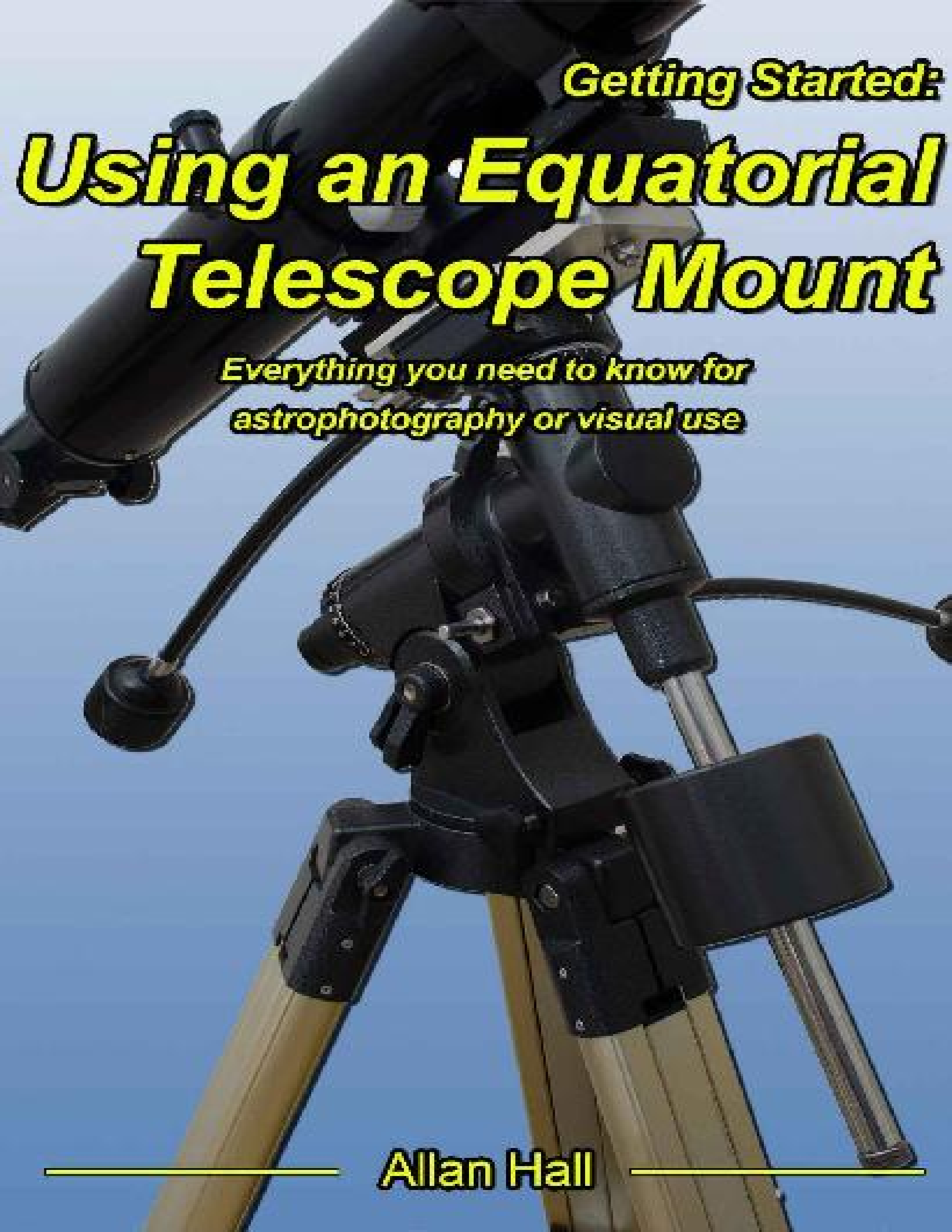


Getting Started:

Using an Equatorial Telescope Mount

Everything you need to know for astrophotography or visual use

Allan Hall

Getting Started:
Using an Equatorial Telescope Mount

Allan Hall

10 9 8 7 6 5 4 3 2 1

Allan Hall
1614 Woodland Lane
Huntsville, TX 77340
www.allans-stuff.com/eq/

TABLE OF CONTENTS

There are a ton of different things you can do to improve your mount's accuracy. Are they all necessary and when do I do which ones?

