facts of Science*, published in 1982, should be very helpful to these individuals, as that research has shown that many of the new findings derived from the theory of the universe of motion can also be derived from purely factual premises, independently of any theory, thus providing an empirical validation of the theoretical results. Among these theoretical conclusions that are now provided with factual proof are the items with which we are presently concerned: the existence of greater-than-unit speeds, and the characteristics of motion at these speeds. In order to emphasize the point that the theoretical findings in this area, however strange they may appear in the light of previously accepted ideas, are fully confirmed by observed facts and logical deductions from those facts, the description of the basic motions of the universe, for purposes of the theoretical development in this work, has been taken from the purely factual derivation given in the 1982 publication.

This factual development was made possible by a recognition of the physical evidence of the existence of scalar motion, and a detailed analysis of the properties of motion of this nature. The scalar nature of the basic motions of

the universe is an essential feature of the Reciprocal System of theory, and has been emphasized from the time of its first presentation. The points brought out in the extract from the 1982 book are simply the necessary consequences of the existence of these basic scalar motions. However, in order to follow the development of thought, it will be necessary to bear in mind some of the special features of scalar motion that were brought out in the previous volumes of this work. Although scalar motion, by definition, has no direction, in the usual sense of that term, it can be either positive or negative. When such motions are represented in a reference system, the positive and negative magnitudes appear as outward and inward respectively. For convenient reference, these are designated as “scalar directions.” Inasmuch as a scalar motion is simply the relation between a space magnitude and a time magnitude, it can be measured either as speed, the relation of space to time, or as inverse speed, the relation of time to space. Inverse speed was identified, in Volume I, as energy. A reciprocal relation, such as that between space and time in motion, is symmetrical about the unit value; that is, speeds of $1/n$ (which we have identified as motion in space) are equivalent to inverse speeds, or energies, of $n/1$, whereas energies of $1/n$ (which we have identified as motion in time) are equivalent to speeds of $n/1$. With the benefit of this understanding of those of the relevant factors that may be unfamiliar, we may now begin the extract from the published description of the high speed regions.

Photons of radiation have no capability of independent motion, and are carried outward at unit speed by the progression of the natural reference

	Motion	In	Out	Net
(1) Photon	Progression		→	+1
(2) At grav. limit	Progression		→	0
	Gravitation	←		
(3) At maximum gravitation	Progression		→	-1
	Gravitation	←		
(4) At zero net speed	Progression		→	0
	Gravitation	←		
	Translation		→	
(5) At unit net speed	Progression		→	+1
	Gravitation	←		
	Translation	→		

system, as shown in (1), Fig. 7. All physical objects are moving outward in the

same manner, but those objects that are subject to gravitation are coincidentally moving inward in opposition to the outward progression. When the gravitational speed of such an object is unity, and equal to the speed of progression of the natural reference system, the net speed relative to the fixed spatial reference system is zero, as indicated in (2). In (3) we see the situation at the maximum gravitational speed of two units. Here the net speed reached is -1 , which, by reason of the discrete unit limitation, is the maximum in the negative direction.

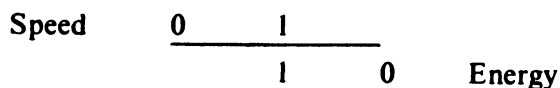
An object moving with speed combination (2) or (3) can acquire a translational motion in the outward scalar direction. One unit of the outward translational motion added to combination (3) brings the net speed relative to the fixed reference system, combination (4), to zero. Addition of one more translational unit, as in combination (5), reaches the maximum speed, $+1$, in the positive scalar direction. The maximum range of the equivalent translational speed in any one scalar dimension is thus two units.

As indicated in Fig. 7, the independent translational motions with which we are now concerned are additions to the two basic scalar motions, the inward motion of gravitation and the outward progression of the natural reference system. The net speed after a given translational addition therefore depends on the relative strength of the two original components, as well as on the size of the addition. That relative strength is a function of the distance. The dependence of the gravitational effect on distance is well known. What has not heretofore been recognized is that there is an opposing motion (the outward progression of the natural reference system) that predominates at great distances, resulting in a net *outward* motion.

The outward motion (recession) of the distant galaxies is currently attributed to a different cause, the hypothetical Big Bang, but this kind of an ad hoc assumption is no longer necessary. Clarification of the properties of scalar motion has made it evident that this outward motion is something in which *all* physical objects participate. The outward travel of the photons of radiation, for instance, is due to exactly the same cause. Objects such as the galaxies, that are subject to gravitation, attain a full unit of net speed only where gravitation has been attenuated to negligible levels by extreme distances. The net speed at the shorter distances is the resultant of the speeds of the two opposing motions. As the distance decreases from the extreme values, the net outward motion likewise decreases, and at some point, the *gravitational limit*, the two motions reach equality, and the net speed is zero. Inside this limit there is a net inward motion, with a speed that increases as the effective distance decreases. Independent translational motions, if present, modify the resultant of the two basic motions.

The units of translational motion that are applied to produce the speeds in the higher ranges are outward scalar units superimposed on the motion equilibria that exist at speeds below unity, as shown in combination (5), Fig. 7. The

two-unit maximum range in one dimension involves one unit of speed, s/t , extending from zero speed to unit speed, and one unit of inverse speed, t/s , extending from unit speed to zero inverse speed. Unit speed and unit energy (inverse speed) are equivalent, as the space-time ratio is $1/1$ in both cases, and the *natural* direction is the same; that is, both are directed toward unity, the datum level of scalar motion. But they are oppositely directed when either zero speed or zero energy is taken as the reference level. Zero speed and zero energy in one dimension are separated by the equivalent of two full units of



speed (or energy) as indicated in Fig. 8.

In the foregoing paragraphs we have been dealing with full units. In actual practice, however, most speeds are somewhere between the unit values. Since fractional units do not exist, these speeds are possible only because of the reciprocal relation between speed and energy, which makes an energy of $n/1$ equivalent to a speed of $1/n$. While a simple speed of less than one unit is impossible, a speed in the range below unity can be produced by addition of units of energy to a unit of speed. The quantity $1/n$ is modified by the conditions under which it exists in the spatial reference system (for reasons explained in the earlier volumes), and appears in a different mathematical form, usually $1/n^2$.

Since unit speed and unit energy are oppositely directed when either zero speed or zero energy is taken as the reference level, the scalar direction of the equivalent speed $1/n^2$ produced by the addition of energy is opposite to that of the actual speed, and the net speed in the region below the unit level, after such an addition is $1 - 1/n^2$. Motion at this speed often appears in combination with a motion $1 - 1/m^2$ that has the opposite vectorial direction. The net result is then $1/n^2 - 1/m^2$, an expression that will be recognized as the Rydberg relation that defines the spectral frequencies of atomic hydrogen—the possible speeds of the hydrogen atom.

The net effective speed $1 - 1/n^2$ increases as the applied energy n is increased, but inasmuch as the limiting value of this quantity is unity, it is not possible to exceed unit speed (the speed of light) by this inverse process of adding energy. To this extent we can agree with Einstein's conclusion. However, his assertion that higher speeds are impossible is incorrect, as there is nothing to prevent the direct addition of one or two *full units* of speed in the other scalar dimensions. This means that there are three speed ranges. Because of the

existence of these three ranges with different space and time relationships, it will be convenient to have a specific terminology to distinguish between them. In the subsequent discussion we will use the terms *low speed* and *high speed* in their usual significance, applying them only in the region of three-dimensional space, the region in which the speeds are $1-1/n^2$. The region in which the speeds are $2-1/n^2$ —that is, above unity, but below two units—will be called the intermediate region, and the corresponding speeds will be designated as *intermediate speeds*. Speeds in the $3-1/n^2$ range will be called *ultra high speeds*.

The foregoing paragraphs conclude the portions of the text of *The Neglected Facts of Science* that are relevant to the intermediate speed range. Consideration of speeds in the ultra high range will be deferred to later sections of this volume, as the phenomena now under review are limited to speeds below two units. However, one point that was mentioned in the extract from the 1982 publication which should have some further emphasis in view of its importance in the present connection is the status of unit speed. The true datum level of scalar motion, the physical zero, as we called it in the earlier volumes, is unit speed, not either of the mathematical zero points. This is significant, because it means that the second unit of motion, as measured from zero speed, does not add to the first unit. It replaces that unit. Although the use of zero speed as a reference level makes it appear that the sequence of units is 0, 1, 2, the status of unit speed as the true physical zero means that the correct sequence is $-1, 0, +1$. The importance of this point is its effect on the second unit of motion. This second unit is not the spatial motion (speed) of the first unit *plus* a unit of motion in time (energy), but the unit of motion in time only.

The speeds of the fast-moving products of the supernova explosions that we are now undertaking to examine are in the intermediate range, where motion is in time. Instead of being blown outward in space in the same manner as the products that are ejected at speeds below unity, these intermediate speed products are blown outward in time. In both cases, the atoms, which were in relatively close contact in the hot massive star, are widely separated in the explosion product, but in the intermediate speed product the separation is in time rather than in space. This does not change either the mass or the volumetric characteristics of the atoms of matter. But when we measure the density, m/V , of the giant stars we include in V , because of our method of measurement, not only the actual equilibrium volume of the atoms, but also the empty three-dimensional space between the atoms, and the density of the star calculated on this basis is something of a totally different order from the actual density of the matter of which it is composed.

Similarly, where the atoms are separated by empty time rather than by empty space the volume obtained by our methods of measurement includes the effect of the empty three-dimensional time between the atoms, which reduces the

equivalent space (the apparent volume), and again the density calculated in the usual manner has no resemblance to the actual density of the stellar material. In the giant stars the empty space between the atoms (or molecules) decreases the measured density by a factor which may be as great as 10^5 or 10^6 . The time separation produces a similar effect in the opposite direction, and the second product of the explosion is therefore an object of small apparent volume, but extremely high density: a *white dwarf* star.

The name “white dwarf” was applied to these stars in the early days just after their discovery, when only a few of them were known. These had temperatures in the white region of the spectrum, and the designation that was given them was intended to distinguish them from the red dwarfs in the lower portions of the main sequence. In the meantime it has been found that the temperature range of these stars extends to much lower levels, leading to the use of such expressions as “red white dwarf.” But by this time the name “white dwarf” is firmly established by usage, and it will no doubt be permanent, even though it is no longer appropriate.

When judged by terrestrial standards, the calculated densities of these white dwarfs are nothing less than fantastic, and the calculations were originally accepted with great reluctance after all alternatives that could be found were ruled out for one reason or another. The indicated density of Sirius B, for instance, is about $130,000 \text{ g/cm}^3$, that of Procyon B is estimated at $900,000 \text{ g/cm}^3$, while other stars of this type have still greater densities. In the light of the relationships developed in this work, however, it is clear that this very high density is no more out of line than the very low density of the giant stars. Each of these phenomena is simply the inverse of the other. The conventional wisdom on the subject is expressed in this statement by Donald Lynden-Bell:

We know already that some stars have collapsed to a size only ten times larger than that at which they would become black holes.⁶⁰

In the face of this asserted “knowledge” it may not be easy to accept the idea that these objects have, in fact, *expanded* to their present size; that is, their components have moved *outward* away from each other in time, and the small size that we observe is merely a result of the way in which the expansion in time appears in the spatial reference system. But this conclusion is a necessary consequence of basic physical principles whose validity has been demonstrated in the preceding volumes of this series, and, as we will see in the subsequent pages, it produces explanations of the white dwarf properties that are in full agreement with all of the definitely established observational information.

Unfortunately, the amount of observational information with respect to the white dwarfs that has been accumulated thus far is very limited, and much of what is available is of questionable accuracy. This scarcity of reliable information is due to a combination of causes. The white dwarfs have been

known for only a relatively short time. The first one to be seen, the “pup” companion of Sirius, the dog star, was observed in 1862, but it was not until about 1915 that the distinctive character of the properties of this star was recognized, and theories to account for these properties were not developed until considerably later. The second reason for the lack of information is the dimness of these objects, which makes them very difficult to see, and limits both the number of stars that can be observed and the amount of information that can be obtained from each.

The third factor that has led to confusion in this area is the lack of a correct theoretical explanation of the white dwarf structure. As indicated in the statement quoted above, the currently accepted theory envisions an atomic collapse. It is asserted that the energy supply of a star is eventually exhausted, and that when energy generation ceases, the star collapses into a hypothetical state called “degenerate matter” in which the space between the hypothetical constituents of the atoms is eliminated, and these constituents are squeezed into a close-packed condition. As explained by Robert Jastrow:

With its fuel gone it [the star] can no longer generate the pressures needed to maintain itself against the crushing force of gravity, and it begins to collapse once more under its own weight.⁶¹

Joseph Silk’s explanation is essentially the same:

The pressure exerts an outward force that withstands the gravity of the star, as long as there is sufficient hydrogen present in the stellar core to produce helium . . .

After the supply of nuclear energy runs out and fails to provide adequate heat and pressure, gravitational collapse must ensue.⁶²

This is an astounding conclusion. To put it into the proper perspective, it should be realized that the hypothetical collapse is something that is supposed to take place *within* the atom; that is, the pressure exerted *on the atoms* becomes so great that they are unable to withstand it. But, in fact, the pressure to which the atoms of the condensed gas are subject *is not significantly altered* by the cooling that results when (and if) the energy generation ceases. Each atom is subject to the pressure due to the weight of all overlying matter in any event, regardless of whether that matter is hot or cold. The pressure due to the thermal motion has nothing to do with conditions inside the atom; it merely introduces additional space *between* the atoms. Certainly, this added space would be eliminated if the star cooled down by reason of the exhaustion of the energy supply, but this would not change the conditions to which the *atoms* are subject.

The books from which an earlier generation of Americans learned to read

contained a story about a man who was returning home from the city with a heavy sack of flour that he had purchased. He was afraid that the weight of the flour would be too much for the horse that he was riding, so to lighten the load on the horse he held the sack in his arms. In those days, the children that read the story found it hilarious, but now we are confronted with essentially the same thing in different language, and we are expected to take it seriously.

Some writers seem to suggest the existence of a kinetic component that would add to the static pressure against the central atoms. Paolo Maffei gives us this version of the “collapse”:

Eventually, when all the lighter energy-producing elements have been depleted, energy will no longer be generated in the interior of the sun. In the absence of the internal pressure that supported them, the outer shells will rapidly fall toward the center due to gravitational attraction. In the course of this very rapid collapse, the atoms will be squeezed together ever more tightly, and the electrons will be disassociated from the nuclei.⁶³

But the assumption that a star could cool down rapidly enough to increase the total pressure significantly is nothing short of outrageous. There is no reason to believe that the heat transfer process within the star will be any faster during the cooling process than in the normal outward flow. Indeed, the cooling will be slowed up considerably by the release of gravitational energy as the outer portions of the star move inward. Furthermore, even under the most extreme assumptions, the critical pressure at which the atomic collapse is presumed to occur could be reached only in the very large stars, since the central atoms in the smaller stars can obviously withstand pressures immensely greater than the static pressure to which they are normally subject. (We know this to be true because atoms of the same kind *do* withstand these immensely greater pressures in the large stars). Thus the collapse, if it occurred at all, could occur only in the stars which current theory says do *not* collapse, but explode. And no one bothers to explain how the layers of matter outside the central regions of the star, which certainly are not subjected to any excessive pressure, are induced to participate in the degeneracy.

The truth is that the question as to *how* matter gets from its normal state into this hypothetical degenerate condition is given scant attention. The astronomers have arrived at an explanation of the extremely high density of the white dwarfs that appears reasonable in the context of the currently accepted theory of atomic structure. That theory portrays the atoms in terms of individual constituents separated by large amounts of space. Elimination of this space seems to be a logical way of accounting for the enormous increase in density. No direct evidence bearing on this issue is currently available, and the hypothesis is therefore free from any direct conflict with observation. Having

this (to them) satisfactory explanation of the *density* of the white dwarf, the astronomers have apparently considered it obvious that the stars must get from their normal condition to this white dwarf state in *some* way. Consequently, they have not considered it necessary to look very closely into the question as to how the collapse is to be accomplished.

Eddington is often credited with having provided the “explanation” of the white dwarfs.⁶⁴ But an examination of one of his discussions of the subject, such as that in the chapter on “The Constitution of the Stars” in his *New Pathways in Science*,⁶⁵ reveals that the whole point of his discussion is to show that the *existence* of degenerate matter is consistent with *accepted atomic theory*. He does not address the question as to how this degeneracy is to be accomplished, except to comment that it can be produced by pressure, which gets us nowhere, as he offers no suggestion as to how the necessary pressure could be produced—the same lacuna that is so evident in the more recent discussions of the subject. Where such a suggestion is attempted, it is usually an obvious absurdity. Here is an example:

Gravitation tends to squeeze the star to smaller and smaller dimensions, but every contraction only strengthens the force, thereby compelling further contraction . . . Its [the star’s] contraction accelerates all the time for the reasons just explained, and outright would collapse into a black hole if forces were not generated to counteract the gravitational contraction. Such a force is the thermal pressure of the gas . . . the pressure eventually begins to balance gravitation.⁶⁶ (M. J. Plavec)

This not only conflicts with the previously noted fact that the thermal pressure does not alter the pressure exerted against the atoms, but is also specifically contradicted by direct observation, as we know from experience that matter in which thermal pressure is *not* “generated to counteract the gravitational contraction”—that is, matter that is near zero absolute temperature—does not “collapse into a black hole.” It remains in the condition that we call the solid state, in which there is a definite minimum distance between the atoms. This is an equilibrium distance, and it can be reduced by application of pressure, but there is no observational indication of any kind of a limit, even though pressures as high as five million atmospheres have been reached in experiments.

The truth is that there is no empirical evidence to support the assumption that gravitation operates *within* atoms. Observations show only that there is a gravitational effect *between* atoms (and other discrete particles). Furthermore, the behavior of matter under compression demonstrates that there is a counterforce, an antagonist to gravitation (the same one that we encountered earlier in our examination of the structure of the globular clusters) that limits the extent to which the gravitational force can decrease the inter-atomic distance.

Plavec's contention that collapse into a black hole will take place unless forces, such as the thermal pressure, are "generated" to oppose gravitation is contradicted by the observed behavior of matter, which shows that the necessary counter-force is inherent in the structure of matter itself, and does not have to be generated by a supplementary process.

In order to clear the way for the "collapse" hypothesis, it is first necessary to assume that there is a limit to the strength of the counter-force, an assumption that is entirely ad hoc, since current science has not even identified the nature of this force, to say nothing of establishing its limits, if any. Then it is further necessary to assume that the gravitational force operates within the atom and that the opposing force is not so operative to any significant extent. The combination of these latter assumptions is inherently improbable, and in view of the lack of any indication of a limit to the resistance to compression, the first assumption has no more claim to plausibility. The theory of atomic collapse is thus simply an excursion into the realm of the imagination.

In the universe of motion stars cannot and do not collapse. The results that are currently attributed to this hypothetical collapse are produced by the expansion of the fastest products of the supernova explosion into time. The factor that controls the course of development of the white dwarf stars is the inversion of physical properties in the intermediate speed region. As we have seen, the expansion into time increases the amount of three-dimensional time occupied by this star. This is equivalent to a decrease in the volume of space; that is, the equivalent spatial dimensions are reduced, resulting in an increase in density when measured as mass per unit of volume.

Contraction of the matter of the white dwarf star under pressure has the opposite effect, just as it does in the case of ordinary matter. Pressure thus *reduces* the density measured on this same basis. The constituents of a white dwarf star, like those of any other star, are subject to the gravitational effect of the structure as a whole, and the atoms in the interior are therefore under a pressure. The *natural* direction of gravitation is always toward unity. In the intermediate region (speeds above unity), as in the time region (distances below unity) that we explored in the earlier volumes, toward unity is outward in the context of a fixed spatial reference system, the datum level of which is zero. Thus the gravitational force in the white dwarf star is inverse relative to the fixed system of reference. It operates to move the atoms closer together in time, which is equivalent to farther apart in space. At the location where the pressure due to the gravitational force is the strongest, the center of the star, the compression in time is the greatest, and since compression in time is equivalent to expansion in space, the center of a white dwarf is the region of lowest density. As we will see later, this inverse density gradient plays an important part in determining the properties of the white dwarfs.

Another effect of the inversion at the unit level can be seen in the relation of the size of the white dwarf to its mass. References are made in the

astronomical literature to the “curious” fact that “the more massive a white dwarf is, the *smaller* its radius.”⁶⁷ When the true nature of the white dwarf is understood, this is no longer curious. A massive cloud of matter expanding into space occupies more space than one of less mass, and the radius of the massive cloud is therefore greater. A massive cloud of matter expanding into time similarly occupies more time than one of less mass, and the radius of the massive cloud (measured as a spatial quantity) is therefore smaller, inasmuch as more time is equivalent to less space.

Astronomical observations give us only occasional disconnected glimpses of the white dwarf stars as they move through the various stages of their existence, but we can arrive at a theoretical picture of their evolution that is in full agreement with the little that is observationally known. The following paragraphs will outline the general nature of the evolutionary development, which will be considered in detail in Chapters 11, 12, and 13.

In what may be called Stage 1, the immediate post-ejection period following the supernova explosion in which the white dwarf is formed, this star is expanding in time. This means that from a spatial standpoint it is contracting in equivalent space. In this stage, the constituent particles, newly raised to intermediate speeds, are emitting radiation at radio frequencies as they move toward isotopic stability at these speeds. (The process by which the radiation is generated will be examined in Chapter 18). Such a star is observable only as an otherwise unidentifiable source of radio emission. A great many such sources—“blank fields,” as they are known to the observers—have been located, and presumably many of these are outgoing white dwarfs.

During this expansion stage energy is being lost to the environment, and there is little generation of energy to replace the losses. Energy production by atomic disintegration is reduced as the temperature rises in the range above unity, as this decreases the inverse temperature, which determines the destructive limits of the elements in the intermediate speed range. Since unity is the natural datum for physical activity, the critical level at which the disintegration of the atom takes place is unit equivalent temperature, corresponding to the speed of light, regardless of whether the pre-disintegration temperature is above or below the unit level. A deviation upward from unity (a decrease in inverse speed) has the same effect on the process as a downward deviation of the same magnitude (a decrease in speed). Inasmuch as the maximum speed is well above unity, only the very heavy elements are initially available as fuel.

When the energy loss to the environment has been sufficient to terminate the contraction in equivalent space, a process of re-expansion begins. The energy loss continues throughout this second evolutionary stage. As the expansion proceeds, and as the temperature falls toward unity, energy production increases to some extent, since successively lighter elements reach their destructive limits in the same manner as in the inverse situation on the opposite

side of the unit temperature level. But the supply of elements heavier than iron was reduced to near zero before the supernova explosion, and the expanding white dwarf therefore has very little fuel for energy generation. The atom building process and the accretion of matter from the environment eventually begin replenishing the supply, but this proceeds at a relatively slow pace. Furthermore, the white dwarf does not have the benefit of gravitational energy, such as that which is released by the contraction of the giant stars, because the effect of gravitation in time is the inverse of the effect of gravitation in space.

Because of the energy losses, the temperatures of the constituents of a white dwarf continually decrease, and eventually they begin dropping below the unit level. As this reversion to the lower speed range proceeds, the star is gradually converted from the status of a white dwarf (a star whose constituents move at intermediate speeds) to that of an ordinary main sequence star (one whose constituents move at speeds below the unit level). The evolution of the white dwarf is thus directed toward the same end as the evolution of the giant stars; that is, a restoration of the state of gravitational and thermal equilibrium that was destroyed by the supernova explosion. In the case of the red giant, the explosion produced a cool and diffuse aggregate which had to contract and heat in order to reach the equilibrium condition. In the case of the white dwarf, the explosion produced a dense hot aggregate that had to expand and cool in order to reach the same equilibrium condition.

Since the astronomers do not recognize the true nature of the white dwarf star, they have had great difficulty in charting an evolutionary course for these objects. As noted earlier, they have developed a theory of stellar evolution that takes the stars as far as the red giant stage. They regard the white dwarfs as being in the last stage on the road to stellar oblivion. It follows, so they conclude, that the stars must, in some way, get from red giant to white dwarf. The amount of progress that has been made toward putting some substance into this pure assumption during the last twenty years can be seen by comparing the following two statements:

We know remarkably little about evolution in population I after the red giants.⁶⁸ (J. L. Greenstein, 1960)

The details of the process by which the red giants evolve into white dwarfs are poorly understood.⁶⁹ (R. C. Bohlin, 1982)

But when a pure assumption of this kind is repeated again and again, its dubious antecedents are eventually forgotten, and it begins to be accepted as established knowledge. The remarkable way in which the status of this assumption as to the location of the evolutionary path has been elevated by the process of repetition, without any addition to the observational support, can be seen from the following statement from an astronomy textbook, in which the “poorly understood” and purely hypothetical evolutionary course becomes a

certainty:

We do not know precisely what happens [to the red giants] at this point, but we are sure that shortly thereafter the star moves rapidly to the left on the H-R diagram and then downward, fading out slowly in the lingering death of the white dwarf.⁷⁰

Even in the light of conventional theory, the hypothesis that the stars “move rapidly to the left on the H-R diagram [from the red giant region] and then downward,” meanwhile shedding mass, is untenable. Movement to the left from the red giant region involves an *increase* in the mass of a Class 1 star, and either an increase or a constant mass for a member of one of the later classes. The stars in the upper left of the diagram are the most massive of all of the known stars. The mass loss assumed to be taking place during this hypothetical leftward movement is incompatible with the observed mass relationships. Nor is there any explanation as to *how* this assumed loss of mass could take place. Shklovsky, for instance, concedes that “we simply do not understand exactly how material is ejected from the envelopes of such [red giant] stars.”⁷¹

Furthermore, even where matter is actually ejected from a star, this does not necessarily mean that it leaves the system. When the issue is squarely faced, it is apparent that there is no evidence of any significant loss of mass from *any* star system, other than the stars that explode as supernovae. There are, of course, many types of stars that eject mass, either intermittently or on a nearly continuous basis, but they do not given their ejecta anywhere near enough velocity to reach the gravitational limit and escape from the gravitational control of the star of origin. This ejected matter therefore eventually returns to the star from which it originated.

In this connection, it should be noted that although the relation of the stellar mass to the variables of the CM diagram is different for the different classes of stars, our findings show that it is fixed for any one of these classes. Stars that are following an evolutionary course that involves an increase of mass cannot lose mass and still continue on that course. This not only rules out the theoretical loss of mass by stars such as the red giants which show no evidence of any significant outflow of matter, but also means that the observed ejection of material by stars like the Wolf-Rayets is a cyclical process of the kind discussed in the preceding paragraph. We will encounter this same kind of a cyclical ejection process in a more extensive form in the case of the planetary nebulae, which will be examined in Chapter 11.

The present chapter is the first in this volume that involves a full-scale application of the reciprocal relation between space and time, the most significant consequence of the postulate of a universe composed entirely of motion. Some of the conclusions of the preceding chapters depend in part on

this relationship, but the *entire* content of this chapter rests on the inverse relation between the effects of an expansion into space and those of an expansion into time. The concept of an object becoming more compact (from the spatial standpoint) as it expands will no doubt be a difficult one for many individuals (although for some reason, most seem to be quite comfortable with the fantastic “holes” in space—black holes, white holes, wormholes, etc.—that figure so prominently in present-day cosmological speculations). But the validity of the reciprocal relation between space and time has been demonstrated in many hundreds of applications in the preceding volumes, and it provides the complete and consistent explanation of the white dwarfs that conventional astronomical theory is unable to supply.

The theory of white dwarfs in the universe of motion contains none of the awkward gaps that are so conspicuous in currently accepted astronomical theory. In the context of this new theory both the *nature* of the white dwarfs and their *properties*—those properties that are so different from those of the familiar objects of everyday life—are necessary consequences of the event in which these stars originated: the supernova explosion. And these properties define the ultimate fate of these objects. There is no need to assume a stellar “death” for which there is no observational evidence. The destiny of the white dwarf, an eventual return to the main sequence, is implicit in the physical characteristics that make it the kind of a star that it is.

CHAPTER 7

Binary and Multiple Stars

The prevalence of binary and multiple systems is one of the most striking facts that has emerged from the astronomers' observations of the stars, but they have not been able thus far to find an explanation for the existence of these star systems that is plausible enough to attain general acceptance. A number of different types of theories have been proposed, but all are subject to serious difficulties. As one astronomy textbook describes the situation:

Our hopes of understanding all stars would brighten if we could explain exactly how binary and multiple stars form . . . Unfortunately we cannot.⁷²

In view of this embarrassing lack of understanding of one of the most prominent features of stellar existence, it is significant that the development of the theory of the universe of motion provides a detailed account of the origin of these binary and multiple systems, not as something of a separate nature, but as an integral part of the explanation of the stellar evolutionary process. Furthermore, this explanation of the origin of these systems carries with it an explanation of the diversity of the components, another item that has hitherto puzzled the investigators. A half century ago, James Jeans made the following comment about this situation, an observation that is equally appropriate today:

Reverting to the special problem of binary systems, it is hard to see how the two constituents can be of the same age, and yet they can only be of different ages if they have come together as the result of capture, a contingency which is so improbable that it can be ruled out as a possible origin for the normal binary system . . . Clearly some piece of the puzzle is missing.⁷³

The existence of two distinct products of the supernova explosions, with speeds in different ranges, is the piece of the puzzle that has been missing. On the basis of the theory of the Type I supernovae outlined in Chapters 4 and 6, *every* star that has been through *one* such explosion is now a star system consisting of two components: an A component on or above the main

sequence, and a B component on or below the main sequence. This means that the seemingly incongruous associations of stars of very different types that are so common are perfectly normal developments. Combinations of giant and dwarf stars, for example, are not freaks or accidents; they are the natural initial products of the process that produces the second generation stars.

The significance of the term “star system” introduced earlier should now be apparent. A star system, in this sense, consists of two or more stars or aggregates of sub-stellar size that have been produced by subdivision of a single star. Inasmuch as the constituents of such a system have originated inside the gravitational limit of the original star, they are gravitationally connected, rather than having a net outward motion away from each other, as is true of the individual stars.

The term “binary” is frequently used by astronomers in an inclusive sense to cover all systems with more than one component, but for the purposes of this present work it will be restricted to the double systems. The star systems with more than two components will be called multiple systems.

In the early stages the pairing varies with the evolutionary age of the system. Immediately after the explosion the A component is merely a cloud of dust and gas which appears as a nebulosity surrounding the white dwarf B component. Later the cloud develops into a pre-stellar aggregate, and then into a giant infrared star. Since these aggregates are invisible, except under special circumstances, the white dwarf appears to be alone during this phase. When the giant star gets into the high luminosity range this situation is likely to be reversed, as the bright star then overpowers its relatively faint companion. Further progress eventually brings the giant down to the main sequence. The development of the white dwarf is slower, and there is usually a stage in which a main sequence star (the former giant) is paired with a white dwarf, as in Sirius and Procyon.

Finally the white dwarf, too, reaches the main sequence, and thereafter both components progress upward along the same path. The upper (more advanced) portions of the main sequence therefore contain no associations of dissimilar stars. Many of these stars are binaries, but they are pairs of the same or closely related types. There are some differences in composition. The white dwarf gets the lion’s share of the heavy elements in the supernova process, and even though it accretes the same kind of matter as the giants, it has a larger content of “metals” in the main sequence stage.

The Wolf-Rayet stars appear to reflect this difference. Their distribution and relative size indicate (on the basis of the theory discussed in Chapter 4) that they are former white dwarfs. They are less massive than the O and B stars with which they are associated.⁷⁴ As noted earlier, they are probably rich in nickel, a white dwarf characteristic, and they are “closely confined to the plane of the Galaxy,”⁷⁵ indicating that they are stars of Class 2 or later. No Wolf-Rayet stars have been found in the Orion Nebula, where O and B stars of

Class 1 are plentiful.⁷⁴

It is suspected that all [Wolf-Rayets] may be components of close pairs, the W stars revolving with larger O type companions, a situation that may provide an important clue to the still mysterious behavior of Wolf-Rayet stars.⁷⁶

This “suspected” pairing with O type stars, reported by an astronomy textbook, is fully in accord with our theoretical findings. The O star is the A component of the binary system, the former giant, while the Wolf-Rayet star is the B component, the former white dwarf.

The astronomers have been unable to arrive at any explanation as to why so many stars are binary, and they are even more at a loss to explain the frequent occurrence of pairs of a very dissimilar nature. The pairing of these dissimilar objects is an anomaly in the context of conventional astronomical theory, which pictures the two stars in a binary system as following the same evolutionary path, and therefore occupying very different locations on that path if they are stars of different types. This presumed difference in evolutionary status is hard to reconcile with the rather obvious probability that the two stars of such a system have a common origin. The fact that the white dwarf is normally (probably always) the less massive of the two stars exacerbates this problem.

Double stars . . . often present the strange circumstance that the more massive star is still a main sequence object, while the less massive star has reached the white dwarf stage. If the two stars are of the same age, and have always been a physical pair, then the more massive star should evolve faster than the other.⁷⁷

Dean B. McLaughlin makes this comment on a specific situation:

It is curious that several other novalike variables, as well as two recurrent novae, T Coronae Borealis and RS Ophiuchi, have red giant stars for companions.⁷⁸

From the standpoint of the findings of this work, there is nothing at all “curious” about this situation. Nor is it a “strange circumstance” that the more massive star is on the main sequence. The seeming anomaly is actually an observational repudiation of current astronomical theory. It exposes the falsity of the assumption upon which the current theory is based: the assumption that all stars follow the same evolutionary course, and that the main sequence stars precede the white dwarf stars on this course. Our finding is that the two constituents of a binary system follow totally different paths,

and at any specific time they are equally far advanced on their respective paths. The path back to the main sequence is, however, somewhat longer for the white dwarfs, which accounts for the variety of the combinations. Because of the nature of the process by which they were formed, *all* of the stars of the white dwarf class, including the novae and related variables, are accompanied by stars or pre-stellar aggregates on or above the main sequence. These companions are not always visible, particularly if they are still in the pre-stellar stage, but if they are observable, they are either giants, sub-giants, or main sequence stars.

It is true that some of the observed double stars do not fit into this evolutionary picture on the basis of their reported composition. For example, Capella is said to be a pair of giants. Neither of these stars can qualify as the B component of a binary. On the basis of the theory of the universe of motion, we must therefore conclude that Capella is actually a multiple system rather than a double star, and that it has two unseen white dwarf or faint main sequence components. The Algol type stars, in which the main sequence star is paired with a sub-giant of a somewhat smaller mass, are similarly indicated as multiple systems. The main sequence star cannot be the B component because it is the larger of the two units and has already attained the equilibrium status, while the sub-giant cannot be the B component because it is above the main sequence. We must therefore conclude that at least one of these stars has undergone a second explosion, and that it is accompanied by a faint B companion. This assessment of the situation is supported by the fact that in Algol itself at least one, and possibly two, small B components have been located observationally.

The second explosive event attributed to such stars as Capella and Algol is a normal development that can be expected to occur in any star system of an advanced evolutionary age, if it is in an appropriate environment. Chronological age alone will not produce this result, as there is no progress up the main sequence unless sufficient material is available for accretion. But where there is an adequate supply of "food" in the environment, the stars continue moving around the cycle until their life span is terminated by a process that will be discussed in Chapter 15.

Each passage of a single star through the explosive stage of the cycle results in the production of a binary system (unless the B component is below stellar size, a possibility that we will examine shortly). The number of stars in the system thus continues to increase with age, as long as sufficient material for accretion is available. Systems with as many as six components are found within the present observational range, and considerations that will be discussed later indicate that even larger systems may exist in the older regions of large spiral and spheroidal galaxies. The status of these multiple systems as combinations of separately produced binaries is clearly indicated by their structures.

In triple systems . . . two stars commonly co-rotate in a *close* orbit, and a third star revolves around the pair at a *great distance*. In quadruple systems, such as Mizar, two close pairs are likely to revolve around each other at a great distance.⁷⁹ (W. K. Hartmann)

The local star group, the concentration of stars in the immediate vicinity of the sun, is composed mainly of Class B stars, those of the main sequence, and since there is ample evidence, such as that contributed by their heavy element content, that these are second generation products, Class 2B, they should be largely binaries. This theoretical conclusion is confirmed by observation. "Single stars are a minority."⁸⁰ Most of the recognized binary systems have main sequence stars in both positions, but there are some main sequence-white dwarf combinations. Few, if any, giant-white dwarf systems are recognized in this region, but this is probably due to the effect of the time factor on the number of stars in each part of the cycle, as the interval during which the giant stars are visible is of short duration compared to the time spent by the white dwarfs in their evolutionary development.

It should be noted in this connection that this local group is representative only of a particular evolutionary stage, not of stellar systems in general, and the proportions in which the various types of stars occur in this local region are not indicative of the composition of the stellar population as a whole. The white dwarf, for instance, is an explosion product, a star of the second or later generation, and stars of this type are almost totally absent from stellar systems such as the globular clusters, which are composed almost exclusively of first generation stars, those which have not yet passed through the explosion phase of the cycle. It should not be assumed, therefore, that the high proportion of white dwarfs in the local region indicates a similar high proportion throughout the universe, or even throughout the Galaxy.

The same caveat should be applied to the estimate, quoted in Chapter 4, that 95 percent of all stars are located on the main sequence. This estimate does not give sufficient consideration to the fact that few of the early type stars, those of the globular clusters and the early elliptical galaxies, have reached this evolutionary stage. These aggregates, which constitute the great majority of stellar systems (although they do not necessarily contain the majority of all stars), are composed almost entirely of Class 1A stars, those that have not yet reached the main sequence. The number of stars of the later classes in these aggregates is no more than can be explained on the basis of the strays, the scattered remnants of disintegrated older structures.

The almost complete absence of the various types of binary stars from these young aggregates is recognized by the observers, but it remains unexplained in current thought. Burnham, for instance, comments that "For some reason not fully understood, eclipsing binaries appear to be very rare in globular star clusters."⁸¹ Likewise novae are scarce. "There are only two cases of novae

in globular star clusters,'⁸² he says. The search for binaries in the center of globular clusters has been totally unsuccessful,⁸³ reports Bart J. Bok. Shklovsky concedes that for Population II stars in general, multiplicity is "fairly rare."⁸⁴

No reason for this near absence of binaries from Population II (Class 1A) stars is given in the astronomical literature. Nor is much support given to the rather half-hearted efforts to explain the origin of the double and multiple systems. The sad fact is that the astronomers are trapped by their upside down evolutionary sequence. The striking difference in the abundance of binaries between two groups of stars that admittedly differ primarily in age shows that this must be an evolutionary effect. But since the astronomers regard the group with almost no binaries as the older, they have to find one process by means of which the binaries are produced in the original star formation, or very soon thereafter, and another process whereby the combinations are uncoupled at some later evolutionary stage. Even the origin of the binaries is without any explanation that is taken seriously, and no explanation at all has been advanced to account for the uncoupling.

When the correct evolutionary direction is recognized, one half of this problem disappears. Only one process remains to be explained: the production of binary systems at some stage of the evolutionary development. In the context of the theory of the universe of motion, this is seen to be a necessary consequence of the division between motion in space and motion in time that takes place in the products of extremely violent explosions. Here, then, this theory provides a complete and consistent explanation of an important feature of the astronomical universe that is without any explanation in terms of conventional astronomical theory.

The clarification of the situation that is accomplished by the new theory does not end at this point. Because of the lack of understanding of the basic principles that are involved, the astronomers are unable to distinguish between cause and effect in these phenomena. For example, Shklovsky expresses the current astronomical opinion in this statement:

Enough has been said to conclude that the doubling of a star decisively controls its evolution.⁸⁵

As the points brought out in the preceding discussion demonstrate, this view of the situation is upside down, like so many other aspects of currently accepted theory. Instead of the doubling of the star determining its evolution, the evolutionary development of the star results in the doubling. The conventional view expressed by Shklovsky really does not explain anything; it merely replaces one question with another. The question as to what causes the evolution becomes a question as to what causes the doubling. On the other hand, the answer derived from the theory of the universe of motion is

complete. This theory explains why stars evolve, why this evolution terminates in an explosive event, and how the doubling of the star results from the explosion.

In a statement quoted in the first volume of the present series, Richard Feynman commented that “Today our theories of physics, the laws of physics, are a multitude of different parts and pieces that do not fit together very well.”⁸⁶ This description is even more appropriate in application to the theories of astronomy.

Despite its tradition, which stretches back many millennia, astronomy does not appear to qualify as a mature science in [Thomas] Kuhn’s sense of the word—a science with an established framework of theory and understanding.⁸⁷ (Martin Harwit)

The binary star theory is one of the individual “parts and pieces” that has little connection with anything else. The existence of binaries is simply taken as given, and a set of conclusions with respect to some of the observed binary phenomena is then drawn from this existence, without fitting these conclusions, and the phenomena to which they refer, into the rest of astronomical theory. This comment is not intended as a criticism; it is simply a statement of one of the aspects of astronomy, as it now exists, that needs to be taken into consideration in order to understand why the theoretical development in this series of volumes arrives at so many conclusions that differ radically from the prevailing astronomical thought. Inasmuch as the astronomers have no *general* structure of theory, either in physics or in astronomy, with which to work, they have had no option but to proceed on this piecemeal basis. Actually, they have made impressive progress in identifying and clarifying the “multitude of different parts and pieces.” What is now needed is to put these parts and pieces together, turning them right side up where necessary, and fitting them together in the correct manner. This is the task that the general physical theory derived from the postulates that define the universe of motion is now prepared to handle.

With the benefit of the information supplied by this new theoretical system, it can now be seen that the behavior characteristics of the binary star systems are inherent in the stars themselves. There is no need to invent processes that call for interaction between the components. Hypothetical processes of this nature are the current orthodoxy.

Interacting double stars—i.e., those in which gas flows from one star to the other—are in vogue to explain many peculiar celestial phenomena. The subject has become a bandwagon during the last decade or less.⁸⁸ (David A. Allen)

In many binary systems the separation between the stars is relatively small, and some interaction between them is a definite possibility (although it should be remembered that where one of the two stars is a white dwarf, there is a separation in time as well as in space, and the stars are not actually as close to each other as they appear to be). But the current tendency is to use the hypothesis of mass transfer from one member of a binary system to the other as a kind of catch-all, to explain away any aspect of binary star behavior that is not accounted for in any other way. The remarkable extent to which this hypothetical mass transfer process is currently being stretched is well illustrated by the purported resolution of what is called the "Algol paradox." As noted earlier in this chapter, the two principal components of Algol are a relatively large and hot main sequence star and a less massive, cooler sub-giant.

Here lies a paradox. The more massive B or A star should be the one to expand first yet the less massive star is the more evolved giant. Why? Is there a fundamental mistake in our idea of stellar evolution?⁸⁹ (W. K. Hartmann)

Very little is actually known about the conditions that exist in these binary systems, and still less is known about the events that have taken place earlier in the lives of these stars. Thus, at the present level of instrumentation and techniques there is no way of *disproving* a hypothesis about these binaries, and the astronomers have taken full advantage of the freedom for invention. "Theoretical studies have resolved the paradox," Hartmann says. It is simply *assumed* that the smaller star was originally the larger, and that after having achieved the more advanced status, it obligingly transferred most of its mass to its companion. In other binary star situations, such as in the cataclysmic variables, the transfer explanation can be used only if the movement is in the opposite direction. So it is cheerfully assumed, in this case, that the transfer is reversed. As Shklovsky explains,

It seems that the hot component has already passed through its evolution and, at some epoch in the past, transferred much of its material to its companion star. But now the companion is returning the favor by restoring to the evolved star the material "borrowed" many millions of years ago.⁹⁰

Of course, we have to keep in mind the difficulties under which the astronomers carry on their work, but nevertheless, there are limits to what can legitimately be classified as scientific. Acceptance of untestable ad hoc assumptions as the resolution of problems, or giving them *any* status other than that of highly tentative suggestions for study, is incompatible with good

scientific practice. It inevitably leads to wrong answers. The correct answer to Hartmann's question is, Yes, there is a fundamental mistake in current ideas of stellar evolution. The so-called "paradoxes" are actually observational contradictions of a theory that has no foundation in fact.

In addition to the binaries, we also observe a considerable number of stars in the local region which appear to be single. Some of these may actually be single stars that have drifted in as a result of the mixing process that occurs by reason of the rotational motion of the Galaxy, but others are double stars in which one of the components is unobservable. We have already noted that the A component of a binary is invisible during a portion of the early evolutionary stage, and all we see under these conditions is a lone white dwarf. The components of the white dwarfs are not dispersed in space, and these stars do not participate in this kind of a retreat into obscurity, but they become invisible for other reasons. As we will find in Chapter 11, they cannot be seen at all until they cool down to a certain critical temperature. Later they may be overpowered by a bright giant or main sequence companion, or they may simply be too dim to be observable at any considerable distance.

Inasmuch as the maximum speed produced by the supernova explosions that we are considering is less—usually considerably less—than two units, the distribution of speeds above and below unity is asymmetric, with the greater part of the mass taking the lower speeds. For this reason, even though some of the matter ejected into space escapes from the gravitational control of the remnants of the star, the amount of retained slow speed material still exceeds the inward-moving mass in most, and probably all, cases. The giant member of the binary system therefore has the greater mass. In Sirius, for example, the main sequence star, originally the giant, has more than twice the mass of the dwarf. Since even the smallest star is subject to a Type II supernova explosion at the age limit, it is evident that in many instances the mass of the dwarf component is below the minimum required for a star, in which case the final product is a single star with one or more relatively small and cool attendants: a planetary system.

In the supernova explosion the material near the center of the star is obviously the part of the mass that acquires greater-than-unit speed, and disperses into time. The remainder of the stellar material is dispersed outward into space. In view of the segregation of heavy and light components which necessarily takes place in a fluid aggregate under the influence of gravitational forces, the chemical composition of the two components of the explosion products differs widely. Most of the lighter elements will have been concentrated in the outer portions of the star before the explosion, those heavier than the nickel-iron group will have been converted to energy, except for the stray atoms mixed in with other material, and the recent acquisitions that had not had time to sink to the center, while the central portions of the star contained a high concentration of the iron group elements.

When the explosion occurs, the outward moving material, which we will call Substance A, consists mainly of light elements, with only a relatively small proportion of high density matter. It can be deduced that the composition of Substance B, the matter of the inward moving component, is subject to a considerable amount of variation. The exploding stars differ in their chemical composition. No doubt there are also differences in some of their physical properties—rotational speed, for example. Because of these differences in the stars from which they originate, the size and composition of the white dwarf components of the explosion products is also variable. If this component is small, it can be expected to be composed almost entirely of the iron group elements. The large white dwarfs contain a greater proportion of the lighter materials.

In each of the two products of the stellar explosions that we are now considering, the primary gravitational forces are directed radially toward the center of the mass of the dispersed material. Hence, unless outside agencies intervene, it is to be expected that any capture of one subsidiary aggregate by another will result in consolidation, the formation of a binary or multiple system being ruled out by the absence of non-radial motions. Ultimately, then, the greater part of the matter of the larger of the two components, the material dispersed in space, will be collected into one unit. The smaller component then acquires orbital motion around the larger, consolidation being unlikely in this case, as neither unit will be moving directly toward the other unless by pure chance. The ultimate result is a system in which a mass, or a number of masses, composed primarily of Substance B is moving in an orbit, or orbits, around a central star of Substance A. If the B component is of stellar size, the system is a binary star; if it is smaller the product is a planet, or a planetary system. Because of interaction during the final stages of the formation process, some of the unconsolidated fragments may take up independent orbital positions, constituting planetary satellites.

This provides an explanation of the origin of the solar system, a matter that has been the subject of much speculation among the members of the human race, who occupy a planet of that system. On the foregoing basis we may conclude that at the beginning of the formative period of the solar system, after the gravitational forces had almost completed the task of aggregating the masses dispersed by the supernova explosion, a large mass of Substance A, with some small subsidiary aggregates and considerable dispersed matter not yet incorporated into the central mass, was approaching a much smaller and less consolidated mass of Substance B. When the combination of the two systems took place under the influence of the mutual gravitational attraction, the major aggregates of the B component acquired orbital motion around the large central mass of the A component. In the process of assuming their positions, these newly constituted planets encountered local aggregates of Substance A which had not yet been drawn into the central star, and under

appropriate conditions these aggregates were captured, becoming satellites of the planets. At the end of this phase all major units had been incorporated into a stable system in which planets composed of Substance B were revolving around a star composed of Substance A, and smaller aggregates of Substance A were similarly in orbit as planetary satellites.

Small fragments are subject to being pulled out of their normal paths by the gravitational forces of the larger masses which they may approach, and while orbital motion of these fragments is entirely possible, the chances of being drawn into one of the larger masses increase as the size decreases. We may therefore deduce that during the latter part of the formative period all of the larger members of the system increased their masses substantially by accretion of fragments of Substance A in various sizes from planetesimals down to atoms and sub-atomic particles. Some smaller amounts of Substance B, in assorted sizes, were also accreted. After the situation had stabilized, the central star, the sun, consisted primarily of Substance A, with a small amount of Substance B derived from the heavy portions of the original Substance A mix and the accretions of Substance B. Each planet consisted of a core of Substance B and an outer zone of Substance A, the surface layer of which contained some minor amounts of Substance B acquired by capture of small fragments.

The planetary satellites, which had comparatively little opportunity to capture material from the surroundings because of their small masses and the proximity of their larger neighbors, were composed of Substance A with only a small dilution of Substance B. It can also be deduced that after the formative period ended, further accretion took place at a slower rate from the remains of the original material, from newly produced matter, and from matter entering the system out of interstellar space, but the general effect of these subsequent additions did not differ greatly from that of the accretions during the formative period, and did not change the nature of the result.

This is the theoretical picture as it can be drawn from the information developed in the earlier pages. Now let us look at the physical evidence to see how well this picture agrees with observation. The crucial issue is, of course, the existence of distinct Substances A and B. Both the deduction as to the method of formation of the planetary systems and the underlying deduction as to the termination of the dense phase of the stellar cycle at the destructive limit would be seriously weakened if no evidence of a segregation of this kind could be found. Actually, however, there is no doubt on this score. Many of the fragments currently being captured by the earth reach the surface in such a condition that they can be observed and analyzed. These *meteorites* definitely fall into two distinct classes, the *irons* and the *stones*, together with mixtures, the *stony-irons*. The approximate average composition is as follows:

Irons		Stones	
Iron	.90	Iron	.25
Nickel	.08	Oxygen	.35
Other	.02	Silicon	.18
	—	Magnesium	.14
Total	1.00	Other	.08
			—
		Total	1.00

The composition of the iron meteorites is in full agreement with the conclusion that these are fragments of pure Substance B. The stony meteorites have obviously been unable to retain any volatile constituents, and when due allowance is made for this fact their composition is entirely consistent with a status as Substance A. The existence of the mixed structures, the stony-irons, is easily explained on the basis of the previous deductions as to the composition of the various sizes of white dwarfs.

It is also reported that the iron meteorites contain practically no uranium or thorium, whereas stony meteorites do.⁹¹ This is another piece of information that fits in with the theoretical picture. The supply of very heavy elements in the central regions of the stars, from which the iron meteorites (Substance B) are derived, was exhausted by the energy generation process before the supernova explosion occurred. But the outer regions of these stars, the source of the stony meteorites (Substance A), contained portions of the heavy element content of the accreted matter that had not yet made their way down to the center. The evidence from the meteorites thus gives very strong support to those aspects of the theory that require the existence of two distinct explosion products, Substances A and B.

There is no proof that the meteorites actually originated contemporaneously with the planets in the manner described, but this is immaterial so far as the present issue is concerned. The theoretical process that has been outlined is not peculiar to the solar system; it is applicable to any system reconstituted after a supernova explosion, and the existence of distinct stony and iron meteorites is just as valid proof of the existence of distinct Substances A and B whether the fragments originated within the solar system, or have drifted in from some other system that, according to the theory, originated in the same manner. The support given to the theory by the composition of the meteorites is all the more impressive because the segregation of the fragmentary material into two distinct types on such a major scale has been very difficult to explain on the basis of previous theories.

Additional corroboration of the theoretical deductions is provided by the spectra of novae. Since these are stars of the white dwarf class, they are composed of Substance B as originally formed. However, the white dwarfs

accrete matter from the surroundings in the same manner as other stars, and within a relatively short time the original star is covered by a layer of Substance A. This material is essentially the same as that in the outer regions of stars of other types, and the composition of the stellar interior is therefore not revealed by the spectra obtained during the pre-nova and post-nova stages. But when the nova explosion occurs, some of the Substance B from the interior of the star forces its way out, and the radiation from this material can be observed along with the spectrum from the exterior. As would be expected from theoretical considerations, the explosion spectra often show strong indications of highly ionized iron.⁹²

Another theoretical deduction that can be compared with the evidence from observation is the nature of the distribution of Substances A and B in the planetary system. The sun has a relatively low density, and we can undoubtedly say that it consists primarily of Substance A, as required by the theory. Whether or not it actually contains the predicted small amount of Substance B cannot be determined on the basis of the information now available. The planet that is most accessible to observation, the earth, definitely conforms to the theoretical requirement that it should consist of a core of Substance B with an overlying mantle of Substance A. The observed densities of the other inner planets, together with such other pertinent information as is available, likewise make it practically certain that they are similarly constituted.

The prevailing astronomical opinion is that the differentiation which produced the iron cores occurred *after* the formation of the planets. This necessitates the assumption that these aggregates passed through a molten, or semi-molten stage, during which the iron "drained into metallic cores."⁹³ Although this theory is still the one that appears most frequently in the astronomical literature, it received what is probably a fatal blow from the results of the Mariner 10 mission to Mercury. A report of these results reads in part as follows:

Somehow in the region where Mercury formed from the dust and gas of the primeval nebula, it first gathered iron-rich materials to form a dense core before adding the outer shells of less dense material. Planetologists here (Jet Propulsion Laboratory) feel this to be true because there is no evidence revealed by Mariner that Mercury could have gone through a subsequent hot period during which iron-rich materials could have differentiated and formed the core.⁹⁴

These observations indicating that the core formation preceded the acquisition of the lighter material are fully in accord with the theory of planetary formation derived in the foregoing pages, a theory which places the differentiation of the iron from the lighter elements in the pre-supernova star, rather than in the

planets.

The observational situation with respect to the major planets is less clearly defined. The densities of these planets are much lower than those of the earth and its neighbors, but this is to be expected, since they have been able, by reason of greater size and lower temperature, to retain the lighter elements, particularly hydrogen, that have been lost by the inner planets. The observations indicate that the outer regions of these major planets are composed largely of these light elements. This leaves the internal composition an open question. It seems, however, that there must have been some kind of a gravitationally stable nucleus in each case to initiate the build-up of the light material, and it is entirely possible that this original mass, which is now the core of the planet, is composed of Substance B. Jupiter has a total mass 317 times that of the earth, and even if the core represents only a small fraction of the total mass, it could still be many times as large as the earth's core.

We may thus conclude that, although the observational data on the outer planets do not definitely confirm the theoretical deduction that they have inner cores of Substance B, the observed properties are consistent with that finding. Since it is highly probable that all of the planets have the same basic structure, this lack of any definite conflict between theory and observation is significant.

The satellites present a similar picture. The verdict with respect to the distant satellites, like that with respect to the distant planets, is favorable to the theory, but not conclusive. The available evidence is consistent with the theory that the inner cores of these satellites, as well as their outer regions, are composed of Substance A, but it does not definitely exclude other possibilities. The satellite that we know best, like the planet that we know best, gives us an unequivocal answer. The moon is definitely composed of materials similar to the stony meteorites and the earth's crust; that is, it is practically pure Substance A, as it theoretically should be.

It is appropriate to point out that this theory of planetary origin derived by extension of the development of the consequences of the fundamental postulates of the Reciprocal System is independent of the temperature limitations that have constituted such formidable obstacles to most of the previous efforts to account for the existing distribution of material. The fact that the primary segregation of Substance A from Substance B antedated the formation of the solar system explains the existence of distinct core and mantle compositions without the necessity of postulating either a liquid condition during the formative period, or any highly speculative mechanism whereby solid iron can sink through solid rock.

This explanation of the formation of the system also accounts for the near coincidence of the orbital planes of the planets, and for the distribution of the planetary orbits in distance from the sun. It has been recognized for two hundred years that the planets are not distributed haphazardly, but occupy positions at distances that are mathematically related in a regular sequence.

This relation, called Bode's Law (although discovered by Titius), has never been explained, and since present-day scientists are reluctant to concede that there are answers which they are unable to find, the present tendency is to regard it as a mere curiosity. "It is probable that the law is no more than an interesting relation of a coincidental nature,"⁹⁵ says one textbook.

The basic principles governing this situation were explained in Chapter 6. The white dwarf is moving in time, and the speeds of its constituents are distributed in the range between one and two units. Increments of speed above the unit level are limited to unit values, but since the motion in the intermediate speed range is distributed over the full three dimensions of time, the applicable units are the three-dimensional units. As we saw earlier, the two linear units from zero to the one-dimensional limit correspond to eight three-dimensional units. The constituents of the white dwarf are thus distributed to a number of distinct speed levels, with a maximum of seven. The distances in equivalent space at the point of maximum expansion are similarly distributed. In the subsequent contraction back to the equilibrium condition these separations are maintained unchanged, although the individual constituents move from one level to the next lower whenever they lose a unit of speed.

During the contraction in time (equivalent to a reexpansion in space) there are two processes in operation. The gravitational force of the aggregate as a whole is pulling the particles in toward the center of mass. Coincidentally, each of the subdivisions of this aggregate defined by the different speed levels is individually consolidating, since all particles in each subdivision are moving at the same speed, and are therefore at rest relative to each other, aside from their mutual gravitational motion. The rate at which each process takes place depends mainly on the mass that is involved and the distance through which the constituents have to travel. If the total mass is relatively large, the central aggregation proceeds rapidly, and the local concentrations are pulled in to the center before they have a chance to develop very far. Where the total mass is relatively small, the distances involved are about the same, and the central force is therefore weaker. In this case the subsidiary aggregates have time to form, and the consolidation of these aggregates into one central mass may not be complete by the time the white dwarf becomes subject to the gravitational effect of its companion in the binary system.

Up to this point the subsidiary aggregates are all in a straight line spatially. They are distributed over three dimensions of time, but the spatial equivalent of this time is a scalar quantity, and it appears in the spatial reference system in linear form. When the white dwarf reaches the vicinity of its giant or main sequence companion, and is pulled out of its original line of travel by the gravitational force of the companion, the various subsidiary aggregates go into orbit at distances from the companion that reflect their separations, as well as the amount by which the line of movement of the white dwarf is offset from a direct central impact on its companion.

Bode's Law reproduces these distances, as they appear in the solar system, as far as the planet Uranus. It provides no explanation as to where its elements come from, but it does correctly identify these elements as two fixed quantities and one variable. The fixed quantities are properties of the particular star system (the solar system), and therefore have to be obtained empirically; they cannot be calculated from theoretical premises. The first of these represents the distance in actual space between the A component and the closest of the planetary masses at the time the orbital motion was established. It is the same for all planets, and has the value 0.4 in terms of the astronomical unit, the mean radius of the earth's orbit. Our finding confirms the value that appears in Bode's Law. The second constant is related to factors such as the masses of the two components of the binary system, and the magnitude of the explosion in which they were produced. In Bode's Law it has the value 0.3. We arrive at a somewhat lower value, 0.267.

The variable in the distance relation is the speed level of the motion in time. There are several factors involved in this relation that make it more complex than the simple sequence in Bode's Law. Two of these factors enter into the values in the first half of the group of planets. There is a 1½ step in the numerical sequence that does not appear in Bode's Law. As we have seen in the earlier volumes, this value frequently appears in such a sequence where the quantity involved is complex, so that it is feasible to have a combination of one-unit and two-unit components. Apparently the big jump from one to two (a one hundred percent increase) favors such an intermediate value, which is relatively rare at the higher levels. The second special factor that enters into the situation we are now considering is that, for reasons explained in Volume I, all magnitudes in equivalent space appear in the spatial reference system as second powers of the original quantities. The distances below $n = 4$ can thus be expressed by the relation $d = 0.267 n^2 + 0.4$. In this lower range the results obtained from this expression are practically identical with those obtained from Bode's Law, as indicated in Table I, where the observed distances are compared with those calculated from the two equations.

In this half of the total distance range, the increments of distance add directly, even though they are the results of increments of motion in time (equivalent space), because they correspond to the first half of the eight-unit speed range, which is on the spatial side of the neutral point. Beyond this point, on the temporal side, the relations are inverted. The n values (number of units from the appropriate zero) move back down, and the distances in equivalent space, expressed in spatial terms, are inversely related to the value of n^2 . Furthermore, the transition from space to time at the midpoint involves a change in the gravitational effect from one positive unit (gravitation in space) to one negative unit (gravitation in time), a net change of two units. On this basis, the neutral point is one unit (0.267) above the 4.7 distance corresponding to $n = 4$ on the space side. One more such unit brings the

TABLE I
PLANETARY DISTANCES

Planet	n	Calc.	Obs.	Bode's Law
Mercury	0	0.4	0.4	0.4
Venus	1	0.7	0.7	0.7
Earth	1½	1.0	1.0	1.0
Mars	2	1.5	1.5	1.6
Asteroids	3	2.8	2.8	2.8
	4	4.7		
Neutral point		4.95		
Jupiter	(4)	5.2	5.2	5.2
Saturn	(3)	8.9	9.5	10.0
Uranus	(2)	19.6	19.2	19.6
Neptune	(1½)	34.5	30.0	—
Pluto	—		39.4	38.8

distance to 5.2. This is 4.8 plus the 0.4 initial value. For the more distant planets, the 4.8 applicable to $n = 4$ is increased in inverse proportion to n^2 , resulting in the values shown in the table. The applicable equation is $d = 76.8/n^2 + 0.4$.

The agreement between the observed and calculated distances is not as close for these outer planets as for the inner group, but it is probably as close as can be expected, except in the case of Pluto. Bode's Law could have a place for Pluto, but only at the expense of omitting Neptune. This is not acceptable, as Neptune is a giant planet, while Pluto is a small object of uncertain status. It appears likely that the inverse speed range corresponding to $n = 1\frac{1}{2}$ is the maximum that was reached by the parent white dwarf, and that both Neptune and Pluto condensed in this relatively wide distance range. This would account for the fact that the calculated value for $n = 1\frac{1}{2}$ falls between the observed distances of the two planets.

This explanation of the interplanetary distances implies that almost all small stars of the second generation or later have similar planetary systems in orbit, a point that we will consider in another connection later. Otherwise, the clarification of the distance situation is not of any special importance in itself. It is significant, however, that when we put together the different properties that the motion of the white dwarf constituent of a small binary system must possess, according to the theory of the universe of motion, we arrive at a series of interplanetary distances that are almost identical with the observed values. This numerical agreement between theory and measurement is a substantial

addition to the evidence supporting the theoretical conclusions as to the nature of motion in the upper speed ranges. The white dwarf is the only object with component speeds greater than the speed of light that is involved in the astronomical phenomena thus far discussed in this volume, the phenomena that take up about 80 percent of a standard astronomy textbook. But the remainder of this work will be concerned *mainly* with objects whose components, and often the objects themselves, are moving at upper range speeds. A full understanding of the nature and properties of the white dwarf will contribute materially to clarification of the more complex phenomena of the intermediate and ultra high speed ranges that will be discussed in the pages that follow.

The smaller components of the solar system include interplanetary dust and gas, meteorites, asteroids, and comets. The asteroids are aggregates of Substance B, from 1000 km in diameter downward, which were never captured by planets, and did not accrete enough material to become planets in their own right. Most of the large asteroids are located in the "asteroid belt" between Mars and Jupiter, and represent the core of a potential planet that failed to complete its consolidation because of the gravitational effect of nearby Jupiter. The orbits of the asteroids are subject to modification by the gravitational forces of the planets, and occasionally one is deflected into an orbit that results in capture by the earth. Those that reach the earth intact, or in fragmentary form, are the previously mentioned iron, or stony-iron, meteorites. Stray aggregates of Substance A similarly captured are the stony meteorites. Most of these latter objects, like the asteroids, date from the original formation of the solar system.

Comets are relatively small aggregates of material drawn in by the sun from distant locations within its gravitational limit. Unless the incoming material happens to make a direct hit, it goes into a very elongated orbit on the first approach. At each return it loses part of its mass and reduces the size of its orbit. Eventually its entire contents are either absorbed by one of the larger bodies of the solar system or distributed in the space surrounding those bodies. The earth participates in this process in a relatively small way, capturing both individual particles (sporadic meteors) and meteor swarms, which are portions of the detached cometary material that follow previous orbits of their parent comets.

The current view is that there must be a "reservoir" of comets at some relatively large distance from the sun. In a sense, this is true, as the long-period comets spend the greater part of their lives in the outer portions of their orbits. But this reservoir is merely a storage location, not a source. There is a certain residual amount of dust and gas within the gravitational limit of the sun, some inflow of diffuse matter from interstellar space, and a small, but continuous, formation of new matter from the incoming cosmic rays. Thus new cometary matter is constantly being made available. The number of comets in the system is probably now at an equilibrium level where the rate of

formation is equal to the rate of loss due to evaporation from the comets and eventual capture of the remnants.

The contents of this chapter identify some of the factors that have a bearing on the question as to where planets are likely to exist, a question that excites a great deal of interest because it is a key element in any assessment of the possibility of the existence of life—particularly intelligent life—elsewhere in the universe. The B component of a binary system is *either* a star or a planetary system, not both. This eliminates all binary stars, and since all Class 1 stars are automatically excluded, it confines the possibility of planets to single Class 2 stars (such as the sun), or to single components of multiple systems (Class 3 and later). Inasmuch as a long period of reasonably stable conditions is probably required for the development of life—certainly for the emergence of any of the higher forms of life—the Class C stars of the second and later cycles, and the stars high on the main sequence, all of which are subject to relatively rapid change, can also be crossed off the list.

This wholesale exclusion of so many different classes of stars may seem to limit the possibility of the existence of extra-terrestrial life very drastically, but in fact, these conspicuous and well-publicized stars constitute only a minor part of the total galactic population. The great majority of the stars of the Galaxy are small, and relatively cool, stars in the lower sections of the main sequence. As we will see in Chapter 12, there is a lower limit to the mass of a white dwarf star, and when the B component of a system is below this limit it cannot attain stellar status. This implies the existence of an immense number of planets among the smaller systems. Of course, there are requirements as to size, temperature, etc., that a planet must meet in order to be available as an abode for life, but there is a zone in each system within which a planet of an appropriate size is quite likely to meet the other requirements. Since Bode's Law (as revised) is applicable to all systems in which the conditions are favorable for planet formation (the small systems), it is probable that all of these systems have at least one planet in the habitable zone.

The findings of this work thus increase the probability that there are a very large number of habitable planets—earth-like planets, let us say—in our own galaxy, as well as in other spiral galaxies. There are few, if any, in the galaxies smaller than the spirals—the ellipticals and the small irregulars—because they are composed almost entirely of Class 1 stars. The situation in the giant spheroidals is not yet clear. There are multitudes of lower main sequence systems in these giants, and these can be expected to have the usual proportion of planetary systems. However, the intense activity that, as we will see later, is taking place in the interior zones of these giants, no doubt rules out the existence of life. Whether enough of this activity carries over into the outer parts of these galaxies to exclude life in these areas as well is uncertain. The oldest of these giants are probably lifeless. As we will find in Chapter 19, there is a strong x-ray emission from these mature galaxies, and

this is probably lethal. So far as we know at present, however, there may be outlying regions in some of the younger galaxies of this class in which the conditions are just as favorable for life as in the spirals.

In today's science fiction, where life in other worlds is a favorite motif, the habitations of the alien civilizations are identified with familiar names, for reasons that are understandable. The thrilling action that the authors of these works describe takes place on planets that circle Sirius, or Arcturus, or some other well-known star. But according to our findings, few, if any, of these familiar stars are capable of having a habitable planet in orbit, and are also old enough to have developed complex forms of life. Sirius, for instance, has a white dwarf companion instead of a planetary system. Arcturus is a young Class C star. The astronomers do not make the mistake of identifying the environments of these stars as the abode of life, but they avoid it by making a different mistake. In selecting the target of their first systematic attempt at interplanetary communication (1974) they were misled by their current view of the evolutionary direction of the stars. This initial effort was directed at the globular cluster M 13, on the assumption that it is a very old structure in which the processes that lead to life have had ample time in which to operate. We now find that the globular clusters are relatively young structures which, aside from a few stray stars that have been picked up from the environment, are composed entirely of Class I stars. These cluster stars have not been through the explosion process, and therefore have no planetary companions at all.

As matters now stand, the available information indicates that habitable planets are plentiful, but that the planets on which life probably exists are not located in any systems that we can call by name. The stars that they are orbiting are undistinguished, anonymous, and with few, if any, exceptions, unseen stars of the lower main sequence.

CHAPTER 8

Evolution - Globular Cluster Stars

Even though a globular cluster may contain as many as a million stars, it is too small to have any major effect on the structure of a large spiral galaxy such as ours when a capture takes place. But since this capture occurs practically on our doorstep, we are able to trace the progress of the clusters into the main body of the galaxy, and to read their history in considerable detail. This process is too slow to be followed observationally, but we can accomplish essentially the same thing by identifying clusters in successively later stages of development, and establishing the order in which the various changes take place.

As brought out in Chapter 3, the globular clusters are being drawn in toward the Galaxy from the surrounding space by gravitational forces, and the observed concentration of the clusters thus far located within a sphere that has a radius of about 100,000 light years is merely a geometrical effect. The clusters move “as freely falling bodies attracted by the galactic center,” and they do not participate, to any significant extent, in the rotation of the Galaxy. Thus the observations indicate that the clusters are on the way to capture by the Galaxy.

The increasing strength of the gravitational forces as the clusters approach closer to the Galaxy has a disruptive effect on the positional equilibrium within the clusters. The outer stars tend to be stripped away, and the clusters therefore decrease in size as they approach. Observations reported in Chapter 3 indicate that a cluster loses more than one third of its mass by the time it reaches a position within 10,000 parsecs of the galactic center. In the capture zone, the region in which the structure of the clusters begins to be disrupted, the losses are still greater, and at the time when contact is made with the Galaxy the remaining stars are numbered in the tens of thousands rather than in the original hundreds of thousands. On entry into the rapidly rotating galactic disk still further disintegration occurs, and the globular cluster separates into a number of *open clusters*. These are relatively small groups, most being in the range from around a dozen to a few hundred stars, although a few have as many as a thousand.

The total mass of a small cluster of this kind is not large enough to produce a gravitational attraction that is equal to the outward progression of the natural

reference system, even when augmented by the gravitational effect of the galaxy as a whole. The open clusters are therefore expanding at measurable rates. One of the results of this rapid expansion is that the lifetime of these clusters is relatively short. In order to account for the large number of such clusters now in existence, which runs into the thousands—one estimate (reference 96) is 40,000—when due allowance is made for the fact that only a small fraction of the total can be identified from our position in the galaxy, there must be some process in operation that continually replenishes the supply. The astronomers have been unable to find any such process. Like other members of the human race, they are reluctant to admit that they are baffled, so the general tendency at present is to assume that the open clusters must originate by means of the star formation process that they believe is taking place in dense dust clouds. But this explanation simply cannot stand up. If the cohesive forces in these clouds are strong enough to *form* a cluster, they are certainly strong enough to *maintain* it. The observed expansion thus contradicts the hypothesis of formation near the present cluster sites.

Of course, it is conceivable that *some* clusters formed under certain favorable conditions might at some later date encounter conditions that would cause them to disintegrate, but *all* open clusters are disintegrating, and astronomical theory has to explain this fact. No stable stellar aggregate exists in the range between the globular clusters and the multiple star systems. If the issue is squarely faced, it is clear that conditions in the Galaxy are favorable for dissolution of the clusters, whereas the existing clusters must have been formed under conditions favorable for such formation.

Those astronomers who do face the issue recognize that current theory has no satisfactory answer to the problem, notwithstanding the wide range of possibilities that has been explored. Bok and Bok, who discuss the question at some length, conclude that at least some classes of clusters are *not* being replaced. The most conspicuous clusters, the Pleiades, Hyades, etc., are disintegrating, and these authors say that “there seem to be no others slated to take their place.” Likewise they conclude that the “open clusters with stars of spectral types A and later . . . may be a vanishing species.”⁹⁷

The obvious answer cannot be ignored completely. Bok and Bok concede that “one might be tempted to think about dismembered globular clusters as possible future Pleiades-like clusters,” but since this conflicts with the prevailing ideas as to the direction of stellar evolution, they resist the temptation, and dismiss the idea as impossible. Here, again, the physicists’ assumption as to the nature of the energy generation process must be supported, whatever the cost to astronomy may be. The two considerations that they say “show how impossible this would be” are first, that the spectral changes required in going from globular to Pleiades-like clusters are impossible, and second, that the “rate of evaporation for globular clusters is far too slow.” The first of these objections is simply a reiteration of the upside

down evolutionary sequence that the astronomers have adopted to conform to the physicists' assumptions. As already explained, the evolutionary path for *all* stars is from globular cluster to main sequence, not vice versa. And the globular clusters that fall into the Galaxy do not shrink slowly by evaporation; they are torn apart quickly by the rotating matter of the galactic disk. The piece of information that has been lacking in the astronomers' view of the situation is the existence of an interstellar force equilibrium that gives an aggregate of stars the physical characteristics of a viscous fluid. The entry of the cluster into the galaxy is physically similar to the impact of one fluid aggregate on another. All of the elements of the problem fall into place when it is viewed in the light of the theory of the universe of motion.

The conclusion as to the origin of the open clusters derived from this theory is reinforced by the available data on the properties of these stellar groups. One of these properties is the density of the group. Any gravitationally bound group of stars has a density greater than that of the field of stars in its environment. Inasmuch as the aggregate of stars in the Galaxy has the characteristics of a liquid, a stellar group whose density exceeds the density of the field stars will fall toward the galactic plane. This is a necessary consequence of the gravitational differential, and the descent will take place regardless of the nature of the influences that are responsible for the separation between the field stars, and regardless of whether the clusters fall into the Galaxy, as asserted by the theory of the universe of motion, or originate somewhere within that structure, in accordance with present-day astronomical theory. Even the much looser "associations" participate in this response to the gravitational differential.⁹⁸

Since the clusters are falling objects, those that are higher above the galactic plane are younger, on the average, than those lower down. One of the most conspicuous members of the higher class is M 67, about 440 parsecs above the plane. At the other extreme are objects such as the double cluster in Perseus, which is in the general vicinity of the plane. It follows directly from the relative positions of the two classes that the clusters of the M 67 class are the younger and those of the Perseus class are the older.

This conclusion derived from the relation of position to cluster density is corroborated by direct observation of density changes. Inasmuch as the clusters are expanding, their densities are decreasing with age. While the density of any individual cluster may reflect the particular conditions to which it has been subject, the average density of the clusters of each class should depend mainly on the amount of expansion that has occurred. It therefore follows that the clusters with the higher average density are the younger, and those with the lower average density are the older. Studies show that the clusters of the M 67 class have the higher average density.⁹⁹ Hence these are the young clusters, and the clusters of the Perseus class are relatively old—the same conclusion that we reach from a consideration of the positions above the

galactic plane. Both of these indications of relative age are *observed* properties of the clusters, and are independent of the astronomical theory in whose context they are viewed. In this case, then, we have something that is very rare in astronomy: a direct observational indication of the direction of evolution.

Here we have *positive proof* that the stars of the main sequence are *older* than the stars of the globular cluster type (the kind of which M 67 is composed). This negates the basic premise on which current theory of stellar evolution is founded. That theory asserts that the stars of the upper main sequence are necessarily young because the supply of hydrogen for production of energy will be exhausted in these stars in a relatively short time. The proof that these stars are *not* young now turns the argument upside down. The demonstrated fact that they are relatively old stars shows that hydrogen is *not* the stellar fuel. With the addition of this evidence to the many items previously noted, we now have a positive definition of the direction of evolution of the stars of the globular and open clusters, and by extension, a definition of the direction of stellar evolution in general. In order to see just how this information fits into the theoretical picture, we will now turn to a consideration of the evolution of the stars in the clusters.

Inasmuch as the remains of disintegrated stars and galaxies are scattered throughout all space, and atoms of matter are continually forming in this space from the decay products of the cosmic rays, there is a certain minimum amount of material subject to accretion in any environment in which a star may be located. Immediately after the formation of a globular cluster star by condensation of a portion of a protocluster, this thin diet of primitive material, and the atom building that takes place within it, are all that is available for growth, and the evolution of the stellar structure is correspondingly slow. The stars of the globular clusters are therefore in an early stage of development. Aside from a few strays from older systems that have been incorporated during the formation of the cluster, the distant clusters contain only Class 1 stars: infrared stars, red giants, sub-giants, long-period Class 1A variables, and variables of the RR Lyrae and associated types. To these, the clusters closer to the Galaxy add some Class 1B stars of the lower main sequence.

As noted in Chapter 4, the CM diagram provides a picture of the most significant changes that take place in the constituent stars of the globular clusters. The first stage of their evolution, after they become observable in area O of the diagram, is a contraction under the influence of the combined gravitational forces of each star itself and the cluster as a whole. This ends for each star when it reaches gravitational equilibrium on the line BC, the main sequence. Thus the paths OAB and OAC on the CM diagram of M 3 are the routes followed by the stars of this cluster in the continuation of the process by which they originated. The locations along this path represent what we may call evolutionary ages. A star at point B or point C has traveled the entire

length of its path OAB or OAC.

Although it is common practice to refer to the pre-stellar aggregate as a dust cloud, it is actually a gas cloud with a small dust content. Thus the physical aspect of the evolution of the newly formed stars is defined by the behavior of an isolated gaseous aggregate subjected to a continuing increase in temperature and pressure under the influence of gravitational forces. Since the matter of the star is above the critical temperature by the time that the pressure reaches significant levels, it has been assumed that the star is gaseous throughout its structure. As expressed in one textbook, "Because the sun (a star) is so hot throughout all its volume, all of its matter must be in the gaseous state."¹⁰⁰

This statement is valid on the basis of the conventional definition of the gaseous state, in which this state has no density limit, but the investigation upon which this work is based (see Volume II) has shown that this definition leads to some erroneous conclusions. In particular, it leads to the conclusion that all matter above the critical temperature conforms to the gas laws—the general gas equation $PV = RT$, and its derivative relations. This is not true. In fact, these laws do not apply to matter at all. They apply only to the *empty space* between the atoms or molecules of the gas. At very low densities the volume of a gas aggregate, as measured, consists almost entirely of empty space, and the gas laws are therefore applicable. As soon as the density increases to the point where the volume occupied by the particles of matter begins to constitute an appreciable proportion of the total, a correction for the deviation of the volume from that of the "ideal gas" (the empty space) must be applied. A further increase in density ultimately brings the aggregate to a critical point at which the correction becomes the entire volume; that is, the empty space has been completely eliminated. The aggregate is now a *condensed gas*.

Inasmuch as conventional physics has no theoretically based relations from which to compute the magnitudes of the various properties of gas aggregates at high pressures, and relies on empirical relations, restricted to a relatively low pressure range, for this purpose, the existence of this third condensed state of matter was not detected prior to the development of the theory of the universe of motion. In the light of this theory, however, the existence of this condensed gas state is a necessary consequence of the nature of physical state. In the gaseous state the individual units—atoms or molecules—are separated by more than one unit of space, and are therefore moving freely as independent particles. In the condensed states—solid, liquid, and condensed gas—the separation has been reduced to the equivalent of less than a unit of space (by the introduction of time). Here the individual particles occupy fixed (solid state) or spatially restricted (liquid and condensed gas) positions in which they are subject to a set of relations quite different from the gas laws. For example, as brought out in Volume II, the volume of a solid aggregate is inversely proportional to the square root of the total pressure, including the internal

pressure, rather than inversely proportional to the external pressure as in the gaseous state.

A study of the volumetric relations carried out in the course of the investigation on which this work is based has disclosed that the transition to condensed gas takes place within the temperature and pressure range of much of the experimental work reported in the scientific literature. For instance, application of the theoretical relations to the volumetric data on water at 1000 C indicates that the transition from the gaseous state to the condensed gas state begins at about 600 atm. pressure, and is completed at about 3000 atm. Above this level the condensed gas volume can be computed by means of the relations that apply to the liquid state. The temperatures in the stars are, of course, vastly greater, but so are the pressures, and both the gaseous and condensed gas states exist within the stellar temperature and pressure range, a fact that has an important bearing on the evolutionary pattern of the stars.

One important property shared by all of the condensed states is that an aggregate in any one of these states has a definite *surface*. This is not true of a gas cloud. Such an aggregate simply thins out with the radial distance until it reaches the density of the surrounding medium. This point is generally recognized in the case of star clusters and galaxies, which are structures of the same kind, differing only in that the constituent units are stars rather than particles. The fact that the dimensions of these objects, as observed, depend on the limiting magnitude reached by the observations is well known, but the corresponding phenomenon in the stars, if it is recognized at all, is not emphasized in the astronomical literature. This is no doubt due, at least in part, to the observational difficulties. The dimensions of the stars of the dust cloud classes can only be observed by means of special techniques of limited applicability (such as interference methods) or under special circumstances (such as in eclipsing variables), and the absence of surfaces has not been evident enough to attract attention. The only star that is readily accessible to observation, the sun, belongs to the other class of stars, those that do have definite surfaces.

The condensation of a dust and gas cloud under the influence of gravitational forces is an equilibrium process, not a static equilibrium like that of the stars on the main sequence, where the variables react in such a way as to maintain *constant* relations, but a dynamic equilibrium, in which the interactions between the variables maintain a uniform *pattern of change* in their relations. Consequently, all of the clouds condensing into stars follow the same evolutionary path, differing only in the rate at which they move along that path. At any given stage of the contraction process along the line OA on the CM diagram all stars therefore have the same effective mass and volume (aside from the variations that are responsible for the width of the line), irrespective of the size of the dust clouds from which they are drawing their material.

In this first part of the evolutionary path the continuing condensation of the

stellar aggregate is made possible only by the assistance of the gravitational effect of the cluster as a whole, as this early type of star is not a self-gravitating object. As indicated in the earlier discussion, however, the gravitational forces of the star are strengthened as it becomes denser, and at a certain point, designated A on the CM diagram, Fig. 3, the star reaches the *critical density* where it becomes self-gravitating; that is, it is capable of further contraction toward gravitational stability without outside assistance. Beyond the point at which the critical density is reached, the two processes, the original growth process and the self-gravitation, are in competition. The outcome depends on the relative rapidity of the processes.

If the growth of the star has taken place all the way from particle size, without the benefit of any gravitationally stable core, the contents of the parent dust cloud are practically exhausted by the time that the star reaches the critical density at point A. In this event the self-gravitation initiated at A proceeds at a more rapid rate than the growth by accretion. The star then pulls away from its surroundings and moves directly down the diagram along the line AB, the line of constant mass.

If the star did have a pre-existing fragment as a nucleus, growth along the line OAC is able to continue. As noted in Chapter 4, the availability of even a very small fragment as a nucleus for condensation gives a star a big advantage over the majority, which have to start from particles. Because of the much larger amount of dust and gas over which they are able to establish gravitational control, these stars that had the head start are usually able to follow the line AC all the way to point C, or at least to the vicinity of that point. In some cases there is a tendency for the observed paths to bend downward shortly before reaching C, indicating that the material for growth has been exhausted. In other cases the trend in the vicinity of point C is upward. This is no doubt due to accelerated accretion from favorable environments.

Inasmuch as the nature of the process by which the primitive cloud of matter was formed, as described in Chapter 1, produces essentially the same initial conditions in each cluster, the equilibrium conditions are practically the same for all clusters. It follows that the critical points A and C on the line OAC are the same for all of these clusters. This conclusion refers, of course, to the true values, the absolute magnitudes. But the astronomers' evaluation of absolute magnitudes is subject to a considerable degree of uncertainty. For present purposes, therefore, it appears to be advisable to deal with the observed magnitudes, using the observed magnitude at some identifiable location in each diagram as a reference point. The resulting diagram is identical with that which would result from the use of the correct absolute magnitudes, except that the magnitude scale is shifted by an amount that reflects the effect of distance and obscuration.

There are some other factors—chemical composition, for instance—in addition to the evolutionary development, that affect the variables represented

on the CM diagram, and these factors, together with the observational uncertainties, result in rather wide evolutionary paths, but aside from these effects, the foregoing theoretical conclusions indicate that the upper sections of all CM diagrams of globular clusters should be identical, to the extent that the evolution of each cluster has progressed.

Fig. 9 shows that this theoretical pattern is followed by six of the most prominent globular clusters. The outlined areas in each cluster diagram show the observed star locations. The boundaries of these areas have been located by inspection of diagrams published in the astronomical literature. Greater accuracy is possible, but this would call for an expenditure of time and effort that did not appear to be justified for the purposes of this somewhat preliminary survey of the situation.

The theoretical evolutionary lines, the diagonal lines in the diagrams, are the same for all clusters, except that in each case the magnitude scale is determined by the reference point. Whatever differences in the lengths and slopes of these lines may exist between the individual diagrams are due to differences in the scales of the original diagrams from which the data were taken. The upper of the three points identified on each line is the reference point. The point corresponding to a B-V color index of 1.4 has been selected as the reference point in most of the CM diagrams in this volume, because it is usually quite clearly defined by the observations, but where the 1.4 location is uncertain some better defined location has been substituted. What the diagrams show is that if the location of the reference point is taken to represent the absolute value of the luminosity, then the points A and B on the line OAC, as previously defined, have the correct theoretical relation to the reference value, within the accuracy of the representation. Some of the evolutionary paths tend to diverge from the theoretical line as they approach the main sequence at point C, but the deviation is within the range of the processes previously mentioned as being applicable in this region.

These considerations that apply to the upper section of the diagram, the line OAC, are likewise applicable to the lower sections, the line AB and the relevant portion of the main sequence, which have been identified observationally for only a limited number of clusters. It then follows that when the location of *any one point* is specified in the manner that has just been described, the M 3 pattern can be applied to a determination of the entire theoretical pattern of any globular cluster. The complete CM diagrams thus obtained for two of the clusters of Fig. 9 are shown in Fig. 10. These clusters clearly conform to the theoretical pattern.

It is true that there is considerable variability in the line AB, but this is easily understood as a result of the expansion and contraction of the cluster during the travel toward the Galaxy. As explained in Chapter 3, the cluster is subject to substantial losses of stars during its approach, because of differential gravitational effects. These losses alter the equilibrium in the cluster, and tend

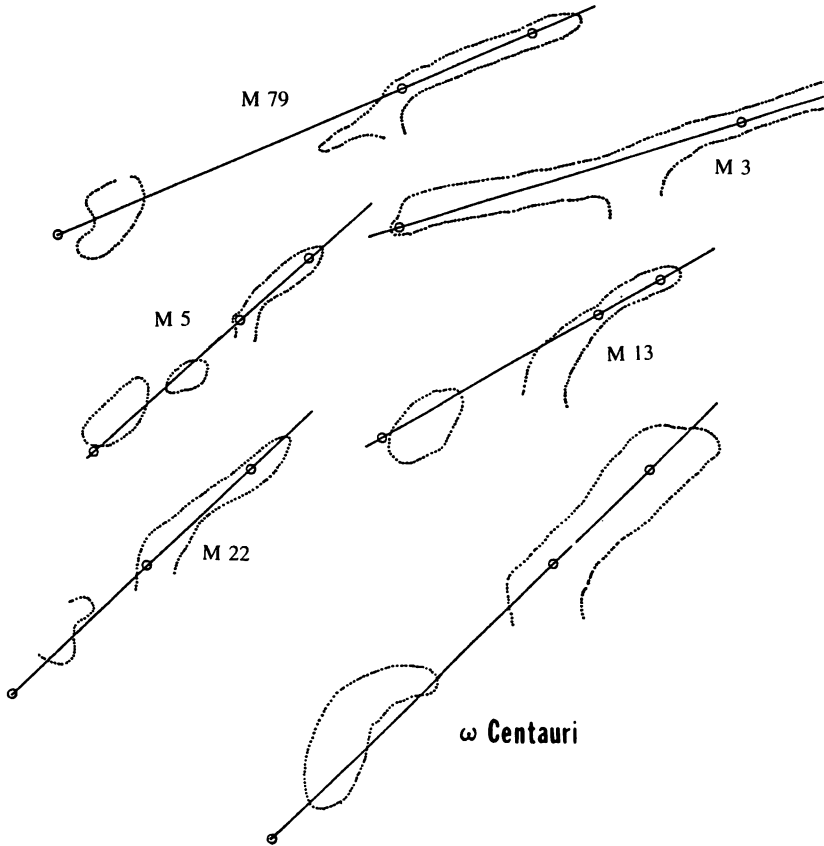


Fig. 9
Upper Sections - Globular Clusters

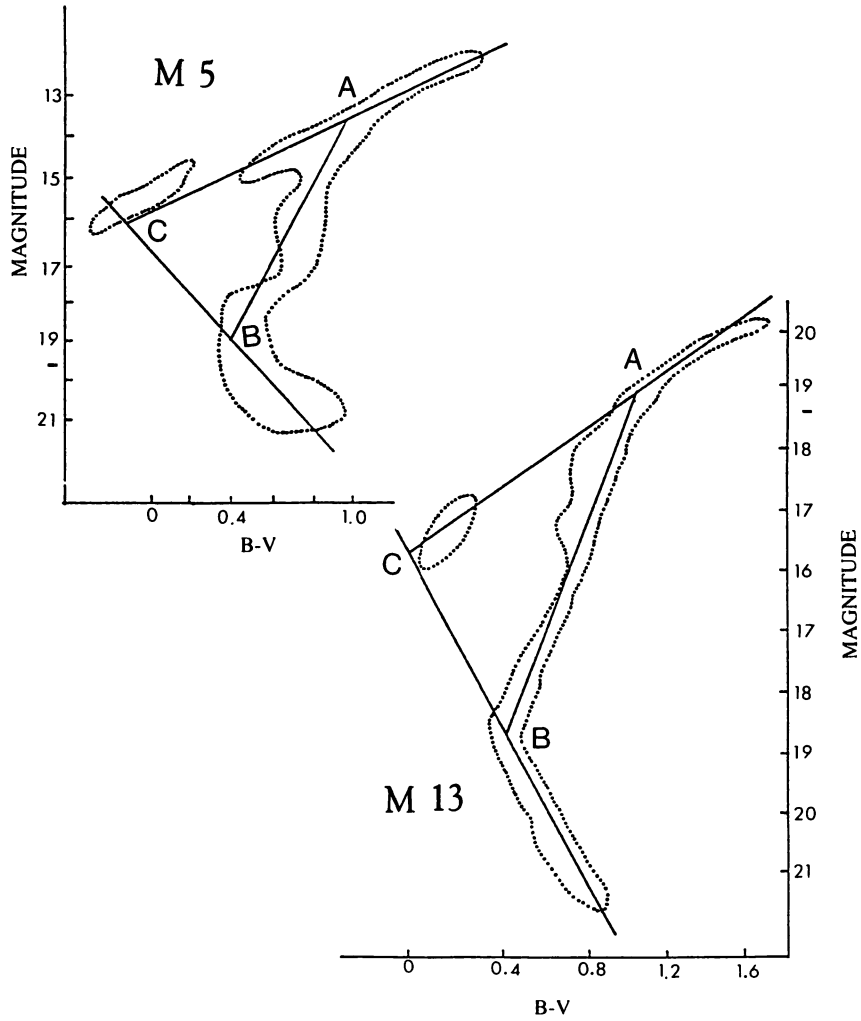


Fig. 10

Complete CM Diagrams

to cause density fluctuations. The variations in the cluster density have a corresponding effect on the pressure that is exerted on the individual stars by the gravitational force of the cluster as a whole, thus transmitting the density fluctuations to the stars. If the cluster and its constituent stars are expanding as the stars approach point A, the contraction along the line AB is delayed to some extent, and the evolutionary path is displaced to the left of the line. Then, when the expansion phase of the density cycle is succeeded by a contraction, the path is displaced to the right at some location farther down the line. There may even be another swing to the left before the main sequence is reached. As can be seen in the diagrams, this cyclic effect is at a minimum in M 13, but it shows up clearly in such clusters as M 3 and M 5.

The red giant section OA of the CM diagram of a globular cluster is usually well defined, even where the limiting magnitude to which the observations have been carried cuts off most of the lower portions of the diagram. Since only one observed point is required in order to establish the complete Class I diagram, and any point in this well defined giant section will serve the purpose, it is not difficult to define the theoretical CM diagram for an ordinary globular cluster. Furthermore, if the observations extend to the main sequence, the accuracy of the diagram thus defined can be verified by the observed positions of the main sequence stars. Thus, as indicated by the diagrams already introduced, there is little question as to the position of the evolutionary paths. Uncertainties arise only in the case of the very distant clusters that are observed with such difficulty that only the most luminous stars can be identified. Even at these distances the diagrams are often well defined. For instance, Fig. 11 shows the relation between the theoretical OAC line and the observed locations of the stars of two of the most distant clusters for which data are available. These clusters, NGC 6356 and Abell 4 have uncorrected magnitudes at a B-V color index of 1.4 of 16.2 and 18.2 respectively. These compare with 12.1 for M 13 and 10.4 for NGC 6397, the cluster closest to the sun. The luminosity of the most distant of these four clusters is less than that of the closest by a factor of more than a thousand.

A point that should be noted in connection with the evolutionary pattern of the globular clusters is that the difference in luminosity (on the logarithmic scale) between point B and point A, 5.6 magnitudes, is twice the difference between point B, and point C, which is 2.8 magnitudes. The significance of this relation will be discussed in Chapter 11.