Section nine: *Equatorial setup and the home position.*

Here is where we get acquainted with your new mount and start getting it ready to get into the field.

Section ten: *Aligning the polar scope.*

You thought the polar scope was for aligning the telescope, now you learn you have to align it? Sheesh!

Section eleven: *Attaching a telescope tube.*

While playing with the mount is fun, you probably bought the mount to put a telescope on so let's find out how.

Section twelve: *Adjusting for cone error.*

Even many advanced users have no idea what cone error is. Here is where we learn what it is and how to correct for it without becoming a cone head!

Section thirteen: *Balancing the mount and telescope.*

Once we get the telescope on the mount we have to make sure it all moves as smoothly as possible. This requires balancing (the telescope, you can put your other foot down now).

Section fourteen: *Finder alignment.*

That little telescope looking thing on the side of the bigger telescope looking thing is called the finder. We need to make sure it and the telescope point at the same thing.

Section fifteen: *Polar alignment.*

Now we need to make sure the mount is pointing to where it needs to be so that it can track objects in the sky correctly.

Section sixteen: *Computer alignment.*

If your mount is a push-to or go-to then it has a computer built in. These need to be aligned and here is where we learn to do that.

Section seventeen: *All Star Polar Align*

You can polar align your mount without using a polar scope and even without being able to see the north or south celestial poles. It's magic!

Section eighteen: *Automatic computer alignment*

You mean I can just let this thing align itself? Yes, no, and it depends. Didn't think you would get a straight answer did you?

Section nineteen: *Common problems and solutions*

Can't figure out why something is not right? Make a booboo and want to know how to fix it? I'm not too proud to tell you how I messed up.

Section twenty: *Where to get more information.*

Where oh where can you look to learn more? Lots of places!Lots of links to places online and even a few books (that I wrote of course!)

Introduction

In the years I have been into astronomy I have purchased more telescopes and mounts than I care to admit. Most of the mounts were of the equatorial design. The one thing I have noticed is that not one of them included anything more than very basic assembly instructions.

The lack of directions led to some serious frustration and at least one fifteen year gap in my astronomy pursuit. I just could not understand how to make the telescope go where it was supposed to go.

Today we are thankful to have many great books on astronomy of which many have sections on the use of these types of telescope mounts. In addition we have online videos which can show us even more.

The problem today is that neither of these are good options for use out in the field under the stars. The books contain so much other material that they tend to be large, heavy and have only the basic information regarding the mounts. The online videos are fantastic except getting internet out in the middle of a field at night is problematic at best.

My solution was to develop this guide to do only one thing, help you setup and use an equatorial telescope mount.

The images and instructions included in this book are based primarily on three different equatorial mounts which include the Sirius, SkyView Pro and SkyView Deluxe, all manufactured by Orion Telescopes.

While other mounts will differ, the basics should be roughly the same. The two Celestron mounts I have used in the past (a CG3 and a CG5) are extremely similar as was the Great Polaris.

I will not waste your time telling you the wonderful features you can see on the moon. I have a book called *Getting Started: Visual*

Astronomy for that. I also will not waste your money on big colorful images of nebulae and galaxies which have nothing to do with using your mount.

Instead I will attempt to show you everything you could possibly need to know about that strange contraption that supports your telescope.

Enough about what you will find in the book, let’s get to it!

What is an equatorial telescope mount?

A telescope mount is the device that supports a telescope and provides the ability of pointing it towards an object in the sky.

The vast majority of amateur astronomers (pretty much everyone who observes the heavens and doesn't make their living doing it) use one of two different types of telescopes mounts; altitude azimuth or equatorial (called EQ for short). The rest use a mount that is probably a derivative or hybrid of these mount types.

Figure 1: A typical altitude azimuth telescope mount.

Altitude azimuth mounts move up, down, left and right. These work fine for a lot of visual observations but suffer from field rotation which we will discuss shortly. This can make it a little more confusing to use visually and very difficult to virtually impossible to use for astrophotography. They are however lighter, cheaper and easier to set up.

Figure 2: An EQ mount showing its rotational axes.

Equatorial mounts are slightly more complex to setup and use than an altitude azimuth mount, but they do not suffer from field rotation. EQ mounts follow the true motion of the sky and move in a sweeping arc. This makes them perfectly suitable for both visual and astrophotography. These can also be quite a bit smoother tracking than altitude-azimuth mounts.

Why use an equatorial mount?

The earth rotates around an axis. This axis is like a line going through the earth from the north to south poles and extending out into space. The point in space seems to be at different places depending on where you are on Earth.

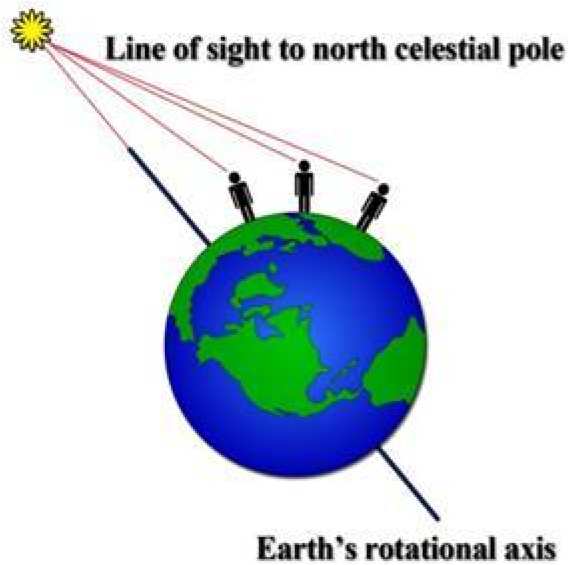


Figure 3 : Illustration of the Earth's rotational axis.

In the previous figure the star in the upper left corner represents the North Star, Polaris, the star that is almost exactly in line with the center of the Earth's axis of rotation. When looking at the night sky (or in the day for that matter) the sky seems to rotate around this point in space in the northern hemisphere. There is a similar point in the southern hemisphere.

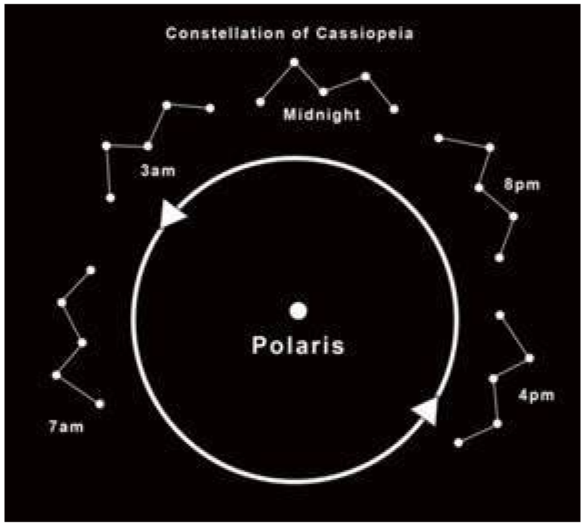


Figure 4 : Illustration of how the stars circle the celestial pole.

In the previous figure note that the constellation Cassiopeia not only moves across the sky, but rotates as it does so. This motion is centered in the northern hemisphere on the North Star, Polaris. The center of the “W” always points towards Polaris.

What this means for you is that as an object you may want to view is moving across the sky, it is also rotating around the rotational axis. This is important to remember as you try to match what you see to maps and images of objects.

This rotation completes one full turn approximately every 23 hours, 56 minutes, and 4 seconds and is referred to as one sidereal day.

The equatorial mount correct for all of this so that object in your eyepiece or camera do not rotate and stay perfectly centered.

Celestial coordinate system

In midrange astronomy most astronomers have completely computer controlled telescopes with high end planetarium programs that can find and track hundreds of thousands of targets including comets without even thinking about it. Unfortunately if we are on a budget or just starting out our software may not include all the targets we want to see, and even if it does, it probably will not point the telescope right to it. Alternately we may have a completely manual telescope or binoculars. So how do we find our targets?