Identification of the globular cluster pattern as a fixed relationship provides a simple and potentially accurate method of determining the distances to the clusters. Inasmuch as the theoretical findings indicate that the pattern is identical for all the clusters, it follows that the absolute magnitude corresponding to any specific color index is the same for all. Like the evolutionary pattern itself, we will have to determine this absolute magnitude empirically for the present but once we have it for one cluster, we can apply it

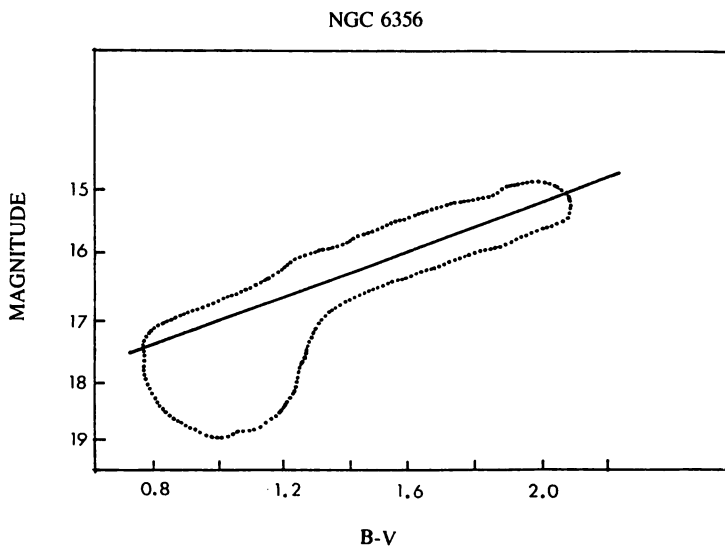
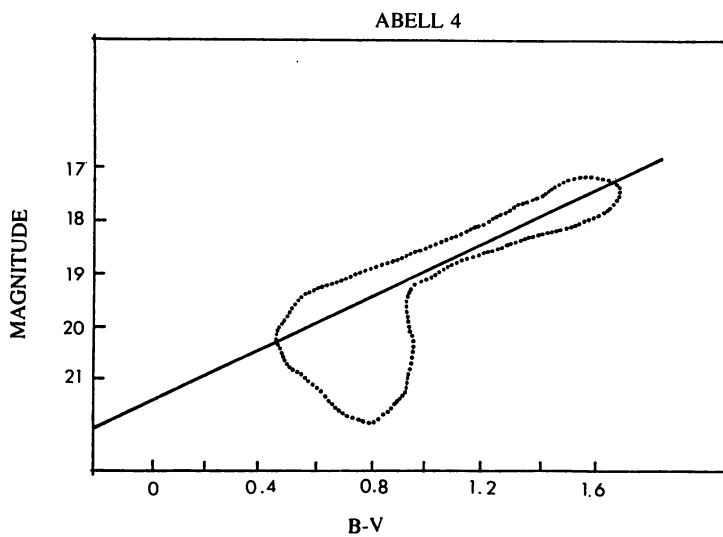


Fig. 11

Distant Clusters

to all clusters. A value of 4.6 at a B-V color index of 0.4 on the main sequence has been selected on the basis of two criteria. First, this agrees with the currently accepted values applicable to the nearest clusters, which are presumably the most favorably situated for accurate observation, and second, this value arrives at practically the same average as the observational values given by W. E. Harris for a long list of clusters.¹⁰¹ These previously reported values from observation should average close to the correct magnitude if there are no systematic errors, even though the error range of the individual values is conceded to be quite wide. The distance moduli (the differences between the absolute and apparent magnitudes) calculated on the 4.6 basis are compared with those given in the tabulation by Harris in Table II. A few distant clusters not listed by Harris are also included. For the benefit of those readers who are not much at home with the astronomers' magnitude system, the distances are expressed in terms of light years in the last column of the table.

The potential accuracy of the method is not fully attained in the present work because of the previously mentioned approximate nature of the process employed in identifying the reference point for each cluster. But even so, more than half of the values calculated on this basis in the course of the present study agree with the values given by Harris within his estimate of the probable error range. Most of the observers' original reports do not specify whether the values shown in their diagrams have been corrected for the reddening due to dust along the line of travel of the radiation. The theoretical distances in the table have been calculated on the assumption that no such correction has been applied to the plotted values. If this is incorrect in any specific case, the calculated distance will be modified accordingly.

The main sequence, as defined by the astronomers,¹⁰² has an absolute magnitude of about 3.8 at a B-V color index of 0.4. This puts it 0.8 magnitudes above the position obtained for the globular clusters from the study of the CM diagrams. The significance of this difference will be discussed later.

The evolutionary age of each cluster is indicated by its position on the CM diagram. The overall range from the earliest to the latest type of star in the cluster remains about the same, but the positions of both the front end of the age sequence, the location of the most advanced stars, and the rear end, the location of the least advanced, move forward. Bart J. Bok comments that the branch of the diagram of the cluster Omega Centauri that is occupied by the red giants "is unusually long," and also that the data "do not reveal the full extent of the main sequence."⁸³ He attributes the length of the giant branch to a high degree of variability in the metal content. Our analysis shows, however, that both of the features of the diagram that Bok mentions are aspects of the same thing. They indicate that Omega Centauri is not as far advanced from the evolutionary standpoint as a cluster such as M 13, for example. There are stars in Omega Centauri that are earlier (that is, farther to the right in the CM

TABLE II
DISTANCES — GLOBULAR CLUSTERS

Cluster	Reddening	Distance Modulus		Distance (lt. years)
		Harris	This Work	
Abell 4			20.2	357,000
Palomar 14			20.0	326,000
NGC 6256			19.2	225,000
Kron 3			18.8	188,000
NGC 6356	0.21	17.07	18.0	130,000
M 14	0.58	16.9	17.7	113,000
Palomar 5			17.2	90,000
NGC 6235	0.38	16.6	16.4	62,000
NGC 6144	0.36	15.6	15.8	47,000
NGC 1851	0.07	15.4	15.8	47,000
NGC 6535	0.36	16.1	15.6	43,000
M 79	0.00	15.65	15.3	37,500
NGC 5053	0.03	16.00	15.3	37,500
M 80	0.21	15.28	15.2	36,000
NGC 288	0.00	14.70	14.9	31,000
M 68	0.03	15.01	14.7	28,000
M 15	0.07	15.26	14.6	27,000
M 3	0.00	15.00	14.6	27,000
M 30	0.01	14.60	14.5	26,000
M 5	0.07	14.51	14.4	25,000
M 12	0.19	14.30	14.3	23,500
Omega Centauri	0.11	13.92	14.3	23,500
47 Tuc.	0.04	13.46	14.2	22,500
M 71	0.28	13.90	14.1	21,500
NGC 3201	0.28	14.15	14.1	21,500
M 13	0.02	14.35	14.1	21,500
M 22	0.35	13.55	13.9	19,700
M 92	0.01	14.50	13.9	19,700
M 55	0.07	14.00	13.7	19,000
M 4	0.31	12.90	13.2	14,300
NGC 6752	0.01	13.20	13.1	13,700
NGC 6397	0.13	12.30	12.3	9,400

diagram) than the earliest stars in M 13, while not enough stars have reached the main sequence to give this cluster a main sequence population comparable to that of M 13.

The evolutionary age of the *matter* of which the stars of a cluster are composed is, of course, related to the age of the cluster, but these ages are not coincident. The chronological age of the matter includes not only the time spent in the star cluster stage, but also the time spent in the diffuse stage that precedes condensation into a star. This is subject to considerable variation. Furthermore, there are circumstances under which the evolution of the matter proceeds much faster than the evolution of the cluster. Thus, although the older clusters are, in general, composed of older matter, there is no direct relation. Some examples of accelerated evolution of matter in clusters will be examined in Chapter 9.

The question as to the ages of the globular clusters has received a great deal of attention from the astronomers because they are presumed to have been formed within a relatively short time after the Big Bang in which most astronomers now believe the universe originated. On this basis, as Bok points out in a recent discussion of the subject, the clusters “seem to be the oldest objects in the Milky Way.”⁸³ But it is agreed that the concentration of “metals” (heavy elements) in an astronomical object is an indicator of its age, and as Bok acknowledges, there are differences in the metal content of the clusters that “imperil” the current theory of their formation. Some, particularly those most distant from the galactic center, are relatively metal-poor, while others have substantially greater metal content. Harris and Racine give us this assessment of the situation: “It is plain that the maximum [Fe/H] decreases roughly linearly with log R [distance from the galactic center], even out to about 100 kpc.”¹⁰³

Many astronomers are beginning to recognize that this radial dependence of the cluster ages, as indicated by the metal abundances, is inconsistent with present-day astronomical theory. Bok, for example, recognizes that something is wrong here. He states the case in this manner: “The spread of ages for the globular clusters conflicts with current models of how the galaxy evolved.”⁸³

Our finding is that *almost all* of the conclusions in this area that have been reached on the basis of current astronomical theory are wrong, either in whole or in part. On first consideration it may seem unlikely that errors would be made on such a wholesale scale, but actually this is an inevitable result of the manner in which astronomical conclusions have to be reached under present conditions, where there is no general theoretical structure connecting the various astronomical areas. In the absence of the restraints that would be imposed by such a general structure, wrong theories and wrong interpretations of observations are able to reinforce each other and resist correction. In the case now under consideration, a wrong theory of stellar energy generation, a wrong theory of the origin of the universe, and a wrong theory of stellar evolution provide mutual support for each other, and for the wrong interpretation of the place of the globular clusters in the astronomical picture.

Correction of these errors one by one is not feasible, because a change in only one of the erroneous hypotheses introduces obvious contradictions with those that are retained. All of the major errors that are relevant to the point at issue have to be corrected simultaneously in order to arrive at a consistent system of thought. This is the objective of the present work.

CHAPTER 9

Gas and Dust Clouds

As explained in Chapter 1, the original aggregates into which the primitive dispersed matter separates are the predecessors of the globular clusters. At first they are merely masses of the primitive matter in gravitational equilibrium, but they are caused to contract for reasons previously stated, and they eventually arrive at a density sufficient to justify calling them clouds of dust and gas. If these clouds remain undisturbed for a sufficient length of time, they ultimately condense into globular clusters of stars, as indicated in the earlier chapters.

Although the protoclusters are probably somewhere near the same size, they are subject to different conditions because of such factors as the amount of fragmentary old material present, and the position of the protocluster in what we have called the group. Consequently, the rate at which condensation into stars takes place is subject to considerable variation. In the preceding pages we have been tracing the development of the faster aggregates, but we have now reached the point where the slower group enters into the evolutionary process in a significant way. We will therefore want to take a look at what has happened to the slower aggregates while all of this development of the faster ones has been going on.

The slower aggregates are subject to the same external gravitational forces as the faster group. Thus they undergo the same kind of combination and capture processes as their more advanced counterparts. It is possible that some of them may remain isolated long enough to complete the process of consolidation into clusters of stars. In that event they follow the course that we have been describing. But because of the difference in the amount of time required for completion of the condensation process, many of the slower aggregates are captured while they are still in the gas and dust cloud stage. As a result, they enter into the galactic structure as clouds of particles rather than as stars.

We have already noted (Chapter 3) the existence of evidence indicating that some globular clusters are being captured by the Galaxy in a pre-stellar stage. One report reads as follows:

The most striking result of surveys of the distribution and motions of neutral hydrogen away from the galactic plane is the discovery of several

high velocity hydrogen clouds or concentrations, nearly all having negative (approaching) radial velocities of up to about 200 km s^{-1} .¹⁰⁴

Here we see that the unconsolidated clusters, like the globular star clusters, are moving “as freely falling objects attracted by the galactic center,”²⁸ in accordance with the conclusions that we derive from the theory of a universe of motion. The observed approach of these aggregates implies that there have been captures of similar aggregates in the past, and that the remains of these immature globular clusters are present in the Galaxy. Unlike the star clusters, which are broken into relatively small units as soon as they fall into the rotating disk, the particles of which the clouds are composed are able to penetrate into the interstellar spaces, and they envelop the stars that they encounter, rather than colliding with their radial force fields. A cloud of this kind therefore tends to maintain its identity for a substantial period of time, although its shape may be greatly modified by the objects that it encounters.

Until quite recently no evidence of gas and dust aggregates of globular cluster size had been found within the Galaxy. Smaller aggregates—*nebulae*, as they are called—have been recognized ever since the early days of astronomy; some bright, others dark. Only within the last few years has it begun to be recognized that many, perhaps most, of these identified nebulae are portions of much larger aggregates. For instance, Bok and Bok report that the Orion nebula, the most conspicuous of these objects, is actually a part of a larger cloud with a total mass of 50,000 to 100,000 solar units (comparable to the size of the globular clusters that are being captured). They characterize the Orion nebula as “just a little sore spot of ionized hydrogen in the larger complex.”¹⁰⁵

Still more recently it has been found that there are many larger clouds of gas in the Galaxy that have masses comparable to those of the large globular clusters, in the range from 100,000 to 200,000 solar masses. According to a report by Leo Blitz, these giant clouds are about 20 times as numerous in the Galaxy as the globular clusters. Both of these characteristics (size and abundance) are in agreement with what would be expected on the basis of the theoretical origin of the clouds as captured immature globular clusters. The gas cloud is less subject to loss of mass in approaching the Galaxy than the star clusters because of the vastly greater number of units involved (particles in one case, stars in the other), while, as already noted, it is not subject to being broken up by contact with the moving stars of the Galaxy in the manner of the globular star clusters.

The report by Blitz contributes some further information that verifies the identification of these giant gas clouds with the immature globular clusters. “The density of the gas in each cloud,” he says, “is 100 times greater than the average density of the interstellar medium.”¹⁰⁶ It is difficult, probably impossible, to explain the formation of a distinct aggregate of this size within a

rotating galaxy, and since the observed density establishes the cloud as a definite unit, distinct from the interstellar medium, the observations lend strong support to the theoretical conclusion that the clouds were formed outside the Galaxy and captured later. Furthermore, Blitz also reports that “the gas in each cloud is organized into clumps whose density is 10 times greater than the average density in the cloud.” He adds that some clumps with much greater density have been observed. The nature of these “clumps” is practically obvious, in the light of our findings. Here, of course, are the immature stars of the immature globular cluster. The clumps that are larger than the average are the aggregates that would have followed the upper branch OAC of the Class I evolutionary path if capture by the Galaxy had not intervened to prevent the consolidation that would have given these clumps the status of stars.

The simple history of these gas and dust clouds, as derived from theory — formation by the globular cluster process, capture by the Galaxy, mixing with the galactic stars, eventually expanding into and merging with the interstellar medium—is in direct conflict with the upside down evolutionary view derived from the physicists’ assumption as to the nature of the stellar energy generation process. Since the astronomers have accepted that erroneous view of the direction of evolution, they are forced to invent processes whereby the normal course of events is reversed. Instead of originating as massive aggregates and being gradually disintegrated by the rotational forces of the Galaxy, forces that are known to exist and to operate in that direction, the astronomers find it necessary to assume the existence of some unknown counterforce that causes the clouds to form and grow to their present size against the normal direction of change. “Some mechanism must be continually forming them in the galaxy,” says Blitz. But he admits that the mechanisms thus far suggested—“density waves,” magnetic effects, etc.—are not convincing. “The solution to the problem of how the complexes form does not seem to be close at hand,” he concludes. This is another understatement of the kind that is so common in the astronomers’ comments on their problems. The solution not only is not “close at hand”; it is not perceptible even in the far distance. The problem is still further complicated for the astronomers because their theory requires the clouds to form, and then disperse again, while they remain in the same environment and subject to the same forces.

The specific words used in the quotation in the preceding paragraph are worth a few comments, as they are repeated over and over again in current astronomical literature, and they epitomize the attitude that has made it possible for such a large theoretical structure of an imaginary nature to develop in the astronomical field. *Some mechanism must exist*, the author says, to take care of the problems that are encountered in trying to reconcile the observations with the deductions from the basic premises of the current theory. We have met this contention many times in the earlier pages, and we will

encounter it again and again in the pages that follow. The observed facts stubbornly refuse to cooperate with the theorists, but the basic assumptions from which the theoretical conclusions are derived, particularly the assumption as to the nature of the stellar energy generation process, are sacrosanct. They cannot be questioned. There *must be* something, somewhere—“some mechanism”—that brings the recalcitrant facts into line, current astronomical thought insists.

One of the reasons why the astronomers are having so much difficulty in dealing with the dust and gas clouds in the Galaxy is that they have never arrived at an understanding of their structure, just what it is that maintains them in their existing condition. As explained by Blitz in his article:

Under normal circumstances the pressure inside a cloud roughly balances the cloud's self-gravitation, which would tend to collapse the cloud if its action were unopposed. What generates the pressure is a major unanswered question.

The truth is that this is the *same* “major unanswered question” that the astronomers face with respect to the structure of the globular clusters. They have managed to avoid conceding their inability to explain the cluster situation, but they have no option in the case of the clouds, as the opportunities for ad hoc assumptions that would enable them to evade the issues are too limited. There is clearly no rotation, and the particle velocities are revealed by the temperature, which is observable. As conceded in the foregoing quotation, it is clear that there is something missing in the current understanding of the physics of the clouds.

The theory of the universe of motion identifies this missing ingredient as the outward progression of the natural reference system relative to the conventional stationary system of reference. Once again we meet the antagonist to gravitation. Both the particles in the cloud and the stars in the cluster are subject to the outward progression as well as to the inward gravitational motion. Main sequence stars are gravitationally stable; that is, the inward gravitational force acting on their outermost atoms exceeds the outward force due to the progression of the reference system. In aggregates of stars or dispersed particles, on the other hand, the net force acting on their outer units is outward unless the mass of the aggregate exceeds a certain limit. For aggregates of the type that we are now considering, this limit is in the neighborhood of the mass of a large globular cluster. Any mass smaller than this limit is subject to expansion and loss of its outer units.

The rate of loss depends on the size of the units, the mass of the aggregate, relative to the limiting value, the speed of movement of the constituent units (the temperature, in the case of the clouds), and the external forces exerted on the aggregate, if any. For the gas and dust clouds that exist in the Galaxy, all

of these factors are favorable to a slow rate of loss. The units are very small, the clouds themselves are large, the temperature is very low, and the net external forces exerted on the clouds are small. It appears probable, therefore, that the existence of a cloud as a distinct unit eventually terminates as a result of processes other than escape of its outer particles, principally the mixing action that takes place by reason of the motion of the associated stars. The effects of this process are clearly visible. The aggregates, originally spherical, are now observed to be irregular in shape and often elongated.

Accretion of matter from a cloud by the stars enveloped within it during the mixing process reduces the mass of the diffuse aggregate substantially while the gradual destruction of the cloud is taking place. This accretion explains the presence of "new" stars in the clouds, especially the hot stars of the O and B classes, whose existence in these locations is currently ascribed to condensation directly from the dust and gas.

The association of O and B type stars with gas and dust clouds is well established. Since the astronomers regard these stars as very young, astronomically speaking, they have concluded that the stars must have been formed *from* the clouds, somewhere near their present locations. Our finding that they are relatively old changes this picture drastically. There is now no reason why we must assume, in the face of all of the evidence to the contrary, that the dust and gas clouds in the spiral arms condense into stars. The simple and logical explanation of the presence of these stars in the clouds is that they are stars of the galactic population that have been mixed into the incoming dust and gas, and have grown to their present size by accretion from the clouds. This explanation fits all of the observational evidence, and it accounts for the existence of stars of these types by the operation of simple processes that are *known* to be capable of producing the observed results, and are *known* to be operative under the conditions existing in the clouds.

The extent to which accretion of material by the stars takes place has long been subject to differences of opinion. Some astronomers regard it as minimal. S. P. Wyatt, for instance, says that "There is virtually no replenishment from the outside."¹⁰⁷ The most that he is willing to concede is the capture of an "occasional meteoroid." In fact, however, even a planet does better than that, in spite of strong competition from the sun. It is reported that "there is an extremely large flux of meteoroids near the planet Jupiter."¹⁰⁸ The truth is that the astronomers' conclusions as to the amount of accretion by stars have been little more than guesswork. The existence of *some* accretion is well established, notwithstanding assertions such as that by Wyatt. The only open question concerns the quantities. In this connection it is significant that within very recent years the general astronomical opinion has moved a long way in the direction of recognizing the importance of dust and gas in the universe, from a concept of interstellar and intergalactic space as essentially empty to a realization that the total amount of matter in these regions is very large, and

may even exceed the amount that has been gathered into stars.

Calculations on which adverse conclusions regarding accretion are based generally assume that the stars are moving through the gas and dust clouds, and that this motion prevents any substantial amount of accretion. Our theoretical study indicates, however, that these clouds are participating in the rotation of the Galaxy in the same manner as the stars, and that the stars are therefore nearly stationary with respect to the clouds, a situation that is much more favorable to accretion. Bok and Bok specifically say that “the interstellar gas partakes in the general rotation of the galaxy.”¹⁰⁹

From the theoretical standpoint, there is nothing uncertain about the accretion situation. In the cyclic universe of motion everything that enters the material sector must be counterbalanced by the ejection of its equivalent. As we will see in the final chapters of this volume, only the explosion products of stars and stellar aggregates can acquire the speed that is needed in order to cross the regional boundary. It follows that all of the gas and dust formed from the primitive matter that enters this sector must either be condensed into stars or accreted by stars. We have already seen that the condensation into stars is not complete. As we trace the pattern of stellar behavior, it will also become evident that a great deal of material escapes from the stars before the final explosive events in which they are ejected from the material sector, and another substantial amount is scattered into space in connection with those explosions. Some of this dispersed matter is incorporated into the globular cluster stars as they are formed, but the rest has to be picked up by existing stars sooner or later. The average star must therefore increase in mass quite considerably during its lifetime.

It is true that matter is being converted into energy in the stars, and is being lost from them by radiation, but in a cyclic universe all processes are in equilibrium. The mass loss by conversion to radiant energy is necessarily counterbalanced by an equivalent conversion of radiation to matter in processes of the inverse nature. Thus the existence of the radiation process does not alter the fact that all of the mass entering the material sector in dispersed form must be aggregated into stars in order to be ejected back into the cosmic sector to keep the cycle in equilibrium.

The foregoing theoretical conclusions can be summarized by stating that they indicate that the dust and gas in interstellar and intergalactic space exists in much greater quantities, and plays a much greater part in the evolutionary development of stars and galaxies, than the astronomers have been willing to concede, on the basis of their observations. Since there is no source of empirical information other than these observations, we have heretofore had to rely on the cogency of the reasoning by which our conclusions were reached, together with the absence of any actual evidence that would contradict those conclusions. Now, however, the situation has been revolutionized by the results of observations with the Infrared Astronomical Satellite (IRAS).

The first observations with this satellite show that dust (and presumably gas) does, indeed, exist in interstellar space on the massive scale required by the theory of the universe of motion. As reported in an article in a current periodical (March 1984), "Dust is what IRAS found everywhere."³⁴⁹ The discovery, also reported in this article, of substantial quantities of dust surrounding Vega and Fomalhaut, together with indications that similar concentrations may exist around 50 other stars, is particularly relevant to the accretion situation. After a quarter of a century, the astronomers are finally arriving at the same kind of a view of the stellar environment as that which was derived from theory, and described in the first edition of this work, published in 1959.

The accretion process is theoretically applicable to stars of all kinds, but if the cloud in which the accretion takes place is located well above the galactic plane, as is true of the Orion nebula and some of the others that are frequently characterized as "birthplaces" of stars, it is probable that most of the stars intermixed with the nebulae are of the globular cluster type. In this event, the effect of the accelerated accretion is to move the stars to the left from their positions on the two branches of the evolutionary path, and to distribute them along nearly horizontal lines intersecting the main sequence at relatively high temperatures. This is where the Orion stars are actually found.¹¹⁰

Occasionally some astronomer does concede that the O and B stars in the nebulae may be accretion products. For instance, George Gamow, like most of his colleagues, minimized the importance of the accretion process, but nevertheless admitted that "it is not impossible that the . . . Blue Giants found in spiral arms are actually old stars formed during the original process which were rejuvenated by accretion."¹¹¹

But the orthodox astronomical view at present is that the stars of the O and T associations are new stars condensed out of the dust and gas clouds by some thus far unidentified process. Wyatt, for example, refers to "the unquestionable evidence that stars form out of interstellar matter."¹¹² Here, then, the same textbook author who tells us that the strong gravitational forces of a stable galactic star are capable of "virtually no" accretion of matter is, at the same time, contending that the galactic dust clouds, which are known to exert no net gravitational force on their constituents, are in some unknown way able to pull those constituents together to form a star. These two propositions are obviously incompatible, and their coexistence illustrates the disconnected and compartmental nature of present-day astronomical theory. The absence of any general structure of theory encourages reliance on negative rather than positive evidence. Since the theorist has no explanation whose validity he can prove, what he attempts to do is to devise an explanation that cannot be disproved. In this connection it is interesting to follow the chain of reasoning by which one prominent astronomer arrives at the currently orthodox conclusion with respect to condensation of stars from dust and gas clouds. The

following are the essential statements from the five paragraphs in which he outlines the development of thought:

There are virtually no clouds observed in which gravity is strong enough to overwhelm the temperature effects based on the measurements that can be made at present . . .

There may be a way out of this dilemma . . .

We really do not yet know how much molecular hydrogen lies in typical atomic hydrogen clouds. Such a situation is tailor-made for any theoretician to work with because there are no data that could contradict any assumption made about the amount of additional matter in the clouds . . .

We assume it [the cloud] must have enough matter to cause it to contract.¹¹³ (Gerrit Verschuur)

This explanation of the background of one of the current theories of star formation in the galactic gas and dust clouds should make it evident why the astronomers are having so much difficulty in getting down to details. Verschuur is simply *assuming* the problem out of existence. Other theorists rely on some different assumptions—a hypothetical process to supplement the effect of gravitation, for example—but they all operate on the same principle; that is, they construct their hypotheses in such a way that “there are no data that could contradict” the assumptions. As might be expected, all details are vague. Verschuur admits that “We are far from understanding all the details of how clouds actually become stars.”¹¹⁴ Perhaps the best assessment of the situation is that it illustrates the validity of this comment from the British scientific journal *Nature* (1974):

Indeed, a great many theoretical astronomers delight in a situation where there is just enough evidence to make model building worthwhile, but not enough to prove that their favored model is incorrect.¹¹⁵

The effect of the availability of dust and gas on the rate of evolution is illustrated by the globular clusters that are located in the Large Magellanic Cloud (LMC). Here the gravitational distortion of the structure of the Cloud has resulted in an irregular distribution of the dust and gas, and some globular clusters have entered regions of relatively high density. The rotational forces that would normally break up the clusters as they approach the central plane of the galaxy (the LMC) have also been greatly reduced by the gravitational distortion. As a result, some of the globular clusters remain intact in dusty regions for a long enough period to permit their constituent stars to reach an evolutionary stage comparable to that of the stars of the open clusters. While the shape and size of these clusters are those of normal globular clusters, their

stars are members of Class 1B, like those of the open clusters.

We can correlate the evolutionary stages of the stars in the two Magellanic Clouds with the galactic ages, although the more heterogeneous populations of these larger aggregates make this correlation less specific than the corresponding results of the globular cluster study. The most significant observation, in this connection, is that the LMC has many red supergiant stars associated with hot blue stars in hydrogen clouds. As brought out in Chapter 5, these two very different types of stars are closely related from the evolutionary standpoint. The hot blue star (Class 1B) is near the supernova stage. The red giant of the second cycle (Class 2C) is the first visually observable post-supernova star. The presence of these red giants thus identifies the LMC as an aggregate in which the most advanced stars have reached the second evolutionary cycle.

No stars of this class are found in the Small Magellanic Cloud (SMC).¹¹⁶ Nor have any supernova remnants been located there.¹¹⁷ Their absence indicates that the most advanced stars of this galaxy are still in the first cycle. The concentration of Cepheid variables per unit of volume is much higher in the SMC.¹¹⁸ This is consistent with the evidence from the giants, as the first Cepheids are Class 1A stars, and the evolution around the cycle reduces the number of stars of the earlier classes. The conclusion to be drawn from these observations is that the main body of the SMC is composed of stars of Classes 1A and 1B, whereas the average star in the LMC is in a more advanced evolutionary stage. The number of 1A stars has decreased and some of the 1B stars have passed into the 2C stage.

The stellar compositions of the two galaxies thus support the conclusion, based on their relative sizes, that the LMC is older than the SMC. They also provide the answer to a question asked in the book from which the data cited above were taken: "Why has the Large Cloud so many more very young stars than the Small Cloud?"¹¹⁹ The answer is that the "very young" stars to which the questioner refers are actually relatively old second generation stars, and the LMC has more of these stars than the SMC because it is an older galaxy.

While the gas and dust clouds in the Galaxy are undergoing the changes that have been described, their constituents are also aggregating into larger units; that is, atoms are combining to form molecules and dust particles. It has been known for many years that a number of the elements above helium are present in these clouds, but recently it has been discovered that these elements are, to some extent, organized into molecules. Over fifty different molecules, some of considerable complexity, have been identified so far.

In view of the extremely low density and low temperature of the clouds, which limit the frequency of contact of the constituents, the observed amount of molecule formation was not anticipated. The results of this present investigation indicate, however, that the conditions in the clouds are much

investigation indicate, however, that the conditions in the clouds are much more favorable for combination, up to a certain limit, than previously believed. The reason was explained in Chapter 1. Inside unit distance, 4.56×10^{-6} cm, the net motion, other than thermal, is inward until an equilibrium point is reached. At the very low temperatures of the clouds, estimated at about 10 K (reference 106), capture on contact, or even on a near miss, therefore has a high probability. As brought out in Volume II, physical state is inherently a property of the individual molecule. At 10 K even the hydrogen molecule is in the solid state. The contact process is thus capable not only of producing a variety of molecules, but also of building up solid aggregates to sizes in the neighborhood of unit distance. As noted in the earlier discussion, the cohesive forces of the molecules enable the maximum size of the dust particles to exceed unit distance by a relatively small amount. Any further increment puts the particle into the region where the net motion is outward, and gravitational control over dispersed matter is possible only in very large aggregates.

With the benefit of the information contained in this and the preceding chapters, we are now in a position to complete the comparison of the Reciprocal System and conventional astronomical theory from the standpoint of their ability to explain what is now known about the globular clusters. This addition to the comparison in Chapter 3 will be set up in the same manner as the original, and since 13 sets of observed facts were discussed in that chapter, we will begin with number 14.

14. *Observation:* The stars of the globular clusters are confined to the region above and to the right of the main sequence in the CM diagram, and to a relatively short section of the main sequence.

Comment: Both theories have explanations for the observed situation. Opinions as to their relative merits will no doubt differ, as long as this situation is considered is isolation.

15. *Observation:* Some clusters (M 67, for example) are classified as open clusters on the basis of size, shape, and location, but have CM diagrams very similar to those of the globular clusters.

Comment: It is difficult to account for the existence of these hybrid clusters in terms of the totally different cluster origins portrayed in conventional theory. The derivation from the theory of the universe of motion arrives at a simple and straightforward explanation. It identifies M 67 and the others of the same general type as former globular clusters, or parts thereof, which have only recently reached the galactic disk. The modification of the cluster structure under the influence of the strong rotational forces of the Galaxy is already under way, but the acceleration of the evolution of the stars by reason of the availability of more dust and gas for accretion is a slower process, and it has not yet had time to show much effect.

16. *Observation:* The observed motions of the stars in the open clusters

show that these groups are disintegrating at a relatively rapid rate. The large number of these clusters now in existence in spite of the short indicated life means that some process of replenishment of the supply must be in operation.

Comment: As indicated in the discussion of this subject in Chapter 8, current astronomical theory has nothing to offer on this problem but pure speculation. The theory of the universe of motion identifies the source of the replacements.

17. *Observation:* Studies indicate that clusters similar to M 67 have a greater density and are located higher above the galactic plane than clusters that resemble the double cluster in Perseus.

Comment: The significance of these observations has also been noted earlier. They constitute prima facie evidence that the accepted view of the direction of evolution of the clusters and their constituent stars is wrong.

18. *Observation:* In addition to globular clusters of the normal type, the Magellanic Clouds contain some clusters that have the size and shape of globular clusters, but are composed of stars that resemble those of the open clusters in the galaxy.

Comment: As Bart J. Bok pointed out in the statement quoted in Chapter 8, the existence of stars of different evolutionary ages in globular clusters is inconsistent with current astronomical theory, which views these clusters as having been formed early in the history of the universe. But it is easily understood on the basis of the theory of the universe of motion.

Summarizing, we can add to the previous count one set of facts (number 14) explained by current astronomical theory, two (15 and 16) without any explanation, and two (17 and 18) for which the current explanations are inconsistent with the observed facts. As reported in Chapter 3, this makes the total score for current astronomical theory 4 items explained, 7 with no explanation, and 7 with untenable explanations. In sharp contrast to this dismal record, the deductions from the postulates that define the universe of motion, which are totally independent of any input from astronomical observation, lead to explanations for all 18 items that are fully consistent with the observations.

This globular cluster situation is not an isolated case. It is merely a particularly conspicuous example of the results of basing astronomical theory on pure assumptions. The principal assumptions that have been made, and the manner in which they have been utilized to construct a wholly imaginary astronomical universe, will be reviewed in Chapter 28, after the pertinent information that can be derived from the theory of the universe of motion has been more fully developed.

CHAPTER 10

Evolution - Galactic Stars

When a globular cluster finally falls into the Galaxy and becomes subject to the forces of the galactic rotation, some rather drastic changes take place, and the CM diagram of the cluster is modified to the point where it is no longer recognizable without some understanding of the effects that are produced by the galactic forces. These effects are illustrated in Fig. 12, which is the CM

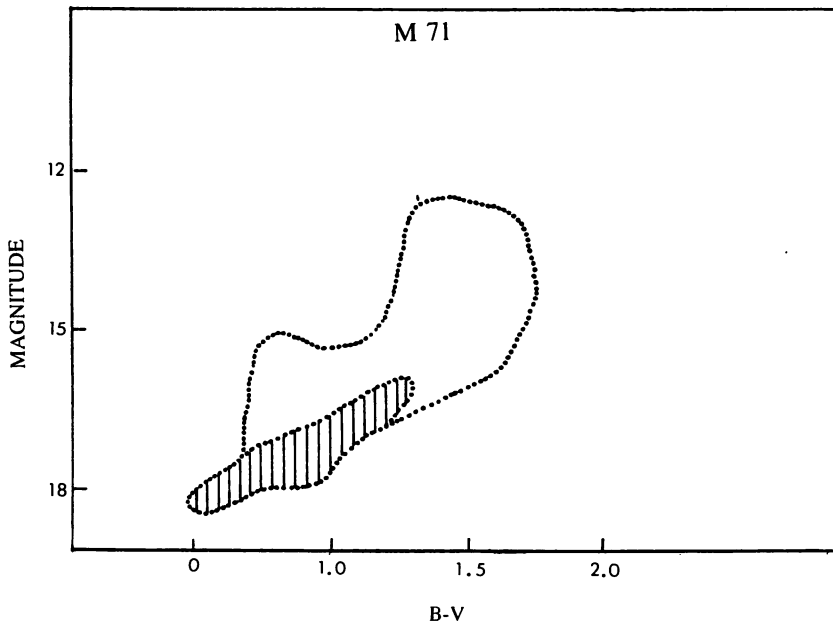


Fig. 12

diagram of the cluster M 71. In this, and the other CM diagrams that will follow, any areas in which the star concentration is sufficiently above average to warrant special consideration are cross-hatched, while sparsely populated

areas that may or may not belong in the diagram are outlined by dashed lines.

M 71 is on the borderline, and has been classified as an open cluster by some observers, although it is now more commonly regarded as a globular.¹²⁰ From this uncertainty as to its true status we can deduce that it is a globular cluster that has reached the edge of the galactic disk and is on the way to becoming an open cluster, or more likely, will break up into a number of open clusters. The CM diagram of this cluster is described by Burnham as having a "red giant sequence resembling that of a globular," with "an unusually large scatter and a steeper slope than normal," but lacking the usual horizontal branch and extension to the main sequence. Thus, even for the astronomers, this diagram leaves a great deal to be explained. In the context of the new information developed in this volume, this diagram has even less resemblance to that of a normal globular cluster, as a "steep slope" of any of the lines in the diagram is inadmissible. The theoretical positions of all three of the evolutionary lines are fixed. The portion of the diagram in the upper right that is being identified as a wide giant branch is too steep to be the red giant line OA, and the slope of the cross-hatched section at the lower end of the diagram is not steep enough to be the evolutionary line AB. The diagram looks like a misfit.

So let us examine the situation from a theoretical standpoint. When the cluster enters the rotating stream, the immediate effect is that the loosely attached matter is stripped away, both stars from the cluster as a whole, and particles from the individual stars. As noted earlier, the differential gravitational forces are already reducing the sizes of the clusters very significantly as they approach the Galaxy, and this loss of stars is accelerated when the rotational forces are added to the radial gravitational effect. Reduction in size has the collateral result of reducing the central condensation.

The globular clusters do not move freely through the field of stars in the manner described by Hoyle in the statement quoted in Chapter 2; they have to push the stars aside in order to clear their paths. But the individual stars do move through the interstellar medium. In so doing they lose the unconsolidated material by which they were surrounded, and from which they were drawing the additional mass that enabled them to follow the normal evolutionary paths. The loss of this material stops the growth of the star, and prevents it from reaching the critical density by the accretion route. However, the star is still subject to the compressive forces due to the gravitational effect of the cluster as a whole, and these forces, together with the self-gravitation of the star, compress the existing gaseous aggregate, and move it downward on the CM diagram along a line of constant mass.

The theoretical results of the stripping action on the locations of the stars in the CM diagram are illustrated in Fig. 13. Diagram (a) is the regular cluster diagram for a cluster in which the most advanced stars have just recently reached the main sequence. Diagram (b) shows where these stars would be if

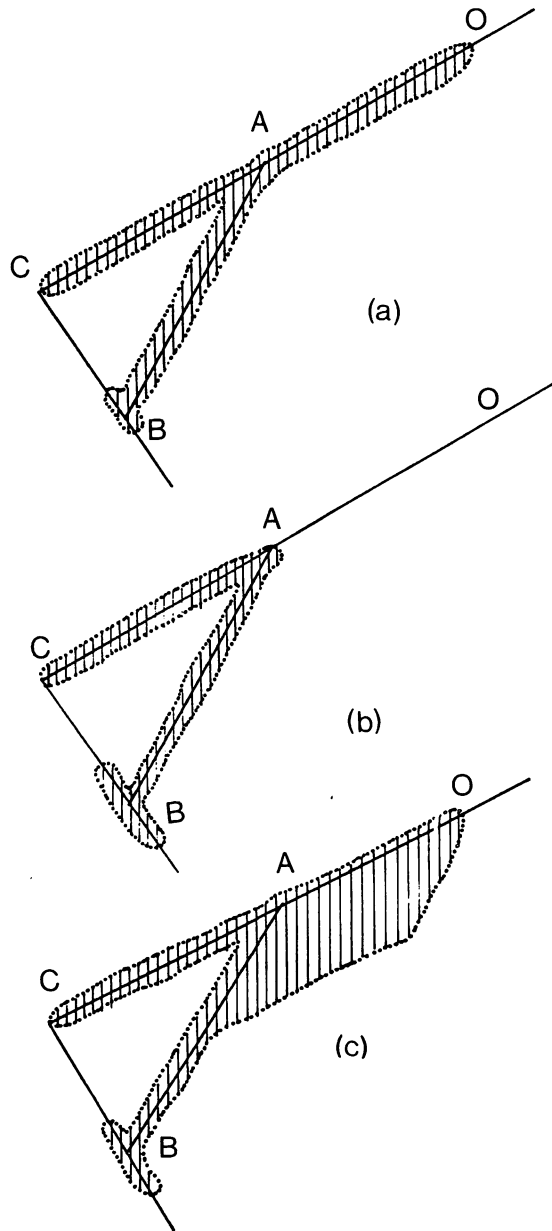


Fig. 13
Theoretical CM Diagrams

the cluster remained isolated long enough to permit the evolutionary development to bring most of the stars down to the main sequence, with only the least advanced stars still on the path AB. If the cluster falls into the Galaxy while it is in the condition shown in (a), the atmospheres of dust and gas from which the stars along the path OA are growing are swept away. These stars are then unable to move forward along this line. Instead of continuing on to the vicinity of point A before the supply of material for accretion is exhausted, they are deprived of this material almost immediately on entering the rotating stream. As a result, each star along the line OA leaves that line from whatever location it may happen to occupy at the time of entry, and moves downward on the diagram along a path parallel to AB, a line of constant mass.

Thus the effect of the interaction with the interstellar medium is to replace the relatively narrow path AB with a path that has the same slope and length, but has a width equal to OA. This path has a lower limit XX' parallel to OA that represents the extent to which evolutionary progress has taken place since the beginning of the capture process. As the evolution continues, the line XX' moves downward on the diagram. The theoretical CM diagram for a captured cluster in a relatively early stage is then similar to (c).

When the last stars have left OA on the downward path, their positions lie along a line YY' parallel to OA, constituting an upper limit to the stellar positions on the diagram. Summarizing this process, in the first interval after the entry of the cluster into the rotational stream the stars are located in the area between OA and the limit XX'. As the downward movement continues, the last stars leave OA, and in the next stage the star locations are between XX' and YY'. Finally XX' is cut off by the main sequence, and in this last portion of the downward movement, the stars are located between YY' and the main sequence, as indicated in diagram (d). After the first stars reach the condition of gravitational equilibrium, the main sequence population continues to increase throughout the remainder of the evolutionary development.

If we apply diagram (c), which shows the theoretical positions of the stars of a newly captured cluster, to the M 71 situation, everything falls into line. M 71 shows both of the characteristics previously mentioned as those of a greatly reduced globular cluster that is entering the fringes of the rotating galactic disk: a relatively low central condensation and a relatively small size. Its diameter is said to be about 30 light years. Double this value would still be below average. The giants exceed 200 light years. The relation of the observed locations of the stars of this cluster to the theoretical diagram is shown in Fig. 14. Here we see that the observations fit neatly within the theoretical parallelogram. The absence of identifiable stars on the line AC, the horizontal branch, is explained by two results of the stripping process: (1) no new stars are moving into the AC region, and (2) the relatively small number of stars that were located on this line prior to the start of the capture process were scattered over the triangular area ABC by the same kind of a downward

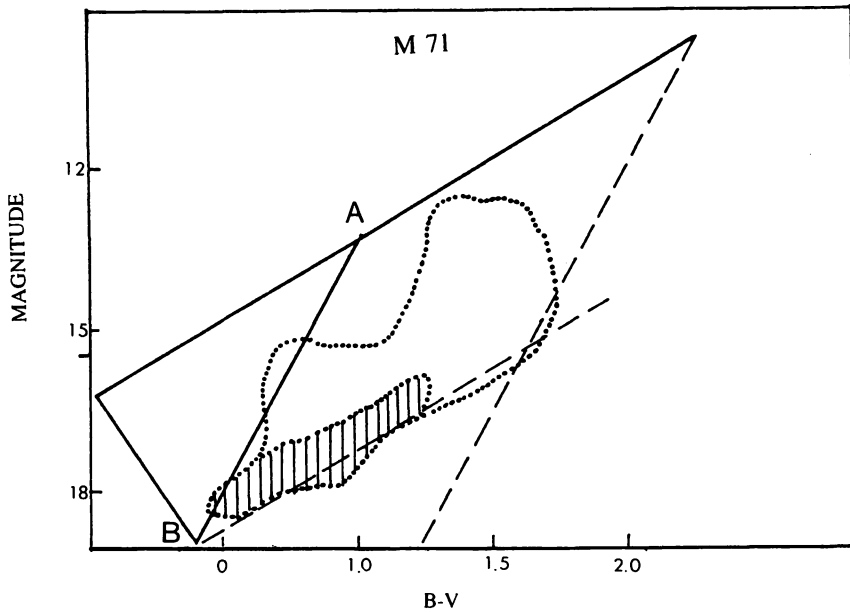


Fig. 14

movement that occurs in the more heavily populated region on the other side of the path AB.

The M 71 pattern is not uncommon. Five other clusters out of those examined in this investigation also show the same kind of evidence that they are just entering the rotational stream. Only one is in the intermediate range where both the upper (YY') and lower (XX') limits are observable. The more advanced clusters that are limited to the lower section of the diagram between YY' and the main sequence are again fairly numerous. But here we find that a new factor has entered into the determination of position on the CM diagram. The main sequence sections of some of these more advanced clusters are well defined, and they show that the clusters in this stage of evolution are subject to an upward displacement of the main sequence.

In the cluster M 67, which is regarded as the prototype of this class of cluster, the shift is about 2.6 magnitudes. Fig. 15 is the CM diagram of M 67. As can be seen, this diagram is similar to those of M 71 and other newly captured clusters, but a considerable number of the stars of the cluster have reached the main sequence, and they do not lie on the line BC, the lower line in Fig. 3. Instead, they follow a line parallel to BC, but above it by the amount of

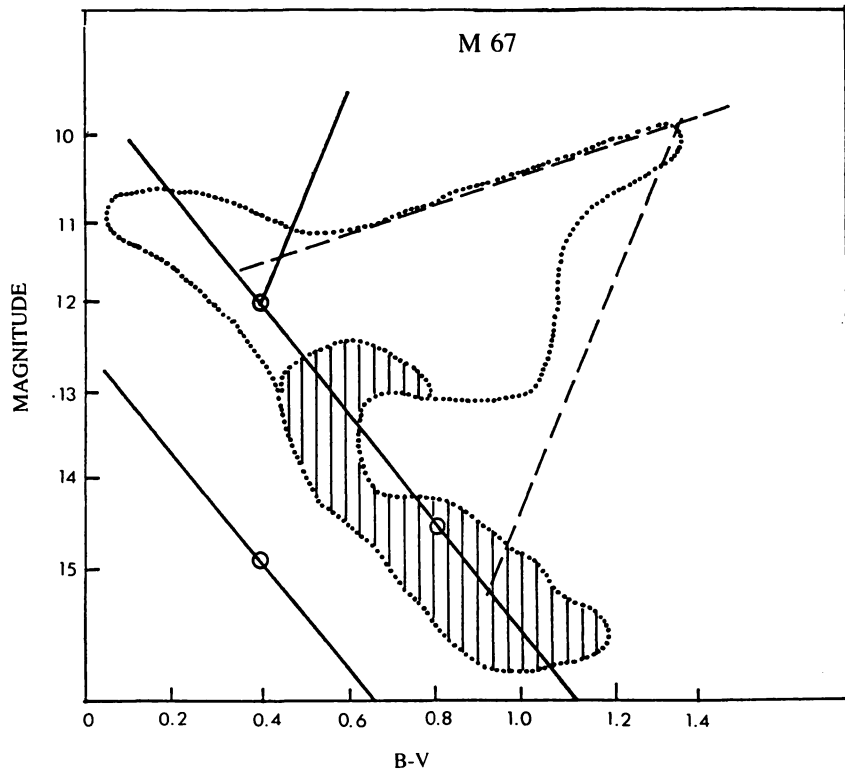


Fig. 15

the displacement. Otherwise, the stellar positions are entirely normal. It is particularly significant that the upper limit of the populated area, the line designated as YY' , is sharp and distinct, because this line has a definite theoretical relation to the evolutionary pattern. It has to be parallel to the theoretical line OA , which is specifically defined mathematically, even though $M\ 67$ actually has no stars in the upper areas of the complete globular cluster diagram.

In order to understand the origin of the displacement of the main sequence, the gravitational shift, as we will call it, the nature of the equilibrium on the main sequence needs to be recognized. Basically, this is an equilibrium between the gravitational force (or motion) and the force (or motion) of the progression of the natural reference system. In the dust cloud state in which the giant stars originate there are two gravitational components, the self-

gravitation of the star and the gravitational effect of the cluster in which the star is located. The net resultant of all forces is inward, and the star therefore contracts. As the contraction proceeds, the net inward force weakens, and ultimately the point is reached where the inward and outward forces are equal. This is the main sequence of the cluster.

Two of the three force components, the progression of the natural reference system and the self-gravitation of the star, are constant for a star of a given mass and volume, but the third component is variable, and it determines the location of the main sequence equilibrium. The stars in a globular cluster occupy equilibrium positions where there is no net force in either direction. In this case, therefore, the variable force component is zero in the equilibrium condition, if the contraction is completed within the cluster. Here the stellar equilibrium within the cluster is identical with that of an isolated star in space.

The stars of the Galaxy also occupy equilibrium positions, but the galactic situation is not a full three-dimensional equilibrium. It has been attained in part by balancing a portion of the inward gravitational effect of the galaxy as a whole against the outward component of the rotational motion. This is a one-dimensional vectorial motion, and while it counterbalances the gravitational motion so far as the representation in the conventional spatial reference system is concerned, it does not offset the full effect of a motion such as gravitation that is effective in all three scalar dimensions. Thus there is a second gravitational component in the main sequence force equilibrium of the galactic stars. The component due to self-gravitation at equilibrium is reduced accordingly; that is, the contraction of the star stops at a lower density (or expands back to that density). This puts the main sequence of the galactic stars somewhat higher on the CM diagram than the main sequence of the globular cluster stars. As indicated earlier, the difference is about 0.8 magnitudes.

This is a theoretical conclusion that takes us into a hitherto unexplored area of astronomy, but it is not without observational support. We note, for instance, that when the main sequence of the clusters is lowered to the 4.6 level, the area of the diagram included between this and the galactic main sequence at 3.8 magnitude includes the positions of a group of stars known as *sub-dwarfs*. "The location of metal-poor subdwarfs is puzzling," say M. and G. Burbidge, "because they seem less bright than [galactic] main sequence stars of comparable surface temperature and hence lie below the main sequence." But then these authors go on to give us the information about the subdwarf stars which, in the light of the theoretical conclusions that we have just reached, provides the explanation.

These subdwarfs . . . are not traveling with the sun in its giant orbit around the hub of our galaxy, and consequently they are moving with high speeds relative to the sun and in one general direction—that opposite to the direction in which the galactic rotation is carrying the sun.¹⁰²

According to our findings, these are stars that have escaped from globular clusters, and have entered the Galaxy from outer space. The fact that they are relatively metal-poor supports this conclusion. But in any event, whatever their origin may have been, the significant point is that they are not “traveling with the sun”; that is, they are not participating (or not participating fully) in the rotation that we find to be the cause of the 0.8 magnitude gravitational shift of the galactic field stars. Actually, they can hardly avoid being affected to some extent by the rotational forces. It follows that they should theoretically be distributed throughout the region between the two main sequence locations. This is just where they are found.

Another item of evidence supporting the theoretical identification of the 0.8 magnitude difference as a gravitational shift will be forthcoming in Chapters 11 and 12, where it will be shown that the gravitational equilibrium applicable to objects moving in time is related to the 4.6 magnitude level, rather than to that of the galactic main sequence.

With the benefit of the foregoing information we are now in a position to explain the gravitational shifts of M 67 and other open, or galactic, clusters. M 67 is a remnant, or fragment, of a globular cluster that has quite recently fallen into the galaxy. It has reached the point where it has begun building up a main sequence population, although its slower stars are still in the process of completing their evolution along the globular cluster path AB and its rightward extension. It is one of the earliest of the objects classified as open clusters, and has the principal characteristics of a recent arrival: a star population that is large for an open cluster, a relatively compact structure, and a position high above the galactic plane. The big decrease from the globular cluster size and the entry into the galactic disk have destroyed the structural stability that existed in the parent globular cluster, and M 67 has begun the expansion that will ultimately terminate its existence as a separate entity.

Now that they are within the Galaxy, the M 67 stars are subject to the same forces as the galactic field stars, and in addition are subject to the residual cohesive force of the cluster. Expressing this in another way, we can say that the stars of the main sequence of the open cluster have not yet completed their transition to gravitational equilibrium. The temporary equilibrium represented by their main sequence positions includes a diminishing component from the gravitational force of the cluster as a whole. The cluster stars will not reach main sequence positions comparable to those of the field stars of the Galaxy until the cluster expansion is complete, and this extra force component is eliminated. In the meantime, the main sequence of each cluster will be above that of the field stars by an amount depending on the remaining cohesive force of the cluster. This gravitational shift is greatest where the clusters are young, large, and compact, like M 67, and decreases as the cluster becomes older, smaller, and looser.

As we saw earlier, when galaxies reach the size at which they capture

substantial numbers of globular clusters they also begin to pull in some unconsolidated clusters, aggregates that are still merely clouds of dust and gas. These clouds arrive too late in the elliptical stage of galactic evolution to have much effect on the properties of the observed elliptical galaxies, although they may be responsible for the occurrence of concentrations of blue stars in some of these galaxies. But when the elliptical structure spreads out to form the spiral, the stars of the galaxy are mixed with the recent acquisitions of dust and gas. The stage is then set for a period of rapid advance along the path of stellar evolution, as the availability of this kind of a supply of material accelerates the evolutionary process.

During the time that the mixing is taking place the dust and gas exist in widely different concentrations in different parts of the galactic structure. The average concentration in the outlying regions that it reaches first is sufficient to support an accretion rate that results in a continuing increase in the mass of the average star. After arrival at the main sequence, the very small stars, those whose growth was cut off prematurely by the entry of the cluster into the Galaxy, take up relatively permanent positions in the lower sections of this sequence, while the larger stars accrete matter and move upward along this path. Since the stars of a cluster, aside from the few captured strays, were all formed in the same event, and are of approximately the same age, most clusters occupy only a limited sector of the evolutionary cycle. The active sector does not expand appreciably, but merely moves forward as the cluster ages and passes through the various evolutionary stages.

In the Hyades, Fig. 16(a), a cluster somewhat older than M 67, a few stars still remain on the contraction path AB, but the majority have reached the main sequence. Fig. 16(b) represents a still more advanced cluster, the Pleiades, in which the last stragglers have attained gravitational equilibrium, and the main body of the active stars has moved up along the main sequence. Whether or not the Pleiades cluster is actually older than the Hyades is uncertain, as the evolutionary age is not necessarily coincident with the chronological age. The Pleiades are located in an observable nebulosity, and the accelerated accretion from this source may account for the more advanced evolutionary stage.

The possible variations in the rate of development of these nearby clusters are of particular interest in connection with the possibility that many of the open clusters in the local region of the Galaxy may be fragments of the same disintegrated globular cluster. It has already been recognized that some of these clusters are similar enough to imply a common origin. This has been suggested, for example, in the case of Praesepe and the Hyades.¹²¹ The principal objection that has been raised to this hypothesis is that the clusters are too far apart (the distance between these two is over 450 light years) to have originated in the same event. This conclusion is, of course, based on conventional astronomical theory. When it is realized that the open clusters are fragments of globular clusters this objection is eliminated, as it is evident

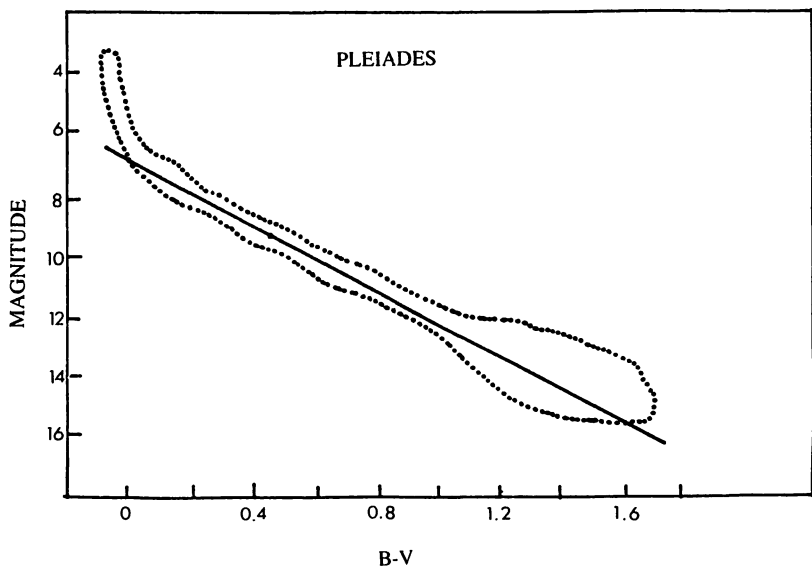
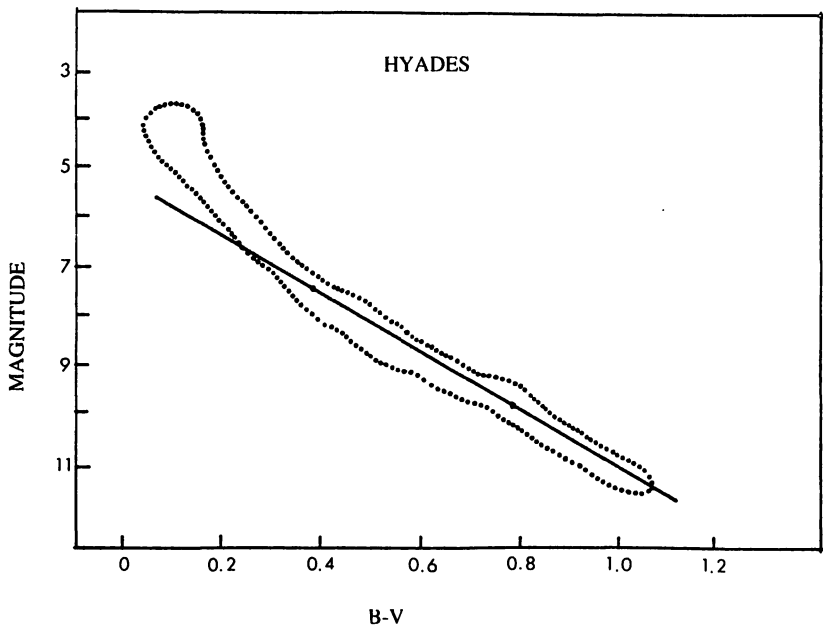


Fig. 16
Open Clusters

that fragments of a disintegrated cluster could be distributed over much greater distances than those that are observed.

In any event, the greater density of the M 67 class of clusters and their higher galactic latitude, taken together with the observed expansion of all open clusters, definitely establish the M 67 class as younger than the main sequence clusters such as the Pleiades and the Hyades. This conclusion, previously reached, is now corroborated by the relative magnitudes of the gravitational shifts. Those of the M 67 class average about 2.5 magnitudes, while those of the main sequence clusters are not much above the 0.8 level of the field stars.

Extension of the findings with respect to accretion by the main sequence stars indicates that continued development of the Pleiades cluster will eventually bring the hottest stars in this group to the destructive limit at the top of the main sequence, and will cause these stars to revert back to the red giant status via the explosion route. In the Perseus double cluster, Fig. 17, such a process has already begun. Here the main body of stars is in the region just below the upper limit of the main sequence, but a number of red giants are also present. We can identify these giants as explosion products, stars of Class 2C, rather than new stars, Class 1A, as this identification keeps all of the stars in the cluster in an unbroken sequence along the evolutionary path, whereas if these were young stars of the first generation they would be unrelated to the remainder of the cluster. The presence of 2C giants implies that there are also young white dwarfs in this cluster, but they may be still in the invisible stage.

Some binary stars are also reported to be present in clusters such as the Hyades and the Pleiades. In these clusters, however, the A components of the binaries are on the main sequence, and there is a wide evolutionary gap between them and the Class 1 main sequence stars of the clusters. There are several possible explanations of their presence: (1) they are not actually members of the clusters, (2) they are strays, older stars that were picked up during the condensation of the globular clusters, or during their subsequent travels, or (3) they were stars from the horizontal branch of the same globular cluster whose vertical branch produced the Class 1 stars of the open cluster. The cluster diagrams indicate that the stars of the two branches reach the main sequence at about the same time. Consequently there is an evolutionary gap between them that is just about right to account for the presence of some Class 2 (binary) stars in the Class 1 main sequence clusters. It seems probable that alternative (3) is the source, or at least the principal source, of these binary stars.

It is important to note at this point that in the context of the theory of the universe of motion, the presence of observable nebulosity is not necessary to account for the position of the hotter stars of the cluster at the top of the main sequence. As explained earlier, the theory definitely requires continued stellar growth even under conditions where the density of the stellar medium is no greater than average. This is something that cannot be confirmed

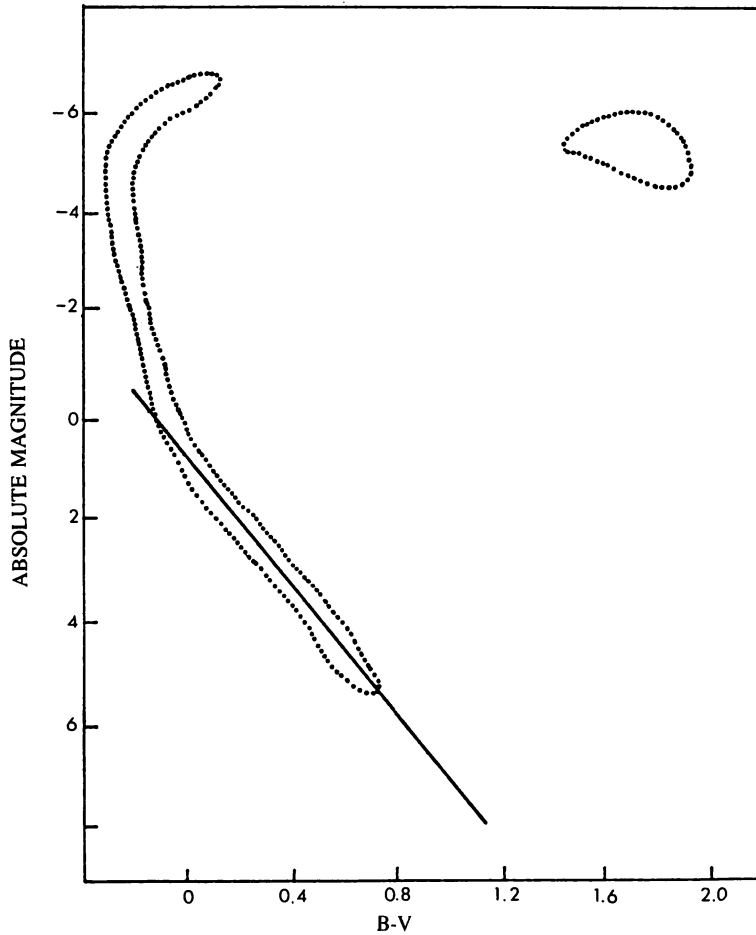


Fig. 17 The Double Cluster in Perseus

observationally with currently available instruments and techniques, but neither can it be disproved. Thus, this aspect of the theory is *not inconsistent* with anything that is actually *known*, which is all that is required in the case of an integrated general theory that is fully verified in other areas.

It is significant, in this connection, that current astronomical theory *is* inconsistent with the observations. This theory places the star formation in dense galactic nebulae. The location most commonly cited as a stellar birthplace is the Great Nebula in Orion, and the association between this nebula and a large group of hot O and B type stars is offered as evidence of recent formation from the existing dust and gas cloud. But no nebulosity can be detected in the Perseus cluster, or in NGC 2362, another similar cluster that

has been extensively studied, or in a number of other clusters in which O and B stars are prominent, while most of the main sequence clusters, such as the Pleiades, that *do* have associated nebulosity have no O type stars. It is commonly recognized that there is a contradiction here that calls for an explanation, but since such contradictions abound in astronomy, it is not taken as seriously as the situation actually warrants.

Some of the open clusters evidently carry over into Class 2B, as there are a large number of loose, somewhat irregular, clusters that have second generation characteristics. Here we find a substantial proportion of giant and subgiant stars, indicating that the clusters are either considerably older or considerably younger than a main sequence cluster such as the Pleiades. These clusters do not have the characteristics of the M 67 class, the predecessors of the Pleiades type of cluster, and their structure (or lack of structure) indicates that they have undergone considerable modification. We can therefore conclude that they are older, and that their giant stars belong to Class 2C. This conclusion is supported by evidence indicating that a large proportion of the stars of these clusters are binaries.

Up to this point no more than casual consideration has been given to the rotation of the various astronomical objects that have been discussed, because the significance of the information available on this subject is not clearly indicated as long as each individual situation is considered in isolation. We have now reached the point, however, where we can put together enough information from different sources to show that there is a general correlation between rotation and age throughout the astronomical universe.

The earliest structures, both the globular clusters and the stars of which they are composed, have little or no rotation. As explained earlier, this is easily understood as a consequence of star and cluster formation under conditions in which only radial forces are operative to any significant degree. But it confronts conventional astronomical theory with difficult problems. The desperate attempts of the theorists to read some signs of rotation into the observations of the globular clusters as a means of accounting for the stability of these structures have already been discussed. In application to the stars, this problem is somewhat less acute, as the stars actually do rotate, and the issue here is a matter of origin and magnitude.

According to J. L. Greenstein, the average rotational speeds of stars of spectral class G and fainter are less than 25 km/sec. His estimates of the giant stars show an increasing trend up to about 200 km/sec for spectral classes A3 to A7, with a decrease thereafter. The peak for the "dwarf" class (that is, the main sequence stars) is placed at a somewhat higher luminosity, in classes B5 to B7, and is estimated at 250 km/sec.²⁹ The existence of these peaks does not mean that the rotation actually decreases in the largest stars. These are surface velocities, and the decrease is merely a reflection of the slowing of the speed of the outer layers of these stars, a differential effect that is evident even in stars

as small as the sun. Current theory offers no explanation as to why speeds of these particular magnitudes should exist. Indeed, Verschuur points out that, on the basis of the prevailing theories, they should be much greater.

The simplest calculations for star formation suggest that all stars should be spinning very, very fast as a result of their enormous contraction from cloud to star, but they do not do so. Why not? The answer is far from known at present.¹¹⁴

Furthermore, there is direct evidence that the rotational speed is a function of age. For example, A. G. Davis Philip reports that the rotational velocities of Ap and Am stars decrease with increasing cluster age (which is decreasing age, according to our findings).¹²² We might also note that the question as to what happens to the rotational speed as stars go through the contortions that are required by present-day evolutionary theory receives practically no attention.

Against this background, the simple, observationally confirmed, picture of the rotational situation derived from the theory of the universe of motion provides a striking contrast. On the basis of this theory, all of the primary astronomical objects—stars, star clusters, galaxies—originate with little or no rotation, and acquire rotational velocities as a consequence of the evolutionary processes. This increase in velocity is primarily due to angular momentum imparted to these objects during the accretion of matter. Globular clusters, which have little opportunity for accretion, acquire little or no rotation. The larger galaxies and the stars of the upper main sequence, which grow rapidly, on the astronomical time scale, increase their rotational velocities accordingly.

From the nature of the evolutionary processes, as they have been described in the preceding pages, it is apparent that no aggregate consists entirely of a single stellar class. However, the very young aggregates approach this condition quite closely, inasmuch as they are composed of young stars, and the only dilution by older material results from picking up an occasional stray that has been ejected from an older aggregate. Aside from these interlopers, the earlier globular clusters are pure Class 1A, and their CM diagrams are somewhere between a concentration at the initial point of the diagram at the extreme end of the red giant region and a distribution similar to that of M 3, Fig. 3.

As brought out in the preceding pages, the evolutionary ages of the observable globular clusters are correlated with their distances from the Galaxy. On first consideration, the existence of such a relation may seem rather surprising, but it is an inevitable result of the kind of a cluster formation process that was described in Chapters 1 and 2. In the equilibrium condition from which the contraction of the group of proto-clusters begins, the proto-clusters in the outer regions of the group are moving inward, exerting a compressive force on those closer to the center of the group. Thus there is a

density gradient from the periphery of the group to one or more central locations, just as there is a similar gradient from the outer regions of the clusters to their centers after they begin contracting individually. These density centers are the locations in which the condensation into stars first takes place, and the combination of the clusters into galaxies begins. Ultimately they become the locations of the major galaxies of each group. The density gradient from the periphery of the proto-group to the condensation centers then takes the form of a gradient from the gravitational limits of the major galaxies to the locations of those galaxies.

The basic physical process in the material sector of the universe is aggregation in space. Growth of the aggregates proceeds by a mechanism called capture, if it occurs on an individual basis, or condensation, if it takes place on a collective basis. The rate of growth is primarily a matter of the density of the medium from which the material is being drawn. Condensation does not occur at all unless the density exceeds a certain critical value. Capture is not so limited, but the rate at which it occurs depends on the probability of making contact, and that probability is a function of the spatial density of the entities subject to capture. All of the aggregation processes therefore speed up as the clusters move toward the Galaxy and into a denser environment. This accounts for the evolutionary changes, already noted, that take place during the travel of the globular clusters from the distant regions of intergalactic space to the point at which they end their existence as separate entities by falling into the Galaxy.

The aggregation of matter on the atomic scale that produces successively heavier elements follows the same general course as the aggregation of the dust and gas particles into stars. The atom-building process, as described in the previous volumes of this series, is also a capture process, and it, too, proceeds at a rate that depends on the density of matter in the environment.

Current estimates of the densities in the different regions through which the clusters pass give a general indication of the magnitudes that are involved. The following are some recent figures:¹²³

	Density (g/cm ³)
Intergalactic space	10 ⁻³¹
Space near edge of galaxy	10 ⁻²⁸
Interstellar space	10 ⁻²⁴

On this basis, the density increases by a factor of 1000 during the travel of the cluster from a distant point of origin to the edge of the Galaxy. Here, then, is the explanation for the differences in composition between the distant clusters and those near the Galaxy that were described earlier. After entry into the galactic environment the increase in density and the corresponding

evolutionary changes are still more rapid.

It is not possible to follow the evolutionary cycle of the stars in the distant galaxies in the same detail as in our own galaxy, but we can apply our findings from the study of evolution in the Galaxy to an explanation of some of the changes in the observable features of these other galaxies. We can deduce that the small elliptical galaxies, including the distorted members of this class currently classified as irregular, are more advanced than the average distant globular cluster, and are in an evolutionary stage comparable to that of the most mature of those clusters. On the basis of the classification that we have set up, this means that they are composed of a mixture of the 1A and 1B classes of stars.

The older and larger elliptical galaxies (not including the giant spheroidals, which are not classified as elliptical in this work) are in the same evolutionary stage as the earliest open clusters, and the CM diagrams of M 67 and the Hyades are representative of the phases through which these elliptical galaxies pass. It should be noted, however, that because of the continuing capture of younger aggregates, the early end of the age distribution is not cut off in the galaxies as it is in the clusters. The CM diagram for an elliptical galaxy in the same evolutionary stage as the Hyades would extend the sector occupied by the Hyades stars all the way back through the globular cluster sector to the original zone of star formation.

The rapid evolution in the early spiral stage eliminates most of the 1A stars, except those in the incoming stream of captured material. Aging of these spirals then results in the production of second generation stars, beginning with Classes 2C and 2D. All of these stars, both the giants (2C) and the white dwarfs (2D), are moving toward the main sequence, on reaching which they enter class 2B, the class to which the sun and its immediate neighbors belong. There are no giants among these local stars, but the presence of white dwarfs in such systems as Sirius and Procyon, and the existence of planets, shows that the local stars passed through the explosion phase fairly recently. We may interpret the lack of giants as indicating that the former giants, such as Sirius, have had time to get back to the main sequence, while their slower white dwarf companions are still on the way. It is not certain that all of the nearby stars actually belong in this same evolutionary group, as some younger or older stars may also be present as a result of the mixing due to the rotation of the galaxy and the gravitational differentials, but there are no obvious incongruities.

The 2B stars in the regions of average accretion or above move upward along the main sequence in the same manner as they did when they were 1B stars of the first cycle, and again undergo the Type I supernova explosions. Eventually they recondense into stars of the third cycle, Classes 3C and 3D. These are three-member systems, if only one of the stars of the Class 2 binary system has exploded, or four-member systems if both have gone through the explosion phase. As indicated earlier, a considerable number of such multiple systems

are known.

Theoretically, this movement around the cycle will continue until the matter of which the star is composed reaches its age limit, providing that the environment is favorable for growth, but as mentioned in the discussion of the spiral structure, the contents of the galaxies are in a physical condition that has the general characteristics of a viscous liquid. In such an aggregate the heavier material moves toward the center of gravity, displacing the lighter units, which are concentrated preferentially in the outer regions. This process is slow and irregular because of the viscosity and the effects of the galactic rotation, but there is a general tendency for the older and heavier systems to sink toward the galactic center, into regions where the supply of material for accretion is limited. One six-member system, Castor, is frequently mentioned in the astronomical literature, but apparently systems of this size, systems of the fourth cycle, are scarce in the readily observable regions of the Galaxy. In view of the smaller amount of material available to the stars in the unobservable regions closer to the galactic center, and the increased competition for the material that is available, because of the higher concentration of stars, it is quite possible that the movement around the evolutionary path is limited to four or five cycles.

Some evidence suggesting continuation to additional cycles is available from the cosmic rays. As explained in Volume I, the nature of the process whereby matter is transferred from the material sector to the cosmic sector, and vice versa, is such that this matter is near its age limit before being ejected from the sector of origin. The cosmic iron content of the cosmic rays (the incoming matter from the cosmic sector) is something on the order of 50 times that of the estimated iron content of the local main sequence (Class 2B) stars. If taken at its face value, this indicates that the evolutionary development which causes the increase in the iron content must extend into more than two or three additional cycles beyond the 2B stage. However, as noted earlier, the spectra of the stars tell us only what is present in the outer regions, and there is reason to believe that the iron content of the older stars in the local environment is substantially greater than indicated by the spectroscopic data. For the present it seems appropriate to interpret the cosmic ray composition as evidence favoring the higher iron content of the Class 2B stars rather than as indicating evolution beyond four or five cycles.

In either case, however, the continuation of the accretion process into a number of cycles means that the proportion of large stars (products of the explosion of stars of maximum size) in the galactic population increases as time goes on. Inasmuch as the oldest stars are concentrated toward the galactic center, it follows that the number of large stars in the central regions of the Galaxy is considerably greater than would be expected from the proportions in which they are observed in the local environment. As we will see later, the presence of this large population of big stars in the central regions of the major

galaxies has some important consequences.

The fact that the development of the spiral structure antedates the appearance of the second generation stars enables defining the general distribution of the stellar classes of the Milky Way galaxy and similar spirals. With the qualification "except for strays from older systems," which has to be understood as attached to all statements in the discussion of stellar populations, we may say that the stars of the second and later generations, Class 2C and later, are confined to the galactic disk (including the arms) and the nucleus. The early first generation stars, Class 1A, are distributed throughout the outer structure. They constitute practically the entire halo population. The main sequence stars of the first generation, Class 1B, occupy an intermediate position, most prominently in the spiral arms.

The identification of the conspicuous hot and luminous stars of the upper main sequence with the spiral arms was the step that led to the original concept of two distinct stellar populations. However, the information that has been developed herein shows that the galactic arms actually contain a very heterogeneous population, including not only stars from the entire first evolutionary cycle, but also stars from several, perhaps nearly all, of the later cycles.

Observational difficulties limit our ability to follow the evolution of the galaxies beyond the stage of the spiral arms by studying the individual stars, but we can derive some further information from the character of the light that is being received from the inner regions. Since the stars in the galactic nucleus are older than those in the disk, they should be more advanced from an evolutionary standpoint, on the average. This difference in age is reflected in a difference in color. However, the correlation is not directly between color and age, but between color and the positions of the stars in the evolutionary cycle.

It should be realized that the great majority of all stars are red. Consequently, we can expect red light under all conditions except where the stellar population includes an appreciable number of the relatively rare blue and white stars of the upper end of the main sequence, and then only because the emission from these hot stars is so much greater than that from the red stars that even a small proportion of them has a major effect on the color of the aggregate as a whole. The hottest stars may be thousands of times as luminous as the average Class 1 star. Thus the color of a galaxy, or a portion thereof, does not identify the stage of evolution of the constituent stars. It merely tells us that the aggregate does, or does not, contain a significant number of stars in that part of an evolutionary cycle which extends into the upper end of the main sequence. The particular cycle to which these stars belong cannot be determined from this information, but since the color changes in galaxies take place gradually, the characteristics of the light emitted by a galaxy, or one of its constituent parts, supplement the evolutionary criteria previously identified.

The integrated light from the larger elliptical galaxies belongs to the spectral

type G (yellow). In the early spirals the emission rises to type F (yellow-white), or even type A (white) in some cases, because of the large number of Class 1B stars that move up to the higher levels of the main sequence. As these stars pass through the explosion stage and revert to the 2C and lower 2B status, accumulating to a large extent in the galactic nucleus, the light gradually shifts back toward the red, and in the oldest spirals the color is much like that of the ellipticals. Summarizing the color cycle, we may say that the early structures are red, because they are relatively cool, there is only a small change in the character of the light during the development of the elliptical galaxy, then a rapid shift toward the blue as the transition from elliptical to spiral takes place, and finally a slow return toward the red as the spiral ages.

Current astronomical theory correctly identifies the stars of the nuclear regions of the galaxies as older than those in the spiral arms, but reaches this conclusion by offsetting one error with another. This theory identifies the globular cluster stars as older than the main sequence stars of the galactic arms. This is incorrect. But then the theory equates the stars of the nucleus with those of the globular clusters. This, too, is an error, but it reverses the first error and puts the stars of the nucleus in the correct age sequence relative to those of the galactic arms. However, this superposition of errors leaves the astronomers with an open contradiction of their basic assumption as to the relation between the age of a star and its content of heavy elements. This embarrassing conflict between current theory and the observations is beginning to be a subject of comment in the astronomical literature. For example a 1975 review article reports measurements indicating that the "dominant stellar population in the nuclear bulges of the Galaxy and M 31 consists of old metal-rich stars."¹²⁴ As the authors point out, this reverses the previous ideas, the ideas that are set forth in the astronomy textbooks. The expression "old metal-rich stars" is, in itself, a direct contradiction of present-day theory. The whole fabric of the accepted evolutionary theory rests on the hypothesis that old stars are metal-poor. The existence of a greater metal content in the central regions of the galaxies is apparently not contested. Harwit makes this comment:

There also seems to exist abundant evidence that the stars, at least in our Galaxy and in M 31, have an increasingly great metal abundance as the center of the galaxy is approached. The nuclear region appears to be particularly metal rich, and this seems to indicate that the evolution of chemical elements is somehow speeded up in these regions.⁸

In the light of our findings it is, of course, unnecessary to assume any speeding up of stellar evolution in the central regions of the Galaxy. All that is needed is to recognize that the stars in these regions are the oldest in the galaxy, and their evolution has continued for a long period of time.

This chapter completes our discussion of the more familiar areas of the

astronomical universe. In the remainder of this volume we will be exploring hitherto uncharted regions, aspects of astronomy where the currently accepted ideas are almost completely wrong, because of the strangely unquestioning acquiescence in Einstein's assumption that the experimentally observed decrease in acceleration at high speeds is due to an increase in mass, and that speeds in excess of that of light are therefore impossible. As has been demonstrated in the course of the development of the theory of the universe of motion, the speed of light is a limit applying only to one-dimensional motion in space, and there are vast regions of the universe in which motion takes place in time, or in multi-dimensional space. Most of these are inaccessible to observation from our position in the universe, but some of the entities and phenomena of these regions do have observable effects on the material sector, the sector in which we make our observations. These effects will constitute the subject matter of the remaining chapters.

Since these subjects will be approached from a totally different direction, the conclusions that will be reached will differ radically, in many cases, from those currently accepted by the astronomical community. As we begin our consideration of these new, unfamiliar, and perhaps disturbing, findings in the admittedly poorly understood areas of astronomy, it will therefore be well to bear in mind what the theory of the universe of motion has been able to do in the presumably quite well understood astronomical areas. It has produced an evolutionary theory that turns the conventional astronomical theories upside down, and it has identified a variety of observational data that confirm the validity of the revised evolutionary sequence, including two sets of observations, the densities of the different classes of open clusters, and the metal content of the stars in the central regions of the galaxies, that provide *definite proof* that evolution takes place in the reverse direction. This ability of the new theory to correct a major error in current thought with respect to the phenomena of the better known regions should inspire some confidence in the validity of the conclusions that are derived from that theory in the relatively unknown astronomical areas, particularly when it is remembered that scarcity of observational information is not a major handicap to a purely theoretical structure of thought, whereas it is usually fatal to theories, like most of those in astronomy, that rest entirely on observational foundations.

CHAPTER 11

Planetary Nebulae

Inasmuch as the system of reference by means of which we define the positions of physical objects in the material sector of the universe, the sector in which we are located, is stationary in space, but moving at the speed of light in time, we cannot detect objects moving in time, except during an extremely short interval while they pass through our reference system, and then only atom by atom. As explained earlier, however, if the net total three-dimensional scalar speed is below the point of equal division between motion in space and motion in time, any time motion component included in the total acts as a modifier of the spatial motion—that is, as a motion in equivalent space—rather than as an independent motion in actual time.

The nature of the modification depends on the magnitude and dimensions of the motion being modified. The participation of time motion in combinations of motion that are multi-dimensional in space (ultra high speeds) will be discussed later, in another connection. The motion with which we are now concerned, motion at intermediate speeds, is one-dimensional, but the original unit of speed (motion in space) has been extended linearly to a second unit, which is a unit of motion in time. Because of the effect of this time component, the successive spatial positions of an object moving freely at an intermediate speed do not lie on a straight line in the reference system as they would if the speed were less than unity. Motion in time has no direction in space. The spatial direction of each successive unit of the time component of the intermediate speed is therefore determined by chance. However, the *average* position of the freely moving object follows the straight line of the purely spatial motion, because the total three-dimensional motion is still on the spatial side of the sector boundary.

As a result of this time effect, the radiation from a white dwarf in its early stages is not received from the surface of the star itself, but from a much larger area centered on the average stellar location. When the inherently weak radiation from this (spatially) very small star is further diluted by being spread out over this wide area it is reduced below the observable level. It follows that the white dwarfs expanding back toward the material sector (evolutionary stage 2) are not observable at all as long as their surface temperature is above the level corresponding to the unit speed boundary. On that boundary the

change of position in time (equivalent space), relative to the natural datum, the unit speed level, is zero, and the radiation from the white dwarf is received at full strength. The white dwarf stars therefore become observable at this point.

Our first concern will be with the relatively large stars, those whose mass exceeds a certain critical level that we will identify later. The detailed study of the white dwarf stars and related phenomena in the context of the theory of the universe of motion is still in the early stages, and we are not yet in a position to calculate the entry temperature for this class of white dwarf, but it can be evaluated empirically, and is found to be in the neighborhood of 100,000 K.

At this temperature, where the relatively large white dwarf enters its third evolutionary stage, it is still a gas and dust cloud in equivalent space; that is, it is in the gaseous state. In this gaseous state in time the B-V color index for a given temperature is different from that of the stars on the spatial main sequence. We find empirically that the color index corresponding to the 100,000 K temperature of the incoming white dwarfs is about -0.3 . On the main sequence this index corresponds to a temperature of about 30,000 K.

Theoretically, these temperatures should be related by a factor of three. On entry into the observable region, the white dwarf is moving in all three dimensions of time (equivalent space). The radiation from this star, the wavelength of which determines the color, is one-dimensional. From the color standpoint, therefore, the radiation consists of three independent components, each of which has the wavelength and color corresponding to one third of the total rate of emission of thermal energy. The temperature, on the other hand, is determined by the total energy emission. Thus the color index of the newly arrived white dwarf of the class we are now considering is the same as that of a spatial main sequence star with a temperature one third that of the white dwarf. Since we do not have the theoretically correct values at this time, we will continue using 100,000 K and 30,000 K, with the understanding that these values refer to a temperature of *about* 100,000 K and a temperature one third as large, *approximately* 30,000 K.

The location of the -0.3 index on the CM diagram coincides, in general, with the position of a rather obscure class of stars known as the *hot subdwarfs*. The "evolutionary status" of these stars "has not been really understood."¹²⁵ say Kudritzke and Simon, but current opinion apparently favors the suggestion that "On the way to becoming a white dwarf, while it is still very hot and just before the thermonuclear reactions cease, a star may find temporary stability in the region below the main sequence."¹⁰² In short, this is presumed to be a way station on the totally unexplained, and poorly defined, route by which, according to current theory, a red giant becomes a white dwarf.

Observational information about these hot subdwarfs is still scarce and somewhat uncertain. A 1961 report by K. Hunger, *et al.*, says that "little is known about their precise location in the H-R diagram."¹²⁶ These authors

make the following comments on matters that are relevant to the present discussion: (1) a major fraction of these stars are binaries, (2) some of them are central stars of planetary nebulae, and (3) the mass of one of them, the star HD 49798, has been evaluated as 1.5 solar masses. According to our findings, *all* of these stars are binaries. The relevance of the other two items will appear as our examination of these stars proceeds.

During the interval between the supernova explosion that produced the white dwarf and the reentry of that star into the reference system, where it is subject to observation, the portion of the original material ejected into space at less-than-unit speeds has also undergone some changes. Immediately following the explosion, the density of the material moving outward was sufficient to carry everything in the vicinity along with it, and the visible object was a rapidly expanding cloud of matter. As the expansion proceeded, the density of the cloud decreased, and in time a point was reached where the outgoing matter passed through the interstellar material rather than carrying that material with it. Eventually the outward motion of the ejected matter came to a halt, and inward motion began under the influence of gravitation, as explained in Chapter 4.

The existence of the hot subdwarfs suggests that the turnaround time is less for the material dispersed in time than for the material dispersed in space, and that the hot star is visible for a time before there is any substantial inflow of material from the environment. But eventually the matter that is being pulled back by the gravitational forces begins falling into the star. The first material of this kind reaching one of these newly arrived white dwarf stars, the hot subdwarfs, encounters the extremely high temperature of this object, and is heated to such an extent that it is ejected back into the surroundings. Since both the incoming and the outgoing material are at a very low density, there is only a limited amount of interaction, and the cold material continues to flow inward through the outward moving matter.

When the incoming matter reaches the hot surface of the star it is not only heated to a very high temperature, but is also strongly ionized. The outgoing ionized matter emits visible radiation, and we therefore see a sphere of ionized matter centered on the young white dwarf. The radiation from ionized atoms occurs when they drop to a lower state of ionization, and as a consequence the greater part of it takes place after the ejected material has traveled far enough to lose a substantial part of its original ionization energy, and before that energy is all dissipated. This leaves a nearly invisible region in the interior of the sphere. To the observer, the resulting structure has the appearance of a ring. Such an object is a *planetary nebula*.

Here we see the significance of the observation, cited above, that some of the hot subdwarfs are central stars of planetary nebulae. According to our deductions from theory *all* of the hot subdwarfs will become central stars of planetary nebulae in due course.

The planetaries are all far distant from our location, and it is difficult to get an accurate observational picture of the complicated processes that are under way in them. Consequently, there is considerable difference of opinion as to just what is happening.

Although we seem to comprehend the broad outlines of their formation and development, much of what we see is confusing and not at all well understood.¹²⁷ (James B. Kaler)

The outward motion of the ionized gas in the typical large nebula is well established, and the general tendency is to take this as indicating that the central star, which is conceded to be a white dwarf, or on the way to becoming a white dwarf, is ejecting mass into its surroundings as a part of the process which, according to current ideas, will eventually reduce it to a burned-out cinder. This observed outward flow of matter seems, on first consideration, to define the nebula as an expanding cloud of material. But there are strong indications that this simple view is incorrect. One significant point is that the nebulae are not actually expanding at the rates indicated by the measured speeds of the outgoing matter. Indeed, some of the nebulae are not expanding at all. For instance, velocity measurements indicate that the diameter of NGC 2392, the Eskimo Nebula, is increasing at the rate of about 68 miles per second. But no definite increase in size is shown in photographs taken 60 years apart.¹²⁸

Our findings now indicate that the prevailing view of the nebulae as expanding structures is incorrect. Instead of being a rapidly dissipating cloud of material ejected from the central star in a single burst, or succession of closely spaced bursts, our analysis indicates that the planetary nebula is a relatively permanent ionization sphere through which the outgoing stream of material flows. We might compare it to the visible area of a river illuminated by the beam of a searchlight.

A report by M. and W. Liller concedes that "Very possibly, all planetary nebulae are ionization spheres,"¹²⁹ but contends that in general these ionization spheres are expanding, although at a slower rate than would be indicated by the measured velocities. The size of the ionization sphere depends on the temperature of the central star and on the density of the nebula, increasing with higher central temperature and decreasing with higher density. The temperatures of the central stars necessarily decrease from the 100,000 K initial level. There is little or no loss of matter from the planetary nebula system, since the initial speeds of the ejected matter, while high by terrestrial standards, are not anywhere near sufficient to carry the outgoing matter to the gravitational limit before being slowed down. In the meantime, additional matter is being drawn in from the environment. Thus the general trend of both temperature and density is in the direction of reducing the size of the ionization

sphere (the observable nebula). It does not follow, however, that this decrease is continuous and uniform throughout the planetary nebula stage. On the contrary, the flow conditions in the nebula are such that fluctuations of a major nature can be expected, particularly in the early portion of this evolutionary stage.

The inward flow of material toward the central star is not observable. Under ordinary conditions very diffuse material at great distances and low temperatures cannot be detected by any means now available. A part of this incoming matter is ionized by the radiation from the star, but the ionizing effect increases as the star is approached, and the transitions to lower ionization states that cause the emission of radiation are minimized. Radiation from the incoming matter is thus minor, and it has not been identified. We can, however, deduce that the initial inflow of the material, when the hot white dwarf first establishes a definite position in space, is relatively heavy, as the site of a recent supernova explosion is well filled with explosion products.

This relatively large amount of incoming matter encounters the maximum 100,000 K temperature, is strongly ionized on contact, and is ejected at a high speed. Thus a large ionization sphere is quickly established when the action begins. The outward movement of the relatively large amount of ejected matter retards the inward flow of matter to some extent. This has two effects. It reduces the amount of material reaching the central star, thereby reducing the amount of ejection, and diminishing the outward flow. Coincidentally, the incoming material that is being held back by the outward flow builds up a concentration in the regions beyond the ionization sphere. Eventually the reduced outward flow is unable to hold back this concentration of material that is being pulled inward by gravitational forces, and there is a surge of matter toward the central star. This recreates the original situation (at a somewhat lower level, since the temperature of the central star has decreased in the meantime), and the whole process is repeated.

During the time that the outward flow predominates, the density within the ionization sphere is decreasing, while because of the reduction in the inflow of cold matter, the surface temperature of the central star remains approximately constant. The ionization sphere therefore expands slowly. When the inward surge of matter occurs, these conditions undergo a rapid change. The density within the ionization sphere increases sharply, and the surface temperature of the central star decreases. The result is a rapid contraction of the ionization sphere. After these effects of the surge have run their course, the heavier outward flow and the expansion of the ionization sphere are resumed, but in the meantime the internal temperature of the central star has dropped, and the surface temperature does not regain its former level. The expansion therefore starts from a smaller size than before, and the next surge occurs before the size of the ionization sphere reaches its earlier maximum. Thus, as the successive expansions and contractions continue, the size of the nebula gradually

decreases. Eventually the open space in the center is eliminated, or at least drastically reduced. The older nebulae are therefore relatively small, and have filled, or partially filled, centers.

One observed phenomenon that tends to confirm the validity of the foregoing explanation of the general behavior of the planetary nebulae is the existence of faint outer rings in some of the nebulae. These are just the kind of remnants that would be left behind if there is a relatively rapid periodic decrease in the size of the ionization sphere, as indicated in the foregoing theoretical account of the process. The currently favored explanation is that the rings were produced by explosive outbursts from the central star that preceded an outburst to which the main portion of the nebula is attributed. But there is no evidence that such explosive outbursts occur, nor does present-day astronomical theory have any explanation of how they could originate.

This is only one of many conflicts between the pattern of evolution of the planetary nebulae, as derived from the theory of the universe of motion, and the view currently prevailing among the astronomers. In that currently accepted view, these nebulae are seen as expanding objects, and the largest ones are therefore regarded as the oldest. But this hypothesis is specifically contradicted by the temperature relations. Examination of the data reported for a selected group of "prominent" nebulae¹³⁰ shows that the temperatures of the central stars range from about 100,000 K to about 30,000 K. The sizes of the nebulae vary widely, but those members of the sample group with temperatures in the neighborhood of 100,000 K all have diameters of a minute of arc or more, while almost all of those at the lower end of the temperature range have diameters of less than 30 seconds. The idea that a "dying star" that "has come close to the end of its life . . . destined soon to become a white dwarf, the last stage before it disappears from view altogether"¹²⁹ is steadily increasing in temperature from 30,000 K to 100,000 K during the planetary stage is preposterous. Even on the basis of the astronomers' own theory, the temperature trend must be downward.

It is true that the *luminosity* of the central star increases substantially as the size of the nebula decreases. The data reported for the sample group show that at the high end of the range of nebular sizes the average magnitude of the central star is about 14. The four with Messier numbers have magnitudes 13.5, 14, 15, and 16.5. From this level the luminosities increase rapidly, and at the low end of the nebular size range the average magnitude is about 11. These are observed, rather than absolute, magnitudes, but the correction for distance, if available, would not change the general picture. Coincidentally, the *temperatures* of the central stars are decreasing. It is evident that what is happening here is that while the total emission is decreasing as the stellar temperature drops, a larger proportion of that total is coming directly from the central star, rather than being passed on to the nebula and emitted from there. The decrease in temperature is the salient feature of the change that takes place

with time, and it establishes the direction of evolution unequivocally.

Turning now to the question as to the location of the planetaries on the CM diagram, the first point to be noted is that we are now dealing with stars that are quite different from those on the upper side of the main sequence. As we saw in Chapter 6, these stars, Class D stars, as we are calling them, were dispersed in time by the supernova explosion, rather than being dispersed in space by the process with which we are more familiar. When they again become visible as stars they are expanding back toward the main sequence, instead of contracting. The color indexes and luminosities of these stars can be measured, and they can therefore be represented on a CM diagram. But, as we have already seen in the case of the Class C stars, the *other* variable properties of the stars do not necessarily maintain the same relations to the color index-luminosity function in the different star classes. For instance, the Class C mass at a given point in the diagram is usually quite different from the mass of a Class A star at that same point. The truth is that, with the exception of the spatial main sequence, which is common to all, the CM diagrams of the different classes of stars are *different diagrams*.

Fig. 4 and the accompanying discussion in Chapter 4 bring out the fact that the major properties of Class A stars, other than those on which the CM diagram is based, are specifically related to the variables of the diagram, so that the stars of this class are alike if they have the same position on the diagram. This is not true, in general, of a Class A star and a Class C star at the same location. Similarly, if the Class D central star of a planetary nebula occupies the same position in the diagram as a certain Class A star, this does not mean that the two are alike. On the contrary, they are very different, because of their dissimilarity in the properties that are not portrayed by the diagram.

This issue does not arise in the case of most of the stars of the dwarf classes, as they are well below the spatial main sequence, but some of the large hot subdwarfs and central stars of the planetary nebulae are close to, or even above, the location of the main sequence. It should be recognized that the diagram is misleading in these cases, and that the stars of these two dwarf classes are actually very different from stars whose motion is in space. In this volume, all Class D stars will be regarded as "below the main sequence" for the purposes of the discussion.

The temperature of about 100,000 K at which the white dwarf reaches the observable region is far above the level of the environment in the material sector of the universe. In order to reach a point of thermal equilibrium in that sector, the star must cool down to a level within the sector energy range (below unit speed). This cannot be accomplished in one continuous operation; a three-step process is required. Conversion to the one-dimensional material status can take place only on a single unit basis, in which a single unit of one-dimensional time motion converts to a single unit of one-dimensional space motion. The

star must first cool down to a limiting temperature where the individual atoms at the stellar surface are in the unit condition in time. This is the temperature which we have identified empirically as approximately 30,000 K. Here the transition from motion in time to motion in space takes place. The third step in the process, a further cooling to the equilibrium temperature, then follows.

From the foregoing, we find that the planetary nebulae are located on the conventional color-magnitude version of the H-R diagram between the two vertical lines drawn in Fig. 18, representing temperatures of 100,000 K and 30,000 K respectively. The plotted points are the locations of the planetary nebulae in the tabulation by G. O. Abell (reference 131). All of these points fall within the temperature limits defined by the specified lines.

For an understanding of the positions and evolutionary changes illustrated by Fig. 18 we need to review some of the findings of the previous volumes of this series with respect to natural units. According to the fundamental postulates of the theory of the universe of motion, the basic constituent of the universe, motion, is limited to discrete units. Since all physical phenomena in this universe are motions, combinations of motions, or relations between motions, it follows from the discrete nature of the units of motion that all of these subsidiary phenomena must also be limited to discrete units.

The basic units of space, time, mass, energy, etc., were evaluated in Volume I. However, these simple units are not directly applicable to complex phenomena. Here a *compound unit* usually applies, a combination of the simple primary units. For example, the primary unit of space has been evaluated as 4.56×10^{-6} cm. But within a unit of space there are compound motions in which the spatial units are modified by certain combinations of units of time. As a result, the phenomena in this region are not related to the simple units of space, but to a compound (or modified) unit of space that amounts to 0.0064 of the full-sized natural unit, or 2.92×10^{-8} cm.

Because of the general applicability of the discrete unit limitation, we can deduce that wherever we encounter a critical value of some kind, we are dealing with a compound unit, or a small number of such units. It is not usually possible to evaluate the compound unit in terms of the simple units of which it is composed until after the theoretical relations that are applicable have been clarified in considerable detail. For instance, in the case of the space units, the factor 0.0064 that relates the compound unit to the simple unit is something that one would not be likely to find unless he had a very good idea as to where to look for it. The development of the theory of the universe of motion has not yet been applied to the quantitative aspects of astronomical phenomena on an extensive enough scale to enable evaluating more than a limited number of the compound astronomical units. But the mere knowledge that some particular magnitude *is* a compound unit, or a small whole number of such units, is very often helpful.

In the present instance, we are able to make use of a feature of the

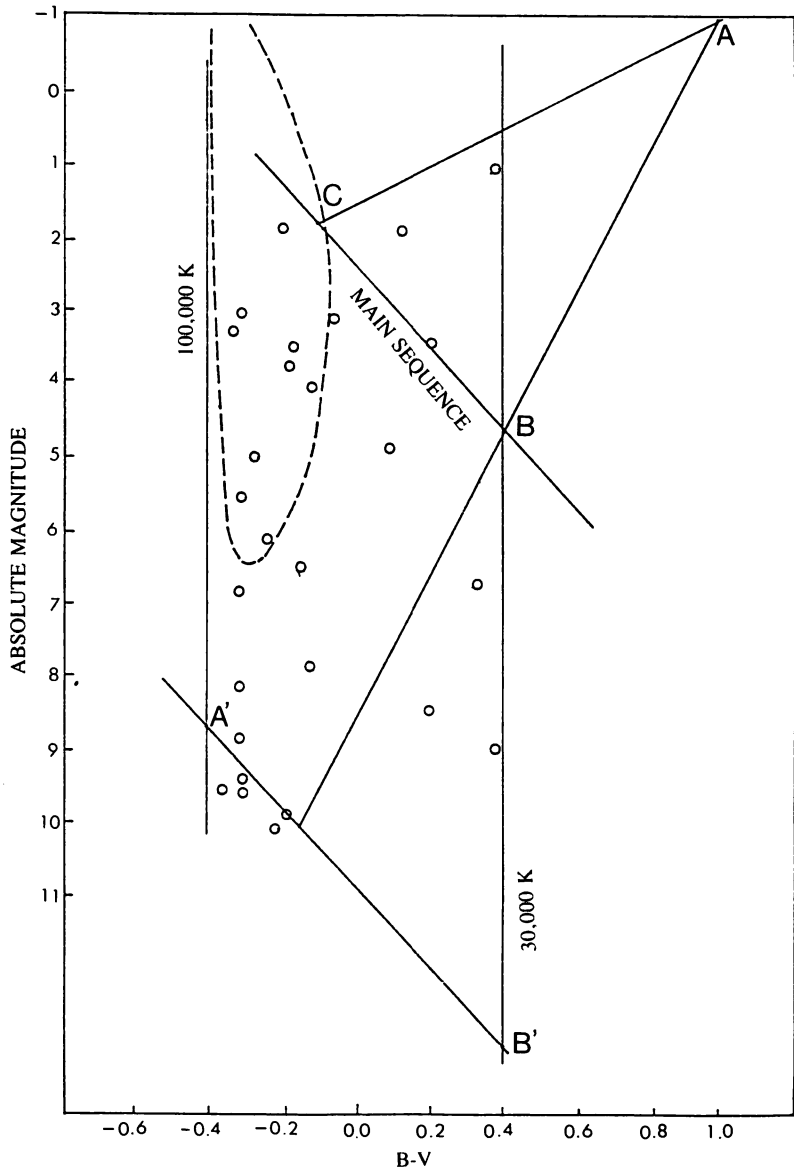


Fig. 18
Planetary Nebulae

evolutionary pattern of the globular clusters that was mentioned, but not discussed, in Chapter 8. As noted there, the difference in luminosity between point A and point B on the CM diagram, on the logarithmic scale, is twice the difference between point B and point C. Inasmuch as these points are all critical points in the evolutionary pattern, the difference in magnitude between any two of them is presumably n compound units, where n is a small whole number.

The nature of this compound unit has not yet been determined, but the logarithmic magnitude scale suggests a dimensional relation, and leads to the surmise that the magnitudes at points B, C, and A are 1, 2, and 3 respectively. There is, of course, a large hypothetical component in this conclusion, at the present stage of theoretical and observational knowledge, but we can treat it like any other hypothesis; that is, develop its consequences and compare them with observation. As will be seen in the discussion that follows, the consequences of this hypothesis do, in fact, agree with the available observational information. Within the limits to which the correlation has been carried, the hypothesis has been verified.

The particular value of this hypothesis is that it gives us a means of locating the critical points in the white dwarf section of the CM diagram. In the earlier volumes it was established that the boundary between motion in space and motion in time has a finite width, and that there are two natural units between the respective unit levels. It follows that if, as we have concluded, point B corresponds to one unit in the spatial direction (+1, we may say), then a point one unit lower on the extension of the line AB corresponds to zero, and point B', two units lower, corresponds to -1; that is, one unit in the temporal direction. The line A'B' parallel to BC is then the equivalent of the main sequence for motion in time.

With the benefit of this information we can now define the evolutionary paths of the planetary stars. Fig. 19 compares these paths with those of the giant stars. The line OAB is the evolutionary pattern of a giant star that has a mass of about 1.1 solar units at point B. Such a star originates with a smaller mass, but accretes material as it moves along line OA, and reaches the 1.1 mass level at point A. This is the critical density level, where the star acquires the ability to contract by means of its own gravitation, without the aid of outside forces. This contraction carries it down to the point of gravitational equilibrium at B.

This star that begins its life as a red giant is in a state of thermal equilibrium; that is, it is radiating the same amount of heat that it generates. But its density is extremely low, far below the level of stability. Its evolutionary course beyond point A, unless modified by accretion, is therefore along a line of constant central temperature *toward* the main sequence, the location of gravitational equilibrium. The early white dwarf, on the other hand, is already in a state of gravitational equilibrium, from the standpoint of gravitation in space, while it is too hot to be thermally stable. This star therefore moves

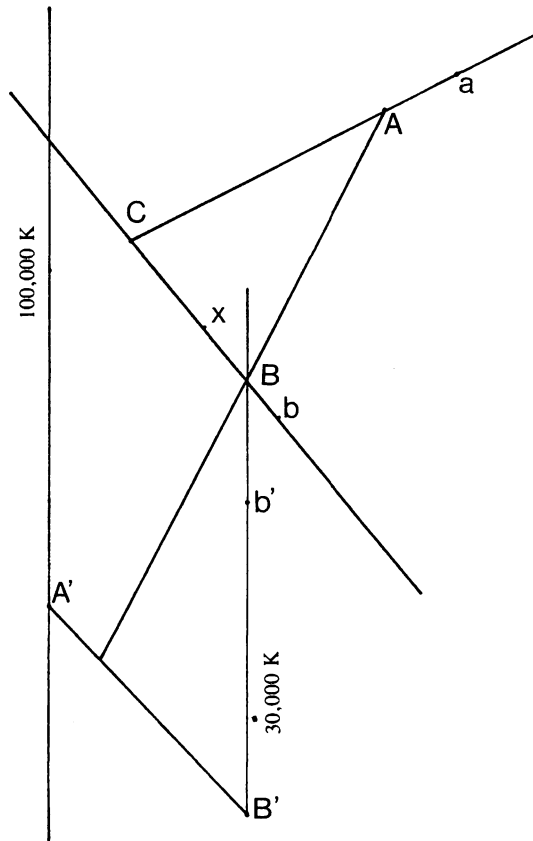


Fig. 19
Evolution of Planetaries

along the line of gravitational equilibrium for motion in time, the equivalent of the spatial main sequence, toward a condition of thermal equilibrium.

The (inverse) volume of the white dwarf star at any given surface temperature is determined by the mass. Thus the more massive stars reach the 100,000 K temperature level while their inverse volume, from which they radiate (a point that will be considered further in Chapter 12) is greater, and their luminosity is consequently higher. The incoming white dwarfs are thus distributed along the 100,000 K line in accordance with their masses. At the 1.1 level, identified as A' in Fig. 19, the white dwarf occupies a critical position somewhat similar to the critical density position at point A on the giant path. This white dwarf of 1.1 solar masses is the smallest star that has sufficient total thermal energy to

maintain the 100,000 K surface temperature in the gaseous type of gravitational equilibrium.

This critical mass star that originates at point A' moves down along the line A'B', gradually converting its outermost atoms from three-dimensional motion in time to one-dimensional motion in time. This conversion is completed at B'. Further cooling then transforms the one-dimensional motion in time at B' to one-dimensional motion in space at B. Thus the giant and dwarf stars of the same mass eventually arrive at the same point on the spatial main sequence.

Giant stars whose growth ceases at some point a between O and A follow a path ab parallel to AB, terminating at point b on the main sequence. Stars that continue adding matter beyond point A have a different evolutionary pattern, as previously explained. In the dwarf region it is the star with a mass *less* than 1.1 solar units that has a different pattern of evolution, one that will be examined in Chapter 12. Since the mass of the white dwarf is constant during its movement along the line of gravitational equilibrium, it follows that each mass has its own equilibrium line. Thus the equivalent of the main sequence for motion in time is a series of lines parallel to the spatial main sequence.

The larger stars that we are now considering originate along the 100,000 K temperature line at locations above point A'. Such a star moves along a path a'b' from a', the point of origin, to b', a point on the line B'B. It then converts to motion in space at point B in the same manner as the star of mass 1.1, but B is not a location of thermal equilibrium for the more massive star. A further movement along the main sequence is required in order to reach the point of thermal stability. The final position of this star in the CM diagram is a point somewhere between B and C, the exact location depending on the mass.

On the diagram, the movement from B to x, the final location, appears anomalous, as a decrease in temperature normally corresponds to a movement to the right. This is another illustration of the fact that the CM diagrams of stars of different classes, or even different sub-classes, are actually different diagrams. The temperature corresponding to a given color index is much lower on the spatial main sequence than on the equivalent path a'b' for motion in time. The movement of the Class D stars toward the left after reaching the spatial main sequence is not a temperature effect, but a result of this difference in the significance of positions in the diagram. The cooling star is actually at a considerably lower temperature in its final position at point x than it was at point b', even though it is farther to the left.

Inasmuch as the white dwarfs are contracting in time rather than in space, the spatial compression due to the gravitational motion toward the galactic center has no effect on these Class D stars. The evolutionary paths shown in Fig. 19 therefore meet at the globular cluster level of the spatial main sequence, rather than at the position of the galactic field stars. The final position, designated x, on the spatial main sequence is, however, subject to the gravitational shift, and

the last phase of the conversion from motion in time to motion in space includes an upward movement of 0.8 magnitudes, as well as the movement to the left from B to x. As noted in Chapter 10, the observed Class D pattern is strong evidence of the reality of the gravitational shift.

Observational information about the two classes of relatively large white dwarfs that we have been considering, the hot subdwarfs and their successors, the central stars of the planetary nebulae, is very limited, but the positions on the CM diagram indicated by the available data are entirely consistent with the evolutionary pattern that we have derived from theory. The locations of the hot subdwarfs as given by M. and G. Burbidge (reference 102) are outlined by the dashed line in Fig. 18. This indicated area is clearly consistent with the theoretical conclusions. As noted earlier, the locations of the representative group of planetary nebulae identified in Fig. 18 are also within the theoretical limits.

Because of their decrease in temperature, the movement of these nebulae on the CM diagram *must be*, at least generally, from left to right. (Even the adherents of conventional astronomical theory concede this. See, for instance, the diagram by Pasachoff, reference 132.) Some further confirmation of the theoretical findings can therefore be obtained by examination of the relation of the diameters of the planetaries on the Abell list to their locations on the diagram. Fig. 20 is a reproduction of Fig. 18, with the diameters in parsecs shown alongside the points indicating the locations. As might be expected, in view of the diversity of the conditions under which the nebulae exist, and to which the observations are subject, there are wide unexplained variations in the individual values, but the general trend is clear. Disregarding the group of nebulae below the line A'B', which are subject to some special considerations that we will examine in Chapter 12, there are 16 nebulae with an average diameter of 84 parsecs in the left half of the identified nebular region, and 7 nebulae with an average diameter of 47 parsecs in the right half.

Observational information on the masses of the planetary stars is minimal, but the little that is available is consistent with the existence of a lower limit at 1.1 solar masses, or at least not inconsistent with it. An average of 1.2 solar masses has been suggested.¹³³ As noted earlier, the mass of one of the pre-planetary stars, the hot sub-dwarfs, has been determined as 1.5 on the same scale. We will see in Chapter 13 that the mass of another star, which we will identify as a former planetary star, has been calculated at 2.1 solar masses. These results are too few in number to confirm the theoretical minimum, but they do point in that direction.

Inasmuch as this shortage of empirical information exists, in one degree or another, throughout the entire range of the white dwarf phenomena, it is again appropriate to call attention to the fact that the validity of the general principles and relations that have been, and will be, applied to explaining these phenomena has already been firmly established in physical fields where factual

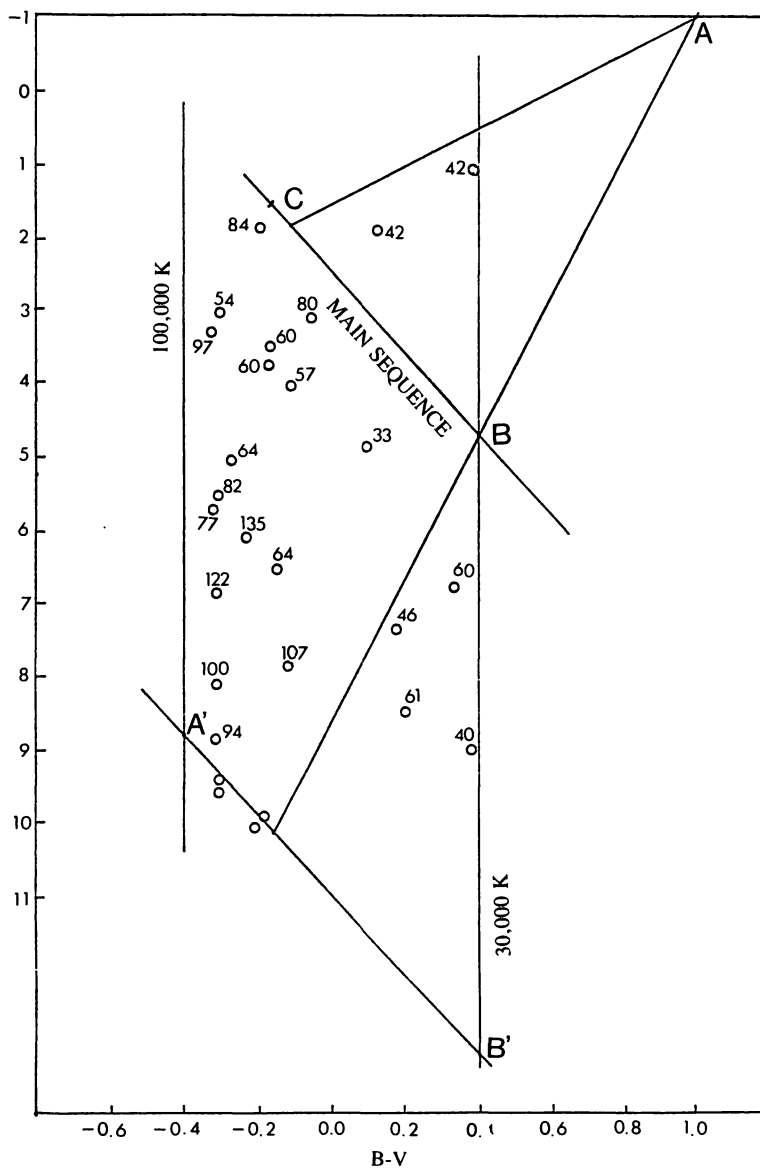


Fig. 20
Diameters of Planetaries

data are abundant and reliable. Thus, even though the correlations between theory and observation that are possible in such areas as that of the white dwarfs are too limited to provide positive confirmation of the validity of the theoretical conclusions, the fact that these conclusions are *consistent* with what is known from observation is sufficient, in conjunction with the validity of the principles on which they are based, to establish a strong probability that they are correct.

It was noted in Chapter 6 that some of the central stars of planetary nebulae are currently identified as Wolf-Rayet stars. The identification is based on their high temperatures and spectra that are similar to those of the massive Wolf-Rayets. In other respects these objects are quite different. As described by Smith and Aller, the central stars of the planetary nebulae are believed to have masses in the neighborhood of solar, and absolute magnitudes fainter than -3 , whereas the Wolf-Rayet stars in the other class are believed to average about ten solar masses and to have absolute magnitudes brighter than -4 . A comparison of typical stars of these two classes leads these authors to the conclusion that they have a "totally different evolutionary status." They admit that they "are led to wonder how many different stages of evolution can yield the Wolf-Rayet form of spectrum."¹³⁴

"It is a further problem," says Anne B. Underhill, "to understand . . . why this physical state may occur early in the life of a massive star (the Wolf-Rayet stars of Population I) and late in the life of a star of small mass (the Wolf-Rayet stars of the disk population)."⁷⁵ This problem is resolved by our finding that the planetary stage follows almost immediately after the Wolf-Rayet stage; that is, the true Wolf-Rayet is a late pre-explosion star, whereas the central star of a planetary nebula currently confused with the Wolf-Rayet is an early post-explosion star. The similarity of the spectra is no doubt due to the existence of very high temperatures in both cases, and to the presence, in both classes of stars, of matter from the stellar interiors that has been brought to the surface by explosive activity.

According to the general description of the dwarf star cycle given in Chapter 4, and the identification of the evolutionary pattern in Fig. 19, the white dwarfs ultimately make their way back to positions on the spatial main sequence. We have now traced the course of one group of these stars along lines parallel to the main sequence from their points of entry into the observable region to positions somewhere near the low temperature limit in the neighborhood of 30,000 K. As has been indicated, the next move will be upward toward the main sequence. Before discussing the nature of the change that takes place in this final dwarf stage, however, it will be advisable to examine another group of white dwarf stars that also has to undergo this final transition to the material status.

The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that proper record-keeping is essential for the integrity of the financial system and for the ability to detect and prevent fraud. The text also mentions the need for regular audits and the role of independent auditors in ensuring the reliability of financial statements.

The second part of the document focuses on the role of the accounting profession. It highlights the need for accountants to adhere to high standards of ethical conduct and to maintain their professional competence through continuous education. The text also discusses the importance of transparency and accountability in the accounting process.

The third part of the document addresses the challenges faced by businesses in the current economic environment. It discusses the impact of global economic uncertainty and the need for businesses to adapt to changing market conditions. The text also mentions the importance of innovation and the role of government in supporting business growth.

The fourth part of the document discusses the role of technology in the financial industry. It highlights the benefits of digitalization and the need for businesses to invest in technology to improve efficiency and reduce costs. The text also mentions the importance of cybersecurity and the need for businesses to protect their sensitive financial data.

The fifth part of the document discusses the role of the financial system in the economy. It highlights the importance of a stable and well-regulated financial system for economic growth and development. The text also mentions the need for financial institutions to be transparent and to provide high-quality services to their customers.

The sixth part of the document discusses the role of the government in the financial system. It highlights the need for government intervention to ensure the stability and integrity of the financial system. The text also mentions the importance of government regulation and the role of government in providing financial services to underserved populations.

CHAPTER 12

Ordinary White Dwarfs

The previous discussion of the white dwarf stars has been directed at the products of the Type I supernovae, the explosions that take place at the temperature limit to which matter is subject. As already mentioned, a similar explosion, known as a Type II supernova, takes place when matter reaches an age limit. This is intrinsically a more violent process, and in its extreme manifestations it produces results that are quite different from those of the Type I supernovae. Discussion of these results and the manner in which they are produced will be deferred to the later chapters. At this time we will want to note that under less extreme conditions the results of the Type II supernovae are identical with those of Type I, except that the products are smaller.

The explanation is that the unique character of the products of the extreme Type II supernovae is due to the ultra high level of the speed imparted to these products by the combination of a large explosion (that is, one involving a large star) and an extremely energetic process. The products of Type I supernovae do not reach this speed level, even though the exploding star is one of maximum size, because the process is less violent. Similarly, the products of a Type II supernova do not reach the ultra high level if the exploding star is small, even though they have the benefit of the very energetic process.

Although the age limit can be reached by stars of any size, and the white dwarf products of Type II explosions extend through a wide size range, the great majority of those that exist in the outer regions of the galaxies are small, simply because the great majority of the stars in these regions are small. Many of these small white dwarfs are below the minimum size of 1.1 solar masses that applies to the central stars of the planetary nebulae. Our next objective will be to examine the evolutionary course of these smaller stars, *ordinary white dwarfs*, as we will call them.

As we saw in Chapter 11, the 1.1 lower mass limit of the planetary nebula region is the white dwarf mass below which the energy content of the star is not sufficient to maintain a gaseous structure in gravitational equilibrium. This is analogous to the critical density of the giant stars. It should be understood that the term “giant” refers to the volume, not to the mass. Most of these giants are low mass stars. Such stars, whose first stage of evolution carries them along the path OA, are unable to reach the critical density in the dust

cloud (gaseous) condition, and have to call upon the compressive forces of the aggregate in which they are located to aid in developing a compact, gravitationally stable, core in order to increase the average density to the required level. What exists here is a situation in which the inward-directed forces operate to force the matter of the star into a gravitationally stable condition. When the star is too small for this condensation to take place in a single operation, applicable to the star as a whole, it proceeds on a two-component basis, in which one component, the central core, is compressed to the condensed gas state, while the remainder of the stellar aggregate continues on the gaseous basis, gradually converting to condensed gas as the star moves down toward the main sequence.

In the case of the white dwarfs there is no gravitational problem, as the white dwarf aggregate is always under gravitational control, but the smaller stars, those with masses less than 1.1 solar units, do not have enough energy content to maintain the surface temperature at 100,000 K in the gaseous state. Hence they, too, have to proceed on a two-component basis, developing a condensed gas component like that of the smaller stars of the giant class. However, the fact that the motion of the constituents of the white dwarf is in time rather than in space introduces some differences. Because of the inverse density gradient in the white dwarf stars this relatively heavy condensed gas component takes the form of an outer shell, rather than that of an inner core. Then, the presence of this shell reduces the radiation temperature to that of a condensed gas surface. This is the same surface condition that exists along the line B'B, the 30,000 K temperature line of the planetaries. Thus the 100,000 K line above point A' becomes a 30,000 K line below that level.

The existence of an outer shell has been recognized observationally, but because of the prevailing theory of white dwarf structure this has been interpreted as a zone of ordinary matter surrounding the hypothetical degenerate matter of which the white dwarf, according to current astronomical theory, is composed. Greenstein reports that there is a non-degenerate envelope about 65 miles deep.¹³⁵ On the basis of our findings, the thickness of the shell at the time of entry into the observable region depends on the size of the star. A white dwarf just below the critical 1.1 mass needs only a thin shell, but the required thickness increases as the mass of the star decreases.

As brought out in Chapter 11, the central star of a planetary nebula moves down the CM diagram along the line A'B', or a parallel line above it, to the level at 30,000 K where the energy content of the outer thermal units of this gaseous aggregate is on the boundary between motion in time and motion in space. Here the transition from units of temporal motion to units of spatial motion takes place. But since the ordinary white dwarfs have to develop an outer shell of condensed gas before they become observable, the energy content of their outer thermal units is already *below* the unit speed boundary. A transition to motion in space on the basis of the full-sized unit is therefore

impossible. These small stars have to cool to a lower critical temperature at which their outer thermal units are at the level of the smaller compound units of the condensed gas state, a state in which the atoms occupy equilibrium positions inside unit distance, in what we have called the time region.

The 30,000 K and 100,000 K temperatures along the line at the left of the CM diagram are critical values in the sense in which this term was used in the discussion of the luminosity scale of the diagram. We may therefore deduce by analogy with the situation in the region above the main sequence that the drop from 100,000 K to 30,000 K at the point A' involves one of the compound natural units of luminosity. The 30,000 K equivalent of the line A'B' is then a parallel line one unit lower in the diagram. This line constitutes the lower boundary of the zone occupied by the ordinary white dwarfs.

Above point A' the constituents of the white dwarf stars are moving freely in time; that is, they constitute gaseous aggregates in time. It follows that they radiate from the surface corresponding to an inverse volume. The more massive stars of this group (the hot subdwarfs and the planetary stars) have the greater inverse volume and are therefore the more luminous. Below point A' the outer layers of the stars are in the condensed gas state, in which they are confined within limited volumes of space. These stars radiate from the spatial surface, the surface corresponding to a direct volume. The more massive stars of this class have the larger inverse volume, and therefore the smaller direct volume (a theoretical conclusion that, as we have noted earlier, is confirmed observationally). Consequently, they are *less luminous than the smaller stars of the same class*.

There may be some question as to why there should be a difference between the radiation pattern of the gaseous state and that of the condensed gas state when the motion is in time, since we do not encounter any such difference in dealing with motion in space. The stars on or above the spatial main sequence radiate in space regardless of their physical state. The answer to this seeming contradiction is that condensed gas aggregates radiate in time if they are condensed in time, whereas they radiate in space if they are condensed in space. The outer shells of the white dwarfs condense in space.

From their initial locations along the entry line, the cooling ordinary white dwarfs move down the CM diagram along lines parallel to the spatial main sequence in the same manner, and for the same reasons, as the planetary stars, within the relatively narrow band between A'B' and the lower zone boundary. Since the radiation from these stars is in space, the color-temperature relation applicable to this radiation is the same as that which applies to the stars of the spatial main sequence. The evolutionary lines of the ordinary white dwarfs therefore continue to their individual temperature limits, rather than terminating at the extension of the low temperature limit of the planetaries.

Consideration of the question as to the location of these low temperature limits of the ordinary white dwarfs will be deferred to the next chapter. At this

time we will merely note that the evolutionary lines followed in the cooling of these stars do not reach the position of the lower portion of the spatial main sequence, which bends sharply downward beyond 4000 K. James Liebert reports that there is a cut-off between magnitudes 15 and 16. This fact that the range of the white dwarfs stops short of the main sequence has come as an unwelcome surprise to the astronomers. Greenstein makes this comment:

An anomaly has been found in the number and relative frequency of cool, red white dwarfs. It has been expected that these would be very common, but, in fact, objects more than 10,000 times fainter than the sun are rare.¹³⁶

Main sequence dwarfs are observed all the way down to about magnitude 19, and it has been anticipated that the white dwarf population would extend to comparable levels. The observed cut-off at a higher luminosity confronts astronomical theory with an awkward problem. The evolutionary sequence, according to orthodox ideas, is protostar to main sequence star to red giant to white dwarf to black dwarf. One of the biggest problems that arises in the attempts to reconcile this theoretical sequence with the observations is how to account for the changes in mass that are required if this sequence is followed. As already noted, the theorists are experiencing major difficulties in accounting for the reduction in mass that is necessary if the red giant is to evolve into a white dwarf. They have no explanation at all for an *increase* in mass during the evolution of the star. The existence of main sequence stars smaller than the white dwarf minimum thus puts them into a difficult position. Liebert, arguing from the premises of accepted theory, states that the observed cut-off implies either (1) an error in the calculations, or (2) a decreased white dwarf birthrate about 10^{16} years ago.¹³⁷

In the context of the theory of the universe of motion aggregates of intermediate speed matter are produced in all sizes from the maximum downward. But the smaller aggregates are unable to complete their consolidation into single compact entities. As explained in Chapter 7, in connection with the formation of planetary systems, the pattern of gravitational forces in the aggregates of intermediate speed matter favors complete consolidation of the larger aggregates, but becomes more favorable to multiple products as the total mass decreases. On this basis, the reason for the absence of white dwarfs below a mass of about 0.20 solar units is not that white dwarf aggregates of smaller sizes do not exist, but that these smaller aggregates are not able to complete their consolidation, and remain as groups of objects of less than stellar size.

The existence of this lower mass limit applying to the white dwarfs is one of the reasons for the big difference in luminosity between the planetary stars and the ordinary white dwarfs that has puzzled the observers. As Richard Stothers

puts it, there is a “luminosity gap” between the coolest planetary star and the hottest of the ordinary white dwarfs.¹³⁸ Some attempts have been made to explain this gap in terms of stellar composition. Greenstein, for instance, tells us that

The only possible explanation of their low luminosity is that hydrogen must now comprise less than 0.00001 of the mass of a dwarf star.¹³⁵

Like so many other astronomical pronouncements, what this assertion really means is that its author is unable to find any other explanation within the limits of currently accepted theory. From the theory of the universe of motion we find that the “gap” between the luminosities is mainly due to the reduction in the luminosity of the ordinary white dwarfs by reason of the outer shell of condensed gas that characterizes these stars. The luminosity difference is increased by the existence of the mass minimum, as this eliminates the small stars that would be the most luminous members of this class.

We can now see the significance of the group of planetary nebulae immediately below the line A'B' on the CM diagram. These are stars that are small enough to require an outer shell, but so close to the dividing line that the shell is too thin to block much of the radiation from the interior. These out-of-place planetaries are found only in a very limited region of the diagram, because as soon as they cool a little more and move down the evolutionary path a short distance the shell thickness increases enough to cut off the planetary type of radiation.

In our examination of the behavior of ordinary white dwarfs we will, as usual, draw upon various sources in the astronomical literature for the observational information that is needed, but the specific comparisons with the theoretical pattern will deal mainly with a group of 60 white dwarfs on which all of the major physical properties have been determined—absolute magnitudes and color indexes by J. L. Greenstein (reference 139), and masses and temperatures by H. L. Shipman (reference 140). Fig. 21 is the CM diagram for this group of stars.

All but three of the masses of the sample group fall within the evolutionary band that has been identified. The average decrease in luminosity is more rapid than that indicated by the theoretical evolutionary lines, but this faster drop is due to known causes. At the upper end of the evolutionary band the entire distribution of masses is shifted upward to some extent. In this early white dwarf stage, when the outer shells are relatively thin, some of the radiation from the interior is evidently penetrating the shell, increasing the luminosity beyond the normal levels. This is a weaker form of the same effect that was noted in connection with the existence of planetary nebulae below the line A'B'. In the remainder of the band the average luminosity gradually drops away from the theoretical line in the same manner, and for the same reason,

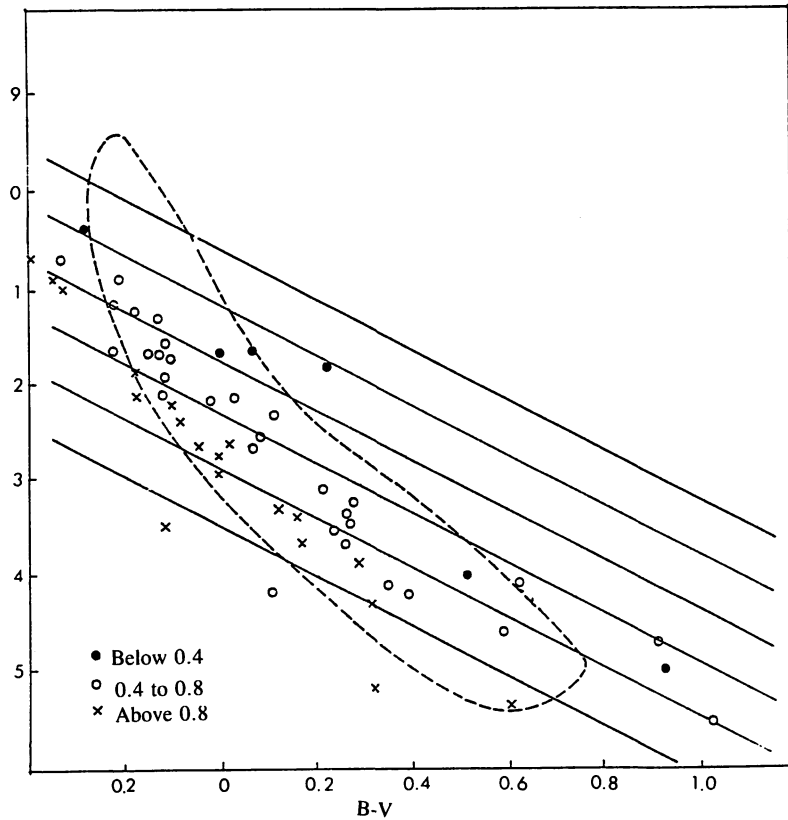


Fig. 21
Ordinary White Dwarfs

that the spatial main sequence turns downward in its lower sections. This is a result of the gradual decrease in the frequencies of the radiation from the stars, which shifts more and more of the radiation into the optically invisible ranges as the temperature drops.

The general relation between mass and luminosity is definitely inverse, as required by the theory. While the positions of the individual members of the three mass groups identified by symbols in Fig. 20 are somewhat scattered, those of the smaller stars are all in the upper portion of the populated areas of the diagram, while those of the group with masses above 0.8 solar units are all in the lower portion. Most of the stars of the intermediate group, those with masses between 0.4 and 0.8, are close to the average.

As noted earlier, the lower section of the evolutionary band of the ordinary white dwarfs is not cut off at the 0.4 color index in the manner of the planetary stars, but continues on to a limit somewhere in the neighborhood of magnitude 16. The faintest star in the sample group has magnitude 15.73. The number of stars below the 0.4 color index in this sample group is rather small, but this is undoubtedly a matter of observational selection. All of the white dwarfs are relatively dim, and the observational difficulties resulting from this cause increase as the stars age and become less luminous. The available data on these objects therefore come preferentially from the earlier, more luminous, stars. As we will see later, “the most numerous kind of white dwarf” is the cool, dim type of star that populates the lower luminosity range, beyond a color index of 0.3 or 0.4, the same range that is so poorly represented in the sample group. The question as to what happens to the stars that reach the lower limit of this white dwarf evolutionary path will be the subject of discussion in the next chapter.

The foregoing findings as to the evolutionary course of the ordinary white dwarfs now enable us to extend the theoretical CM diagram of the planetary stars, Fig. 19, to include the stars of this smaller class, and to show how the zone occupied by these ordinary white dwarfs is related to the positions of the other classes of stars. For comparison, this enlarged diagram, Fig. 22, also indicates the location of the ordinary white dwarfs as identified in the illustration accompanying the previously cited article by M. and G. Burbidge.¹⁰²

The spectra of the white dwarfs show a considerable amount of variation, and on the basis of this variability these stars are customarily assigned to a number of different classes. Greenstein distinguishes nine classes, and the designations that he has applied in his tabulation¹⁴¹ are in general use. However, the basic distinction appears to be between the hydrogen-rich stars, designated as Class DA, a few hybrid classes, particularly DAF, and the balance, which are helium-rich. Much of the discussion in the literature is carried on in terms of DA and non-DA. H. M. Van Horn, for instance, comments that “The existence of white dwarfs with non-DA (hydrogen deficient) spectra has not yet been satisfactorily explained.”¹⁴²

Because of this lack of an acceptable explanation, the astronomers have not reached any consensus on the question as to whether the observed differences that have led to the distinction between the various classes reflect actual differences in composition, or are products of processes that take place during the evolution of the stars. The theoretical development in this work leads to the conclusion that these differences are primarily evolutionary. Before discussing these theoretical reasons *why* changes take place in the atmospheres of the white dwarfs as they age, we will first examine the evidence which demonstrates that these stars do, in fact, undergo significant changes as they progress along their evolutionary paths.

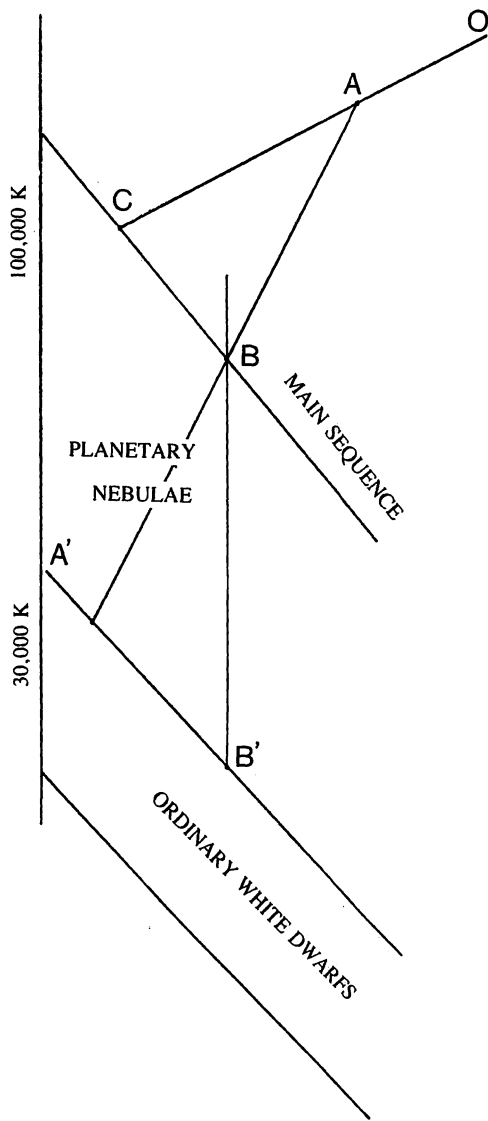


Fig. 22
Locations of Class D Stars

In this case, as is usual in astronomy, the observations give us only what amounts to an instantaneous picture, and do not specifically indicate whether the regularities that are observed are time related. This is the reason for the existing uncertainty. But the new information developed in the foregoing pages has now provided a basis from which we can approach the question. As shown in Fig. 21, the ordinary white dwarfs of different masses follow parallel cooling lines on the CM diagram, with the smaller stars at the top of the luminosity range and the larger ones at the bottom. From this demonstrated fact that the lines parallel to the main sequence in the white dwarf region of the diagram are lines of equal mass, as the theory requires them to be, it follows that on a plot of mass against the B-V color index, Fig. 23, where the lines of equal mass are horizontal, the distance from the left side of the diagram along any one of these lines represents time; that is, it measures the amount of evolutionary development. The general trend obviously is from the hydrogen-rich stars, Class DA, to the classes marked \times on the diagram, the DC group, we might call them, all of which are classified by Shipman as helium-rich.

At temperatures above a dividing line in the vicinity of 8000 K the great majority are DA stars, with only about ten percent in the DC group. Below this temperature all of the stars fall into the DC group or a transitional class. A specific segment of the general transition from the DA status to that of the DC group can be recognized in the larger stars. Greenstein defines a class DAF, in which the hydrogen lines characteristic of the DA spectrum are weaker, and Ca II lines are present. This is followed by Class DF, in which Ca II appears, but hydrogen does not. Evolution through the entire sequence DA, DAF, DF is taking place in stars with mass above 0.50.

Next let us turn to the question as to what causes this shift from a hydrogen atmosphere to a helium atmosphere as the white dwarf ages. The astronomers have no answer to this question. As explained by James Liebert in a 1980 review article, "The existence of nearly pure helium atmosphere degenerates over a wide range of temperatures has long been a puzzle."¹³⁷ The "cooler helium-rich stars," he reports, are "the most numerous kind of white dwarf." Furthermore, the concentration of still heavier elements in the atmospheres of these stars is also too high to be explainable on the basis of current astronomical theory. Since the interior of the white dwarf is in an unusual physical state (this is true regardless of whether the matter is "degenerate," as seen by conventional theory, or expanding into time, as seen by the theory of a universe of motion), the matter in the atmosphere, which is normal, must have been accreted from the environment. Liebert points out that

The metals in the accreted material should diffuse downward, while hydrogen should remain in the convective layer. Thus the predicted metals-to-hydrogen ratios would be *at or below solar* (interstellar) values, yet real DF-DG-DK stars have calcium-to-hydrogen abundance

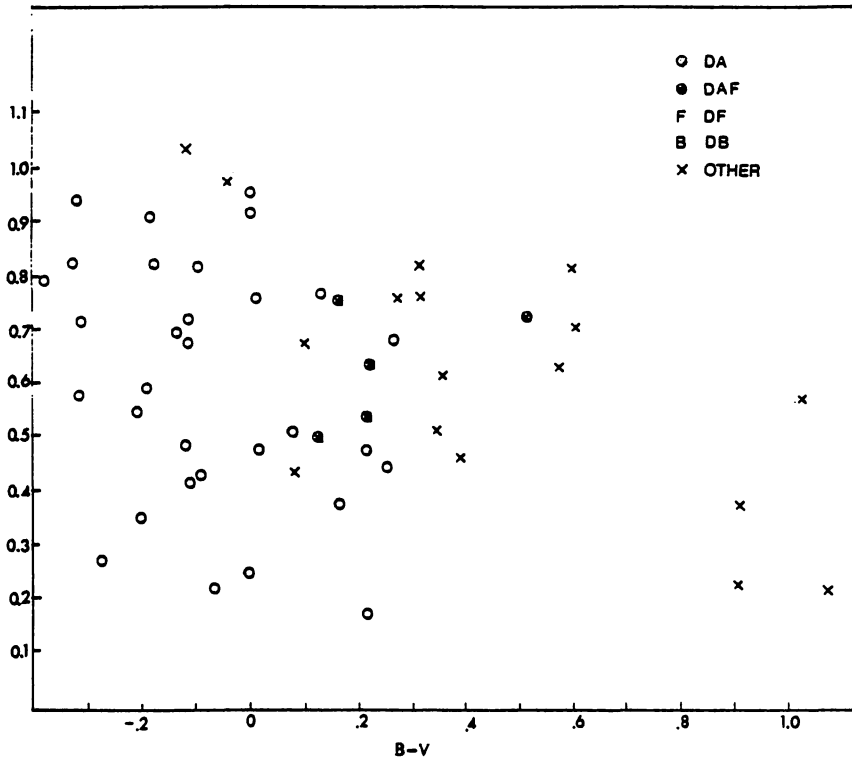


Fig. 23
White Dwarf Masses

ratios ranging from about solar to well above solar.¹³⁷

The only possibility that Liebert is able to suggest as a solution to the “puzzle” is that the hydrogen accretion must be “blocked by some mechanism.” This is clearly a “last resort” kind of hypothesis, lacking in plausibility, and wholly without factual support. On the other hand, the explanation of the structure of the white dwarf derived from the postulates that define the universe of motion *requires* just the kind of a situation that is found by the observers. As Liebert says, on the basis of conventional theory, “the metals in the accreted material should diffuse downward.” But on the basis of the theory described in this work, the center of the white dwarf is the region of *least* density. According to this theory, then, the *hydrogen* should “diffuse downward,” and the *metals* should remain in the outer regions. The helium, too, should remain behind while the lighter hydrogen sinks. The observed distribution of the three components, hydrogen, helium, and metals, in the classes of stars identified by Liebert is exactly what the theory of the universe of motion tells us it should be in the older white dwarfs.

The presence of hydrogen atmospheres in the earlier stars, and the gradual nature of the transition to helium atmospheres are due to slow transmission of physical effects across any boundary between motion in space and motion in time. Originally, the white dwarf, located in the middle of the debris left by the supernova explosion, was able to accrete matter at a relatively rapid rate. Inasmuch as these accreted explosion products consisted mainly of hydrogen, the accretion gave the white dwarf a hydrogen atmosphere. But there was a small proportion of helium and other heavier elements in the accreted matter. Long-continued preferential movement of hydrogen into the stellar interior therefore resulted in a gradual increase in the proportion of heavier elements in the atmosphere. Meanwhile the accretion rate was decreasing as the residue from the explosion was swept up by the white dwarf and its giant companion. Eventually the incoming hydrogen passed into the interior of the star as fast as it arrived. Beyond this point, which we located in the vicinity of 8000 K, the atmospheres of the white dwarfs are predominantly helium. In view of the complete inability of the astronomers to find any tenable explanation of these helium atmospheres within the limits of accepted physical and astronomical theory, the agreement with the theory of the universe of motion is impressive.

This is an appropriate point at which to emphasize one of the most significant aspects of a *general* physical theory, one that derives all of its conclusions in all physical fields by deduction from a single set of basic premises, independently of any information from observation. The development of such a theory not only produces explanations for *known* phenomena that have hitherto resisted explanation, but also, because of its purely theoretical foundations, is able to supply explanations in advance for phenomena that have not yet been discovered. Items of this anticipatory character have had

only a minor impact on the presentation in the preceding pages of this volume, as the subject matter thus far covered has been confined almost entirely to phenomena that were already known prior to the first publication of the theory of the universe of motion in 1959. But the remainder of this volume will deal mainly with astronomical phenomena that have been discovered, or at least recognized in their true significance, since 1959. The explanations that will be given for these phenomena will be taken directly from the 1959 publication, or derived by extension of the findings described therein. One entire chapter (Number 20) will be devoted to describing the predictions made in 1959 with respect to the origin and properties of a then unknown group of objects that are now identified with the quasars, pulsars, and related objects.

The phenomenon that we are now considering, the existence of helium atmospheres in certain classes of white dwarf stars, is a more limited example of the same kind of anticipation of the observational discoveries. Here the explanation was provided before the need for it was recognized. The essential feature of this explanation is the inverse density gradient. The existence of this inverse gradient is not an ad hoc assumption that has been formulated to fit the observations, in the manner of so many of the "explanations" offered by conventional theory. It is something that is definitely required by the basic postulates of the theory of the universe of motion, and was so recognized, and set forth in the published works, long before the existence of the helium atmospheres was reported by the observers, and the need for an explanation of this seeming anomaly became evident. The 1959 publication stated specifically that "The center of a white dwarf star is the region of lowest density."

Once the existence of the inverse density gradient was recognized, the presence of helium atmospheres in the older white dwarf stars could have been deduced, independently of any observations, if the investigations had been extended into more detail. This was not feasible as a part of the original project, because of the limited amount of time that could be allocated to astronomical studies in an investigation covering the fundamentals of all major branches of physical science. The answer to the problem of the helium concentration was, however, available for immediate use as soon as the problem was specifically recognized. In the pages that follow, this experience will be repeated time and time again. We will encounter a long succession of recent discoveries— some of a minor character, like the helium atmospheres; others that have a major significance to astronomy—and we will find simple and logical explanations of these discoveries ready and waiting in the physical principles that were previously derived from the postulates of the theory of the universe of motion.

This ready availability of deductively derived answers to current problems is something that conventional astronomical theory does not have. The astronomers first have to make the discovery, and then look for an explanation

of what they have found. Almost all important new discoveries come as surprises. Thus it is to be expected, in a rapidly growing field of knowledge, that there will be many phenomena that are still unexplained, or not satisfactorily explained, in terms of accepted theories and concepts. This situation is not looked upon as particularly serious, inasmuch as explanations of a more or less plausible character can reasonably be expected to be forthcoming for most of these items as more observations are made and the general level of knowledge in the relevant areas rises. But the prevalence of these issues of a work-in-progress nature tends to obscure the fact that among the unexplained phenomena there are some that clearly *cannot* be reconciled with the accepted theories, and therefore provide definite proof that there is something seriously wrong in the currently prevailing structure of theory.

Spontaneous movement of heavy atoms against the density gradient does not occur in the real world. Technetium *cannot* rise from the core of a normal star to the surface through an overlying volume of hydrogen. Helium and the metals *cannot* remain on the surface of a normal star, or a highly condensed star, while hydrogen sinks to the center. Inasmuch as the observations show that technetium *is* present in the surface layers of some stars, and the heavier elements *do* remain in the surface layers of some of the white dwarfs, it is evident that the current theories are wrong in some essential respects. In the first of these cases, there is adequate evidence to show that technetium is present in stars of normal characteristics; that is, matter is not being ejected from the interiors explosively. It then follows that the technetium is *not* produced in the core of the star in accordance with the prevailing ideas. In the white dwarf situation, there is adequate evidence to demonstrate that the concentration of heavy elements in the outer layers of certain classes of these stars is greater than that in the matter that is being accreted from the environment. Here, then, the hydrogen is preferentially sinking into the stellar interior. In this case it necessarily follows that the white dwarf is not a normal star, or a star composed of “degenerate” matter, but a star with an inverse density gradient.

CHAPTER 13

The Cataclysmic Variables

The white dwarf situation is a good example of the way in which an erroneous basic concept can cause almost endless confusion in an area where the information from observation is erroneously interpreted. This is one of the two most misunderstood areas in astronomy (aside from cosmology, which belongs in a somewhat different category), and it is significant that the other badly confused area, the realm of the quasars and associated phenomena, is another victim of the same basic error: a misunderstanding of the cause of the extremely high density of such objects as white dwarfs and quasars.

The wrong conclusion as to the nature of the very dense state of matter leads to an equally wrong conclusion as to the ultimate destiny of the stars that attain this state: the conclusion that they must, in the end, sink into oblivion as black dwarfs, cold, lifeless remnants that play no further part in the activity of the universe. This is the basis for the assumption, already discussed, that the white dwarfs must have evolved from the red giants. Extension of this line of thought then leads to the conclusion that, except for “freaks,” the stars of the high density classes should line up in some kind of an evolutionary sequence. As previously noted, the position of the planetary nebulae in the CM diagram has been interpreted by the astronomers as indicating that they are the first products of the unidentified hypothetical process that carries the red giants into the white dwarf region. It then follows that the central stars of the planetary nebulae must evolve into the ordinary white dwarfs.

Shklovsky regards this as incontestable. “There can be no question,” he says, “but that the stable object into which the nucleus of a planetary nebula evolves should be a white dwarf.”¹⁴³ But even this essential step in the hypothetical evolutionary course runs into difficulties. Aller and Liller give us this assessment of the situation:

Our evidence indicates that they [the central stars of the planetary nebulae] evolve into white dwarfs, but we do not yet know whether they represent an intermediate stage for most stars or not. Neither do we know from what specific kinds of stars they may evolve.¹⁴⁴

This problem persists all the way down the line. The theorists not only have

difficulty in explaining how the planetaries evolve from the red giants, and how the ordinary white dwarfs evolve from the planetaries; they are also confronted with the problem of how to account for the existence of a variety of high density objects for which their evolutionary sequence has no place. The novae, for instance, must fit into the picture somehow. But there does not seem to be any place for them in the astronomers' version of the evolutionary path. "Nova outbursts are too rare to be a typical stage in stellar evolution,"¹⁴⁵ says Robert P. Kraft. Because of the lack of any explanation consistent with the accepted theories of stellar evolution, there is a rather general tendency to dismiss the novae and related objects, the *cataclysmic variables*, as aberrations. For example, one astronomy textbook offers this comment:

Very little is known about the reason for a nova's outburst. It appears that something has gone wrong with the process of nuclear energy generation in the star.¹⁴⁶

Development of the theory of the universe of motion now shows that the planetaries and the ordinary white dwarfs follow parallel, rather than sequential, evolutionary paths. All of these dwarf stars enter the observable region along a critical temperature line at the left of the CM diagram, and move downward and to the right along parallel lines as they cool (evolutionary stage 3). On reaching the temperature at which a transition to motion in space takes precedence over further cooling of the atoms moving in time, a temperature that is determined by the stellar mass, each star converts to motion in space. This change takes it upward on the CM diagram (evolutionary stage 4). The general nature of the conversion process is the same for all of these stars, but the specific character of the observable results depends on the magnitudes of the factors involved. Our next objective will be to examine the details of this process.

As successive portions of the intermediate speed matter of which the two classes of white dwarf stars are composed cross the unit speed boundary in their continuing loss of thermal energy, they form local concentrations of gas—bubbles, we may say—with particle speeds in the range below unity. Because of the inverse density gradient in the interior of the white dwarf star, these gas bubbles move downward to the center, the location of lowest density, and accumulate there. Some interchange takes place between the gas and the surrounding intermediate speed matter, tending to convert part of the gas back to intermediate speeds, but this interchange is slower than the oppositely directed movement across the unit boundary that produces the gas in the outer regions. A gas pressure therefore builds up at the center of the star. When this pressure is high enough, the compressed gas breaks through the overlying material, and the very hot matter from the interior is exposed briefly at the

surface of the star, increasing its luminosity by a factor that may be as high as 50,000. The star also becomes an x-ray emitter. The significance of this emission will be discussed in Chapter 19.

Within a relatively short time (astronomically speaking) the small amount of matter brought to the surface by the outburst cools, and the star gradually returns to its original status. A white dwarf is inconspicuous and, since the first observed events of this kind could not be correlated with previously identified objects, they were thought to involve the formation of entirely new stars. As a result, the inappropriate term *nova* was applied to this phenomenon.

From the foregoing description it is apparent that the nova process is periodic. As soon as one gas accumulation is ejected, the compressive and thermal forces in the interior of the star begin working toward development of a successor. Inasmuch as the gravitational forces operating within the star are gradually expanding it toward the condition of equilibrium for motion in space represented by the spatial main sequence (that is, they are drawing the constituent atoms closer together in time), the resistance to the gas pressure that builds up in the center of the star decreases as the star moves through this stage of its existence. The decreasing resistance shortens the time interval between explosions. The first event of this kind may not occur for a very long time after the beginning of the observable life of the star, but as the star approaches closer to the point of full conversion to motion in space the time interval decreases, and a number of novae have repeated within the last 100 years.

Novae are relatively infrequent phenomena, and observationally difficult because of the relatively short duration of the active period, and the rapid changes that take place during this time. Meaningful information about them is consequently limited. The theoretical conclusions with respect to this stage of the evolution of the stars on the dwarf side of the main sequence can therefore be compared with observation only to a very limited extent. We will have to be content, in most cases, with a showing that the theoretical findings are not inconsistent with what has been observed.

Two of the brightest novae, T Coronae Borealis and RS Ophiuchi, are in the class known as *recurrent novae*, having repeated three or four times during the period in which they have been subject to observation. This is another name that is not very appropriate, as some novae of the more common "classical" type have also been observed to repeat their outbursts, and theoretical considerations indicate that all will eventually repeat many times. T Coronae is estimated to have a mass of 2.1 solar units,¹⁴⁷ which puts it, and presumably RS Ophiuchi, in the class of the larger white dwarfs, those that were formerly the central stars of planetary nebulae. This large mass is consistent with the high luminosity of the two novae that have been mentioned.

The nature of the nova process is the same regardless of the size of the star

that is involved. In all cases there is a pressure build-up that eventually breaks through the overlying layers of the star. But there are differences in the rate of pressure increase, and in the weight of matter through which the confined gas must force its way in order to escape, and the variability in these factors results in major differences in the character of the outbursts from different classes and sizes of stars. In the white dwarfs of the larger (planetary) class, the luminosity and temperature changes required to move a star from the point on the evolutionary line where it begins its final transition to motion in space to the appropriate main sequence position on the line segment BC are relatively small, averaging about three magnitudes, and they are accomplished quite rapidly. This accounts for the short interval between the outbursts of these stars.

On the other side of the dividing line the situation is quite different. The first stars of the smaller class, the ordinary white dwarfs, not only enter the observable region at a much lower luminosity, but undergo a greater decrease in luminosity and temperature as they cool, so that when they arrive at the point where they are ready to begin the transition from motion in time to motion in space they have a long way to go, as Fig. 21 clearly indicates. The time between outbursts is correspondingly long. On the other hand, the magnitude of the outburst is not related to the amount of energy decrease involved in the transition, but to the size of the star, which determines the resistance to escape of the confined gas. Even the largest of the novae produced by ordinary white dwarfs are therefore less violent than those of the T Coronae class, although their range of magnitudes is greater. Initially they repeat only at very long intervals, too long for more than one event to have occurred during the time that observations of these phenomena have been carried on.

Novae are classified by the observers as slow, fast, or very fast, depending on the rate at which the luminosity develops and returns to normal. Aside from details of the spectra, which are not being covered in this work, available quantitative information about these objects includes the maximum and minimum luminosity, together with the difference between the two: the total luminosity range. The distances to the novae are not known, and the absolute magnitudes are therefore unavailable. The most significant luminosity measurement is the total range, which is independent of the distance, except to the extent that there has been absorption of light in passing through the intervening matter. Table III compares the ranges of the group of novae tabulated by McLaughlin (reference 148) with the assigned classifications and with the number of days required for the luminosity to decline seven magnitudes, a rough check on the validity of the classification.

Some general conclusions can be drawn from this information. Theoretically the earliest outbursts of the largest novae should be the fastest, and should have the maximum magnitude range, since these largest stars are at the bottom of

Table III

NOVAE

Nova	Range (magnitudes)	Class	Decline (days)
CP Pup	16.6	VF	140
V450 Cyg	>14.0	S	—
DQ Her	13.6	S	8880
EL Aql	13.5	F	—
GK Per	13.3	VF	300
CP Lac	13.2	VF	154
V476 Cyg	12.5	VF	170
V603 Aql	11.9	VF	260
Q Cyg	11.8	VF	250
RR Pic	11.5	S	1000
CT Ser	>11.0	F?	—
V630 Sgr	11.0	VF	123
T Aur	11.0	S	1800
V528 Aql	10.7	F	—
DK Lac	10.5	F	500
V465 Cyg	10.1	S?	—
V360 Aql	>10.0	VF	—
V606 Aql	9.9	F	320
DL Lac	9.8	F	300
V604 Aql	>9.2	F	230
XX Tau	>9.0	F	<500
V356 Aql	9.0	S	1100
HR Lyr	8.7	S	600
Eu Ser	>8.6	F	70
T Cr B*	8.6	VF	300
DM Gem	8.5	VF	150
V841 Oph	8.3	S	5000
DO Aql	>7.9	S	—
DN Gem	7.9	VF	550
V8490 Oph	>7.6	S	—
T Pxy**	7.6	S	—
V1017 Sgr**	7.5	S	400
WZ Sge**	7.4	F	300
RS Oph*	6.7	VF	—

* “recurrent”

** “repeated outburst”

the white dwarf evolutionary band. Both the rate of luminosity change and the magnitude range should decrease as the white dwarf star ages. The mass does not change significantly. The slowest novae with the smallest magnitude range should therefore be those in which the stars are at the low end of the nova size range, and also near the end of their nova stage. In between these two extremes, the magnitude range is determined by the size and age of the nova. Average range may indicate either an old large nova, or a young small one, or one that is near average in both respects.

The information available from observation gives only a very general indication of how well the novae conform to this theoretical pattern, but the little that is available is clearly in agreement with the theory. Most of the novae with large magnitude ranges are in the very fast category, and there is a general trend toward the next lower rating, the "fast" class, as the range decreases. Only one nova with a range greater than 11 magnitudes is definitely classified as fast. Below this magnitude level, the fast group outnumbers the very fast by about three to one. This is consistent with the theoretical conclusion that the earliest outbursts of the largest novae should have the maximum magnitude range, that this range should be less for the smaller novae, and that in all cases the range should decrease as time goes on and the outbursts are repeated.

While the slow novae are not concentrated at the lower end of the list as strongly as the very fast are concentrated at the upper end, there is a definite increase in the proportion of slow novae as the magnitude range decreases. If we omit the two stars of the larger class (identified as recurrent), the proportion of slow novae in the group with magnitude range 9.0 or below is 64 percent. In the group with ranges above this level it is only 24 percent. In between the extremes there are some relatively slow novae that are quite high on the list, and some of the very fast class that are quite low. Theoretically, the latter should be quite small stars and the former quite large. This cannot be confirmed observationally, as matters now stand.

The novae that are observed to have repeated are at the low end of the list; that is, they have the lowest magnitude ranges. Of course, these are not the only novae in the list that have repeated; they are merely the white dwarfs that are approaching the end of the nova stage of their existence, and are repeating their outbursts at short enough intervals to have had at least two within the time interval during which observations have been made. Their position at the low end of the list is another agreement with the theory.

At this point we need to take into account the fact that the possible speeds in the intermediate speed range do not constitute a continuous succession of values, but are confined to eight distinct levels, a characteristic of this speed range that we have already had occasion to recognize in applications such as the explanation of the relation known as Bode's Law. As noted earlier, four of the eight speed levels are on the spatial side of the dividing line, and

correspond to identifiable locations in equivalent space. In the planetary stars, which are in the gaseous state throughout, the particles moving at the different speed levels are well mixed, and there is a continuous density gradient from the outer to the inner regions. Here the build-up of pressure and eventual escape of the compressed gas follows essentially the same pattern irrespective of the size of the star. The situation in the ordinary white dwarf stars is quite different because the outer shell of these stars is in the condensed gas state. In this state, as in a liquid, matter of different densities stratifies. The outer shell is therefore not homogeneous, but consists of a number of layers, initially four. Since the white dwarf aggregate is a time structure, rather than a space structure, the gas bubbles in the center of the star (space structures) remain *in* the aggregate, rather than separating from it. Thus they accumulate in the lowest of the four layers, and are confined by the weight of the three overlying denser layers.

Smaller stars of the same surface temperature have lower internal temperatures, and at some point in the mass range the fourth speed level is vacant. The compressed gas in the central regions of these smaller stars is located in the third level, and is subject to the weight of only two overlying denser levels. This very substantial reduction in the weight that is confining the gas results in a corresponding reduction in the pressure that has to be built up before the compressed gas can break through. It can be expected, therefore, that at some definite level of white dwarf mass the nova type of outburst will be replaced by a different type of eruptive behavior in which the outbursts are more frequent but less violent.

This theoretical expectation is fulfilled observationally. While the white dwarf stars that reach the main sequence at the higher luminosities are observed as novae during the conversion from motion in time to motion in space, those that are smaller, and less luminous in their final state, follow what may be described as a nova pattern in miniature, with less violent outbursts and much shorter periods, ranging from about a year downward. These small scale novae, of which SS Cygni and U Geminorum are the type stars, are classified together with the true novae, the recurrent novae, and certain nova-like variables, as cataclysmic variables.

The magnitude at which the change in behavior occurs is a critical level that, on the basis of the considerations previously discussed, should be related to the other critical levels of the CM diagram by integral numbers of natural (compound) units. We have identified the difference between points B and C on the spatial main sequence, 2.8 magnitudes, as one such natural unit. The explanation just given for the transition from nova to a less violent type of outburst suggests that it should take place one natural unit below the upper limit of the normal, or "classical" novae, which coincides with the lower limit of the planetary stars at point B on the diagram, magnitude 4.6. This puts the boundary between the two types of cataclysmic variables at 7.4 magnitudes on

the spatial main sequence. The corresponding mass is 0.65 solar units. Thus the ordinary white dwarf in the range above 0.65 solar masses follows the nova pattern in its conversion to motion in space, while those in the range immediately below 0.65 solar masses are SS Cygni variables in the conversion stage.

We have identified the novae as white dwarfs that have component particles with speeds in all four of the levels on the (equivalent) spatial side of the dividing line, and the SS Cygni variables as white dwarfs in which the component speeds are limited to three of these four levels. On the basis of the same considerations that are applicable to the novae, the magnitude range of the SS Cygni stars, after conversion to motion in space, should be between 7.4 and 10.2, and the mass range should be from 0.65 to 0.40 solar units. Inasmuch as there are white dwarfs with still smaller masses, it follows that there should exist a class of these stars in which component speeds occupy only two levels. Since this leaves only one level overlying the one in which the gas is accumulating, it can be expected that the gas bubbles in these stars will break out at a relatively early stage before they reach any substantial size. The observations indicate that this third theoretical class of cataclysmic variable can be identified with the *flare stars*. These are theoretically stars of from 0.40 to 0.25 solar masses, with main sequence magnitudes, after conversion to motion in space, in the range from 10.2 to 13.0.

The 0.25 lower limit of the mass of the flare stars leaves room for some white dwarfs with only one speed level, as the minimum mass of the ordinary white dwarfs is somewhat lower, probably around 0.20. There is no significant amount of resistance to escape of gas from these stars, other than the viscosity of the condensed gas through which it has to make its way, but since the gas comes out in the form of bubbles, it is probable that there are visible flares from these stars similar to those from the two-level class, known to the astronomers as UV Ceti stars. The flare stars are not usually included in the classification of cataclysmic variables but they share the distinguishing characteristic of those variables, periodic outbursts of very energetic matter, and differ mainly in the magnitude of the outbursts. As indicated in the preceding paragraphs, there is a specific place for them in the pattern of the cataclysmic variables that has been derived from the theory of the universe of motion, the pattern that applies also to the novae and the SS Cygni stars.

Turning now to a consideration of the information that is available from observation, we find that the average magnitudes reported by the observers are within the theoretical limits, but these limits are so wide that the agreement with observation is not very significant. The mean absolute magnitude of the SS Cygni stars is reported as 7.5 ± 0.7 (reference 149) and that of the UV Ceti flare stars as 13.1 (reference 150). The cataclysmic variable stage begins at about magnitude 16, the low limit of the ordinary white dwarfs, and extends to the level of the galactic main sequence, 0.8 magnitudes above the limiting

magnitudes on the undisplaced basis as noted above. Since the conversion process accelerates, the average position of these variable stars, as observed, should be well below the midpoint of the magnitude range. The 13.1 magnitude reported for the UV Ceti stars is consistent with this prediction. The 7.5 magnitude of the SS Cygni stars is too high, near the upper end of the theoretical range, but it is likely that this value includes a large contribution from the after effects of the interior heat released during the outbursts.

Other data on the smaller classes of cataclysmic variables are scarce. Unlike the novae, which are spectacular, but rare because of the long intervals between outbursts, the SS Cygni stars are dim and hard to detect. It is reported that about 100 of them have been located, but only a few of them have been studied in detail. These are found to have a "period-amplitude relation whereby the stars of longer period show the more violent outbursts,"¹⁵¹ thus continuing the pattern of the true novae, noted earlier. The maximum observed magnitude range is near 6 magnitudes, about one magnitude below the minimum of the true novae indicated in Table III.

Very little is known about the properties of the flare stars, aside from those that they share with the other cataclysmic variables. A. H. Joy describes them as "extremely faint M-type dwarfs" in which the "light curve rises to maximum in a few seconds or minutes of time and declines to normal in less than a half hour."¹⁵² These light curves "are similar in form to the light-curves of novae,"¹⁵³ an observation that supports the theoretical identification of the flare stars as junior members of the group headed by the novae.

The heterogeneous group of stars known as the nova-like variables do not constitute a separate class, but are members of the classes already identified, with some special characteristics that distinguish them from the type stars of their respective classes. For instance, R. Aquarii and similar stars differ from SS Cygni mainly in that in SS Cygni both components of the binary system are dwarfs, whereas R. Aquarii combines a red giant and a hot blue dwarf.¹⁵⁴ Z Andromedae is the prototype of a group of stars that undergo outbursts of about three magnitudes, and "combine the features of a low temperature red giant and a hot bluish B star which is probably a subdwarf."¹⁵⁵ The terms applied to the dwarf components in these quoted descriptions of the binary systems are appropriate for the white dwarf members of cataclysmic variable pairs. A "blue dwarf" is simply a hot white dwarf, while a "subdwarf" is a dwarf star below the spatial main sequence in the area in which the cataclysmic variables are theoretically located. As noted previously, a combination of a red giant and white dwarf is not unusual; it is an early evolutionary stage that in time evolves into the more familiar combination of main sequence star and white dwarf.

It is now generally accepted that all cataclysmic variables are binary systems,

as required by the theory developed herein. The following is an expression of the current view:

A dwarf nova, like all cataclysmic variables (novae, recurrent novae, dwarf novae, and novalike variables) is a close binary system in which the primary component is a white dwarf. The secondary is a normal star.¹⁵⁶

The current tendency is to ascribe the explosive behavior to this binary nature of the system. “The sudden outbursts” of the SS Cygni stars, says Burnham, “are undoubtedly connected in some way with the duplicity of the system, but the exact details are uncertain.”¹⁵⁷ Notwithstanding the use of the word “undoubtedly” in this statement, our findings are that the binary nature of the cataclysmic variables, which we confirm, has no connection with their explosive behavior. This is why the astronomers have not been able to explain *how* their hypothetical process operates. These systems are binary because they originate in supernova explosions powerful enough to accelerate some of their products to intermediate speeds, and the white dwarf member of the binary system is explosive because the intermediate speed component of the supernova products goes through an explosive stage on its way back to the normal speeds of the material sector. The theoretical conclusions agree with the observed fact—the binary nature of these objects—but they disagree with the prevailing assumption as to the nature of the process responsible for the explosive outbursts.

The situation with respect to the location of the cataclysmic variables on the CM diagram is similar. We deduce from the theory that these objects are on the way from the white dwarf status to positions on the spatial main sequence, and therefore occupy intermediate positions. The observers agree as to the positions.

From their luminosities, which are similar to the sun on the average, we are forced to conclude that they [the novae] are small superdense stars somewhat like white dwarfs, but not so extreme.⁷⁸ (D. B. McLaughlin) Virtually all known post-nova stars are objects of the same peculiar type, hot bluish subdwarfs of small radius and high density, apparently intermediate between the main sequence stars and the true white dwarfs.¹⁵⁸ (R. Burnham) The prenova is below the main sequence intermediate between white dwarf and main sequence stars.¹⁵⁹ (E. Schatzman)

Where our findings differ from astronomical theory is in the direction of the evolution of the cataclysmic variables. The prevailing astronomical opinion is that the evolutionary direction is down the CM diagram from some location

above the main sequence, generally identified as the red giant region, toward the white dwarf stage. The white dwarf is seen as the last form in which the less massive stars are observable, the penultimate stage on the way to extinction as black dwarfs. This leaves the planetaries and the cataclysmic variables dangling without any clearly identified role. Shklovsky calls them "freaks."

Our analysis now shows that here again the astronomers' evolutionary sequence is upside down. The white dwarfs of both classes (planetaries and ordinary white dwarfs) enter the field of observation at the left of the CM diagram from an unobservable condition analogous to that of the earliest of the protostars that eventually enter the diagram in the red giant region. Just as these giants move to the *left* and *down* the diagram to the equilibrium positions on the spatial main sequence, the white dwarfs move to the *right* and *up* the diagram to reach similar equilibrium positions on that sequence. The upward movement takes place in the cataclysmic variable stage.

As the foregoing survey of the results of observation of the cataclysmic variables indicates, existing empirical knowledge is much too limited to provide a clear picture of these objects. But each of the isolated bits of information currently available fits into the general pattern derived from the theory of the universe of motion. While the theoretical pattern of behavior conflicts to some extent with current astronomical thought, it is really not accurate to say that the results of this present investigation contradict the astronomers' theory of the cataclysmic variables, because, aside from the rather vague idea of a giant star "shedding mass" and moving toward the hypothetical black dwarf status along an unspecified route, the astronomers have no theory of these objects. "Severe problems remain,"¹⁴² in arriving at an understanding, says H. M. Van Horn. The situation with respect to the stars of the SS Cygni class is described by A. H. Joy in this manner:

The general problem of the SS Cygni stars is so complicated that little progress has been made toward its solution . . . No satisfactory explanation of the novalike outbursts which occur at semi-regular intervals in the variable stars of this class has been proposed, and their relationship to other groups has yet to be determined.¹⁶⁰

Gallagher and Starrfield give us a similar assessment of the current state of knowledge with respect to the novae.

It is clear that there are few problems relating to the novae that we may consider as solved, and many phenomena for which we have yet even to identify the nature of the underlying physical processes.¹⁶¹

The nova problem is viewed even more pessimistically by Dean B.

McLaughlin. He sees little prospect of improvement.

The cause of nova outbursts is not likely to be identified directly by observation. At best we can only hope to arrive at an idea of the cause by devising hypotheses, calculating their consequences, and comparing the expected results with the observed facts.¹⁶²

The development in this work, based on deductions from the postulates that define the universe of motion, has now provided the kind of a complete and consistent theory of the cataclysmic variables that has heretofore been lacking. In the course of this development we have identified the three basic errors that have diverted astronomical thinking about the white dwarfs into the wrong channels: (1) the assumption that conversion of hydrogen into heavier elements is the energy production process in the stars, (2) the assumption that speeds in excess of that of light are impossible, and (3) the assumption that the white dwarf is a dying star. Correction of these errors and application of the physical principles governing motion at speeds greater than light, derived in the preceding volumes of this work, have arrived at a logical and consistent theory of the entire class of cataclysmic variables.

These results show that Shklovsky's characterization of the cataclysmic variables as "freaks" is totally wrong. These stars (and the planetaries as well) are in the direct line of one of the two coordinate branches of the stellar evolutionary cycle. They are *all* white dwarfs, differing only in the properties that are affected by the particular evolutionary stage at which each type of object makes its appearance, and they *all* go through the same general processes of cooling to a critical temperature level and then converting from motion in time to motion in space. Meanwhile the companions of these white dwarfs are going through the successive stages of the giant evolutionary cycle. The two stars of each of these binary systems are at comparable evolutionary stages, regardless of the difference in their properties, and they ultimately arrive at the same kind of a gravitationally and thermally stable state. When their relatively short excursion away from the main sequence is ended, both of the partners will settle down for another long stay in that equilibrium condition.

CHAPTER 14

Limits

One of the most significant features of the physical universe, as it emerges from the development of the consequences of the postulates that define the universe of motion, is the existence of *limits*. Everywhere we turn we find ourselves confronted with some kind of limit — a gravitational limit, a mass limit, an age limit, and so on and on. These limits exist because the postulates define a universe that is finite, with effective magnitudes that extend, not from zero, but from unit motion; that is, unit speed or unit energy. Since the deviations from this datum are finite, neither infinity nor zero is ever reached (except in a mathematical sense where the difference between two existing quantities of equal magnitude enters into some physical situation).

Many of the errors in present-day scientific theory owe their existence to a lack of recognition of the reality of these limits. Some particularly far-reaching conclusions of an erroneous nature that are pertinent at this stage of our investigation have been drawn from the Second Law of Thermodynamics. This law has been stated in a number of different ways. One of the simplest makes use of the physical quantity known as entropy, which is essentially a measure of the unavailability of energy for doing work. The statement of the Second Law on this basis is that the entropy of the universe continually increases. In the absence of recognition of any limits applicable to this process, the conclusion has been reached that the universe is on the way to becoming a featureless uniformity in which no significant action will take place. As expressed by Marshall Walker, “Apparently the universe is ‘running down,’ and in the remote future it will consist of a disordered cold soup of matter dispersed throughout space at a uniform temperature of a few degrees above absolute zero.”¹⁶³ Many writers dispense with qualifying words such as “apparently,” and express this point of view in uncompromising terms. Paul Davies, for example, puts it in this manner:

Unless, therefore, our whole understanding of matter and energy is totally misconceived, the inevitability of the end of the world is written in the laws of nature.¹⁶⁴

James Jeans, writing half a century earlier, was already firmly convinced,

and makes this equally positive assertion:

The energy is still there, but it has lost all capacity for change . . . We are left with a dead, although possibly a warm, universe—a “heat death.” Such is the teaching of modern thermodynamics. There is no reason for doubting or challenging it, and indeed it is so fully confirmed by the whole of our terrestrial experience, that it would be difficult to find any point at which it could be open to attack.¹⁶⁵

But in that earlier day, when the “heat death” idea was new and still controversial, Jeans found it necessary to explain the reasoning by which this conclusion was reached (something his modern successors usually do not bother with), and in the course of this explanation he tells us this:

Thus the main physical process of the universe consists in the energy of exceedingly high availability which is bottled up in atomic and nuclear structures being transformed into heat-energy at the lowest level of availability.¹⁶⁶

As we have seen in the preceding pages, this is *not* the “main physical process of the universe.” It is merely one of the subsidiary processes, an eddy in the main stream. The primary process of the material sector of the universe does not *begin* with energy of high intensity “bottled up in atomic structures”; it *ends* in that form, as the result of a long period of aggregation under the influence of gravitation. This high intensity state is one of the *limits* of the primary physical process. The highly dispersed state from which the aggregation started is the other. These limits could be compared to the high and low points in the travel of a pendulum. At its highest point the pendulum is motionless, but it is subject to gravitation. The gravitational force pulls it down to its low limit, but in so doing imparts a motion to it, and this motion then takes the pendulum back to the level from which it started. Similarly, the new matter in the material sector is widely dispersed and motionless. Gravitational forces pull the dispersed units inward to a limiting concentration, but in so doing impart a system of motions to the matter. These motions initiate a chain of events that ultimately brings the matter back into the same dispersed and motionless condition from which it started.

This definition of the fundamental action of the universe as a cyclic process carries with it the existence of limits to the various subsidiary quantities. This present chapter will be addressed to an examination of some of the most significant of these limits.

The Reciprocal System of theory deals exclusively with *units* of motion, and thus it is quantitative from the start. As noted in the earlier volumes, the quantitative development goes hand in hand with the qualitative development

as the theory is extended into additional areas and into more detail. Thus far in the present volume, however, the treatment of the subject matter has been almost entirely qualitative. There are two reasons for this. The first is that the objects with which astronomy deals are aggregates of the same kind of matter that was discussed in the previous volumes, differing only in that the range of sizes of the aggregates, and the range of conditions to which these aggregates are subject, are much greater than in the situations previously considered. By and large, therefore, the quantitative relations applicable to the astronomical aggregates are the same relations that were developed in the previous volumes. Thus one reason why there was not much quantitative discussion in the preceding pages is that most of the pertinent quantitative relations had already been covered in the earlier volumes.

The other reason for the limited amount of quantitative development is that, as noted in Chapter 1, the quantities of interest in astronomy are largely applicable to individual objects, whereas our present concern is with classes of astronomical objects and the general evolutionary patterns of those objects, rather than with individuals. Furthermore, even where quantitative relations are relevant to the subject matter under consideration, and have not been previously derived, it has appeared advisable, in most cases, to delay discussing them until after the general aspects of the astronomical universe, as seen in the context of the theory of the universe of motion, were examined and placed in their proper relations with each other. To the extent that this examination has not yet been carried out, these items will be discussed at appropriate points in the pages that follow. This chapter will take up the question of the quantitative limits applicable to some of the phenomena already examined from the qualitative standpoint in the earlier pages.

Chief among these, because of its fundamental nature, is the gravitational limit. On the basis of the general principles developed in Volume I, the gravitational limit of a mass is the distance at which the inward gravitational motion of another mass toward the mass under consideration is equal to its outward motion due to the progression of the natural reference system relative to our stationary system of reference. If the unit gravitational motion acted directly against the unit outward speed imparted to the mass unit by the outward progression of the reference system, the gravitational limit for unit mass would be at one natural unit of space, by reason of the relation between the natural units explained in Volume I. But the gravitational effect is distributed over all of the many dimensional variations of both the rotational and translational motion, and its effective magnitude is reduced by this dimensional distribution. As we saw in the earlier volumes, the rotational distribution extends over 128 units in each dimension. Since motion in space involves three dimensions of space and one dimension of time, the total rotational distribution is $(128)^4$. Additionally there is a translational distribution over the eight units that we have previously identified as the linear

maximum. The total of both distributions amounts to $8 (128)^4 = 2.1475 \times 10^9$. What this means is that the gravitational motion is distributed over 2.1475×10^9 units, only one of which is acting against the outward progression of the natural reference system in the line of the progression. The effective component of the gravitational force (motion) is thus reduced by this ratio, the *rotational ratio*, as we will call it.

Inasmuch as the one-dimensional analog of this rotational ratio, the inter-regional ratio, includes an additional component amounting to $2/9$ of the 128 rotational units, increasing the ratio to 156.444, there may be some question as to why the rotational ratio does not contain a similar extra component. The explanation is that the atomic rotation is a rotation of a linear vibration. The total atomic motion is therefore distributed among the vibrational units ($2/9$ of 128) as well as among the 128 rotational units. But the 8-unit translational distribution included in the rotational ratio covers *all* of the possible linear motion, including the basic vibrational motion that is being rotated. Thus no additional term is required in the rotational ratio.

Within the gravitational limit the effective gravitational motion (or force) is inversely proportional to the square of the distance. Without the distribution to the multiple units, the equilibrium equation under unit conditions would be $m/d_0^2 = 1$; that is, the gravitational force exerted by the natural unit of mass at the natural unit of distance would be in equilibrium with the unit force of the progression of the natural reference system. The distribution of the gravitational force reduces its effective value by the rotational ratio. The effective equilibrium is then

$$4.65661 \times 10^{-10} m/d_0^2 = 1 \quad (14-1)$$

Solving for d_0 , the gravitational limit, we obtain

$$d_0 = 2.15792 \times 10^{-5} m^{1/2} \quad (14-2)$$

To convert this equation from natural to conventional units we divide the coefficient by the number of natural units of distance per light year, 2.0752×10^{23} , and by the square root of the number of grams per natural unit of mass, 1.65979×10^{-24} . In terms of grams and light years, equation 14-2 then becomes

$$d_0 = 8.0714 \times 10^{-17} m^{1/2} \text{ light years} \quad (14-3)$$

The mass of the sun has been calculated as 2×10^{33} grams. Applying the coefficient of equation 14-3, we find that the gravitational limit of the sun is 3.61 light years. This is consistent with the observed separations. The nearest star system, Alpha Centauri, is 4.3 light years distant, and the average

separation of the stars in the vicinity of the sun is estimated to be somewhat less than 2 parsecs, or 6.5 light years. Sirius, the nearest star larger than the sun, has its gravitational limit at 5.3 light years, and the sun, 8.7 light years away, is well outside this limit.

It is evident that such a distribution of a very large number of objects in space, where the minimum separation is two-thirds of the average, requires some kind of a barrier on the low side; it cannot be the result of pure chance. The results of this present investigation show that the reason why the stars of the solar neighborhood *do not* approach each other closer than about four light years is that they *can not* do so. This finding automatically invalidates all theories that call for star systems making contact or a close approach (as contemplated in some theories of the formation of planetary systems), and all theories that call for the passage of one aggregate of stars through another (such as the currently accepted theory of “elongated rectilinear orbits” of the globular clusters).

Furthermore, these results show that the isolation of the individual star system is permanent. These systems will remain separated by the same tremendous distances because each star, or star system, or prestellar cloud continually pulls in the material within its gravitational range, and this prevents the accumulation of enough matter to form another star in this volume of space. The immense region within the gravitational limit of each star is reserved for that star alone.

The interstellar distance calculated from the number of stars per unit volume is less in the interiors of the globular clusters and the central regions of the galaxies. But since the three-dimensional region of space extends only to the gravitational limit, the reduction in volumetric dimensions beyond this limit, due to the gravitational effect of the aggregate as a whole, is in equivalent space rather than in actual space. It therefore does not alter the spatial relation of a star to the gravitational limits of its neighbors.

Galactic masses are usually expressed in terms of a unit equal to the solar mass. Since we have already evaluated the gravitational limit of the sun, we may express equation 14-3, for application to the galaxies, in the convenient form

$$d_0 = 3.6t (m/m_s)^{1/2} \text{ light years} \quad (14-4)$$

This relation enables us to verify the conclusions reached in Chapter 2 with respect to the process of cannibalism by which the giant spheroidal galaxies have reached their present sizes. As noted in that earlier discussion, the development of theory indicates that galaxies as large as the Milky Way are pulling in not only a large amount of diffuse material, but also individual stars, globular clusters, and small galaxies. The Magellanic Clouds were identified as galaxies in the process of being captured. In order for such a capture to take

place, the smaller unit must be within the gravitational limit of the larger. Let us see, then, just what distances are involved.

Estimates of the mass of the Galaxy range from 10^{11} to 5×10^{11} solar masses. If we accept an intermediate value, 3×10^{11} , for present purposes, equation 14-4 indicates a gravitational limit of about two million light years. On this basis, the Magellanic Clouds are well on their way to capture by the Galaxy.

It was also brought out in the previous discussion that the irregular structures of the Magellanic Clouds are due to distortion of the original spiral or elliptical structures by differences in the gravitational forces acting on different parts of the Clouds. The diameters of the Clouds are approximately 20,000 and 30,000 light years respectively. These distances are obviously large enough in proportion to the distance from the Galaxy to give rise to significant differences between the forces acting on the near sides of the Clouds and those acting on the far sides.

Both of these findings with respect to the Magellanic Clouds can be generalized. We can say that *any* galaxies within a distance of about two million light years of a galaxy as large as the Milky Way are in the process of being pulled in toward the galaxy and will eventually be captured. We can also say that *any* galaxy on the way to capture will experience structural distortion in the last stages of its approach.

The calculations that support the theoretical conclusions as to what is now happening to the globular clusters and small galaxies in the vicinity of larger aggregates can be extended to confirm the further conclusions concerning what is going to happen in the future as the evolutionary development of the galaxies proceeds. In the original discussion of the aggregation process it was pointed out that the possibility of growth by capture depends on the location of the gravitational limit. Consolidation of two star systems cannot take place, because each such system is *outside* the gravitational limits of all others, and these limits can be extended only at a relatively slow rate, since there is nothing in interstellar space subject to capture other than diffuse matter and a few small objects such as comets. On the other hand, the theoretical consideration of the galactic situation in Chapter 2 showed that the globular clusters and early type galaxies are *inside* the gravitational limits of their immediate neighbors because of the nature of the process by which they were formed. Consolidation of these objects into larger and larger aggregates therefore proceeds until the greater part of the mass in each large region of space is gathered into one giant spheroidal galaxy.

This theoretical finding implies that most of the galaxies included in what is known as the Local Group—our Milky Way, the Andromeda Galaxy, M 33, the newly discovered Maffei galaxies, and a considerable number of smaller aggregates—will eventually combine. For an evaluation of the likelihood of such an outcome, let us look at the gravitational limits. We have found that if

we take the mean of present estimates of the size of our galaxy, its gravitational limit is about two million light years. But if we take the highest of the previously quoted values, this limit becomes 2½ million light years. It is generally believed that the Andromeda Galaxy, M 31, about two million light years distant, is somewhat larger than our own. Thus, if the higher estimate of the mass of the Milky Way is correct, we are *already* within the gravitational limit of M 31.

If the actual masses are smaller than these estimates indicate, this conclusion is premature. But M 31 is growing. Intergalactic space contains a multitude of material aggregates—globular clusters, unconsolidated dust and gas clouds of globular cluster size, dwarf galaxies, and stray stars—all of which are subject to capture by the giant spirals, along with quantities of diffuse matter. If the Milky Way is not yet within the gravitational limit of M 31, it certainly will be within that limit when the capture process is a little farther along. In the meantime, the total mass of the various aggregates and diffuse matter between the major galaxies helps to hold the Local Group together while those galaxies continue their cannibalism. The calculation of the gravitational limits of the local galaxies thus confirms the theoretical conclusion from more general premises that the eventual result of the evolutionary process will be a giant spheroidal galaxy containing most of the mass of the Local Group.

It is even possible that both M 31 and the Milky Way galaxy may be swallowed by a larger, hitherto unrecognized, member of the group. A very large volume of space in our immediate vicinity is hidden from our view by the dense portions of our own galaxy, and we do not know what is behind this barrier. The two Maffei galaxies were just recently discovered on the fringes of this unobservable zone, and there are reports indicating the existence of two more in a “heavily obscured region in Cygnus.”¹⁸ One is said to be a “bright elliptical.” If this is correct, the elliptical galaxy could be the dominant member of the Local Group.

The conclusion as to the ultimate consolidation of most of the mass of the Local Group conflicts with current astronomical opinion, as expressed by Gorenstein and Tucker, who assert flatly that “the probability of our galaxy’s ever colliding with the Andromeda galaxy is close to zero.”¹⁶⁷ But that opinion is a relic of the traditional view of the galaxies as objects that originated in essentially their present forms in the early stages of the existence of the universe, and are moving randomly, a view that, although it is still orthodox doctrine, is gradually giving way as more and more evidence of galactic collisions and cannibalism accumulates.

Another critical magnitude in which we are interested is the limiting distance beyond which all galaxies recede at the full speed of light. The importance of this distance lies in the fact that its relation to the speed of light determines the rate of increase in the recession speed relative to the distance, the Hubble constant, as the astronomers call it. This is a place where the theory of the

universe of motion arrives at conclusions that are altogether different from those that the astronomers have reached from their consideration of the only piece of observational information that has been available to them, the existence of a galactic recession at a speed that is proportional to the distance. On this slender factual basis, they have erected an elaborate framework of assumption and inference that serves as the orthodox theory of the large-scale action of the universe. The cosmological aspects of this theory will be discussed in the final chapters of this volume. Our concern at present is with the recession speed. In the absence of any evidence to the contrary, the astronomers have assumed that the Hubble constant is a fixed characteristic of the physical universe, and they further assume that the increase in the recession speed with increasing distance continues indefinitely, approaching the speed of light asymptotically.

While these two assumptions seemed reasonable in the light of the information available to their originators, the development of a theoretical understanding of the recession process now shows that both of them are wrong. The recession is not peculiar to the galaxies. It is a general property of the universe, a relation between the reference system that we utilize and the reference system to which natural phenomena actually conform, and it applies not only to the galaxies, but to all material objects, and also to non-material entities, such as the photons. The outward motion of the photons at the speed of light is the same phenomenon as the recession of the galaxies, differing only in that the galactic recession is slowed by the opposing gravitational forces, whereas the photons are not subject to any significant amount of gravitational retardation, except in the immediate vicinity of very large masses. The Hubble “constant” is not, as currently assumed, a basic property of the physical universe. Like the gravitational limit, it is a property of each individual mass aggregate. In application to the galactic recession this so-called constant is a function of the total galactic mass, exclusive of the outlying globular clusters and halo stars that are still in free fall.

The assumption that the speed of light is a limiting value which the recession speed never quite reaches is also invalidated by the theoretical findings. As we saw earlier in this chapter, the effect of the distribution of the gravitational motion over all of the rotational and translational units involved in the atomic rotation is to require 2.1475×10^9 mass (gravitational) units to counterbalance each unit of the outward motion of the natural reference system. The point at which this is accomplished is the gravitational limit. Here the net speed, relative to the conventional spatial reference system, is zero. Beyond the gravitational limit the reduced gravitational speed is only able to neutralize a part of the outward progression, and there is a net outward motion: the galactic recession.

The net outward speed increases with the distance, but it cannot continue increasing indefinitely. Eventually the attenuation of the gravitational motion

by distance brings it down to the point where the remaining motion of each mass unit is sufficient only to cover the distribution over the dimensional units involved in direct one-dimensional contact between motion in space and motion in time. Less than this amount (a natural compound unit) does not exist. Beyond this point, therefore, the gravitational effect is eliminated entirely, and the recession takes place at the full speed of light. The limiting distance with which we are now concerned can thus be obtained by substituting the one-dimensional relation, $128 (1+2/9) = 156.44$ (previously identified as the inter-regional ratio), for the rotational ratio in equation 14-1. The new equilibrium force equation is then

$$1/156.44 \times m/d_1 = 1 \quad (14-5)$$

Again, solving for the distance, which in this case we are calling d_1 , we have

$$d_1 = m^{1/2}/12.5 \quad (14-6)$$

which can be expressed in terms of solar masses as

$$d_1 = 13350 (m/m_s)^{1/2} \text{ light years} \quad (14-7)$$

If we again take the intermediate estimate of the mass of the Galaxy that was used earlier, 3×10^{11} solar masses, and apply equation 14-7, we find that the limiting distance, d_1 , is 7.3×10^9 light years. Disregarding the relatively short distance between the Galaxy and its gravitational limit, we may now calculate the distance from our galaxy to any other galaxy of the same or smaller mass by converting the redshift in the spectrum of that galaxy to natural units (fraction of the speed of light), and multiplying by 7.3×10^9 light years, or 2.24×10^9 parsecs. This is equivalent to a value of 134 km/sec per million parsecs for the Hubble constant.

This calculated value for the Hubble constant does not apply to the recession of a galaxy larger than our own, as the effective gravitational force that defines the limiting distance is the force exerted by the larger of the two aggregates. The mass of the smaller aggregate is immaterial from this standpoint. It is true that the controlling mass exerts a greater gravitational force on a large mass than on a smaller one, but the opposing effect of the progression of the natural reference system is subject to the same proportionate increase, and the equilibrium point remains the same. The astronomers' estimates of the value of the Hubble constant are based largely on observations of the more massive galaxies, the ones that are most easily observed. The masses of these giant galaxies are quite uncertain, and the estimates vary widely, but as a rough approximation we may take the mass of a galaxy of maximum size to be ten

times that of the Milky Way galaxy. Substituting this mass for that used in the previous calculation, we obtain a Hubble constant of 42 km/sec per million parsecs.

The value currently accepted by most astronomers is between 50 and 60 km/sec. Before 1952 the accepted value was 540. By the time the first edition of this work was published in 1959 it was down to about 150. Subsequent revisions have brought it down to the present 50 or 60. These latest results are consistent with the theoretically calculated values within the accuracy of the galactic mass determination.

Emission of radiation from the rotating atoms of matter is also subject to a dimensional distribution, but radiation is a much simpler process than the gravitational interaction, and the distribution is correspondingly more limited. As noted in Volume II, where the dimensional distribution effective in gravitation was discussed, the theoretical conclusions with respect to the dimensional distribution of the primary motions are still somewhat tentative, although the satisfactory agreement with observation gives them a significant amount of support. It appears from these findings that the radiation distribution is confined to the basic 128 rotational positions in one dimension.

The application of this distribution with which we are now concerned is its effect on the magnitude of the increase in the wavelength of radiation (the redshift) due to the outward progression of the reference system. Since all physical entities are subject to this progression, it has no effect on ordinary physical phenomena, but it does alter the neutral point, the boundary between motion in space and motion in time. The outward progression in space relative to the location from which we are making our observations shifts the boundary in the direction of longer wavelengths. Observers in the cosmic sector (if there are any) see a similar shift in the direction of the shorter wavelengths.