We start by understanding how to navigate the sky manually. There are two types of navigation, altitude & azimuth and right ascension & declination.

Altitude & azimuth is a very simple system that measures the angle in degrees of an object above the horizon (altitude) and the angle in degrees of an object from north in a clockwise direction.

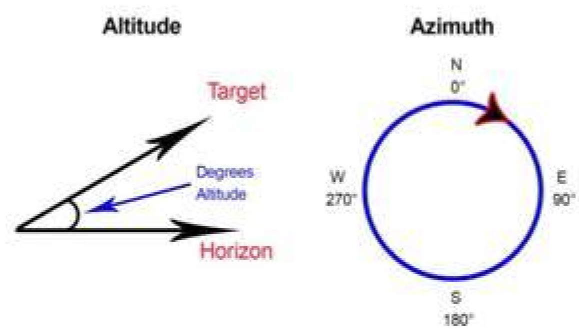


Figure 5 : Illustration of altitude and azimuth.

An example would be the North Star, Polaris. At my location Polaris would have an altitude of approximately 30.5 degrees and an azimuth of approximately 0 degrees since it is almost exactly north.

Altitude and azimuth make it very fast and easy to find any object in the sky, but it does have one big drawback and that is that these coordinates are always valid for a given date, time and location since the earth is constantly rotating (with the exception of Polaris of course). This means that if an object is at an altitude of 30 degrees with an azimuth of 94 degrees, in an hour that will have changed to different coordinates as the object will have changed position in the sky.

Think of it this way, early in the morning the sun rises in the east at 90 degrees (not really, but for the purposes of this example let's say it does). Further, let's say a day is exactly 8 hours long at this time of year. That means the sun moves at 180 degrees in 8 hours or 22.5 degrees per hour. So if the sun in our example was at altitude 0 at 8am, it would have an altitude of 22.5 degrees at 9am, 45 degrees at 10am, 67.5 degrees at 11am and 90 degrees at noon, directly overhead. Yes, that would be a really short day, but it should help you visualize what is happening with this coordinate system.

Next comes the right ascension and declination method (RA/DEC) which is a little harder to use, but does not depend on the date or time at all.

Declination is basically the same thing as latitude, or a measurement from the equator which is 0 degrees to the poles, positive 90 degrees to the North Pole, and negative 90 degrees to the South Pole. Think of this as being projected from the surface of the planet out into space, so an object that is in a direct line above the North Pole would be at +90 degrees declination regardless of where on earth you were standing. Declination is measured in degrees, minutes and seconds from the celestial equator.

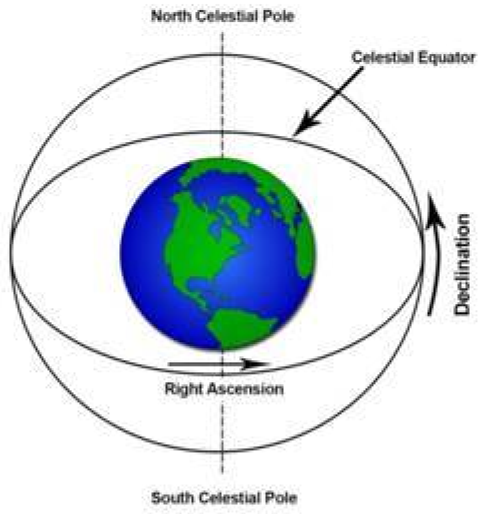


Figure 6 : Illustration of right ascension and declination.

Right ascension can be a tough one for people to understand. There is an imaginary point in space called the Vernal Equinox which is the starting point of measurements in a circle running along the celestial equator (if you took the equator on earth and projected it into space, this would mark the celestial equator). If you started at this imaginary point and spun the earth one full revolution back to that same point that would be 24 hours of rotation, always measured at the celestial equator. Right ascension is measured in hours, minutes and seconds from that point east.

Every object has a single RA/DEC coordinate which remains the same regardless of date or time. Messier 42, the great Orion nebula for example is RA 5h 35.4m and DEC -5 degrees 27'.

How in the world would you be able to use RA/DEC? Most equatorial mounted telescopes have both RA and DEC setting circles built into the mount. The easy method is to point the telescope at a target you know, set the setting circles for the correct values, and then move the telescope until the setting circles show you are pointed at the new target you want to find.

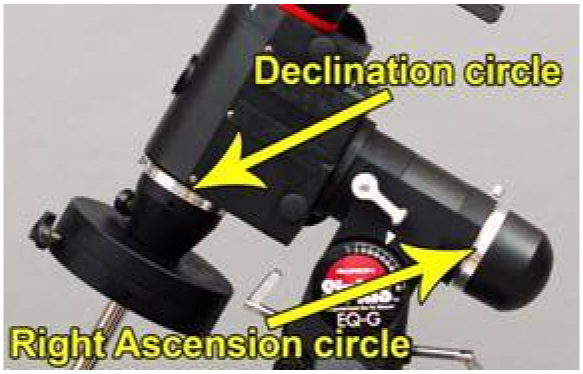


Figure 7 : Setting circles on an EQ mount.

If you are not using an EQ mount you can still use this system the same way, by finding a known target and moving from there. Additionally computer software can typically have the coordinates entered to show you a particular target.

Features of an equatorial mount

The followingimage shows the German Equatorial mount, sometimes called the GEM, sometimes called an EQ. Recently the Japanese manufacturers have released different designs that accomplish the same tasks as the GEM but with a substantially different design. So instead of having GEMs and JEMs, I just call them all EQ mounts.

Figure 8: A refractor on an EQ mount.

As we discussed, EQ mounts are designed to track the motion of the stars including field rotation. This means, if you look at the moon when it is rising and a particular crater is at the top center of the eyepiece, that crater will be in the top center of the eyepiece hours later when the moon is setting.

These mounts can start at a few hundred dollars or so for just the mount without a telescope. EQ mounts are the best for astrophotography but are also excellent for visual.

EQ mounts are lined up pointing towards the celestial pole, a process called polar alignment. This is what allows them to follow the arc of the objects through the sky.

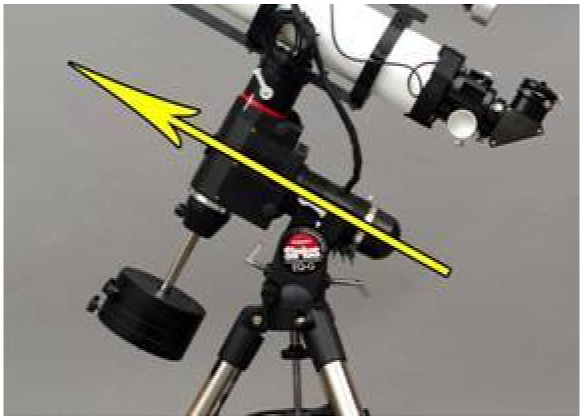


Figure 9: Direction of polar alignment with an EQ mount.

Another interesting feature of EQ mounts is that they use weights to balance the scope assembly to make tracking a target smooth and easy. If you look at most EQ mounts you will see one or more round weights at the end of a shaft extending from the bottom of the mount in front of the tripod.

EQ mounts are rated in how much weight they can carry, excluding the counterweights. What this means is how much weight can go on the top of the mount which includes things like the telescope, finders, eyepieces, dew prevention devices, etc. This is balanced out by roughly equal weight on the bottom using the weights. You do not add the weight of the scope and weights together.

One disadvantage of EQ mounts is that they cannot track all night uninterrupted as this would cross the meridian (an imaginary line in the sky directly overhead running from the north celestial pole to the south celestial pole). They can track up to the meridian, and then we preform what is called a meridian flip where the scope flips directions while pointing at the same place, and then it can continue on tracking for the rest of the night.

Figure 10: How an EQ mount moves.

Another disadvantage to this design is that they can put the eyepiece in some pretty tricky positions when looking at overhead objects compared to an Alt-Az mount.