Inasmuch as the natural unit in vibrational motion is a half cycle, the cycle is a double unit. The wavelength corresponding to unit speed is therefore two natural units of distance, or 9.118×10^{-6} cm. The distribution over 128 positions increases the effective distance to 1.167×10^{-3} cm (11.67 microns). This, then, is the effective boundary between motion in space and motion in time, as observed in the material sector. On the high frequency (short wavelength) side of the boundary there is first the near infrared, from 1.167×10^{-3} cm to 7×10^{-5} cm, next the optical region from the infrared boundary to 4×10^{-5} cm, and finally the x-ray and gamma-ray regions at the highest frequencies. Because of the reciprocal relation between space and time these high frequency regions are duplicated on the low frequency (long wavelength) side of the neutral level.

Inasmuch as the processes of the region below unit speed involve transfer of fractional units of speed—that is, units of energy—the frequencies of the normal radiation from these processes are on the energy side of the boundary. This is high frequency radiation. At speeds above unity, this situation is

reversed. The physical processes at these speeds involve transfer of fractional amounts of energy, and the frequencies of the normal radiation are on the speed side of the unit boundary. In the regions accessible to our observation, these low frequency processes are less common than those in the high frequency range, and the instrumentation that has been developed for dealing with them is much less advanced. Consequently they are not as well known, and only two subdivisions are recognized. The far infrared corresponds to the near infrared and the optical ranges, while the radio range corresponds to the x-ray and gamma ray ranges.

The term "normal" in the foregoing paragraph refers to radiation in full units of the type appropriate to the speed of the emitting objects. For example, thermal radiation is a product of processes operating at speeds below unity (the speed of light). The full units produced at these speeds constitute frequencies on the upper side of the unit boundary. Fractional units do not exist, but the *equivalent* of fractional changes in the amount of space can be produced by adding or subtracting units of time. This enables extension of a portion of the frequency distribution of thermal radiation into the far infrared, below the unit level. In fact, if the radiating object is cool, it may radiate entirely in this lower range. But if this radiating object is hot enough to produce a substantial amount of radiation, the great bulk of this radiation is in the upper frequency ranges. Thus *strong* thermal radiation comes from matter in the speed range below unity. The same principle applies to radiation produced by any other processes of the low speed range. Conversely, strong radiation of the inverse type—far infrared and radio—comes from matter in the upper speed ranges (above unity).

The existence of a sharp line of demarcation between the kind of objects that radiate in the near infrared and the kind that radiate in the far infrared is clearly recognized, even at this rather early stage of infrared astronomy, but the fact that there is an equally sharp distinction in the nature of the *radiation* from these objects has not yet been recognized by the astronomers. For example, Neugebauer and Becklin suggest that the observed strong radiation from some objects at 100 microns is "thermal radiation from dust heated by starlight";¹⁶⁸ that is, it is essentially equivalent to the radiation from cool stars, although they also report that the objects which radiate strongly at two microns (in the near infrared) are altogether different from those that radiate at 20 or 100 microns (in the far infrared). The ten brightest sources at two microns, they report, are all stars: three supergiants, three giants, and four long-period variables—the same stars that are bright in the visible region. On the other hand, none of the ten brightest sources at 20 microns is an ordinary star. They include the center of the Galaxy, several nebulae, and a number of objects whose nature is, as yet, not clearly understood. As the investigators say, "At present we lack the information needed to understand the sources unambiguously."

Our findings show that what is needed is a recognition of the existence of the unit boundary at 11.67 microns. Strong radiation in the far infrared, beyond 11.67 microns, comes from matter with speeds in the upper ranges, above the speed of light, not from relatively cool thermal sources like those that radiate weakly in the far infrared. As we will see in the pages that follow, strong infrared emission is one of the conspicuous features of the objects that we will identify as involving motion at upper range speeds: quasars, Seyfert galaxies, the cores of other large galaxies, exploding galaxies such as M 82, etc. The infrared radiation from the quasars is estimated to be 1000 times the radiation in the visible range.¹⁶⁷ The association between infrared emission and radiation in the radio range (which we identify with upper range speeds) is another feature of these objects, which, like the infrared emission, is unexplained in current astronomical theory. The significance of the results of the surveys of the infrared sources within the Galaxy, such as the one reported by Neugebauer and Becklin, is that they demonstrate the existence of the line of demarcation between the far infrared of the upper range speeds and the near infrared of the speeds below unity.

In the case of complex objects in which both upper range and normal speeds are strongly represented, the existence of a discontinuity is evident in the spectra. For instance, the IRAS observations show that "The spectrum of the Crab nebula 'breaks,' or turns over in the far infrared," leading to the conclusion that "something must happen in the infrared region that lies between the near infrared and radio bands."³⁵⁰

The processes other than thermal that give rise to these various radiation frequencies, and their identification with the speeds of the emitting objects, will be discussed in Chapter 18.

As we saw in Chapter 6, the increase in speed in the range below the unit level is accomplished by the inverse process of adding energy. Addition of $n-1$ units of energy to zero speed ($1-1/1$) results in a speed of $1-1/n$.² Obviously, this is a very inefficient method of increasing the speed, inasmuch as a large increment of energy produces only a very small increase in the speed. Furthermore, the maximum speed that can be attained by this means is limited to one unit (that is, the speed of light). But in spite of these highly unfavorable aspects, this is the way in which additions to the speed are made in the range between zero speed and unit speed, simply because there is no alternative. Fractional units of speed do not exist.

The subsequent pages of this work will be concerned mainly with phenomena that take place at speeds in excess of unity, and one of the arguments that will be advanced against the reality of such speeds by the adherents of orthodox physical thought will be that the amount of energy required to produce speeds of this magnitude is incredibly great. Indeed, such arguments are already being raised against suggestions that call for the ejection of galactic fragments at speeds that merely *approach* the speed of light. The answer to these objections

is that the upper range speeds are not produced by the inefficient inverse process of adding energy; they are produced by the direct addition of units of speed, a much more efficient process.

To illustrate the difference, let us consider the result of adding energy or speed to the initial situation just mentioned, where the energy is unity and the net speed is $1 - 1/1 = 0$. (Most speeds in the material sector are differences, $(1 - 1/n^2) - (1 - 1/m^2)$, but it will be convenient to deal with the simpler situation). If we add two units to the energy component the net speed increases to $1 - 1/9 = 0.889$. On the other hand, if we add two units to the speed component the net speed increases to $3 - 1/1 = 2.000$, at the threshold of the ultra high speed range. The significance of these figures lies in the fact that in the universe of motion a unit of speed and a unit of energy are equivalent. It follows that an event that is capable of increasing the net speed of an object only as far as 0.889 by the process of adding energy is capable of increasing it to 2.000 by the process of adding speed, if speed is available in unit quantities. The conclusion that we reach from the theoretical development is that matter reaches its age and size limits under conditions that result in gigantic explosions in which speed is, in fact, released in unit quantities, and is available for acceleration of the explosion products to the upper range speeds. This means that intermediate and ultra high speeds are well within the capability of *known* processes.

It is probable that most readers who encounter this idea for the first time will see it as a strange and unprecedented addition to physical thought. But, in fact, the basic principle that is involved is the same one that governs a well known, and quite common, type of physical situation. The only thing new is that this principle has not heretofore been recognized as applying to the phenomenon now being discussed. The truth is that what we are here dealing with is simply a threshold effect, something that we meet frequently in physical theory and practice. The photoelectric effect is a good example. In order to eject electrons from cold metal, the frequency of the impinging radiation must be above a certain level, the threshold frequency. The result cannot be accomplished by increasing the total amount of low frequency energy. Ejection does not take place at all unless the energy is available in *units* of the required size. When units of this size *are* applied, even a small total energy is sufficient. The production of speeds in excess of the speed of light is governed by the same kind of a limitation. Speed *units* of the required magnitude must be available.

A number of other magnitudes that are significant in the quantitative description of the evolution of the contents of the universe are subject to calculation on the theoretical basis that has been provided, including such items as the average duration of the various evolutionary stages, maximum and minimum sizes of the various aggregates, and so on. Lack of time has prevented undertaking any systematic investigation of these subjects, but some

results have been obtained as by-products of studies made for other purposes. These are mostly properties of objects moving at upper range speeds, and they can be discussed more conveniently in connection with the general examination of the phenomena of these upper speed ranges in the subsequent chapters.

CHAPTER 15

The Intermediate Regions

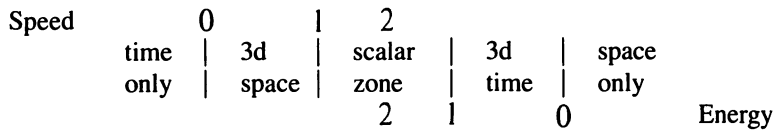
We are now ready to begin a full-scale examination of the only one of the regions into which the universe is divided by the reversals that take place at the unit levels of speed, space, and time, that has not yet been considered. This is an appropriate point at which to review the general situation, and to see just how each of the several regions fits into the overall picture.

As brought out in detail in the preceding pages of this and the earlier volumes, the region that can be accurately represented in a spatial system of reference is far from being the whole of the physical universe. There is another equally extensive, and equally stable, region that is not capable of representation in any spatial reference system, but could be correctly represented in a three-dimensional temporal reference system, and there is a large, relatively unstable, transition zone between the two regions of stability. The phenomena of this transition zone cannot be represented accurately in either a spatial or a temporal reference system.

Furthermore, there is still another region at each end of the speed-energy range that is defined, not by a unit speed boundary, but by a unit space or time boundary. In large scale phenomena, motion in time is encountered only at high speeds. But since the inversion from motion in space to motion in time is purely a result of the reciprocal relation between space and time, a similar inversion also occurs wherever the magnitude of the *space* that is involved in a motion falls *below* the unit level. Here motion in space is not possible, because less than unit space does not exist, but the *equivalent* of a motion in space can be produced by adding motion in time, since an energy of $n/1$ (n units of energy) is equivalent to a speed of $1/n$. This region within one unit of space, the *time region*, as we have called it, because all change that takes place within it is in time, is paralleled by a similar *space region* at the other end of the speed-energy range. Here the equivalent of a motion in time is produced inside a unit of time by the addition of motion in space.

With the addition of these two small-scale regions to those described above,

the speed-energy regions of the universe can be represented in this manner:



The extent to which our view of the physical universe has been expanded by the development of the theory of the universe of motion can be seen from the fact that the one section of this diagram marked '3d [three-dimensional] space' is the only part of the whole that has been recognized by conventional science. Of course, this is the only region that is readily accessible to human observation, and the great majority of the physical phenomena that come to the attention of human observers are phenomena of this three-dimensional spatial region. But the difficulties that physical science is currently encountering are not primarily concerned with these familiar phenomena; they arise mainly from attempts that are being made to deal with the universe as a whole on the basis of the assumption that nothing exists outside the region of three-dimensional space.

By developing the necessary consequences of the postulates that define the universe of motion, we have identified the nature and properties of the primary entities and phenomena of the three-dimensional region of space and those of the time region. The inverse regions, the three-dimensional region of time and the space region, are unobservable, but since they are exact duplicates of the regions that we have examined in detail, the findings with respect to those observable regions are also applicable, with space and time interchanged, to the two inverse regions. The subdivision that remains to be explored is the transition zone between the two three-dimensional regions, identified in the diagram as the scalar zone.

The separation of the two sectors of the universe into distinct regions is a result of the fact that the relation between the natural and conventional reference systems changes at each unit level, because the natural system is related to unity, while the conventional system is related to zero. Since the natural system is the one to which the universe actually conforms, any process which, in fact, continues without change across a regional (unit) boundary reverses in the context of the arbitrary fixed spatial reference system. Each region thus has its own special characteristics, when viewed in relation to the spatial reference system.

Inasmuch as the three scalar dimensions are independent, the maximum speed in each is two units, as shown in Fig. 8 (Chapter 6). Thus there are six total units of speed (or energy) between the absolute speed zero and the absolute energy zero. It follows that the neutral point is at three units. At any net speed below this level, the motion of an object, as a whole, is in space.

This fact has an important bearing on the nature of the motion. As we have seen in our examination of fundamentals, an object can move either in space, at a speed of $1/n$, or in time, at a speed of $n/1$, but it cannot move in *both* space and time (relative to the natural datum of unity) coincidentally, since the speed cannot be both above and below unity. As pointed out earlier, it then follows that where motion in time exists as a minor component of a motion that, in total, takes place in space, the motion in time acts as a modifier of the magnitude of the motion in space, rather than as an actual motion in time. In other words, it is a motion in the spatial equivalent of time: a motion in *equivalent space*.

As indicated in Fig. 8, the second unit of translational motion is motion in time, but since the translational motion as a whole is in space as long as it remains below three units, this second unit of motion takes place in equivalent space. Such motion can be represented in the conventional spatial reference system to the extent that the magnitudes that are involved are within the limits of the reference system: zero and unity. As can also be seen from Fig. 8, the motion in the second unit of one dimension, the motion in time (equivalent space), is fully coordinate with the motion in the first unit, and has the same kind of a relation to the natural datum, unity, as the original unit. It therefore *substitutes for* the original unit, rather than *adding to* it. The motion in equivalent space in this second unit is similar to the motion in space in the first unit, except that it is inverse, and reduces, rather than increases, the equivalent spatial magnitudes. These magnitudes therefore remain within the limits of the reference system, and can be represented in it, as we see in the case of the reduction in the size of the white dwarf.

On the other hand, when the motion is extended to a third unit, a unit of motion in space, so that there is motion in both a dimension of space and a dimension of equivalent space, the magnitudes are additive, and the increment due to the motion in equivalent space is outside the one-unit limit of the reference system. It follows that this increment cannot be represented in the reference system, although it appears in measurements such as the Doppler shift that deal with total scalar magnitudes, and are not subject to the limitations of the reference system.

The two linear scalar units of motion effective in the intermediate region are not restricted to a specific scalar dimension. Consequently they are distributed over all three of these dimensions by the operation of probability. This means that there are eight possible orientations of the units of motion. Motion in actual space is restricted to one of these by the nature of the reference system that defines what is considered to be actual space. Inasmuch as this reference system imposes no restrictions on time, the other seven orientations are available for the motion in the spatial equivalent of time (equivalent space).

In the absence of any influences tending to favor one orientation over another, the total scalar motion is distributed equally among the eight

orientations. However, for reasons that were explained in Volume I, all quantities in equivalent space are two dimensional in terms of actual space. The seven equivalent units are divided between the two dimensions, usually equally. One of the two resulting speed components adds to the speed in actual space. The other does not. Furthermore, the second power relation between the quantities of the two kinds (actual space and equivalent space) leads to a similar relation between the units. Thus the fractional unit of equivalent space comparable to the fractional unit n of actual space is $n^{1/2}$. Where the spatial speed is n , the corresponding speed in equivalent space (the distribution in one dimension) is normally $3.5 n^{1/2}$, and the total equivalent spatial speed is $n+3.5 n^{1/2}$.

This quantity, the total equivalent spatial speed, is the total scalar magnitude in the dimension of the reference system, the quantity that is measured by the Doppler shift. Motion in the low speed and intermediate ranges is confined to one spatial dimension, and is limited to the value n , generally represented by the symbol z in this application. Extension of the motion to a second spatial dimension in the ultra high speed range adds the magnitude represented by the term $3.5 z^{1/2}$. Thus the Doppler shift of any object moving at ultra high speed is normally $z+3.5 z^{1/2}$. This theoretical conclusion will be compared with the results of observation in Chapter 22.

In conventional physical thought the reception of radiation from an object traveling away from our location at a speed greater than that of light would be impossible, even if such speeds exist, which conventional theory denies. The reasoning is that an object moving at such a speed would be traveling faster than the signal that it is emitting. But in the universe of motion any motion at a speed greater than unity (the speed of light) is a motion in time at an inverse speed less than unity. This means that the object is moving slower than light in time. The radiation from an object moving away from us at such a speed therefore reaches us through time rather than through space, if we are appropriately located relative to the moving object.

Although the neutral point between motion in space and motion in time is at three units of equivalent speed, the maximum net translational speed that can be attained is actually two units, because of the gravitational reversal. When the net speed reaches the two unit level, reversal of the gravitational direction (from motion in space to motion in time) results in a net increase in speed of two units. Any further increase in equivalent speed beyond this two-unit level is accomplished by reduction of the magnitude of the inverse speed; that is, by decreasing the motion in time.

While *net* speeds exceeding two units take the motion across the sector boundary and out of the observable region, as indicated above, ultra high speeds can exist in the material sector in conjunction with oppositely directed speeds of different origin that keep the net effective speed below the two unit level, at least temporarily. Under these conditions, the distinctive features of

ultra high speed motion, such as existence in two spatial dimensions, are applicable to objects that are still within the observable range.

The intermediate, or scalar, zone is separated into two regions by the sector boundary. One of these, from two units of inverse speed to one unit, is on the cosmic side of the sector boundary, and is unobservable. The other, from one unit of speed to two units, is outside the region that can be represented accurately in the spatial reference system (the three-dimensional region of space), but it is within the material sector, and it does have effects on physical magnitudes in that sector. These effects enable us to detect objects moving in the upper speed ranges, and to determine their properties. The results of an investigation of these properties will constitute the subject matter of the remainder of this volume, except for the last two chapters.

The effects of translational speed in the intermediate range, between one and two units, insofar as they apply to aggregates of stellar size, were discussed in Chapter 6. Some similar effects are produced in galaxies, but it will be convenient to consider these after the characteristics of matter moving at ultra high speeds are developed. Examination of these intermediate galactic phenomena will therefore be deferred to Chapters 26 and 27. We will now turn our attention to motion at ultra high speeds, in the range between two and three units.

Extension of motion to this higher speed range results in the production of some new and different classes of astronomical phenomena. We will examine the most significant of these phenomena individually in the pages that follow, but in order to lay a foundation for the subsequent discussion, and to emphasize the unitary character of the theory that will be applied to an understanding of the individual items, the general aspects of ultra high speed motion, as derived from the postulates that define the universe of motion, will be developed at this point, where they can be considered independently of the particular conditions that surround the specific applications.

In order to produce speeds in this ultra high range it is, of course, necessary that there be explosive phenomena that are more violent than the Type I supernovae. We will have no difficulty in identifying such phenomena. While the ultra high speed range is a full unit greater than the intermediate range of speeds produced by the Type I explosion, the availability of the direct process of adding units of speed, as discussed in Chapter 14, makes the required addition to the violence of the explosion much smaller than would be indicated by the effects of energy addition in the range below unit speed.

We saw in Chapter 6 that when the Type I supernova explosion occurs, the material in the central regions of the star is blown outward in time, producing a white dwarf star. A more violent explosion that accelerates the fastest of the explosion products to ultra high speeds has the same kind of an effect on the matter in the central regions, except that it adds an outward translational motion in a second dimension of space to the outward (inward from the spatial

standpoint) expansion in time. This explosion product is another white dwarf, differing from the white dwarfs discussed in the earlier chapters, in that it is moving outward at a high rate of speed.

At the time of origin, the explosion product is subject to gravitational forces—that is, to motion in the inward direction—and even though the explosion speed is in the $3-1/n^2$ range, the net speed is below two units, and the moving object is observable. As this object travels outward, the gravitational effect is gradually reduced, and unless external forces intervene, the net speed eventually reaches the two-unit sector limit. Further reduction in the gravitational component then takes the net speed across the boundary and into the cosmic sector. At this boundary, gravitation begins operating in time rather than in space. The constituents of this aggregate then move outward from each other in space because of the progression of the natural reference system, now no longer offset by inward gravitational motion. Coincidentally, the process of aggregation in time begins. Ultimately the aggregate in space ceases to exist, and its constituents aggregate in time.

The normal fate of the ultra high speed products of the most violent supernova explosions is thus ejection from the material sector. But unlike the intermediate region white dwarf, whose destiny is foreordained, the ultra high speed product may deviate from the normal pattern. Elimination of gravitation in space does not affect the other influences that tend to reduce the speed of the moving material object, particularly the resistance due to the presence of other matter in the line of travel. Instead of continuing to increase, as gravitation in time becomes increasingly effective, the speed of this object may, under certain conditions, reach a maximum at some point above the two-unit level, and then decrease, eventually dropping back into the region of motion in space. Such objects return to the low speed range in essentially the same condition in which they left it. They have never ceased to be *material* aggregates. Only a very limited range of initial explosion speeds will produce this kind of a result, but it is common enough to give rise to a distinct class of phenomena that will be examined in Chapter 19.

As we have seen, motion at intermediate speed adds an expansion to the original translational motion of a material object. Ultra high speed adds another unit of motion, which takes the form of a translational motion of the expanding object. The fast-moving white dwarf that we are now considering is expanding in time, like any other white dwarf, and moving translationally in a scalar dimension of space other than the dimension of the spatial reference system. But there is no reason why the combination of the two added scalar motions must necessarily take place in this manner. Other things being equal, it is just as possible for the expansion to take place in the second dimension of space, and the translational motion of the expanding object to be in time.

In the central regions of an exploding star, the white dwarf type of product is favored because the compressive forces produced by the explosion act on

matter that is already highly compressed, and is so situated geometrically that it cannot relieve any of the pressure by outward motion. The entire action is therefore inward in space, which is equivalent to outward in time. In the outer regions of the star the initial compression is less, and much of the explosion pressure can be absorbed by motion of the matter against which the pressure acts. Here the general direction of the action is outward. These conditions are favorable for production of the alternate type of combination of motions, that in which the expansion is in space and the translation is in time.

Expansion in space is equivalent to contraction in time, and vice versa. Thus, in either of the alternative motion combinations the expansion produces a compact object. Expansion in time, as in the white dwarf, produces a compact object in space. This object then moves linearly in space. The *constituents* of the object are moving in time; the *object as a whole* is moving in space. In the alternate motion combination, the constituents of the compact object are moving in space, while the object as a whole is moving in time.

As has been emphasized repeatedly in all of the volumes of this work, the conventional fixed spatial reference system is severely limited in its ability to represent the motions that take place in the universe. Many kinds of motion cannot be represented in this system at all, and others cannot be represented accurately. The linear outward motion in the second scalar dimension of space is incapable of representation, as is all motion in actual time. But where *aggregates* expanding at the upper range speeds are observable in the reference system, the speed magnitudes are reflected in the dimensions of these aggregates. We have already seen how this effect accounts for the extremely small observed size of the white dwarf. Now we will need to recognize that expansion into a second scalar dimension of space produces the same kind of a result in the inverse manner; that is, the moving object appears in greatly extended form in the spatial reference system.

Some of the change of position due to the unobservable ultra high speeds is represented in the reference system in an indirect manner. In the initial stage of the outward motion of the ultra high speed explosion product, much of the explosion speed is applied to overcoming the inward gravitational motion of this object. Inasmuch as that gravitational motion has altered the position (in the reference system) of the matter that now constitutes the explosion product, elimination of the gravitational motion results in a movement of this matter back to the spatial position that it would have occupied if the gravitational motion had not taken place. Since it reverses a motion in the reference system, this elimination of the gravitational change of position is observable in that system, even though the change of position due to the motion that produced this effect, the ultra high speed motion in time or in a second scalar dimension in space, is itself unobservable.

The gravitational retardation of the speed is at a maximum at the time of ejection, and decreases thereafter, reaching zero at the point where the

explosion-generated motion arrives at the unit speed level. Thus the greater the net speed of the explosion product, the smaller the resulting change of position in the reference system. Here we have another of the many findings of this present investigation that seem nothing short of preposterous in the light of current scientific thinking. But again, as in the previous instances of a similar nature, we will find that the validity of this conclusion is verified in a number of astronomical applications.

Inasmuch as the spatial motion component of the ultra high speed motion is in a second scalar dimension, it is perpendicular to the normal dimension of the reference system. This perpendicular line cannot rotate in a third dimension because the three-dimensional structure does not exist beyond the unit speed level. Thus the representation of the motion in the reference system is confined to a fixed line. Consequently the first portion of the expansion of this ultra high speed aggregate is linear rather than spherical. The spherical expansion cannot begin until the net speed reaches the unit level and the linear movement has ceased.

As we saw in our examination of the fundamentals of scalar motion, this type of motion does not distinguish between the direction AB and the direction BA, since the only inherent property of the motion is a magnitude. Unless external influences intervene, any linear motion originating at a given point is therefore divided equally between two opposite directions by the operation of probability. In its initial stages the expanding cloud of ultra high speed particles thus takes the shape of two oppositely directed cylindrical streams of matter (jets, in the language of the observers) moving outward from the point of origin.

In the next stage, after the head end of the jet has reached the linear limit, and spherical expansion has begun, each half of the expanding cloud is a weaker and more irregular jet, or stream, of matter, with a knob on the outer end. In its unmodified form, the expanding object as a whole has what is called a dumbbell shape during this stage. In the last stage, the jet has disappeared, and there are now two spherically expanding clouds of ultra high speed matter, each centered at one of the limits of the linear expansion.

In many instances the physical situation is such that expansion in one of the two directions is prevented, or at least impeded. In that event, the result is a single jet, sometimes accompanied by a small counterjet. In other cases, obstructions, or motions of the expanding object in the dimension of the reference system during the period of expansion, modify the shape and direction of the jet, even to the extent, as we will see in the next chapter, of altering the structure to the point where it is no longer recognized as a jet.

The two alternative expansion patterns of these ultra high speed explosion products, as viewed in the context of the spatial reference system—one a small, dense, and inconspicuous object, the other an enormous double cloud of widely dispersed matter spread over an immense volume of space—are so

radically unlike that without a theoretical understanding of their nature and origin one would not suspect that they are related in any way. But, as we have just seen, they are simply two manifestations of the same thing: the result of ultra high speed motion, a form of motion that involves both expansion and linear movement. In one case the expansion takes place in time, and the linear motion in space. In the other the roles of space and time are reversed; the expansion takes place in space and the linear motion in time. The expansion in time produces an object that is extremely small from the spatial standpoint. The expansion in space produces one that is extremely large spatially.

In the pages that follow we will examine a variety of astronomical phenomena that belong in this category, and we will find that, notwithstanding their apparent dissimilarities, they can all be explained on the basis of the theory set forth in the preceding paragraphs. Each of the particular applications has some special features that are peculiar to the existing situation. This has the effect of confusing the essential issues, as they tend to be buried under a mass of detail that has little, if any, relevance to the basic elements of the phenomena that are involved. Furthermore, the prevailing view of the particular situation is, in most cases of the kind we are now considering, incorrect in some significant respects, and it is hard for those accustomed to these currently accepted ideas to avoid being influenced by them. It is therefore advantageous to consider the essential issues on an abstract basis, as we are doing in this chapter, without the complications that accompany the specific applications, and to establish the theoretical relations on a firm basis before undertaking to apply them to the individual cases to which they are applicable.

One more feature of the intermediate regions that should have attention from the standpoint of fundamental theory before beginning consideration of the observable phenomena of this region is the nature of the thermal radiation from objects moving with upper range speeds. As we saw in the earlier volumes, this thermal radiation originates from linear motion of the small-scale constituents of material aggregates in the dimension of the spatial reference system. The effective magnitude of this motion is measured as temperature.

Inasmuch as motion at intermediate speeds is in the same scalar dimension as the motion at speeds below unity, the vibrational motion that produces the thermal radiation continues into the upper speed ranges. But because of the reversal at the unit speed level, the temperature gradient in the intermediate region is inverse; that is, the maximum intensity of the thermal vibration, and the resulting radiation, is at the unit speed level, and it decreases in both directions. In this intermediate region, an increase in speed (equivalent to a decrease in inverse speed) *decreases* the thermal radiation.

Furthermore, the radiating units of matter are confined within one unit of time at the upper end of the intermediate temperature range (the lowest inverse temperatures), just as they are confined within one unit of space at the lower

end of the normal temperature range. This alters the character of the observed radiation. As brought out in the earlier volumes, and reviewed in Chapter 6, speeds less than unity can be attained only by addition of units of the inverse quantity, energy. The result of such an addition is a speed of $1-1/n^2$, where n is the number of units of energy. A wider range of values is then possible by means of combinations of the form $(1-1/n^2)-(1-1/m^2)$. When an atom moves independently, as it does in the true gaseous state, it can only move with certain specific speeds, the speeds that are defined by the foregoing equation with the applicable values of the energy components m and n . Thus each kind of atom (each element) has a specific set of possible radiation frequencies, and a *line spectrum*.

The radiation is emitted from the atom at these same frequencies regardless of the physical state of the aggregate in which the atom exists, but at the low end of the ordinary temperature range, where matter is in the solid or liquid state, the thermal motion of the atom takes place entirely within one unit of space. The radiation originating from this motion has to be transmitted across the boundary between the region inside the unit boundary, the time region, to the outside region where it is observed. For reasons that have been explained in detail in the earlier volumes, this radiation is distributed in direction, and over a range of frequencies, in the inter-regional transmission process. This radiation therefore has a *continuous spectrum*.

The same situation prevails in the intermediate region, if it is viewed in terms of inverse speeds and temperatures. When expressed in terms of the speeds and temperatures of the low speed region, the relations in the intermediate region are inverse. The radiation at speeds just above unity comes from atoms that are still in the gaseous state, and are moving freely in time. This radiation, like that in the corresponding range on the lower side of the unit level, has a line spectrum. As the speed increases still further, the intensity of the radiation decreases, just as it does at speeds farther from unity in the low speed region. At a critical level of inverse temperature and pressure the atom drops into the space region, the region inside unit time; that is, the aggregate of these atoms condenses into the inverse solid state. The optical radiation from this region, like that from the time region where ordinary solids are located, has a continuous spectrum.

CHAPTER 16

Type II Supernovae

The derivation of the principal characteristics of objects moving at ultra high speeds in the preceding chapter gives us a foundation on which we can construct a theoretical picture of the nature and properties of astronomical objects of this class. Before so doing, however, it will be appropriate to give some attention to the process by which the ultra high speeds are generated.

As explained in Volume II, the continued existence of matter is subject to two limits, one related to the temperature, and therefore to the mass of the star in which the matter is located, and the other related to the age of the matter itself, subject to some modification by reason of its location. We have seen that when the temperature limit is reached in the center of a star, that star explodes in an event known as a Type I supernova. Arrival at the age limit results in a similar explosion, which is called a Type II supernova. While these explosions are basically alike, in that each results from the sudden conversion of a substantial portion of the mass of the star into energy, and each produces some products that move with speeds greater than that of light, as well as slow moving products, there are also some significant differences that we will want to explore.

The upper destructive limit of matter is actually a limiting value of the magnetic ionization, but this is a function of age, because the magnetic ionization level continually increases under normal conditions. This ionization is equalized when atoms come into effective contact. All components of a solid aggregate are therefore at the same ionization level. In the fluid states—liquid, gas, and condensed gas—the equalization process proceeds more slowly. Where the material aggregate is as large as a star, and there is a substantial inflow of matter from the environment, an ionization gradient is produced, extending from the lower level of the accreted material to the higher level of the older matter in the interior. When the ionization level in the interior reaches the destructive limit, and the explosion occurs, the matter that is still below the destructive ionization level is dispersed in space and in time in a manner similar to the dispersion of the products of the Type I supernova.

Reliable information about supernovae is very limited. Unfortunately, observations of the individual explosive events can only be made under some rather severe handicaps. No supernova has been observed in our galaxy for

nearly 400 years, and information about the active stage of these objects can be obtained only from extragalactic observation, aside from such deductions as can be made from imprecise eyewitness accounts by observers of the supernovae of 1604 and earlier. The most meaningful information comes from examination of certain astronomical objects, a few of which are known to be remnants of old supernovae, and others that are similar enough to justify including them in the same category. Even at best, however, hard evidence is scarce, and it is not surprising that there is considerable difference of opinion among the astronomers as to classification and other issues. As might be expected under these circumstances, our deductions from physical theory conflict with some current astronomical thought.

The Type I explosion, according to our findings, originates in a star that has reached the size and temperature limits. This is a hot, massive star at the upper end of the main sequence, a member of a group of practically identical objects. Thus our theoretical conclusion is that all Type I supernovae are very much alike. The validity of this conclusion is conceded by the observers. Here are some typical comments:

Type I supernovae display a fascinating homogeneity of photometric and spectroscopic properties.¹⁷⁰ (David Branch)

Supernovae of Type I form a fairly homogenous group with relatively little variation between the spectrum of one star and that of the next . . .

Supernovae of Type II constitute a much less homogenous group than those of Type I.³¹ (Robert P. Kirshner)

The supernovae other than those of Type I are actually so diverse that serious consideration has been given to defining several additional types. In the light of our findings it is apparent that a substantial degree of variation in the Type II events can be expected by reason of the differences in the masses of the exploding stars, and in their physical condition; that is, in the stage of the evolutionary cycle in which they happen to be at the time when they arrive at their age limits. Some of the observations show indications of mass differences. For instance, R. Minkowski reports that "The supernova of 1961 in NGC 4303 which Zwicky designates as Type III, shows properties that suggest strongly a supernova of Type II with unusually large ejected mass."¹⁷¹ Massive objects are, of course, relatively rare in a sample drawn at random from the general run of stars, the great majority of which are small.

The astronomers have not been able to find a satisfactory explanation for the difference between the two classes of supernovae. Shklovsky, for instance, points out that this is one of the things that a theory of stellar explosions should explain:

Why, for instance, are the light curves of type I supernovae so similar to

one another? And why are the light curves of type II supernovae so diverse? Theoreticians have found these questions very difficult indeed.¹⁷²

The principal roadblock in the way of arriving at an answer to these questions is the prevailing commitment to the upside down evolutionary sequence, which is the basis for the current belief in astronomical circles that the Type II explosions are the ones that originate from the hot massive stars. Again quoting Shklovsky:

As for the stars that become type II supernovae, it is logical to infer that they are young objects. This conclusion follows from the simple fact that they are located in spiral arms, where stars are formed out of a gas-dust medium.¹⁷³

The lack of force in this argument can be appreciated if it is recalled that this same author characterized the current theory of star formation as “pure speculation.” This is another of the places where the uncritical acceptance of the physicists’ assumption as to the nature of the stellar energy generation process has diverted the astronomers’ thinking into the wrong channels, and induced them to close their eyes to the direct astronomical evidence. When the correct age sequence is recognized, all of the observations fall into line without difficulty.

Type I supernovae are found to be distributed among all of the various kinds of galaxies. This is consistent with our findings, as the limiting mass may theoretically be reached early in the life of a star, under appropriate circumstances. Age, on the other hand, is inconsistent with an early type of galaxy (with the usual exception that some old stray stars may be picked up by a young galaxy). A Type I event, if it occurs at all, must precede the Type II event that marks the demise of the star. Since the Type II supernova is a result of age, the explosions of this type are primarily phenomena of the older galaxies. The absence (or near absence) of Type II supernovae from the Magellanic clouds, for instance, is easily understood on the age basis, as these Clouds are clearly much younger than the Galaxy, according to the criteria that we have developed. On the other hand, this is a distinct embarrassment for the prevailing “massive star” theory of Type II supernovae. As explained by Shklovsky,

The fact that only Type I supernovae appear in irregular galaxies such as the Magellanic Clouds would seem inconsistent with the picture we have outlined, for these galaxies contain a great many hot, massive stars. Why is it that Type II supernovae are not observed there?¹⁷³

What needs to be recognized is that when the observed facts are “inconsistent with the picture,” then they are telling us that the picture is wrong. This is the same message that we get from a whole assortment of astronomical observations that were discussed item by item in the preceding pages of this volume. All agree that the objects— stars, clusters, galaxies—characterized by astronomers as the older members of their respective classes are, in fact, the younger. This is to answer the Shklovsky’s question, and to a wide range of similar problems.

In spite of the absence of observed events, Type II supernovae are not *totally* excluded from small elliptical or irregular galaxies, or even from globular clusters. As pointed out earlier, all of these aggregates contain a few old stars that have been picked up from the environment during the formation and subsequent travel of the aggregates. When these old stars reach their age limits, supernova explosions take place. The absence of observed events of this kind is due to their scarcity. The Large Magellanic Cloud does contain a few supernova *remnants* that can be identified with Type II events, indicating that at least a few Type II supernovae have occurred in this galaxy within the last 100,000 years.

The *observed* Type II events are largely in the arms of the spiral galaxies, as indicated in one of the quotations from Shklovsky, but we find from theory that the great majority of the Type II supernovae occur in the unobservable inner regions of the giant spheroidal galaxies and the largest spirals. This is where the oldest stars are concentrated. The number of stars that undergo Type II explosions is considerably greater than the number that undergo Type I explosions, since all must eventually meet the Type II fate. This is offset in part by the fact that many stars repeat the Type I explosion at least once, in some cases several times. Aside from occurring much later in the life span of the star—at the very end—the most distinctive feature of the Type II explosion is that the intensity of the explosion, relative to the stellar mass, is much greater than in Type I. The total mass participating in the explosion is, in most cases, less than that of the massive star that becomes a Type I supernova, as the mass of the star involved in the Type II event may be anywhere between the maximum and minimum stellar limits. But the Type II explosion converts a much larger proportion of this mass into energy, and the ratio of energy to unconverted mass is therefore considerably higher, increasing the proportion of the mass going into the products with upper range speeds, and the maximum explosion speed of these products.

The optical emission from the explosion products comes mainly from the low speed component, the material that is expanding outward into space. Since the amount of this material is much smaller in the Type II events than in those of Type I, the optical magnitude of the Type II supernova at the peak is considerably less than that of the Type I events. One investigation arrived at average magnitudes of -18.6 for Type I and -16.5 for Type II.¹⁷⁴ The

emission from Type II also drops off more rapidly at first than that from Type I, and the light curves of the two types of explosions are thus quite different. This is one of the major criteria by which the observational distinction between the two types is drawn.

In view of the limited optical activity and the relatively small mass of the remnants, there has been some question as to what happens to the energy of these Type II events. Poveda and Woltjer, for instance, comment that they find it difficult to reconcile current ideas as to the energy release in the Type II supernovae with the present state of the remnants.¹⁷⁵ This question is answered by our finding that the great bulk of the energy that is generated goes into the upper range explosion products, most of which are not optically visible.

These products include some that are moving at intermediate speeds, and are unobservable because their radiation is widely dispersed by the motion in time, and others moving at ultra high speeds and therefore optically visible only during the linear stage of their expansion. The ultra high speed matter moves outward with the low speed products during this early stage. The intermediate speed matter has no spatial motion component of its own, but much of it is entrained with the outward-moving products. As a result this outward-moving cloud of matter contains local aggregates in which there are substantial amounts of material with the speeds and other characteristics of the white dwarf stars.

The long-continued radio emission of the remnants of the Type II supernovae is due to the presence of these upper range products. It was noted in Chapter 6 that the early white dwarf product of the Type I supernova is not visible optically, and manifests itself only by its radio emission. The same is true of the local concentrations of intermediate speed matter in the remnants, which are the equivalent of small-scale white dwarfs, and pass through the same evolutionary stages. Because of their small size, their evolution proceeds more rapidly, and even in the relatively short time during which the remnants are observable there are portions of the intermediate speed matter in all stages, including small aggregates with the outer shell of condensed gas that is characteristic of the white dwarfs in the visible stages. Thus the radiation from the remnants is not limited to dissipation of the kinetic energy imparted to the explosion products by the supernova. There is a continued generation of energy *within the remnants*. As the observers concede, the brightness of the supernova remnants decreases much less rapidly with increase in radius than conventional theory predicts.¹⁷⁶ The supplemental energy generation is the answer to this problem.

Continued generation of energy in the remnants is manifested not only by the persistence of the radio emission, but also by direct evidence of energetic events within these structures. Inasmuch as conventional astronomical theory provides no means of generating energy in the explosion products, the

prevailing view is that any emission of energy exceeding that which can be ascribed to the initial explosion must be introduced into the remnant from some separate source. In the case of the Crab Nebula, the remnant of a supernova observed in 1054 A.D., it has been estimated that an input of energy “of the order 10^{38} erg/sec” is required to maintain the observed emission.¹⁷⁷ The current belief is that this energy is derived from a dwarf star located in the center of the nebula, but this is purely hypothetical, and it depends on the existence of a transfer mechanism of which there is no evidence, or even a plausible theory.

The explanation that we derive from the theory of the universe of motion is that the continued supply of energy is due to radioactivity in the local concentrations of upper range matter in the remnants. It is the existence of this secondary energy generation in the Type II remnants that accounts for the great difference between the maximum period of observable radio emission in the Type I remnants, perhaps 3000 years, and that of the Type II remnants, which is estimated at more than 100,000 years. As an example of this difference, there is a nebulosity in the constellation Cygnus, known as the Cygnus Loop, which is generally considered to be a remnant of a Type II supernova, and is estimated to be about 60,000 years old. After all of this very long time has elapsed, we are still receiving almost twice as much radiation at 400 MHz (in the radio range) from this remnant as from all three of the historical (1006, 1572, and 1604) Type I supernova remnants combined.¹⁷⁸

There are a number of other remnants with radio emissions that are far above the magnitudes that can be correlated with Type I. Also there are some remnants whose radio emission is within the range of the Type I products, but whose physical condition indicates an age far beyond the Type I limit. These must also be assigned to Type II. In general, it is probably safe to say that unless there is some evidence of comparatively recent origin, all remnants with substantial radio emission can be identified with Type II supernovae, even though Type I events may be more frequent in the observable region of our galaxy.

The conclusions as to the relative magnitude of the radio emission enable us to classify the most conspicuous of the remnants, the Crab Nebula, as a Type II product. The radio flux from this remnant is about 50 times that of the remnant of the Type I supernova that appeared in 1006, and is therefore of practically the same age. The Crab Nebula was originally assigned to Type I by the astronomers, mainly on the basis of the differences between it and Cassiopeia A, the remnant of a supernova that occurred about 1670 A.D., which was regarded as the prototype of the Type II remnant. More recently it has been recognized that the differences between the Crab Nebula and the Type I remnants are more significant. Minkowski, for instance, reports that “an unbiased assessment of the evidence leads to the conclusion that the Crab Nebula is not a remnant of a supernova of Type I.”¹⁷¹

This nebula consists of two physically distinct components, "one is an amorphous distribution of gas . . . and the other is a chaotic network of filaments."¹⁷⁹ In the center of the nebula there is a dwarf star of the Type II class, the nature and characteristics of which will be discussed in the next chapter. The presence of a star of this type definitely identifies the nebula as a product of a Type II supernova large enough to produce maximum speeds in the ultra high range.

On the basis of the theoretical considerations discussed in the preceding chapter, the presence of ultra high speed matter in the inward-moving product of the Type II supernova implies the existence of an observable outward-moving ultra high speed component, which should consist of one or more jets of material. Instead, as indicated above, the observers report the presence of a "chaotic network of filaments." So let us take a look at the nature of these filaments.

The dictionaries define the word "filament" as a "slender, threadlike object." We are accustomed to the way in which astronomical magnitudes dwarf those of our ordinary experience. Indeed, we commonly use the term "astronomical" in the sense of "extremely large." But even so, it comes as somewhat of a shock when we are told that "on the average the bright filaments are 1.4 arc sec. in diameter, which corresponds to a width of 2.5×10^{11} km."¹⁸⁰ The "slender" object is more than a hundred billion kilometers in diameter. But this does give us an answer to the question as to the nature of the filaments. These "slender" filaments are clearly the same kind of entities that we call jets in a different context. Their erratic courses are undoubtedly due to the resistance that they meet as they make their way through the clouds of matter moving at lower speeds.

There is also a problem in connection with the so-called "amorphous" component of the nebula. It must consist in part of the low speed products of the supernova explosion, but the properties of this component do not resemble those of a hot gas and dust mixture. In fact, even though it is identified as a "gas," its spectrum is continuous, like that of a solid. This seeming anomaly gives us the clue that points the way to an explanation of the observations. An explosion that is powerful enough to give some of its products speeds in the ultra high range also accelerates other portions of its products to speeds just below the ultra high level; that is, the upper part of the intermediate range. These intermediate products are moving in time only, and have no capability of independent motion in space, but most of them are entrained in the moving components. Those that mix with the low speed matter are carried along until the particles individually drop out of the stream. This settling out process begins immediately after ejection. The outward motion of the products of the Crab supernova has therefore left the volume of the nebula filled with scattered particles of intermediate speed matter concentrated toward the center,¹⁸¹ rather than toward the periphery, as in the shell structures that are typical of

supernova remnants in general.

As we saw in our examination of the theoretical aspects of the upper range speeds in the preceding chapter, particles moving with speeds in the upper portion of the intermediate speed range radiate in the same manner as those in the lower portion of the range below unity; that is, with a continuous spectrum. The physical state of this material is the temporal equivalent of the solid state: a condition in which the atoms occupy fixed positions in three-dimensional time, and the emission is modified in the same manner as in the solid state. Here we have another concept that is totally foreign to conventional physical thought. For that reason it will undoubtedly be difficult for many persons to accept. But it is clearly the kind of a result that necessarily follows from the general reciprocal relation between space and time. The two speed ranges with continuum emission are symmetrically related with respect to the natural datum level: unit speed. Furthermore, the intermediate range continuum radiation is not limited to supernova remnants. We will meet the same kind of radiation from matter in the same temperature range later, under different circumstances.

The theoretical presentation in Chapter 15 also explains why the filaments, which are in a still higher speed range, have a line spectrum. As brought out there, motion in a second scalar dimension is incapable of representation in the conventional spatial reference system, but the elimination of the gravitational effect by this motion does cause an observable change of position in that system. This indirect result applies to the thermal motion as well as to the unidirectional translational motion previously considered, but in both cases the magnitude of the observed motion is subject to the limitations on the gravitational speed in one dimension; that is, it is confined to the range below unity. Thus, even though the speeds of the particles in the filaments are in the ultra high range, the observable thermal effect is in the low speed range, and the radiation that is produced has a line spectrum like that of an ordinary hot gas.

It has not been possible to extend the present investigation to an analysis of the spectra of astronomical objects because of the amount of time that would be required for such an undertaking. Some aspects of these spectra that are of special significance in connection with the subjects under discussion will, however, be noted briefly as we proceed. In the case of the Crab Nebula much stress has been laid by the astronomers on two points: (1) that the radiation is non-thermal, and (2) that it is polarized. It will therefore be appropriate to point out that, according to our theoretical findings: (1) *all* radiation from objects with upper range speeds, except that generated by indirect processes such as the one explained in the preceding paragraph, is non-thermal, and (2) *all* such radiation is polarized as emitted. Where a lower polarization is observed, this is due to depolarizing effects during travel of the radiation. A three-dimensional distribution of radiation is impossible in a two-dimensional

region.

As noted earlier, the observed characteristics of Cassiopeia A, the other very conspicuous (at radio frequencies) supernova remnant, are quite different from those of the Crab Nebula, even though it is now conceded (not without dissent) that both are Type II remnants. Here again, there are two components of the remnant, but neither resembles a component of the Crab Nebula. Both appear to consist mainly of local concentrations of ordinary matter distributed in the volume of space occupied by the remnant. The objects of one class are moving rapidly, and are located mainly at the periphery of the remnant in what is commonly described as a shell. The other objects are larger, more evenly distributed throughout the remnant, and nearly stationary. The shell is no doubt composed of the outward-moving low speed explosion products. The problem of accounting for the quasi-stationary objects in the context of conventional astronomical theory has been very difficult; so difficult, in fact, that there is a tendency to try to dodge the whole issue, as in the following statement:

The only possible interpretation of the stationary filaments in Cas A is that these filaments were present before the supernova outburst.¹⁸²

Here again we meet the assumption of omniscience that is so curiously prevalent among the investigators of the least known areas of science. From the very start of the investigation whose results are being reported in this work, the answers to outstanding problems have almost invariably been found in areas in which the adherents of orthodox theories have claimed that they have examined all conceivable alternatives. The Cassiopeia A situation is no exception. The explanation that these authors characterize as impossible can be obtained from a consideration of the theory that is being discussed in this work.

There is no indication of the existence of a Type II dwarf in the remnant. We can conclude from its absence that the Cassiopeia A supernova was not energetic enough to produce significant amounts of ultra high speed products. On this basis, the two components of the remnant can be identified as low speed and intermediate speed products. This raises another issue, because intermediate speeds in the dense central core of an exploding star would normally cause inward motion and production of a Type I dwarf. No such product is observed. From its absence we can conclude that the star of which Cassiopeia A is a remnant did *not* have a dense core; that is, it was a star of the giant, or pre-giant, class, in an early stage before there was much central condensation. The Type II explosion can take place at any stage of the stellar cycle. If it happens during a diffuse stage, the explosion involves the entire structure, the explosion forces are predominantly outward, and they are distributed so widely that they do not reach the ultra high levels. In this case

the intermediate speed products are entrained in the outgoing low speed matter, and are distributed in the remnant in much the same manner as the amorphous mass in the Crab Nebula, but in local concentrations because of the lower density of the moving matter in which they are being carried.

Explosion of a relatively cool and extremely diffuse star would not be as spectacular an event as an ordinary supernova. This is probably the reason, or at least a major part of the reason, why there is no record of an observation of the supernova that produced Cassiopeia A. The explanation of the strength of the radiation now being received from this remnant, and the rather rapid decrease in the amount of this radiation, will become apparent when the process by which the radiation is generated is described in Chapter 18.

From the explanations that have been given, it can be seen that the unique characteristics of both Cassiopeia A and the Crab Nebula are due to the youth of these objects. These are features of the very early post-explosion stages. Within a few thousand years these early phases of the evolutionary development will be completed. The optically observable activity in the remnant will then be confined almost entirely to the outer shell, where the outward-moving low speed component is concentrated. Radio and x-ray emission will continue on a reduced scale for a considerable period of time. The Vela remnant, estimated to be about 10,000 years old, has already reached this more advanced age.

CHAPTER 17

Pulsars

As indicated earlier, the maximum product speeds of the least powerful Type II supernovae, those in which the exploding star is relatively small, are in the intermediate range. Like the fast-moving products of the Type I explosions, the products of these smaller Type II supernovae are white dwarfs. On the average they are smaller than the white dwarf products of the Type I supernovae, and their iron content is less, but they follow the same evolutionary pattern. The ultra high speed products of the more powerful Type II explosions follow a different course. As we saw in Chapter 15, they move linearly outward, and in the usual case ultimately arrive at a net explosion speed exceeding two units, and disappear into the cosmic sector.

Those of the ultra high speed products that are expanding in *time* and moving linearly in *space* are fast-moving Stage I (not optically visible) white dwarfs. Their most distinctive feature is the intermittent nature of the radiation that is received from them, and for this reason they are called *pulsars*.

Up to the time when *Quasars and Pulsars* was published in 1971, about 60 pulsars had been located. This number has now risen to over 300. Aside from the discovery of x-ray pulsars and the identification of their properties, progress in the pulsar field during the intervening years has consisted mainly of accumulating more data of the same nature as that available in 1971. There has been a great deal of theoretical activity, but since this has been based almost entirely on the “neutron star” hypothesis, no progress has been made toward recognition of what this work has identified as the true nature of the pulsars. This lack of basic progress is clearly demonstrated by the current inability to account for the two fundamental processes that are involved. As reported by F. G. Smith in a review of the existing situation, the manner in which the pulsar is produced by the supernova explosion “is not understood,” and “little is known about . . . the mechanism of the radiation.”¹⁸³

Furthermore, no one can explain *how* the hypothetical neutron stars originate. As brought out in Chapter 6, the arguments advanced in support of the assumption of a “collapse” under the influence of self-gravitation are absurd, and no other way of producing “degenerate matter” has been identified. But the astronomers continue to insist that neutron stars must nevertheless exist.

Even now, however, we have no theories that satisfactorily explain just how a massive star collapses to become a neutron star. We know that neutron stars are possible in our universe only because we see that they are there—not because we understand how they form.¹⁸⁴ (Martin Harwit)

Harwit defines a neutron star as “a collapsed, compact star whose core consists largely of neutrons.”¹⁸⁵ Only one of the descriptive words in this definition is supported by the astronomical evidence. This evidence shows that the object that is being called a “neutron star” is indeed a compact object. But, as Harwit himself admits, there is no evidence to support the assertion that it is a “collapsed” star. No one can explain *how* a star could have collapsed. Nor is there any evidence that this object has a core, or that it is composed, to any significant extent, of neutrons. The definition does not define the observed object; it defines a purely hypothetical object dreamed up by the theorists.

Harwit says that “we see that they [the neutron stars] are there.” This is definitely not true. He and his colleagues see that *compact stars* are there, but the further assertion that these are neutron stars is pure assumption. It is simply another of the many instances where astronomical thought has lost touch with reality because of the prevailing tendency to assume that the most plausible theory available at the moment must necessarily be correct, regardless of how many questions it leaves unanswered, and how often it conflicts with the evidence from observation. The case in favor of the neutron star hypothesis is the same “there is no other way” argument that we have met so often in the earlier pages of this and the preceding volumes. Of course, the practice of arriving at conclusions by a process of elimination does have merit under appropriate circumstances. It is not the use, but the misuse, of this argument that is subject to criticism. As Fred Hoyle pointed out in connection with one of these misuses:

So the argument amounts to nothing more than the convenient supposition that something which has not been observed does not exist. It predicates that we know everything.¹⁸⁶

This is the crux of the situation. The use of the “no other way” argument is legitimate only in those cases where we have good reason to believe that we *do* know everything that is relevant. In any case where the relevant factors are well understood, the elimination of all but one of the recognized possibilities creates a rather strong presumption (although still not a proof) that the one remaining possibility is correct, *providing that this possibility does not involve any conflict with observation or measurement*. The serious mistake that is so often made in present-day scientific practice, not only in astronomy, but in

other areas of physical science as well, is in accepting this kind of an argument in cases, such as the assumption of the existence of neutron stars, where the foregoing requirements are *not* met. The result is that the distinction between fact and fancy is lost.

The distribution and observed properties of the pulsars indicate that they are situated within, or close to, the Galaxy. Since one of them is associated with the Crab Nebula, and another with the Vela Nebula, both supernova remnants, it seems evident that the pulsars are products of supernovae. The validity of this currently accepted conclusion is confirmed by our theoretical development. The fact that both of these objects are located in Type II remnants also supports our finding that the pulsars are products of Type II explosions only. Some members of the astronomical community are reluctant to accept this conclusion, as it is difficult to reconcile with current views as to the nature of the pulsars. Shklovsky, for example, admits that “The two known pulsars in SNR are associated with SN II explosions,”¹⁸⁷ but nevertheless expresses the belief that pulsars may yet be discovered in association with Type I remnants. The conclusion that no pulsars form in Type I explosions is “at least premature,” he contends. His argument is that the light curves of all supernovae are best explained by continued input of energy from pulsars within the remnants, in the manner assumed in the case of the Crab Nebula, and that the pulsars therefore probably exist in Type I remnants even though none have been detected.

The truth is that Shklovsky’s argument is very much stronger if it is turned upside down. It contains three statements: (1) the energy in the Crab Nebula is supplied by the pulsar (neutron star in current thought), (2) the power supply is the same in all remnants, and (3) the observations show that there are no pulsars in Type I remnants. Shklovsky assumes that statement (1) is valid, and deduces from the foregoing that statement (3) is false. But (3), the observation, is far more reliable as a premise on which to base our reasoning. If we take this observation at its face value, we deduce that statement (1) is false, and that the energy of the Crab Nebula is *not* supplied by the pulsar. This agrees with the conclusion that we reach by deduction from the postulates of the theory of the universe of motion.

Those astronomers who reject the idea that there are concealed pulsars in Type I remnants have no explanation for the restriction of the pulsars to Type II events, but generally agree with F. G. Smith that “the association with Type II supernovae seems established without further argument.”¹⁸⁸

No pulsars have been discovered in external galaxies, but as noted in Chapter 15, there are a few remnants of Type II supernovae in the Large Magellanic Cloud, indicating that pulsars occasionally do appear in relatively small galaxies, as well as in the larger aggregates. This is consistent with what we have previously found with respect to the existence of a few older stars in the younger galaxies.

In a number of instances, the observations of the pulsars arrive at results that seem contradictory. It has been found that many, probably most, of them are moving rapidly, with speeds often exceeding 100 km/sec.¹⁸⁹ Furthermore, the average height of the pulsars above the galactic plane is considerably greater than is normal for the objects from which they presumably originated. These motions and positions are seemingly inconsistent with the fact that the Crab and Vela pulsars have remained near the *center* of their respective remnants.

In the universe of motion, the spatial position of the pulsar and its observable spatial speed are related to the gravitational retardation. The explosion speed, and the resulting change of position in a second scalar dimension of space, are not capable of representation in the spatial coordinate system, but, as we saw in Chapter 15, when a portion of the gravitational motion is eliminated by the oppositely directed motion generated by the explosion, the outward motion that was being counterbalanced by gravitation becomes effective, and appears as an observable spatial motion equal in magnitude and opposite in direction to the gravitational motion that is neutralized. Thus, during the first portion of the outward travel of the ultra high speed explosion product, there is an observable spatial speed, and a corresponding change of position in the reference system, the magnitude of which depends on the strength of the gravitational force that has to be overcome.

The gravitational effect on an object moving through a portion of the Galaxy is continually changing. Initially the exploding star is outside the gravitational limit of its nearest neighbor (unless it is a member of a double or multiple system), and the gravitational restraint on the pulsar is mainly due to the mass of the slow-moving remnants of the explosion. This effect decreases rapidly, and as the pulsar moves farther away from the initial location, the integrated effect of all mass concentrations within effective range becomes the dominant factor.

This variation in the gravitational restraint explains some of the observations that otherwise seem mutually contradictory. All pulsars are moving. If the supernova explosion occurs in an isolated star in the outer regions of the galaxy, the gravitational restraint on the pulsar is relatively weak, and the outward movement resulting from elimination of the gravitational effect is correspondingly small. The Crab pulsar, for example, is moving very slowly with respect to the nebula, and according to present estimates it will not escape for about 100,000 years.¹⁹⁰ At present it is still near the center of the nebula.

On the other hand, pulsars produced by explosions that are more centrally located in the galaxy are subject to substantial gravitational forces due to the effects of the central mass as a whole. In this case, the spatial component of the explosion speed, which causes a change of position in the space of the reference system, is relatively large. It follows that, as a rule, we can expect to find the pulsars produced by isolated stars in the outer regions of the galaxy

moving quite slowly and located in or near the remnants, whereas those produced in central locations will be moving rapidly, and most of them will be found well away from the galactic plane. The pulsars produced in binary or multiple star systems, or in clusters, are subject to more gravitational restraint than the single stars, and if they are located in the outer regions they follow an intermediate course, not attaining the high speeds of those produced in the central regions, but moving fast enough to leave the vicinity of the remnants within a few thousand years. This accounts for the absence of pulsars from most of the observable remnants.

Another apparent anomaly is that the observed number of pulsars in the Galaxy seems to require a rate of formation that is considerably in excess of the observed frequency of Type II supernovae. Smith calls this "a serious discrepancy between the theory of origin of pulsars in supernovae, and the observations of their ages and numbers in the Galaxy."¹⁹¹

Our findings clarify this situation. On the basis of theoretical conclusions reached in the preceding discussion, the number of Type II supernova explosions occurring in the Galaxy is not only ample, but greatly in excess of that required to account for the observed number of pulsars. However, our findings are that the oldest stars, the ones that reach the age limit and explode as supernovae, are concentrated mainly in the central regions of the galaxy, the oldest portions of the structure. The great majority of the Type II supernovae therefore take place in these central regions, where they are unobservable because of the strong background radiation and obscuration by intervening material. Furthermore, since the stellar aggregates have the general characteristics of viscous liquids, they resist penetration by the explosion products. In the central regions of the largest galaxies, all of the explosion products are confined by the overlying matter, and the pulsars included in these products are, like the supernovae, unobservable individually. In galaxies of less than maximum size, such as the Milky Way, some of the pulsars originating in the outer portions of the central regions are able to make their way out to join the pulsars originating from isolated supernovae in the galactic disk. Thus there is no difficulty in accounting for the number of Type II supernovae required in order to support the estimated pulsar population.

Conventional pulsar theory rests to a large extent on the current interpretation of the observations of the Crab Nebula. According to these ideas, the emission of radiation from the nebula is powered by energy from the pulsar located at its center. But only a few of the known pulsars are associated with supernova remnants (only two such associations are definitely confirmed). Some other explanation of the long-continued emission of energy from the other remnants is therefore required in any event, and when this is available there is no need for a special process in the Crab Nebula. The theory of the universe of motion supplies a source of energy that is independent of the existence of pulsars in the remnants.

The most characteristic property of the pulsars, the one that has given them their name, is the pulsating nature of the radiation that we receive from them. In the early days of the pulsar investigation, just after the discovery of the first of these objects, the extreme regularity of the pulses and the absence of any known natural process whereby they could be generated, suggested that the pulses might be artificially produced, and for a time they were facetiously called messages from little green men. When more pulsars were discovered it became evident that they are natural phenomena, and the little green men had to be abandoned, but no explanation of the origin of the pulsed radiation that the astronomers have been able to put together thus far is any less fanciful than the little green men. As F. G. Smith, one of the prominent investigators in the field, said in the statement previously quoted, "little is known" in this area.

The big problem is that natural processes capable of producing regularly pulsed radiation are hard to find within the arbitrarily circumscribed boundaries of conventional physical science. The only such process thus far suggested that has received any appreciable degree of support is rotation. In the absence of any competition, this is the currently accepted hypothesis, although, as indicated in the statement by Smith, it is recognized that this explanation has not been developed to the point where it can be considered satisfactory. It depends too much on the assumed existence of special conditions of which there is no observational evidence, and it leaves a number of the observed properties of the pulsars unaccounted for. Furthermore, when the rotation process is applied to explaining the periodicity, the theorists are precluded from using it to explain some other phenomena that, on the basis of the observational evidence, and independently of any theory, are almost certainly due to rotation—the "drifting sub-pulses," for example.

In the universe of motion, the periodicity of the radiation received from the pulsars is a necessary consequence of the property that makes them pulsars: the ultra high speed. An object moving in the explosion dimension with a speed in this ultra high range arrives at the gravitational limit when its *net* speed in this dimension (the explosion speed minus the effective gravitational speed) reaches unity. At this point the effective gravitational speed, as we saw in Chapter 14, is equal to the oppositely directed unit speed of the progression of the natural reference system. On the basis of the theory of radiation set forth in the earlier volumes, this means that at the gravitational limit radiation is being emitted at such a rate that we receive one unit of radiation from each mass unit per unit of area per unit of time. At distances beyond this limit, the average amount of radiation received is less because of the further distribution over equivalent space. But radiation is a type of motion, and motion exists only in units. The decrease in the average amount of radiation received can therefore be accomplished only by a reduction in the number of units of time during which radiation is being received. Radiation from a pulsar beyond the gravitational limit is received at the same *strength* as that from one at the

gravitational limit, but only during a constantly decreasing proportion of the total *time*. All of the mass units of a star enter the pulsation zone within a very short time, only a small fraction of the observed period. Thus, even though the total radiation from the star is distributed over an appreciable time interval, it is received as a succession of separate pulses.

All pulsar periods are lengthening (except in the pulsating x-ray emitters, which we will consider in Chapter 19). The period is thus clearly an indication of the age of the pulsar, but the specific nature of the relation is not immediately apparent. At first it was believed that the age could be determined by simply dividing the period by the rate of change, and “characteristic ages” thus defined are found in reference works. But it is now evident that the situation is more complicated, and that most of the ages thus calculated are too high.

The first study of the pulsar ages in the context of the Reciprocal System of theory likewise took a wrong turn, and arrived at ages that are now seen to be too low. As pointed out in Volume I, the status of this system of theory, the theory of the universe of motion, as a *general* physical theory means that it should be able to provide the correct explanation for *any* physical situation. But this explanation does not emerge automatically. A substantial amount of study and investigation may be required in any specific case before the correct answers are obtained. The first such study frequently turns out to be deficient in some respect. Relevant factors may have been overlooked, or may not have been taken fully into account, even where the development of theory may have been correct, so far as it went. This was the case in the original pulsar study, which we now find arrived at results that are correct in their general aspects, but require modification in some of the details. A full-scale review of the pulsar phenomena undertaken in connection with the preparation of the text of this new edition has clarified a number of points that were not correctly interpreted either in conventional astronomical thought or in *Quasars and Pulsars*. This clarification is still not complete, but some significant advances in understanding have been accomplished.

Fig. 24 is a diagram that is found in many recent discussions of the pulsar period relationship, with some lines added for purposes of the present review. It is recognized that the diagonal line at the right of the diagram, with a slope proportional to the fifth power of the period, represents the cut-off at which the pulsed radiation ceases. It is also realized that there must be some significance in the absence of observations that fall in the lower left part of the diagram. But, in essence, what this diagram does for the astronomers is to identify some of the questions. It does not give the answers.

In the context of the theory of the universe of motion, the outer boundary of the material sector, the sector of motion in space, is a *spatial* limit. Since space and time, in this sector, are subject to the relation $s = at^2$, where a is a constant applicable to the specific phenomenon involved, the time magnitude

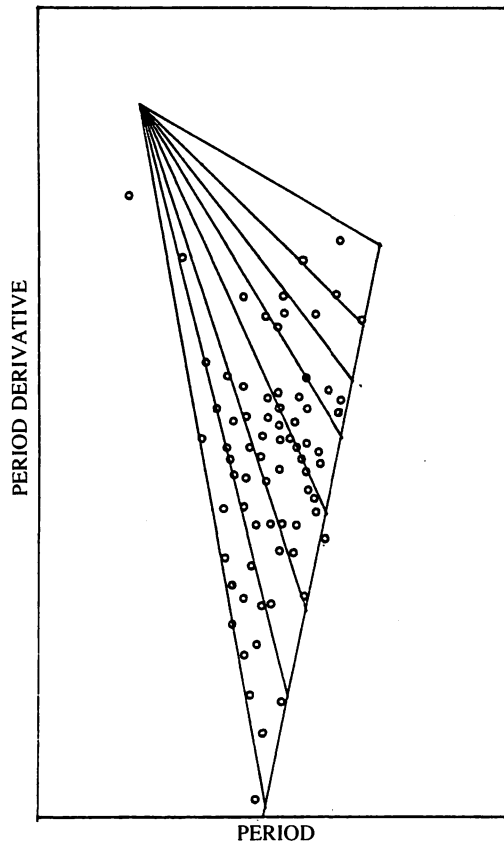


Fig. 24 Pulsar Periods

that enters into the quantities related to the sector limit is t^2 . Furthermore, the sector limit applies to the total motion, the motion in all three scalar dimensions; that is, to t^6 . The time interval between successive radiation pulses, the *period* of the pulsar, is related to the total time. The rate of change of the period, as observed, is therefore the derivative of P^6 . The period decreases with time, but because of the inversion at the unit level, the applicable quantity is not the derivative of the reciprocal of P^6 , but the reciprocal of the derivative of P^6 ; that is, the reciprocal of $6 P^5$.

This indicates that the points farthest to the left in Fig. 24 define another line with the same slope as the cut-off line on the right of the diagram, and intersecting the latter at a period of about 0.62, as shown in the diagram. This downward-sloping line is the path of the period-derivative relation for a pulsar that conforms to the $1/6 P^{-5}$ relation without modification, and 0.62 seconds

is the period at which the pulsar reaches the sector limit. As we saw in Chapter 15, however, there are eight ways in which the motion in the region of equivalent space can be distributed, only one of which results in transmission of the effects across the boundary into the three-dimensional region. Where the motion is distributed over n of the eight, the observed period is increased to nP . Or, if we let P represent the *observed* period, the true period becomes P/n , and the reciprocal of the derivative is $1/6 (n/P)^5$. Each distribution thus has its separate path extending from the same initial point to a terminus on the cut-off line at a period of $0.62 n$ seconds.

While the observed points clearly follow the theoretical lines, as shown in Fig. 24, in some instances, there is also considerable scatter in the diagram, the significance of which is not yet clear. The existence of half-integral effective values of n is undoubtedly one of the contributing factors. As we have noted frequently in the pages of the earlier volumes, in cases where the probability considerations favoring n and $n+1$ are nearly equal, the result often is that half of the units involved take the n value and the other half the $n+1$ value, making the effective magnitude $n+1/2$. The existence of an evolutionary line based on $n = 1/2$ is so evident that this line has been included in the diagram. Similar half-integral values may exist throughout the total range, and this may be all that is needed to explain the scatter of the observed points. If not, there probably are some transitions from one value of n to the next as the net speed increases.

At the present stage of the theoretical development it is not possible to arrive at a firm theoretical value for the reference magnitude, the period corresponding to the sector limit where $n = 1$. In fact, this period may be, to some extent, variable. The value 0.62 seconds quoted in the foregoing discussion has been derived empirically by fitting the theoretical shape of the diagram in Fig. 24 to the observed points.

The pulsar age involves another reference value for which we will have to use an empirically determined magnitude, 3.25×10^5 years, pending further theoretical study. The current age of the pulsar is the product of this value, the distribution factor n , and the square of the period in terms of the 0.62 unit (that is, $(P/0.62)^2$). For the Crab pulsar, which is designated 0531+21, from which the value of the age constant was derived, we have $(0.033/0.62)^2 \times 1 \times 3.25 \times 10^5 = 921$ years. The Vela pulsar, 0835-45, is on the 1.5 evolutionary line, and its theoretical age is $(0.089/0.62)^2 \times 1.5 \times 3.25 \times 10^5 = 10046$ years. This agrees with the age of the supernova remnant, estimated at about 10,000 years. The theoretical life spans of these two pulsars, if they stay on their present evolutionary paths, are 3.25×10^7 years and 1.10×10^6 years respectively. The maximum concentration of pulsars is on, or near, the lines with n values of 2 and 3. The corresponding lifetimes are 2.6×10^9 and 8.8×10^6 years. These results are consistent with current estimates based on observation of various pulsar

characteristics. F. G. Smith, for instance, arrives at this conclusion: "We therefore take . . . the maximum lifetime for most pulsars as 3×10^6 years."¹⁹²

From the theoretical explanation of the nature of the pulsation it is evident that the shape, or profile, of the pulse is a reflection of the shape of the radio structure of the object from which the radiation is emitted. The width of the pulse is determined by the dimensions of the pulsar in the line of sight, and the amplitude by the lateral dimensions. Thus the pulse profile is a representation of a cross-section of the pulsar or, more accurately, the summation of a series of cross-sections.

The most common profile, a single hump, with or without irregularities, clearly originates from a globular object, which may be somewhat irregular. This simple profile, called Type S, predominates in the younger pulsars, those in the upper left of Fig. 24. As explained in Chapter 15, however, an object whose components are moving at speeds in the ultra high range, between two and three natural units, appears to observation at radio frequencies as a double structure. The separation, initially zero, increases with the distance, and most of the older pulsars therefore have complex profiles, Type C, with double or multiple peaks.

As the rotation of the pulsar carries its various features across the line of sight, the amplitude of the radiation varies, giving rise to variations in the individual pulses. But when the data on these individual pulses are combined into an integrated profile that reflects the total emission during the full rotational cycle, the profile remains constant, except to the extent that actual changes in the pulsars (movement of local concentrations of matter, etc.) take place. The integrated profiles therefore show "well-organized and characteristic behavior."¹⁹³

The rotation imparted to the pulsar by the original explosion is generally quite limited, and ordinarily it takes from 500 to 2000 or more pulses for the integrated pulse profile of a young pulsar to reach the stable form which indicates that a full rotational cycle has elapsed. Interaction with the environment tends to increase the rotational speed, and many of the older pulsars, those approaching the cut-off line in Fig. 24, are rotating fast enough to cause an observable drift of the sub-pulses. "The sub-pulses of successive pulses tend to occur at earlier phases, so that they drift fairly uniformly across the profile."¹⁹⁴

It has been noted by observers (see, for instance, Manchester and Taylor, reference 195) that differences between the pulse shapes at radio and optical frequencies, together with the discontinuity between the corresponding spectra, suggest different emission processes, whereas the time coincidence of the peaks indicates that the processes are closely related. These seemingly contradictory observations are explained by our finding that the time pattern of the pulses of radiation is independent of the process by which the radiation is

produced. At any specific time, all of the radiation emitted from the matter in a specific section of the pulsar becomes observable, irrespective of its origin.

Inasmuch as the pulsation is due to the attenuation of the radiation by distance, rather than to any feature of the emitter or the emission process, radiation from all objects moving at ultra high speeds is received in pulsed form if emitted during the time that the object is passing through the pulsation zone, irrespective of the nature of the emitting object. However, the radiation from the giant clouds of particles that constitute the second type of ultra high speed explosion product is too diffuse to be observed, while that from galaxies or galactic fragments is unobservable because the individual stars of which these aggregates are composed are so far apart that the pulsations in the radiation received from them are not synchronized.

Since the pulsar radiation originates in a two-dimensional region, it is distributed two-dimensionally; that is, it is *polarized*.

Individual pulses, and especially those that have a simple Gaussian shape, are highly polarized . . . The polarization often reaches 100 percent.¹⁹⁶ (F. G. Smith)

According to the theory of the universe of motion, *all* radiation originating in the intermediate speed range is 100 percent polarized at the point of origin, but there are many depolarizing influences along the line of travel in most cases. The observed percentage of polarization is an indication of the amount of depolarization rather than of the initial situation. Thus we note that the radiation from the short-period pulsars with simple pulse profiles, classified as Type S, which have not yet had time to separate from the cloud of debris at the site of the supernova explosion, is weakly polarized, while that from the long-period complex (Type C) pulsars shows strong polarization.¹⁹⁷ Similarly, the sub-pulses and micropulses are, in general, more highly polarized than the integrated profiles, a difference that is generally attributed to depolarization.¹⁹⁸

Development of the details of the universe of motion as they apply to the pulsar phenomena has not yet been carried far enough to arrive at firm conclusions concerning the quantitative relations. We can, however, obtain some tentative results that are probably at least approximately correct. According to the findings described in the preceding pages, the size of the pulsar is indicated by the width of the pulse. The basic period, we found empirically, is 0.62 seconds. The equivalent space is $0.62 \times 3 \times 10^5$ km = 1.86×10^5 km. The average width of the pulse is reported to be about three percent of the period.¹⁹⁹ The indicated diameter of the average pulsar is then $0.03 \times 1.86 \times 10^5$ km = 5580 km. On this basis, most pulsars are in the range from 5000 to 6000 km in diameter. This is within the white dwarf range.

We may now divide the corresponding circumferential distance by the time

required to stabilize the integrated pulse profile, and arrive at an approximate value of the equatorial speed of rotation. For a rapidly rotating pulsar that reaches a stable pulse form in 10 pulses of one second each, the equatorial speed is about 1800 km/sec. This is very fast, but not out of line for an object that has been traveling at an extremely high speed. It is an order of magnitude less than some of the rotational speeds suggested in connection with previous theories.²⁰⁰ Where 1000 pulses are required before the integrated profile is stable, the equatorial speed is less than 20 km/sec.

One of the major advantages of a *general* physical theory is that it is a theory of the unknown physical phenomena of the universe, as well as a theory of the known phenomena. Of course, as long as a phenomenon remains unknown it is not particularly helpful to have a theory that explains it, unless that theory helps, in some way, to make discovery of the phenomenon possible. But once the hitherto unknown phenomenon is discovered, the existence of a general theory leads almost immediately to an understanding of the place of this phenomenon in the physical picture, something that may take a long time to achieve if no theory is available in advance.

In the case of the pulsars, the development of the astronomical aspects of the theory of the universe of motion had already been carried far enough prior to their discovery to provide an explanation of the nature and properties of the *general class* of objects to which they belong: ultra high speed products of stellar disintegration at the age limit. The deductions made in the course of the original investigation, and published in 1959, will be discussed in Chapter 20. This early investigation was directed primarily at the products of galactic explosions, but as soon as the pulsars were discovered, it was evident that these objects belong in the same class as the galactic explosion products whose existence was predicted in the 1959 publication, differing only in those respects where size is a significant factor.

Conventional science, on the other hand, has no general physical or astronomical theory, and this has left the pulsar field wide open for speculation. The theorists' imaginations have had full play. As matters now stand, the prevailing opinion is that the pulsars belong to the hypothetical category of "neutron stars." Where difficulty is experienced in fitting the neutron stars into the picture, a further exercise of the imagination produces a "black hole."

In considering the conflicts between current astronomical thought and the theory of pulsars derived from the postulates of the Reciprocal System, it should be recognized that there is no independent evidence of the existence of such things as neutron stars or black holes. They are purely hypothetical, and they have been introduced only because accepted ideas as to the nature and properties of the white dwarfs impose limits on the roles that these objects can play in physical phenomena; limits that are wholly theoretical and have no factual support. From an observational standpoint, all of the high density stars

are alike. There is no physical evidence to indicate any division by sizes of the nature required by present-day theory. The truth is that the inability of the conventional white dwarf theory to account for the full range of these observationally similar objects is a serious defect in the theory; one which, in most fields of science, would be enough to prevent its acceptance. But in this case, the weakness in the white dwarf theory is used as an argument in favor of the black hole theory, or at least, as conceded by some of the proponents of the theory, it is a “key link” in that argument.²⁰¹

When the existence of matter at extremely high densities was first brought to light by the discovery of the white dwarf stars it was found possible to devise a theory of this density that appeared plausible in the context of the facts that were known at that time. But later, when the *same* phenomenon—extremely high density—was encountered in the quasars, where the white dwarf theory that had been constructed is obviously inapplicable, instead of taking the hint and reexamining the white dwarf situation, the theorists directed their efforts (so far unsuccessfully) to finding some different explanation that would fit the quasars.

Then, when the same extremely high density showed up in the pulsars, still another explanation was required, and this time the neutron star hypothesis was invented. Further discoveries have revealed the existence of extremely high density in material aggregates of other kinds where neither white dwarf theory nor neutron star theory meets the requirements. So here we must have another new theory, and the resourceful theorists have brought forth the black hole. Thus, in order to explain the different astronomical manifestations of *one* physical phenomenon—extremely high density of certain material aggregates—we have an ever-growing multitude of separate theories, one for the white dwarfs, one for the pulsars, at least two for the x-ray emitters, several for the dense cores of certain types of galaxies, and no one knows how many for the quasars.

Even in astronomical circles, the absurdity of this situation is beginning to be recognized. For instance, this comment was made recently (1980) by M. Ruderman:

Theoreticians have apparently found it easy to understand them [the pulsars] for they have produced not only a theory of pulsars but dozens of theories of pulsars.²⁰²

The application of the Reciprocal System of theory to this problem merely accomplishes something that was long overdue in any event: a reevaluation and reconstruction of the entire theory of extremely dense aggregates in the light of the increased amount of information that is now available. This theoretical development shows that the extremely high density results, in all cases, from the same cause: component speeds exceeding the speed of light,

unit speed in the universe of motion. All of the stars with extremely high density, regardless of whether we observe them as white dwarfs, novae, pulsars, x-ray emitters, or unidentified sources of radio emission, are identically the same kind of objects, differing only in their speeds and in the current stage of their radioactivity. Quasars are objects of the same nature, in which the extremely fast-moving components are stars rather than atoms and particles.

CHAPTER 18

Radiative Processes

Aside from what can be learned from particles or aggregates of matter encountered by the earth in the course of its motion through space, empirical information about astronomical entities and phenomena comes almost entirely from incoming electromagnetic radiation. Until 1932 the observations of this radiation were limited to the optical range and a portion of the adjoining infrared. In that year radiation at radio wavelengths originating from extraterrestrial sources was detected. Sixteen years later, x-ray radiation from astronomical sources joined the list, and gamma rays soon followed. In the meantime, coverage of the infrared range has gradually been extended. As matters now stand, the entire electromagnetic spectrum is supplying astronomical information.

The most significant result of this widening of the scope of the observations is not the increased *quantity* of information that has been obtained, but the much greater *variety* of information. The new observations have not only brought to light new aspects of known astronomical objects, but have resulted in the discovery of classes of objects that were previously unknown and unsuspected. The most unexpected feature of these new kinds of objects, and the most difficult to explain on the basis of conventional astronomical theory, is the magnitude of the non-thermal components of the radiation being received. Non-thermal radiation plays only a relatively minor role in the astronomical phenomena that were known prior to the recent opening up of the high and low frequency ranges of the spectrum. But the radiation from many of the newly discovered objects is mainly non-thermal. This has confronted the astronomers with a problem for which they have not yet been able to find a satisfactory solution within the boundaries of accepted thought.

“We must admit at the outset,” says F. G. Smith, “that we have a very poor understanding of the processes by which pulsars radiate.”²⁰³ The primary radiation from these and the other very compact astronomical objects is definitely non-thermal. As expressed by M. and G. Burbidge, with particular reference to the continuous radiation from the quasars, “it is clear that the observed continuous energy distribution does not accord with any model in which the radiation is emitted thermally from a hot gas.” These authors then assert that “There are only two processes that appear to be possible in this

situation. They are synchrotron emission and emission by the inverse Compton process.’’²⁰⁴

This is the same kind of a situation that we have encountered so often in the subject areas examined earlier. No *satisfactory* explanation is available for the event or phenomenon under consideration within the limits of existing physical theory, and the investigators are unwilling to concede that the fault may lie in that theory. The prevailing policy, therefore, is to take what they consider the least objectionable of the known alternatives, the synchrotron process, and to accept it as the correct explanation, on the strength of the assertion that “there is no other way.” Time after time in the pages of this and the preceding volumes we have encountered this assertion, and invariably our theoretical development has shown that there *is* another way, one that *does* lead to a satisfactory answer. So it is in the present case.

Actually it should be obvious that synchrotron emission is not the *kind* of a process that meets the requirements as the *principal* source, or even a major source, of non-thermal radiation from astronomical objects. It is clearly one of the class of what we may call *incidental processes* of generating radiation, processes that produce limited amounts of radiation under very special conditions, and have no significant impact on the radiation situation in general.

The basis of the synchrotron process is the property of electrons whereby they radiate if they are accelerated in a magnetic field. Both an adequate supply of very high energy electrons and a magnetic field of the necessary strength are therefore required in order to make this kind of radiation possible. Such a combination is present only under very unusual circumstances. Indeed, there is little, if any, evidence that the required conditions actually exist *anywhere* in the astronomical field. Thus this currently accepted theory relies on the existence of very special and uncommon conditions to account for phenomena that are so common and so widely distributed that it is almost self-evident that they are products of the normal evolutionary development; features of the matter itself, rather than processes originated by conditions in the environment.

Strong magnetic fields are relatively uncommon. Large concentrations of “relativistic” electrons—that is, electrons with extremely high speeds—are still less common. As expressed by Simon Mitton, “our general experience is that sufficiently large volumes of space are essentially electrically neutral.”²⁰⁵ Furthermore, there are serious problems in accounting for the containment of the hypothetical concentrations of electrons, and the persistence of these concentrations over the long periods of time during which the non-thermal radiation is being emitted. And no one is facing up to the problem of explaining how the energy of these electrons is *maintained* during these long periods of time. The output of energy from many of the sources is enormous, and the theorists are not even able to account for the generation of these huge amounts of energy, to say nothing of explaining how that energy is

continually converted into the form of high energy electrons.

The prevailing tendency is to *assume* that the non-thermal radiation is produced by the synchrotron process, and then to deduce from this that the conditions necessary for the operation of the process must exist in the objects from which the radiation originates. The following statement from Bok and Bok is typical:

The fact that radio-synchrotron radiation is observed as coming from the direction of known supernova remnants, such as the Crab Nebula, indicates that large-scale magnetic fields are associated with them.²⁰⁶

The situation here is very similar to that of the “neutron stars” discussed in the preceding chapter. In that case, the argument goes like this: (1) pulsars exist, (2) they are thought to be neutron stars, (3) consequently, some method of producing neutron stars must exist, even though no one is able to suggest a feasible process for their production. Similarly, in the present instance, we are offered this argument: (1) non-thermal radiation exists, (2) it is thought to be synchrotron radiation, (3) consequently, the conditions necessary for the production of synchrotron radiation (such as strong magnetic fields) must exist, even though there is no observational indication that this is true.

Other investigators go still farther, and find “proofs” of the validity of the identification of the non-thermal radiation as a product of the synchrotron process in some of the characteristics of the radiation, such as the polarization. Here the argument is (1) synchrotron radiation is expected to be at least partially polarized, (2) the radiation from some of the non-thermal sources is totally or partially polarized, (3) therefore the observed radiation must be synchrotron radiation. In order to “save” this obviously invalid conclusion, the theorists invoke the “no other way” argument, and assert that the synchrotron process is the only possibility (the inverse Compton process suggested in reference 204 is usually ignored). This is a flagrant example of the presumptuous attitude criticized by Hoyle: “It predicates that we know everything.”

Similarly, Shklovsky deduces theoretically that synchrotron radiation from distributed sources such as the supernova remnants should decrease rapidly as these sources expand. He then asserts categorically that “The detection of the theoretically predicted rapid decline in the radio flux of Cassiopeia A affords a direct proof of the synchrotron theory and all its implications.”²⁰⁷

Such assertions are preposterous, regardless of how eminent their authors may be, or how widely they are accepted. All that has been demonstrated by the agreement with observation in each of these two instances is that, in some cases, the synchrotron theory meets *one* of the many requirements for validity. The “direct proof” claimed by Shklovsky can come only from meeting *all* of these requirements in all cases—at least all *known* cases. At the current stage

of astronomical knowledge, *no* theory of the non-thermal radiation can legitimately claim to be verified by astronomical observation. The observational data are simply far too limited. The astronomers admit that their theory lacks credibility in application to extreme situations. For instance, we are told that “synchrotron theory is severely strained to explain the radiation from highly polarized quasars.”²⁰⁸ It is increasingly evident that some less restricted explanation has to be found for the extremely powerful and highly variable emission from these and other major radiation sources. But a theory that is capable of accounting for these powerful emissions can be applied to the simpler situations as well. There is no need for the synchrotron process.

The truth is that the astronomers have not yet realized that their discovery of the very energetic compact extra-galactic objects has opened up a totally new field of study. The strong non-thermal radiation from these objects, including vast outpourings of radiant energy unparalleled elsewhere in the universe, are so different in magnitude, and in their widespread distribution, from the relatively insignificant terrestrial phenomena such as synchrotron radiation, that it should be evident that there is a difference in kind. The observers have recognized that the compact objects which they have recently discovered—pulsars, quasars, etc.—are physical entities of a kind heretofore unknown, and that some new insight into physical fundamentals will be required in order to gain a comprehensive understanding of these objects. What is now needed is an extension of this recognition to the radiation from these unfamiliar entities, a realization that there, too, some new processes are involved.

One of the basic assumptions generally accepted by scientists is that the fundamental laws and principles that are found to be valid in terrestrial experience are applicable throughout the universe. From this it follows that all physical phenomena, wherever located, should be capable of explanation by means of these same laws and principles. These are reasonable assumptions, and their validity has now been confirmed in the course of the development of the Reciprocal System of theory. But there is an unfortunate tendency to extend this line of thought to the further assumption that all physical phenomena, regardless of location, must be explainable by means of the same *processes* that are found to be in operation in the terrestrial environment. This assumption is definitely *not* valid, because the physical conditions prevailing on earth are limited to a very small part of the total range of those conditions.

It is obviously possible that there may be processes in operation elsewhere in the universe that cannot be duplicated on earth because the conditions necessary for the operation of those processes, such as, for example, extremely high temperatures or pressures, are unattainable. In the previous pages we have seen that such processes do, in fact, exist. The unwarranted assumption that they do not exist has therefore had a very detrimental effect on astronomical understanding. We have already seen how its application to the

stellar energy generation problem has resulted in a monumental distortion of evolutionary theory. Now we meet a similar situation in the application of this assumption to the theory of non-thermal radiation.

Enough information is now available to show that non-thermal radiation is a major feature of the physical universe. It is the *predominant* form of radiation emitted by a variety of astronomical objects, including the most powerful of the known sources of radiation. The theories that attempt to explain these very common phenomena of a major character by means of processes that require very uncommon conditions are clearly on the wrong track. They are committing the proverbial error of sending a boy to do a man's work. It is true that strong radiation of this non-thermal type is restricted to certain particular classes of objects (not clearly identified in current practice, but identified in the theory of the universe of motion as objects moving at speeds in excess of the speed of light). But within those classes of objects it is normal, rather than exceptional. The radiation process must therefore be one that becomes operative in the normal course of events.

The explanation of the non-thermal radiation that is derived from the Reciprocal System of theory conforms to this requirement. It brings the large-scale emission of this type of radiation into the mainstream of physical activity, where it clearly belongs. The finding of this present work is that the strange astronomical objects discovered in recent years, and identified as sources of strong non-thermal radiation, are ordinary material aggregates—stars, galaxies, or fragments thereof—that have been accelerated to speeds in excess of the speed of light by violent explosions, and are moving in, or returning from, the upper speed ranges discussed in Chapter 15. The strong non-thermal radiation from these objects is generated by processes that are normal features of physical activity where these upper range speeds are involved.

Since the existence of speeds beyond the speed of light has not been recognized by the astronomers, who accept the physicists' speed limit with the same unquestioning faith that they manifest in accepting the physicists' equally misleading assumption as to the nature of the stellar energy generation process, we will be dealing with a hitherto unexplored field in our examination of the radiation currently classified as non-thermal. This is a place where we will be able to make good use of the ability of a *general* physical theory, one that derives all of its conclusions from the same set of premises, to deal with the previously unknown areas of the physical universe, as well as those with which we are already familiar. All of the physical principles, laws, and relations that we will need in order to get a complete and consistent picture of the radiation situation in the upper speed ranges are already available. They have been identified and verified in the physical areas where the empirical facts are readily accessible to accurate observation and measurement, and they have been explained in detail in the preceding pages of this and the earlier volumes.

Nothing new is required.

Our first concern will be to identify the different classes of radiation with which we will be dealing. The customary classification of all radiation into two categories, thermal and non-thermal, is a reflection of the very narrow limits within which terrestrial experience is restricted. In the universe as a whole, non-thermal radiation plays a much larger role than the thermal radiation that is so prominent in the local environment. Actually, there are four kinds of radiation that can be classified as major features of the physical activity of the universe, in addition to the processes that, as noted earlier, are minor and incidental. Thermal radiation is one of the four. The radiation commonly classified as non-thermal includes the emission at radio wavelengths, x-rays and gamma rays, and an inverse type of thermal radiation.

As explained in Chapter 14, ordinary thermal radiation is a high frequency phenomenon, in the sense that it is produced at wavelengths shorter than 11.67 microns. This thermal radiation is produced by matter at temperatures below that corresponding to unit speed. Matter at temperatures above this level produces *inverse thermal radiation* by the same process, but at wavelengths longer than 11.67 microns, and with an energy distribution that is the inverse of the normal distribution applicable to thermal radiation. In both cases, a portion of the radiation produced by matter in any of the condensed states (solid, liquid, or condensed gas) is degraded in passing out of the sub-unit region in which it is produced. This minor component appears as radiation of the inverse frequency, but it conforms to the energy distribution of the radiation class to which it belongs. The thermal energy emission in the infrared, for instance, decreases with increasing wavelength.

Here, then, is the explanation of the infrared component of the observed non-thermal radiation. Like ordinary thermal radiation, this inverse type is produced by the normal motions of the matter from which it emanates, and the process requires neither a special set of environmental conditions in which to operate, nor a separate energy source. Since every atom contributes to this radiation, all that is necessary in order to constitute a strong source is a sufficiently large aggregate of matter at a temperature not too far above that corresponding to unit speed. As we will see in the pages that follow, several classes of compact objects meet these requirements.

The difference between the thermal and inverse thermal radiation enables us to make a positive identification of the speed range of the components of astronomical aggregates. Strong inverse thermal radiation at wavelengths greater than 11.67 microns (in the far infrared) identifies the emitter as one whose components are in the upper speed ranges. We may also go a step farther, and deduce that if this emitting object produces radiation at any wavelength outside the inverse thermal range, this will be radiation at radio wavelengths.

The inverse thermal process is not capable of producing strong radiation in

the radio range. Like the thermal process, it is one of low intensity relative to the natural datum at unit speed, and it is therefore limited mainly to wavelengths that are relatively close to the unit level of 11.67 microns. It has long been understood that most of the observed radiation at very short wavelengths, x-rays and gamma rays, is not produced thermally, but by processes of a different kind, involving some more fundamental activity of greater intensity in the emitting matter. Our finding is that the same is true of the radiation at very long wavelengths, those in the radio range. In both cases, the principal process involved is radioactivity, the nature of which was examined in detail in Volume II. As brought out in that discussion, the essential feature of radioactivity is a change in atomic structure.

In all radioactive events, the function of the electromagnetic radiation is to take care of the fractional amounts of motion that remain after the major redistributions, such as the emission of alpha and beta particles, are accomplished. As we have seen, the equivalent of a fractional unit of speed is an integral number of units of the inverse entity, energy. Spontaneous radiation from matter moving at less than unit speed therefore involves emission of photons of equivalent speed $1/n^2$ (or $1/n^2 - 1/m^2$), where n is the number of units of energy. And since the fraction $1/n^2$ is small, for reasons explained in the detailed discussion in Volume II, n is a relatively large number. The radiation thus consists of high energy photons, x-rays and gamma rays. In radiation from matter moving at speeds greater than unity, the full unit is a unit of energy, and the equivalent of a fractional unit is attained by adding units of speed. Spontaneous radiation from matter moving at upper range speeds involves emission of low energy photons, with frequencies in the radio range.

With this understanding of the radiation pattern, we are now able to identify the general nature of the strong emitters of radio and x-ray radiation. A small or moderate amount of radiation of these types may originate in any one of a number of ways, but the discrete astronomical sources of strong radiation are objects in which radioactive processes are taking place on a vast scale. For an understanding of how such extremely large quantities of radioactivity originate, we need to turn to a phenomenon that is not recognized in conventional science, but was discovered in the course of the theoretical development described in Volume II. This is the process that we are calling *magnetic ionization*. Just as soon as the nature of electric ionization was clarified in the original phase of the investigation, prior to the publication of the first edition of this work, it became obvious that there must be a two-dimensional analog of the one-dimensional electric ionization. The level of this magnetic ionization is the principal determinant of the stability of the various *isotopes* of the chemical elements.

As explained in Volume II, an atom of atomic number Z has a rotational mass, m_r , equal to $2Z$. At a magnetic ionization level of zero, this is the

atomic weight (subject to some modifications of a minor character). When raised to the magnetic ionization level I, the atom acquires a vibrational mass component, m_v , of magnitude $I m_r^2/156.44$. The total of m_r and m_v establishes the atomic weight (or isotopic weight) corresponding to the center of the zone of isotopic stability. If an isotope is outside this zone of stability, it undergoes a spontaneous radioactive process that moves it back to this stable zone. The composition of the motions of a stable isotope of an element can be changed only by external influences, such as a violent contact, or absorption of a particle, and the occurrence of such changes is related to the nature of the environment, rather than to anything inherent in the atom itself. Atom building is therefore a slow and uncertain process. On the other hand, an unstable isotope is capable of moving toward stability on its own initiative by *ejecting* the appropriate motion, or combination of motions. The isotopic adjustment process begins automatically when conditions change.

The magnetic ionization level of matter is determined by the concentration of neutrinos in that matter. The level of concentration is primarily a function of age. Those aggregates that have existed long enough to reach one or the other of the destructive limits, and become supernovae, are therefore magnetically ionized. When a portion of such an aggregate is accelerated to a speed in excess of unity (the speed of light), its constituent atoms move apart in time, as explained in the previous pages. The neutrinos of the material type, which cause the magnetic ionization, cannot move through space, inasmuch as they are inherently units of space, and the relation of space to space is not motion. But these neutrinos are capable of moving in the empty time that exists between the fast-moving atoms in the intermediate speed range, since the relation of space (neutrinos) to time *is* motion. The diffusion of the neutrinos into this additional time reduces the neutrino concentration drastically, and the aggregate consequently drops to a lower ionization level. This lowers the zone of stability, and leaves some isotopes above the stability zone. These isotopes are then unstable, and must undergo radioactivity to eliminate some of their vibrational mass. As noted earlier, radioactivity in the intermediate speed range results in the emission of radiation at radio wavelengths.

Large-scale production of radiation in the radio range thus takes place under conditions in which extremely large quantities of matter are transferred from one speed range to a higher range in a relatively short period of time. Such conditions are, almost by definition, a result of explosive processes. (For an explanation of the concepts such as magnetic ionization, rotational and vibrational mass, and neutrino concentration, that enter into the description of the radiation production process, see Volume II).

The time required for isotopic adjustments varies widely, but many of the isotopes are short-lived in the unstable state. These isotopes are quickly eliminated, and the radioactivity of the explosion products therefore decreases quite rapidly in the early stages following the explosion. But there are also

many isotopes with much longer half-lives, some extending to billions of years, and a certain amount of radioactivity persists for a long period of time. Both the total length of the active period, and the time during which the radiation is at peak intensity are extended substantially when the aggregate is initially at a high magnetic ionization level, as the ionization is reduced successively from one level to the next as the expansion into time proceeds. Each of these reductions puts a new group of isotopes outside the stability limits, and initiates a new set of radioactive transformations.

There are no aggregates of intermediate or ultra high speed matter in the material (low speed) sector of the universe, other than these explosion products, but, as noted earlier, if an object ejected into the intermediate region by an explosion does not have enough speed to reach the two-unit level and escape from the material sector, it loses speed in interactions with the environment, and eventually returns to the region of motion at less than unit speed. In addition to the outward-moving explosion products, the material sector thus contains a population of returning objects of the same nature. As the speed of such an object decreases, the changes that took place during the outward movement are reversed. The amount of empty time between the components of the aggregate is reduced, the concentration of neutrinos (the magnetic temperature) is increased, and the aggregate moves step by step up to its original ionization level. Each successive increase in the ionization level leaves some isotopes below the new location of the zone of stability, and therefore radioactive. The last step in this process is a result of the transition from motion in time to motion in space. In this case the isotopic adjustments take place in matter that has dropped below unit speed, and the accompanying radiation is in the high frequency range; that is, it consists of x-rays and gamma rays.

Observers comment on "the great power of the [radiation] sources" and the "rapid and complex variability." Both of these features are explained by the theory outlined in this chapter. Strong radioactive emission from masses of stellar magnitude is obviously sufficient to explain the observed power, while the emission from constantly changing groups of isotopes, with half-lives all the way from seconds to billions of years, accounts for both the rapidity and the complexity of the variations. The existence of both radio and x-ray emission from certain sources has also been noted. This is a result of the turbulent conditions in the material aggregates in which very energetic processes are taking place. While the net movement across the speed boundary determines the principal emission, there are local and temporary reversals of the general trend.

The radio-emitting objects thus far discussed are three classes of white dwarf stars: ordinary white dwarfs, pulsars, and central stars of planetary nebulae. Most pulsars are known *only* by their radio emission. Only two of those located to date (1983) are optically visible, and if it were not for the pulsations,

the remainder, like the non-pulsating Stage 1 and Stage 2 white dwarfs, would be merely unidentified radio sources. The relatively small class of pulsars whose radiation consists primarily of x-rays will be examined in the next chapter. Later we will consider a variety of radio-emitting objects of galactic size. All of these originate in the manner described in this chapter; that is, they are either explosion products that have been accelerated to speeds in the upper ranges, or they are aggregates that contain substantial quantities of such products.

The biggest problem that has confronted the astronomers ever since they extended the range of their observations beyond the relatively peaceful Milky Way galaxy and into the realm of violent events that take place in some of the extra-galactic aggregates, has been to account for the enormous energies that are involved in some of these events. Many different hypotheses have been advanced, mainly of a highly speculative nature, but none of these has reached the stage where it can withstand a critical scrutiny. As expressed by Simon Mitton:

Although we can now give a qualitative picture of certain types of interaction, each time we have to pull a rabbit out of the hat—a mysterious source of energy. The evidence that the energy is there in abundance is convincing. But we have only begun to scratch the surface in the battle to explain whence this energy has come.²⁰⁹

As noted earlier, a major weakness of much of current astronomical theory is that it calls upon the existence of some very special conditions to explain general features of the evolution of aggregates of matter. In the theory of the universe of motion, on the other hand, the general evolutionary features are results of conditions that necessarily arise in the normal course of events. The basic energy production process in this universe, we find, is the conversion of rotational motion (mass) to linear motion (energy) at the age and temperature limits of matter. This one process accounts for the entire range of energy generation, from supplying the modest fuel requirements of the quiet stars, to providing the enormous energy required for the ejection of a quasar. And it requires no special conditions or unusual circumstances to bring it into operation. *All* matter eventually arrives at one or the other of these limits.

The manner in which the energy requirements of the violent astronomical phenomena are met will be developed in detail in the pages that follow. As we will see there, the current estimates of the energy output of the quasars are grossly overstated, and the largest sustained emission that we have to account for is comparable to that of the radio galaxies. In order to get an idea of the amount of energy that is involved, we may turn to the results of a calculation by Mitton, which he summarizes as follows:

If we are allowed to turn matter into energy with total efficiency we need something like . . . 100,000 stars. On the other hand, if we are only allowed to use conventional astrophysics, 10 million solar masses must be involved in the production of the requisite energy.²¹⁰

The processes that take place at the destructive limits of matter, as described in the preceding pages of this and the earlier volumes have a maximum capability of complete conversion of matter into energy, but in practice operate at a lower rate, and thus require an amount of participating mass somewhat greater than Mitton's lower figure. As we will see in the later chapters, this is well within the theoretical limits of the mass concentrations.

With the benefit of the additional information developed in this chapter, we are now in a position to enlarge upon what was said in Chapter 14 with reference to the conclusions that are currently being drawn from the Second Law of Thermodynamics. It is now evident that this law does not have the significance that present-day science attributes to it. The First Law of Thermodynamics, which expresses the principle of conservation of energy, defines "energy" in a broad manner, including in this concept both kinetic energy and potential energy. In the reasoning by which the conclusions as to the eventual "heat death" are reached, it is taken for granted that the term "energy" has the same meaning in the statement of the Second Law. In the words of the authors quoted in Chapter 14, "energy flows always in the same direction" from the highest level "in the hot interior of a star" to the lowest level, "a disordered cold soup of matter dispersed throughout space." But this is not true of potential (that is, gravitational) energy. The potential energy of the matter in the hot interior of a star is at a minimum, while that of the dispersed "cold soup" is at a maximum. The evolutionary direction of this potential energy is opposite to that of the kinetic energy.

It should be noted, in this connection, that there is no thermal motion *in space* at the temperature of the "cold soup," only a degree or two above absolute zero. Hydrogen is in the solid state below its melting point at 14 K. In that state (a property of the individual atom or molecule) the thermal motion is in time (equivalent space), and within the spatial unit in which each atom is located. Thus there is no outward force acting on the atoms of matter in this cold dispersed state other than that due to the outward progression of the natural reference system. Any sufficiently large volume of dispersed matter is therefore subject to a net gravitational force, and will eventually consolidate in the manner described in Chapter 1, converting its potential energy into kinetic energy.

Thus the "energy" to which the Second Law applies is not the same "energy" that is defined in the First Law. The Second Law applies only to kinetic energy. When this fact is recognized, the conclusions that can be drawn from the Second Law are completely changed. It then becomes clear

that, in application to the large-scale activity of the universe, the Second Law of Thermodynamics is valid only in conjunction with the gravitational law. The result of this combination, instead of being a relentless progression toward a “heat death”—the “end of the world” envisioned by Davies—is a cyclic movement from maximum kinetic energy and minimum potential energy, in the stellar interior, to maximum potential energy and minimum kinetic energy, in the cold and diffuse state, followed by a swing back to the original combination. The findings of this present investigation show that the aggregation of the diffuse matter under the influence of gravitation is just as inevitable as the degradation of kinetic energy in thermodynamic activity. Indeed, as pointed out in Chapter 14, aggregation is the *primary* process. *All* matter entering the material sector is eventually incorporated into stars, but only part of it is returned to the diffuse state in space by means of the processes to which the Second Law applies. The remainder is ejected into the cosmic sector, and returns to the diffuse state in space by a longer route.

CHAPTER 19

X-ray Emission

As we saw in the preceding pages, some of the products of the supernova explosion reach their maximum speeds in the range between one and two units, intermediate speeds in our terminology. Inasmuch as these objects continue losing energy to the environment, they ultimately return to the region of three-dimensional space, below the unit speed level, where they are observed as white dwarf stars. The general nature of the evolutionary development of the white dwarfs was discussed in the earlier chapters. At this time we will review the situation from the standpoint of the changes in the radiation pattern that take place as the stars move through their successive evolutionary stages.

The radiation during Stage 1, the immediate post-ejection stage, as we have seen, is at radio frequencies. As explained in Chapter 18, it results from the isotopic readjustments required to bring some of the components of the star back into the zone of stability, after they have been left outside that zone by the decrease in the magnetic ionization level that follows the expansion of the stellar aggregate into time.

It was established in Volume II that the earth is at the one-unit magnetic ionization level. As we found earlier in the present volume, the solar system is somewhere near the average age of the stars in the galactic arms. We may therefore conclude that unit magnetic ionization is normal in the outer regions of the Galaxy. This means that, in the local environment, only one downward step is usually involved in the decrease of the magnetic ionization level on entry into the intermediate speed range. In view of the expansion into a second scalar dimension that occurs at unit speed, it then follows that the series of changes which ultimately result in the production of radio radiation are initiated immediately after crossing the unit speed boundary. The isotopic adjustments that are necessary are therefore substantially complete by the end of the outward travel of the white dwarfs. Consequently, there is little or no radio emission from these objects during the unobservable stage of the return (Stage 2), or during the time that they are observable as stable stars (Stage 3). Furthermore, there is a substantial amount of accretion of low speed matter in this latter stage, facilitated by the fact that the white dwarf remains spatially stationary in the debris left by the supernova explosion. During stage 3, the observable radiation from the white dwarfs comes mainly from the low speed

matter.

Evolutionary Stage 4, which follows, involves a return to the speed range below unity. This reverses the process that took place when the unit speed level was exceeded in the outward stage of the travel of these stars. The volumetric change accompanying the drop into the lower speed range increases the neutrino concentration. This restores the unit magnetic ionization level, which raises the zone of isotopic stability, and leaves some of the existing isotopes below the limits of the zone. A series of isotopic adjustments then follows, accompanied by radioactivity. Since these processes take place after the speed drops below the unit level, the radiation is in the x-ray range. The Stage 4 white dwarfs, the cataclysmic variables, are therefore x-ray emitters. "Almost every CV looked at with Einstein [the orbiting observatory] was an emitter of x-rays."²¹¹ (Mason and Cordova)

Here, then, we have a simple x-ray production process that is a direct result of changes that take place during the normal evolution of the white dwarf stars, and does not require the existence of any special or unusual conditions. This contrasts sharply with the production mechanisms postulated in current astronomical thought, as described in this statement from a report of a symposium on x-ray astronomy:

Most of the known, realistic, mechanisms for the generation of x-rays lead to somewhat complicated theoretical statements, and the number of adjustable parameters is often too great for comfort.²¹²

Since all outgoing explosion products that attain upper range speeds emit radio radiation, while only part of them return to the lower speed range and emit x-rays, the total radio emission is much greater than the total radiation at x-ray frequencies. It is also more easily observed, as a large part of the radiation at radio frequencies penetrates the earth's atmosphere, and can be observed at the surface, whereas the x-ray radiation is almost completely blocked, and can be observed only by instruments that are lifted above the greater part of the atmosphere. But the objects that emit x-rays are moving at speeds below unity, and are optically visible, while most of the radio-emitting objects within the Galaxy are invisible. For this reason, the new x-ray branch of astronomy has accumulated a substantial amount of information about the x-ray emitters and their properties, in spite of the observational difficulties.

One of the important results of this addition to the body of astronomical knowledge has been a significant increase in the volume of evidence supporting the evolutionary pattern of the white dwarf stars that has been derived from the theory of the universe of motion. According to that theory, the white dwarfs originate in supernova explosions, are accelerated to speeds in excess of the speed of light, move outward in time to a limiting distance, then reverse their course, and move back to their original positions and to

speeds below the unit level. These stars undergo certain processes on the outward trip, and are then subjected to the *same* processes in *reverse* during the return. The finding that the processes leading to the emission of x-rays are the inverse of the corresponding processes that result in the emission of radio radiation establishes a specific relationship of a fixed character between the various features of the x-ray emitters and those of the radio emitters. This means that the nature and properties of the x-ray emitters are strictly defined theoretically. The fact that all of the observational evidence is consistent with the rigid theoretical requirements is therefore an impressive confirmation of the whole interlocking structure of white dwarf theory.

From this theory we find that the x-ray emitters of the type that we are now considering are components of binary, or multiple, systems in which they are associated with stars that originate from the low speed supernova products as infrared stars, and pass through a giant or supergiant stage as they move toward gravitational equilibrium on the main sequence. Thus far, only about 20 percent of the x-ray emitters that have been identified as stars are definitely known to have companions, and the theoretical conclusion that they are *all* components of binary or multiple systems has been confirmed only to that extent, but there is no evidence to indicate that the remainder do *not* have companions. Indeed, one of the prominent investigators in this field, R. Giacconi, reports that the evidence from observation warrants "a working hypothesis that all galactic x-ray sources are either members of a binary system or supernova remnants."²¹³

The theoretical identification of one class of x-ray emitters as white dwarfs is also in agreement with the observational finding that the x-rays "must originate from relatively small, compact objects."²¹⁴ This description is applicable both to the stars currently recognized as white dwarfs and to the stars not currently included in the white dwarf class, but theoretically identified as Stage 4 white dwarfs: the novae and other cataclysmic variables.

Another observable characteristic of the discrete x-ray emitters in the Galaxy is their distribution. Inasmuch as the observable white dwarfs are distributed somewhat uniformly among the stars in the disk of the Galaxy, as the theory requires, it is to be expected that the discrete x-ray emitters will share this distribution. The observations are in full agreement with this expectation. The correlation between the distribution of the planetary nebulae (early Stage 3 white dwarfs), which are more observable than the ordinary white dwarf stars, with the discrete x-ray sources (Stage 4 white dwarfs) is particularly close.²¹⁵

According to a 1977 report, seven of the approximately 130 observable globular clusters are probable locations of known x-ray sources.²¹¹ This is consistent with the conclusion that we derive from theory; that is, the only products of supernova explosions that exist in objects as young as the globular clusters are those produced from the relatively small number of old stars that have been incorporated into the young aggregates.

The observations support the theoretical finding that the x-ray emission from the white dwarfs occurs mainly during Stage 4 of the evolution of these objects, the cataclysmic variable stage. A number of papers concerning the x-ray emission from these variables were presented at a recent symposium. As one participant observed, reports of such observations are now "appearing in profusion." Both soft and hard x-rays have been detected from the cataclysmic variables, according to another of the investigators, who concedes that "production of hard x-rays, as detected in several of these sources, is hard to understand."²¹⁶ The appearance of x-rays in some of the objects of this class and not in others has also been regarded as anomalous.

Both of the seeming anomalies are readily explained by the theory discussed in these pages. The cataclysmic variables are in the last stage of the life of the stars as white dwarfs. Some of them naturally make faster progress toward completion of the transition process than others. Thus some are still emitting hard x-rays, while others have eliminated the hard x-ray sources, the short-lived isotopes, and are emitting soft x-rays. Furthermore, both the character and the magnitude of the emission are subject to variation because of the intermittent nature of the explosive activity. During the explosive outburst, which exposes some of the material from the interior, where the radiation originates, the emission is at a maximum, and the x-rays are "hard"; that is, their frequency is relatively high. Between these outbursts, the radiation is reduced, both in quantity and in frequency, by absorption and re-radiation during its travel through the outer shell of the star.

From the explanation of the nature of the ejections from the cataclysmic variables in Chapter 13 it is evident that those ejections which are accompanied by relatively strong x-ray emissions are nearly continuous in two groups of these objects: the smaller ones, and the older ones, those that are nearing the end of the eruptive stage. It follows that there are continuous, as well as intermittent, x-ray emitters among the Stage 4 white dwarfs. By the time these stars reach the main sequence, the isotopic adjustments are well along toward completion, and the remaining x-ray radiation is reduced to lower frequencies on the way out from the stellar interior, without further explosive activity.

We now turn to the other class of discrete galactic x-ray emitters, the pulsars. As we saw in Chapter 17, the distinguishing characteristic of the pulsars is that they are traveling at ultra high speed in the explosion dimension. Ordinarily these stars increase their net speed as the gravitational force is gradually attenuated by distance, and they eventually disappear into the cosmic sector. But there are influences other than gravitation that tend to reduce the pulsar speed, particularly the resistance due to the presence of other matter in the path of movement. In some instances, where the original explosion speed is only slightly above the two-unit level, the retardation due to these causes may be sufficient to prevent the net speed from reaching two units. And even if the pulsar does enter the speed range above two units, where there is no longer any

gravitational restraint on a material object, the pulsar is still subject to the other influences of the material sector. Under appropriate conditions, therefore, the net speed of the outgoing pulsars may reach a maximum somewhere in the vicinity of the two-unit level, decreasing thereafter, and eventually dropping back to levels below unity. A small proportion of the pulsars thus return to the material status rather than escaping into the cosmic sector, as most pulsars do.

Since the linear outward motion of the pulsar is in a dimension of space, the transition at the two-unit level carries it into the region of motion in time. Those pulsars that return, after crossing the two-unit boundary, resume motion in space. The isotopic adjustments that follow this change are therefore accompanied by radiation at x-ray frequencies. On this return trip the pulsars pass through the same pulsation zone that they traversed in the opposite direction in their outgoing stage, and in so doing they emit pulsed x-rays in the same manner in which they emitted pulsed radio radiation on the outward course. By the time the pulsar has passed through the pulsation zone it has had time to complete the adjustments involving the short-lived isotopes which produce the hard x-rays, and the x-rays from "most of the persistent sources that do not pulse" are relatively soft.²¹⁷ Eventually the incoming pulsars revert to the status of normal white dwarfs, and follow the regular white dwarf evolutionary pattern, including a resumption of x-ray emission in Stage 4 of that evolution.

The pulsating x-ray emitters have some features that are quite different from those of the radio pulsars, and those differences have aroused a great deal of speculation, much of which is little more than fantasy. It is among the complex x-ray emitters, pulsating and non-pulsating, that the theorists are finding candidates for designation as black holes. The explanation of the x-ray emitting objects that we derived from the theory of the universe of motion requires none of these imaginative constructions. As can be seen from what has been said in the foregoing paragraphs, all that is necessary to explain the x-ray emission and its pulsation is to invert the theory already developed for the radio-emitting objects. The expansion into time during the outward travel of the pulsar lowers the zone of isotopic stability, and initiates isotopic adjustments. On the return trip there is a contraction which raises the zone of stability back to the original level, and causes a reversal of the changes in the isotopes. The adjustments during the outward travel take place while the speeds of the pulsar components are above unity. The fractional residues of the adjustment process are therefore units of speed, which are ejected in the form of radiation at radio frequencies. The adjustments during the return take place while the component speeds are below unity. Here the fractional units are units of energy, and they are ejected in the form of x-ray radiation. The x-ray process is simply the inverse of the radio process.

According to the observers' reports, the incoming pulsars are concentrated toward the galactic center, as would be expected in view of our finding that

this is where most pulsars originate. Since, as we have seen, the pulsars that are produced in these central regions of the Galaxy are moving rapidly outward to a limiting position in space during their radio pulsation stage, it follows that any of these objects which return as x-ray emitters will move down from this limiting position to their original locations as gravitation again becomes effective. The following is a comment by Shklovsky about one of the most conspicuous of the incoming pulsars:

The radial velocity of HZ Herculis, close to 60 km/s, is directed *toward* the galactic plane. The reason could be that the star has already reached its maximum distance from the galactic plane and is now moving back down.²¹⁸

In considering the effects of these motions of the pulsars, it is essential to recognize that the motions being observed are taking place in a *second* scalar dimension of space. As explained earlier, such motion is represented in the reference system only under some special conditions, and it has no effect on the spatial relationships in the original scalar dimension. Thus the association between the low speed and ultra high speed products of the Type II supernova is maintained in essentially the same manner as the association between the white dwarf product of the Type I supernova and its low speed companion that we examined in the earlier chapters. In the early stages, the low speed companion of the pulsar is merely an expanding cloud of dust and gas, and it is doubtful if the life period of an outgoing pulsar is long enough to enable this cloud to contract into an observable object. (One such case has been reported, but this identification needs to be investigated further).

The incoming pulsars are, of course, much older, and their low speed companions have developed to the point where they are observable. The x-ray emitters are therefore recognizable as binary systems. The pulsars most likely to fall just short of reaching the point of no return are those produced by explosions of very large stars. These are products of rapid accretion, and a large proportion of their total mass is below the destructive ionization limit at the time of the explosion, because of the amount of time required for equalization of the ionization levels. This results in an explosion speed near the lower limit of the ultra high range, and increases the probability that the outward motion will be halted. When one of these pulsars returns to the speed range in which it is observable as an x-ray emitter, its large low temperature component is seen to be a giant or supergiant. A 1975 report states that 5 of the 8 then known binary x-ray stars incorporate massive supergiants (relatively rare in the Galaxy).²¹⁹

The white dwarf product of the explosion of a massive star is also a large object of its class. In Cygnus X-1 the x-ray star is estimated to be in the range from 6 to 10 solar masses, while the optical star is twice as large. This object

is currently the favored candidate for the black hole status, on the ground that the accepted theories limit both the white dwarfs and the hypothetical neutron stars to smaller masses. Shklovsky, whose estimates of the masses of the components of Cygnus X-1 are quoted above, follows these figures with the comment, "so it would follow that the Cygnus X-1 source is a black hole."²²⁰

Here one can see how little substance there is to the structure of reasoning on which the case for the existence of black holes is based. Certain observed entities that have all the properties of the class of objects called white dwarf stars are excluded from this classification on the strength of a wholly unsupported theoretical conclusion that the white dwarfs are subject to a mass limit in the neighborhood of two solar masses. Then these objects that are observationally indistinguishable from white dwarfs, but are above the hypothetical mass limit, are arbitrarily assumed to have some different type of structure. Finally, a structure, the black hole, is invented for these objects on an ad hoc basis.

When the black hole concept was first proposed, it was recognized in its true colors. As expressed in one comment published in 1973, only the "counsel of desperation" leads to invoking this hypothesis.²²¹ This situation has not changed. The black hole hypothesis has no more foundation today than it had ten years ago when that judgment was passed. But the intangible nature of the hypothesis, which prevents testing its validity, and its constant repetition in the astronomical literature, together with the general retreat from strict scientific standards in recent years, has resulted in a quite general, although somewhat uneasy, acceptance of the black hole. There is now an increasing tendency to call upon this purely hypothetical concept for the solution of all sorts of difficult astronomical problems.

In reaching the conclusion that the compact astronomical objects in the stellar size range are all white dwarfs differing only in properties related to their speeds, this present work is not in conflict with any observed facts; it is merely challenging some unfettered flights of the imagination. In this connection, it should be noted particularly that the assumption that gravitation is effective *within the atom* is the cornerstone of all of the currently accepted theories of the various compact astronomical objects. There is no evidence whatever to support this assumption. Observation tells us only that gravitation acts *between* atoms. The assumption that it also plays a role within the atom rests entirely on a theory of atomic structure that, as brought out in the preceding pages of this and the previous volumes, is contradicted by many definitely established physical facts, and is kept alive only by invoking the aid of a whole series of ad hoc assumptions to evade the contradictions.

There are some special conditions under which it is theoretically possible for outgoing pulsars to emit pulsed x-rays. As noted earlier, those pulsars that originate in locations where the gravitational retardation is minimal have

relatively low spatial speeds, and remain near the location of the supernova explosion for a considerable period of time. While the entire aggregate of ultra high speed explosion products maintains its identity in time, and all of its components move at the same explosion speed, so that their pulsations are synchronized, some portions of the whole are entrained in the material moving outward in space, in the same manner as the local aggregates of intermediate speed matter discussed in Chapter 15. Since these spatially detached portions of the pulsar are in close contact with the low speed matter, interaction with that matter reduces the speeds of some of the constituent particles below the unit level, causing isotopic adjustments and emission of x-rays. Similar interactions take place at the surface of the main body of the pulsar, particularly where, as in the Crab Nebula, the pulsar still remains in the midst of the debris at the site of the supernova explosion.

The strong x-ray emission from the Crab Nebula pulsar is not duplicated in the Vela pulsar, the second of these objects located in a supernova remnant. It appears that the slow-moving explosion products which are still dense around the 900-year old Crab pulsar have been largely dispersed in the 10,000 years since the Vela pulsar was produced. This conclusion is consistent with the difference in the polarization of the radio radiation, which is relatively low (about 25 percent²²²) in the radiation from the Crab Nebula and pulsar, but almost complete in that from the Vela pulsar.²²³

As noted in Chapter 16, it is currently believed that the energy radiated by the Crab Nebula is generated by the central star, the pulsar, and is transferred to the nebula, where the radiation is presumed to be produced by the synchrotron process. We have seen that the arguments in favor of the synchrotron hypothesis depend mainly on the "there is no other way" contention, and cannot stand up under critical scrutiny. The hypothetical energy transfer mechanism is likewise without any firm support. The astronomers admit that "the mechanisms for the transport of the pulsar power through the nebula and for the acceleration of the electrons are not well understood."²¹⁷ "Not well understood" is, of course, the currently fashionable euphemism for "unknown."

Earlier we found that the energy which powers the radio radiation from the supernova remnants is not a product of the explosion, but is generated by radioactive processes in aggregates of intermediate speed matter that have been entrained in the outgoing low speed explosion products. From the points brought out in the preceding paragraphs it can now be seen that the x-ray radiation from the remnants originates in a similar manner; that is, from spatially separated portions of the pulsar. But the x-ray radiation is only a minor component of the total radiation from an outgoing pulsar, and it therefore terminates relatively soon. Consequently, the pulsed x-ray emission of this nature is limited to very young supernova remnants of the Crab Nebula type. This nebula itself is the only known instance at present (1983). The

emission from the young remnant Cassiopeia A is not pulsed, because, as we saw earlier, the maximum speed of the explosion products that constitute this remnant was never great enough to carry them to the pulsation zone.

Any x-ray radiation from outgoing pulsars should be accompanied by strong radio emission, and pulsed x-rays without any more than a weak radio accompaniment can usually be regarded as originating in incoming pulsars. However, the most distinctive characteristic of each class of pulsar is the direction of the change in the period. The periods of the outgoing pulsars are increasing. Those of the incoming pulsars are decreasing. Most of the decreasing periods are longer than those of the outgoing pulsars, and because the return motion is subject to a variety of environmental conditions, they do not conform to the kind of a regular pattern that we find in the periods of the outgoing pulsars.

Inasmuch as the pulsar moves outward in the explosion dimension as a unit, irrespective of the spatial locations of its components, and the pulsation rates are determined by the speed, these rates are the same for all types of emission. Otherwise, the characteristics of the pulses produced by the different processes can be expected to differ. They may be out of phase, the relative intensity of the pulses may vary, or x-ray emission may cease while radio emission is taking place, or vice versa. A number of such dissimilarities are reported to be present in the radiation from the Vela pulsar.

The "x-ray stars" are relatively rare. Only about 100 are known to exist in the Galaxy, about 20 of which are pulsating,²¹⁷ and it is believed that the observed number is almost complete. This is consistent with the conclusion that the pulsars that fail to reach the conversion level at unit speed are mainly those originating in explosions of very large stars, which are likewise rare outside the unobservable central regions of the galaxy. Actually, none of the classes of discrete x-ray sources thus far considered is observable in large numbers. R. Giacconi points out that the compact x-ray sources are either "exceedingly rare or represent short-lived x-ray emitting phases in stellar evolution."²²⁴ The increase in the number of weak emitters of soft x-rays detected in recent years modifies the observational situation to some extent, but the conclusion is still valid. The theoretical identification of the soft x-rays with age, and the evidence from the remnants that ages from 25,000 to 50,000 years are sufficient to reduce the emission to the soft status, show that Giacconi's second alternative is the correct one.

In the case of the x-ray stars, the returning pulsars, the time that was spent above the two-unit speed level was too short for any large amount of isotopic adjustment to have taken place, and the reversal of the changes that did occur is accomplished relatively rapidly. The isotopic composition of the ordinary white dwarfs is fully adjusted to the intermediate speed during the outward travel of these objects, and the reverse adjustment continues over a long period of time, but here the strong radiation is intermittent. It escapes from the star in

major quantities only under special circumstances of short duration. Smaller amounts are emitted as leakages or in minor outbursts.

The supernova remnants provide an opportunity for observing the evolution of the x-ray emission. The more distant an isotope is from the center of the zone of stability, the more energetic its radiation, and the shorter its half-life, generally speaking. Consequently, the original hard, or energetic, x-rays from matter dropping back into the low speed range are followed by softer emissions as time goes on and the short-lived isotopes are eliminated. The initial x-ray radiation from the remnants is identical with that from the hard compact sources. For instance, the x-rays from Cassiopeia A are reported to be "quite hard."²²⁵ The radiation then continues on a soft basis for a relatively long period of time. For example, the x-rays from the Cygnus Loop, one of the older remnants, are all in the soft range, below 1 KeV.²²⁶

Because of the variety of sources and conditions involved in the observed emission of x-rays, it is possible to establish some limitations on the x-ray production process that can be compared with the theoretical deductions. First, we can conclude that it is extremely unlikely that two different processes for production of *strong* x-ray radiation would be put into operation by the same supernova event. The mechanism by which the x-rays are produced must therefore be one that is applicable to *both* of the observed types of supernova products: compact sources and extended remnants. (It is generally conceded that the supernova which produces a compact x-ray emitter also leaves a remnant). This imposes some severe constraints on the kind of a process that can be given consideration.

Furthermore, when the observed emission of x-rays from the *remnants* of supernovae is considered in conjunction with the results of observations that have sought, but failed to detect, high frequency radiation in significant amounts from the *supernovae*,²²⁷ a still more rigid requirement is imposed on x-ray theory. The fact that the emission occurs both from concentrations of matter (hot spots) and from diffuse clouds (extended sources) in the remnants means that the emission must result from the condition of the matter itself, not from the way in which that matter is aggregated. But the absence of x-ray radiation during the observable stage of the supernova explosion, when the particle energies are at a maximum, shows that the thermal processes are not, in themselves, adequate to account for the strong x-ray emission.

In the remnants, the x-rays come from matter that has been losing energy for a considerable period of time, more than 50,000 years in some cases, and is now at an energy level well below the peak reached in the explosion. The observations thus require the existence of a process in which matter that *loses* a portion of its energy *after* having reached the high energy level of a violent explosion undergoes some kind of a change that involves emission of x-rays. In the preceding pages we have seen that the development of the theory of the universe of motion leads to just such a process.

All of this development of theory had taken place long before the astronomical x-ray emitters were discovered. It had already been determined that the fast-moving products of stellar and galactic explosions undergo inverse radioactivity on crossing from the low speed to the upper speed ranges, and thereby produce radiation at radio frequencies. It had also been found, from theoretical considerations, that certain of these explosion products acquire sufficient speed to escape from the material sector into the cosmic sector, whereas others do not attain the escape speed, and eventually return to the relatively low speeds that are normal in the material sector. All that was required in order to complete the theoretical understanding of the x-ray emitters was a recognition of the rather obvious fact that the process previously deduced as the source of the radiation at radio frequencies from the outgoing products of stellar and galactic explosions also works in reverse to produce x-rays and gamma rays from those of the explosion products that return to the low speed range.

We thus have a theoretical definition of the origin and properties of the x-ray emitters that has not been constructed to fit the observations, in the manner in which most scientific theories are devised, but had already been deduced from the postulates that define the universe of motion, and *had been published prior to the discovery of the astronomical x-ray emission*. The close agreement between this pre-existing theory and the observational information now available is thus highly significant. Two features of this explanation of the x-ray emission are especially noteworthy. First, the theoretical x-ray process is an essential element of the theoretical energy production process. Hence it is not necessary to provide a separate explanation of how the energy is produced. Second, the *same* process is applicable to *all* of the strong x-ray emitters.

Meanwhile, conventional astronomical theory is faced with the problem of having to put together a new combination of energy generation and radiation production processes for almost every new type of x-ray emitter that is encountered. Current thinking in this area is centered largely on the situation in the Crab Nebula. Here the astronomers have been able to construct a theory with which they are reasonably comfortable, although, as indicated earlier, they are somewhat uneasy about their inability to identify the mechanism by which the energy transfer required by their theory is carried out. In this theory the central pulsar is a rotating neutron star, which releases energy by slowing its rotation. This energy is transferred to the nebula, which then radiates "by means of the synchrotron process, emitting radio waves, visible light, and X-rays."²²⁶ But few of the radiation sources conform to this pattern. Aside from these few, the radio emitting pulsars have no associated remnants, and the supernova remnants contain no pulsars. Some different hypotheses are therefore required to account for the radio emission from these sources. The x-ray emitters complicate the situation still further. Rotation is ruled out as a

source of energy for these objects, as only a few of them exhibit the pulsation that is interpreted as evidence of rotation, and in these few the pulsation periods are decreasing. Giacconi points out that, because of this speed-up, “energy could not come from rotation,” and he goes on to say:

The only remaining plausible source of the energy was gravitational energy released by accretion of material from the companion star onto the x-ray emitting object.²²⁸

Here, once again, we meet the ubiquitous “no other way” argument. There is no physical evidence to support the assumption that such a process is actually in operation. Whether or not this is “plausible,” it is simply a hypothesis based on a set of assumptions about the nature of the two components of the x-ray emitting binary system, assumptions that, as we have shown, are invalid.

Neither the synchrotron process nor the accretion process is applicable to the remnants, other than those of the Crab Nebula type, so still another x-ray emission process has to be devised for them. Here the assumption is that “the high energy radiation is generated by heating as the gas of the remnant collides with the interstellar medium.”²²⁹ Two big problems confront this hypothesis: (1) it is hard pressed to account for the existence of “hot spots” in the interiors of many remnants, particularly where, as in Cassiopeia A, the hot spots are quasi-stationary, and (2) the energy emission from the remnants decreases much more slowly than this explanation predicts.

The x-ray emission as a whole is another example of the way in which present-day astronomical theory arrives at many different explanations of the same thing. In view of the incomplete nature of astronomical knowledge as it now exists, in spite of the remarkable progress that has been made in the past few decades, it is not possible to test these hypotheses against established facts. In the absence of the disproof that would follow from such a test, each of these explanations has a degree of plausibility, when considered individually, although all are based almost entirely on assumptions. But like the many different theories devised to account for the individual manifestations of extremely high density that were enumerated in Chapter 17, the multiplicity of explanations of the same phenomenon has the cumulative effect of exposing the artificiality of the foundations of the hypotheses. The demonstrated need to devise a new explanation of a phenomenon whenever it is encountered in new setting is *prima facie* evidence that there is something wrong with the current understanding of this phenomenon.

As might be expected, extra-galactic observations add still further dimensions to the problem. All galaxies emit some x-rays. In many cases, this radiation evidently originates from sources similar to those that are observed in our own Milky Way galaxy. Both discrete sources and x-ray

emitting supernova remnants have been identified in some of the other galaxies that are close enough to be within the range of available observational facilities. Among the more distant galaxies there are some much more powerful x-ray emitters. The Seyfert galaxies, a class of very active spirals that will be discussed in Chapter 27, are observed to be strong x-ray sources. Galaxies that show evidence of violent activity, such as M 82 and NGC 5128, also radiate enormous amounts of x-ray energy. Quasars are likewise prodigious emitters of x-rays, as would be expected from the turbulent conditions in these objects, which are undergoing rapid and drastic changes.

Another recent finding that has attracted a great deal of attention is the discovery of x-rays in the intergalactic space in some distant clusters of galaxies. A 1980 report by Giacconi identifies two classes of these emissions, one in which the emitting sources are "clumped around individual galaxies or groups of galaxies" and another in which the emission is "concentrated near the center and falls off smoothly with distance."²²⁸ According to Gorenstein and Tucker, the x-ray emission comes from clusters with "a centrally located supergiant elliptical [spheroidal] galaxy."¹⁶⁷ These authors also report that M 87, the nearest galaxy of the giant class, and a member of the Virgo cluster, "is enveloped by an x-ray emitting cloud nearly a million light years across."

The x-ray emission in these clusters of galaxies is currently attributed to the presence of a hot gas. "The space within such clusters is pervaded by gas heated to some 10 million degrees,"²²⁸ asserts Giacconi. It is evident that this situation calls for some more critical consideration. In the light of what is known about the fundamentals of heat and temperature, a high temperature in a medium as sparse as that of intergalactic space is impossible. As explained in Volume II, the temperature of a gas is the result of *containment*. The pressure is a measure of the containment, while the temperature is a measure of the energy imparted to the gas that is subject to pressure. Thus the temperature, T , is a function of the pressure, P . For a given volume, V , of "ideal gas," the two quantities are directly proportional, as indicated by the general gas law, $PV = RT$, where R is the gas constant. If the pressure is very low, as in the near vacuum of intergalactic or interstellar space, the temperature is likewise very low. It is measured in degrees, not in millions of degrees.

It is often asserted that portions of the gas in the vicinity of hot stars or active galaxies are "heated by radiation." But radiation does not repeal the gas laws. Absorption of radiation does not increase the temperature if the gas is free to expand. The radiation may ionize the atoms of the gas, and there appears to be an impression that this elevates the temperature, but this conclusion is incorrect. The degree of ionization is an indication of the intensity of the ionizing agency, whatever it may happen to be. At very high temperatures, thermal ionization takes place; that is, a part of the thermal motion is converted to the type of motion known as ionization. In this case the degree of ionization is actually an indication of the temperature, the intensity of the thermal

motion. But ionization by another agency, such as radiation, is independent of the temperature. Motion in the form of radiation is converted directly to motion in the form of ionization. Here the degree of ionization is an indication of the intensity of the radiation, and has no relation to the temperature. The possibility of a radiative addition to the gas temperature must therefore be ruled out. The x-rays in the space around the giant galaxies cannot be thermally produced. They must be generated by a non-thermal process at the locations where they are observed.

In the universe of motion the x-ray emission is due to leakage of intermediate speed matter from the high pressure region in the interiors of the giant galaxies. Where the temperature of the leaking matter is in the lower section of the intermediate speed range, a relatively small amount of cooling carries some of the particles across the unit speed boundary and into the lower speed range. In this case the emission begins shortly after the leaking matter leaves the galaxy, and the emission "falls off smoothly with the distance" as in Giacconi's second category, and around M 87. A higher initial temperature delays the start of the x-ray radiation, and favors emission in the vicinity of the other galaxies of the cluster, where the matter escaping from the giant is cooled by contact with the outlying matter of those galaxies. The distribution of the x-ray emissions then follows the "clumpy" description in Giacconi's first category. As we will see in Chapter 27, the Seyfert galaxies are also losing intermediate speed material from their interiors, and the x-ray emission from these objects, while considerably stronger, for reasons that will be explained in the subsequent discussion, is a result of essentially the same process that is operating around the distant giants.

These conclusions with respect to the origin of the x-rays that are observed in the vicinity of the giant galaxies are also applicable, on a smaller scale, to the production of x-rays in the surroundings of individual stars. These x-rays are believed to originate in the stellar coronas, and it has therefore been concluded that "temperatures of a million to 10 million degrees"²²⁸ exist in these coronas. Here, again, the existence of such temperatures is excluded by basic thermal principles. Consequently, the x-rays cannot be produced thermally in these locations. But, as in the galactic situation, the x-ray production is easily explained on the basis of leakage of intermediate speed matter from the interiors of the stars, followed by a return to the low speed range in the coronas.

This "leakage" explanation also accounts for the relative emission rates from the different classes of stars, one of the areas in which the new observational findings are upsetting previous theories. "The predictions of x-ray emission based on classical theories," says Giacconi, "fail completely to account for the observations."²²⁸ As can be seen from the description of the stellar energy generation process in the earlier pages, the central regions of all stars are in the condition where the combined thermal and ionization energies are

just sufficient to begin imparting intermediate speeds to a considerable number of particles. In view of this near uniformity of the internal situation, the principal determinant of the amount of leakage, aside from the mass of the star, is the thickness of the layer of matter through which the intermediate speed particles have to make their way. It follows that the leakage rate should be relatively greater in the smaller stars. This is confirmed by the Einstein observatory results, which show that the ratio of x-ray to optical emission is 100,000 times as large in the small main sequence stars of spectral class M than in the sun, a member of the larger class G. These results, says Giacconi, "will force a major reconstruction of theories of both stellar atmospheres and stellar evolution."²²⁸

CHAPTER 20

The Quasar Situation

The existence of quasars strongly suggests that we are dealing with phenomena that present-day physics is at a loss to explain. Perhaps we are making fundamentally wrong interpretations of some data or it might indicate that there are laws of physics about which we know nothing yet.²³⁰ (Gerrit Verschuur)

The most obvious and most striking feature of the quasars, the point that has focused so much attention on them, is that they simply do not fit into the conventional picture of the universe. They are “mysterious,” “surprising,” “enigmatic,” “baffling,” and so on. Thus far it has not even been possible to formulate a hypothesis as to the nature or mechanism of these objects that is not in open and serious conflict with one segment or other of the observed facts. R. J. Weymann makes this comment:

The history of the our knowledge of the quasi-stellar sources has been one surprise after another. Indeed, almost without exception, every new line of observational investigation has disclosed something unexpected.²³¹

The irony of this situation is that long before the quasars were discovered, there was in existence a physical theory that predicted the existence of the class of objects to which the quasars belong, and produced an explanation of the major features of these objects, those features that are now so puzzling to those who are trying to fit them into the conventional structure of physical and astronomical thought. Although the application of the theory of the universe of motion to astronomical phenomena was still in a very early stage at that time, nearly a quarter century ago, the existence of galactic explosions had already been deduced from the basic premises of the theory, together with the general nature of the explosion products.

Observational knowledge was far behind the theory. At the time the first edition of this work was published in 1959 the study of extra-galactic radio sources was still in its infancy. Indeed, only five of these sources had yet been

located. The galactic collision hypothesis was still the favored explanation of the generation of the energy of this radiation. The first tentative suggestions of galactic explosions were not to be made public for another year or two, and it would be three more years before any actual evidence of such an explosion would be recognized. The existence of quasars was unknown and unsuspected.

Under these circumstances, the extension of a physical theory to the prediction of the existence of exploding galaxies, and a description of the general characteristics of these galaxies and their explosion products was an unprecedented step. It is almost impossible to extend traditional scientific theory into an unknown field in this manner, as the formulation of the conventional type of theory requires some experimental or observational facts on which to build, and where the phenomena are entirely unknown, as in this case, there are no known facts that can be utilized.

These theoretical steps have to be founded on observational data. Where no data base exists, the logic of theory alone provides no help.²³² (Martin Harwit).

A comprehensive *general* theory, one that derives all of its conclusions from a single set of basic premises, without introducing anything from any other source, is not limited in this manner. It is, of course, convenient to have observational data available for comparison, so that the successive steps in the development of theory can be verified as the work proceeds, but this is not actually essential. There are some practical limitations on the extent to which a theory can be developed without this concurrent verification, as human imagination is limited and human reasoning is not infallible, yet it is entirely possible to get a good general picture of observationally unknown regions by appropriate extensions of an accurate theory. The subject matter of the next six chapters of this volume, the phenomena of the final stages of the life of material galaxies, provides a very striking example of this kind of theoretical penetration into the unknown, and before we undertake a survey of this field as it now stands, it will be appropriate to examine just what the theory of the universe of motion was able to tell us in 1959 about *phenomena that had not yet been discovered*.

We have seen in the preceding pages of this and the earlier volumes that the structure of matter is such that it is subject to an age limit, the attainment of which results in the disintegration of the material structure and the conversion of a portion of its mass into energy. Inasmuch as aggregation is a continuing process in any region of the universe in which gravitation is the controlling factor (that is, exceeds the recession due to the progression of the natural reference system), the oldest matter in the universe is located where the process of aggregation has been operating for the longest period of time, in the

centers of the largest galaxies. Ultimately, therefore, each of the giant old galaxies must reach the destructive age limit and undergo a violent explosion, or series of explosions.

At a time when there was no definite supporting evidence, this was a bold conclusion, particularly when coming from one who is not an astronomer, and is reasoning entirely from basic physical premises. As expressed in the 1959 edition:

While this is apparently an inescapable deduction from the principles previously established, it must be conceded that it seems rather incredible on first consideration. The explosion of a single star is a tremendous event; the concept of an explosion involving billions of stars seems fantastic, and certainly there is no evidence of any gigantic variety of supernova with which the hypothetical explosion can be identified.

The text then goes on to point out that some evidence of explosive activity might be available, as there was a known phenomenon that could well be the result of a galactic explosion, even though contemporary astronomical thought did not regard it in that light.

In the galaxy M 87, which we have already recognized as possessing some of the characteristics that could be expected in the last stage of galactic existence, we find just the kind of a phenomenon which theory predicts, a jet issuing from the vicinity of the galactic center, and it would be in order to identify this galaxy, at least tentatively, as one which is now undergoing a cosmic explosion, or strictly speaking, was undergoing such an explosion at the time the light now reaching us left the galaxy.

In addition to predicting the existence of the galactic explosions, the 1959 publication also forecast correctly that the discovery of these explosions would come about mainly as the result of the large amount of radiation that would be generated at radio wavelengths by reason of the isotopic adjustment process. The conclusion reached was that

Objects which are undergoing or have recently (in the astronomical sense) undergone such [extremely violent] processes are therefore the principal sources of the localized long wave radiations which are now being studied in the relatively new science of radio astronomy.

Altogether, the theoretical study published in 1959 made the following predictions:

- (1) That exploding galaxies exist, and would presumably be discovered sooner or later.
- (2) That radio astronomy would be the most probable source through which the discovery would be made.
- (3) That the distribution of energies in the radiation at radio wavelengths would be non-thermal.
- (4) That the exploding galaxies would be giants, the oldest and largest galaxies in existence.
- (5) That two distinct kinds of products would be ejected from these exploding galaxies.
- (6) That one product would move outward in space at a normal low speed.
- (7) That the other, containing the larger part of the ejected material, would move outward at a speed in excess of that of light.
- (8) That this product would disappear from view.
- (9) That the explosions would resemble radioactive disintegrations, in that they would consist of separate events extending over a long period of time.
- (10) That because of the long time scale of the explosions it should be possible to detect many galaxies in the process of exploding.

In the quarter century that has elapsed since these predictions were published, the first three have been confirmed observationally. Evidence confirming the next five is presented in this work. The information now available indicates that the last two are valid only in a somewhat limited sense. We now find that the predicted long series of separate explosions are supernovae in the galactic interiors preceding the final explosion of the galaxy, and that the latter is an event resembling a boiler explosion. There is evidence that the products of the supernova explosions do actually build up in the central regions of the galaxies over a long period of time, as suggested in item 10. This evidence will be discussed at appropriate points in the pages that follow.

In one respect the 1959 study stopped just short of reaching an additional conclusion of considerable importance. Inasmuch as one of the products of the galactic explosion is accelerated to speeds in excess of that of light, it was concluded that this component of the explosions products would be invisible. This is the ultimate fate of almost all material ejected with ultra high speeds, including the galactic explosion products. However, the subsequent finding that the galactic explosion occurs when the internal pressure in the galaxy becomes great enough to break through the overlying structure means that the ejected material comes out in the form of fragments of the galaxy—aggregates of stars—rather than as fine debris. These fragments are subject to strong gravitational forces, and even though the speeds imparted to them by the explosion exceed the speed of light, the *net* speeds after overcoming the

oppositely directed gravitational motion are less than that of light for a finite period of time. It follows that, although the fast-moving component of the explosion products will finally escape from the gravitational limitations and move off into the unobservable regions, there is a substantial interim period in which these objects are accessible to observation. Here, of course, are the quasars, and this is how close the theoretical study came to identifying them years before they were found by observation; a point that is all the more worthy of note in view of the fact that conventional theory still has no plausible explanation of their existence.

As pointed out in the discussion of the pulsars in Chapter 17, what was actually accomplished in this area in the original investigation reported in 1959 was to predict the existence and properties of the *class of objects* to which both the pulsars and quasars belong. The properties defined in that publication are those which are shared by all objects of this class. All are explosion products. All have speeds in the upper ranges, above the speed of light. All are moving outward, rather than being stationary in space like the related intermediate speed objects, the white dwarfs. Except for the few, such as those discussed in Chapter 17, that lose enough speed to reverse direction and return to the material status, all ultimately disappear into the cosmic sector. What the original investigation failed to do was to carry the theoretical development far enough to disclose the existence of two different kinds of objects of this class, one originating from the explosion of a star, the other from the explosion of a galaxy.

The special features of each type of object are due to the differences between stars and galaxies. The quasar is long lived because it is ejected from a giant galaxy and is subject to powerful gravitational forces. The pulsar, on the other hand, is ejected from a relatively small object, a star, and is initially subject to little gravitational restraint. It is therefore short lived. The many evolutionary features of the quasars have no counterparts in the life of the pulsar because that life is too short for much evolution. Conversely, although the pulsed radiation that is the most distinguishing feature of the pulsars undoubtedly exists in the quasars as well, it is unobservable because the individual pulsations are lost in the radiation from millions of stars that have entered the pulsation zone at different times.

As the information in the foregoing paragraphs demonstrates, the theoretical exploration of the galactic explosion phenomenon carried out prior to 1959, and reported in the book published in that year, well in advance of any observational discoveries in this area, supplied us with a large amount of information which, as nearly as we can now determine on the basis of existing knowledge, is essentially correct. This is a very impressive performance, and it demonstrates the significant advantage of having access to a theory of the universe as a whole, one that is independent of the accuracy—and even of the existence—of observational data in the area under consideration.

Meanwhile, conventional astronomy has been baffled. It has been unable to arrive at any definite conclusions as to *what* the quasars are, *where* they are, or *how* their unusual properties originate. The following is an assessment of the existing situation taken from a current textbook on astronomy:

The most accurate assessment of the quasar problem is that no satisfactory explanation has been found for the existence of these objects, whose puzzling properties place them beyond the limits of current astronomical knowledge.²³³

In this connection, it should be noted that the difficulties which conventional theory is having with the quasars—those difficulties that have made “quasar” almost synonymous with “mystery”—are not due to any lack of knowledge about these objects, but to too much knowledge; that is, more knowledge than can be accommodated within the limits of the existing concept of the nature of the universe. It is easy to fit a theory to a few bits of information, and the scientific community currently claims to have a sound theoretical understanding of a number of phenomena about which very little is actually known—even about some phenomena that we now find are totally non-existent. But by this time a great many facts about the quasars have accumulated. As a consequence, orthodox theory is currently in a position where any explanation that is devised to account for one of the observed features of the quasars is promptly contradicted by some other known fact.

There is no light on the horizon to indicate that a solution of the existing difficulties is on the way. More and more data are being gathered, but a basic understanding still eludes the astronomers. A review of the situation in 1976 by Strittmatter and Williams included this comment, which is equally appropriate today:

In general this [the large amount of information accumulated in the past seven years] has led to new problems related to the QSO's, rather than to solution of the many long-standing problems associated with these objects. The QSO's remain among the most exciting but least well-understood astronomical phenomena.²³⁴

Ironically, the principal obstacles that have stood in the way of an understanding of the quasar phenomena are not difficult and esoteric aspects of nature; they are barriers that the investigators themselves have erected. In the search for scientific truth, a complicated and difficult undertaking that needs the utmost breadth of vision of which the human race is capable, these investigators have gratuitously handicapped themselves by placing totally unnecessary and unwarranted restrictions on the allowed thinking about the subject matter under consideration. The existing inability to understand the

quasars is simply the result of trying to fit these objects into a narrow and arbitrary framework in which they do not belong.

Most of these crippling restrictions on thinking result from a widespread practice of generalizing conclusions reached from single purpose theories. This practice is one of the most serious weaknesses of present-day physical science. Many of our current theories, both in physics and in astronomy, are in this single-purpose category, each of them having been devised solely for the purpose of explaining a single set of observed facts. This very limited objective imposes only a minimum of requirements that must be met by the theory, and hence it is not very difficult to formulate something that will serve the purpose, particularly when the prevailing attitude toward the free use of ad hoc assumptions is as liberal as it is in present-day practice. This means, of course, that the probability that the theory is correct is correspondingly low. Such a theory is not, in the usual case, a true representation of the physical facts. It is merely a model that represents *some* of the facts of the physical situation to which it applies. When conclusions derived from such a theory are applied to phenomena in related fields, the inevitable result is a distortion of the true relations.

The most damaging of these generalizations based on far-reaching extrapolations of conclusions derived from very limited data is the pronouncement that there can be no speeds greater than that of light. For some strange reason, the scientific Establishment has decreed that this product of a totally unsubstantiated assumption must be treated as Holy Writ, and accepted without question. "Thou shalt not think of speeds greater than that of light," is the dictum. The conservation laws may be questioned, causality may be thrown overboard, the rules of logic may be defied, and so on, but one must not suggest that the speed of light can be exceeded in any straightforward way.

Using a theory of this highly questionable nature as a basis for laying down a limiting principle of universal significance is simply absurd, and it is hard to understand why competent scientists allow themselves to be intimidated by anything of this kind. But the "iron curtain" is almost impenetrable. There are a few signs of a coming revolt against strict orthodoxy. Some investigators are beginning to chafe under the arbitrary restrictions on speed, and are trying to find some way of circumventing the alleged limit without offering a direct challenge to relativity theory. "Tachyons," hypothetical particles that move faster than light, but have some very peculiar ad hoc properties that enable them to be reconciled with relativity theory, are now accepted as legitimate subjects for scientific speculation and experiment. But such halfway measures will not suffice. What science needs to do is to cut the Gordian knot and to recognize that there is no adequate justification for the assertion that speeds in excess of the speed of light are impossible.

By an unfortunate coincidence, a universal principle, recognition of which would have avoided this costly mistake, has never been accepted by physical

science. Most other branches of thought recognize what they call the Law of Diminishing Returns, which states that the ratio of the output of any physical process to the input does not remain constant indefinitely, but ultimately decreases to zero. The basis for the existence of such a law has not been clear, and this is probably one of the principal reasons why scientists have not accepted it. In the light of the theory of the universe of motion it is now evident that the law is merely an expression of the fact that the status of unity as the datum for physical activity precludes the existence of infinity. Zero may exist as a difference between two finite quantities, but there is no simple zero, and there are no infinities in nature.

Present-day physicists realize that they are dealing with too many infinities. "If we put all these principles [the "known" principles of physics] together . . . we get inconsistency, because we get infinity for various things when we calculate them,"²³⁵ says Richard Feynman. But the physicists have not conceded the existence of the universal law that bars *all* infinities, and they have allowed Einstein to assume that the relation $F = ma$ extends to infinity. (This, of course, is the assumption on which he bases his conclusion that the limiting zero value of a corresponds to an infinite value of m .)

Meanwhile, conclusions derived from other single purpose theories have compounded the difficulties due to the arbitrary exclusion of speeds greater than that of light from scientific thought. The accepted explanation of the high density of the white dwarfs cannot be extended to aggregates of stars, and therefore stands in the way of a realization that the high density of the quasars results from exactly the same cause. Acceptance of the Big Bang theory of the recession of the distant galaxies, a theory designed to explain one observed fact only, prevents recognition of the scalar nature of motion of the recession type, and so on.

An unfortunate result of the proliferation of these single purpose theories is that it places a barrier in the way of correcting errors individually, the step by step way in which scientific knowledge normally advances. Each of these erroneous theories applicable to individual phenomena rests in part on equally erroneous theories of other phenomena, and has been forced into agreement with those other theories by means of ad hoc assumptions and other expedients. Correction of the error or errors in any *one* of these interlocking theories is unacceptable because it leaves that theory in conflict with all others in the network. Scientists are naturally reluctant to make a wholesale change in their theories and concepts. But when they have maneuvered themselves into the kind of a theoretical position that they now occupy in the area that we are discussing, there is no alternative. Elimination of errors must take place on a wholesale scale if it to be done at all. The broad scope of the revisions of astronomical thought required by the theory of the universe of motion should therefore be no surprise.

It is true that correction of a multitude of errors in one operation leads to

theoretical descriptions of some phenomena that are so different from previous views that it might almost seem as if we are dealing with a different world. But it should be remembered, as we begin consideration of the quasar phenomena, the terra incognita of modern astronomy, that the criterion of scientific validity is agreement with the observed facts. Furthermore, the acid test of a theory, or system of theories, is whether that agreement, once established, continues to hold good as new facts are disclosed by observation or experiment. Of course, if the theory can *predict* the observational discoveries, as the theory of the universe of motion did in the case of the galactic explosions and a number of the features of the products thereof, this emphasizes the agreement, but prediction is not essential. The requirement that a theory must be prepared to meet is that it must be consistent with *all* empirical knowledge, including the *new* information continually being accumulated. This is the rock on which so many once promising theories have foundered.

Many other theories have survived only with the help of ad hoc assumptions to evade conflicts. This currently fashionable expedient is not available to the Reciprocal System of theory, which, by definition, is barred from introducing anything from outside the system; that is, anything that cannot be derived from its fundamental postulates. But, as can be seen in the pages of this volume, this new system of theory has no need for such an expedient. The principal elements of the new observational information acquired by the astronomers during the last few decades have all been identified with corresponding elements of the theoretical structure without any serious difficulty, and there is good reason to believe that the minor details will likewise be accounted for when someone has time to examine them systematically.

It has been necessary to *extend* the theoretical development very substantially, not only to account for the facts disclosed by the new observations, but also to deal with areas not covered in the original investigation. That original study was not primarily concerned with astronomical phenomena as such, but rather as physical processes in which the physical principles derived from the theory could be tested in application under extreme conditions. In this present volume the objectives have been broadened. In addition to using astronomy as a proving ground for the laws and principles of fundamental physics, we are using these laws and principles, now firmly established, to explain and correlate the astronomical observations.

CHAPTER 21

Quasar Theory

The key to an understanding of the quasars and associated phenomena is a recognition of their status as the galactic equivalents of the class of white dwarfs known as pulsars. The theory of the upper speed ranges developed in Chapter 15 and applied to the products of the supernova explosions in the subsequent discussion can be applied in the same manner to the quasars, with such modifications as are appropriate in view of the differences between stars and galaxies.

Aside from these differences due to the larger size, more complex structure, stronger gravitational forces, etc., the galactic explosions are analogous to the supernovae, the major products of the galactic explosions are analogous to the major products of the supernovae, and the unusual properties of the ultra high speed component of the galactic explosion products are analogous to the unusual properties of the ultra high speed product of the Type II supernova, the fast-moving white dwarf that we call a pulsar. The “mysterious” quasars are not so mysterious after all, except in the sense that all entities and phenomena are mysterious if they are viewed in the context of erroneous theories or assumptions.

The analogy between the white dwarfs and the quasars is so obvious that it should have been recognized immediately, in general, if not in detail, when the quasars were first discovered. The white dwarf is a star whose distinctive property is a density far outside the range of the densities of normal stars. The quasar is an aggregate of stars, one of the most distinctive properties of which is a density far outside the range of the densities of normal stellar aggregates. The conclusion that these new objects, the quasars, are the galactic equivalent of the white dwarfs follows almost automatically. But however natural this conclusion may be, the astronomers cannot accept it because they are committed to conflicting ideas that have been derived from single purpose theories and have been generalized into universal laws.

The explosive events that produce these two classes of objects differ in some respects, but the general situation is the same in both cases. One component of the products of both types of explosions is ejected with a speed less than that of light. Since this is the normal speed in the material sector of the universe, this product is an object of a familiar type, a rather commonplace aggregate of the

units of which the exploding object was originally composed. The constituent units of a star are atoms and molecules. When a star explodes it breaks down into these units, and we therefore see a cloud of atomic, molecular, and multi-molecular particles emanating from the site of the explosion. But there is also a second component, a peculiar object known as a white dwarf star, which we have now identified as a cloud of similar particles that has been ejected with a speed greater than that of light, and is therefore expanding into time rather than into space.

Some of the products of the galactic explosion are likewise reduced to atomic or particle size, but the basic units of which a galaxy is composed are stars, and hence the material ejected by the explosion comes out mainly in the form of stars. Instead of clouds of gas and dust particles, the galactic explosion produces "clouds" of stars: fragments of the original giant galaxy. Here, as in the supernova explosion, one of the products of a full scale galactic explosion acquires a speed in excess of that of light, while the other remains below that level. The aggregate of stars traveling at normal speed is also normal in other respects, the only prominent distinguishing feature being the strong radio emission in the early stages, due to the intermediate speed matter incorporated in the aggregate. This product is a *radio galaxy*. The ultra high speed product is a quasar.

As noted in Chapter 20, while the additional studies that have been made since the original publication of the theory in 1959 have confirmed most of the conclusions therein expressed, the early views as to the mechanism of the galactic explosion have been modified to some extent. It is now evident that there is a build-up of pressure in the interiors of the giant galaxies due to Type II supernova explosions that occur in large numbers when the old stars in the central regions begin to reach their age limits. The enormous internal pressure thus generated eventually reaches a point at which it blows out a section of the overlying mass of the galaxy, in the manner of a boiler explosion. When the pressure is relieved, the galactic structure reforms, and the building up of the internal pressure is resumed. In due course this results in a repetition of the galactic explosion. As predicted in the 1959 edition, a long series of such explosive events ultimately destroys the galaxy.

The build-up of internal pressure that occurs in the central regions of the giant galaxies, according to our deductions from the postulates that define the universe of motion, would be impossible on the basis of previous astronomical thought, as conventional theory provides no means of containment of energetic stars or particles. But our finding is that the stars in any aggregate occupy equilibrium positions, and they resist any displacement from these positions. The outer regions of a galaxy thus act as the walls of a container, resisting the internal forces, and confining the high speed material to the interior of the galaxy where the large-scale disintegration of stars is taking place. As we saw in Chapter 19, there is some leakage through the confining walls, but the fact

that evidence of leakage is detected only in the vicinity of the largest galaxies (Reference 167) indicates that it does not reach major proportions until the internal pressure is almost strong enough to accomplish the break-through. When the internal pressure does finally arrive at the level at which it overcomes the resistance, a whole section of the overlying portion of the galaxy is blown off as a quasar.

A study of quasar sizes, which will be discussed later, indicates that these ejected fragments of the giant galaxies range in size from about 7×10^7 stars, the size of a dwarf elliptical galaxy, to about 2×10^9 stars, the size of a small spiral. In the pages that follow it will be shown that the theoretical properties of galactic fragments of these sizes, moving at ultra high speeds in the explosion dimension, are identical with the observed properties of the quasars.

It is worth noting at this point that the foregoing explanation of the nature and origin of the quasars is not in conflict with existing quasar theory, as the astronomers have not yet been able to formulate a theory of the quasars.

As yet we have no unique theory and no single model that explains the nature of quasars, let alone their origin or source of energy.²³⁶ (Martin Harwit)

Nor do they have a theory as to how and why galaxies explode. Even their theories of *stellar* explosions are admittedly little more than speculations.

We should emphasize at the outset that modern science does not yet have a genuine theory of stellar explosions at its disposal.²³⁷ (I. S. Shklovsky)

Motion of an astronomical object perpendicular to the line of sight—proper motion, as it is known to the astronomers—can be measured, or at least detected, by observation of the change of position of the object with respect to the general pattern of astronomical positions. Motion in the line of sight is measured by means of the Doppler effect, the change in the frequency of the radiation from the object that takes place when the emitter is moving toward or away from the observer. No proper motion of the quasars or other very distant galaxies has been detected, and we may therefore conclude that the random vectorial motions of these galaxies are too small to be observable at the enormous distances that separate us from these objects. By reason of the progression of the natural reference system, however, the distant galaxies are receding from each other and from the earth at high speeds that increase in direct proportion to the distance. The Doppler effect due to these speeds shifts the spectra toward the red in the same proportion. Inasmuch as an approximate value of the relation between redshift and distance (the Hubble constant) can be obtained by observation of the nearby galaxies whose distance can be

approximated by other methods, the redshift serves, in current practice, as a means of measuring the distances to galaxies that are beyond the reach of other methods.

One of the most striking features of the quasars is that their redshifts are fantastically high in comparison with those of other astronomical objects. While the largest redshift thus far (1983) measured for a normal galaxy is 0.67 (Reference 238), some of the quasar redshifts are near 4.00. If we assume, as most astronomers now do, that these are ordinary recession redshifts, then the quasars must be by far the most distant objects ever detected in the universe.

Our theoretical development indicates that from the standpoint of distance *in space* this conclusion is erroneous. In the context of the theory of the universe of motion, the normal recession redshift cannot exceed 1.00, as this value corresponds to the speed of light, the full speed of the progression of the natural reference system, the level that is reached when the effect of gravitation becomes negligible. Even without any detailed consideration, it is therefore evident that the observed quasar redshift includes another component in addition to the recession shift. From the account that has been given of the origin of the quasar it can readily be seen that this excess over and above the redshift due to the normal recession is a result of the motion in additional dimensions that has been imparted to the quasar by the violent galactic explosion.

As brought out in Chapter 15, an object with a speed intermediate between one unit (the speed of light) and two units is moving in the spatial equivalent of a time magnitude. This motion in equivalent space is not capable of representation in the spatial reference system, except where it reverses a gravitationally caused change of position. The Doppler shift, on the other hand, is a simple numerical relation, a scalar total of the speed magnitudes in all dimensions, independent of the reference system. The *effective* portion of the speed in equivalent space therefore appears as a component of the quasar redshift.

The qualification “effective” has to be included in the foregoing statement because the quasar motion beyond the unit speed level takes place in two scalar dimensions, only one of which is coincident with the dimension of the spatial reference system. The motion in the other equivalent space dimension has no effect on the outward radial speed, and therefore does not enter into the Doppler shift.

Perhaps it would be well to add some further explanation on this point, since the idea of scalar motion in two dimensions is unfamiliar, and probably somewhat confusing to those who encounter it for the first time. In application to scalar motion, the term “dimension” is being used in the mathematical sense, rather than in the geometrical sense; that is, a two-dimensional scalar quantity is one that requires two *independent* scalar magnitudes for a complete definition. When such a two-dimensional scalar quantity is superimposed on a

commensurable one-dimensional quantity, as in the extension of the one-dimensional scalar motion into the two-dimensional region, only one of the two scalar magnitudes of the two-dimensional quantity adds to the one-dimensional magnitude. Since the other is, by definition, independent of the magnitude with which it is associated in two dimensions, it is likewise independent of the one-dimensional quantity that adds to that associated magnitude.

On the basis of the theory developed in Chapter 15, the total redshift (a measure of the total effective speed) of an object moving with a speed greater than unity is the recession redshift plus half of the two-dimensional addition. As explained in the earlier discussion, the resulting value is normally $z + 3.5 z^{1/2}$. Since both the recession in space and the explosion-generated motion in equivalent space are directed outward, no blueshifts are produced by either component of the quasar motion.

The question as to the interpretation of the redshifts has been a lively source of controversy ever since the original discovery of the quasars. Both of the alternatives available within the limits of conventional astronomical theory are faced with serious difficulties. If the redshift is accepted as an ordinary Doppler effect, due to the galactic recession, the indicated distances are so enormous that other properties of the quasars, particularly the energy emission, are inexplicable. On the other hand, if the redshift is not due, or not entirely due, to the recession speed, current theory has no tenable hypothesis as to the mechanism by which it is produced. So the question at issue, as matters now stand, is not which alternative is correct, but which of the two untenable alternatives currently available should be given preference for the time being.

Firm evidence bearing on this issue is difficult to obtain. Arguments on one side or the other of the question are based mainly on apparent association between quasars and other objects. Apparent associations with similar redshifts are offered as evidence in support of the simple Doppler shift, or "cosmological," hypothesis. The opponents counter with what appear to be associations between objects whose redshifts differ, evidence, they contend, that two different processes are at work. Each group brands the opponents' associations as spurious.

Obviously, a kind of evidence that supports both sides of an argument does not settle the issue. Something more than the mere existence of what *may* be an association between astronomical objects is needed before a firm conclusion can be derived from observation. In the next chapter we will examine the only case now known in which enough additional information is available to enable reaching firm conclusions.

Some attempts have been made to derive support for the cosmological hypothesis from the existence of absorption redshifts, the thought being that the absorption may take place in a cloud of matter existing somewhere in the

line of sight, but this idea has never made much headway, as it has become increasingly clear that the absorption redshifts are intrinsic to the quasars. Correlation of redshift with observed brightness has also been called upon to provide an empirical foundation for the currently popular hypothesis. For example, the results of a comparison by Bahcall and Hills were summarized in a news report as follows: "The point is simply that, by and large, quasars with large redshifts seem dimmer than those with small redshifts, just as we would expect if they are farther away."²³⁹ This is valid evidence against the "local" hypothesis, which asserts that the quasars have been ejected from our own, or some nearby, galaxy, but it does not favor the cosmological hypothesis over the assertions of its present-day critics, who merely contend that there is a second component in the observed redshift, in addition to the component due to the normal recession.

A somewhat more substantial item of support for the cosmological hypothesis that has been increasing in popularity in recent years is the finding that there is observable "fuzz" surrounding many of the quasars. This is interpreted as evidence that the quasars are simply the active cores of highly disturbed galaxies, similar to the Seyfert galaxies, but more extreme, Super-Seyferts, so to speak. However, conclusions of this kind, which are welcomed by the investigators because they tend to support currently popular theories, are not usually given the critical scrutiny that is applied to less favored products. If we look at this conclusion without the rose-colored glasses, we will note the following points: (1) Some "fuzz" can be expected around many of the quasars without any normal galaxy being present. Its existence is demonstrated by the absorption redshifts. (2) In view of the presence of the very bright quasars, much, perhaps most, of the optical radiation from the "fuzz" is reflected light. (3) The properties of the quasars are not merely more extreme manifestations of the properties of the Seyferts; in many respects they are quite different. (4) Even if this "fuzz" argument were valid, it does not come to grips with the key problem of the cosmological hypothesis: the utter inability to account for the enormous energy output. Thus it does not change the essential element of the situation.

Most astronomers accept the cosmological hypothesis, not because of the weight of the evidence, but because they know of no mechanism whereby the second redshift component can be generated, and they are not willing to concede the existence of an unknown mechanism. This leaves them with the necessity of finding a new mechanism whereby energy can be generated in amounts vastly exceeding not only the capabilities of any known energy generation process, but also the total energy available in any known source. Just why this should be the preferred alternative is rather difficult to understand. In either case, something *new* must be found, but an explanation of the energy generation process must also provide for an enormous extension of the *magnitude* of known energy generation processes. Some hypotheses of

a far-out nature have been advanced to meet this requirement, but as noted by Jastrow and Thompson:

These ideas [about the energy of the quasars] are not supported by observational evidence. They are no more than desperate efforts by the astronomer to take the most luminous single objects that he has ever discovered and scale these objects upward in size and mass by factors of a millionfold or more, without any valid theoretical reason for doing so.²³³

In any event, the application of the theory of the universe of motion to this situation now eliminates the need for any new kind of a mechanism, as it identifies the second redshift component as another Doppler shift, produced in the same manner as the normal recession redshift, and constituting a scalar addition to the normal shift.

As in the case of the pulsars discussed in Chapter 17, the quasar remains as a discrete object in the spatial reference system until the two-unit boundary of the material sector is reached. But there is an important difference. The gravitational retardation of the pulsar by the remnants of the star from which it originated is relatively minor. It may be slowed up to some extent at a later stage of its existence by the combined effect of other stars in the neighborhood, but it is never subject to any strong gravitational effect. As a result it reaches the sector boundary and converts to motion in time relatively soon. It is therefore a short-lived object (astronomically speaking). The quasar, on the other hand, is subject from the start to the gravitational forces of an entire galaxy of somewhere near 10^{12} solar masses. It therefore accelerates slowly, and appears as a visible object in space for a long period of time while the gravitational attraction is being overcome.

If the quasar is not destroyed by internal violence during its visible life, it finally disappears when the point of conversion to the cosmic status is reached. As we saw in Chapter 15, the explosion redshift, $3.5 z^{1/2}$, at this point is 2.00. The corresponding recession redshift is 0.3265, and the total quasar redshift is 2.3265. (In the ensuing discussion the last digit will be dropped, as the redshift measurements are not currently carried to more than four significant figures.) Here the motion in space converts to motion in time. An alternative that may take precedence under appropriate conditions will be discussed in Chapter 23.

In this connection, it is interesting to note that while current astronomical theory regards the range of quasar speeds as extending without interruption up to beyond the 3.5 level, the observers have reported evidence indicating that *something* occurs in the vicinity of what we have identified as the cut-off point at 2.326. This evidence and its implications will be included in the discussion in Chapter 23.

The energy imparted to the galactic fragment identified as a quasar is, of course, shared between the motion of the individual stars within the fragment, that of the associated dust and gas, and the motion of the object as a whole. Indeed, a considerable portion of the total energy involved is communicated to the constituent stars during the build-up of the explosive forces before the ejection actually takes place. We may deduce, therefore, that most, or all, of the stars in the quasar are individually moving at speeds in the upper ranges. The quasar is consequently expanding in time, which means that it is contracting in equivalent space. Hence, like the white dwarfs, which are abnormally small stars, the quasars are abnormally small galaxies (from the spatial standpoint).

This is the peculiarity that has given them their name. They are “quasi-stellar” sources of radiation, mere points like the stars, rather than extended sources like the normal galaxies. Some dimensions and structure are now being observed with the aid of powerful instruments and special techniques, but this new information merely confirms the earlier understanding that as galaxies, or galactic fragments, they are extremely small. The most critical issue in the whole quasar situation, as seen in the context of current thought, is “the problem of understanding how quasars can radiate as much energy as galaxies while their diameters are some thousand times smaller.”²⁴⁰

But this is not a unique problem; it is a replay of a record with which we are already familiar. We know that there is a class of *stars*, the white dwarfs, which radiate as much energy as some ordinary stars, while their diameters are many times smaller. Now we find that there is a class of *galaxies*, the quasars, that has the same characteristics. All that is required for an understanding is a recognition of the fact that these are phenomena of the same kind. It is true that the currently accepted theory of the white dwarfs contains an explanation of their small sizes that cannot be extended to the quasars, but the obvious conclusion from this is that the current theory of the white dwarfs is wrong. In the universe of motion the abnormally small dimensions are due to the same cause in both cases. Speeds in excess of the speed of light introduce motion in time which has the effect of reducing the equivalent space occupied by each object. As pointed out earlier, the quasars are simply the galactic equivalent of the white dwarf stars.

The brightness of the quasars, another of their special characteristics, is also a result of their abnormally small spatial size. The area from which the radiation of a quasar originates is much smaller than that of a normal galaxy of equivalent size, while the emission is greater because of the greater energy density. In this case, the situation is somewhat more complex than in the white dwarf stars. The increase in the intensity of emission from these stars is mainly a matter of radiating a similar amount of energy from a smaller surface. The corresponding increase in the emission per unit of surface area of the stars of the quasar has no effect on the radiation per unit of surface area of this

object as a whole, but an increase in the radiation intensity is produced by the greater stellar density—that is, the larger number of stars per unit of volume—due to the small size of the quasar. The intensity of the radiation is still further increased by the emission from the large concentrations of fast-moving gas and dust particles in the quasars, a galactic component that is not present in normal galaxies. The radiation from these two separate sources in the quasars can be identified with the two observed radiation components, that with a line spectrum from diffuse matter, and that with a continuous spectrum from the stars.

Because of the diversity of the processes that are taking place in the quasars, the frequencies of the emitted radiation extend over a wide range. As explained in Chapter 18, thermal and other processes affecting the linear motions of atoms generate radiation that is emitted principally at wavelengths relatively close to that corresponding to unit speed, 9.12×10^{-6} cm, whereas processes such as radioactivity that alter the rotational motions of the atoms generate radiation that is mainly at wavelengths far distant from this level. Explosions of stars or galaxies, particularly the latter, cause rotational readjustments of both the material and cosmic types, hence these events generate both very long wave radiation (radio) and very short wave radiation (x-rays and gamma rays), as well as thermal and inverse thermal radiation.

The question as to the origin of the large amount of energy radiated from the quasars has been a serious problem ever since the discovery of these objects. The new information derived from the theory of the universe of motion has now resolved this problem. First, it has drastically scaled down the indicated magnitude of this energy. The finding that the greater part of the quasar motion indicated by its redshift has no effect on the position of this object in space, and that, as a consequence, the quasar is much less distant than the cosmological interpretation of the redshift would indicate, makes a very substantial reduction in the calculated energy emission. The further finding that the radiation is distributed two-dimensionally rather than three-dimensionally simplifies the problem even more significantly.

For example, if we find that we are receiving the same amount of radiation from a quasar as from a certain nearby star, and the quasar is a billion (10^9) times as far away as the star, then if the quasar radiation is distributed over three dimensions, as currently assumed, the quasar must be emitting a billion billion (10^{18}) times as much energy as the star. But on the basis of the two-dimensional distribution that takes place in equivalent space, according to the theory of the universe of motion, the quasar is only radiating a billion (10^9) times as much energy as the star. Even in astronomy, where extremely large numbers are commonplace, a reduction of the energy requirements by a factor of a billion is very substantial. An object that radiates the energy of a billion billion (10^{18}) stars is emitting a million times the energy of a giant spheroidal galaxy, the largest aggregate of matter in the known universe (about 10^{12}

stars), and attempting to account for the production of such a colossal amount of energy is a hopeless task, as matters now stand. On the other hand, an object that radiates the energy of a billion (10^9) stars is equivalent, from the energy standpoint, to no more than a rather small galaxy.

While the theory is thus drastically scaling down the amount of energy to be accounted for, it is at the same time providing a large new source of energy to meet the reduced requirements. The disintegration of an atom at the upper destructive limit can result in the complete conversion of the atomic mass into energy. Inasmuch as the magnetic ionization of the matter of which a star is composed is uniform throughout a large portion of the mass, the explosion of the star at this upper limit is theoretically able to convert a major part of the stellar mass into energy: It should also be noted that the quasar is not called upon to provide its own initial energy supply. The kinetic energy that accelerates a quasar as a whole and its constituent stars to upper range speeds is provided by the giant galaxy from which the quasar is ejected. All that the quasar itself has to do is to meet the subsequent energy requirements.

A point that has given considerable trouble to those who are attempting to put the observational data with respect to the quasars into some coherent pattern is the existence of relatively large fluctuations in the output of radiation from some of these objects in very short intervals of time. This imposes some limits on the sizes of the regions from which the radiation is being emitted, and thereby complicates the already difficult problem of accounting for the magnitude of the energy being radiated. Our new theoretical development has eliminated these difficulties. The answers to the size and energy problems have been derived from the fundamental premises of the theory of the universe of motion in the foregoing pages. When viewed in the context of these general findings, identification of the primary source of the energy as a large number of individual stellar explosions that accelerate their products to speeds in excess of the speed of light is sufficient to account for the fluctuations.

One feature of the quasars that has been given a great deal of attention by the astronomers is their distribution in space. Almost from the beginning of radio astronomy, it has been noted that there is an apparent excess of faint radio sources; that is, if it is assumed that the luminosity is related to the distance in the normal inverse square manner, the density of the sources increases with the distance. Since the radiation that is now being received from the more distant sources has been traveling for a longer time, the observations may be interpreted as indicating that the average density of the objects that emit radio radiation was greater in earlier eras. Such a conclusion, if valid, would be highly favorable to the evolutionary theories of cosmology, and the available evidence has been closely scrutinized for this reason.

As matters now stand, the majority opinion is that the issue has been settled in favor of the contention that the density of these radio sources is less now than at the time the radiation left the distant sources; that is, the density is

decreasing with time. However, this conclusion is based on the assumption that the distribution of the radiation is three-dimensional, and it is invalidated by our finding that the radiation from the quasars is distributed two-dimensionally. On the basis of this new finding, the excess of faint sources merely means that some of the sources are quasars, which we already know without the benefit of the radio source counts.

Because of the much more rapid decrease in visibility on the three-dimensional basis as compared to the two-dimensional distribution, the theoretical development indicates that the observable sources of radiation beyond a certain limiting magnitude should *all* be objects radiating in two dimensions; that is, quasars. This theoretical conclusion is confirmed by a study by Bohuski and Weedman which found that the curve representing the relation of the number of distant radio sources to the magnitude has a slope of 0.4, corresponding to a two-dimensional distribution, rather than the 0.6 slope that would result from a distribution in three dimensions. As expressed by the investigators, "virtually all stellar objects at high galactic latitude with magnitude of 23 or above are quasars."²⁴¹ Some further observational information supporting the theoretical two-dimensional distribution of the quasars will be presented in the chapters that follow, especially Chapter 25.

The idea of a two-dimensional distribution of radiation is not as unprecedented as it may seem. It has been recognized that there are aspects of the quasar and pulsar radiation that are indicative of a distribution in less than three dimensions. Current theory of the pulsars is expressed in terms of "beams." For instance, A. Hewish, in a review article on pulsars, refers to "beaming in two coordinates,"²⁴² which is merely one way of describing a two-dimensional distribution. The essential difference between the conventional view and the explanation derived from the theory of the universe of motion is that the astronomical hypotheses depend on the existence of special mechanisms of a highly speculative nature, whereas the deductive derivation of the properties of the universe of motion leads to a two-dimensional distribution of *all* radiation originating from objects moving at upper range speeds.

The discussion in this chapter can appropriately be closed with some reflections on a comment by Gerrit Verschuur that reads as follows:

At present there are many areas of astronomy (big bang theory, quasars, black holes) in which conventional physics seems to fail, and seeking understanding of these strange phenomena may yet lead to a revolution in thought.²⁴³

The perplexity with which the astronomers view the facts that they have accumulated about the properties of the quasars is well illustrated by this comment which classifies these observed, but not understood, objects with two

hypothetical entities, the Big Bang and the black hole, that are not only “strange,” but wholly non-existent. Verschuur’s suggestion that arriving at a better understanding of the quasar phenomena might require a change in physical thinking has now been verified, but in the reverse sequence. As the contents of this chapter show, it is the revolution in physical thought resulting from the development of the theory of the universe of motion that has enabled understanding of the quasar phenomena. The chapters that follow will extend this understanding into more detail.

CHAPTER 22

Verification

The quasar theory described in Chapter 21 accounts for the major features of these objects: what they are (fast-moving galactic fragments), how they originate (by explosions of massive old galaxies), where their energy comes from (large numbers of supernovae), what gives them their unique characteristics (speeds greater than that of light), and what their ultimate destiny will be (escape into the cosmic sector, the sector of motion in time). These are all necessary consequences of the physical principles of the universe of motion, as developed in the earlier volumes of this work, and the quasars are directly in the main line of the cyclic evolution of matter as described in the preceding pages of this present volume. But in view of the unfamiliar nature of some of the physical principles that are applicable to objects moving at upper range speeds, and the important part that these unfamiliar principles play in the quasar theory, it will be advisable to supply some additional verification of the validity of that theory by locating some specific situations in which we can compare the predictions of the theory with the results of observation.

The most significant situations of this kind are those in which the predictions of the new theory are unique; that is, those in which the development of the Reciprocal System of theory arrives at conclusions that are totally different from those derived from other sources. Situations that lead to quantitative answers are particularly meaningful. One such item is that there is a specific mathematical relation between the normal recession redshift and the explosion redshift, the increment due to the ultra high speed imparted to the quasar by the galactic explosion. The existence of this fixed relation is due to the fact that the motion generated by the explosion is a scalar motion of the same general nature as the recession, differing only in the number of dimensional units involved. The retarding effect of gravitation is variable, but it applies equally to all units, except as modified by the inter-regional relations. As explained in Chapter 15, where the recession redshift is z , the corresponding explosion redshift is $3.5 z^{1/2}$ (except under some special conditions that will be discussed later). A crucial test of the theory can therefore be accomplished by identifying the relative magnitudes of the two redshift components in a representative number of quasars, and comparing the results with the theoretical values.

As matters now stand, there is no way by which we can separate the observed redshift of an ordinary quasar into its two components, other than by means of the theoretical relation. But because of the manner in which the quasars originate, each of these objects is a member of a three-component group consisting of (1) the galaxy in which the explosion occurred, (2) the quasar, and (3) a radio galaxy. As a result of the reversal of directions at the unit speed level, the radio galaxy is ejected in the spatial direction opposite to that of the motion of the quasar. These two objects are therefore located on opposite sides of the galaxy of origin. All three members of each group occupy adjacent locations in space, and their recession redshifts are approximately equal, differing only by the amounts due to the random motion in space and to the relatively small change of position since the explosion. Disregarding these minor items, a three-component association resulting from a galactic explosion should consist of a central galaxy with redshift z , an ordinary radio galaxy with redshift z , and a quasar with redshift $z + 3.5 z^{1/2}$. In any case where at least one of the associates of a quasar in such a group can be identified, and the redshifts have been measured, we can test the validity of the theoretical relation by computing the value of the quasar redshift that theoretically corresponds to the value z obtained from the associated object at the same spatial location, and comparing it with the observed quasar redshift.

As it happens, Dr. Halton Arp, a prominent American astronomer, has made an intensive search for radio sources associated with galaxies of a "peculiar" nature. Since both the quasar and the radio galaxy ejected in a galactic explosion are strong sources of radiation at radio frequencies, these explosion-generated groups are likely candidates for discovery in a search such as that conducted by Dr. Arp. We may logically conclude that at least some of those of Arp's associations that have the required composition—a central galaxy that shows visible signs of internal disturbance, and two radio-emitting objects on opposite sides of this central galaxy, one of which is a quasar—are explosion systems. This provides us with an opportunity to make a clear-cut test of the validity of the theoretical conclusions.

If we were working with data of unquestionable reliability, we would simply go ahead with the calculations without further ado. But the task that Dr. Arp has performed is a difficult one, and it is unrealistic to expect that *all* of his "associations" define groups of objects of common origin. Indeed, the majority of his colleagues seem unwilling to concede *any* validity to these results, as would be concluded from the general preference for the cosmological explanation of the quasar redshifts, which attributes them entirely to the normal galactic recession, and thus denies the existence of the second redshift component that must exist if Arp's associations are physically real. We are therefore in a position where we have a double task. We must verify the reality of the associations in the same operation by which we verify the theoretical redshift relation from the available data.

In order to deal with what may be a mixture of correct and incorrect identifications, it is necessary to rely upon probability considerations. If the quality of the data available for analysis is poor, it might not be possible to reach any definite conclusions by this method, as the results that we obtain may not differ enough from random probability to be statistically significant, but if a reasonable percentage of Arp's identifications represent actual physical associations, some meaningful results can be obtained. Inasmuch as the theory being tested calls for the existence of a specific mathematical relation, *any* degree of conformity with that relation exceeding random probability is evidence in favor of the theoretical conclusion. A *high degree* of correlation, much in excess of random probability, is tantamount to proof, not only of the validity of the theoretical relation, but also of the accuracy of the identifications.

The nature of the process is such, however, that some stringent precautions are necessary in order to avoid introducing some kind of bias that would invalidate the probability argument. The most essential requirement is that the data that are utilized must be random with respect to the point at issue. One of the best ways to insure randomness is to utilize data that were previously compiled *for some other purpose*. Since Arp carried out his work for one purpose, and we are making use of it for an entirely different purpose, randomness of the data, with respect to the object of our inquiry, is achieved automatically.

One further requirement that must be observed, however, if conclusions based on probability considerations are to be beyond reproach, is that the data must be homogeneous, because unless they are homogeneous they are not likely to be completely random. We must therefore use only information that has been gathered on the basis of the same set of criteria and the same processes of judgment. This means that where a process of selection has been involved in accumulating the data, we must use these data in their original form, and exclude later additions or modifications, as it is practically impossible to maintain the original selection criteria unchanged over any substantial period of time. Even if a conscious effort is made to avoid changes, events taking place in the interim, and the natural evolution of thinking in the course of time will alter the criteria in ways that are difficult to identify.

For this reason, the comparisons in this chapter are all based on Arp's first extensive set of results, published in 1967, which was confined to objects included in the 3C (Third Cambridge) catalog of radio sources.²⁴⁴ Subsequent to this publication Dr. Arp modified some of his original groupings and identified a number of additional associations, some on the basis of the original considerations, and some on other grounds. But we cannot use this additional material in conjunction with the original, because if we do, we no longer have the homogeneous set of random data that is required

in order to assure the validity of our probability arguments.

For example, Arp has found that there are several quasars located in a straight line apparently proceeding from the galaxy NGC 520, and he regards this as evidence of physical association. But an identification of association of quasars or other objects based on linear alignment is something quite different from an identification based on the presence of two radio emitters on opposite sides of a "peculiar" galaxy, and we are not justified in taking either of these into account when we are undertaking to apply probability principles to an assessment of the validity of identifications made on the other basis. Whatever conclusions we may draw from the NGC 520 alignment are separate and distinct from those derived from the study of objects from the 3C catalog selected on an entirely different basis. The additional material can, of course, be used for *other* studies of the same subject, and the results thereof are entitled to the same kind of consideration as the results of the present analysis, but it must be *separate* consideration.

With the benefit of the foregoing understanding as to what we propose to do, and how we propose to go about it, we may now proceed to an examination of the ten associations from Arp's study of the 3C objects that are available for this purpose. His list is much longer, but for present purposes we are interested only in those associations in which one of the observed radio emitters is a quasar. On beginning the examination, the first thing that we encounter is the necessity of making some further exclusions, because *the theory itself* identifies some of the presumed associations as incorrect, and hence these associations cannot provide any comparison of theory with observation. Where the theory itself asserts that no agreement is to be expected, a demonstrated lack of agreement is meaningless.

Dr. Arp says that he does not expect to be able to identify the central "peculiar" galaxies beyond a recession of 10,000 km/sec.²⁴⁵ The quasar 3C 254, with a redshift of 0.734, of which 0.039 is the normal recession, is theoretically receding at slightly over this limiting recession speed, and is therefore approximately at the point beyond which the theoretically correct central galaxy is unobservable. According to the theory, then, any identification of a central galaxy with a quasar appreciably more distant than 3C 254 (in Arp's association 148) is *prima facie* wrong, and a comparison of the redshifts has no significance. We can test the theory only by checking the correlation in those cases where the theory says that there *should* be an agreement. On this basis, the only significant correlations with the central galaxy are the first four in Table IV. In *all* of these cases the theoretical and observed values show a satisfactory agreement. (The ratio 2.78 for association 134 would not be satisfactory at a higher *z* value, but obviously the random motions and other incidental factors have a higher proportionate effect where the recession is so small).

Beyond the point where the correct galaxy of origin becomes unobservable it

TABLE IV

Association Number	Quasar Redshift	Basis of Calculation	Excess/ $z^{1/2}$
134	.158	C	2.78
160	.320	C	3.41
125	.595	C	3.31
148	.734	C	3.76
201	1.037	R	3.56
139	1.055	R	3.31
5055	1.659	R	5.59
Excluded			
5223	.849	C	5.3
143	1.063	C	9.1
197	2.38	C	16.7

is still possible that the radio galaxy associated with a particular quasar may have been correctly identified, as the radio galaxies can be detected at distances well beyond those at which the features distinguishing a "peculiar" galaxy can be recognized. The correlations in our analysis have therefore been made on the basis of the radio galaxy, if the necessary redshift measurement is available, rather than the central galaxy, for all distances greater than that of association 148, as indicated by the symbol R in the third column of the table.

Here, again, there is an upper observational limit. It is somewhat indefinite, because of the wide range of emission energies, but the available evidence indicates that only the exceptional radio galaxy can be detected (or could be detected with the facilities available in 1967) at the distance corresponding to the theoretical location of the quasar 3C 280.1 in association 5055. The legitimacy of this association is therefore open to question. Since we must exclude associations 5223, 143, and 197 on the grounds previously cited, this questionable case, number 5055, is the only one in the entire list where there is a lack of agreement with the theory. All of the other associations in which the observed relation between quasar redshift and normal recession redshift *could* agree with the theoretical relation *do* show such an agreement.

The relevant data from Table IV are shown graphically in Fig. 25. Each plotted point on the graph indicates the relation of the excess redshift of the particular quasar, the amount by which the quasar redshift exceeds that of the galaxy with which it is presumably associated, to the square root of the redshift of the associated galaxy. The relation to which these points should theoretically conform is shown by the diagonal line. If the prevailing

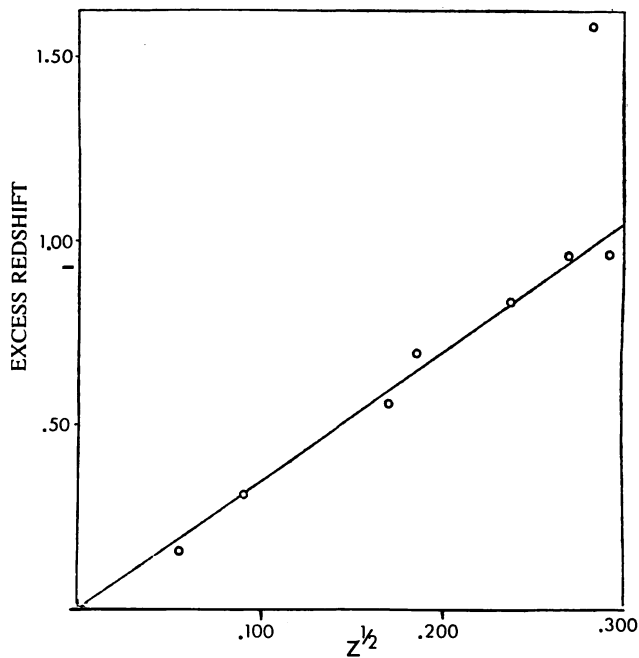


Fig. 25 Quasar Redshifts

astronomical opinion were correct, and the redshifts of the quasars were due to the normal recession alone, there would be no definite relation between the quasar redshift and that of the object or objects that are grouped with it. In that event the plotted points would scatter randomly, not only over the area of the graph as shown, but also over a much larger area above it, extending up to a value of 30 or more, as can be seen from the figures applying to the "excluded" group in Table IV. The same would be true if the associations are real, but, as Arp himself suggests, the excess redshift is due to some cause other than motion, and hence not directly related to the normal recession.