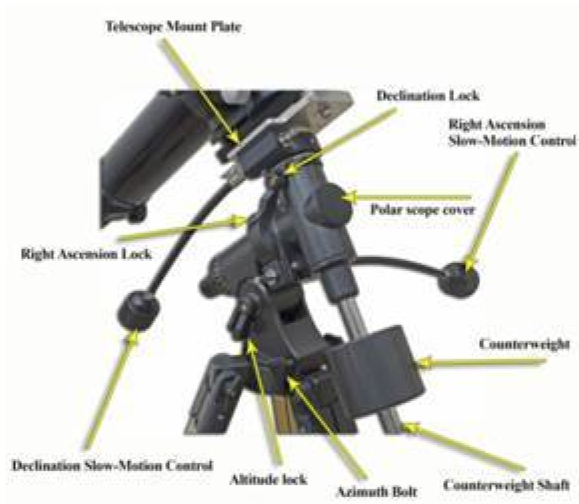


Figure 11: Diagram of a manual EQ mount.

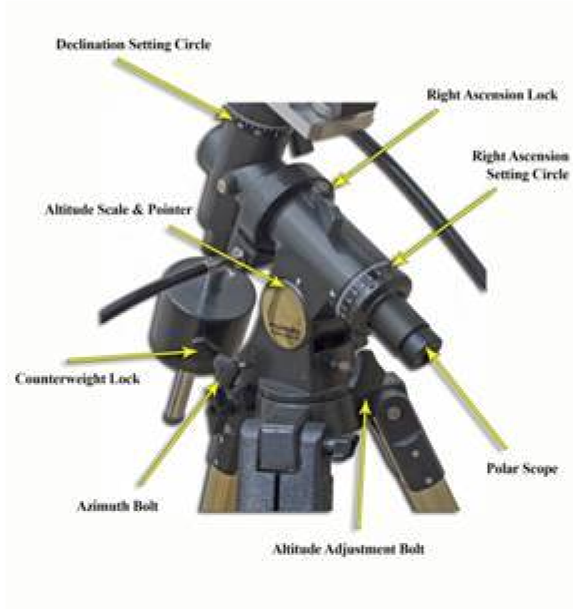


Figure 12: Diagram of a manual EQ mount, reversed.

Manual, tracking, push-to and go-to

There are several ways to find and follow objects in the night sky. If you have a telescope with no computer built in, you can navigate the sky using what is called ‘star hopping’ which is where you hop from one known star to the next until you reach your target.

If your scope is equipped with a computer, it is likely one of two types used on most of today’s telescopes: push-to and go-to.

The difference between the two is that the push-to scope tells you where you need to move the scope manually to find the object whereas a go-to will actually move the scope by itself to that object. Unfortunately these computers cost money, money that you could spend on eyepieces, filters, a better telescope, a better mount, software, pizza, etc. Convenience costs.

Now you may wonder that if you can’t see fainter stars to locate objects, how can the computerized telescope mount see them? That would be a fair question. My primary mount is connected to a computer and the software I run can sync on any target in the sky. What that means is that I really need to be able to see three celestial objects, spread apart as far as possible. Examples include the moon (second brightest object to the Sun), Venus (brighter than any star) and Sirius (the brightest star in the sky).

Some mounts will not sync on the moon, or planets. Some will. Some use a small telescope and camera mounted to the main scope that can see through some of the light pollution. Heck, some of them can completely align themselves while you sit back drinking hot chocolate!

Computerized telescopes will come with a hand controller that allows you to interact with the on board computer. You use this controller to tell the telescope the current date, time and location. This allows the telescope to compute where the stars should be. Then you use the controller to perform an alignment which tells the telescope where it is pointing so it can calculate where to point the telescope to get the object you want in your eyepiece.

Personally I see go-to and push-to as a time saver that allows me to get on target fast, even targets I can't see with my naked eyes at all. Using go-to I can spend the majority of my time observing instead of searching.

On the other hand I probably do not know the sky nearly as well as I would if I used a completely manual telescope for most of my observing. To each their own.

Figure 13: Typical go-to telescope hand controllers.

This absolutely will be a personal choice as there is no one "correct" answer. Choose which option works best for what you want to do, and which you can comfortably afford, and go from there.

There is a difference between computerized telescopes and tracking telescopes. Tracking scopes have no idea where anything is, they simply track whatever target you point them towards. Cheaper tracking mounts may only be able to keep a target in the eyepiece for a few minutes while more expensive mounts can track a target all night when properly set up.