But they are definitely *not* random. On the contrary, five of the six points fall essentially on the theoretical line; that is, within the margin that can be attributed to the distances the ejected objects have moved since the explosion, to random spatial motion, and other minor effects. The probability that five out of the six would by chance fall on a straight line coinciding with a theoretically derived relation is negligible. The results of the investigation are therefore conclusive. They constitute a positive verification of the theoretical $3.5 z^{1/2}$ value of the explosion redshift.

All of the other evidence, both for and against the association of the quasars with objects of lower redshift, has been indefinite. Most of it rests upon correlations between the redshifts of objects whose projections on the sky are

close enough to indicate that these objects *may* be contiguous. As a general proposition, a finding of this kind, a showing that *some* of the members of a given class conform to a specified relationship, has only a very limited significance. It remains little more than speculative unless further study enables defining a sub-class such that *all* of the members of this sub-class conform to the specified relation.

The reason why the results obtained by Arp are conclusive, whereas the other findings are not, is that Arp has done what no one else has been able to do; that is, he has defined a class of objects, associations of a specified nature between radio emitters included in the 3C catalog, which, when further limited by the criteria developed in this work, *do* conform to a definite and specific redshift relation. The associations that he has identified are not merely groups of objects whose observable positions indicate that they *may* be neighbors. They are groupings whose physical characteristics are similar, and are in agreement with the theoretical results of galactic explosions. Their identification depends not only on apparent proximity, but also on (1) abnormalities in the central galaxy (which are consistent with its having exploded), (2) radio emission from the presumed ejecta (which is characteristic of high speed explosion products), and (3) existence of the presumed ejecta in pairs at comparable distances and in positions on opposite sides of the central galaxy (the positions that they would occupy if they had been thrown off simultaneously in opposite directions as required by the theory). The number of associations included in Table IV is small, to be sure, but these are *all* of the associations of this type that Dr. Arp was able to identify among the objects of a catalog which, at the time of its compilation, covered all of the accessible extragalactic radio sources then known. In the sample area that it covers, the study is therefore comprehensive, and the results are conclusive.

These results show that the additional component that is present in the quasar redshift is due to a physical mechanism that is *specifically related to the normal recession*. The existence of two distinct components makes any hypothesis such as that of "tired light" untenable, while the fixed mathematical relation between the two components rules out anything, such as a redshift of gravitational origin, that is independent of the recession. Conventional physical theory has no other explanation to offer, but these features to which the observations point are the *same* features that we find when we apply pure reasoning to the properties of space and time as defined in the postulates of the Reciprocal System of theory. The explosive event that is required by the theory produces exactly the kind of an association of three related objects—a central galaxy with a radio galaxy on one side and a quasar diametrically opposite—that Arp has identified in his studies. The ultra high speed imparted to the quasar by the tremendous amount of energy released in the galactic explosion exists in a second dimension of motion, and provides a second redshift component, related to, but distinct from, the normal recession

redshift, and the mathematical statement of that relation, as derived from theory, is identical with the relation between the measured values.

While the pattern of redshift values illustrated in Fig. 25 is conclusive in itself, it does not exhaust all of the corroboration of the theory that we can extract from Arp's associations. The *distances* of the radio emitters from the central galaxy also have a significance in this respect. As explained in Chapter 15, gravitation is effective in all three scalar dimensions, and therefore operates against the explosion-generated motion as well as against the normal recession. As a result, the *net* explosion speed is initially small, and increases with the distance in the same manner, except for the two-dimensional effect, as the recession speed. On the other hand, since the greater part of the explosion speed is initially applied to overcoming the effect of gravitation, which operates within the fixed spatial reference system, there is a rapid *change of position* in the reference system during this initial period when the net total speed, including the scalar speed not capable of representation in this reference system, is quite small. The rate of change of position then decreases as gravitation is gradually overcome and the net speed increases. Thus the theory leads to the decidedly unconventional conclusion that the faster the quasar moves in the explosion dimension, the less its position in space changes.

According to the theory, the relative spatial speed of the quasar, the component that manifests itself by changing the quasar position in space, is the difference between 1.0, the speed of light, and the explosion component of the quasar redshift, $3.5 z^{1/2}$ in the quasars of Table IV. The relative speed of the radio galaxy is the average outward speed of the stars that fail to reach the 1.0 speed level, and are therefore ejected in space rather than becoming constituents of the quasar. Since the distribution of these speeds was initially the tail of a probability curve from 1.0 downward, the average at the time of observation should be somewhat above 0.5, and nearly the same in all cases. Here, again, Arp's associations provide a sample that we can test to see if this theoretical requirement is met. In these associations we can measure the ratio of the distances of the two ejected objects from the central galaxy, since the three objects lie on a straight line. Inasmuch as the distance traveled since the explosion is proportional to the average spatial speed, the distance ratio thus determined is also the ratio of the average speeds. Applying this ratio to the spatial speed in the explosion dimension derived from the redshift measurement, we arrive at the speed of the radio galaxy.

For this test we are able to use only those associations in which all three components—central galaxies, quasars, and radio galaxies—have been clearly identified. Four of the associations listed in Table IV are within the 10,000 km/sec range in which identification of the central galaxy is feasible, but the radio galaxy in association 148 is unidentified optically. Its approximate location is known, and it can therefore be included in the study, along with the three associations that are clearly identified, with the understanding that the

results on 148 are subject to some uncertainty. Table V shows the observational data on these four associations, and the speeds of the radio

TABLE V

Association Number	Excess Redshift	Spatial Speed	Distance Ratio	R.G. Speed
134	.155	.845	.73	.62
160	.312	.688	.91	.62
125	.566	.434	1.35	.59
148	.695	.305	2.57	.78

galaxies as calculated from these data.

Column 2 of the table gives the explosion redshift of the quasar in the association identified in Column 1. Column 3 is the relative spatial speed of the quasar, the difference between unity and the value in column 2. Column 4 is the measured distance ratio. Multiplying Column 4 by Column 3, we arrive at the speed of the radio galaxy, relative to an explosion speed of 1.0.

These results given in Column 5 meet the requirements set forth earlier; that is, they arrive at essentially the same speed for all four radio galaxies (if we make allowance for the lack of certainty in the position of the radio galaxy in association 148), and this calculated speed is within the limits that we can establish from more direct considerations. Furthermore, a very wide range of quasar speeds is included, as the theoretical spatial speed of the quasar 3C 273 in association 134 is twice that of 3C 345 in association 125, and almost three times that of 3C 254 in association 148. The downward trend in the relative distance of the quasars from the central galaxy as the speed increases is unmistakable.

Verification of a theoretical conclusion of this nature, one that is nothing short of outrageous in the context of conventional theory is particularly significant because it shows that a *drastic* change in fundamental theory is required before the full range of physical phenomena can be understood. The customary process of adjustment and modification of existing theory by means of additional ad hoc assumptions is clearly incapable of dealing with discrepancies of this magnitude. No amount of tinkering with the conventional theory of motion can reconcile a decrease in the rate of change of spatial position with an increase in speed. Some new light on the general situation is indispensable.

A related phenomenon that is equally inexplicable in terms of conventional physical thought is the nearly constant separation of the radio emitting regions in most quasars. Although the distances to different quasars vary over an extremely wide range, the apparent separation of the two radio components is

usually close to a constant value. For example, Table VI shows the separations (in seconds of arc) measured by D. E. Hogg,²⁴⁶ excluding three

Table VI

COMPONENT SEPARATIONS

Quasar	Separation	Quasar	Separation
3C 181	6.0	3C 273	19.6
3C 204	31.4	3C 275.1	13.2
3C 205	15.8	3C 280.1	19.0
3C 207	6.7	3C 288.1	6.4
3C 208	10.5	3C 336	21.7
3C 249.1	18.8	3C 432	12.9
3C 261	10.8	MSH 13-011	7.8
3C 268.4	9.4		

values that will be considered later.

Similar measurements by Macdonald and Miley include a substantial proportion of larger separations, but these authors comment that their list includes many objects in which the radio components are so far distant from the optical center that, in their words, "If the radio structures of the larger QSOs were not symmetric about the optical QSO they might not have been identified."²⁴⁷ This suggests that the quasars with the larger component separations represent a different group of objects, the members of which have a second observable set of laterally displaced components. Such a hypothesis is supported by a further comment from the investigators which indicates that, in some instances, both types of component separation are present in the same structures. "Many sources," they say, "have large scale structure but small scale components dominate."

The almost constant angular separation of such a large proportion of these radio components of quasars stands out as an observed fact for which conventional astronomical theory has no explanation. As expressed by K. I. Kellerman, "either: The linear dimensions of radio sources depend on redshift in just such a way as to cancel the geometrical effects of the redshift, or: The geometric effect of the redshift on apparent size is negligibly small."²⁴⁸ Since neither of these alternatives can be accommodated within the boundaries of conventional theory, astronomy, Kellerman says, is confronted with a paradox.

In approaching the question theoretically, we note first that the outward radial movement of the quasars is beyond the limits of the reference system, and it is therefore incapable of representation in that system. As explained in

connection with the derivation of the applicable general principles in Volume II, motion in a second dimension is normally excluded from representation in the spatial reference system because the presence of motion in the original dimension preempts the full capacity of the reference system. But when representation of the motion in the original scalar dimension is ruled out for some reason, representation of the motion in the second dimension becomes possible. The lateral motion of the distant quasars is analogous to the lateral magnetic motion discussed in Volume II. As in electromagnetism, the motion in the second dimension of the intermediate speed range appears in the reference system with a direction perpendicular to the line of motion in the original dimension. In the case of the quasars, this direction is perpendicular to the line of sight.

The recession speed in the second dimension is the same as in the dimension coincident with the reference system, but as observed it is reduced by the inter-regional ratio, 156.444. Since it originates in a two-dimensional region, it is observed as a second power quantity. Thus the ratio of lateral to radial motion is $(2/156.444)^2$. In the terms in which the lateral displacement is generally expressed by the astronomers, this observable recession in the lateral direction amounts to 16.9 seconds of arc.

Inasmuch as the outward motion of a quasar has a specific direction, as seen in the spatial reference system, the lateral motion is confined to one specific perpendicular line. As noted earlier, however, scalar motion does not distinguish between the direction AB and the direction BA. The lateral recession outward from point X is therefore divided equally between a direction XA and the opposite direction XB by the operation of probability. Matter moving translationally at upper range speeds thus appears in the reference system in two locations equidistant from the line of motion in the coincident dimension (the optical line of sight, in most cases), and separated by 33.8 seconds of arc.

It does not follow, however, that the separation observed from the earth will be this large. If the quasar is a distant one, no evidence of its existence can be detected here until the radiation has had time to travel the long intervening distance. When first received, this radiation will disclose only the situation that existed at the location and time of ejection, before the lateral recession had begun. The progress of the recession will be revealed gradually by the radiation subsequently received, but the observed recession will lag behind the true magnitude by the time required for the travel of the radiation, until the observed separation reaches the limiting value. In the meantime, the separation will be observed at some value intermediate between zero and the maximum.

This explains why the observed separations vary, and are generally less than the calculated 33.8 seconds of arc. As can be seen from the foregoing explanation, these observed separations should be related to the time that has

elapsed since the explosive event that produced the fast-moving products from which the radiation is being emitted. A rough indication of this time is provided by the relation of the optical and radio emissions. The ratio of these emissions is affected by the evolutionary changes that take place in the various stages of the existence of the quasar, but by limiting our consideration to a homogeneous group of objects we can minimize the effect of these changes. For such a group the radio emission should decrease with time, as the isotopic adjustment progresses toward completion, and the ratio of optical to radio emission should increase accordingly. The magnitude of this ratio should therefore give us an approximate measure of the relative quasar ages.

An appropriate group of this kind consists of the six quasars in Hogg's list with redshifts above 1.00 for which luminosity data are available in the

TABLE VII
COMPONENT SEPARATIONS

Quasar	R_L	Separation	
		Calc.	Obs.
3C 204	0.279	26.2	31.4
3C 208	0.113	12.4	10.5
3C 432	0.112	12.3	12.9
3C 268.4	0.075	9.2	9.4
3C 181	0.033	5.7	6.6
3C 280.1	0.031	5.6	19.0

tabulations in Chapter 25. Examination of these data indicates that the approximate ratio (R_L) of optical to radio luminosity is related to the separation of the radio components (S) by the expression: $S = 83 R_L + 3.0$. Separations calculated on this basis are compared with Hogg's measurements in Table VII.

All but one of these correlations are within the range of variation that can be expected in view of the diversity of the conditions affecting the individual quasars. The reason for the discrepancy in the values applicable to the quasar 3C 280.1 is not known, but it could be the result of a second, very recent, outburst that has renewed the radio emission. On this basis, the low R_L value is produced by the radiation from the second explosive event, whereas the 19.0 figure is the separation between the products of the earlier event.

The separations greater than about 35 seconds of arc that are included in the reports that were quoted, those of the three quasars omitted from the tabulation of the Hogg results, and a larger number from the work of Macdonald and Miley, are due to a different cause. They are the results of actual motion of the ultra high speed dust and gas from which the radio emission originates, motion

that has taken this material away from the location where the optical radiation is being produced. This is the process by which the separation of the radio components of the radio galaxies originates, and it will be examined in connection with the discussion of these objects in Chapter 26. As we will see there, this process is not operative beyond a distance of 1.00 in the explosion dimension (total redshift 1.081). Thus there should be no component separations above 33.8 seconds by more than the observational error at redshifts above 1.081. This is consistent with the findings of both of the investigations cited.

In addition to the major explosive events that produce the larger radio aggregates, there is also a continuing series of explosions of a more limited character (to be explained in Chapter 24) in the older quasars. In some instances these result in scattered centers of emission along the normal lateral line, but a large proportion of the total energy is generated by the radioactivity of the short-lived isotopes, which is observed at or near the optical location. As we will see shortly, there is also another factor that confines some of the radio emission in the older quasars to the center position. Thus there is a tendency toward three, rather than two, major locations of radio emission. The prevalence of the three-component pattern is illustrated in the data reported by Macdonald and Miley. These investigators say that only 6 of the 36 objects for which they determined radio structures are definitely double, whereas 23 have, or may have, a third component at the center. The remaining 7 are more complex.

The finding that the radio emission from the distant quasars originates mainly at the same spatial location as the optical emission, but that we see it at two or more locations in the reference system, is another conclusion that appears outrageous in the context of current physical thought, but like the equally unconventional findings previously discussed, it is in agreement with the physical observations, and provides the explanations for aspects of those observations that are in conflict with conventional astronomical theory. In reality, it is not a strange or unusual phenomenon; it is merely unfamiliar. Multiple images produced by other means—mirrors, for instance—are commonplace.

All radiation from a quasar is subject to the same considerations, but the stellar constituents from which the optical emission originates are usually moving at speeds below the two-unit level. Thus the optical position of a quasar normally shows no lateral displacement. In some stars, however, the internal speeds may be in the ultra high range. In that event, both the optical and the radio emissions originate from the laterally displaced locations. The recently discovered cases of "twin quasars," which are thought to be duplicate images produced by gravitational lenses, may well be single quasars with ultra high speed optically emitting components.

When the quasars have reached the point where their *net* speed exceeds two

units and enters the cosmic range, the gravitational effect is inverted, and motion in time replaces motion in space. This eliminates the lateral recession in equivalent space that is responsible for the double character of the radio structure, as seen in the spatial reference system. The radiation from the quasar is still observable until the motion in time has continued long enough to destroy the status of the quasar as a spatial aggregate, and in the meantime this radiation is observed in the undisplaced radial location.

Observations indicate that many of the oldest of the visible quasars are in this transitional stage. A substantial proportion of those quasars that, on the basis of criteria such as the presence of absorption redshifts, large radio emission, and high z values, are in an advanced stage of development, show no spatial extension other than that corresponding to the spatial dimensions of the optical objects.

Thus the theory of the universe of motion provides an explanation of the major features of the quasar structures. Kellerman's "paradox," we find, is simply a message from nature, and it is the same message that we get from our analysis of the redshifts in Arp's associations. It tells us that inasmuch as the lateral displacements, like the excess redshift, are *directly related* to the recession, and are therefore observable effects of *motion*, the conventional narrow view of motion, which limits it to speeds less than that of light and to effects that can be represented within a three-dimensional spatial system of reference, must be broadened. But this is not something new that we are just now finding out by examination of the astronomical situation. It is a direct consequence of the inherent nature of the motion of which the universe is composed, and it plays just as significant a part in the fundamental physical relations as in the astronomical phenomena we are now considering. The principles here being applied were developed deductively in the earlier volumes, and were there utilized in application to many physical phenomena. For example, the physical principle that explains why radio sources are double (or triple) is not peculiar to this particular application; it is a *general* property of scalar motion that has previously been shown to provide the explanation for such diverse phenomena as the induction of electric charges and the deflection of light by massive objects.

As demonstrated in this and the preceding chapter, the deductions from the Reciprocal System of theory, incorporating this more comprehensive view of the nature of motion, are in full agreement with the results of observation in the quasar areas examined thus far. In the pages that follow it will be shown that this one-to-one correspondence between the theoretical deductions and the observational results is maintained throughout the entire range of the quasar phenomena. Some of the features of the account of the origin and nature of the quasars thus derived are in conflict with current astronomical thought, to be sure, but this merely reveals the erroneous nature of much of the current thinking. For example, present-day theory sees no way in which the forces

necessary to eject a galactic fragment can be built up within a galaxy. “Obviously a normal assemblage of stars cannot be hurled about like a snowball,”²⁴⁹ says Arp. However, the observational evidence makes it clear that fragments *are* ejected under some circumstances; that is, they *are* hurled about like snowballs. Current astronomical literature is full of references to, and hypotheses dependent upon, ejection of “assemblages of stars” from galaxies. In explaining how this is possible, and indeed, inevitable in the normal course of galactic evolution, the Reciprocal System is simply filling a conceptual vacuum.

CHAPTER 23

Quasar Redshifts

Although some of the objects now known as quasars had previously been recognized as belonging to a new and different class of phenomena, because of their peculiar spectra, the actual discovery of the quasars can be said to date from the time, in 1963, when Maarten Schmidt identified the spectrum of the radio source 3C 273 as being shifted 16 percent toward the red. Most of the other identifying characteristics originally ascribed to the quasars have had to be qualified as more data have been accumulated. One early description, for example, defined them as “starlike objects identified with radio sources.” But present-day observations show that in most cases the quasars have complex structures that are definitely un-starlike, and there is a large class of quasars from which no significant radio emission has been detected. But the high redshift has continued to be the hallmark of the quasar, and its distinctive character has been more strongly emphasized as the observed range of values has been extended upward. The second redshift measured, that of 3C 48, is 0.369, substantially above the first measurement, 0.158. By early 1967, when about 100 redshifts were available, the highest value on record was 2.223, and at the present writing it is up to 3.78.

Extension of the redshift range above 1.00 raised a question of interpretation. On the basis of the previous understanding of the origin of the Doppler shift, a recession redshift above 1.00 would indicate a relative speed greater than that of light. The general acceptance of Einstein’s contention that the speed of light is an absolute limit made this interpretation unacceptable to the astronomers, and the relativity mathematics were invoked to resolve the problem. Our analysis in Volume I shows that this is a misapplication of these mathematical relations. In the situations to which those relations actually do apply, there are contradictions between values obtained by direct measurement and those obtained by indirect means, such as, for instance, arriving at a speed measurement by dividing coordinate distance by clock time. In these instances the relativity mathematics (the Lorentz equations) are applied to the *indirect* measurements to bring them into conformity with the direct measurements, which are accepted as correct. The Doppler shifts are direct measurements of speeds, and require no correction. A redshift of 2.00 indicates a relative outward motion with a scalar magnitude of twice the speed of light.

While the high redshift problem was circumvented in conventional astronomical thought by this sleight-of-hand performance with the relativity mathematics, the accompanying distance-energy problem has been more recalcitrant, and has resisted all attempts to resolve it, or to evade it. Reference was made to this problem in Chapter 21, but inasmuch as it constitutes a crucial issue, for which the theory of the universe of motion has an answer, while conventional theory does not, a review of the situation will be appropriate in the present connection.

If the quasars are at cosmological distances—that is, the distances corresponding to the redshifts on the assumption that they are ordinary recession redshifts—then the amount of energy that they are emitting is far too great to be explained by any known energy generation process, or even any plausible speculative process. On the other hand, if the energies are reduced to credible levels by assuming that the quasars are less distant, then conventional science has no explanation for the large redshifts.

Obviously something has to give. One or the other of these two limiting assumptions has to be abandoned. Either there are hitherto undiscovered processes that generate vastly more energy than any process now known, or there are hitherto unknown factors that increase the quasar redshifts far beyond the normal recession values. For some reason, the rationale of which is difficult to understand, the majority of astronomers seem to believe that the redshift alternative is the only one that requires a revision or extension of existing physical theory. The argument most frequently advanced against the contentions of those who favor a non-cosmological explanation of the redshifts is that a hypothesis which requires a change in physical theory should be accepted only as a last resort. What these individuals are overlooking is that this last resort is the only thing left. If modification of existing theory to explain the redshifts is ruled out, then existing theory must be modified to explain the magnitude of the energy generation.

Furthermore, the energy alternative is much more drastic, inasmuch as it not only requires the existence of some totally new process, but also involves an enormous increase in the *scale* of the energy generation, a rate far beyond anything now known. All that is required in the redshift situation, on the other hand, even if a solution on the basis of known processes cannot be obtained, is a new process. This process is not called upon to explain anything more than is currently recognized as being within the capability of the known recession process; it merely has to account for the production of the redshifts at less distant spatial locations. Even without the new information derived in the development of the theory of the universe of motion it should be evident that the redshift alternative is by far the better way out of the existing impasse between the quasar energy and redshift theories. It is therefore significant that this is the explanation that emerges from the application of the Reciprocal System of theory to the problem.

Such considerations are somewhat academic, as we have to accept the world as we find it, whether or not we like what we find. It is worth noting, however, that here again, as in so many instances in the preceding pages, the answer that emerges from the new theoretical development takes the simplest and most logical path. Indeed, the answer to this quasar problem does not even involve breaking as much new ground as expected by those astronomers who favor a non-cosmological explanation of the redshifts. As they see the situation, some new physical process or principle must be invoked in order to add a "non-velocity component" to the recession redshift of the quasars. But we find that no such new process or principle is needed. The additional redshift is simply the result of an added speed; one that has hitherto escaped recognition because it is not capable of representation in the conventional spatial reference system.

The preceding chapter explained the nature and origin of the second component of the redshifts of the quasars, the explosion-generated component, and showed that the validity of this explanation is confirmed by an analysis of the three-member "associations" identified by Halton Arp. In this present chapter we will examine the quasar redshifts in more detail.

As indicated in the preceding pages, the limiting value of the explosion speed, and redshift, is two net units in one dimension. If the explosion speed is divided equally between the two active dimensions of the intermediate region, the quasar can convert to motion in time when the explosion component of the redshift in the initial dimension is 2.00, and the total quasar redshift is 2.326. At the time *Quasars and Pulsars* was published only one quasar redshift that exceeded the 2.326 value by any substantial amount had been reported. As pointed out in that work, the 2.326 redshift is not an absolute maximum, but a level at which conversion of the motion of the quasar to a new status, which it will ultimately assume in any event, *can* take place. Thus the very high value 2.877 attributed to the quasar 4C 05.34 either indicated the existence of some process whereby the conversion that is theoretically able to occur at 2.326 is delayed, or else was an erroneous measurement. Inasmuch as no other data bearing on the issue were available, it did not appear advisable to attempt to decide between the two alternatives at that time. In the subsequent years, many additional redshifts above 2.326 have been found, and it has become evident that extension of the quasar redshifts into these higher levels is a frequent occurrence. The theoretical situation has therefore been reviewed, and the nature of the process that is operative at the higher redshifts has been ascertained.

As we have seen, the 3.5 redshift factor that prevails below the 2.326 level is the result of an equal division of seven equivalent space units between a dimension that is parallel to the dimension of the spatial motion and a perpendicular dimension. Such an equal division is the normal result of the operation of probability where there are no influences that favor one

distribution over another, but other distributions are not totally excluded. There is a small, but not negligible, probability of an unequal distribution. Instead of the normal $3\frac{1}{2}$ – $3\frac{1}{2}$ distribution of the seven units of speed, the division may become 4 – 3 , $4\frac{1}{2}$ – $2\frac{1}{2}$, etc. The total number of quasars with redshifts above the level corresponding to the $3\frac{1}{2}$ – $3\frac{1}{2}$ distribution is relatively small, and any random group of moderate size—say 100 quasars—would not be expected to contain more than one, if any. A representative random group of quasars examined in Chapter 25 has none.

An asymmetric dimensional distribution has no significant observable effects at the lower speed levels (although it would produce anomalous results in a study such as the analysis of Arp's associations in Chapter 22 if it were more common), but it becomes evident at the higher levels because it results in redshifts exceeding the normal 2.326 limit. Because of the second power nature of the inter-regional relation, the 8 units involved in the explosion speed, 7 of which are in the intermediate region, become 64 units, 56 of which are in that region. The possible redshift factors above 3.5 therefore increase in steps of 0.125. The theoretical maximum, corresponding to a distribution to one dimension only, would be 7.0, but the probability becomes negligible at some lower level, apparently in the neighborhood of 6.0. The corresponding redshift values range up to a maximum of about 4.0. The largest redshifts thus far measured are as follows:

Quasar	Redshift		Redshift Factor
	Observed	Calculated	
2000-330	3.78	3.75	6.000
OQ 172	3.53	3.54	5.625
2228-393	3.45	3.47	5.500
OH 471	3.40	3.40	5.375

An increase in the redshift factor due to a change in the dimensional distribution does not involve any increase in the distance in space. All quasars with redshifts of 2.326 and above are therefore at approximately the same spatial distance. This is the explanation of the seeming inconsistency involved in the observed fact that the brightness of the quasars with extremely high redshifts is comparable to that of the quasars in the redshift range around 2.00.

The stellar explosions that initiate the chain of events leading to the ejection of a quasar from the galaxy of origin reduce a large part of the matter of the exploding stars to kinetic and radiant energy. The remainder of the stellar mass is broken down into gas and dust particles. A portion of this dispersed material penetrates into the sections of the galaxy surrounding the region where the explosions take place, and when one such section is ejected as a quasar it contains some of this fast-moving dust and gas. Since the maximum

particle speeds are above those required for escape from the gravitational attraction of the individual stars, this material gradually makes its way outward, and eventually assumes the form of a cloud of dust and gas around the quasar—an atmosphere, we might call it. The radiation from the constituent stars of the quasar passes through this atmosphere, giving rise to absorption lines in the spectrum. The dispersed material surrounding a relatively young quasar is moving with the main body, and the absorption redshift is therefore approximately equal to the emission value.

The constituent stars grow older during the time that the quasar moves outward, and in the later stages of its existence some of these stars reach their destructive limits. These stars then explode as Type II supernovae in the manner previously described. As we have seen, such explosions eject one cloud of explosion products outward into space, and another similar cloud outward into time (equivalent to inward in space). When the explosion speed of the products ejected into time is superimposed on the speed of the quasar, which is already near the sector boundary, these products pass into the cosmic sector and disappear.

The outward motion of the explosion products ejected into space is equivalent to an inward motion in time. It therefore opposes the motion of the quasar, which is outward in time. If this inward motion could be observed independently it would produce a blueshift, as it is directed toward our location, rather than away from it. But since this motion occurs only in combination with the outward motion of the quasar its effect is to reduce the net outward speed and the magnitude of the redshift. Thus the slower-moving products of the secondary explosions move outward in the same manner as the quasar itself, and their inverse speed components merely delay their arrival at the point where conversion to motion in time takes place.

A quasar in one of these later stages of its existence is thus surrounded not only by an atmosphere moving with the quasar itself, but also by one or more independent clouds of particles moving away from the quasar in time (equivalent space). Each cloud of particles gives rise to an absorption redshift differing from the emission value by the magnitude of the inward speed imparted to these particles by the internal explosions. As pointed out in the discussion of the nature of scalar motion, any object that is moving in this manner may also acquire a vectorial motion. The vectorial speeds of the quasar components are small compared to their scalar speeds, but they may be large enough to cause some measurable deviations from the scalar values. In some cases this results in an absorption redshift slightly above the emission value. Because of the inward direction of the speeds resulting from the secondary explosions, all other absorption redshifts differing from the emission values are below the emission redshifts.

The speed imparted to the ejected particles has no appreciable effect on the recession, z . Like the increase in effective speed beyond the 2.326 level,

therefore, the change has to take place in the redshift factor, and it is limited to steps of 0.125, the minimum change in that factor. The possible absorption redshifts of a quasar thus exist in a regular series of values differing by $0.125 z^{1/2}$. Inasmuch as the value of z for the quasars reaches a maximum at 0.326, and all variability of the redshifts above 2.326 results from changes in the redshift factor, the theoretical values of the possible absorption redshifts above the 2.326 level are identical for all quasars, and coincide with the possible values of the emission redshifts.

Since most of the observable high redshift quasars are relatively old, their constituents are in a state of violent activity. This vectorial motion introduces a margin of uncertainty into the measurements of the emission redshift, and makes it impossible to demonstrate an exact correlation between theory and observation. The situation is more favorable in the case of the absorption redshifts because the measured absorption values for each of the more active quasars constitute a series, and a series relation can be demonstrated even where there is a substantial degree of uncertainty in the individual values.

This is illustrated in Table VIII, which compares the measured absorption redshifts of three of the high redshift quasars with the theoretically possible values. The correlation is impressive in the case of the quasar OH 471. With the exception of the value at redshift factor 3.75, all of the observed redshifts are within 0.01 of the theoretical values, and only one of the first seven theoretically possible absorption redshifts is missing from the observed list. In this instance the agreement between the values is close enough to be conclusive in itself. The differences between the theoretical and measured values for the other quasars in the table are typically about 0.02. Since the interval between successive theoretical redshifts is only 0.07, the 0.02 discrepancy is uncomfortably large, when each correlation is considered individually. But when all of the values for the quasar 4C 05.34 are compared, as a series, with the series of theoretical values, the two series clearly agree. The data for the third quasar in the table are more scattered, but the general trend of the values is similar.

Because the explosion redshift is the product of the redshift factor and $z^{1/2}$, each quasar with a recession speed (z) less than 0.326 has its own set of possible absorption redshifts, the successive members of each series differing by $0.125 z^{1/2}$. One of the largest systems in this range that has been studied thus far is that of the quasar 0237-233, the observed redshifts of which are compared with the theoretical values in Table IX. An asterisk indicates an average of two or more measured values.

Similar data for the quasars PHL 938 and 0424-131 are included in the tabulation. The theoretical absorption redshifts in this table are calculated from the observed emission redshifts (indicated by the symbol E_m) and are therefore subject to any errors that may have been made in the determination of the emission shifts. Apparently no major errors are involved, as the

TABLE VIII
ABSORPTION REDSHIFTS

Redshift Factor	Calc.	OH 471	4C 05.34	0830+115
5.25	3.33	3.34		
5.125	3.25	3.25		
5.00	3.18	3.19		
4.875	3.11	3.12		
4.75	3.04			
4.625	2.97	2.97		2.95
4.50	2.90	2.91	2.88	2.91
4.375	2.83		2.81	
4.25	2.75		2.77	2.77
4.125	2.68			
4.00	2.61		2.59	
3.875	2.54			
3.75	2.47	2.49	2.47	
3.625	2.40			
3.50	2.33			
3.375	2.25			2.22
3.25	2.18		2.18	
3.125	2.11			2.13

correlations between theory and observation are just as close as in Table VIII, where the theoretical absorption values are independent of any measurements.

In general, the negative component added to the particle speed by the secondary (internal) explosions is limited to about 1.50, but in some cases absorption redshifts 2.00 or more below the emission values have been reported. The significance of these very low values is still uncertain. Since the speed of the secondary explosion products is independent of that of the main body of the quasar, the dimensional distribution of this speed may be different from that of the speed of the quasar, and it is not unlikely that the low redshifts are due to combinations of explosion speed and change in the dimensional distribution. There is no currently available information against which this hypothesis can be checked, and the very low values have therefore been omitted from the tabulations.

Absorption redshifts have been identified in many quasar spectra, but the number of rich systems thus far located is relatively small. This is significant because the length of the absorption series is an indication of the extent to which disintegration of the quasar by destruction of its constituent stars has

TABLE IX
ABSORPTION REDSHIFTS

Factor	0237-223		PHL 938		0424-131	
	Calc.	Obs.	Calc.	Obs.	Calc.	Obs.
3.5	2.223	2.223Em	1.955	1.955Em	2.165	2.165Em
3.375	2.154	2.176				
3.25						
3.125	2.019	2.013				
3.0	1.948	1.955				
2.875						
2.75			1.588	1.592	1.763	1.768
2.625			1.696	1.715		
2.5	1.674	1.673*	1.465	1.463		
2.375	1.605	1.623*			1.561	1.579
2.25	1.536	1.526*			1.494	1.532
2.125			1.281	1.261		
2.00	1.399	1.364	1.220	1.227*		

taken place. Some quasars are already so badly disintegrated that they will probably never reach the point at which they convert to motion in time while they are still in the form of aggregates of stars. No doubt the number of these rich systems will be increased to some extent as more observations are made, but it seems evident, on the basis of the information now available, that they are a minority. Most of the larger quasars apparently convert to motion in time while the quasar structure is still practically intact.

The reason for the difference in behavior between these two classes of quasars is that two different processes are involved. Demise of the quasar within the spatial reference system is due to *age*. When the great majority of the stars that constitute the fast-moving galactic fragment that we call a quasar have reached the age limit of matter, and have individually disintegrated, the quasar ceases to exist as such, irrespective of where it may happen to be at that time. On the other hand, the disappearance of the quasar at the sector boundary, the point at which it begins moving in actual time, is a matter of speed, and consequently of *distance*. A quasar that originates at a distant location begins moving outward in time away from our location when the net total explosion speed relative to our galaxy, including the component due to our distance from the point of origin of the quasar, reaches the two-unit level. However, the transition from gravitation in space to gravitation in time does not take place until the explosion speed alone is two units. A quasar that has

left our field of view by reason of the sector limit is still observable from other locations closer to the point of origin until the gravitational transition occurs.

Ordinarily a long period of time is required to bring a significant number of the stars of a quasar up to the age limit that initiates explosive activity. Consequently, absorption redshifts differing from the emission values do not usually appear until a quasar reaches the redshift range above 1.75. From the nature of the process, however, it is clear that there will be exceptions to this general rule. The outer, more recently accreted, portions of the galaxy of origin are composed mainly of younger stars, but special conditions during the growth of the galaxy, such as a relatively recent consolidation with another large aggregate, may have introduced a concentration of older stars into the portion of the structure of the galaxy that was thrown off in the explosion. These older stars then reach their age limits and initiate the chain of events that produces the absorption redshifts at a stage of the quasar life that is earlier than usual. It is unlikely, however, that the number of old stars included in any newly ejected quasar is ever large enough to generate the amount of internal activity that would lead to an *extensive* absorption redshift system.

In the higher redshift range a new factor enters into the situation and accelerates the trend toward more absorption redshifts. A substantial amount of explosive activity is normally required in order to impart the increments of speed to the dust and gas components of the quasar that are necessary for the production of absorption systems. Beyond an explosion speed of two units, however, this limitation no longer applies. Here the diffuse components are subject to the environmental influences of the cosmic sector, which tend to reduce the inverse speed (equivalent to increasing the speed), thus producing additional absorption redshifts in the normal course of quasar evolution, without the necessity of further generation of energy in the quasars. Above this level, therefore, "the quasars . . . all show strong absorption lines." Strittmatter and Williams, from whose review of the subject the foregoing statement was taken, go on to say that

It is as if there were a threshold for the presence of absorbing material at emission redshifts of about 2.2.²³⁴

This empirical conclusion agrees with our theoretical finding that there is a definite sector boundary at redshift 2.326.

In addition to the absorption redshifts in the optical spectra, to which the foregoing discussion refers, some absorption redshifts have also been found at radio frequencies. The first such discovery, in the radiation from the quasar 3C 286, generated considerable interest because of a rather widespread impression that the radio absorption requires an explanation different from that applicable to absorption at optical frequencies. The original investigators concluded that the radio redshift is due to absorption by neutral hydrogen in

some galaxy lying between us and the quasar. Since the absorption redshift is about 80 percent of the emission redshift in this case, they regarded the observations as evidence in favor of the cosmological redshift hypothesis. On the basis of the theory of the universe of motion, the radio observations do not introduce anything new. The absorption process that operates in the quasars is applicable to all radiation frequencies, and the existence of an absorption redshift at a radio frequency has the same significance as the existence of an absorption redshift at an optical frequency. The measured radio redshifts of 3C 286 in emission and absorption are 0.85 and 0.69 respectively. At redshift factor 2.75, the theoretical absorption redshift corresponding to the emission value of 0.85 is 0.68.

CHAPTER 24

Evolution of Quasars

On the basis of the theoretical findings outlined in the preceding pages, the isotopic readjustment activity in the ejected fragment of the exploding galaxy that constitutes the quasar is at a high level in the initial stage immediately following the explosion. The radio emission is correspondingly strong. As time goes on the internal activity gradually subsides, and eventually radio emission ceases, or at least declines to unobservable levels. This radio-quiet stage comes to an end when the constituent stars of the quasar begin to arrive at their age limits in substantial numbers, and the explosions of these stars renew the isotopic adjustment activity. Radio emission then resumes.

The most distant of the quasars that have been identified belong to the class of radio-emitting quasars that follows the radio-quiet stage, Class II, as we will call it. Below a redshift of about 1.00, however, both classes are present, and in order to distinguish between the two it is necessary to identify some properties in which there is a systematic difference between the values applicable to the two classes of objects. Ultimately it should be possible to establish such lines of demarcation from pure theory, but for the present we will have to rely on semi-empirical distinctions. We can expect, for instance, that the evolution of the quasars from the early to the later stages will be accompanied by color changes. Identification of certain specific color characteristics that vary systematically with the quasar age will be sufficient for present purposes. A full explanation of the reason for the observed differences can be left for future investigation.

As noted earlier, the colors of astronomical objects are customarily expressed in terms of *color indexes*. At this time we will be concerned mainly with the U-B index, which is the difference between the magnitude measured through an ultraviolet filter and that measured through a blue filter. Later we will introduce the B-V index, the color index that we used in dealing with the radiation from the stars, which is the difference between the blue magnitude and the visual, or photographic, magnitude, obtained through a yellow filter. The empirical data indicate that in the quasars the U-B index is a rough indication of *temperature*. In main sequence stars the U-B index is positive; that is, more energy is received in the blue range. (It should be remembered that the magnitude scale is inverse.) This index is also positive in ordinary

galaxies, which are composed mainly of such stars. Because of the inversion that takes place when the speed of light is exceeded, the theoretical development indicates that in the quasars the color trend should be reversed, and the U-B index should be negative, indicating that more energy is received in the ultraviolet range. All of the U-B values quoted in this chapter are negative, and should be so understood.

The number of quasars on which fairly complete measurements are now available runs into the hundreds, and it will not be feasible to analyze all of these data in a work of a broad general nature. Our examination will therefore have to be limited to a representative sample. The group of quasars studied in *Quasars and Pulsars* was one for which the redshifts and color data were tabulated by M. and G. Burbidge in their book *Quasi-Stellar Objects*.²⁵⁰ It includes all of the quasars for which these data were available up to the time of publication, and is therefore free from selection effects, except insofar as it favors the objects that are the most accessible to observation. No significant modifications of the conclusions drawn from the original study have been necessary, and the following discussion will be taken from the earlier publication, with the addition of the results from some subsequent studies, mainly of the same group of objects, those listed in the Burbidge table 3.1.

The color indexes are determined primarily by the internal activity (the temperatures, together with the isotopic adjustments and their consequences) within the quasars. The pattern of change during the evolution of the quasars should therefore be capable of being evaluated on a purely theoretical basis. Such a project is beyond the scope of this work, but the general nature of the changes that take place in the indexes, as empirically determined, shows a definite qualitative correlation with the changes that theoretically occur in the generation and dissipation of energy. We can therefore set up some defining criteria for these quasar classes on a semi-empirical basis.

In the original study reported in *Quasars and Pulsars* the division was established at $U-B = 0.60$ and an absolute ratio flux (R.F.) of 6.0 measured at 178 MHz. All quasars with U-B values less than 0.60 were placed in Class I. Those having higher U-B, but R.F. below 6.0 were found to be continuous with the low U-B quasars in their properties, and were also assigned to class I. The high R.F.-high U-B quasars form a discontinuous group with quite different properties, and were identified as members of Class II.

Fig. 26 shows the relation between U-B and R.F. for those of the Class I quasars listed in the Burbidge Table 3.1 for which the necessary information is available. This diagram is essentially equivalent to the astronomers' "two-color diagram," except that the scales have been inverted because we are here dealing with phenomena of an inverse region, the region of intermediate speeds. We will use both colors later, with and without the radio flux. It would be convenient to define the quasar classes on the basis of color alone, and some progress in this direction will be made when the B-V index is

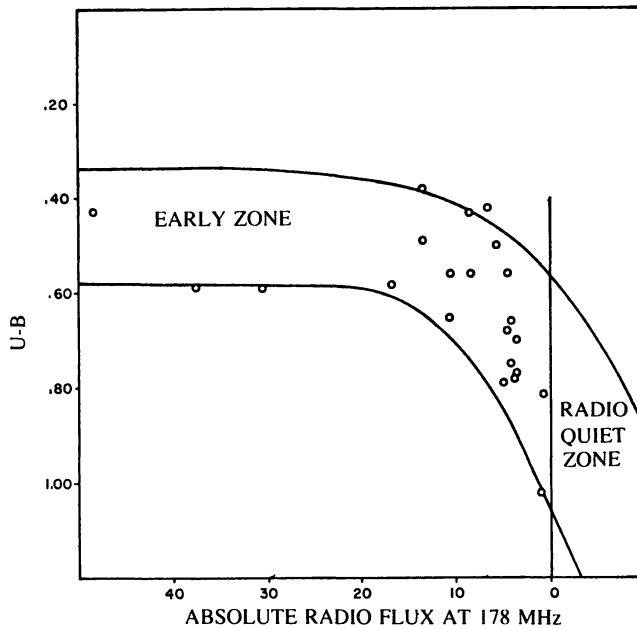


Fig. 26 Class I Quasars

introduced later in this chapter, but color criteria that are capable of defining these classes in a manner that is free from ambiguity have not yet been developed.

When a quasar is first ejected from the galaxy of origin, its constituents are in a state of violent activity, and its radio flux is abnormally high. Only one of the quasars included in the group under consideration is still in this very early stage. This is 3C 196, which has $U-B = 0.43$ and absolute R.F. = 48.3. Its redshift is 0.871, of which 0.054 is the normal recession component. In this work the symbol z is used to represent the normal recession redshift only. The explosion-generated component, usually $3.5 z^{1/2}$, but subject to modification of the redshift factor 3.5, will hereafter be designated as q , and the total quasar redshift will be represented by the symbol Z . We then have the relation $Z = z + q$. We will also want to recognize that the redshift component q represents an equivalent distance (that is, a distance in the spatial equivalent of time), and we will call this the *quasar distance*. The quasar distance of 3C 196 is 0.817, which makes it one of the most distant Class I objects in the Burbidge table.

After the initial spurt of activity in a quasar dies down to some extent, it can be found in the zone designated "early" in the upper left of fig. 26. As it ages, and its activity drops still further, it moves to the right (toward lower

R.F.) and downward (toward higher U-B). Ultimately it passes the zero radio flux line and enters the radio quiet stage.

The tabulated data show that at the time they were compiled no Class I quasars had been detected at quasar distances greater than 0.900, and no objects of this class that are old enough to have U-B indexes above 0.60 had been found beyond a quasar distance of approximately 0.700. The significance of these figures lies in the fact that the high R.F. quasars with U-B indexes above 0.60 (Class II) *can* be detected beyond a quasar distance of 0.700. Indeed, we can follow them all the way out to the ultimate limit at 2.00. It is clear, then, that these more distant objects are *not* in the same condition in which they were when they were originally ejected. In order to move into the range in which they are now observed these distant Class II quasars must have undergone some process that released a substantial amount of additional radiant energy at radio wavelengths.

We have already deduced that such a process exists. Because of the long period of time during which a quasar is traveling outward before it arrives at the point where it converts to the cosmic status, some of its constituent stars reach the age that corresponds to the destructive limit. Secondary Type II explosions then occur. Obviously, this is just the kind of a process that is required in order to explain the emergence of a second class of radio-emitting quasars at distances beyond the observational limit of Class I objects. It should be noted that a secondary series of explosions is a natural sequel to the original explosion of the giant galaxy. That original explosion was initiated as soon as enough of the oldest stars in the galaxy reached their age limits. The stars in the ejected fragment, the quasar, were younger, but many of them were also well advanced in age, and after another long period of time some of these necessarily arrived at the age limit.

The original stellar explosions occurred outside the portion of the galaxy that was ejected as a quasar; that is, they took place in the interior of the giant galaxy of which the quasar is a fragment. Thus the radio emission from a Class I quasar is mainly a result of the extremely violent ejection. On the other hand, the secondary explosions occur in the body of the quasar itself, and the emission from the Class II quasars comes directly from the exploding stars. This difference in origin is reflected in the relation between the U-B index and the radio flux, enabling us to utilize this relation as a means of distinguishing between the two classes. Fig. 27 is a plot of U-B vs. R.F. for the Class II quasars in the Burbidge table. As can be seen, the points representing these objects fall entirely outside the section of the diagram occupied by the quasars of Class I. There is no indication in this diagram that the Class II quasars follow any kind of an evolutionary pattern, but we will give this question some consideration later.

The quasar 3C 273 is of particular interest. This is definitely a Class II quasar, according to the criteria that have been defined, but its distance is far

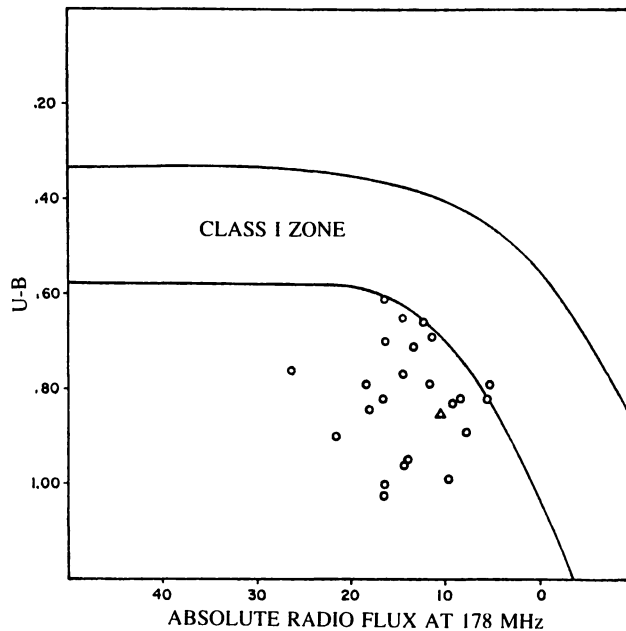


Fig. 27 Class II Quasars

out of line with that of all other known objects of its class. No other Class II quasar in the group we are now examining has a quasar distance less than 0.315, whereas the quasar distance of 3C 273 is only 0.156. Ordinarily we can consider that when we measure the redshift of an object we are also determining its maximum possible age, as this age cannot be greater than the time required to move out to its present position. On this basis, we would interpret the low redshift of 3C 273 as an indication that it is an unusually young Class II quasar. This could be true. It was pointed out in the earlier discussion that the secondary explosions may occur relatively soon after the original ejection, inasmuch as some of the stars in the galactic fragment that is ejected as a quasar may already be near the age limit at the time of the explosion. Very young Class II quasars are therefore definitely possible.

But 3C 273 is not necessarily young. It may be very much older than the 0.156 quasar distance would indicate, as the general relation between redshift and age does not hold good at very short distances where the magnitude of the possible random motion is comparable to that of the recession. Two galaxies that are separated by a distance in the neighborhood of their mutual gravitational limit can maintain this separation almost indefinitely, and the width of the zone in which the relative motion can be little or none at all is increased considerably if there is random motion with an inward component.

Hence 3C 273 may have spent a long time near its present position relative to our Milky Way galaxy, and may be just as old as the quasars at distances around 0.300.

The observational information currently available is not adequate to enable making a definite decision between these alternatives, but where we have a choice between attributing an unusual situation to a chance coincidence that has resulted in an object of a relatively rare type being located very close to us, or attributing it to a unique characteristic which we know that the object in question does possess—its proximity—the latter is clearly entitled to the preference pending the accumulation of further evidence. We therefore conclude tentatively that 3C 273 is at least as old as the Class II quasars in the vicinity of quasar distance 0.300.

The position of 3C 273 in Fig. 27 is indicated by a triangle. As can be seen from the diagram, this quasar is among the weaker radio emitters in its class (although we receive a large radio flux from it because it is so close) but, so far as its properties are concerned, it is not abnormal, or even a borderline case. Its proximity therefore provides a unique opportunity to observe at relatively close range a member of a class of objects that can otherwise be found only at great distances.

Further experience in application of the U-B criterion to distinguishing the quasar classes has indicated that it is somewhat ambiguous in the region of high U-B values and low radio emission. An adjustment of the selection criteria has therefore been made by introducing the B-V index. In this region of high (more negative) U-B values, the location where the original criteria proved to be deficient, there are some quasars with low radio emission that have absorption redshifts. As brought out in Chapter 23, this is an indication of advanced age, which places them in Class II. These objects have B-V indexes in the upper portion of the full range of values, whereas the indexes of the relatively low redshift quasars in this region, which can be expected to be Class I objects, fall in the lower portion of this range. We may tentatively establish a dividing line at $B-V = +0.15$, and instead of assigning all quasars with low radio emission and high U-B indexes to Class I, we will put those members of this group that have B-V indexes above 0.15 in Class II. Until such time as we are able to base the selection criteria on a theoretical rather than an empirical foundation we can hardly expect precision, but this change to a two-color basis undoubtedly brings us closer to the correct line of demarcation. The revised color index pattern for quasars at distances below 1.00 is shown in Table X. Included in this revision is a change in the U-B classification boundary from 0.60 to 0.59.

The identification of the evolutionary status of the quasars by color and radio flux (or distance) enables utilizing the data with respect to the other observable features of the quasars to verify the theoretical conclusions as to the differences

Table X

QUASAR CLASSES

Class	U-B (negative values)	B-V (positive values)	R.F.
I early	Below 0.59		Below 6.0
I late	Above 0.59	Below 0.15	Below 6.0
II early	Above 0.59	Above 0.15	Below 6.0
II late	Above 0.59		Above 6.0

between the classes, and between the earlier and later members of each class, something that we could not do if these features entered into the criteria by which the classes are identified. For instance, we have deduced from theoretical premises that the absorption which gives rise to the absorption redshift lines in the quasar spectra takes place in clouds of material accelerated to high inverse speeds by internal supernova explosions in these objects. No absorption occurs, therefore, until these explosions occur on a sufficiently large scale. As noted earlier, this point is not reached until the quasar is somewhere in the radio quiet stage, while it is evident from the nature of the requirements for the production of multiple absorption redshift systems that multiplicity will not appear until a still higher level of activity is reached. On the basis of this evolutionary pattern, we can deduce the following rules regarding the occurrence of absorption redshifts:

1. Class I quasars have no absorption redshifts.
2. Absorption redshifts approximating the emission values are possible throughout most of the radio-quiet region, and in the Class II radio-emitting quasars.
3. Absorption redshifts differing from the emission values by more than the amount that can be attributed to random motion are possible only in Class II quasars and relatively old radio-quiet quasars.

A check of 29 quasars with absorption redshifts listed in a 1972 compilation by Burbidge and O'Dell²⁵¹ shows that all of these objects are in compliance with the foregoing rules when the assignment to classifications is made on the basis that has been specified. Here, then, we have a significant confirmation of the theoretical description of the conditions under which the absorption redshifts occur.

It was noted earlier that there would be a further advantage in being able to distinguish the two classes of radio-emitting quasars by color alone without

having to consider the magnitude of the radio emission. As indicated in Fig. 28, which is a combination of Figs. 26 and 27, with the B-V index substituted for the radio flux, this is *almost* accomplished by the resulting two-color

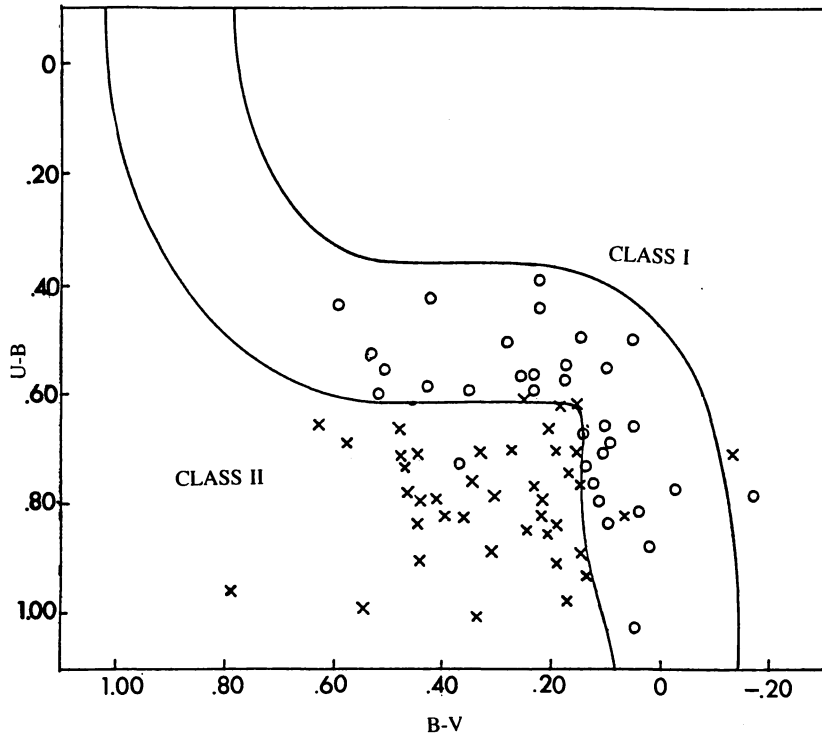


Fig. 28

diagram. There is some uncertainty along the dividing line at the 0.15 B-V index, and there is one deviant object, 3C 280.1, which has a B-V index of -0.13 , although its redshift far exceeds the Class I limit. Otherwise, the two classes of quasars are located in separate portions of the diagram, as in Figs. 26 and 27. The deviation of 3C 280.1 from the normal range of B-V indexes is probably due to the same cause as the deviation of this quasar from the normal radio pattern, as shown in Table VII, Chapter 22.

Thus far we have been looking at the color indexes and radio flux as means of differentiating between the various classes of quasars. Now we will want to examine the significance of the *changes* that take place in these quantities

during the evolution of the quasars. The magnitudes of all of the properties that we are now considering undergo evolutionary changes. Thus any one of them can serve as an indicator of quasar age. Obviously, however, the properties that change most uniformly with time are the best indicators, and on this basis we may consider the radio flux in Figs. 26 and 27 as indicating the quasar age. These diagrams thus show how the quasar temperature (U-B) varies with age (R.F.). We now find that the B-V index follows approximately the same trend as the radio flux, which means that this index is also an indicator of age, and can be substituted for the radio flux in the diagrams.

The U-B indexes of the earliest Class I quasars fall in the range from about -0.40 to -0.59 . As these quasars age, the index moves almost horizontally to the vicinity of $B-V = +0.15$, and then turns sharply downward on the diagram (toward more negative values) as the radio-quiet zone is approached. The B-V index of the earliest Class I quasar in the sample under examination is 0.60 . This index decreases as the quasar ages, reaching positive or negative values near zero at the radio-quiet boundary. The U-B indexes of the Class II quasars range from -0.59 to about -1.00 , with no apparent systematic variation. The corresponding B-V indexes for most of the Class II quasars with relatively low redshifts (below 0.750) are in the neighborhood of $+0.20$. Beyond 0.750 the index increases, and the maximum values around 0.60 or 0.70 are reached near the 1.00 distance. This peak is followed by a decrease to a level at which most values are comparable to those of the early members of this class.

While the actual mathematical relations between the internal activity of the quasars and their color indexes have not yet been examined in the light of the Reciprocal System of theory, the evolutionary pattern followed by the values of these indexes, as described in the preceding paragraph, shows a definite qualitative correlation with the changes that theoretically take place in the generation and dissipation of energy. In Class I the initial energy is high, but it gradually subsides, as no continuing source of large amounts of energy is available to these objects. Both color indexes respond to this change by moving toward more negative values as the quasars age. In Class II the initial activity develops slowly, as it originates from many small events rather than from one big event, and the Class II quasars do not reach the high temperatures that are characteristic of the early Class I objects.

The lowest (least negative) U-B values in Class II are in the neighborhood of the dividing line at -0.59 , and the full range extends to about -1.00 . The five radio-quiet quasars in the Burbidge tables for which color indexes are given have U-B indexes in the range from -0.78 to -0.90 . It follows that only those quasars with U-B indexes between about -0.75 and the -0.59 limit can be regarded as having a temperature increment due to the secondary explosions, and even in this group, which includes about 40 percent of the total number of Class II quasars, the increment is not large. There is no systematic

change with age in the U-B indexes of these Class II objects. This is understandable on the basis of the conclusion that this index is related to the temperature, as the temperature variations in Class II are due to events that can take place at any time during the Class II stage of quasar existence.

The pattern of values of the B-V index that was previously described indicates that the processes which determine the magnitude of this index are increasing in strength throughout the Class II stage. The specific nature of these processes has not yet been established but obviously they are aspects of the motion of the quasar constituents, and for the present we can use the very general term "internal activity" in referring to them. As the quasar distance increases, the average age of the observable quasars rises, inasmuch as the age range is continually being extended. This increase in age is accompanied by a corresponding increase in internal activity, and, below a quasar distance of 1.00, by an increase in the B-V index. As already mentioned, this index decreases beyond 1.00 distance, probably because of a decrease in the intensity of the internal activity due to the dimensional distribution of the various properties of the quasars that occurs in this distance range.

Inasmuch as the concentration of energetic material in the interior of the giant spheroidal galaxy from which a quasar was ejected was built up gradually over a long period of time, the isotopic adjustments taking place in this material at the time of the ejection are mainly of the long-lived types. Thus the decrease in radio emission and "internal activity" in the early quasar stage should be quite gradual. The temperature, on the other hand, is raised to a very high level by the explosion, and can be expected to take a very sharp initial drop. We would normally expect, therefore, that the early Class I stage would begin with an exponential decrease in the U-B index (temperature) as a function of the B-V index (age). But this is not at all what Fig. 28 indicates. There is little, if any, decrease in the U-B index in the early Class I stage. Let us see, then, if we can account for the observed situation.

One obvious possibility is that the rapid decrease in the temperature *precedes* the earliest quasar stage. On this basis, the temperature of the newly ejected galactic fragment drops rapidly to a certain level, which we can identify as that of the earliest Class I quasars ($U-B = -0.40 \pm 0.10$), remains at this level to about $B-V = +0.15$, and then resumes a rapid drop to a minimum level near -1.00 . On first consideration, this may appear to be another of the combinations of ten percent fact and ninety percent speculation that are so common in the relatively uncharted areas of physics and astronomy. However, there actually is in existence a class of objects, not currently identified as quasars, that occupies the position in this U-B vs B-V diagram in which the theoretical very early group of quasars would fall if the foregoing explanation of the nature of the early evolutionary pattern is correct.

Like the quasars, these objects are abnormally small, very powerful extragalactic bodies. Their existence was first recognized when the radiation

from the “variable star” BL Lacertae was found to have some very peculiar properties. Several dozen similar objects have since been located. Because their properties are in some respects unique, they have been placed in a new astronomical category. However, no consensus has been reached on a name for these objects. As matters now stand, we have a choice between BL Lac objects, lacertids, and lacertae. The latter term will be used in the discussion that follows.

Most of the differences between the lacertae and the quasars are merely matters of degree, as would be expected if the lacertae are very young quasars. For instance, the evidence of association with giant galaxies is much stronger than in the case of the quasars. The results of a recent (1981) investigation in which both lacertae and quasars were examined are described by Joseph S. Miller as follows:

We conclude that the data are consistent with all BL Lac objects being located in luminous giant elliptical galaxies . . . No galaxy components were definitely detected for any of the QSOs in this study.²⁵²

These observations are consistent with the status of the lacertae as pre-quasar explosion products. The observed galaxies are the giants—spheroidal, in the terminology of this work—from which these objects were ejected. The parent galaxies are more likely to be observed while the explosion products are still in the lacertae stage immediately following ejection because these products have not yet had time to travel very far. By the time the quasar stage is reached the ejected fragment has moved farther away from the galaxy of origin, and the association between the two is not necessarily evident.

All known lacertae are radio sources, whereas many, perhaps most, quasars are radio quiet. Here again, the difference is accounted for if we accept the conclusion that the lacertae are the initial products of the galactic explosions; that is, they are in the violent post-ejection stage. This conclusion is supported by the observation that “The BL Lac type objects appear to be very closely related to violently variable QSO’s like 3C 279 and 3C 345 (two quasars of Early Class I).”²⁵³ The reason for the lack of radio-quiet lacertae is then evident. The violent internal activity that produces the radiation at radio frequencies continues throughout both the lacertae and Early Class I stages.

It has been found that the bright lacertae are not associated with extended radio sources,²⁵⁴ whereas most quasars of the early classes do show such an association. Here, again, extreme youth is the explanation. The extended sources have simply not had time to develop.

The radiation from the lacertae includes optical, radio, and infrared components, all of which are to be expected from young explosion products moving at upper range speeds. No x-ray radiation has been detected. This, too, is consistent with the theoretical evolutionary status of the lacertae. There

are no x-rays in very young explosion products, as we saw earlier in the case of the supernovae. X-rays are emitted by objects that lose energy after having been accelerated to upper range speed levels. By the time the ejected fragment reaches the quasar stage, some loss of energy has taken place, and production of x-rays has begun.

A clear picture of the relation between lacertae and quasars is provided by the respective colors. To illustrate this point, the colors of a representative group of lacertae²⁵⁴ have been added to Fig. 28, and the enlarged diagram is shown

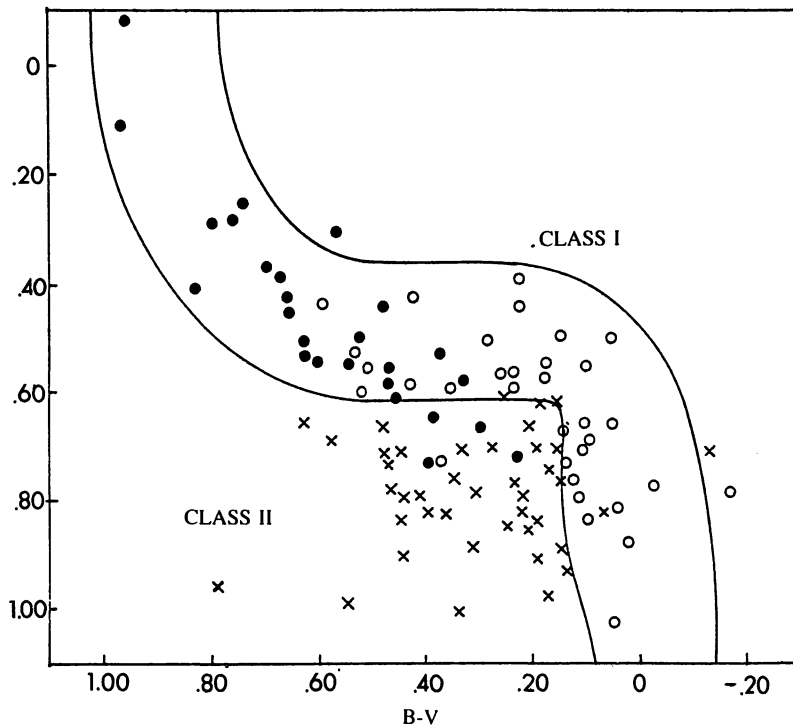


Fig. 29

in Fig. 29. Quite clearly, the positions of the lacertae in this two-color diagram are fully consistent with the theoretical conclusion that these objects are the initial products of the galactic explosions, and precede the early Class I quasars in the evolutionary development of the ejecta from the explosions. Except for a few objects that have penetrated into the Class II region of the diagram, the

evolutionary path of the lacertae joins that of the Class I quasars in a smooth transition, and the combined path follows the pattern that, as explained earlier, we would expect the galactic explosion products to follow in their early stages, on the basis of the theory that we have developed.

One more of the distinctive characteristics of the lacertae remains to be examined.

The most intriguing difference between quasars and lacertae is that the quasars have strong emission lines in their spectra that the lacertae lack. The reason for this is not yet understood.²⁵⁵ (Disney and Veron)

This, too, is readily explained on the basis of the theoretical description of the immediate post-ejection conditions. The principle that plays the most important role in this situation has been encountered repeatedly in connection with other phenomena discussed in the preceding pages, but it is one of those items that is so foreign to existing physical thought that it may be a source of conceptual difficulty for many readers. A more detailed discussion is therefore appropriate at this point, where the relevant observational evidence is more extensive than in the applications considered earlier.

For reasons already specified, the radioactivity and the accompanying emission of radiation at radio frequencies decline slowly throughout the Class I quasar stages. This decline is illustrated in Fig. 30. Here the absolute radio emissions are plotted against the U-B color indexes (indicative of the temperature) in steps 0.02 of the index. This procedure results in some values that are averages of two or three individual emissions, thereby smoothing the resulting curve to some extent. The average values are indicated by the circled points. Those not so identified are single values. As might be expected from the nature of the radio emission process, there are a few widely divergent values, but the general trend is clearly represented by a line such as that in the diagram, which conforms to the theoretical expectation.

The optical situation is more complicated because the stellar component speeds that are produced by acquisition of a part of the explosion energy are much lower than those of the gas and dust particles that supplied the original explosion energy. These stellar components therefore return to the speed range below unity during the evolution of the Class I quasars. The effect on the optical emission is shown in Fig. 31, which is similar to Fig. 30, with the absolute optical luminosities substituted for the radio emissions. (The methods of calculating the absolute values of both the optical and the radio emissions will be explained in Chapter 25.) Here we see that the luminosity remains nearly constant in the initial range, up to about $U-B = -0.50$. It then begins a rapid rise to a point in the neighborhood of -0.59 . At this point the emission drops by one half. During the late Class I stage, which follows, there is a moderately fast decrease to a level below -0.05 at the point of entry into the

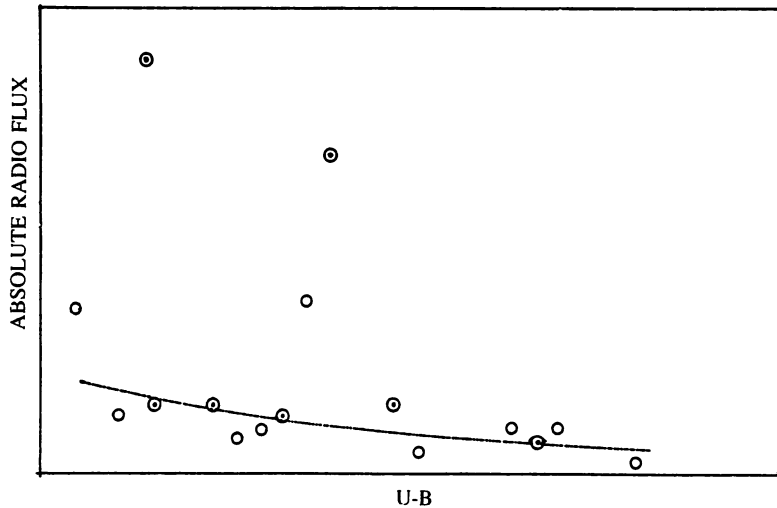


Fig. 30
Radio Emission - Class I Quasars

radio-quiet zone.

Since the stellar component speeds that are primarily responsible for the magnitude of the optical luminosity are subject to the same conditions that apply to the radio emission; that is, a gradual decay of the effects of the explosive ejection, the peak in the luminosity curve is somewhat surprising on first consideration. But, in fact, two different processes are involved. The isotopic adjustments that produce the radio emissions decrease gradually in intensity as more and more of them are completed. The optical emission is a function of the temperature; that is, of the speeds of the component particles. In the low speed range with which we are all familiar, the rate of emission of radiation increases with the component speeds (the temperature). It might seem that a still further increase in the speed would lead to a still greater rate of emission. But in the universe of motion directions are reversed at the unit level. Consequently, the same factors that cause the radiation to increase as the component speeds approach unity from lower levels also operate to increase the radiation as unit speed is approached from the higher levels. It follows that the radiation is at a maximum at the unit level, and decreases in both directions.

Applying this principle to the Class I quasars, we see that in the U-B range as far as -0.45 , the component speeds are nearly constant as they slowly

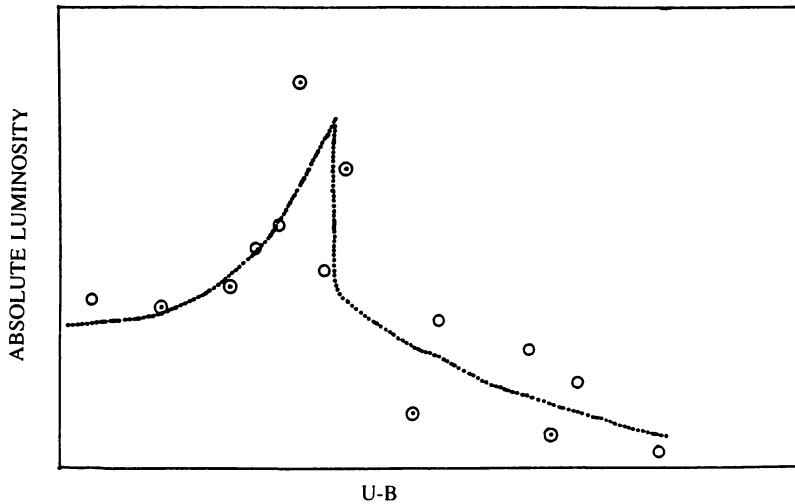


Fig. 31
Optical Emission - Class I Quasars

approach their maximum, and begin to decrease. Then the continued radiation losses with no comparable replacements accelerate the rate of decrease, reaching a maximum at the unit speed level. During this interval, while the speeds are still above unity, the *decrease* in speeds results in an *increase* in the rate of emission, reaching a peak at unit speed. As the diagram indicates, this peak coincides with the dividing line between classes I and II at $U-B = -0.59$. Beyond this point the speed drops into the range below unity, the range in which a decrease in temperature results in a decrease in the radiation. Like gravitation, the radiation process is operative in both of the active dimensions of the intermediate region. Half of the radiation is therefore eliminated at the unit speed level.

The lack of emission lines in the spectra of the lacertae is another result of this radiation pattern. The immediate post-explosion speeds of the gaseous component of the explosion products are very high, probably close to the two-unit level. As brought out in Chapter 15, this is the zero for motion in time, and the physical condition of an aggregate at this temperature is similar to that of an aggregate at a temperature near the zero of motion in space. The explanation of the lack of emission lines, then, is that the temperatures of the gases in the lacertae are *too high* to produce a line spectrum. At these extremely high temperatures (low inverse temperatures) the aggregate is in a

condition in time that is analogous to a solid structure in space, and like the latter it radiates with a continuous spectrum. This is another example of the same phenomenon that we noted in Chapter 16 in connection with the continuum emission from the Crab Nebula. By the time the quasar stage is reached, the temperature has dropped enough to give the aggregate the normal characteristics of a gas, including a line spectrum.

It was evident from the time of the earliest studies of the different classes of quasars, reported in *Quasars and Pulsars*, that the -0.59 value of the U-B index marks some kind of a physical division, and this was one of the criteria on which the classification of the quasars in that publication was set up. It can now be seen that the -0.59 U-B level corresponds to unit temperature. The fact that the evolutionary path of the Class I quasars (including the lacertae) contains a horizontal section, rather than decreasing somewhat uniformly from the initial to the final state, as might be expected where there is no source of replacement for the energy that is being lost by radiation, is explained by the transition from two-dimensional to one-dimensional motion. The energy of the second dimension of motion in the intermediate speed range is analogous to the heats of fusion and vaporization. When the change to one-dimensional motion takes place, the energy of motion in the other dimension becomes available to maintain the temperature, and the U-B index, at a constant level for a time before the decreasing trend is resumed.

Incorporation of the lacertae into the path of development now completes the evolutionary picture of the Class I explosion products from the time they are ejected from the galaxy of origin to their entry into the radio-quiet stage. Some of these objects may disappear during that stage, for reasons that will be explained in the next chapter. The remainder eventually undergo secondary explosions and attain the Class II status. There is no systematic relation between the temperature and age in Class II, because both the time at which the secondary explosions occur and their magnitude are subject to major variations. Each individual Class II quasar does, however, follow a course that eventually brings it to the point where it crosses the sector boundary and disappears.

There are many pitfalls in the way of anyone who attempts to follow a long chain of reasoning from broad general principles to specific details, and since this is an initial effort at applying the Reciprocal System of theory to the internal structural features of the quasars, it must be conceded that modification of some of the conclusions that have here been reached is likely to be necessary as observational knowledge continues to accumulate, and further advances in theoretical understanding are made in related areas. However, the general picture of the quasar structure and evolution derived from theory corresponds so closely with the information now at hand that there seems little reason to doubt its validity, particularly since that picture was developed easily and naturally from the same premises on which the earlier

conclusions regarding the origin and nature of the quasars were based.

It is especially significant that nothing *new* is required to explain either the existence or the properties of the quasars (including the lacertae). Of course, nothing new can be *put into* a purely deductive theory of this kind. Introduction of additional hypotheses or ad hoc assumptions of the kind normally employed in the adjustment of theories to fit new observations is excluded by the basic design of the theoretical system, which calls for deriving all conclusions from a single set of premises, and from these only. Some new principles and hitherto unknown phenomena are certain to be revealed by any new theoretical development of this magnitude, and many such discoveries have, in fact, been made in the course of the theoretical studies thus far undertaken. Such items as those utilized in the foregoing applications of the theory to the various aspects of the quasar situation—the status of all physical phenomena as more or less complex relations between space and time, the inversion of these relations at unit levels, the role of time as equivalent space, and the asymmetric transmission of physical effects across unit boundaries—are all new to science. But these are not peculiar to the quasars; they are *general* principles, immediate and direct consequences of the basic postulates, the kind of features that distinguish the universe of motion from the conventional universe of matter, and they were discovered and employed in a variety of applications decades before the quasar study was undertaken. All of the novel principles deduced from theory and utilized in this work were explicitly stated in the initial presentation of the Reciprocal System of theory in the first edition of this work, published in 1959, years before the quasars were discovered.

Furthermore, many of the consequences of these general principles, in the form of physical phenomena and relations, that are now seen to play important parts in explaining the origin and evolution of the quasars were likewise pointed out in detail in that 1959 publication, four years before Maarten Schmidt measured the redshift that ushered in the era of the quasar “mystery.” The status of stellar aggregates as structures in positional equilibrium, which permits the building up of internal pressures in the galaxies, and the ejection of fragments; the existence of two distinct divisions of the explosion products, ejected in opposite directions, one moving at normal speed and the other moving at a speed in excess of that of light; the reduction in the apparent spatial size of aggregates whose components move at upper range speeds; the generation of large amounts of radiation at radio wavelengths from the explosion products; and the eventual disappearance of the ultra high speed material; were all derived from theory and discussed in the published work, not only long before the discovery of the quasars, but years before any definite evidence of the galactic explosions that produce the quasars was found.

CHAPTER 25

THE QUASAR POPULATIONS

Now that we have identified the different classes of quasars, located them in the evolutionary course of development, and established criteria by which to distinguish one from another, it will be of interest to undertake what we may describe as a census, to get an idea as to the relative numbers of observable objects of the various classes, the factors that are responsible for the differences between these classes, and the effect of the evolutionary development on these various populations.

The list of known quasars is continually being extended, both by increasing the capability of the available instrumentation, and by more use of the existing equipment. A complete survey of the observable quasars is therefore impossible, as matters now stand. The best that we can do is to examine all those on which the necessary information was available up to some particular date. Under the circumstances there is no advantage to a very large sample. As the modern poll takers have demonstrated, a relatively small sample is adequate if it is actually representative. Rather than attempting to cover all of the quasars currently known, we will therefore review and update the results of a study made some years ago on the same group of quasars examined in the studies reported in the preceding chapter, those on which the relevant data were available in 1967.

The total number of quasars included in the 1967 tabulation by the Burbidges is 102, but color indexes were not available for 26 of these. The study was therefore confined to the other 76. Of these, 45, or sixty percent, were quasars of Class II. The spatial distribution of these objects is quite uniform out to a quasar distance of 1.00. On the two-dimensional basis that we have seen is applicable to the intermediate speed range, two independent distributions are possible in three-dimensional space. The existing quasars can be located either in the scalar dimension that is represented in the conventional spatial reference system, or in a dimension that is perpendicular to it. It follows that only half of the existing quasars are visible. There are 20 visible Class II quasars within a 1.00 radius (quasar distance) and 5 within 0.50. Both of these figures represent the same density: 20 quasars in a sphere of radius 1.00. We may therefore take this as the true density of Class II quasars observable in this distance range with the 3C instruments and procedures. The total number of

these quasars in equivalent space is twice this number, or 40 per spherical unit.

In the second quasar distance unit, from 1.00 to 2.00, there is another division between two perpendicular dimensions, which again reduces the visibility by one half, cutting the visible number to one quarter of the total. This means that where the actual quasar population remains unchanged, only 10 Class II quasars per spherical unit are visible in the quasar distance range from 1.00 to 2.00.

The number of Class II quasars calculated on the foregoing basis for spheres of successively larger radius is compared with the observed number in Table XI. There are a number of factors that cause some deviations from the theoretical distribution at very short distances, but the number of quasars involved is so small that the effect on the distribution pattern is negligible. Except for the normal amount of random fluctuation, the theoretical distribution is maintained throughout the quasar distance range up to about 1.80. Beyond this point there is a slow decrease as the normal limit at 2.00 (total redshift 2.326) is approached, and an increasing number of quasars become unobservable because they cross the boundary into the cosmic sector.

The relation of the number of visible quasars to the distance has been a matter of much interest to the astronomers because of the bearing that it has, or may have, on the question as to whether the density of matter in the universe is decreasing, as required by the Big Bang cosmological theory. This has been a hotly contested subject, but the present consensus, as reported by H. L. Shipman, is that "Quasars were far more abundant in the early universe than they are now."²⁵⁶ But this conclusion is based on the assumption that the quasars are distributed three-dimensionally, and the data of Table XI that confirm the two-dimensional distribution, together with the corroborative evidence presented earlier, cut the ground out from under the astronomers' conclusions. From these data it is evident that there has been no change in the quasar density during the time interval represented by the quasar distance of 2.00.

The close correlation between the calculated and observed quasar distributions not only demonstrates the uniformity of the quasar density throughout space, but also confirms the validity of the theoretical principles on which the calculations were based. It should be emphasized that this is not merely a case of providing a viable alternative to the currently accepted view of the situation. The fact that uniformity of distribution on the two-dimensional basis has been demonstrated not only for the total number of radio-emitting quasars in a representative sample, but also individually for each of the three classes of objects included in this total puts the findings on a firm basis. The essential concept of the Big Bang theory is thus invalidated.

The data for the other two classes of radio-emitting quasars, early Class I and late Class I, are included in Table XI. Here the distribution is reproduced with space densities of 40 and 60 quasars per spherical unit respectively. We thus

TABLE XI

DISTRIBUTION OF QUASARS

Quasar Distance	Number		Quasar Distance	Number	
	Calc.	Obs.		Calc.	Obs.
	Class II Number = $20 q^2$		Class I — Early Number = $20 q^2$		
0.1	0	0	0.1	0	0
0.2	1	1	0.2	1	0
0.3	2	1	0.3	2	0
0.4	3	5	0.4	3	2
0.5	5	5	0.5	5	2
0.6	7	5	0.6	7	7
0.7	10	7	0.7	10	11
0.8	13	8	0.8	13	14
0.9	16	15	0.9	16	16
1.0	20	20			
	Class I — Late Number = $10 q^2 + 10$		Class I — Late Number = $30 q^2$		
1.1	22	23	0.1	0	0
1.2	24	25	0.2	1	1
1.3	27	29	0.3	3	3
1.4	30	31	0.4	5	7
1.5	33	32	0.5	8	9
1.6	36	34	0.6	11	11
1.7	39	36	0.7	15	14
1.8	42	41			
1.9	46	44			
2.0	50	45			

find that the predominance of Class II quasars in the observed list does not reflect the true situation. Instead of being a 40 percent minority, the Class I objects actually constitute about 70 percent of the total number of radio-emitting quasars.

The sample on which the study was conducted contains no quasars with quasar distances above 2.00, a fact which indicates that the asymmetric redshift factors, discussed in Chapter 23, that lead to redshifts exceeding the normal limit are relatively uncommon.

Although we know the quasars (and other astronomical objects as well) only as sources of radiation, the amount of information that can be extracted from this radiation is surprisingly large; so large, in fact, that much of it will not be needed for purposes of the kind of a general survey of the various quasar populations that we are now undertaking. The current status of the quasars as astronomy's greatest mystery is not due to a lack of sufficient information, but to the astronomers' inability, thus far, to construct the kind of a theoretical framework that would enable placing the many items of information that now seem irrelevant or contradictory in their proper places relative to each other, and to the astronomical universe as a whole. Availability of a purely deductive system of theory, in which all conclusions are derived by development of the consequences of the fundamental properties of space and time, now provides what is needed.

Our present undertaking is to examine the primary characteristics of the different classes of quasars and to show how they fit into the general picture. We will make use of the information developed in the preceding chapters, particularly that referring to the color indexes, the recession redshift (and distance), z , and the quasar distance (and redshift), q . The other magnitudes with which we will be mainly concerned are the optical luminosity, l , its absolute value, L , and the radio emission or flux, for which we will use the customary symbol S .

The optical radiation as received is ordinarily expressed in terms of the astronomical magnitude scale. This system of measurement is presumably satisfactory to the astronomers, since they continue using it, but it is confusing to just about everyone else. Actually, it is a historical accident. The magnitudes were originally ordinal numbers— simply positions in a series. The brightest stars were designated as stars of the first magnitude, the next brightest as stars of the second magnitude, and so on. Later these magnitudes were adjusted to conform to a specific mathematical relation, so that they became a measurement scale, but in order to avoid major changes, the upside down ordinal sequence was retained. Thus the stars with the greatest numerical magnitude are not the brightest, but the faintest. For the same reason, the numerical scale, which for convenience is exponential, was constructed on an awkward basis in which 2.5 magnitudes are equivalent to a factor of 10. It has been necessary to refer to astronomical magnitudes to some extent in this work in order to maintain contact with the astronomical literature. To facilitate translating these values into terms that are more familiar to most readers of this volume, the following table of equivalents may

be helpful:

Factor	Magnitude Difference	Factor	Magnitude Difference
2	0.75	10	2.50
4	1.50	50	4.25
5	1.75	100	5.00
8	2.25	1000	7.50

The quantity that is being measured in terms of the magnitude scale is the *luminosity* of the object. For our present purposes we will want to deal with the actual luminosity, and we will therefore convert the magnitudes to luminosities. In order to keep the numerical values within a convenient range we will state the luminosity in terms of the increments of magnitude above 15, converted to the luminosity basis. Such values represent the ratio of the measured luminosity to the luminosity corresponding to visual magnitude 15. For example, the value 0.200 indicates a luminosity one fifth of the reference level. As indicated by the foregoing tabulation, reducing the luminosity by a factor of 5 adds 1.75 to the magnitude. The value 0.200 thus corresponds to magnitude 16.75. We will be concerned mainly with the *absolute luminosity*, the actual emission from the quasar, rather than with the observed value, which varies with the distance. For this purpose, we will establish a reference datum at the point where q is 1.00 and z is 0.08. The absolute luminosity will be expressed in terms of the measured value projected to this datum by the appropriate relation.

No doubt some exception will be taken to the use of an unorthodox measurement scale in the comparisons that follow, but in addition to generating values that are more convenient to handle, this different scale of measurement will help to avoid the confusion that might otherwise arise from the fact that the basis for projecting the observed luminosity to the absolute system is not the same in our calculations as in conventional practice, and the calculated absolute luminosities corresponding to the observed values will not usually agree.

The same considerations apply to the radio emission values. The values given in the tables are absolute emissions recalculated from the data of Sandage,²⁵⁷ and expressed on a relative basis similar to that used for the optical emission.

As we have seen in the preceding pages, the distinctive characteristics of the quasars and related astronomical objects are due to their greater-than-unit speeds. However, in undertaking to follow the course of development of these objects it will be necessary to recognize that the quasar is a complex object with many speeds, each of which may vary independently of the others. These include:

1. Quasar speeds. The quasars are ejected with scalar speeds exceeding two units. During the interval in which it is restrained by gravitation, each quasar has a speed of z in space, due to the normal recession, and a net speed of $3.5 z^{1/2}$ in time (equivalent space) in the dimension of the spatial reference system. The observed quasar redshift is a measure of the scalar total of these two redshift components.

2. Stellar speeds. The pre-explosion activity and the violent explosion raise the speeds of most of the constituent stars of the ejected galactic fragment (the quasar) above the unit level. It is this intermediate speed of the stars of the quasar, and the consequent expansion into time, that are responsible for the small apparent sizes of the quasars. They are galactic equivalents of the white dwarf stars.

3. Stellar component speeds. The speeds of the individual atomic and molecular components of the stars (temperatures) are independent of the speeds of the stars. Like the stellar speeds, they are increased to levels in the intermediate range by the energy released during the explosion, but they are subject to radiation losses, while the speeds of the stars are not affected by radiation. Consequently, the speeds (temperatures) of the stellar components decrease relatively rapidly, and in most quasars they return to the speed range below unity at the end of the early Class I stage. The stellar speeds, on the contrary, remain in the intermediate range throughout the entire life of the quasar.

4. Independent particle speeds. Dust and gas particles are accelerated to high speeds in the stellar and galactic explosions, and they retain these speeds (temperatures) longer than the atomic and molecular constituents of the stars because of the lower rate of radiation in the gaseous state. Radio emission therefore continues through both Class I stages.

As indicated in the foregoing paragraphs, the initial speeds of the quasar system are imparted by the explosive forces. Prior to the explosion that produces the quasar, the interior of the giant galaxy of origin is in a state of violent activity resulting from a multitude of supernova explosions. The products of these explosions are confined to this interior region by the overlying stellar aggregate, which, as pointed out earlier, has physical characteristics resembling those of a viscous liquid. The dust and gas particles in the agitated interior are moving with speeds greater than that of light. When the internal pressure finally becomes great enough to blow out a section of the overlying material as a quasar, a large quantity of this fast-moving material becomes part of the quasar aggregate. The violent readjustments resulting from the explosion accelerate a substantial proportion of the component stars of the quasar to these same intermediate speeds.

After the initial sharp decrease during the lacertae stage, the status of the quasar speeds at the beginning of the early Class I stage is as follows: The quasar as a whole is moving unidirectionally outward at ultra high (above two

units) speed, but is subject to the gravitational effect of the galaxy of origin. This results in the net speed reflected in the observed redshift, $z + 3.5 z^{1/2}$. The constituent stars of the quasar are moving at intermediate (between one and two units) speeds, and are therefore expanding into time, causing the apparent spatial dimensions of the quasar to decrease. The atomic and molecular constituents of the stars are likewise moving at intermediate speeds, with similar results, putting the stars into the white dwarf condition. The gas and dust particles, which acquired upper range speeds prior to the explosion, undergo a relatively slow speed decrease. All matter accelerated to a higher speed level by the explosion is experiencing isotopic adjustments, and is therefore emitting strong radiation at radio wavelengths.

As the quasar ages and moves away from the galaxy of origin its net outward speed *increases* because of the continual reduction of the retarding gravitational force. All of the internal speeds *decrease* because the large initial energy content is supplied by the galactic explosion, and there is no active source of energy in the quasar itself, other than the normal stellar generation processes, which are wholly inadequate to maintain the high energy concentration that exists initially. The internal motions therefore lose energy in radiation and other interactions with the environment.

This decrease in the internal activity results in a corresponding decrease in the optical luminosity. In determining the true, or absolute, luminosity from the observed value, one of the factors that must be taken into consideration is the effect of the distribution to two perpendicular planes. This applies to the radiation as well as to our ability to see the quasars, and it means that only half of the radiation originating from the quasar components that are moving at speeds below unity is included in the observed luminosity. If the quasar components from which the radiation originates are moving at intermediate speeds, the distribution of the radiation is extended to the full eight units of the intermediate region. In calculating the absolute luminosity, the measured value is thus subject to an increase by a factor of 2 or 8. The limitation of the intermediate range speeds (temperatures) to the early Class I stage restricts the application of the ratio of 8 to 1 to this class. For all other classes of quasars the ratio is 2 to 1.

The other determinant of the relation between the observed and absolute luminosities is the distance. The magnitude of this effect depends on the route by which the radiation travels. The normal recession in space of a quasar ejected from a nearby galaxy is small, and the quasar motion is therefore primarily in time from the very start. Consequently, the radiation from this object travels back to us through time. On the other hand, a quasar ejected from a distant galaxy is receding at a high speed in space at the time of the explosion, and a substantial period of time elapses before the motion in time in the explosion dimension reaches the recession level. In the meantime the radiation from this quasar travels back through space. Eventually, however,

the continually increasing net explosion speed exceeds the speed of the recession, after which the travel of the radiation from this distant quasar, like that from the one nearby, takes place through time.

On this basis, the radiation from the lacertae, the quasars of early Class I, the youngest members of Late Class I, and a few small, rapidly evolving, members of the radio-quiet class, travels in space. That from the remainder of late Class I, most of the radio-quiet quasars, and the quasars of Class II, travels in time. Quasars that are very close, where random motion in space plays a significant role, may continue on the space travel basis beyond the normal transition point.

Because of the two-dimensional distribution of the quasar radiation originating in the intermediate speed range, the radiation received through space is proportional to the first power of the distance in space, z . Inasmuch as $q = 3.5 z^{1/2}$, it is also proportional to q^2 . The distribution of the radiation in time is likewise two-dimensional, and the quasar radiation received through time is proportional to the first power of the distance in time (equivalent space), q . In the discussion that follows all distances will be identified in terms of q (time) or q^2 (space).

Table XII gives the observational data for the early Class I quasars in the group under consideration, expressed in the terms that have been described, together with two calculated values, the quasar distance, q , and the visibility limit. This visibility limit is the approximate luminosity that a quasar of a given class and distance must have in order to be located by a survey with the equipment and techniques available to the observers whose results constitute the quasar sample that is being examined.

A purely theoretical determination of this limit would require a quantitative evaluation of the capabilities of the equipment in use at the time the observations were made, an undertaking that is not feasible as a part of the present investigation. The visibility limits for the quasars of the various classes have therefore been determined empirically from the minimum luminosities of the observed Class II quasars; that is, it is assumed for present purposes that the limiting luminosity actually observed approximates the true limit.

The faintest magnitudes reached in the results here being studied were 19.44 (3C 280.1), 19.35 (3C 2), and 19.25 (1116+12). The corresponding absolute luminosities are 0.025, 0.017, and 0.037. The quasar distance of 3C 2 is 0.962. If we assume that this quasar, which has the lowest luminosity of any Class II object in the sample group, is almost at the visibility limit, we can take a luminosity of 0.016 (magnitude 19.50) as the limit at $q = 1.00$. The corresponding limits, on the q basis, for 3C 280.1 and 1116+12 are then 0.020 and 0.029 respectively; that is, both of these quasars are close to the limit of visibility. This should be sufficient to justify using 0.016 for the visibility limit on the q basis for the purposes of our investigation.

TABLE XII
CLASS I QUASARS - EARLY TYPE

Quasar	Z	q	U-B	B-V	S	m	Limit	L
1049-09	.344	.335	-.49	+.06	.17	16.79	.057	.172
3C 48	.367	.357	-.58	+.42	1.49	16.2	.065	.337
1327-21	.528	.507	-.54	+.10	.31	16.74	.132	.413
3C 279	.538	.516	-.56	+.26	.76	17.8	.136	.162
3C 147	.545	.523	-.59	+.35	2.79	16.9	.140	.381
3C 275.1	.557	.534	-.43	+.23	3.77	19.00	.146	.057
3C 345	.595	.569	-.50	+.29	.72	16.8	.166	.495
3C 261	.614	.586	-.56	+.24	.25	18.24	.176	.140
3C 263	.652	.621	-.56	+.18	.48	16.32	.197	.913
3C 207	.684	.650	-.42	+.43	.43	18.15	.216	.186
3C 380	.692	.637	-.59	+.24	2.61	16.81	.221	.653
1354+19	.720	.682	-.55	+.18	.42	16.02	.238	1.455
3C 254	.734	.695	-.49	+.15	.78	17.98	.247	.247
3C 138	.760	.718	-.38	+.23	1.33	17.9	.264	.285
3C 196	.871	.817	-.43	+.60	3.25	17.6	.342	.486
0922+14	.895	.838	-.52	+.54	.23	17.96	.360	.365

The objects that have been used for the evaluation of this limit are quasars of Class II, in which, as we have seen, the radiation travels through time (on the q basis). The radiation from most of the Class I quasars travels through space, and this modifies the visibility limits. The principal factor that enters into this situation is that there is a difference between the *brightness*, or luminosity, of an astronomical object, and what we may call the *intensity* of the radiation, if the radiating matter is moving at a speed greater than unity (the speed of light). This difference arises because of the introduction of a second time component at the higher speed. At speeds less than unity the only time entering into the radiation process is the clock time. At higher speeds there are also changes in position in three-dimensional time (relative to the natural datum). Here it becomes necessary to distinguish between the time of the progression of the natural reference system, the time that is registered on a clock, and the total time involved in the physical phenomenon under consideration. This total time is the sum of the clock time and the change in time location.

Ability to detect radiation with equipment of a given power is determined by the intensity of the radiation, the radiation per unit of time. Distribution of the radiation over additional units of time reduces the intensity. The luminosity, however, is measured as the amount of radiation received during the total time corresponding to a unit of clock time (one of the components of the total), and

it is not affected by the number of units involved in this total.

If the radiation travels through time its magnitude is a scalar quantity in spatial terms. It therefore has no geometrical distribution, and is received at full strength. However, if radiation from an object in the intermediate speed range travels through space it is distributed in the spatial equivalent of time; that is, in equivalent space. As we saw in Chapter 23, the full distribution extends over 64 effective units. Only two of these are collinear with the scalar dimension of the spatial reference system. Thus the radiation received through space from an object in the intermediate region per unit of total time, the intensity of the radiation, is 1/32 of the total emission.

It follows that the visibility limit for travel in space corresponding to the 0.016 limit for travel in time is $32 \times 0.016 = 0.512$. This is the limit applying at quasar distance 1.00. For other distances, the limits are $0.016 q$ (time travel) and $0.512 q^2$ (space travel). The limits shown in Table XII and the tables of the same nature that will follow have been calculated on this basis.

While this general distribution of the radiation over the full 64 units in time does not affect the luminosity, we have already found that there are other distributions in space that reduce the ratio of the observed radiation to the original emission by a factor of 8 for the early Class I quasars and a factor of 2 for all others. The ratio of intensity to luminosity for motion through space is then the ratio of intensity to emission, 1/32, divided by the ratio of luminosity to emission, 1/2 or 1/8. This gives us 1/4 for the early Class I quasars and 1/16 for the others.

The significance of these ratios is that they enable us to determine the visibility limits in terms of the observed magnitudes (luminosities) for those Class I quasars whose radiation travels through space. The 1/4 ratio tells us that quasar radiation originating in the intermediate speed range and received through space (q^2 basis) has only one quarter of the intensity that it would have if travel through time (q basis) were possible. This is equivalent to a difference of approximately 1.5 magnitudes. The q^2 limit corresponding to the 19.50 magnitude of the q limit applicable to the quasar sample under investigation is thus 18.00. While the equipment used in collecting the data included in this sample was capable of observing Class II quasars at 19.50 magnitude, early Class I quasars, whose radiation travels through space, had to be 1.5 magnitudes (4 times) brighter in order to be detected.

The reality of the 18.00 limit can be seen by inspection of the values in Table XII. Only one of the magnitudes in this list exceeds this limit by more than the amount that can be expected in view of the variability in the luminosity of these extremely active objects. The one exception, 3C 275.1, is a very strong radio emitter, with the largest radio output of any quasar in the sample under examination. It was probably located optically in an intensive search with powerful equipment.

The gradual decrease in the energy level of the quasars that we observe in the

early Class I stage continues during the late Class I stage, as indicated in both the radio emission (Fig. 30) and the optical luminosity (Fig. 31). Since the spatial change of position is initially very slow, the travel of the radiation is still mainly in space (q^2 basis) at the start of the late stage, but by its end the radiation from many of the smaller objects (those below about 0.50 absolute luminosity) is reaching us through time (q basis). Coincidentally, the color indexes become less reliable as an indicator of quasar age, as the smaller aggregates evolve more rapidly.

These factors introduce some uncertainty into the determination of the absolute luminosity of objects of this class. Any individual late Class I quasar outside of the local region in which random motion is significant may be just beyond the early stage, so that its radiation is still traveling in space, or it may have originated nearby, so that the currently indicated distance represents travel in time. Usually, however, the relation of the luminosities calculated on the two different bases to the applicable visibility limits indicates the correct alternative. Most of the quasars whose absolute luminosities calculated on the q^2 basis are above the q^2 limits probably have true luminosities in the neighborhood of the values calculated on that basis. Conversely, where the luminosity on the q basis is only slightly above the corresponding limit, the quasar radiation probably travels through time. In those cases where the luminosity calculated on the q basis is substantially above the q limit, but the quasar does not qualify as visible on the q^2 basis, the absolute luminosity is somewhere between the q and q^2 values, and its true magnitude cannot be determined from the information now available.

Luminosity data for the late Class I quasars of the reference list are given in Table XIII. The basis (either q or q^2) on which each of the absolute luminosities in the last column was calculated is indicated by the column in which the corresponding visibility limit is shown. For these quasars, whose luminosity to emission ratio is $1/2$, the intensity to luminosity ratio becomes $1/16$. This corresponds to a magnitude difference of 3.0, which puts the visibility limit for this quasar class at 16.50. The limiting magnitudes for the different classes of quasars are summarized in this tabulation:

	Intensity	Luminosity	I/L	Limiting Magnitude
Time travel	1	1	1	19.50
Early Class I	1/32	1/8	1/4	18.00
Other space travel	1/32	1/2	1/16	16.50

The limitation of the Late Class I quasars to the shorter distances is a conspicuous feature of Table XIII, as there are absolute luminosities among this group of objects that are high even by the standards of the Class II quasars,

TABLE XIII
CLASS I QUASARS — LATE TYPE

Quasar	Z	q	U-B	B-V	S	m	Limits		L
							q ²	q	
2135-14	.200	.197	-.83	+.10		15.53	.020		.048
1217+02	.240	.235	-.87	+.02	.06	16.53	.028		.027
PHL1093	.260	.255	-1.02	+.05		17.07		.004	.038
PHL1078	.308	.301	-.81	+.04		18.25		.005	.015
3C249.1	.311	.303	-.77	-.02	.22	15.72	.047		.095
3C277.1	.320	.312	-.78	-.17	.20	17.93		.005	.021
3C351	.371	.360	-.75	+.13	.33	15.28	.066		.200
3C47	.425	.411	-.65	+.05	.58	18.1		.007	.024
PHL658	.450	.435	-.70	+.11		16.40	.097		.104
3C232	.534	.513	-.68	+.10	.18	15.78	.135		.257
3C334	.555	.532	-.79	+.12	.35	16.41	.145		.155
MSH03-19	.614	.586	-.65	+.11	.60	16.24	.176		.219
MSH13-011	.626	.596	-.66	+.14	.48	17.68		.010	.051
3C57	.68	.646	-.73	+.14	.01	16.40	.214		.230

which can be seen all the way out to the 2.00 sector limit. No quasars in Table XIII have a quasar distance beyond 0.646. This early cut-off is a result of the 16.50 limiting magnitude, together with the steep rise of the visibility limit on the q^2 basis applying to space travel. Quasars originating nearby and moving out to a greater distance have passed out of the Class I stage before traveling this far, whereas most of those originating beyond 0.500 are cut off by the rapidly rising visibility limit, which is up to 0.128 at this point. The most distant late Class I quasar in the list, 3C 57, is a relatively large fragment, with absolute luminosity 0.230, just above the 0.214 visibility limit corresponding to this distance.

The existence of the 16.50 magnitude limit is clearly demonstrated in the table. Nine of the quasars in this list have a high enough luminosity in proportion to the visibility limit to make it probable that their radiation is transmitted through space, and none of these is appreciably above 16.50 magnitude (that is, less luminous).

A comparison of the values in Table XIII with those of Table XII shows the extent of the decrease in energy emission that takes place as the Class I quasars grow older. Because the early Class I quasars are products of extremely violent galactic explosions, their emission is very high, both at optical and radio frequencies, much above that of any other quasar class. In the absence of any adequate source of replacement of the energy that is lost by radiation, the

internal activity gradually subsides, and the average emission in the late Class I stage is much lower. The maximum emission in the early class, both optical and radio, is six times the maximum of the late class. The average optical luminosity of the quasars of early Class I is four times the average of those of late Class I. The average radio emission in early Class I is also four times the average emission of those members of the late class for which radio data were available.

Since the radio and optical radiation are produced by different processes, their decline as a result of the gradual decrease in the internal energy content of the quasars does not necessarily have to proceed at exactly the same rate, but the fact that the relative emissions of the two groups are the same for both types of radiation is a significant confirmation of the validity of the theoretical relations on which the calculations are based.

The Class I radio-quiet quasars are a distinctive and quite homogeneous group, and some consideration of their place in the general picture is appropriate, but only two of them appear in the sample under examination. In order to have an adequate sample, the quasars of this class listed in the 1972 compilation by Burbidge and O'Dell²⁵¹ have been added to those in the 1967

TABLE XIV
CLASS I RADIO-QUIET QUASARS

Quasar	Z	q	Limit	L
B 234	.060	.060	.001	.006
B 264	.095	.094	.002	.016
TON 256	.131	.130	.009*	.015*
B 154	.183	.180	.003	.007
B 340	.184	.181	.003	.030
BSO-2	.186	.183	.003	.006
B 114	.221	.217	.003	.015
PHL 1186	.270	.264	.004	.010
B 46	.271	.265	.004	.020
PHL 1194	.299	.292	.005	.029
RS 32	.341	.332	.005	.009
PHL 1027	.363	.353	.006	.054
PHL 1226	.404	.391	.006	.020
B 312	.450	.435	.007	.010

* q^2 basis

list. Table XIV gives the emission data for these quasars. As would be

expected on theoretical grounds, these are small objects, their average luminosity being only 0.018, whereas the average of those of the late Class I radio-emitting quasars of Table XIII that are in the same distance range is 0.064. The reason for this difference is that the smaller quasars have less energy to start with, and they dissipate it more rapidly because of their greater ratio of surface area to mass. They consequently pass through the various stages of evolution in less time, and some of them reach the radio-quiet stage while the larger Class I quasars of the same age are still radio emitters.

This more advanced evolutionary status is reflected in the mode of travel of the radiation. While the radiation from the majority of the late Class I radio-emitting quasars travels in space, all but one of the radio-quiet quasars in Table XIV has reached the stage where the travel of the radiation is in time. One of the factors that contributes to this result is that the visibility limit of these small objects on the q^2 basis is reached relatively soon. Only three of the 14 quasars listed in Table XIV have absolute luminosities over 0.020. The visibility limit on the q^2 basis corresponding to 0.020 luminosity is at a quasar distance of about 0.200. This means that a Class I radio-quiet quasar whose radiation travels in space is visible only within this relatively short distance.

As in the case of the Class I radio emitters, the limitation on the distance of the radio-quiet quasars whose radiation travels in time is a result of evolutionary development. By the time these objects have moved from their relatively near locations of origin out to a quasar distance of about 0.400 their optical emission has decreased to the point where it is not detectable with equipment of the kind used by the investigators whose results are reported in Table XIV. The most distant quasar of this group is at a quasar distance of 0.435. There are no radio-quiet objects between this distance and $q = 1.136$ in either of the two samples that we are examining. They reappear in the range beyond 1.136. The factors that are responsible for this distribution pattern will be considered later in this chapter.

There is considerable doubt as to the true status of some of the small objects that have been classified as quasars. A recent (1982) news item reports that B 234, the closest object in Table XIV ($Z = 0.060$) and B 272, another object that has been regarded as a nearby quasar ($Z = 0.040$), are H II galaxies, in which the radiation originates in large regions of ionized hydrogen²⁵⁸. The members of this recently recognized class of galaxies appear to be in the size range of small spirals, and in approximately the same evolutionary stage, but they have not yet acquired the spiral structure. It is possible that more of the small nearby "quasars" are actually galaxies of this new class, but this should not change any of the conclusions reached herein, other than the estimate of the minimum quasar size, which might be increased slightly.

Inasmuch as the Class II stage is the last of the phases through which a quasar passes between its origin and its disappearance, a normal Class II quasar has been traveling outward for a very long time. It therefore follows that the

absolute luminosity of such an object should approximate the value calculated on the q basis. Table XV gives the luminosity data thus calculated for the

TABLE XV

CLASS II QUASARS — BELOW $q = 1.00$

Quasar	Z	q	U-B	B-V	S	m	Limit	L
3C 273	.158	.156	-.85	+.21	1.50	12.8	.012	.369
2251+11	.323	.315	-.84	+.20	.15	15.82	.005	.148
1510-08	.361	.351	-.74	+.17	.35	16.52	.006	.087
1229-02	.388	.376	-.66	+.48	.20	16.75	.006	.075
3C 215	.411	.398	-.66	+.21	.21	18.27	.006	.020
2344+09	.677	.643	-.60	+.25	.30	15.97	.010	.263
PHL 923	.717	.679	-.70	+.20		17.33	.011	.079
3C 286	.849	.797	-.82	+.22	2.21	17.30	.013	.096
3C 454.3	.859	.806	-.66	+.47	2.13	16.10	.013	.293
1252+11	.871	.817	-.75	+.35	.26	16.64	.013	.181
3C 309.1	.904	.846	-.77	+.46	1.33	16.78	.014	.164
0957+00	.906	.847	-.71	+.47	.23	17.57	.014	.080
3C 336	.927	.866	-.79	+.44	.69	17.47	.014	.089
MSH 14-121	.940	.877	-.76	+.44	.95	17.37	.014	.099
3C 288.1	.961	.895	-.82	+.39	.56	18.12	.014	.050
3C 245	1.029	.955	-.83	+.45	.68	17.25	.015	.120
CTA 102	1.037	.962	-.79	+.42	1.91	17.32	.015	.114
3C 2	1.037	.962	-.96	+.79	.83	19.35	.015	.017
3C 287	1.055	.977	-.65	+.63	1.24	17.67	.016	.084
3C 186	1.063	.984	-.71	+.45	.95	17.60	.016	.090

Class II quasars from the reference list that are nearer than $q = 1.00$. There is one exceptional case in this tabulation. As noted earlier, when a relatively large quasar is very close to the location from which we are observing it, the outward movement may be retarded long enough to enable the quasar to reach Class II status before the transition from radiation travel in space to travel in time. The quasar 3C 273 is in this condition.

Table XVI is a similar presentation of the corresponding data for the Class II quasars at quasar distances greater than 1.00. The objective of separating the Class II objects into these two groups is to show that, from a luminosity standpoint, the two groups are practically identical. The range of values in each case is about the same, and the average luminosity for the group below 1.00 is 0.126, while that for the more distant group is 0.138. In both the average and the maximum luminosities there is a small increase at the far end

TABLE XVI

CLASS II QUASARS - ABOVE $q = 1.00$

Quasar	Z	q	U-B	B-V	S	m	Limit	L
3C 208	1.110	1.024	-1.00	+ .34	.98	17.42	.016	.111
3C 204	1.112	1.026	-.99	+ .55	.19	18.21	.016	.053
1127-14	1.187	1.090	-.70	+ .27	1.51	16.90	.017	.190
BSO-1	1.241	1.136	-.78	+ .31		16.98	.018	.183
1454-06	1.249	1.142	-.82	+ .36	.45	18.0	.018	.072
3C 181	1.382	1.254	-1.02	+ .43	1.02	18.92	.020	.034
3C 268.4	1.400	1.269	-.69	+ .58	.73	18.42	.020	.055
3C 446	1.403	1.271	-.90	+ .44	1.48	18.4	.020	.056
PHL 1377	1.436	1.298	-.89	+ .15		16.46	.021	.339
3C 298	1.439	1.301	-.70	+ .33	3.30	16.79	.021	.250
3C 270.1	1.519	1.367	-.61	+ .19	1.03	18.61	.022	.049
3C 280.1	1.659	1.480	-.70	-.13	.80	19.44	.024	.025
3C 454	1.757	1.559	-.95	+ .12	.82	18.40	.025	.069
3C 432	1.805	1.597	-.79	+ .22	.93	17.96	.026	.104
PHL 3424	1.847	1.630	-.90	+ .19		18.25	.026	.082
PHL 938	1.93	1.695	-.88	+ .32		17.16	.027	.232
3C 191	1.953	1.713	-.84	+ .25	1.18	18.4	.027	.075
0119-04	1.955	1.715	-.72	+ .46	.39	16.88	.027	.304
1148-00	1.982	1.736	-.97	+ .17	.84	17.60	.028	.158
PHL 1127	1.990	1.742	-.83	+ .14		18.29	.028	.084
3C 9	2.012	1.759	-.76	+ .23	.41	18.21	.028	.091
PHL 1305	2.064	1.800	-.82	+ .07		16.96	.029	.295
0106+01	2.107	1.833	-.70	+ .15	.56	18.39	.029	.081
1116+12	2.118	1.841	-.76	+ .14	.90	19.25	.029	.037
0237-23	2.223	1.922	-.61	+ .15	.74	16.63	.031	.429

of the distance range, above 1.70, due to the changes that take place as the sector limit at 2.00 is approached, changes that were previously discussed in connection with the redshifts (Chapter 23) and the color indexes (Chapter 24). Otherwise, wherever we draw out a random sample of Class II objects we obtain practically the same luminosity mixture.

This does not mean that the optical characteristics of all Class II quasars are identical; it merely means that whatever differences do exist are distributed throughout the Class II evolutionary stage. There are periods in the life of Class II quasars when the internal explosive activity is at a level above normal, but these active periods are not confined to any one phase of the Class II existence, and may occur at any time.

One of the significant results of the near identity between these two quasar groups at much different distances, when their absolute luminosities are calculated by means of the first power relation derived from theory, is to supply another confirmation of that relation; that is, to confirm the two-dimensional nature of the quasar radiation. The validity of this relationship was demonstrated in *Quasars and Pulsars* by a direct correlation between quasar distance and the average luminosities of small groups of quasars in which all group members are at approximately the same distance. Now the relation is verified in a different manner by showing that the distribution of luminosities calculated on this first power basis is, with the one exception that has been noted, independent of the distance. Obviously, sample groups from different sections of the range of distances would not show the close approach to uniformity that is evident in the tables unless the basis for reducing observed to absolute luminosity is correct. The identification of the Class II quasars above $q = 1.00$ is positive, as no other quasars have quasar distances in this range. It then follows that the agreement between the properties of the two groups of Class II quasars also validates the criteria by which the members of the group below 1.00 were differentiated from the Class I quasars that exist in the same distance range.

It is clear from the entries in Table XVI that the quasars do not thin out gradually with distance, as expected on the basis of conventional theory. On the contrary, there is evidently a sharp cut-off at some point just beyond the last object of the sample group (quasar distance 1.922). This is not due to decreased visibility, as the visibility limit at the 1.922 distance is 0.031, far below the 0.133 average luminosity of the Class II quasars. It must result from some other limiting factor that comes into operation at this distance. This is in full agreement with the theoretical conclusion that the quasars that retain the normal $3\frac{1}{2}-3\frac{1}{2}$ distribution of the intermediate region units of motion convert to motion in time, and disappear from view, at quasar distance 2.00.

The radio-quiet quasars included in Table XVI are relatively large objects, their average absolute luminosity being 0.145, in sharp contrast to the Class I radio-quiet quasars of Table XIV, which average only 0.018. A substantial size is thus indicated as a requirement for attaining the Class II radio-quiet status. This is understandable when we consider the nature of the process that is responsible for the Class II activity. As we have seen, the Class II stage is initiated when a considerable number of the stars of the quasar reach their age limits and undergo supernova explosions. If some or all of the explosion products are confined within the interior of the structure, the quasar becomes a Class II radio emitter. If it is not big enough, or compact enough, to confine these products, they are ejected as they are produced, or at intervals, and the quasar gradually disintegrates.

The luminosity data for the various classes of quasars are summarized in Table XVII. The most conspicuous feature of this tabulation is the high

TABLE XVII
QUASAR LUMINOSITIES

Class	Max.	Min.	Av.	Max/Min
I-Early	1.455	.057	.422	25
I-Late (under 0.76)	.257	.024	.155	11
I-Late (over 0.76)	.155	.015	.057	10
I-Radio Quiet	.054	.006	.017	9
II-Below 1.00	.369	.017	.126	22
II-Above 1.00	.429	.025	.138	17

luminosity of the early Class I objects. However, when we consider the enormous disparity in size between the exploding galaxy that produced the early Class I quasar and the exploding fragment that constitutes the Class II quasar, the difference in luminosity between these two classes is easily accounted for. The relatively low emission of the late Class I objects is obviously a result of the energy losses during the time that has elapsed since the galactic explosion. At the end of the Class I stage, the quasars are in what we may call a condition of minimum internal activity.

Table XVII separates the 14 quasars of late Class I into two groups of 7 each, with the dividing line at $U-B = 0.76$. The ratio of maximum to minimum luminosity in these two sub-groups is practically identical, indicating that the decrease in internal activity continues throughout the late Class I stage, as would be expected from theoretical considerations, and that the difference between the tabulated values for the two groups reflects a decrease in the luminosity level because of the reduced activity, rather than a difference in the sizes of the quasars in the two groups. We may thus conclude that the absolute luminosity of a radio-emitting quasar of minimum size in a condition of minimum internal activity is about 0.015.

As indicated earlier, the radio-quiet quasars in the Class I distance range differ from the coexisting radio emitters mainly in size. Addition of this radio-quiet class brings the minimum size down to 0.006, or to make some allowance for the rather small sample, let us say 0.005. Some question may be raised as to why there should be a minimum size; that is, why the explosion does not produce debris of all sizes from sub-atomic particles up to some maximum size of fragment. The answer is that the quasar is the *whole cloud* of ultra high speed matter ejected by the explosion, including stars, star fragments, dust, and gas. We see the cloud as a discrete object because of the great distances that are involved.

The maximum luminosities vary considerably more than the minimum. This is evidently due to the fact that in the quasars, as well as in the pre-explosion

galaxies, the internal activity can build up to a higher level in the larger aggregates before breaking through the overlying layers of material. The effect of this factor is shown by the ratios of maximum to minimum luminosities, which range from 17 to 25 in the active quasar classes, but average only about 10 in the relatively inactive late Class I groups. Since each of the larger quasars passes through all of the stages represented by the various radio-emitting classes, the range of sizes should be the same in each, if the sample is representative. The 0.155 maximum of the sub-group of late Class I in which the U-B index is over 0.76 should therefore be the maximum value comparable to the 0.015 minimum that we found to be applicable under the condition of minimum internal activity.

Since the sample is small, there may be some larger objects elsewhere, but the continuity of the maximum-minimum ratio throughout Class I indicates that the 0.155 value is at least close to the maximum. Furthermore, the quasar 3C 334, which has the 0.155 luminosity, may still have somewhat more than the minimum internal activity. These possibilities tend to counterbalance each other. It thus appears that a value of about 0.150 is acceptable as the maximum absolute quasar luminosity under conditions of minimum internal activity.

What we now want to consider is the meaning of these maximum and minimum values in terms of the masses of the quasars; that is, are they consistent with the theoretical conclusion that the quasar is a fragment of a giant spheroidal galaxy? The various factors that enter into this situation are not yet defined clearly enough to enable an accurate calculation, but an approximation is all that is needed in order to answer the question as stated. The most convenient way of obtaining this answer is to make a direct comparison between a quasar and the galaxy from which it was ejected, both of which are at the same *spatial* distance. The logical pair for this purpose is the one that we know the best, the quasar 3C 273 and its associate, the giant galaxy M 87.

The largest uncertainty in this evaluation is in the relative mass-to-light ratios of these two objects. It is known that there is a systematic increase in this ratio as the size of the galaxy increases, as would be expected from the theoretical information about the galactic structure developed in the preceding chapters. A recent review by Faber and Gallagher reported relative values for spiral galaxies ranging from 1.7 for the smaller class to 10 for the large s_0 spirals.²⁵⁹ Information with respect to the giant spheroidal galaxies, the parent objects of the quasars, was reported to be scarce, but the available data indicated a substantially higher ratio, probably at least 20.

The increase in the mass-to-light ratio with the size of the galaxy is mainly due to the increasing amount of confined high density, high temperature, material in the galactic interiors. At the level of minimum internal activity the quasars contain much less of this dispersed material, without the confinement.

The stars are still moving at upper range speeds, and the star density remains high, but this does not affect the mass-to-light ratio, which is determined primarily by the extent to which upper range speeds exist in the *constituents* of the stars. As previously noted, these constituents return to temperatures below unity at the end of the early Class I stage. The mass-to-light ratios of the quasars in the minimum activity condition should therefore approximate those of the smaller spiral galaxies. An estimate of 2 should be reasonable. This means that the ratio of the masses of the minimum activity quasars to those of the galaxies of origin is less by a factor of about 10 than the ratios of the luminosities.

As indicated in Table XVII, the Class II quasars are about twice as luminous as the quasars in the stages of minimum internal activity. This brings the mass-to-light ratio of 3C 273 down to about 1/20 of that applicable to M 87. The observed magnitudes of M 87 and 3C 273 are 9.3 and 12.8 respectively. The corresponding ratio of luminosities is 25. Applying the correction for the difference in the mass-to-light ratios, we arrive at the conclusion that M 87 is 500 times as massive as 3C 273.

From the data in the tables in this chapter it appears that 3C 273 is somewhere near the maximum quasar size. On this basis, then, only about 0.2 percent of the mass of a giant galaxy is ejected in the form of a quasar, even when the fragment is one of maximum size. This is only a very small portion of the galaxy, but the galaxy itself is so immense (about 10^{12} stars, according to current estimates) that 0.2 percent of its mass is a huge aggregate of matter. It is equivalent to about two billion stars, enough to constitute a small spiral galaxy. The smallest quasar, radio quiet by the time we observe it, represents only about 0.007 percent of the galactic mass—a mere chip, one might say—yet it, too, is a very large object by ordinary standards, as it contains approximately 70 million stars, the equivalent of about 100 large globular clusters, or a dwarf elliptical galaxy.

The data examined in this volume, and the two that preceded it, together with the interpretation of these data in terms of the quasar theory derived from the postulates of the Reciprocal System give us a picture of the quasars that is complete and wholly consistent. As this analysis shows, if a fragment of a giant galaxy, of a size consistent with the theory, has been ejected at a speed greater than that of light, as required by the theory, then the optical emission from the constituent stars of the fragment, occurring at a rate consistent with the normal emission from such stars, at the distance theoretically indicated by the redshift, and distributed in space and its equivalent in the manner required by the theory, will be received here on earth in just the quantities that are actually observed. There are no inconsistencies of the kind that are so conspicuous in the application of conventional theory to the quasars. *All* of the observations fit easily and naturally into the theoretical structure.

As brought out in the preceding pages, this is true not only of the general

situation, but also of the minor details. The correlation between theory and observation provides individual confirmation of many of the special features of the theory, such as the first power relation between distance and luminosity, the changes in color and distribution of the radiation that take place when the speed exceeds one or another of the unit levels, the special characteristics of the early type quasars, the differences between the limiting magnitudes of the various quasar types, etc.

Furthermore, the theory from which all of these results have been obtained is not something that has been constructed to fit the observations. Each and every conclusion that has been reached is a necessary consequence of the basic assumptions *as to the properties of space and time*. The theoretical development shows that just because space and time have these postulated properties, quasars *must* exist, and they *must* have exactly the characteristics that are now revealed by observation.

CHAPTER 26

Radio Galaxies

As predicted in the first edition of this work, the fast-moving products of galactic explosions that are now known as quasars were discovered in the course of observations of radiation at radio wavelengths. A dozen years earlier, the first radio galaxy, Cygnus A, had been identified. The optical object corresponding to this radio source was found to have the appearance of two galaxies in collision. When another very strong radio emitter, Centaurus A, was discovered and identified with an optical object, NGC 5128, that likewise appeared to be a pair of colliding galaxies, the galactic collision hypothesis became the favored explanation of the origin of the extra-galactic radio emission, although no one could explain *how* collisions could produce the observed radiation.

As more radio observations accumulated, it became clear that the great majority of the radio sources are not colliding galaxies. The necessity of providing some other explanation for most of the sources raised doubts as to the validity of the collision hypothesis, and “by 1960 the colliding-galaxy theory of radio sources had all but expired.” Ten or twelve years later the pendulum had swung back in the other direction. The authors of the foregoing comment on the situation in 1960 saw it this way in 1973:

We suspect that in NGC 3921 and similar objects one is witnessing the vigorous tumbling together or merger of what until recently were two quite separate galaxies.²⁶⁰

A realization that galactic collisions, once thought to be rare events, are actually quite common, has been a significant factor in this change of attitude. There are many galaxies with distorted shapes, and it has been found that a substantial number of these are, or at least appear to be, double structures of some kind, suggesting that two separate galaxies are, or have been, interacting. In NGC 5128 what we apparently see is a spiral galaxy plowing into the middle of a giant elliptical galaxy. This view is supported by the observation that “the gaseous disk is apparently rotating much faster than the elliptical component.”²⁶¹ The galaxy NGC 4650A is reported to have a similar structure, with an elliptical core and an outer spiral galaxy revolving

around the core.²⁶²

In considering the situation from a theoretical standpoint, the first point to be noted is that colliding galaxies produce radio frequency radiation by the same process as any other strong radio emitter; that is, the radiation comes from particles that have been accelerated to upper range speeds. The acceleration can be produced in any one of a number of different ways. Thus it is quite possible that some of the observed radio emission may be a result of galactic collisions, even though in the majority of the radio emitters it results from explosive processes. It would be expected, however, that the explosions, the more violent of the two processes, would produce the stronger radiation.

What needs to be explained, then, in the case of the two sources Cygnus A and Centaurus A, is the exceptional strength of their radio emissions. The answer that we obtain from the theory is that the strong emission is not a direct result of the collision but an indirect result, in which sources of radiation already present are released. It is evident from observation that in each case one of the two colliding objects is a giant. We have previously deduced that the interiors of such giant galaxies contain concentrations of intermediate and ultra high speed matter, enough to make these galaxies strong sources of radio emission even when their structures are intact and only a small part of the radiation that is produced is able to pass through the material that overlies the producing zone. These giant galaxies are large enough, and stable enough, to be able to absorb globular clusters or small galaxies without any significant disturbance of their own structures, but a collision with a large spiral can be expected to result in some disruption of the outer structure of the giant, allowing the escape of large quantities of explosion products from the interior. Here, then, is a source of radiation that is easily able to account for the strong emission from the two objects in question.

The alteration of the normal pattern of development of the internal activity by escape of matter and radiation during collisions is not likely to have any long run significance. It can be expected that when the consolidation of the two galaxies is complete the new galactic structure will be able to contain the material moving with upper range speeds, and the build-up of this material will be resumed, continuing to the ultimate limit in the normal manner. However, some drastic changes in the pattern of evolution of the galaxy may result if the large-scale *explosive* activity is premature. This possibility will be explored in the next chapter.

Two objections have been raised to the collision hypothesis in application to NGC 5128: (1) the "dark lane is wider than would be normal for the disk in a spiral galaxy," and (2) the "lane is more disturbed than the matter in the disk of a spiral galaxy should be."²⁶³ Neither of these objections is tenable once it is understood that the stars of a galaxy occupy equilibrium positions. Disturbance of this equilibrium by contact with another galaxy generates effects that extend over great distances.

The recent discovery that NGC 5128 is a strong x-ray source supports the conclusion that a collision has disrupted the structure of the giant galaxy, as the intermediate speed component of the matter escaping from the central region of the galaxy begins emitting x-rays as soon as its temperature drops below the unit level. Inasmuch as the x-ray radiation originates from matter moving at less than unit speed, it should be emitted mainly from the optical location rather than the radio locations. This theoretical conclusion is confirmed by observation.²⁶⁴

Whether the speeds responsible for the radio emission of the colliding galaxies are produced in part by the collision, or whether the fast-moving matter released by the rupture of the outer layers of the larger galaxy is the sole source of this radiation is not definitely indicated by the information now available, but the indications are that the contribution of the collision is no more than minor. The disruption of the outer structure of a giant spheroidal galaxy is clearly the process that leads to the greatest release of radio-emitting material, and it accounts for the fact that such objects as Cygnus A are *extremely strong* radio emitters.

Smaller amounts of such material escape from other galaxies and from quasars under special conditions. The giant galaxy M 87, for example, apparently has a hole in its outer structure through which ultra high speed matter is escaping in the form of a jet. In still another class of radio emitting objects, the Seyfert galaxies, the containment is quite limited, and the ultra high speed material escapes continuously, or at short intervals. These latter two classes of objects will be given some further consideration in the next chapter.

Another special kind of radio galaxy is the one known as the N galaxy. Most of these objects are far distant. Consequently they have not been studied as extensively as those more accessible to observation, and the amount of information about them that is now available is rather limited. For this reason, whatever conclusions we may reach with respect to them will have to be somewhat tentative. However, the theory that has been developed from the postulates of the universe of motion requires the existence of a class of objects with the same characteristics as those thus far observed in the N galaxies. On the basis of the information currently available, it thus appears probable that the N galaxies are the objects that the theory calls for.

Inasmuch as there is no gravitational effect beyond a quasar distance of 1.00, the explosion speed has no component in the dimension of the reference system in the range from 1.00 to 2.00. From our point of view, therefore, a quasar originating beyond $q = 1.00$ remains at its original spatial location (subject to the normal recession) during its entire life span. Ordinarily the radiation from the quasar overpowers that of the galaxy of origin, and the quasar appears to be alone. In some circumstances, however, the presence of the galaxy can be detected. Furthermore, we can deduce from probability

considerations that some of the quasars are located directly behind the heavily populated galactic centers from which, according to the theory, they originate. In this case the quasar radiation is absorbed and reradiated.

This means that there should exist a class of galaxies in which the galactic nucleus is abnormally bright and emits radiation with some of the spectral characteristics of the radiation from the quasars. The distinguishing feature of the N galaxies is a nucleus of this nature, and it is now conceded that "the spectra and colors of quasars are similar to those of the nuclei of N galaxies."²⁶⁵ Indeed, the similarities between these galaxies and the quasars are so evident that it has been suggested that *all* quasars may be N galaxies with very prominent nuclei.

One specific observation that has been interpreted as evidence in favor of this hypothesis is a change of three magnitudes (a factor of about 16) in the emission from the galaxy X Comae. This leads the observers to conclude that this is "an object that apparently can change temporarily from an N-type galaxy to a QSO." This, they say, "clearly supports the hypothesis" that quasars are simply very bright galactic nuclei.²⁶⁶ However, the explanation provided by the theory presented in this work is not only equally consistent with the observations, but also explains how and why the change takes place, something that is conspicuously lacking in the "bright nucleus" hypothesis. If the quasar is behind the galaxy from which it was ejected, as we have concluded that the N galaxies are, it is quite possible for changes to occur, as the galaxy rotates, in the amount of matter through which the quasar radiation must pass. Such changes are probably no more than minor in the usual case, but they obviously *can* extend all the way from a condition in which the entire radiation from the quasar is absorbed and reradiated, so that we have nothing but an N galaxy, to a condition in which that radiation passes through essentially unchanged, and we see only a quasar.

It has also been reported²⁶⁷ that in some of the objects of this class the quasar component is "off center" with respect to the underlying galaxy. This is very difficult to explain on the basis of the hypothesis that the N galaxy is a galaxy with a quasar core, but it is easily understood if what is being observed is a galaxy with a quasar *almost* directly behind the galactic center. Another significant observation is that "the underlying galaxy [of the N system] has the same colors as a giant elliptical (E) galaxy."²⁶⁵ This supports the theoretical finding that the underlying galaxy in the N system is a galaxy of maximum size (and age) that exploded and ejected the quasar.

Further support for this explanation comes from the observation that the N galaxies are x-ray emitters. After having been raised to the radio-emitting speed level by the strong radiation from the quasar, some of the gas and dust of the N galaxy loses energy in its interaction with the other galactic constituents, and returns to the lower speed range. This initiates x-ray emission. "All optically known N galaxies out to a red shift of 0.06 are detected as x-ray

emitters.’’²²⁷

The general run of radio galaxies—those that are not members of special classes such as the ones that have been described—are explosion products. As we saw earlier, a radio galaxy is normally produced jointly with each quasar. It is also possible that in some galaxies large-scale supernova activity may begin before the galaxy has reached the size that makes it capable of resisting internal pressures in the ultra high range. In that event, the galactic explosion will be less violent, and the major explosion product will not attain the ultra high speed that characterizes the quasar. Instead, it will be a radio galaxy. In all cases, however, a radio galaxy is an ordinary galaxy, differing from the other members of its class only in that it contains gas and dust that has been accelerated to speeds greater than that of light, and is therefore undergoing the isotropic adjustments that produce radiation at radio frequencies.

Many quasars are strong radio sources, as could be expected from the fact that secondary explosions take place in the older quasars, giving them a source of replacement for the particles and the energy that are dissipated. As we saw in our examination of the absorption spectra, the particle speeds are actually increasing in the older quasars. Radio galaxies, on the other hand, are limited to the original supply of matter and energy that they acquire in the explosive event. It should be noted, however, that the strength of the radiation from the distant quasars is greatly overestimated in current practice, because the absolute value of the emission is calculated on the basis of a three-dimensional distribution. As explained earlier, the actual distribution is two-dimensional.

In those scientific areas where data from observation and experiment are scarce and subject to a variety of interpretations, the generally accepted choice from among the alternatives often fluctuates in a manner reminiscent of the changes of fashion in clothing. The changing attitudes toward the process responsible for the generation of the radiation from the radio galaxies that were mentioned earlier in this chapter now appear to be entering still another phase. The “high fashion” in today’s astrophysical theory is the black hole. Wherever problems are encountered, the current practice is to call upon the black hole to provide the answer. So it was probably inevitable that black holes would find their way into the theory of the radio galaxies.

Just *how* the black hole accomplishes the observed result is not explained. We are simply expected to say “black hole” as we would say “open sesame,” and take it for granted that we have the answers. For example, K. I. Kellerman reports evidence supporting the “speculation that the efficient transport of energy from the black hole to the extended radio lobes occurs by what is commonly referred to as a relativistic beam or jet.”²⁶⁸ The basic questions as to how and why a black hole produces a “relativistic beam” are passed over without comment.

Since the astronomers know of no means of producing strong radio radiation other than the synchrotron process, they assume that this process must be

operating, even though they realize that, as matters now stand, there is no plausible explanation of how the conditions necessary for the operation of this process could be produced on such an enormous scale. J. S. Hey tells us that

The synchrotron theory has remained undisputed as the principal process of radio emission. But the problems of the production of relativistic particles and their replenishment by repeated activity have prompted a great deal of speculation . . . There are at least as many theories as there are theoretical astronomers.²⁶⁹

As this statement indicates, the astronomers' view of this phenomenon has not advanced beyond the highly speculative stage. H. L. Shipman sums up the situation in this manner:

We have no definite explanation for the appearance of even the most common form of radio galaxy, the double radio galaxy.²⁷⁰

Here again, the theory of the universe of motion produces the answers to the problems in the course of a systematic and orderly development of the consequences of its basic postulates, without the necessity of making any further assumptions, and without calling upon any black holes or any other figments of the imagination. This theory tells us that, except for some minor contributions from processes such as galactic collisions, the energy of the radio radiation is produced explosively. Gas and dust particles are accelerated to upper range speeds, and radiation at radio frequencies is then produced in the manner described in Chapter 18. Where conditions are such that the speed of certain particles drops back below the unit level at some stage of the evolution of the explosion products, x-ray emission takes place, as also explained in an earlier chapter.

Where the maximum explosion speeds are in the intermediate range, below two units, the explosion products expanding in time have no other motions. The radio emission therefore takes place from the original spatial position—that is, the optical location—of the exploding object, except to the extent that some of the intermediate speed matter may be entrained in the outward-moving low speed products. The general run of white dwarfs and many other radio emitters are therefore single radio sources. Explanation of these sources presents no particular problem, except the basic requirement of accounting for the production of *strong* radio radiation. Current astronomical theory has nothing to offer as a means of meeting this requirement except the synchrotron process, which, as brought out earlier, is wholly inadequate. But the isotopic adjustment process discussed in Chapter 18 provides an explanation that is in full agreement with the observations.

The most glaring deficiency in the current astronomical views regarding the

radio radiation is the one that authors such as Shipman are conceding in their discussions of the subject: the lack of *any* plausible explanation of the structure of the extended sources. Our finding is that these sources are expanding clouds of matter not essentially different, except in the distribution of their component motions, from the other strong radio sources that we have examined.

In all explosive events within our ordinary experience we observe that an expanding cloud of material is ejected from the exploding object. A supernova remnant is such a cloud. One of the rather surprising results of the development of the consequences of the postulates of the theory of the universe of motion is the finding that the white dwarf, a small compact object, is likewise an expanding cloud of material. It is essentially the same kind of thing as the cloud that is expanding in space, differing only in that it is expanding into time, and is therefore contracting when viewed from the spatial standpoint. This difference in behavior is easily understood when the inverse nature of motion in time (as compared to motion in space) is taken into consideration. Expansion into space *increases* the spatial size of one cloud of explosion products. Expansion into time *decreases* the size of the other.

The “mysterious” pulsars have an equally simple explanation. They are merely moving white dwarfs. The ordinary white dwarf, as we have seen, is a stationary expanding object; stationary in space (aside from ordinary vectorial motion) and expanding in time. The pulsar is moving at ultra high speed, the next higher speed range. This object therefore adds another motion, expanding in time like any other white dwarf, and, in addition, moving translationally in a dimension of space other than the one represented in the conventional spatial reference system.

The quasars have the same kind of a combination of motions as the pulsars. Thus we can describe both of these classes of objects as stationary in the dimension of the reference system (except for the normal recession and possible random motion in space), expanding into time (equivalent space), and having a linear motion in a second spatial dimension. Here the explosive increase of speed into the ultra high range has resulted in the addition of two more motion components to the original spatial motion, an expansion and a translational motion. Because of the alternation of space and time in the basic motion, one of these added components must be motion in time and the other motion in space. In the case of the quasars and the pulsars, the expansion is in time and the translation is in space. But, as we saw in Chapter 15, where the theoretical situation was examined, it is equally possible, under appropriate circumstances, for the expansion to take place in space (that is, in the second spatial dimension) and the translation to take place in time. This produces the same results, except that space and time are interchanged. Here we have expansion in space and translation in time.

Although the combination of motions is essentially the same in both cases, the *observed* phenomena are totally different, because of the limitations of the

spatial reference system. To observation, quasars and pulsars are small, very compact, contracting objects. Inverting the roles of space and time in this description, we find that the explosion products of the inverse type are large, very diffuse, expanding objects.

In both cases, the motion in the early stages, immediately following the explosion, is modified by gravitation. As we saw in the case of the quasars, the spatial motion in the second scalar dimension is normally unobservable, but for a time subsequent to the explosion this unobservable scalar motion is acting against gravitation. The gradual elimination of the gravitational effect allows the progression of the natural reference system that was counterbalanced by gravitation to become effective, reversing the change of position in the reference system that resulted originally from gravitation. It was noted in Chapter 22 that this process results in an observable movement in space during the early part of the quasar life, gradually decreasing, and terminating at a quasar speed of 1.00.

In this instance, Case I, as we will call it, an object that is expanding in time, and is therefore compact in space, undergoes a linear outward motion in space. In the inverse situation, Case II, an object that is expanding in space, and therefore extends over a large spatial volume, undergoes a linear outward motion in time (unobservable). In both cases, the first portion of the spatial motion operates against gravitation, and the gravitational change of position that is eliminated is observable. Thus in Case I there is an observable linear translational motion that terminates at a quasar distance of 1.00, where the net gravitational motion reaches zero. In Case II there is an observable *linear expansion* terminating at the same 1.00 distance. Beyond this point the expansion takes the normal spherical form that results from a random distribution of directions.

A rapidly moving stream of particles is commonly called a jet. Thus the spatial expansion at ultra high speeds takes the form of a jet and sphere combination. As we saw earlier, scalar motion does not distinguish between the direction AB and the opposite direction BA. It follows that where there is no obstacle in the way of the expansion, two oppositely directed jet and sphere combinations originate at each explosion site. The objects inversely related to the quasars and pulsars therefore manifest themselves by a radiation pattern that can be described as having a dumbbell shape.

This widely dispersed matter is not generally regarded as an ‘‘object’’ in the same sense in which this term is applied to a quasar, but actually the two are identical in form, aside from the inversion of space and time. The quasars and pulsars are compact in space and spread out over a very large expanse of time. The radio-emitting dumbbell is compact in time and spread out over a very large expanse of space. Both of these kinds of objects are essentially nothing but expanding clouds of explosion products. The difference between them, as they appear to our observation, is due to the manner in which we are observing

them; that is, we are able to detect changes of position in three dimensions of space, but our direct apprehension of time is limited to the scalar progression. We detect other motion in time only by its effect, if any, on spatial positions.

Deviations from the dumbbell pattern are caused by obstructions in the way of travel of the explosion products, by supplementary explosive activity, by vectorial motion of the galaxy of origin during the expansion stage, or by interaction with neighboring galaxies. The structure of the radio-emitting cloud of matter thus has a considerable amount of diversity, but the division into two somewhat symmetrical regions is generally apparent, except where a specific direction is imparted to the motion of the explosion products by escape through a single orifice.

Distant radio galaxies are subject to the same lateral displacement of the radio image that applies to the quasars, but this displacement is small compared to that resulting from the linear expansion of the explosion products, and it is generally obscured by elements of the structure due to that expansion. However, as noted in Chapter 22, both the large scale structure and the small scale displacements are observed in some cases.

The ultra high speed motion in the interiors of the giant galaxies is thermal motion, in which the directions of the motions of the individual particles are continually changing because of repeated contacts of the moving particles. When the galactic explosion occurs, those of the ultra high speed particles that escape from the galaxy are incorporated into the two major explosion products. Here the forces tending to confine this material are inadequate to accomplish total confinement, and the ultra high speed thermal motion is therefore gradually converted into ultra high speed linear outward motion. Thus both of the major products of the galactic explosion, the quasar and the radio galaxy, are ejecting the dumbbell type of radio-emitting clouds.

As brought out in the theoretical discussion in Chapter 15, the ultra high speed particles expanding into space in the combination jet and sphere pattern are moving at the same total speed as the pulsars. Thus their ultimate fate is the same. Except for a relatively small proportion that are slowed down sufficiently by environmental factors to reduce their speeds below the two-unit level, the individual particles of the expanding cloud of matter eventually cross the boundary and escape into the cosmic sector in the same manner as the pulsars and the quasars. The x-ray radiation from the relatively small number of particles that return to the lower speed ranges is too widely scattered to be observable. Optical radiation is visible only from entrained material in the early jet stage. The ultra high speed expansion is therefore primarily a radio phenomenon.

In addition to the components moving at less than unit speed, and the components moving at ultra high speed that have just been discussed, the products of the most violent explosions also include particles moving with intermediate speeds. As we have seen in the earlier pages, motion in this

speed range (the speeds of the components of the white dwarfs) does not change the position in space. From a spatial standpoint, the particles that constitute this intermediate speed component are motionless. The spatial densities of the outward-moving material are high enough to carry most of this otherwise motionless matter with the streams, but some of it remains at the explosion site. In those cases where the size of this remainder is substantial, the radio emission pattern has three main centers rather than only two. Some of the entrained intermediate speed matter may also drop out of the stream during the jet stage, resulting in local concentrations of material, often called “knots,” in the jet.

The discussion of the cloud of ultra high speed matter that produces the dumbbell type of radio-emitting structure in this chapter completes the identification of the different types of motion combinations that are involved in the phenomena of the upper speed ranges. Summarizing these findings, it can be said that, although the objects included in this category show a wide diversity of shapes and sizes, all the way from tiny, but extremely dense, aggregates to very diffuse clouds of material spread out over vast regions of space, they can all be described as fast-moving clouds of matter, either clouds of particles or clouds of stars. The very diffuse objects are clouds of matter widely dispersed in space by the forces of the explosions. The very compact objects are clouds of matter widely dispersed in time by forces of the same kind.

The variations in the way in which these clouds appear to observation are due to the differences between motion in space and motion in time, and to the variability in the manner in which these different motions are distributed among the three speed levels of the material sector of the universe. The relations between the different kinds of observed objects are brought out clearly by the comparison in Table XVIII. Here we see that all of the new type of objects discovered by the astronomers during the last few decades, from the rather commonplace supernova remnants to the “mysterious” quasars, are explosion products, differing in the way in which they appear to observation because some are aggregates of particles while others are aggregates of stars, and because there are variations in two properties of the motions of their components: the speed level (which determines whether the motion is in space or in time), and the motion distribution—unidirectional (linear) or random (expansion or contraction). An additional variation is due to the fact that some of these objects (the white dwarfs, for example) are single entities while others are combinations in which a relatively compact object, such as a radio galaxy, is associated with an extended cloud of material.

In this connection, it should be understood that expansion in time, like any other time motion, acts as a modifier of the spatial dimension of a cloud—that is, as a contraction in equivalent space—as long as the total motion of the object has a net spatial resultant. Thus, even though motion in time is not, in

TABLE XVIII

MOTION COMBINATIONS AT UPPER RANGE SPEEDS

Aggregates of particles	Speed level		
	1	2	3
White dwarf — early		ET	
White dwarf — late		CT	
White dwarf remnant	ES		
Pulsar — outgoing		ET	LS
Pulsar — incoming		CT	LS
Pulsar remnant			
Component A	ES		
Component B		LT	ES
Aggregates of stars			
Quasar		ET	LS
Radio Galaxy	LS		
Intermediate speed gas component		ET	
Associated radio cloud		LT	ES
E expanding	S in space		
C Contracting	T in time		
L moving linearly			

itself, observable, the decrease in the size of an astronomical object due to expansion in time can be observed.

It is appropriate to emphasize that the explanations that emerge from the application of the Reciprocal System of theory to the extremely compact objects, and related phenomena, that have been brought within the scope of astronomical observation in very recent years, are not drawn from the land of fantasy in the manner of “black holes,” “degenerate matter,” and the like, but are simple and direct results of two aspects of motion that have not been recognized by previous investigators: motion in time and motion at speeds exceeding that of light.

When the full range of motions is recognized, the explanations of the newly discovered objects and phenomena emerge easily and naturally, each taking its specific place in the evolutionary pattern of the material sector of the universe. This characteristic of the theoretical development continues what has been one of the outstanding features of the previously described results of the application of the theory of the universe of motion to the astronomical field. Instead of being a collection of unrelated classes of entities, each originating under a special set of circumstances, all of the observed astronomical objects

are found to have their definite places in an evolutionary path resulting from aggregation under the influence of gravitation.

We have seen, for instance, that the formation of stars and galaxies is not the result of hypothetical processes that operate only under very special conditions, as assumed in present-day astronomy. Instead, the formation of each class of objects takes place at the appropriate point in the evolutionary path as the direct result of gravitational aggregation, a process that is known to exist and to be operative under the conditions existing at the point of formation of the particular object. The situation with respect to the other phenomena that have been examined in the preceding pages is similar. It was not necessary to call upon processes that require the existence of special conditions of an unusual nature to explain the strong radiation at radio or x-ray frequencies that is received from certain classes of objects. Here again, the observed phenomena are explained by means of processes that *necessarily* take place at certain stages of the evolutionary development. Nor do we have to follow the astronomers' practice of evading the task of accounting for such phenomena as the cataclysmic variables by calling them "freaks." These phenomena have places on the evolutionary path that are just as specific as those of the better known astronomical objects.

The view of the newly discovered compact objects and other "puzzling" features of the large-scale activity of the universe that we obtain by applying the physical principles developed in the two preceding volumes of this work differs quite radically from the way in which these phenomena are portrayed in current astronomical theory. But when it is realized that the astronomical theories in these areas are based almost entirely on assumptions, it should be evident that such conflicts are inevitable. The astounding extent to which astronomical science has degenerated into science fiction will be described in Chapter 29. In the interim we will examine a few phenomena that were not taken up earlier because it was evident that they could be more conveniently considered after the role of the quasars and associated phenomena had been clearly defined.

CHAPTER 27

Pre-Quasar Phenomena

In the preceding pages we have seen that a Type II supernova in the outer regions of the galaxy, originating from a relatively large star, produces a pulsar that moves away from the explosion site at ultra high speed, and also an assortment of products of smaller sizes and lower speeds, both above and below unit speed (the speed of light). We have also seen that when large numbers of these supernova explosions occur in the interiors of the oldest and largest galaxies (as most of them do, since the oldest stars are concentrated in the central regions of these galaxies), the pressure that is built up by the fast-moving explosion products ultimately blows out a section of the overlying layers of the galaxy. This fragment then moves off at ultra high speed as a quasar. Now we will want to give some consideration to the events that precede this ejection.

The fact that the energy of each of the major explosive events comes from an accumulation of relatively small (compared to the final energy release) energy increments contributed by explosions of individual stars not only establishes the normal pre-quasar pattern, but also determines the kind of variations from the normal pattern that are possible. Since any small galaxy, or even a globular cluster, may incorporate a few remnants of disintegrated old galaxies, Type II supernovae may occur in any aggregate, but they are relatively rare in the small young structures, and most of their products escape immediately from these structures. However, when a galaxy reaches the stage in which some of its constituent stars other than the strays begin to arrive at their age limits, the number of supernovae in the galactic interiors, where the oldest stars are concentrated, increases dramatically. Coincident with the increase in age, a galaxy also increases in size, and the interior regions in which the explosive activity is taking place are enclosed by a continually growing wall of overlying matter. In the ordinary course of events this growth leads the increase in internal activity by a sufficient margin to prevent the escape of any large amount of explosion products until the quasar stage is reached. The normal pre-quasar period is therefore characterized by a slow, but steady, build-up of intermediate and ultra high speed matter in the galactic interiors.

With the possible exception of one class of galaxies that we will consider shortly, the galaxies of the normal evolutionary sequence, those that will

eventually eject quasars if they are not captured by larger aggregates before they reach the critical age, show no structural evidence of the activity that we find from theory is taking place in their interiors. There are, however, two observable phenomena that indicate the existence and magnitude of this activity. One of these is radio emission. The magnitude of the radiation at radio frequencies indicates the rate at which isotopic adjustments are taking place in matter recently accelerated to speeds greater than unity by the supernova explosions. It has been shown by Fanti *et al.*, that the amount of radio emission is related to the brightness, and hence to the size, of both spiral and elliptical galaxies, as the theory requires.²⁷¹ All of the more advanced spirals are radio emitters, and the giant spheroidal galaxies are strong radio emitters.

Further evidence of the presence of upper range speeds in the galactic interiors is provided by the high density that is characteristic of the central cores of the larger galaxies. According to current estimates, the density in the core of our Milky Way galaxy is 30 or 40 times as great as would normally be expected, while the central regions of M 87, the nearest, and consequently the best known of the giants, are estimated to be at least 80 times the normal density. Current efforts to explain these abnormal densities are based on the assumption that there must be a large number of high density *objects* in these central regions: white dwarfs, or the hypothetical neutron stars or black holes.

The development of the theory of the universe of motion now reveals that the extremely high density of *all* of the compact astronomical objects—white dwarf stars, pulsars, x-ray emitters, galactic cores, quasars, etc.—is due to the same cause: speeds in excess of unity (the speed of light). The conventional explanation of the high density of the white dwarfs is based on the idea of a “collapse” of the atomic structure, and it therefore cannot be extended to an aggregate composed of stars. The effect of upper range speeds, on the other hand, is independent of the nature of the moving entities. The reduction in the effective distance between objects by reason of these speeds is a specific function of the speed, irrespective of whether these objects are atoms or stars.

Thus, the high density of the central regions of the larger galaxies is not due to the presence of unusual concentrations of very dense objects, but to the distortion of the scale of the reference system that results from the high speeds of the normal constituents of the galactic interiors. The cores of these galaxies are in the same physical condition as the white dwarf stars and the quasars; that is, their density is abnormally high because introduction of the time displacement of the upper range speeds has reduced the equivalent space occupied by the central portions of the galaxies. In brief, we may say that the reason for the abnormal density in the older and larger galaxies is that these galaxies have white dwarf cores—not white dwarfs *in* the core, but cores in which the constituent stars and particles are in the same condition as the constituent particles of a white dwarf star.

We do not have enough information to enable tracing the build-up of the internal activity of the galaxies from its beginning, but we do have some knowledge about the interior of a galaxy that is not yet very far along this road. This is our own Milky Way galaxy, where we have the advantage of proximity, and can observe details that would otherwise be beyond the scope of our instruments. A small region, known as Sagittarius A, apparently located at the dynamic center of the galaxy, has some unusual characteristics which indicate that it is the kind of a core that we could expect in a spiral of moderate age. The picture is not entirely clear as yet, but as one report puts it, "Radio observations indicate that something quite unusual is going on at the center of our own galaxy."²³¹ Another observer draws the same conclusion from the infrared emission which, he says, is "so intense that it cannot easily be interpreted unless we believe that something very special is occurring there."²⁷²

Here we have another instance of the association of strong radio and strong infrared emission that was discussed in Chapter 14, an association that the astronomers have never been able to explain. Referring particularly to the quasars, Shipman calls this "the infrared puzzle."²⁷³ Both of these types of radiation are characteristic of matter that is moving at upper range speeds. Their existence in the core of the Milky Way galaxy shows that this galaxy has already developed the kind of an intermediate speed core—a white dwarf core—that we would theoretically expect in a galaxy of this size and age.

The optical radiation from the core is unobservable because of absorption in the intervening matter, but some information as to the size and properties of this core has been derived from infrared and radio measurements. It is generally assumed that the radiation at about two microns wavelength is thermal, and that its intensity is proportional to the star density. As indicated in Chapter 14, our findings are in agreement with this conclusion. On this basis it is estimated that there are about 70 million solar masses within 10 parsecs of the center of the core, and that the density in the innermost volume of 0.1 parsec radius is 100 million times the star density in the vicinity of the sun.²⁷⁴ On first consideration such a concentration may seem incredibly large, but when it is realized that this observed high spatial density is actually a very low density in time, it becomes evident that the observed magnitude is not out of line with other limiting densities. For instance, the density of solid matter at zero temperature and pressure is in the neighborhood of 100 million times the density of the most diffuse stars.²⁷⁵

The radiation in the near infrared comes from stars that are moving at upper range speeds (which accounts for their high spatial density), but are composed of particles whose speeds (temperatures) are in the range below unity (which accounts for the thermal character of the radiation). In addition to this type of radiation, there is also a very intense radiation in the far infrared, a non-thermal radiation that "is presumed to be synchrotron radiation."²⁷⁶ In the

light of the findings detailed in the preceding pages, it is evident that this presumption is incorrect, and that the non-thermal radiation, both the infrared and the associated radio emission, originates from isotopic adjustments in matter that has been accelerated to upper range speeds. The existence of radiation of this nature identifies the Milky Way galaxy as one that has a good start toward the build-up of matter with speeds in the upper ranges which will eventually lead to the kind of a gigantic explosion that ejects a quasar. "Astronomers," says Hartmann, "are still groping for explanations of what is happening at the center of the Milky Way."²⁷⁷ Here is the framework of the explanation that they are looking for.

As noted earlier, the evidence of internal activity increases as the galaxy becomes older and larger. We are not yet able to make a quantitative determination of the maximum size from theoretical premises, but we know from theory that such a limit exists, and this is confirmed by observation. Fred Hoyle points out that "Galaxies apparently exist up to a certain limit and not beyond."²⁷⁸ Rogstad and Ekers give us an idea as to the location of that "certain limit." They report that an absolute photographic magnitude of about -20 is a necessary condition for a spheroidal galaxy to be a strong radio source.²⁷⁹

Some of the giant galaxies that are in the neighborhood of this limiting size have jets of high speed material issuing from their central regions. The nature and properties of these jets were examined in Chapter 26. Our present concern is with their origin. Such a jet is a conspicuous feature of the giant galaxy M 87. Like the quasar 3C 273, with which it is associated, M 87 is of special interest because it is the only member of its class near enough to be accessible to detailed investigation. This object has all of the features that theoretically distinguish a galaxy that has reached the end of the road. It is a giant spheroidal, with the greatest mass of any galaxy for which a reasonably good estimate can be made; it is an intense radio source, one of the first extragalactic sources to be identified; and a jet of high speed material emitting strongly polarized light can be seen originating from the interior of the galaxy. These indications of explosive activity are so evident that they were recognized in the original application of the Reciprocal System of theory to the astronomical field, just as soon as the theoretical limits to the life of the galaxies were discovered, long before any observational evidence of galactic explosions was recognized by the astronomers. The 1959 publication contained this statement: "It would be in order to identify this galaxy [M 87], at least tentatively, as one which is now undergoing a cosmic explosion."

Jets such as that issuing from M 87 are obviously produced under conditions in which pressure is released in a specific direction. Since the galactic explosion that produces a quasar blows out a particular segment of the outer structure of the galaxy, the spatial motion of the quasar is given such a direction. Similar conditions may exist where fragmentary material is ejected,

and in that event the initial ejection takes the form of a jet. The observable astronomical jets are fast-moving streams of unconsolidated material with individual speeds (temperatures) that extend into the upper ranges. On this basis they should theoretically be strong emitters of radiation at radio wavelengths, particularly at the ends of the jets, and the radiation should be highly polarized. These deductions, based on the theoretical relations developed in the earlier pages, are in agreement with the observations.

The theoretical development likewise accounts for a remarkable feature of the jets that is inexplicable in the context of current astronomical theory. This is the nearly uniform thickness of the M 87 jet and others of a similar nature. The hypothesis that the astronomers have invoked to account for the radio emission and the polarization would result in a rather rapid expansion and dissipation of the jet. Why does this not occur is, to them, a mystery. Simon Mitton makes this comment:

The thickness of the jet is only tens of light years, so there must be a powerful constraint to the natural expansion of the gas.²⁸⁰

The development of the theory of the universe of motion identifies this "powerful constraint." Aside from some entrained low speed matter, the constituents of these jets are atoms and particles moving at speeds in the two upper ranges. At these speeds the cloud of particles that constitutes the jet is expanding into time, rather than into space, and its spatial dimensions are decreasing slightly, rather than increasing.

The available evidence does not indicate specifically how the jet originated. It is possible that the hole in the outer structure of the galaxy through which the material of the jet is issuing may be the result of a collision similar to that which seems to have taken place in NGC 5128 and some other radio galaxies. However, the relatively small cross-section of the jet and the absence of any indication of major distortion of the galactic structure suggest that the jet is more likely to be an after-effect of the ejection of a quasar or other explosion product. It no doubt takes an appreciable time to close the opening left by the ejection of a section of the outer wall of the galaxy, and during this interval there must be some loss of energetic material from the interior. If this is a correct interpretation of the situation, the leakage now visible as a jet will eventually terminate as the outer wall of the galaxy reforms and closes the existing gap.

There is at least one quasar in the immediate vicinity that could have been ejected from M 87 recently. According to Arp, the average recession speeds of the galaxies in different parts of the region around M 87 range from about 400 km/sec more than the speed of M 87 to about 400 km/sec less.²⁴⁴ Any quasar or radio galaxy whose normal recession is within about 0.0015 of the recession of M 87 is therefore a probable member of the cluster of galaxies

centered around M 87, and is a possible product of an explosion of that galaxy. Included within these limits is a quasar, PKS 1217+02, with a redshift of 0.240, which is equivalent to a recession shift of 0.0045 (almost the same as that of M 87). There are also several radio galaxies in the same neighborhood, with redshifts that qualify them as possible partners of this quasar. It thus appears likely that PKS 1217+02 and one of the nearby galaxies, perhaps 3C 270, with redshift 0.0037, were ejected in a relatively recent explosion.

Of course, it is not possible to reconstruct the exact sequence of events in this crowded area where there are so many galaxies that are interacting with each other, but it is clear that the whole range of explosion products is present, from the very old Class II quasar, 3C 273, to the jet of M 87, which originated only yesterday, astronomically speaking. There may even have been an explosion of M 87 that did not produce a quasar. It has been noted that the galaxy M 84 (radio source 3C 272.1) is aligned with the M 87 jet in such a manner as to suggest that this galaxy may have been formed from material ejected in a more violent period of the activity of the galaxy that preceded the production of the jet.²⁸¹ The present activity of M 87 could well be the concluding phase of that explosive event.

Ultimately, after a number of ejections have occurred, an exploding galaxy will have lost so much of its substance that it will be unable to resume its normal shape and once more confine the explosion products to the interior of the structure. Thereafter the pressures necessary for the ejection of fragments of the galaxy will not be generated, and the products of the supernova explosions will be expelled at more moderate speeds in the form of clouds of dust and gas. The galaxy M 82, the first in which definite evidence of an explosion was recognized, seems to be in this stage. Photographs of the galaxy taken with the 200-inch Palomar telescope show immense clouds of material moving outward, and the galactic structure appears badly distorted.²⁸²

Just how large M 82 may have been in its prime, before it began ejecting mass, cannot be determined from observation, but presumably it was in the giant class. At present it is in the range of the spirals. Sooner or later the remnants of all such overage galaxies will be gathered into their younger and larger neighbors. The eventual fate of M 82 is clearly foreshadowed by a comment in an article by A. R. Sandage that the evidence of explosive events in this galaxy was discovered in a survey of "a group of visible galaxies centered on the giant spiral galaxy M 81."²⁸² Capture of one after another of this group of galaxies will eventually build M 81 up to the maximum size. The giant thus produced will then continue on its way to the ultimate destruction that it, in turn, will experience, leaving behind remnants that will be incorporated into the new galaxies that form in the regions of space that are vacated.

Identification of the galaxies that, like M 82, are in the process of disintegration, is complicated by the fact that galaxies in the process of consolidation display many of the same features. A collection of galaxies with these features, an "Atlas of Peculiar Galaxies," compiled by Halton Arp, probably contains a mixture of both types. The galactic combinations should outnumber the disintegrations by a rather wide margin, since many combinations are required to produce one giant spheroidal candidate for disintegration.

Before turning to another subject, it may be of interest to note that the astronomers have been so frustrated in their attempts to understand M 82 as an exploding galaxy that they are now shifting to other ideas in the hope of getting something that they can fit into the prevailing structure of astronomical theory. The following is a recent statement by Harwit:

The brightest far-infrared extragalactic source known (M 82) at one time was thought to be an exploding galaxy because hydrogen is seen streaming out of its central portions at velocities of 1,000 kilometers a second. Energetic processes that we do not yet understand appear to be active in this galaxy.²⁸³

This is a good example of the operation of one of the policies that has taken modern astronomical theory out of the real world and into the land of fantasy. M 82 exhibits some of the characteristic features of an exploding object. Recognition of these features naturally led at first to the conclusion that an explosion was in process in the interior of the galaxy. But as more information has been accumulated, difficulties have been experienced in reconciling this information with current theories as to the nature of such an explosion. As Harwit reports, the situation is not understood. The rather obvious implication of these difficulties is that the current astronomical theories, insofar as they apply to the M 82 situation, are wrong, but rather than pursuing this line of thought the theorists have chosen to develop some new hypotheses to replace the explosion assumption—hypotheses that are more speculative and less subject to disproof by testing against observation. The present-day tendency toward this kind of a retreat from reality will be given some further consideration in the next chapter.

Another kind of galactic phenomenon results from what we may call premature explosive activity. A galaxy may, for example, capture a number of relatively old stars quite early in its life, or it may even pick up some old star clusters or a remnant of a disintegrated galaxy. These older stars will reach their age limits and explode before the galaxy arrives at the stage where such explosions are normal events. If the premature activity of this nature is not extensive, the energy that is released is absorbed in the normal motions of the galaxy. But where a considerable number of stars—those in a captured

cluster, for instance—reach the age limit in advance of the normal time, some significant results may follow.

If large scale activity of this kind begins when the galaxy is in an earlier stage in which it is smaller and less compact than the giant spheroidals, the concentration of explosion products in the interior may break through the overlying material before the pressure required for the ejection of a quasar is attained. The theoretical results of this kind of a situation are observed in a class of objects first identified and described by Carl Seyfert, and known as *Seyfert galaxies*. These are spiral galaxies, much smaller than the giant spheroidals, and by reason of their spiral structure, in which much of the mass is spread out in the form of a disk, their central regions are relatively exposed, rather than being buried under the outlying portions of the galaxies, as in the giants. The action that is going on in the Seyferts is thus more accessible to observation.

Present-day astronomical theory is totally unable to account for the observed properties of these galaxies. With reference to the facts that are now known about them, D. W. Weedman makes the comment that “The reason for their existence remains one of the most pressing astronomical mysteries.”²⁸⁴ As in so many of the “mysteries” examined in the preceding pages, however, these observations are readily explained in the context of the universe of motion. The biggest enigma for the astronomers is the magnitude of the energy emission. Radiation of the upper range types—radio and far infrared—is being emitted from these Seyfert galaxies in the same manner as from the core of the Milky Way galaxy, but at an immensely greater rate. As reported by Neugebauer and Becklin:

The amount of power such galaxies radiate in the infrared corresponds to as much as 10^{11} times the power output of the sun. This is approximately the amount of power radiated by all the stars in our galaxy at all wavelengths.¹⁶⁸

“Conventional concepts of nuclear physics are woefully inadequate in accounting for such a large energy output from such a miniscule region,”²⁸⁵ says Mitton. The astronomers’ perplexity is still more vividly expressed in this statement:

One cannot help wondering what strange machine is hidden at the center of that galaxy [NGC 1275, a Seyfert] and others similar to it. Such prodigious emission of energy and matter from a region that appears to be shrinking, the more we study it, poses questions to which we have no answers.²⁸⁶ (P. Maffei)

Now that we have established the nature of the quasars, the finding that the

Seyferts are premature quasars identifies the source of the energy, and eliminates the problem of the size of the emitting region. This region appears small only if we look at it as a spatial domain, which it is not. It is actually a large region containing a huge number of stars, but its extension is in time, rather than in space.

The violent motion required by the theory of the universe of motion has been detected in the cores of these Seyfert galaxies. R. J. Weymann reports that the emission spectra of the Seyfert galaxies “indicate that the gases in them are in a high state of excitation and are traveling at high speeds in clouds or filaments. Outbursts probably occur from time to time, producing new high-velocity material.” This, of course, is a description of the state of affairs that the theory says *should* exist, not only in the Seyfert galaxies, but in the cores of the giant spheroidals as well. To the astronomers the whole situation is a “puzzle” because, unlike the Reciprocal System, conventional astronomical theory provides no means, other than gravitation, of confining high-speed material within a galaxy, and gravitational forces are hopelessly inadequate in this case. Weymann summarizes the situation in this manner:

If we accept the fact that the gas inside the tiny core of a Seyfert galaxy is moving at the high apparent velocity indicated by the spectra, and if we assume that the gas is not held within the core by gravitation, we must explain how it is replaced or conclude that the violent activity observed in the core is a rare transient event caused by some explosive outburst.

But the latter possibility, he concedes, is inadmissible, because the Seyfert galaxies “cannot be considered particularly rare.” Hence this piece of observational evidence that is such a significant and valuable item of confirmation of the theory described in this work, not only the theory of the Seyfert galaxies, but the whole theory of the galactic explosion phenomena, including the quasars, is nothing but another enigma to conventional theory.

Weymann also points out that the spectral characteristics of the light from the nuclei of these Seyfert galaxies are quite different from those of the light coming from the outlying regions.

Ordinary stars (such as our sun) emit more yellow light than blue light. This is also the case if one observes a Seyfert galaxy through an aperture that admits most of the light from the galaxy. As the aperture is reduced to accept light only from the central regions, however, the ultraviolet and blue part of the spectrum begins to predominate.²³¹

This is another piece of information that fits neatly into the general theoretical picture. We have deduced from theory that the predominantly yellow light (positive U-B) that we receive from ordinary galaxies is characteristic of

matter moving with speeds less than that of light, while the predominantly ultraviolet light (negative U-B) is characteristic of matter moving with upper range speeds. Now we observe an otherwise normal galaxy with a nucleus in which there is some unusual activity. From theoretical considerations we identify this activity as being due to a series of supernova explosions that are accelerating some particles or aggregates of matter to speeds in excess of the speed of light, and we find that the light from this galaxy displays just the characteristics that the theory requires.

The existence of some kind of an unidentified energetic process in the interiors of the Seyferts—a “strange machine,” as Maffei called it in the statement previously quoted—is generally recognized. Simon Mitton makes this comment:

The variations in NGC 1068 [a Seyfert galaxy] require a non-thermal mechanism for the generating source of the intense infrared emission . . . Because of the difficulties with the hot dust concept, Rieke and Low prefer to attribute the radiation to a mysterious non-thermal source.²⁸⁷

As reported by Mitton, it is now generally agreed that there is sufficient evidence to show that there are “periodic explosions in the Seyfert nucleus that blast debris into the surrounding regions.” But these explosions are unexplained in current astronomical thought. “All models of Seyfert nuclei ultimately rely on the *ad hoc* existence of a primary energy source.”²⁸⁵

The theory developed herein resolves all of these issues. Furthermore, it explains the *periodic* nature of the explosive activity. This is one of the most difficult aspects of the situation from the standpoint of current theory. Observations confirm the existence of high speed matter in the interiors of the Seyfert galaxies in the intervals between explosions, but, as pointed out by Weymann, conventional astronomical theory has no way of explaining the build-up and containment of this very energetic material. In this case, as in so many others, the Reciprocal System, by providing an explanation, is filling a conceptual vacuum.

The same factor that makes the internal activity of the Seyfert galaxies more accessible to observation than that of the giant spheroidals, the thinner layers of overlying material, also limits the kind of products that can result from this activity. In these smaller galaxies it is not possible to build up the great concentration of energy that is necessary in order to eject a quasar, and the emissions of material therefore take less energetic forms. The most common result is nothing more than an outflow of matter in an irregular pattern, but in some instances small fragments of the galaxy are ejected, without the ultra high speed of the quasar.

Because of the periodicity of the explosive events in the Seyfert galaxies the nature and magnitude of the radiation from the products are variable.

Immediately after an outburst the galaxy is a strong radio and infrared emitter, as noted in Chapter 18. As time goes on, the isotopic adjustments are completed and this radiation therefore decreases. As a result, the radio emission from some of the Seyferts is little, if any, greater than that from the average spiral galaxy. Except for that portion which is entrained in the outgoing low speed matter, the intermediate speed products of the explosion remain in the immediate vicinity of the galaxy because of the absence of translational motion in space in the intermediate speed range. Ultimately this material cools enough to drop back below the unit speed level. This initiates isotopic adjustments of the inverse nature, producing x-rays. Thus some Seyferts are strong x-ray emitters, while in others little or no x-ray radiation is detected,²⁶⁴ depending on the stage in which the galaxy happens to be when observed. As would be expected, the stronger sources, both radio and x-ray, are subject to large variations.

It is quite evident that there is some kind of a connection between the Seyferts and the quasars. As expressed by Weymann, "Except for an apparent difference in luminosity, Seyfert galaxies and quasars represent essentially similar phenomena."²³¹ Many astronomers believe that quasars are simply distant Seyfert galaxies, the basis for such a conclusion being the finding that a number of quasars are surrounded by diffuse matter that has the same redshift as the quasar itself.

It is difficult, however, to see why this conclusion should necessarily follow from the observed facts. Some of the reports specify that what has been observed is "nebulousity" that presumably indicates the presence of hot gas. But the presence of hot gas surrounding an object does not preclude that object from being a quasar. Indeed, our findings with respect to the origin of the quasars indicate that they *must* be surrounded by hot gas in their early stages, and probably are in their later stages as well. Nor is the hypothesis as to the identity of the Seyferts and the quasars entitled to any more credence because an association has been found between a quasar and a galaxy of the same redshift. The logical conclusion in this case is that the previous classification was in error, and that the observed object is actually a Seyfert galaxy.

The Seyferts are difficult to identify at great distances because the cores are so much more luminous than the surrounding structure. It can be expected, therefore, that improvements in instrumentation and procedures will result in identifying an increasing number of objects of this type among the distant objects now classified as quasars. Only a small proportion of the spiral galaxies have thus far been recognized as Seyferts. Weedman estimates about one percent.²⁸⁴ Even a substantial increase over this percentage would be consistent with the theoretical status of the Seyferts as deviants from the normal evolutionary pattern, the pattern that culminates in the production of quasars.

The analog of the Seyfert galaxy is not the quasar but the giant spheroidal

galaxy from which the quasar was ejected. Both of these types of galaxies are subject to periodic outbursts in which quantities of dust, gas, and galactic fragments are ejected. But the giant galaxy also ejects quasars and diffuse material at ultra high speeds, while the Seyfert explosions are not powerful enough to accelerate any of their products into the ultra high range. Consequently there are no counterparts of the quasars in the Seyfert products. Nor do these products have any of the other ultra high speed properties, such as the characteristic radio structure.

No Seyfert galaxy exhibits a double radio structure such as that found in most radio galaxies and quasars.²⁸⁶ (P. Maffei).

To conclude the discussion of the pre-quasar situation, we turn now to the earliest ancestors of the giant galaxies that produce the quasars, the globular clusters. The general run of stars of these clusters are far too young to become supernovae, but as emphasized in the earlier pages, the dispersed material from which the globular clusters were formed contained a few remnants of disintegrated galaxies—stars and small star clusters. These are incorporated into the newly formed globular clusters, usually serving as nuclei for the cluster formation. They are already well along the way to their limiting age, and may reach it while the cluster is still an independent unit.

In a large cluster, one that has not yet undergone the attrition that takes place in the immediate vicinity of a galaxy, the amount of material overlying the central regions is sufficient to withstand a considerable amount of internal pressure. Any ultra high speed explosion products probably escape, but those that are moving at less than unit speed are largely confined, while the intermediate speed products, aside from those that are entrained in the outward-moving material, remain at the location of origin, inasmuch as they have no spatial motion components. The presence of these intermediate speed products results in the existence of a high density region in the center of the cluster, a small-scale replica of those in the cores of the large galaxies. After the few very old stars are gone there is no replacement of the energy lost from the explosion products, and their temperature therefore decreases. At some point it drops below the unit level. This initiates x-ray emission.

A 1977 publication reported that seven “x-ray stars” had been found in the globular clusters of our galaxy.²⁸⁸ Unlike the returning white dwarfs, whose x-ray emission is observable only when the material from the interiors of these stars breaks through the overlying low speed matter in a nova explosion, these “x-ray stars” are actually concentrations of explosion products similar to those in the observable supernova remnants, and they continue their emission in the manner of those remnants, gradually decreasing as the isotopic adjustments are completed.

CHAPTER 28

Inter-sector Relations

Unquestionably, the most intriguing new finding that has emerged from the development of the theory of the universe of motion is the existence of an inverse sector of the universe that duplicates the material sector which has heretofore been regarded as the whole of physical existence. As might be expected, this finding has met with a cold reception by those scientists who adhere strongly to orthodox lines of thought. This is, in a way, rather inconsistent, as these same individuals have been happy to extend hospitality to the same ideas in different forms. The concept of an “antiuniverse” composed of antimatter surfaced almost as soon as antimatter was established as a physical reality; the hypothesis of “multiple universes” gets a respectful hearing from the scientific Establishment; and astronomical literature is full of speculations about “holes” that may constitute links between those universes—black holes, white holes, wormholes, etc.

It should therefore be emphasized that the theory of the universe of motion which identifies an inverse sector is not based on radical departures from previous thinking, but on concepts that were already familiar features of scientific thought. Actually, all that has been done in the extension of the new theory into this area is to take the vague concept of an antiuniverse, put it on a solid factual foundation, and develop it in logical and mathematical detail. Many of the conclusions that have been reached in the course of this development are new, to be sure, but they are implicit in the antiuniverse concept.

Observational identification of antimatter in our local environment shows that the observed universe and the antiuniverse are not totally isolated from each other; some entities of the “anti” type exist in observable form in our familiar physical universe. It is only one step farther—a logical additional step—to a realization that this implies that the *complex* entities of the observed type may have *components* of the “anti” nature. Once this point is recognized, it can be seen that the unorthodox conclusions that have been reached in the preceding pages are simply the specific applications of the antiuniverse concept.

For example, additions to the linear component speeds (temperatures) *decrease* the density of ordinary astronomical objects. It follows from the inverse nature of the “anti” sector, the cosmic sector, as we are calling it, that

addition of speeds of the “anti” character *increases* the density. Similarly, addition of rotational motion in space to an atom of matter *decreases* the isotopic mass, while addition of rotational motion of the inverse type (motion in time) *increases* the isotopic mass. And so on.

The new theoretical development has merely taken the familiar idea of a universe of motion, and the equally familiar idea of existence in discrete units only, and has followed these ideas to their logical consequences, an operation that was made possible by the only real innovation that the new development introduces into physical theory: the concept of a universe composed *entirely* of discrete units of motion. With the benefit of this new concept, it has been possible to define the physical universe in terms of the two postulates stated in Volume I. The contents of this present volume describe the detailed development of the consequences of these postulates, as they apply to astronomy. Before concluding this description, and taking up consideration of some of the other consequences and implications of the findings, it will be appropriate to give further attention to the few, but important, direct contacts between the two sectors of the universe.

In one sense, the two primary sectors of the universe, the material and the cosmic, are clearly differentiated. The phenomena of the material sector take place at net speeds that cause changes of position in space, whereas the phenomena of the cosmic sector take place at net speeds that cause changes of position in time. But the space and time of the material sector are the *same* space and time that apply to the cosmic sector. For this reason, the phenomena of each sector are also, to some degree, phenomena of the other as well.

Some of the observable effects of this inter-sector relationship have already been discussed. In Volume I the cosmic rays that originate in the cosmic sector were considered in substantial detail, and in the preceding chapters of this present volume similar consideration has been given to the quasars and pulsars that are on their way to the cosmic sector. In these areas previously examined, we have been dealing with phenomena in which physical objects acquire speeds, or inverse speeds, that cause them to be ejected from one sector into the inverse sector, where the combinations of motions that constitute these objects are transformed into other combinations that are compatible with the new environment. In addition to these actual interchanges of matter between sectors, there are also situations in which certain phenomena of one sector make observable contact with the other sector because of this point that has just been brought out: the fact that the events of both sectors involve the same space and time.

As we have seen in the earlier pages, the dominant physical process in each sector is aggregation under the influence of gravitation. In the material sector gravitation operates to draw the units of matter closer together in space to form stars and other aggregates. When portions of this matter are ejected into the cosmic sector in the form of quasars and pulsars, gravitation ceases to operate

in space. This leaves the outward progression of the natural reference system unopposed, and that progression, which carries the constituent units of the spatial aggregates outward in all directions, destroys the spatial structures and leaves their contents in the form of atoms and particles widely dispersed in both space and time. Meanwhile, gravitation in time has become operative, and as it gradually increases in strength it draws the dispersed matter into stars and other aggregates in time. These aggregates then go through the same kind of an evolutionary course as that followed by the aggregates in space.

As this description indicates, the basic physical units maintain the continuity of their existence regardless of the interchanges between sectors, merely altering their distribution in space and time. In the material sector they are distributed throughout the full extent of the three dimensions of the spatial reference system, but they move only through the restricted region of time traversed in a linear progression. In the cosmic sector these distributions are reversed. Contacts between the entities of the material sector and those of the cosmic sector are therefore limited. In view of the relatively low density of matter in the universe as a whole, a cosmic entity moving one-dimensionally through three-dimensional space will, on the average, have to travel a long way before encountering a material object. Nevertheless, some such encounters are continually taking place.

The key factor in this situation is the nature of the relation between space and time. Not until comparatively recently was it realized that such a relation actually exists. Even in Newton's day these two entities were still regarded as being totally independent. The current view is that time is one-dimensional, and constitutes a kind of quasi-space which joins with three dimensions of space to form a four-dimensional space-time framework, within which physical objects move one-dimensionally. While this four-dimensional space-time concept is relatively new, the basic idea of space and time as the elements of a framework, or setting, for the activity of the universe is one of long standing. Indeed, it is so deeply embedded in physical thought that it is very difficult to recognize the existence of any alternative. The problem involved in making a break with this familiar habit of thought is illustrated by the fact that even in the first edition of this work, the postulates of the theory being described were still expressed in terms of "space-time." Eventually, however, it was realized that space-time is actually motion.

Throughout the development of thought concerning this subject, it has been recognized by everyone that motion is a relation between space and time. The magnitude of the motion, the speed or velocity, has been expressed accordingly, in terms of centimeters per second, or some equivalent. The four-dimensional concept embraced by current science assumes that a totally different kind of relation also exists. In application to entities of a fundamental nature, such a duality is inherently improbable, and the development of the theory of the universe of motion now indicates that the assumption is

erroneous. Our finding is that *any* relation between space and time is motion or an aspect of motion.

It is now evident that the concept of space-time employed in conventional physical theory, and carried over into the early stages of the development of the theory of the universe of motion, is a partial, and rather confused, recognition of the nature of the fundamental relation between space and time. This so-called "space-time," a simple relation between a space magnitude and a time magnitude, is the basic *scalar* relation between space and time; that is, "space-time" is actually scalar motion. Fundamentally, this relation is *mathematical*. Its dimensions are therefore mathematical, or scalar, dimensions. From the mathematical standpoint, an n-dimensional quantity is simply one that requires n independent scalar magnitudes for a complete definition. It follows that in a three-dimensional universe there can be three scalar dimensions of motion.

The spatial aspect of one (and only one) of these can be represented geometrically in a reference system of the conventional coordinate type. Here we are dealing with three dimensions of *space*, but only one dimension of *motion*. The reference system is not capable of representing motion in the other two scalar (mathematical) dimensions. But the fact that the *same* space and time are involved in all types of motion means that there are some effects of the motion in these other dimensions that *are* observable, at least indirectly, in the reference system. The force of gravitation, for example, is reduced by a distribution over all three dimensions, and only a fraction of it is effective in the space of the reference system.

Use of the term "dimension" in both mathematical and geometric applications leads to some confusion. The term is usually interpreted geometrically, and many persons are puzzled by the introduction of scalar dimensions of motion into the physical picture. It has therefore been suggested that some different designation ought to be substituted for "dimension" in one of the two applications. However, *all* dimensions are inherently mathematical. The geometric dimensions are merely *representations* of numerical magnitudes.

Motion at a speed less than unity causes a change of position in space. The three-dimensionality of the universe applies to the spatial aspect of this motion as well as to the motion as a whole. The space involved in one of the scalar dimensions of motion can therefore be resolved into three independent components, which can be represented geometrically. Since no more than three dimensions exist, there is no basis, within three-dimensional geometry, for representation of the spatial aspects of the other two scalar dimensions of motion, except under certain special conditions discussed in the preceding pages. Motion at a speed greater than unity causes a change of position in three-dimensional time. If independent, this motion cannot be represented in the spatial reference system. However, if it is a component of a combination

of motions in which the net total speed is on the spatial side of the neutral level, the temporal speed acts as a modifier of the spatial speed; that is, as a motion in equivalent space.

From the foregoing it can be seen that the universe is not four-dimensional, as seen by conventional science, nor is it six-dimensional (three dimensions of space *and* three dimensions of time), as some students of the Reciprocal System of theory have concluded. We live in a three-dimensional universe. Just how these three dimensions manifest themselves in any specific case depends on the individual circumstances.

Two physical entities make contact when they occupy adjacent units of either space or time. It is commonly believed that the essential condition for contact is to reach the same point in space at the same time, but this is not necessarily true. Objects located in the spatial reference system must be at the same stage of the progression—that is, the same *clock* time—in order to make contact, but this is only because there is a space progression paralleling the time progression recorded by the clock, and unless two such objects are at the same stage of this space progression they are not at the same spatial location. Two objects that are in contact in space are not usually at the same location in three-dimensional time. Likewise, objects that are in contact in time are usually at different spatial locations.

This fact that the spatial contact is independent of the time location accounts for the containment of the material moving at upper range speeds in the interiors of the giant galaxies prior to the explosions that produce the quasars. Since the components of this high speed aggregate are expanding into time at speeds in excess of the speed of light, it might be assumed that they would quickly escape from the galaxy. But the increased separation in time does not alter the spatial relations. The equilibrium structure in space that exists in the outer regions of the giant galaxy is able to resist penetration by the high speed material in the same manner in which it resists penetration by matter moving at less than unit speed.

The motions of cosmic entities in time are similarly restrained by contacts with cosmic structures, but these phenomena are outside our field of observation. The phenomena of the cosmic sector with which we are now concerned are the observable events which involve contacts of material objects with objects that are either partially or totally cosmic in character. Interaction of a *purely material* unit with a cosmic unit, or a *purely cosmic* unit with a material unit follows a special pattern. Where the structures are identical, aside from the inversion of the space-time relations, as in the case of the electron and the positron, they destroy each other on contact. Otherwise, the contact is a relation between a space magnitude and a time magnitude, which is motion. Viewed from a geometrical standpoint, these entities move *through* each other. Thus matter, which is primarily a time structure, moves through space, while the uncharged electron, which is essentially a rotating space unit, moves

through matter.

Material and cosmic atoms, and most sub-atomic particles, are composite structures that include both material (spatial) and cosmic (temporal) components. Inter-sector contacts between such objects therefore have results similar to those of contacts between material objects. To an observer, such a contact appears to be the result of a particle entering the local environment from an outside source. These results are indistinguishable from those produced by an incoming cosmic atom. The contact will therefore be reported as a cosmic ray event. The cosmic atoms involved in these events are moving at the ordinary inverse speeds of the cosmic sector, rather than at the very high inverse speeds of the atoms that are ejected into the material sector as cosmic rays. The most energetic of the reported cosmic ray events therefore probably result from these random encounters.

One other cosmic event that has an observable effect in the material sector is a catastrophic explosion, such as a supernova or a galactic explosion, that happens to coincide with the time of the spatial reference system. The radiation received in the material sector from ordinary cosmic stars is widely dispersed in space, because only a few of the atoms of each of these stars are located in the small amount of space that is common to the cosmic star and the spatial reference system as they pass through each other. But a cosmic explosion releases a large amount of radiation in a very small space, just as an explosion of the material type releases a large amount of radiation in a very short time. We can thus expect to observe some occasional very short emissions of strong radiation at cosmic frequencies (that is, the inverse of the frequencies of the radiation from the corresponding explosions of the material type).

Both the theoretical investigations and the observations in this area are still in the early stages, and it is premature to draw firm conclusions, but it seems likely that the theoretical short, but very strong, emissions of radiation can be identified with some of the gamma ray "bursts" that are now being reported by the observers. A reported "new class of astronomical objects" is described in terms suggesting cosmic origin. These objects, says the report, "emit enormous fluxes of gamma radiation for periods of seconds or minutes and then the emission stops."²⁸⁹ Martin Harwit tells us that "remarkably little is known about gamma ray bursts,"²⁹⁰ and elaborates on that assessment by citing an observers' summary of the existing situation, the gist of which is contained in the following statement:

Neither the indicated direction or coincidence in times of occurrence have yet established an association between these bursts and any other reported astrophysical phenomena. Even today, 1978, with 71 bursts cataloged, and with improved directional resolution available, the sources of these bursts remain unidentified without even a strong suggestion of the class or classes of objects responsible.²⁹¹

In addition to these events involving contacts between the entities of the two sectors, there are other phenomena which result from the fact that photons of radiation exist on the sector boundary, and therefore participate in the activities of both sectors. This is a consequence of the status of unit speed as the speed datum, the physical zero, as we called it in the earlier discussion. From the standpoint of the natural reference system, a speed of unity measured from zero speed, and an inverse speed of unity measured from zero energy (inverse speed) are equal to each other, and equal to zero. An object moving at this speed relative to the conventional spatial reference system, or to an equivalent temporal reference system, is not moving at all from the natural standpoint. The photons of radiation, which move at unit speed in the conventional reference system, are thus stationary in the natural system of reference, regardless of whether they originate from objects in the material sector, or from objects in the cosmic sector. It follows that they are observable in both sectors.

Because of the inversion of space and time at the unit level, the frequencies of the cosmic radiation are the inverse of those of the radiation in the material sector. Cosmic stars emit radiation mainly in the infrared, rather than mainly at optical frequencies, cosmic pulsars emit x-rays rather than radio frequency radiation, and so on. But these individual types of radiation are not recognized as such in the material sector because, as we found earlier, the atoms of matter that are aggregated in time to form cosmic stars, galaxies, etc., are widely separated in space. The radiation from all types of cosmic aggregates is received from these widely dispersed atoms as a uniform mixture of very low intensity that is isotopic in space.

This "background radiation" is currently attributed to the scattered remnants of the radiation originated by the Big Bang, which are presumed to have cooled to their present state, equivalent to an integrated temperature of about 3K, in the billions of years that are supposed to have elapsed since that hypothetical event occurred.

The Big Bang is one of the major features of the universe as it appears in modern astronomical theory. The next chapter will present a comparison of this astronomical universe with the universe of motion defined by the postulates of this work. It will be shown that, although the building blocks of the astronomers' universe are observed entities —stars, galaxies, etc.—that exist in the real sense, the universe that they have constructed as a setting for these real objects is a purely imaginary structure that has no resemblance to the real physical world.

Inasmuch as science claims to have methods and procedures that are capable of arriving at the physical truth, it may be hard to understand how the astronomers, who presumably utilize scientific methods, could have reached such very unscientific results. But an examination of astronomical literature quickly shows just what has gone wrong. The astronomers have followed the

lead of a modern scientific school whose methods and procedures do not conform to the rigid standards of traditional science.

Of course, this assertion will be vigorously denied by those whose activities are thus characterized. So let us see just what is involved in this situation. Aside from gathering information, the traditional way of extending scientific knowledge is by means of what is known as the hypothetico-deductive method. This method involves three essential steps: (1) formulation of a hypothesis, (2) development of the consequences thereof, and (3) verification of the hypothesis by comparing these consequences with the facts disclosed by observation and measurement. The nature of this process allows a wide latitude for the construction of the basic hypotheses. On the other hand, the constraints on item (3), the verification process, are extremely rigid. In order to qualify as an established item of scientific knowledge, a hypothesis must be capable of being stated explicitly, so that it can be tested against observation or measurement. It must be so tested in a large number of separate applications distributed over the entire field to which this item is applicable, it must agree with observation in a substantial number of these tests, and it must not be inconsistent with observation in *any* case.

It is important to bear in mind that a physical proposition of a general nature, the kind of a hypothesis that enters into the framework of the astronomers' universe, cannot be verified directly in the manner in which we can verify a simple assertion such as "Water is a compound of oxygen and hydrogen." Direct verification of a general relation would require an impracticable number of separate correlations. In this case, therefore, it is necessary to rely on probability considerations. Each comparison of one of the consequences of a hypothesis with observed or measured facts is a test of that hypothesis. Disagreement is positive. It constitutes disproof. If even one case is found in which a conclusion that definitely follows from the hypothesis is in conflict with a positively established fact, that hypothesis, in its existing form, is disproved.

Agreement in any one comparison is not conclusive, but if the tests are continued, every additional test that is made without encountering a discrepancy reduces the probability that any discrepancy exists. By making a sufficient number and variety of such tests, the probability that there is any conflict between the consequences of the hypothesis and the physical facts can be reduced to a negligible level. Just where this level is located is a matter of opinion, but the principle that is involved is the same as that which applies to any other application of the probability laws. *Many* positive correlations are required in order to establish a probability strong enough to validate a hypothesis. If only a few tests can be made, the probability of validity remains too low to be acceptable.

To illustrate the effect of a small number of correlations with empirical knowledge, let us consider one of the coin tossing experiments that are used

extensively in teaching probability mathematics. We will assume, for purposes of the illustration, that the participants have not been given the opportunity to examine the coin that will be used in the experiment. Thus there is a small possibility that this coin is a phony object with heads on both sides. If the first toss comes up heads, this is consistent with a hypothesis that a two-headed coin is being used, but clearly, this one case of agreement with the hypothesis does not change the situation materially. The odds are still overwhelmingly in favor of the coin being genuine. Not until a substantial number of successive heads have been tossed—perhaps nine or ten—could the double-headed coin hypothesis be taken seriously, and a still longer run would be required before the hypothesis could be considered validated.

The effect of the number of trials, or tests, on the probability of the validity of a hypothesis is independent of the nature of the proposition being tested. Astronomical conclusions are subject to the same considerations as any other hypotheses, including the hypothesis of the double-headed coin. But very few of the key features of the astronomers' picture of the basic structure of the universe are supported by more than one or two correlations with observation. Some have none at all. The fact that the one or two cases of agreement between theory and observation, where they exist, does not add significantly to the probability of validity thus means that these crucial astronomical conclusions are unconfirmed. As scientific products they are incomplete. The final step in the standard scientific procedure, verification, has not been carried out.

To make matters worse, many of the conclusions are not merely unverified. The processes by which they have been reached are such that a large proportion of them are necessarily wrong. The reason is that these conclusions rest, in whole or in part, on general principles that are *invented*. The status of invention as a source of physical theory was discussed in Volume I, but a review of the points brought out in that discussion that are relevant to the astronomical situation will be appropriate at this time.

Modern physical theory is a hybrid structure derived from two totally different sources. In most physical areas, the small-scale theories, those that apply to the individual physical phenomena and the low-level interactions, are products of induction from factual premises. Many of the *general* principles, those that apply to large-scale phenomena, or to the universe as a whole, are invented. "The axiomatic basis of theoretical physics cannot be an inference from experience, but must be free invention,"²⁹² is Einstein's contention.

There is a great deal of misunderstanding as to the role of experience in the first step of the scientific process, the formulation of a hypothesis, largely because of the language that is used in discussing it. For example, in describing "how we look for a new [physical] law," Richard Feynman tells us, "First we guess it."²⁹³ This would seem to leave the door wide open, and such statements are widely regarded as sanctioning free use of the imagination

in theory construction. But Feynman goes on to stipulate that the hypothesis must be a “good guess,” and enumerates a number of criteria that it must satisfy in order to qualify as “good.” Before he is through he concedes that “what we need is imagination, but imagination in a terrible strait-jacket.”²⁹⁴

What Feynman calls a “good” guess is actually one that has a substantial probability of being correct. As he points out, there are an “infinite number of possibilities” if invention is unrestricted. The probability of any specific one of these being correct is consequently near zero. The scientific way of arriving at a reasonably probable hypothesis (the way that Feynman describes, even though some of his language would lead us to think otherwise) is to utilize inductive processes such as extrapolation, analogy, etc., to obtain the kind of an “inference from experience” to which Einstein objects. A hypothesis derived inductively—that is, an inference from experience—is, in effect, pre-tested to a considerable extent. For instance, an analogy in which a dozen or so points of similarity are noted is equivalent to an equal number of positive correlations subsequent to the formulation of a hypothesis. Thus the inductive theory has a big head start over its inventive counterpart, and is within striking distance of proof of validity from the very start.

But inductive reasoning requires a factual foundation. Inferences cannot be drawn from experience unless we have had experience of the appropriate nature. In many of the fundamental areas the necessary empirical foundations for the application of inductive processes have not been available. The result has been a long-standing inability to find answers to many of the major problems of the basic areas of physics. Continued frustration in the search for these answers is the factor that has led to the substitution of invention for inductive methods.

A similar situation exists throughout most of the astronomical field, where normal inductive methods are difficult to apply because of the scarcity of empirical information and the unfamiliar, and seemingly abnormal, nature of many of the observed phenomena. The astronomers have therefore followed the example of the inventive school of physicists, and have drawn upon their imaginations for their hypotheses. Application of this policy has resulted in replacement of the standard scientific process of theory construction by a process of “model building.” This process starts with a “free invention,” a “castle in the air,” as H. L. Shipman describes it. Beginning with “a small, neat castle in the air,” he says, you “patch on extra rooms and staircases and cupolas and porticos.”²⁹⁵ The result is not a *theory*, an explanation or description of reality, it is a *model*, something that, as Shipman explains, is merely intended to facilitate understanding of the real world. “The model world exists only in people’s minds,”²⁹⁶ he says.

The fatal weakness of this kind of a program, based on invention, is that inventive hypotheses are *inherently wrong*. The problems that they attempt to solve almost invariably exist because some essential piece, or pieces, of

information are missing. This rules out obtaining the answer by inductive methods, which must have empirical information on which to build. Without the essential information the *correct* answer cannot be obtained by *any* means (except by an extremely unlikely accident). The invented answer drawn from the imagination to serve as the basis for a model is therefore necessarily wrong.

Of course, the erroneous invented theories, or models, cannot meet the standard tests of validity, and the same process of invention has been applied to the development of expedients for evading the verification requirements. Not infrequently these are employed to evade *actual conflicts* with the observed facts. Chief among them is the ad hoc assumption. When the consequences of a hypothesis are developed, and it is found that they disagree with observation in some respects, instead of taking this as disproof of the validity of the hypothesis, the theorist uses his ingenuity to invent a way out of the difficulty that cannot be tested, and therefore cannot be disproved. He then *assumes* this invention to be valid. Like the invented theories themselves, and for the same reasons, these inventions that take the form of ad hoc assumptions are inherently wrong.

Another of the expedients frequently employed to justify acceptance of a hypothesis whose validity has not been, or cannot be, tested is the “There is no other way” argument that we have had occasion to discuss at a number of points in the preceding pages. No further comment should be necessary on the usual form of this argument, but we often meet it in a somewhat different form in astronomy. There are many astronomical phenomena about which very little is known, and only one or two correlations with observation are possible, as matters now stand. There is a rather widespread impression that, under the circumstances, if a hypothesis is consistent with observation in these instances, its validity is established. Here the argument is that the hypothesis has been tested in the only way that is possible, and has withstood that test. The fallacy involved in calling this a verification can be seen when it is realized that the limitation of the testing of a hypothesis by reason of the unavailability of more than one or two tests is equivalent to discontinuing the coin-tossing tests of the double-headed hypothesis after the first or second toss. The truth is that the increase in the probability of validity of a hypothesis that results from a favorable outcome of one or two tests is insignificant, regardless of the reasons for the limitation of the testing to these cases.

What the current practice amounts to is that instead of *proof* the astronomers are offering us *absence of disproof*. Shipman makes this comment about the situation in one of the poorly tested areas:

To a great extent this picture [of stellar evolution] is based on limited models, blind faith, and a few observed facts.²⁹⁷

“Blind faith” may be appropriate in religion, but it is totally unscientific. One of the most unfortunate results of the reliance on absence of disproof is that it favors departures from reality in the construction of theories. The farther a hypothesis diverges from reality, the less opportunity there is for checking it against established facts, and the more difficult it is to disprove. By the time the speculation reaches such concepts as the black hole, all contact with reality has long since been lost.

For example, examination of the case in favor of the black hole as the explanation of the x-ray source Cygnus X-1, the object that is supposed to provide the best observational evidence for the existence of a black hole, reveals that this case is argued entirely on the basis of what this object is *not*. It is not a white dwarf, so it is claimed, because it is larger than the accepted *unverified hypothesis* as to the nature of the white dwarf stars will permit. It is not a neutron star, because, for the same reason, the observations conflict with the accepted *unverified hypothesis* as to the nature of the hypothetical neutron stars. “It is difficult to explain Cygnus X-1 as anything but a black hole,”²⁹⁸ says Shipman. In less credulous times, the inability of an investigator to find a viable explanation for a phenomenon would have been regarded as an indication that his job is still unfinished. But now we are expected to accept the best that he can do as the best that can be done.

In justice to this author, however, it should be noted that, although he accepts the existence of the black hole as “probable” on the strength of the foregoing argument, he evidently has some qualms about giving unreserved support to such an excursion into the land of fantasy, because he goes on to say:

Black holes are, so far, entirely theoretical objects . . . It is very tempting, especially for people who like science fiction, to succumb to the Pygmalion syndrome and endow their model black holes with a reality that they do not yet possess.²⁹⁹

It is, of course, true that the opportunities for gathering factual information are severely restricted in astronomy, where experimentation is not possible and observation is limited by the immense distances and very long times that are involved in the phenomena under consideration. The structure of astronomical theory thus rests on a very narrow factual base, and it is to be expected that more than the usual amount of speculation will enter into astronomical thinking. But the presence of this speculative component in current thought is all the more reason for taking special precautions to maintain a strict distinction between those items that have met the test of validity and those that are still unverified. In order to preserve the contact with reality, it is particularly important to avoid *pyramiding* unverified results.

Here the demands of science collide with the interests of the scientists, especially the theorists. Advancement of theoretical knowledge is a slow and

difficult task. Few of those who undertake this task ever accomplish anything of a lasting nature, other than minor modifications of some features of previous thought. But the professional scientists of the present day are under intense pressure to produce results of *some* kind. Financial support, personal prestige, and professional advancement all depend on arriving at something that can be published. As expressed among the university faculties, "Publish or perish." So the theorists concentrate their efforts mainly in the far-out regions where there are only a minimum of those inconvenient facts that are the principal enemies of theories, and they fill the scientific literature with products that cannot be tested because they have too few contacts with physical reality. It is the pyramiding of these untestable hypotheses that has produced the imaginary universe of modern astronomy that we will examine in the next chapter.

To the extent that the theorists make any attempt to justify their wholesale use of imaginary entities and phenomena in the construction of their models, they rely on the contention that "there is no other way"; that the amount of factual information available for their use is totally inadequate to provide the foundation for theoretical development. This is a specious argument. It serves the purpose of the individual whose primary purpose is to find something that he can publish, but it makes no contribution toward the advancement of knowledge. On the contrary, to the extent that the imaginary results are accepted, it places obstacles in the way of real advances.

Furthermore, the lack of factual information is not nearly as acute as the astronomers depict it. It is true that the amount of information about individual phenomena is often quite limited, but this is not peculiar to astronomy. It is common to all areas of inquiry, and science has found ways of overcoming this handicap. For example, information in several areas may sometimes be pooled. The concept of "energy," which has played an important part in the development of physical theory, did not emerge from the study of any one individual area. It was derived by the process known as abstraction, involving the use of data from many such areas. It would have been equally possible for the astronomers to have abstracted the property of "extremely high density" from a number of different astronomical phenomena, and to have examined it in the light of the large amount of factual information thus collected. This might well have resulted in the discovery of the true cause of this high density before it was brought to light by the theory of the universe of motion.

Such considerations are now no more than academic in application to astronomy, since it has been demonstrated in the preceding pages that the physical principles developed from the postulates that define the universe of motion are capable of dealing with the whole range of astronomical phenomena. But one of the things that many scientists have envisioned is the eventual application of scientific methods and procedures to the solution of the problems of some of the non-scientific branches of thought that have long been mired down in confusion and contradiction. Before anything of this kind can

be accomplished, it will obviously be necessary for the scientific profession itself to return to the traditional methods and procedures that are responsible for its record of achievement. The black holes, the quarks, the Big Bang, and similar fantasies are the products that are publicized as the fruits of scientific research in the media, and the ordinary individual cannot be expected to realize that the remarkable accomplishments of science over the past several centuries have not been made by such flights of fancy, but by a steady application of the traditional methods of science to one problem after another, testing each answer as it is obtained, and building up a solid and stable structure of theory brick by brick. If science is to be applied to economics, for example, it will have to be in this slow, careful, and painstaking way. Economics already has too many of the economic equivalents of the black hole.

CHAPTER 29

The Non-existent Universe

Chapter 28 completes the description of the new view of astronomical phenomena that we get from the development of the theory of the universe of motion, to the extent that this development has thus far been carried. Before beginning consideration of a different aspect of the physical universe in the final two chapters of this volume, it will be appropriate to take a second look at the universe that this new understanding replaces, the non-existent universe of the imaginative theorists that plays such a major role in present-day physics and astronomy. The non-existent entities and phenomena that make up this phantom universe have been discussed in detail in the earlier pages, but since this discussion has been distributed over three volumes, there would seem to be some merit in a recapitulation that brings the major astronomical items together, so that the connections between the various items can be recognized, and the almost incredible extent of this realm of fantasy that has grown up within the boundaries of the scientific disciplines can be fully appreciated.

Construction of this elaborate network of figments of the imagination would have been impossible in the prosaic and conservative science of Galileo and Newton, but when the progress of experimental and observational discovery carried empirical knowledge beyond the range of Newtonian theories, and thereby undermined their authority, Einstein was able to secure acceptance of his contention that his distinguished predecessors were wrong in believing that “the basic concepts and laws of physics . . . were derivable by abstraction, i.e., by a logical process, from experiments.”²⁹² General acquiescence in his dictum that “the axiomatic basis of theoretical physics cannot be an inference from experience, but must be free invention” opened the gates to a free and unrestrained exercise of the imagination. Accordingly, Bohr pioneered the idea of inventing new physical laws for application in those areas where problems were encountered in applying the established laws and principles, Einstein introduced the concept of flexible magnitudes, Heisenberg promulgated a principle of uncertainty to legitimize discrepancies, and soon the era of scientific invention was in full swing.

Now we are going to examine the structure of fantasy that has been erected by those who have taken advantage of this license to give free rein to the imagination under the banner of science, so that we can see just how far the

universe of modern astronomy has diverged from the universe of physical reality. Although it is fictional, this imaginary universe has a logical structure. It is carefully reasoned from specified premises. But some of these premises involve departures from reality. These are assumptions—free inventions—in areas where the true facts were unknown, or not yet recognized, prior to the investigation reported in this work. With the aid of such assumptions to complete their foundations, the inventive astronomers have been able to build an elaborate structure of theory extending far beyond the limits of the real universe and into the land of fantasy.

As pointed out in Chapter 28, the retreat from reality is primarily due to the fact that little or no attempt has been made to subject the inventions, and the theoretical conclusions based upon them, to the standard tests of validity. Inasmuch as the ties that bind this structure of theory to the solid ground of observed and measured facts have been severed only at a few specific points, it is usually difficult to determine by examination of any one particular physical situation just how much is fact and how much is fiction. But we can establish a clear line of demarcation between the real and the fictional by identifying the points at which the false assumptions have been made, and following the lines of reasoning, based on these assumptions, that lead to the kind of non-existent entities, phenomena, and relations that populate the phantom universe of present-day science.

We will be concerned mainly with the astronomical fantasies, not only because astronomy is the primary subject matter of this present volume, but also because it deals with the physical extremes, and therefore has the effect of magnifying the departures from reality. It is here, in the astronomical field, that we find the black holes, the degenerate matter, the singularities, and other extravagances of fertile imaginations. But the initial points of departure from the real world are at a more fundamental level. The physicists are the ones that first strayed from the straight and narrow path. Astronomy has suffered the consequences.

Of course, the astronomers do not recognize the remarkable extent to which their discipline has taken on a fictional character, but at least some of them realize that there is little connection between their theoretical universe and what is actually observed. As Harwit puts it, there is “a gap between theorists and observers.” He comments on the “remarkable detachment” between observation and theory, and goes on to say:

The astrophysical concepts that lead us to an understanding of cosmic phenomena have a history that is all but decoupled from the actual discovery of the phenomena . . . Theory and observation pursue their own somewhat separate ways, and the major cosmic phenomena continue to be discovered mostly by chance.²³⁶

It is also beginning to be recognized that this gap will eventually have to be closed by means of a reconstruction of basic theory. As noted elsewhere in this volume, there is a tendency in astronomical circles to expect this reconstruction to take place in the fundamental physical laws, rather than in astronomy itself. As demonstrated in this work, a drastic revision of physical fundamentals is indeed required, but such a revision necessarily has significant repercussions on the superstructure that the astronomers have erected on the physical foundations that must now be rebuilt. At least some members of the astronomical community are beginning to recognize this point. For example, Geoffrey Burbidge, Director of the Kitt Peak National Observatory, made this comment in a recent (1983) interview:

My suspicion is that Chip Arp [Mount Wilson and Las Campanas Observatories] is right, and some of the main pillars of extra galactic astronomy are going to tumble down.³⁰⁰

After all, astronomy is merely large-scale physics, and the astronomers are in the awkward position of having to place the foundations of their theoretical structure in what Paul Davies (one of the most enthusiastic of the current generation of fantasy-constructors) describes as “the Alice-in-Wonderland world of the New Physics, a world alive with paradoxes, mysteries, and discontinuities.”³⁰¹ As might be expected in an Alice-in-Wonderland world, the retreat from reality starts at the very base of the theoretical structure. This can be seen in the following comparison:

1. *In the imaginary universe:* The fundamental constituents of the universe are elementary units of matter.
In the real universe: There are no elementary units of matter.

The word “elementary” in this context means “irreducible.” In earlier eras matter was regarded as elementary, in this sense, and since it was known to consist of discrete units, the existence of an elementary unit of matter was taken for granted. One of the major objectives of investigators in the physical field has been to identify the elementary unit. In the meantime, however, the discovery of processes whereby matter can be transformed into non-matter, and vice versa, has provided concrete proof that matter is *not* elementary. Since matter and radiation, for example, are interconvertible, they must necessarily be different forms of the same thing. And since matter cannot qualify as radiation, nor radiation as matter, it follows that neither can be elementary. Both must be forms of the elementary entity. Thus there are no elementary particles of matter in the real universe.

2. *In the imaginary universe:* The elementary units of matter are quarks.

In the real universe: There are no quarks.

Non-existent particles obviously cannot be found by the normal scientific process of *discovery*. They have to be invented. There seems to be a general impression that if the inventions are held to a minimum in any specific case, the development of thought is still scientific; that is, it continues to be a study of nature. But this view greatly underestimates the effect of a single deviation from reality. The original step into the phantom world may be relatively harmless. In itself, the issue as to whether or not there is an irreducible unit of matter has no significant effect on the general physical situation. But one false step leads to another, and soon the development of thought is far out of touch with reality.

No invention can anticipate the results of future empirical discoveries. Consequently, the history of inventive theories is one of never-ending modifications and adjustments, usually moving farther and farther away from the original point of contact with empirical facts. The quark hypothesis is the end result (so far) of the effort to identify the non-existent elementary particle, or particles, of matter, and it carries this process to the point of absurdity. The quark is purely hypothetical. There is no actual evidence of the existence of anything of this kind. Indeed, one of the principal activities of "elementary particle physics" is dreaming up plausible reasons why such evidence cannot be found.

3. *In the imaginary universe:* The atom is constructed of particles that are made up of quarks.

In the real universe: The atom is an integral unit that has no "parts."

The quarks are not the only postulated particles that the investigators cannot find in the real world. They cannot find the particles that are supposed to be constructed of quarks either. They confuse this issue by giving these imaginary particles, the hypothetical constituents of the atoms, the same names as observed particles such as electrons and neutrons. But calling different objects by the same name does not make them the same kind of objects. Regardless of what they are called, objects belong in the same category only if they have the same properties. The properties that have to be ascribed to the hypothetical sub-atomic particles in order to make it theoretically possible for them to be constituents of atoms differ widely from the properties of the observed particles that are called by the same names.

Stability, for instance, is an essential property of any atomic constituent, including the hypothetical particle that is currently called a "neutron." The observed neutron is *not* stable. It lives only about 15 minutes. Similarly, the properties that the hypothetical atomic constituent currently called an "electron" must have in order to fit into its prescribed place in the atomic

structure are quite different from those of the observed electron. We can deal with these imaginary electrons only on a statistical basis, and as Herbert Dingle points out, we can make these statistical methods effective “only by ascribing to the particles properties not possessed by any imaginable objects at all.”³⁰² Furthermore, as many leading theorists tell us, the atomic electron cannot be regarded as a “real” particle. It does not “exist objectively,”³³⁷ they say. The idea that the real world can be constructed of elementary units that are *not* real—that do not even “exist objectively”—is the kind of an absurdity that is characteristic of the Wonderland of the imaginary universe.

4. *In the imaginary universe:* The atom has a “nuclear” structure in which a positively charged nucleus containing most of the mass is surrounded by negatively charged electrons.

In the real universe: The atom is a single integral unit, not a collection of parts. The experimental “nucleus” is actually the atom itself, and contains *all* of the mass.

Even though there are no “elementary” particles of matter, the “smallest” or “simplest” particles of matter can be identified, and if these small or simple particles had the properties that would qualify them as constituents of the larger particles, it would be in order to postulate that the larger particles are so constituted. But since we know that matter is not composed of elementary units of *matter*, there is no justification for assuming that the atoms must necessarily be constructed of smaller particles of matter. It follows that there is no reason why there *must be* atomic constituents. This eliminates any grounds that may have existed for conjuring up imaginary constituents such as quarks, or for inventing modifications of known particles to make them suitable as building blocks. Since no real particles capable of meeting the requirements that apply to constituents of atoms can be found, the logical conclusion (the one that has been reached in this work from different premises) is that the atom is not constructed of subsidiary units. The prevailing concept of a “nuclear” structure is a hypothetical assemblage of imaginary particles; assumption piled upon assumption.

5. *In the imaginary universe:* Atomic behavior is governed by a set of laws differing in significant respects from the laws governing the behavior of macroscopic matter.

In the real universe: The same physical laws are applicable everywhere.

The inventive theorists find it necessary to invent new laws (a) to account for the hypothetical behavior of the non-existent constituents of the atom, and (b) to account for the phenomena of the region inside unit distance, where the inversion that occurs at all unit levels (not yet recognized by conventional

science) alters the manner in which the physical laws apply. Even with an unlimited license for making ad hoc assumptions, the builders of the imaginary universe have not been able to devise a set of laws for their atoms that is logical and self-consistent. In order to justify holding on to their concept of the nature of the atomic structure they have therefore advanced the strange contention that their atom has these incomprehensible characteristics because nature itself is illogical and inconsistent in the realm of the very small.

6. *In the imaginary universe:* At the atomic level the universe is illogical and incomprehensible.

In the real universe: Phenomena at the atomic level have the same character as those at the macroscopic level.

The physicists' atom is not a real physical entity:

The modern atom is "the solution of a wave equation, and nothing more."³⁰³ (E. N. da C. Andrade) It is "in a way, only a symbol."³⁰⁴ (Werner Heisenberg) The hypothetical electron constituent of the atom is an "abstract thing, no longer intuitable in terms of the familiar aspects of everyday experience."³⁰⁵ (Henry Margenau)

The theory of that atom (the quantum theory) is incomprehensible:

I think I can safely say that nobody understands quantum mechanics.³⁰⁶ (Richard Feynman) An understanding of the 'first order' is . . . almost by definition, impossible for the world of atoms.³⁰⁷ (Werner Heisenberg)

As these statements from prominent scientists demonstrate, present-day science does not even pretend that its atom belongs to the world of reality. But it asks us to believe the preposterous assertion that the reality which admittedly does not exist at the atomic level is somehow acquired in the course of combining these phantom atoms into macroscopic structures. P. W. Bridgman states the case specifically in these words:

The world is not intrinsically reasonable or understandable; it acquires these properties in ever-increasing degree as we ascend from the realm of the very little to the realm of everyday things.³⁰⁸

This is utter nonsense, quite out of character for Bridgman, one of the keenest analysts that the scientific profession has produced. A real structure can be built of real bricks. An imaginary structure can be built of imaginary bricks. But a real structure cannot be built of these imaginary bricks. What Bridgman has described is not the world as it actually exists, but the *physicists'*

understanding of that world. A real world *can* be built of real entities that the physicists do not understand. Bridgman has used the term “not understandable” where the correct term is “not understood.” The practice of treating that which is not understood as not understandable is quite common, but obviously without justification. If this unwarranted extrapolation is removed from Bridgman’s statement, it becomes something like this:

The world is not fully understood. It is understood to an increasing degree as we ascend from the realm of the very little to the realm of everyday things.

Here we have a correct description of the situation as it stood prior to the development of the theory of the universe of motion described in this and the preceding volumes. The point that is being brought out in this present chapter is that, in the absence of an understanding of the phenomena of “the realm of the very little,” the theorists have invented a universe that they can manipulate to produce imaginary solutions for whatever problems they may encounter. Thus far in our examination of the framework of this non-existent universe we have been following the physicists’ line of reasoning based on the assumption (now known to be contrary to fact) that the basic entities of the universe are elementary units of matter, a development of thought that arrives at an imaginary structure of the atom of matter. Next we will trace a similar line of reasoning based on a contrafactual assumption as to the nature of the energy generation process in the stars, and we will examine the fantastic features of the imaginary world that result from the merging of these two lines of thought.

7. *In the imaginary universe:* The light elements are the fuel for the energy generation in the stars.

In the real universe: The heavy elements are the stellar fuel.

Like the nuclear atom, the hydrogen conversion process appeared plausible when it was first proposed. Direct observation of the energy production is not possible, but the assertion that the energy is produced by the only process then known that appeared capable of meeting the requirements seemed reasonable at that time. However, as soon as the astronomical consequences of the production of energy by this process were examined, it should have been clear that this is not the process that the stars utilize in the real world. A multitude of astronomical observations are in conflict with the consequences of this assumption.

8. *In the imaginary universe:* The hot, massive stars are young. The stars of the globular clusters are old.

In the real universe: The hot, massive stars are the oldest stars of their

respective generations. The stars of the globular clusters are relatively young.

The stellar age sequence in the imaginary universe of present-day astronomy is one of the direct consequences of the assumption as to the nature of the energy generation process, and it is a classic example of how an erroneous assumption in one limited area can have consequences of a far-reaching nature. So far as the energy generation process itself is concerned, the question as to which constituents of the star supply the energy is not a critical issue, as long as the energy source is adequate and controllable. But the indirect results of this error have been disastrous. The general acceptance of the hydrogen conversion process as the stellar energy source has seduced the astronomers into embracing an upside down view of the entire evolutionary process. If they had been presented with this entire package as a whole, and had realized that it was all dependent on an assumption as to the nature of an unobservable process, it is unlikely that this package would ever have been accepted. But here, as in so many other cases, most of the fictional components of theories are the results of extended lines of reasoning in which the crucial role of the erroneous basic assumptions tends to be obscured. Many astronomers are uneasy about this situation, and recognize that a fictional element has entered into astronomy somewhere. Maffei makes this comment:

We are now moving beyond those concepts and the knowledge familiar to us in the first half of this century, and we are entering a world in which science and fantasy intertwine.³⁰⁹

It is evident, however, that there is no general understanding of how far the current astronomical thinking has diverged from reality, or where the excursions into the land of fantasy have originated. Item number 8 is one of the major points of departure. Another consequence of the erroneous assumption as to the nature of the stellar energy generation process that has played a significant part in diverting astronomical theory into fantasy-land is the conclusion that the stars eventually run out of fuel.

9. *In the imaginary universe:* The light element fuel supply of a star is eventually exhausted, and the star ultimately cools down to the temperature of interstellar space.

In the real universe: The fuel supply is continually replenished by accretion of matter from the environment.

At this point the lines of development from the basic products of the imagination that we have identified thus far join to produce some further non-existent phenomena.

10. *In the imaginary universe:* “With its fuel gone it [the star] can no longer generate the pressure necessary to maintain itself against the crushing force of gravity.”⁶¹

In the real universe: Gas pressure operates in all directions equally; downward as well as upward. The gravitational forces therefore remain the same regardless of the magnitude of the gas pressure.

The structure of matter at zero absolute temperature, where thermal forces are absent, arrives at an equilibrium condition, in which the gravitational force is counterbalanced by an opposing force that has not been identified by conventional science, other than as an “antagonist.”²⁶ There is no observational indication that this force is subject to any kind of a limit, and we now find that in the universe of motion no such limit exists. The “antagonist” is the force generated by the progression of the natural reference system relative to the conventional reference system, and it cannot be overcome by the gravitational force, however great that force may be.

11. *In the imaginary universe:* “The crushing force of gravity” acting against the interior atoms of the star, after the elimination of the gas pressure, collapses their structure.

In the real universe: (a) Elimination of the gas pressure, if it occurred, would not increase the force acting on the central atoms. (b) The structure of the atom does not collapse under pressure.

The “collapse” is an imaginary breakdown of the structure of the imaginary nuclear atom. In this hypothetical atomic structure the imaginary positively and negatively charged constituents are widely separated (on the atomic scale), leaving nothing but empty space in the greater part of the volume occupied by the atom. The collapse is presumed to eliminate most of this empty space, and bring the atomic constituents into contact. There is ample observational evidence to support the theoretical conclusion that such a collapse is impossible. The mere *existence* of stars that are 50 or 100 times as massive as the sun is positive proof that the inter-atomic equilibrium is able to withstand the greatest pressures of which we have any definite knowledge, those which exist at the center of such a star. The contention that this pressure is increased when, and if, the star cools because of the exhaustion of the fuel supply is pure nonsense. The matter in the center of the star is subject to the full pressure due to the weight of the overlying material regardless of whether that material is hot or cold.

12. *In the imaginary universe:* the collapse of the atomic structure converts the matter of the star into a strange hypothetical state called “degenerate matter.”

In the real universe: There is no degenerate matter.

In this connection, it should be realized that the “collapse” is not merely an assumption that has no observational support. It is an assumption that is specifically contradicted by the observed facts. As pointed out above, the existence of very massive stars is definite proof that the inter-atomic equilibrium is maintained under the greatest pressures that are known to be brought against it—immensely greater than the maximum pressures reached in the smaller stars: the ones that are presumed to collapse into the degenerate state. The truth is that the collapse is merely another addition to the chain of inventions. It is a mythical collapse of a hypothetical assemblage of imaginary particles. The degenerate matter is an imaginary product of that mythical collapse.

13. *In the imaginary universe:* The speed of light is an absolute limit on the speed of material objects.

In the real universe: The speed of light is the limiting speed in one of the three scalar dimensions in which motion can take place.

Here, again, the product of the imagination is specifically contradicted by observation and measurement. As brought out in detail in Volume I of this work, and in other previous publications, the Doppler shifts of the quasars are direct speed measurements, and values exceeding 1.00 indicate speeds greater than that of light. The customary application of Einstein’s relativity mathematics to reduce these speeds below the 1.00 level is an unwarranted use of a relationship developed for, and justified in, a totally different kind of a situation.

In this case, what the erroneous assumption has done is the inverse of the results of the other basic errors that have been discussed. Those others opened the door to imaginative ideas having no connection with reality; that is, they resulted in the extension of physical and astronomical theory into areas that *do not* exist. General acceptance of the assumption of an absolute limit at the speed of light has prevented extension of the theory into some areas of the universe that actually *do* exist. It has blocked any investigation of the phenomena of the realm of the very fast, and has enabled the fantasies of the “degenerate matter” type to be taken seriously because they have had no competition.

14. *In the imaginary universe:* The white dwarf is an aggregate of degenerate matter produced by the collapse of a star of small or moderate size.

In the real universe: The white dwarf is one of the products of a supernova explosion. It is composed of ordinary matter that has been accelerated to speeds in excess of that of light, and is therefore expanding

outward in time (equivalent to inward in space).

The white dwarf is an aggregate of ordinary matter produced from another aggregate of such matter (a star) by one of the processes to which ordinary matter is subject, and it has the properties of ordinary matter. Its only distinctive observable feature is the magnitude of one of these properties, its density. Conventional science has no explanation for densities in the range in which the white dwarf densities fall, because it accepts the dictum of the inventors of the imaginary universe that speeds greater than that of light (the speeds that are responsible for the high density) do not exist.

15. *In the imaginary universe:* the ordinary white dwarf eventually cools and becomes a black dwarf: a dead star.

In the real universe: The white dwarfs lose energy to the environment. In the case of those produced by Type I or relatively small Type II supernovae, this energy loss eventually reverses the process that is responsible for the small size and high density of the white dwarfs, and expands them back into main sequence stars. There are no dead stars.

The black dwarf is purely hypothetical. There is no observational evidence that any such objects exist. Like so many other features of the non-existent universe of present-day astronomy, the black dwarf hypothesis survives only because the existing astronomical facilities are not capable of producing the physical evidence that would demonstrate that there are no such objects.

One of the problems that the astronomers have encountered in building their imaginary universe is that the consequences of some of their basic assumptions do not agree with the consequences of some of the others. The white dwarf is a case in point. It is the result of lines of reasoning based on the erroneous assumptions that have been identified in the foregoing paragraphs. But another assumption, likewise accepted by most astronomers, leads to a totally different result.

According to conventional physics we should expect stars at the ends of their lives to contract under their own gravity until their gravitational fields become so strong that light no longer escapes from them and they become invisible.³¹⁰

The feature of conventional physics to which this statement refers is Einstein's assumption that gravitation is a distortion of space-time due to the presence of matter.

16. *In the imaginary universe:* Gravitation is a distortion of space-time and therefore acts within the atoms as well as between them.

In the real universe: Gravitation is a *motion* of the individual units (atoms and sub-atomic particles) and therefore acts only between the units.

This is another of the basic departures from reality that have taken the astronomers' perception of the universe into the land of fantasy. From the space distortion hypothesis the theorists have derived the concept of self-gravitation of the atom. It is assumed that application of sufficient external force brings matter to a critical point where this self-gravitation becomes effective. Beyond this point the atoms continue contracting by virtue of their own gravity.

This process is quite different from the "collapse" envisioned in the theory that leads to the astronomers' conception of the white dwarf. Thus there are two competing theories in this area. To further complicate the situation, the results of observation do not agree with either of these theories. The statement quoted above as to the conclusions of "conventional physics" goes on to say: "in fact, we observe the reverse. Stars typically explode at a certain critical phase of their lives." Faced with this real-life observation, which could not be ignored, the astronomers have worked out a compromise between the observations and their two theories. As it happens, they have never been able to ascertain what stars explode, or why the explosions occur. In the absence of this information, the latitude for ad hoc assumptions is almost unlimited, and the theorists have been able to put enough of them together to construct an explanation that meets the current liberal standards of acceptability; that is, there is not enough information available to disprove it. It is assumed that, for some unspecified reason, large stars are unable to collapse quietly into white dwarfs in the manner of their smaller counterparts, and instead terminate their lives with explosions. Then it is further assumed that only the explosion products reach the self-gravitation stage.

17. *In the imaginary universe:* Stars that exceed a certain mass limit terminate their existence with explosive events that leave residues denser than the white dwarfs.

In the real universe: Every star eventually reaches either a mass limit or an age limit, and explodes, producing a white dwarf, or its inverse equivalent, or both.

Presumably the hypothetical critical density is somewhat above that of the hypothetical degenerate matter. As one investigator in this field remarks, "precision is not possible, because we do not know enough about the properties of matter at the 'supernuclear densities' of a white dwarf."²⁰¹ But according to the astronomers' theory, there must be a physical state intermediate between the white dwarf and the self-gravitating object. To meet this demand the theorists again call upon the remarkable property of the

imaginary neutron, that of becoming stable whenever stability is required by a theory.

18. *In the imaginary universe:* The high density products of explosions of stars in the intermediate size range are neutron stars. They are observed as pulsars.

In the real universe: The pulsars are fast-moving white dwarfs. There are no neutron stars.

The general impression today is that the status of the pulsars as neutron stars is an established fact, although as Martin Harwit admits in a statement quoted earlier, the astronomers “have no theories that satisfactorily explain just how a massive star collapses to become a neutron star.”¹⁸⁴ The problems involved in explaining the properties of the pulsars in terms of neutron stars are equally intractable. F. G. Smith, one of the leading investigators in the field, concedes, in another of the earlier references, that little is known about either the origin or the mechanism of the pulsars.¹⁸³ Our development shows that the neutron star is a typical product of the imagination. The inability to define its properties is not surprising. The properties of non-existent entities are always difficult to define precisely. The pulsars are actually white dwarf stars produced by supernova explosions that are powerful enough to give some of their products speeds in the ultra high range. These result in outward translational motion, as well as the expansion into time that is characteristic of all white dwarfs.

19. *In the imaginary universe:* The terminal events in the lives of the largest stars produce compact objects whose density is above the critical level. These are black holes.

In the real universe: There are no limits on the size of white dwarfs, other than those that apply to all stars. There are no black holes.

“Of all the conceptions of the human mind from unicorns to gargoyles to the hydrogen bomb perhaps the most fantastic is the black hole . . . Like the unicorn and the gargoyle, the black hole seems much more at home in science fiction or in ancient myth than in the real universe.”²⁰¹ This comment by K. S. Thorne, one of the enthusiastic searchers for evidence of these “fantastic” phenomena, is an eminently correct assessment of the situation. This author goes on to assert that, “Nevertheless, the laws of modern physics virtually demand that black holes exist.” This, too, is true, but only because the particular “laws of modern physics” to which he refers are not the laws of the solid and stable areas of physics. They are the laws of the phantom universe.

Without the self-gravitation concept, the theorists have no way of producing the extreme densities of the black holes. But once they invoke the aid of this

concept they have no way of stopping it. Indeed, it must accelerate. The same imaginary process that accounts for the existence of black holes in the imaginary universe therefore limits these entities to no more than a transient existence. The black hole contracts to a point.

20. *In the imaginary universe:* There is no limit to the process of contraction by self-gravitation. It therefore continues until the entire star has shrunk to a mere point: a *singularity*.

In the real universe: There are no singularities.

One of the recognized principles of logic, the branch of thought upon which scientific procedure is organized, is the *reductio ad absurdum*, in which the falsity of a proposition is established by demonstrating that a logical development of its consequences leads to an absurdity. The singularity is an absurdity. It is totally foreign to all that we actually know about the physical universe. It therefore follows that there is an error somewhere in the line of thought that produced this absurd result. The findings of this present investigation have now identified *many* such errors, but even without this new information it should be clear that every assumption in the lines of thought leading to the singularity is open to doubt until the situation is clarified.

The general assumption that the existence of black holes is at least quasi-permanent is, in effect, a denial of the validity of the singularity hypothesis. But those who have so much to say about the extraordinary properties of black holes are silent on the question as to why, or how, the contraction process should stop at this black hole stage. Such details, it seems, are unimportant in a universe of the imagination.

21. *In the imaginary universe:* The existing physical universe originated in a gigantic explosion: the Big Bang.

In the real universe: There was no Big Bang. The information now available does not indicate how the universe originated, or whether it had an origin.

In the singularity hypothesis the observed limits of gravitational contraction are ignored, and this concept is carried to the point of absurdity. In the Big Bang hypothesis the same treatment is accorded to the concentration of energy. We find from observation that the greatest concentration of energy (matter and the motion of matter) in the material sector of the universe is in a giant spheroidal galaxy containing somewhere in the neighborhood of 10^{12} stars, and we have reasons to believe, even without the positive information derived from the theory of the universe of motion, that this is a limiting concentration imposed by natural laws. The Big Bang theory ignores this limitation, and again the result is an absurdity: a hypothetical event whose antecedents are

completely unknown, whose mechanism cannot be explained, and whose results, as we will see in Chapter 30, do not agree with what we actually observe.

A comparison of the Big Bang theory (which describes the theoretical results of an *extremely large* explosion) with the astronomers' theory of the origin of black holes in supernova events (which describes the theoretical results of *large* explosions) provides a good illustration of the inconsistencies so prevalent in the imaginary universe. In their study of the ultimate fate of large stars, the theorists have produced a hypothesis, based on the concept of self-gravitation derived from Einstein's theories, that specifies the results of a supernova explosion. If the *same* hypothesis is applied to the Big Bang explosion, the result of the Big Bang will be an immense black hole, or singularity, surrounded by a relatively small amount of material expanding in space. This obviously is not the universe that we observe, so the astronomers simply repudiate Einstein and his gravitational theories, so far as their application to the Big Bang is concerned, and invent another, very different, theory for this special situation.

This concludes the description of the principal features of the imaginary universe that modern theorists have constructed to explain the phenomena that they have not been able to bring within the bounds of the current understanding of the universe of physical reality. It is not feasible to examine the immense amount of detail into which the development of this imaginary universe has been carried—the elaborate computer-designed fictitious evolutionary paths of the stars, for instance, or the remarkably detailed (but somewhat discordant) accounts of what happens in the first few seconds after the hypothetical Big Bang, the comprehensive description of the insides of the imaginary black holes, and so on—but the points that have been covered in the preceding pages should be sufficient to indicate the extent of this imaginary universe, and the major part that it plays in present-day physics and astronomy.

It should also be noted that this description is limited to those items with which most astronomers agree, as matters now stand. The imaginations of the theorists are by no means restricted to the areas that have been covered here. A host of books and articles are currently explaining in great detail the hypothetical properties of other non-existent entities and processes. "Holes" are the current fad, and new kinds are appearing in profusion. Some are merely variations of the plain black hole—mini black holes, superholes, rotating black holes, expanding black holes, etc.—while others step out boldly with new concepts: white holes, for example, or even "wormholes." The hypothetical conditions existing in the first minutes after the imaginary Big Bang are likewise high fashion at the moment, and are being called upon to provide explanations for the formation of galaxies, the origin of the background radiation, the production of those chemical elements that are not otherwise accounted for, and a variety of other items.

This is indeed a happy time for the theorists. They live in an era in which the universe of the imagination is the prevailing orthodoxy, and they are provided with a fertile field in which to work, one in which there are only a bare minimum of those inconvenient observed or measured facts that have been the downfall of so many of the cherished products of their less fortunate predecessors. The case in favor of the most typical features of the imaginary universe, such items as degenerate matter or singularities, is entirely negative; that is, it rests on the absence of any observational evidence that specifically *disproves* these hypotheses. Thus the farther one of these products of the imagination departs from reality, the easier it is to meet the requirements for acceptance by the scientific community.

One of the strangest features of the whole situation is that while the theorists are letting their imaginations run wild, and indulging in speculations of the most fantastic character, all in the name of science, they are religiously observing a taboo that prevents them from investigating the one hitherto unexplored area of the real universe in which the answers to many of their problems can be found: the region of speeds greater than that of light. There is nothing irrational or illogical about such speeds. Indeed, up to the beginning of the present century there was no suggestion that there might be any inherent limitation on speed. But Einstein has laid down an interdict that prohibits the exploration of the consequences of motion at speeds greater than that of light, and since a challenge to this ukase is unthinkable in the present-day scientific community, the astronomers are barred from even speculating about the immense field of physical existence at speeds greater than that of light, the field to which the entire latter half of this present volume has been devoted. Current physical and astronomical theory stops dead at the speed of light. Inductive reasoning, or exercise of the imagination, beyond this point are, in effect, prohibited.

The construction of the astronomers' imaginary universe has been a gigantic task because of the never-ending revisions, re-adjustments, and corrections that have been required by the new information continually being produced by the work of the observers and experimenters. Those who have participated in the undertaking are very proud of what has been accomplished, and those who are now chronicling their endeavors characterize them in superlatives, such as the following from Paul Davies, referring specifically to the elucidation of the hypothetical details of the epoch immediately following the imaginary Big Bang:

The study of this violent primeval epoch must rank as one of the most exciting intellectual adventures of modern science.³¹¹

No doubt this task has been exciting for those who have been engaged in carrying it out, and in this sense it is an "adventure," but the primary aim of

science is to increase our knowledge of nature, and from a scientific standpoint the psychological reactions of the investigators are irrelevant. The only legitimate scientific criterion by which the feats of the imagination involved in constructing the imaginary universe can be judged is whether or not they have, in fact, added to our knowledge of nature. They certainly have not done so directly, since false information is not an addition to knowledge. Perhaps these excursions into the land of fantasy may have stimulated some thinking along lines that eventually produced some items of real knowledge. However, it is more probable that the net result of the effort expended on the investigation of the properties of non-existent entities and phenomena has been to obstruct the advance of knowledge, rather than to facilitate it. As pointed out in the discussion of this subject in *The Neglected Facts of Science*, "It would appear that the main purpose served by inventing a theory is to enable the scientific community to avoid the painful necessity of admitting that they have no answer to an important problem."³¹²

In any event, there is no longer any need for a science fiction approach to astronomy. The development of the theory of the universe of motion has provided a solid foundation of positive knowledge and a comprehensive theoretical framework that enables fitting all of the observed phenomena into their proper places in the grand design.

The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that every entry should be supported by a valid receipt or invoice. This ensures transparency and allows for easy verification of the data. The second part of the document provides a detailed breakdown of the financial data, including a list of all accounts and their respective balances. It also includes a summary of the total assets and liabilities, which shows that the organization is in a strong financial position. The final part of the document contains a list of recommendations for future actions, such as improving internal controls and strengthening the relationship with key stakeholders. These recommendations are based on the findings of the audit and are designed to help the organization achieve its long-term goals.

CHAPTER 30

Cosmology

Long before the first records of human activity were scratched on rocks or indented into clay, the more thoughtful members of the human race were already wondering about the origin of the world in which they found themselves living, and about its ultimate fate. We know this to be true because these first records indicate that the thinking about such matters had already reached a rather high level of sophistication. That early thinking was, of course, purely speculative; the connection between the premises on which it was based and the conclusions that were reached was too nebulous to justify calling it inductive reasoning. Furthermore, these speculative ideas relied almost entirely on supernatural processes, and they were essentially religious in character.

In the course of time, as various fields of thought split off from religion, and secular branches of knowledge were originated, the questions as to the origin and fate of the universe came to be accepted as philosophical issues. Such subjects as cosmology and cosmogony were therefore defined, until quite recently, as subdivisions of philosophy. Within the present century, however, some physical phenomena have been discovered that are believed to have a bearing on these issues, and as a result, most of the theoretical activity in this area is now carried on in scientific terms, and even though it is just about as speculative as ever, it is regarded as scientific. As expressed by Hermann Bondi, "Nowadays we regard cosmology as a branch of science, or to be more precise, a branch of astronomy."³¹³

Bondi defines cosmology as "the field of thought that deals with the structure and history of the universe as a whole." An astronomy textbook gives this somewhat more explicit definition:

Cosmology is concerned with the nature and origin of the entire universe—its structure today, its past, and its future.³¹⁴

The scope of the subject, as thus defined, is greatly extended beyond the earlier objectives. We may, indeed, regard the modern additions to cosmology as a separate field of knowledge. This is the view taken by the *Encyclopedia Britannica*, which places cosmology under two separate headings:

“Cosmology, in astronomy” and “Cosmology, philosophical.” In this work the subject will be divided in essentially the same way. This chapter will examine the aspects of astronomy that are generally classed as cosmological, and Chapter 31 will then take up a consideration of the implications of our physical and astronomical findings on questions of a more philosophical nature.

Present-day cosmological theories can be described as variations of two themes. Ever since Hubble’s discovery of the recession of the distant galaxies, accounting for this recession has been regarded as the number one requirement of such a theory. The current favorite, the Big Bang theory, assumes that an enormous explosion at some time in the remote past hurled the entire contents of the universe out into space at the tremendous speeds now observed. One variation of this theory sees the expansion as continuing indefinitely, and the ultimate fate of the universe as a condition in which its constituent parts are separated by distances too great for any interaction. An alternative view is that the expansion will ultimately reach a limit, and will be succeeded by a contraction that will terminate with another Big Bang, the cycle being repeated indefinitely.

These theories based on a Big Bang are evolutionary in character. They depict the universe as undergoing a continual change from an initial to a final state, with or without a reversal, depending on the particular version of the theory. The Steady State theories, the only alternatives to the Big Bang that have been taken very seriously, portray the universe as unchanging in its general aspects. In fact, one approach to this type of theory bases it on a “Perfect Cosmological Principle,” which asserts that this uniformity is a fundamental principle of nature. In order to maintain the uniformity, the steady state concept, in its present form, requires the continual creation of new matter from which new galaxies can be formed to fill the spaces left vacant by the outward movement of the previously existing galaxies.

The fortunes of these rival theories have fluctuated as new observational discoveries have posed difficulties for one or the other of them, and as revisions of the theories have been made to accommodate them to the new information. As matters now stand, the steady state type of theory is at a low ebb. It has for years been contending against observational data which are asserted to indicate that there are more faint radio sources at great distances than would be found under steady state conditions. In 1965 it received another blow when an isotropic background radiation was discovered and attributed to the remnants of the Big Bang. The present tendency on the part of the astronomers is to conclude that the Steady State theories are “almost certainly excluded by two independent sets of facts,”³¹⁵ and to accept the Big Bang theory as having been established by default, there being no other contenders.

In view of the very limited amount of factual data available in this area, and the open questions as to the relevance of these data to the points at issue, the

near unanimity of astronomical opinion is clearly a bandwagon effect. As J. N. Bahcall pointed out in a recent (1971) article, “We frequently settle important scientific issues by acclamation rather than observation.”³¹⁶ The general acceptance of the Big Bang theory is a prize example of this wholly unscientific practice. A few words of caution are being heard. For instance, Bernard Lovell had this to say:

No one acquainted with the contortions of theoretical astrophysicists in the attempt to interpret the successive observations of the past few decades would exhibit great confidence that the solution in favour of the hot big bang would be the final pronouncement in cosmology.³¹⁷

Fred Hoyle states the case more bluntly. He tells us, “I have little hesitation in saying that a sickly pall now hangs over the big-bang theory.”³⁵¹ One of the problems involved in making a critical examination of invented theories is that they are generally vague enough to leave room for differences of opinion on major details—often on vital details. Current scientific literature is full of references to different “interpretations” of various theories of this type. The Big Bang cosmological theory is no exception. In fact, the differences between the interpretations of this theory are so extreme that these interpretations actually constitute different theories rather than different versions of the same theory. For this reason, the comments and criticisms that apply to one are not necessarily applicable to another. To cope with this situation we will first consider the original form of the theory, in which a highly concentrated aggregate of matter “explodes and ejects the galaxies in all directions.”³¹⁸ Subsequently we will give some attention to the more recent interpretations.

The principal objections to the original Big Bang theory, as seen in the context of conventional astronomical thought, without taking into account the new information derived from the theory of the universe of motion, which will be considered later, can be summarized as follows:

1. The Big Bang is pure assumption. There are no physical principles from which it can be deduced that all of the matter in the universe would ever gather together in one location, or from which it can be deduced that an explosion would occur if the theoretical aggregation did take place.
2. Theorists have great difficulty in constructing any self-consistent account of the conditions existing at the time of the hypothetical Big Bang. Attempts at mathematical treatment usually lead to concentration of the entire mass of the universe at a point. “The central thesis of Big Bang cosmology,” says Joseph Silk, “is that about 20 billion years ago, any two points in the observable universe were arbitrarily close together. The density of matter at this moment was infinite.”³¹⁹ This concept of

infinite density is not scientific. It is an idea from the realm of the supernatural, as most scientists realize when they meet infinities in other physical contexts. Richard Feynman puts it in this manner: “If we get infinity [when we calculate] how can we ever say that this agrees with nature.”²³⁵ This point alone is enough to invalidate the Big Bang theory in all of its various forms.

3. The scale of the magnitudes involved is far out of line with experience, or even any reasonable extrapolation from experience.
4. As noted in Chapter 29, the results attributed to the Big Bang are inconsistent with the physical and astronomical theories currently employed in application to supernova explosions.
5. It is difficult, if not impossible, to account for the isotropy of the observed universe on the basis of the Big Bang hypothesis. As expressed by Dennis Sciama, this is “a headache to the astrophysicist.”³²⁰ This problem is particularly acute in reference to the background radiation that is currently supposed to provide the best support for the theory.
6. The problem of the formation of the galaxies has never been solved in the context of this theory. “Moreover,” says W. H. McCrea, “those who have explored it most fully seem to be the ones who are most convinced that almost no progress has been made.”³²¹ H. L. Shipman concedes that this is a significant point. “Since galaxies exist, it is embarrassing that we can’t make galaxies in a hot, Big Bang cosmology.”³²²
7. The theory provides no explanation for a large number of physical phenomena that are directly connected with the evolution of the hypothetical explosion products.
8. Because of this lack of tie-in with observational information, the number of deductions that can be made from the theory is very limited. This minimizes the possibility of conflict with observation, and gives the impression that there are few criticisms that can be levied against the theory from the observational standpoint. In reality, however, what this means is that the theory cannot be tested.

This is a devastating list of criticisms to be levied against one of the most highly publicized elements of present-day astronomical thought. Most astronomers are reluctant to subject the currently favored hypotheses in their field to critical scrutiny, but it is obvious that these objections to the Big Bang demolish most of the arguments advanced in favor of that theory in its original form. A large segment of the astronomical community has therefore abandoned the original concept, and has substituted other, very different, ideas, retaining only the Big Bang name. We now find many assertions such as the following in the astronomical literature:

Many people (including some scientists) think of the recession of the

galaxies as due to the explosion of a lump of matter into a pre-existing void, with the galaxies as fragments rushing through space. This is quite wrong . . . the expanding universe is not the motion of the galaxies *through* space, away from some center, but is the steady expansion of space.³²³ (Paul Davies)

This conceptual change eliminates some of the serious objections to the original Big Bang hypothesis, but what does not seem to be realized by its proponents is that it also eliminates the explanatory character of that hypothesis. The original Big Bang is based on an analogy with observed explosions. Matter, we know, has an internal energy content that, under appropriate circumstances, can be released explosively. The Big Bang is assumed to accomplish such a release on a gigantic scale. But this explosive process propels matter *through* space, the effect that Davies specifically repudiates. In order to produce “steady expansion of space” explosively it would be necessary to have either a means of applying the energy of matter to space, something that is totally foreign to physical science as we know it, or a source of energy in space itself, something of which there is no indication whatever. Consequently, there is neither observational nor theoretical justification for the assumption that the concept of an explosion is applicable to space. Thus the new version of the Big Bang expressed by Davies eliminates the “bang.” In fact, it eliminates all explanatory content from the hypothesis, and reduces it to nothing more than a restatement of the observational situation. It merely asserts that the space between galaxies is continually increasing.

Another alternative to the original hypothesis calls for replacing the Big Bang with a multitude of little bangs.

The theory seems to call for enormous numbers of small bangs . . . all essentially simultaneous, close together, and nearly identical.³²⁴ (Lyman Spitzer, Jr.)

This suggestion avoids the fatal weakness of the space expansion version of the Big Bang described by Davies, but only at the expense of introducing many other problems, such as the question as to how the explosions are synchronized, the exacerbation of the isotropy problem, etc. Consequently, the little bang hypothesis has received little attention thus far. The principal significance of the present-day swing away from the original Big Bang concept in all but name is that it demonstrates a recognition on the part of those who are supporting the revised hypotheses that the objections to the original Big Bang are insurmountable.

An examination of the astronomers’ Steady State theory, again without considering the new knowledge made available by the development reported in

this work, discloses the following major objections:

1. In this theory the expansion is a pure assumption. No mechanism for accomplishing it is provided.
2. The theory requires the continuous creation of matter, which conflicts with the conservation laws. Like the concept of infinite magnitudes, this is a resort to the supernatural.
3. The theory has no explanation for the formation of galaxies, a key factor in the events that this theory purports to explain.
4. The theory has no explanation for the observed background radiation (aside from a suggestion by Fred Hoyle³²⁵ that approximates what we now find to be the true explanation, but was not taken seriously).
5. In this theory the oldest galaxies are removed from the system by “disappearing beyond the time horizon” to maintain the unchanging galactic composition. This hypothesis breaks down when the galaxy from which the universe is being observed becomes the oldest within the observational limits. Thereafter the age of the oldest galaxy within these limits continually increases, violating the basic premise of the theory.
6. The theory provides no explanation for a large number of physical phenomena that are directly connected with the evolutionary pattern that it predicts.
7. Because of this lack of detail, it is untestable.

A critical examination of this “theory” quickly shows that it is not a theory, nor even a hypothesis. It is merely an unelaborated idea, the idea that is contained in what is known as the Perfect Cosmological Principle. Most astronomers accept, at least on a tentative basis, the Cosmological Principle, which asserts that the universe appears the same, aside from small scale irregularities, from all locations in space. The Perfect Cosmological Principle extends this idea to include the assertion that it likewise appears the same from all locations in time. This extension has considerable appeal on broad philosophical grounds, but in order to give it the status of a cosmological hypothesis that can be subjected to scientific tests of its validity, it is necessary to identify and postulate mechanisms whereby the uniformity that is called for can be maintained. There are four major requirements: (1) a source of raw material for the formation of new galaxies, (2) a mechanism for accomplishing this formation, (3) a mechanism for implementing the galactic recession, and (4) a means of removing the over-age galaxies from the system.

The Steady State “theory” proposed by a group of astronomers does not come anywhere near providing these details that would convert it from a mere idea into a testable hypothesis. Its protagonists have suggested a continuous process of creation as the source of the new matter, and have offered a process of disappearance over the time horizon as an answer to the problem of

removing the over-age galaxies. The latter, as already noted, is unacceptable. No attempt has been made to account for the formation of galaxies, or for the observed recession, in the context of the theory.

The Big Bang is a full-fledged hypothesis—not merely an idea like its competitor—but if cosmology is to deal with the universe as a whole, as indicated by the definitions quoted earlier, it is *not* a theory of cosmology. It deals only with the origin of the universe and with the galactic recession, aside from a misapplication of the second law of thermodynamics, and says nothing at all about the large number and variety of phenomena that constitute the activities of the universe as a whole. Calling it a cosmological theory is equivalent to asserting that the galactic recession is the only thing of any significance that occurs in the universe subsequent to its origin.

It should be evident that, even on the basis of previously available observational information, without the benefit of the new knowledge contributed by the theory of the universe of motion, neither of these present-day cosmological theories is anywhere near tenable in its present form. The only justification for giving either of them any consideration at all is the rather tenuous possibility that a continuing effort to overcome, or at least minimize, their many shortcomings might eventually result in the construction of a viable theory by a process of modification. But the case for these theories is not currently being argued on these grounds. What we are being told is that there is no alternative.

When astronomers express dissatisfaction with both the Big Bang and the Steady State concepts of the universe, they are in trouble, because it is hard to imagine radical alternatives.³²⁶ (Nigel Calder)

On the next page of his book, however, the author makes a statement that illustrates where the trouble lies: why alternatives to these untenable theories are so hard to find. “The only way any anyone has thought of to avoid this conclusion [that the contents of the universe were formerly much more closely crowded together than they are now],” he says, “is to suppose that . . . less matter existed in the universe than does now.”

Here again we meet the ubiquitous “only way” argument. As in so many similar cases examined in the earlier pages of this and the preceding volumes, the so-called “only way” has that status only if it is assumed that the relevant portions of currently accepted physical and astronomical theory *are correct in all respects*. This is a totally unwarranted assumption. Any impasse such as that which exists in this case calls for a critical examination of the premises on which the accepted view of the situation is based. The long list of cases in which the investigation reported in this work uncovered new alternatives where it had been generally accepted, on the basis of assurances from Einstein and other leading scientists, that no such alternatives existed, is a graphic

illustration of the need for a more critical examination of the *foundations* on which the current ideas rest.

What makes alternatives to the existing ideas so difficult to find is that a totally new view of some essential element in the situation is usually required before the alternative possibilities can be recognized. It is quite unlikely that the author of this work would have been able to identify all of the many previously unrecognized alternatives that have provided the answers to long-standing problems discussed in these volumes if he had not had the benefit of a general physical theory that enabled him to arrive at these alternatives by a straightforward process of deduction. The cosmologists have been at a disadvantage, in that they have not had any assistance of this kind. The Big Bang and Steady State theories are the only alternatives that they have been able to see *in the context of the current physical and astronomical theories*, and they have not explored the possibility that these theories might be wrong. Their inability to see the true picture is understandable, but this does not make their conclusions any more acceptable. As this work has demonstrated, astronomy has not yet produced enough data on which to build a tenable cosmological theory, and there is no indication that it is likely to do so in the foreseeable future.

The present data in cosmology are still limited, ambiguous, and fragmentary, and they all depend on complex instruments stretched right to the limits of their sensitivity and performance.³²⁷ (Martin Rees)

A significant feature of this situation is that the spectacular increase in the scope and quantity of observational information in the astronomical field in the last few decades has not resulted in any significant progress toward an understanding of the cosmological problem. The case in favor of any cosmological theory is still being argued mainly on the basis of the shortcomings of the alternatives. Each step forward from the observational standpoint seems to introduce new difficulties. This accumulation of unsolved problems is a clear indication of the need for new ideas. In his book, *The Structure of Scientific Revolutions*, Thomas Kuhn points out that the need for a new and better theory is generally indicated by "a state of growing crisis."

The emergence of new theories is generally preceded by a period of pronounced professional insecurity. As one might expect, that insecurity is generated by the persistent failure of the puzzles of normal science to come out as they should. Failure of existing rules is the prelude to the search for new ones.³²⁸

The existence of such a crisis in astronomy and cosmology is revealed by the current reactions to the inability of accepted theory to deal with the many

problems now confronting these disciplines. More and more scientists are coming to realize that some *basic* changes in the existing structure of theory will be required. Typical of the comments now being made in increasing numbers are the following:

In some places, too, the extraordinary thought begins to emerge that the concepts of physical science as we appreciate them today in all their complexity may be quite inadequate to provide a scientific description of the ultimate state of the universe.³²⁹ (Bernard Lovell)

It [radio astronomy] is at present producing more and more data that cast more and more doubt on the big bang and other evolutionary cosmologies, and it will probably continue to do so until someone is able to propose an entirely new approach to cosmology; for example, proposing a new physical law whose consequences can be tested by astronomers.³³⁰ (G. Verschuur)

Clearly, the physics of radio galaxies and quasars, the nature of the red shift, and perhaps fundamental physics itself are being questioned by these measurements [recent radio observations].³³¹ (K. I. Kellerman)

Astronomers are looking more and more toward a revision of *physical theory* as an answer to their currently outstanding problems. In the statements quoted above, Lovell suggests that the *concepts of physical science* may be inadequate; Kellerman says that *fundamental physics* is subject to question; and Verschuur predicts that a *new physical law* will be required. The physicists do not offer much resistance to these conclusions. They have problems of their own that are equally as recalcitrant as those that baffle the astronomers, and they realize that their theories are in need of some overhauling. Feynman, for instance, tells us that "All the principles that are known are inconsistent with each other, so something has to be removed."³³² He defines the problem in these terms: "We have to find a new view of the world that has to agree with everything that is known, but disagree in its predictions somewhere . . . and in that disagreement it must agree with nature."²⁹⁴

As Feynman concedes, this is an "extremely difficult" assignment. The irony of the situation is that the greater part of the difficulty is not inherent in the problem; it is gratuitously introduced by the investigators themselves. Feynman's statements show just where the trouble lies. When he says that the "new view . . . has to agree with everything that is known," he is using the word "known" in the sense of "positively established." This is the only sense in which the statement is valid. But when he says that "the principles that are known are inconsistent with each other," he is using the word "known" in the sense of "currently accepted."

The practice of elevating the popular opinion of the moment to the status of established truth is the root of the present difficulty. It not only stands in the

way of finding the answers to unsolved problems, but also prevents recognition of those answers if and when they are obtained in spite of all obstacles. Replacement of an erroneous theory of long standing is difficult enough without this unnecessary handicap, as scientists, like their counterparts in other fields of human activity, are reluctant to change ideas to which they are accustomed. In principle, new ideas are welcome, but in practice those that disturb previous lines of thought encounter an atmosphere of hostility. The following comment by Geoffrey Burbidge, reported in a news item, describes the existing situation:

As is always the case when scientific questions are really fundamental, new ideas which, if they prevail, will overturn the old ones, are resisted by all means, in the name of science, but by any means that come to hand.³³³

The theory derived from the postulates that define the universe of motion, and presented in this work, encounters this antagonism in full force when it is extended into the astronomical field, because it conflicts with many cherished ideas, some of very long standing. The astronomers should realize, however, that when they reach the point where they have to hoist the distress signal, and call for help by way of a “drastic revision” of physical theory, they must expect some similar major changes in astronomical theory. The changes required by the theory of the universe of motion are far-reaching, to be sure, but nothing less will serve the purpose.

While the case in favor of this new theory is affirmative; that is, it is demonstrated in the preceding pages that the physical universe does, in fact, conform to the principles and relations derived from the postulates of the theory, the new findings that have emerged from the development of the consequences of the postulates have added still further dimensions to the case against both of the astronomers’ cosmological theories. For example, the finding that matter is subject to a destructive temperature limit precludes the existence of a concentration of matter such as that assumed in the Big Bang hypothesis. Likewise, the finding that the net motion of the galaxies is *inward* within the gravitational limits, and outward in *two* dimensions beyond 1.00 redshift, rather than always outward in three dimensions, invalidates the recession explanation in all versions of the Big Bang. These examples could be multiplied manifold.

The universe of motion described in this work is a universe of the steady state type. It conforms to the Perfect Cosmological Principle on which the astronomers’ Steady State theory is based; that is, the large-scale features of the universe are unchanging, both in space and in time. But it is also evolutionary, differing from the Big Bang theory in that the evolution is a continuing process: a cyclic evolution rather than a linear evolution. This

cyclic feature eliminates the need for continuous creation of matter, one of the principal objections to the astronomers' Steady State theory, while it also negates the prediction of a cold and lifeless ultimate state of the universe, a feature of the original Big Bang theory that is philosophically distasteful to many scientists. Thus the cosmological aspects of the theory of the universe of motion combine the more desirable features of the astronomers' cosmological theories, while avoiding the most objectionable aspects of each.

Unlike its predecessors, which, as noted earlier, are limited to providing explanatory hypotheses for only a few of the cosmological aspects of the universe, the results of the theoretical development now being described constitute a comprehensive cosmological theory in which the evolutionary development of the constituents of the universe— atoms, molecules, stars, galaxies, etc.—is an integral part of the cosmological process. This understanding derived from the theory of the universe of motion participates in the proof of the validity of the theory as a whole that is accomplished by the application of the probability relations. It may, however, be of interest to supplement this proof by a summary of the items that are relevant to the validity issue. Most of the content of such a summary can be expressed by the statement that *none* of the objections against either the Big Bang or the Steady State theory identified in the preceding pages is applicable to this cyclic theory. The following additional points should be noted:

1. No ad hoc assumptions are employed. *All* conclusions are derived deductively from the postulates that define the universe of motion.
2. The expansion of the material sector of the universe, as indicated by the recession of the distant galaxies, is a direct consequence of these postulates.
3. The high degree of isotropy of the matter in the universe is a result of the fact that the matter entering from the cosmic sector is distributed in space in accordance with probability considerations.
4. The background radiation currently attributed to the remnants of the Big Bang is the cosmic equivalent of starlight and other observed radiation of the material sector. It is isotropic because it is emitted by cosmic sector matter that is aggregated in time but dispersed in space.
5. The formation of stars, star clusters, and galaxies is a logical and natural part of the aggregation process deduced theoretically.
6. No creation of matter is required.
7. No special scheme for getting rid of the mature galaxies is necessary. The existing matter moves in a closed system.
8. The cosmological theory is a part of a *general* physical theory, applicable to all physical phenomena. There are innumerable opportunities to test its validity by correlation with observation.

This item number 8 is the key element in the whole situation. As Martin Rees pointed out in a statement quoted earlier, the serious handicap under which present-day cosmology labors is the lack of an adequate supply of relevant and reliable data. Without a solid base from which to work, no refinement of the reasoning process will enable reaching correct conclusions. Irwin Shapiro makes this comment:

All chains of reasoning in cosmology are elastic. Almost any observation interpreted to support one conclusion can, in the hands of a moderately adroit theoretician, be reinterpreted to support the opposite.³³⁴

The availability of a general theory of the physical universe now supplies the solid theoretical foundation that has been lacking, not only in cosmology, but in astronomy as well. This fully integrated theoretical structure applicable to the entire range of physical phenomena throughout the universe enables formulating the general physical principles from purely theoretical premises, and verifying them in areas that are readily accessible to observation. We are then able to apply them with confidence to the fields such as cosmology where the information from observation is meager, or, in many cases, non-existent.

CHAPTER 31

Implications

A scientific theory, such as the one described in the several volumes of this work, the theory of the universe of motion, consists of a set of assumptions that define the theory, together with the consequences of these assumptions, developed by applying logical and mathematical processes to the basic premises. The ordinary scientific theory covers only a limited portion of the total scientific field, and it is therefore an addition to established scientific knowledge rather than an independent structure. Hence it necessarily utilizes various items from the currently accepted body of scientific knowledge in the development of its consequences. The theory of the universe of motion, on the other hand, deals with the physical universe as a whole, and is entirely self-contained. All of the conclusions as to the consequences of this theory are derived from the basic postulates without introducing anything from any other source.

We have now arrived at the point, however, where it should be recognized that the foregoing statement applies to the theory of the universe of motion *as a scientific product*. Science itself is not entirely self-contained. In order to make scientific investigation possible, and to give meaning to the results thereof, it is necessary to make certain preliminary assumptions of a philosophical nature. The validity of these assumptions is accepted by the workers in the field of science as a condition of becoming scientists, and since these assumptions form a background for all scientific work, they are not ordinarily mentioned in scientific discourse, except in those instances where the topics under consideration are on the borderline between science and philosophy. In this concluding chapter of the present volume we will undertake to examine some of the questions that arise along this borderline, and in preparation for that examination we will want to look at the philosophical underpinnings of physical science: “the metaphysical presuppositions of science,”³³⁵ as one writer calls them. These include the following:

- (a) It is assumed that the universe is rational.
- (b) It is assumed that the same physical laws and principles apply throughout the universe.
- (c) It is assumed that the results of specific physical actions are

reproducible.

- (d) It is assumed that the subject of scientific investigation is an objectively real universe.
- (e) It is assumed that physical changes (effects) result from causes.
- (f) It is assumed that the results of scientific investigation, when verified in accordance with standard scientific practice, are certain and permanent.
- (g) It is assumed that the laws and principles of the physical universe are, in effect, restrictions, and that whatever they do not prohibit exists.

Most members of the scientific community simply take these assumptions as axiomatic. Indeed, the great majority of rank and file scientists would be quite surprised to find that anyone questions such assumptions as the rationality of the universe, for example. But some exceptions have been taken to specific items in the list, mainly by individuals who are particularly interested in the philosophical aspects of science. An element of uncertainty has thus been introduced into the substratum of physical science. The development of the theory of the universe of motion has now clarified this situation, and has demonstrated that the criticisms of these basic assumptions are invalid. It appears, however, that a few of the criticisms that have been offered are of sufficient interest, in view of the publicity that they have received, to warrant some discussion in this work. The assumptions to which the following comments refer are identified by the same letter symbols that were used in the earlier listing.

(a) If the universe were not rational, the scientific objective of arriving at a systematic understanding of the activities of the universe would be an impossible task. It is true that, as noted in Chapter 29, some prominent scientists have characterized the realm of the very small as irrational, but what this amounts to is excluding this domain from the scientific field. Our findings indicate that this exclusion is unnecessary.

(b) In present-day practice, the Principle of Uniformity, as we may call it, has not been accepted in its entirety, because the theorists have been unable to find explanations on this basis for the phenomena of some special areas, such as the sub-atomic region or the interiors of the stars. However, it is accepted in a kind of a selective way, and regarded as applying whenever it does not inconvenience the theorists, but leaving open the possibility of deviations in special situations. The clarification of the physical relations in the far-out regions that has been accomplished by the development described in this work has now shown that there are no exceptions to this general principle. The difficulties in the special areas that have led to suggestions as to exceptions have been due to inadequate understanding of the phenomena in these areas.

(c) The assumption of reproducibility is usually stated in terms of the reproducibility of experiments, but it is equally applicable to any other type of physical action.

(d) One school of philosophy contends that the universe exists only in our minds. This is a difficult position to contravene, as its defenders can simply extend it to apply to the premises of any adverse argument. But as scientists, we can dismiss this point of view as irrelevant. A subjective universe cannot be distinguished from an objectively real universe by any means at our command, and from a scientific standpoint where there is no distinction there is no difference.

A modification of this point of view that has some support among scientists concedes reality only to the information received by the senses. The advocates of this interpretation point out (correctly) that we do not perceive physical objects directly; we have direct knowledge only of the “sense-data.” Our concepts of physical objects are theoretical constructs based on these data. The conclusion that they have drawn from this is that only the sense data have objective reality, and that all else is a creation of the human mind. As expressed by G. C. McVittie:

A preferable alternative to the doctrine of the rational External World is to regard science as a method of correlating sense-data . . . On this view, the corpus of sense-data may, or may not, form a rational whole, but the human mind by selecting classes of data succeeds in grouping them into rational systems . . . Unobservables such as light, atoms, electromagnetic and gravitational fields, etc., are not constituents of an independently existing rational External World; they are but concepts useful in the manufacture of systems of correlation.³³⁶

Other observers have adopted an intermediate position, conceding reality to some features of the universe, primarily macroscopic objects, but denying the reality, in this same sense, of other features—atoms and electrons, for example. Heisenberg cautions us specifically that we must not regard the smallest parts of matter as being objectively real in the same sense in which rocks and trees are real.³³⁷ “Atoms are neither things nor objects,” he says, “atoms are parts of observational situations.”³³⁸ In another attempt to describe this strange half-world in which the “official” school of modern physics places the basic units of matter, he characterizes the atom as “in a way, only a symbol.”³³⁹

The theory of the universe of motion has provided a definitive answer to these questions about reality. There *is* an external universe independent of the human race, and independent of any observations that they may make. The physical universe is a universe of motion; that is, *motion is the reality* of which the universe is composed. Motions and combinations thereof are therefore “real” in any ordinary sense of the word. The relations between these motions have a somewhat different status, and whether they can be considered real depends on how that term is defined. In any event, some of the

“unobservables” of modern physics, the nucleus of the atom, for instance, are wholly non-existent. Some, such as electromagnetic and gravitational fields, are merely special ways of looking at physical situations—that is, describing the relations between motions—and belong in the same category in which we place such concepts as the center of gravity or the poles of the earth. But the smallest subdivisions of matter, the atoms and sub-atomic particles, have exactly the same claim to reality as the largest aggregates of matter; the smallest subdivisions of electricity, the electrons, have the same claim to reality as the heaviest electric currents; and so on. Whether or not the entity in question is observable, as matters now stand, is irrelevant.

It should be understood, however, that reality, as defined above, is *physical* reality; that is, the reality of the universe of motion. This does not necessarily exclude the possibility that there may be reality of a different nature: a non-physical reality.

(e) The same frustrations that have led modern scientists to invent theories where their efforts to apply inductive reasoning to their problems have encountered difficulties have also impelled them to jettison any of the previously accepted scientific or philosophical principles that might happen to stand in the way of the inventions. Some are even ready to discard logic, one of the foundations of the structure of scientific knowledge. For example, F. Waismann asserts that “Quantum physics presents a strong case against traditional logic”,³⁴⁰—an upside down conclusion, if there ever was one. But the favorite target of those who seek to make things easier for the theorists is the connection between cause and effect.

Like Waismann, most of the others who are attempting to brush aside those principles that stand in the way of the currently fashionable ideas rely primarily on the quantum theory, with some assistance from relativity and other theoretical products of the modern era, according these theories a status superior to that of the previously accepted principles. As it happens, this quantum theory that is now being used as ammunition with which to attack some of the essential features of traditional scientific procedure is itself based on a sound principle, existence only in discrete units, that was derived by one of these standard scientific procedures: generalization of empirical findings. The development of the theory of the universe of motion has now shown that this discrete unit principle is one of the key elements in the basic framework of the physical universe. But because conventional science is unaware of the directional reversals that take place at the unit levels, it has not been able to arrive at a theoretical explanation of events inside unit distance that is consistent with the established laws of physics. This put the theorists in a position where it seemed that they either had to give up quantum theory or sacrifice some of the established philosophical principles. They chose the latter course, and quantum theory, as now constituted, not only defies logic, but also causality and continuity of existence (that is, it asserts that an object

may exist at point A at one time and at point B at another time without having been anywhere in the interim). The abandonment of causality is particularly stressed by the expositors of the theory, as in the following statement:

Whenever he [the physicist] penetrates to the atomic, or electronic level in his analysis, he finds things acting in a way for which he can assign no cause, for which he can never assign a cause, and for which the concept of cause has no meaning, if Heisenberg's principle is right. This means nothing more nor less than that the law of cause and effect must be given up.³⁴¹ (P. W. Bridgman)

In the universe of motion all entities and phenomena are motions, combinations of motions, or relations between motions. It follows that any physical event X involves modification of an existing motion combination A by another motion or combination B. Motion B is then the cause of event X. However, the initial combination A was itself the result of a previous event Y in which a then existing motion combination C was modified by a motion D to produce combination A. Thus D can also be regarded as a cause of event X. In fact, any physical event has what amounts to an infinite number of causes. This event is the intersection of two or more causal systems, and might be compared to a major river, which is the result of continual joining of the products of intersection of an almost infinite number of rivulets. Thus the conclusions of quantum theory leading to the abandonment of causality must be rejected.

In this connection, however, it is necessary to distinguish between causality and determinism. "There is some disagreement among scientists about the concept of causality. Among many it is essentially equivalent to the notion of *determinism*."³⁴² (R. B. Lindsay) But there is a distinct difference between the two concepts. Causality implies nothing more than the existence of a cause for every physical event. Determinism includes the further premise that the same cause applied to the same kind of a situation always produces the same result. In the universe of conventional science, which is a universe of matter, non-material causes act upon material "things," and there are grounds for concluding that the same cause should produce the same effect if applied to the same thing under the same conditions. However, the real world does not act in this manner, and the reaction of "modern science" has been to throw the baby out with the bath water; that is, to reject causality.

Our finding that both matter and non-material phenomena are manifestations of motion now resolves the problem. On this basis, cause and effect are simply aspects of the interaction of motions. Causality is maintained in all cases, because a motion cannot be changed except by an interaction with another motion (since nothing exists but motions). But, as we have seen in the preceding pages, there are continual interchanges between different kinds of

motion—between scalar and vectorial motion, between one-dimensional motion and two or three-dimensional motion, between motion in space and motion in time—and many of these interchanges involve redetermination of direction or magnitude by chance processes. Because of this intervention by chance, the exact results of such interactions are unpredictable. Thus, while causality is maintained throughout the physical world, determinism is ruled out.

(f) On the basis of this assumption, physical science has a permanent, and ever-growing, core of positively established knowledge. This is the view of traditional science, a view that is still accepted by the great majority of scientists. But the general relaxation of scientific standards that has accompanied the introduction of inventive theories in modern times has confused the situation to the point where there is no longer any clear distinction between today's best guess and established fact. This has led to a contention on the part of some scientists and philosophers that *no* scientific findings are positively established, an assertion that is welcomed in some quarters because it tends to excuse the deficiencies of many unverified theories. "The notion that scientific knowledge is *certain* is an illusion,"³⁴³ says Marshall Walker.

This point of view is based largely on an unrealistic concept of "certainty." It is true that no physical statement can be verified with what we may call *mathematical certainty*, in which the probability of error is zero. Because of the nature of physical observations, the best that we can do in *any* physical situation is to arrive at a point where the probability of error is negligible, a *physical certainty*, we may say. But from a practical standpoint, this physical certainty is fully equivalent to mathematical certainty. Drawing a distinction between the two is meaningless hairsplitting. A theory is verified when its validity is established with physical certainty.

In this connection, it is important to recognize that scientific statements can be verified only if they are properly expressed so that they stay within the limits to which comparisons with observation can be made. Much of the erroneous thinking in this area is due to a lack of precision in defining the items that are involved. For example, we cannot ordinarily verify a statement in the form $y = 3x$, where x and y are physical variables (unless this proposition can be incorporated into one of greater scope that can be verified as a whole). In order to be verifiable, the statement will usually have to be put into the form: Within the limits $x = a$ and $x = b$, $y = 3x$ to an accuracy of one part in 10^z . When thus expressed and validated by comparison with the results of observation, this statement constitutes exact and permanent knowledge, regardless of whether some future findings may show that the relation is invalid somewhere outside the limits specified, or that there is a deviation of less than one part in 10^z under some circumstances. As Lecomte du Nouy points out, "science has never had to retract an affirmation based on facts that are well established within accurately defined limits."³⁴⁴

In support of his assertion that there is no certain scientific knowledge, Walker tells us that “New models are often quite radically different from their predecessors, and often require the abandonment of ideas that have long been considered obvious and axiomatic.” This comment illustrates one of the common errors in thought that underlie the denial of scientific certainty. Walker bases his conclusion on the observation that many “models” and presumably “obvious and axiomatic” ideas ultimately had to be abandoned. But the truth is that few models ever qualify as scientific knowledge. Models do not attempt to cover all aspects of the phenomena with which they deal (if they did, they would be theories, not models), and consequently they are *inherently* erroneous, either in part or in their entirety. The failure of these models to stand the test of time therefore has no relevance to the status of firmly established knowledge. Likewise, if an assertedly “obvious and axiomatic” idea can be definitely verified, it then constitutes scientific knowledge, and is both certain and permanent. If it fails the test of comparison with the observed facts, then it is not, and never was, “obvious and axiomatic,” nor is it scientific knowledge, and the necessity of discarding it has no significance in the present context.

(g) This principle is commonly expressed in the statement that “What can exist does exist.” K. W. Ford puts it in this manner:

One of the elementary rules of nature is that, in the absence of a law prohibiting an event or phenomenon, it is bound to occur with some degree of probability. To put it simply and crudely: Anything that *can* happen *does* happen.³⁴⁵

This author uses the word “happen” rather than “exist,” but as he notes in another connection, at the basic level “there is no clear distinction between what is and what happens.”³⁴⁶

This principle is not as well known, as a principle of nature, among scientists in general as those previously discussed, but they all employ it, usually unconsciously, in a great variety of applications. It is this principle that provides the justification for interpolation and extrapolation. It has been the key factor in such theoretical anticipations as Mendeleev’s prediction of previously unknown elements, Dirac’s prediction of the positron, and myriads of other, less dramatic, scientific advances. And it is the essence of the lines of reasoning that are being employed in the current attempts to evaluate the possibility of life elsewhere in the universe. As can be seen in these illustrations, the absence of a prohibition is first established in one area. The principle that what can exist does exist is then invoked to justify the assertion that the phenomenon in question also exists in the other areas.

The validity of this principle, in application to the physical universe, has been clearly established by our findings. In many cases, entities or phenomena that

would otherwise exist, on the basis of this principle, are excluded by adverse probabilities or other specific factors. Aside from these exclusions, all of the entities or phenomena that are theoretically possible within the area thus far covered in the investigation have their counterparts in the observed physical universe. It is true that only a relatively small portion of the universe as a whole has been examined in the context of the new theoretical system, but the area of coverage includes the basic phenomena of all of the major subdivisions of physical science, and many thousands of individual items. The probability that there is any violation of this principle anywhere in the universe has thus been reduced to a negligible level.

Addition of these philosophical principles to the physical knowledge set forth in this and the preceding volumes now puts us in a position where we are able to arrive at answers to some long-standing questions about fundamental issues. We will begin with

1. Is the physical universe finite or infinite?

In past discussion of this subject it has usually been assumed that the question reduces to a matter of whether or not *space* is finite. Those who favor the finite alternative generally envision some kind of a space curvature, a geometry that permits space to be finite, yet unbounded. As brought out in Volume I, space as ordinarily conceived—extension space, in terms of this work—is not a physical entity. It is merely a reference system, a purely mental construction. As such, it can be thought of as infinite. But the space that actually exists in a physical sense is the space aspect of the existing motion of the universe. The question as to whether *this* space is finite or infinite therefore becomes a question as to whether the amount of *motion* in the universe is finite.

The finding that the activity of the universe is cyclic answers this question immediately. A cyclic system is a closed system; it is finite. In the universe of motion, spatial structures exist only for a limited time; that is, a limited segment of the time progression. Temporal structures (in the cosmic sector) exist only during a limited segment of the space progression.

The principal obstacle that stands in the way of acceptance of the idea of a finite universe is the observed outward motion of the photons of light and other electromagnetic radiation. On first consideration, it would seem that, regardless of what the aggregates of matter may be doing, the radiation is being dispersed outward into space, and is eventually lost from the universe as we know it. But we now find that this apparent outward movement of the photons is an illusion due to the inward movement of the gravitationally bound system from which we are doing our observing. The photons actually have no capability of independent motion. This is why the physicists have never been able to find a mechanism for the “propagation of radiation.” There is no such

propagation, and therefore no need for a mechanism. The prevailing impression is that Einstein provided an explanation for this phenomenon, but, in fact, what he did was to dismiss the problem as too difficult. In a statement quoted in Volume I, he characterizes the situation in this manner:

Our only way out . . . seems to be to take for granted the fact that space has the physical property of transmitting electromagnetic waves, and not to bother too much about the meaning of this statement.³⁴⁷

Since the photons of radiation remain at their points of origin, in the natural system of reference, their ultimate fate is not to be lost in the depths of space, as observations from our locations in the universe of motion appear to indicate. We are doing our observing from locations that are moving inward at high rates of speed, and our observations are distorted accordingly. All photons remain in the space over which the matter of the universe is distributed. It follows that they must ultimately encounter, and be absorbed by, matter. They are then transformed into thermal motion, or participate in the atom building process by which radiation is reconverted into matter. A small fraction of the total are able to pass into the cosmic sector, appearing there as a “background radiation” of the type discussed in Chapter 30.

2. Did the universe evolve from a primitive condition, or has it been in the same condition in which we now observe it during its entire existence?

The results of the development of theory in the preceding pages of this and the previous volumes are consistent with either of these alternatives. The evolution in each sector begins with matter in a primitive dispersed condition, but it does not necessarily follow that there was ever a time at which *all* matter was in this condition. In any event, even if the universe did originate in a primitive condition, theoretical considerations indicate that it would eventually arrive at an equilibrium such as that which now appears to exist.

3. Did the universe have a beginning, or has it always existed?

The two parts of this question are not mutually exclusive, as they appear to be. We can answer the second part affirmatively, but this does not necessarily mean that the answer to the first part is negative. Such words as “always” and “before” presuppose the existence of time. “Always” means “during all time.” “Before” means “at an earlier time.” The universe has always existed; that is, it has existed throughout all time, because time exists only as a constituent of that physical universe.

In the sense in which it is being asked, the first part of this question is meaningless, as it assumes that the existence of time is independent of the

existence of the universe. Whether or not the question might have a real significance on the basis of something other than a sequence in time is beyond the scope of the present work.

4. Will the universe eventually come to an end?

All individual objects in the physical universe, including the earth and the solar system, have finite life spans, and their existence will eventually terminate. But there is nothing in the physical system that would end the existence of the universe as a whole. The physical universe is a self-contained, and self-perpetuating mechanism. It will continue on the present basis indefinitely, unless it is destroyed by some outside agency. The question as to whether any such outside agency exists will be considered later.

5. Was the universe created by some agency?

The development of theory in this work sheds no light on the question of creation. The only thing that exists in the physical universe is motion. Our theory, as it now stands, defines what motion *is*, and what it *does*, but not how it originated, or whether it had an origin. Since time, in a universe of motion, exists only as an aspect of that motion, the universe and time are coeval. On this basis, the universe has existed always—during all time—regardless of whether or not it originated from an act of creation. Neither the theory of the universe of motion, nor the many hitherto unrecognized physical facts uncovered during its development, gives any indication as to whether a creation occurred. This remains a wide open question, so far as science is concerned.

6. Is the activity of the physical universe purposeful, or is it simply mechanistic?

The finding that the physical universe consists entirely of a finite quantity of motion means that it is purely mechanistic. However, this does not preclude the possibility that the *existence* of this machine may have a purpose. This is an issue on which our study of the mechanism sheds no light, although it does clear the way for a study of the problem.

7. Is the human race merely part of the machine, or does it, in some way, have an independent role?

Conventional science takes a somewhat ambivalent attitude toward this question. It portrays the universe as strictly mechanistic, and yet introduces the concept of an “observer,” whose presence is presumed to have a

significance with respect to the outcome of physical processes. The effect of the new information derived from the development of the theory of the universe of motion on our understanding of the relation of the human race to its physical environment has been explored in connection with an extension of the physical investigation into the non-physical fields, the results of which will be reported in a separate publication.

8. Are we alone, or is there intelligent life elsewhere in the universe?

This is a long-standing question that has entered a new phase since the development of communication processes that are, at least potentially, capable of transmitting and receiving messages from distant planets. It is now a lively subject of discussion and speculation, and some steps have been taken toward a systematic search for evidence of extra-terrestrial life. This question can be subdivided into the following three parts:

1. Are there other locations in the universe in which the physical conditions are suitable for the existence of life?
2. Does life necessarily develop in some fraction of the suitable locations?
3. Where life exists, does it necessarily evolve into intelligent life under the most favorable conditions?

The results obtained from the theory of the universe of motion enable giving an affirmative answer to the first of these subsidiary issues. As brought out in Chapter 7, our findings indicate not only that there are an enormous number of planetary systems, but also that the planets in these systems are distributed in distance from their controlling stars in accordance with Bode's Law (as revised). This means that the great majority of the systems include at least one planet within the habitable zone, a planet that may be suitable for the development of the higher forms of life.

Inasmuch as the results reported in the several volumes of this work do not extend into the biological field, they do not provide answers for the other two subdivisions of the main question. However, these results have verified the status of the postulates of the theory of the universe of motion as a correct definition of the *physical* universe. If life is a physical phenomenon, then it, too, is defined by these postulates. Thus the theory opens an avenue of approach to these other two issues. A preliminary study along these lines has been included in the extension of the physical investigation that was mentioned in the answer to question 7.

9. If there are intelligent beings elsewhere in the universe, will we eventually be able to make some kind of contact with them?

At the present stage of our knowledge, any answer to this question would be pure speculation.

10. Is there anything outside (that is, independent of) the universe of motion?

This is probably the most important question that can be asked by members of the human race. Many persons, particularly those with strong religious ties, will be inclined to contest this assertion, having in mind issues that are more directly connected with their specific beliefs. But we can safely predict that if these alternative questions are carefully examined it will be found that they have no meaning unless this question number 10 can be answered affirmatively.

Conventional science gives us a negative answer. It regards space and time as constituting a background, or setting, in which physical entities exist, and in which physical activity takes place. All existence, according to this view, is *in* space and *in* time. It then follows that there *cannot be* any existence outside of space and time. The prevailing scientific opinion is that this is an incontrovertible conclusion. Furthermore, it is claimed that every fact to which we have access can reasonably be explained in terms of the physical universe alone, as would be expected on the basis of the foregoing assertions.

Although it is generally conceded that this is the verdict of science at the present stage of knowledge, it is, to most scientists, an unwelcome conclusion. The great majority of these individuals have some kind of religious or philosophical convictions about non-physical existence that they are not willing to give up, regardless of how strong a case against the reality of such an existence science may present. For some this has created a very difficult situation. As expressed by du Nouy:

It cannot be contested that the heart of many men is the stage of a conflict between the strictly intellectual activity of the brain, based on the progress of science, and the intuitive, religious, self. The greater the sincerity of the man, the more violent is the conflict.³⁴⁸

The fact that the clarification of the physical relationships in our study of the universe of motion has opened the door to an extension of this study into the non-physical realm thus has a profound significance. The physical findings clearly demolish what previously seemed to be an unassailable case against the reality of outside existence. Even the most casual consideration of the claim that every known fact has a reasonable explanation in physical terms is sufficient to show that the validity of this claim rests entirely on a subjective assessment of what constitutes a reasonable explanation in each individual case. The prevailing scientific position with respect to evidence of non-physical existence thus amounts to nothing more than a refusal to recognize

any evidence that is offered in favor of such existence. It follows that the scientific rejection of the possibility of existence outside the physical universe has no basis other than the premise that all existence is *in* space and *in* time.

In the universe of motion, this is not true. Space and time do not constitute a container for the entities and phenomena of that universe; they are *contents* of the universe. Once this is understood, the obstacle in the way of non-physical existence disappears. The results of the investigation here being reported show that the physical universe consists entirely of *a specific finite quantity of a particular kind of motion*. The question at issue now becomes: Can anything exist other than this quantity of this kind of motion?

This is an issue that can be investigated by standard scientific methods and procedures. We cannot apply the purely deductive method by which we have derived the answers to similar questions within the boundaries of the physical universe after establishing the validity of the fundamental postulates of the Reciprocal System of theory, as we have no assurance that the laws and principles of the physical universe are applicable to the outside region. We can, however, *postulate* the applicability of those of the previously established principles that are not subject to any obvious regional limitations, and test the validity of that postulate in the regular manner. In so doing, we are using one of the versatile tools of inductive reasoning: the extrapolation process. We are making the kind of an “inference from experience” upon which scientific theory was based before the “inventive” school of Einstein and his successors gained control of the scientific Establishment.

First, we assume the validity of the Principle of Uniformity, identified as Principle (b) in the list given at the beginning of this chapter. This principle then carries with it the validity of the other items in the list that are relevant to the point at issue, particularly the rationality of the outside existence, principle (a), and the assertion that what can exist does exist, principle (g). We know from observation that motion can exist. Our observations tell us only that it exists in a certain form and in a certain finite quantity, but there is no indication of any kind of a limiting factor that would restrict it to this form and to this quantity. Principle (g) therefore tells us that motion can exist in other forms and in other quantities if our hypothesis as to the applicability of the Principle of Uniformity to the outside existence is valid.

Having formulated this hypothesis by extrapolating the principles and relations that we have established in the physical universe, we are then ready to verify it in the standard manner by developing the consequences of the hypothesis and comparing them with observation. Notwithstanding the scientific contention that all observed phenomena can be explained on a purely physical basis, it quickly becomes evident, when the verification process is undertaken, that many of the effects of non-physical existence required by the uniformity hypothesis are, in fact, observable. Their true status as *unexplained non-physical phenomena* has not heretofore been recognized

because they coexist with many *unexplained physical phenomena*, and have not been distinguished from these obscure features of physical existence.

The findings of this extension of the investigation of the physical universe into the non-physical region are much too voluminous to be included with the physical results, and will be described in a separate publication, but it would not be appropriate to conclude the discussion in this volume without calling attention to the manner in which the clarification of the properties of the physical universe sets the stage for a confirmation of the reality of existence outside that universe. The more complete understanding of physical existence opens the door to an exploration of existence as a whole, including those non-physical areas that have hitherto had to be left to religion and related branches of thought. It is now evident that our familiar material world is not the whole of existence, as modern science would have us believe. It is only a part—perhaps a very small part—of a greater whole.

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