Some mounts are available in several varieties such as the Orion SkyView Pro which can be purchased as a manual mount or as a go-to mount. It can also be purchased as a manual mount and upgraded to either a tracking mount or go-to mount with add-on kits. I have the go-to version and think it is an excellent medium-duty visual mount.

Assembling an equatorial mount

EQ mounts typically come in several pieces that need to be assembled. Those pieces are the tripod, the mount head, counterweights, slow motion controls and possibly an electronic hand controller.

It is possible that the tripod will even require some assembly. This usually consists of sliding the leg section into the top plate, inserting a bolt through the two pieces and tightening a nut onto the bolt to hold them together.

These should not be over tightened. Tighten sufficiently to keep everything in place and reduce any slack, then stop.

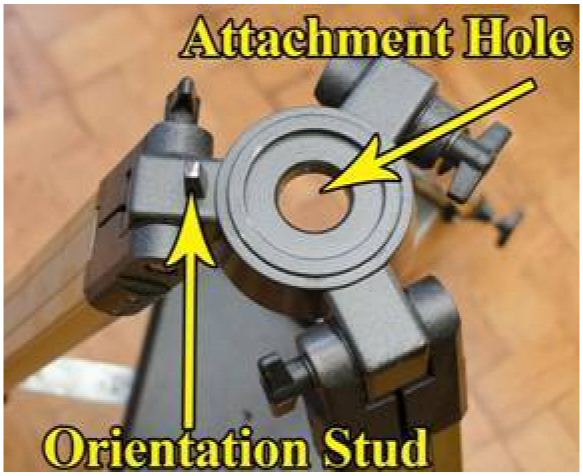


Figure 14: Top plate of tripod.

The next step is usually attaching the mount head to the tripod. First you will need to align the orientation stud with the front of the mount (the part near where the weights attach). This is typically secured by means of a bolt or threaded rod through the bottom of the tripod top plate into the bottom of the mount head.

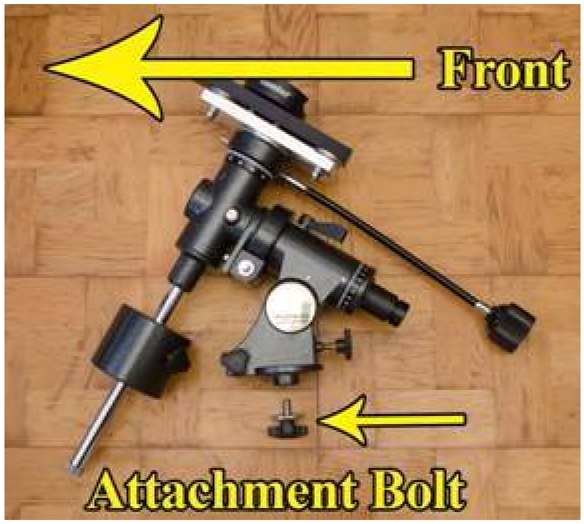


Figure 15: Mount shown with attachment bolt.

Smaller mounts like this SkyView Deluxe use a mount bolt. Larger mounts such as the SkyView Pro and Sirius use a threaded rod which attaches to a spreader that keeps the tripod legs apart and under tension. This rod then screws into the bottom of the mount just like an attachment bolt.

Next we need to assemble the weight or weights as shown on the shaft in the previous image. The weights just slip onto the shaft and are hand tightened with a locking knob or lever which is tightened against the shaft to prevent the weight from moving.

If the weight tries to slide even when the locking device is engaged, remove everything from the shaft and clean it with alcohol. Now reassemble the weights and see if it holds better.

On the bottom of the shaft there is a piece commonly called a “toe saver” which screws into the bottom of the shaft and is just hand tightened. This stops the weight from sliding all the way off should it get loose on the shaft.

If the mount uses an attachment bolt, or otherwise does not bolt the leg spreaders (this is sometimes built into an accessory tray) you can now attach the leg spreaders and/or accessory tray.

Leg spreaders can attach in a variety of ways but they are typically quite easy to figure out. The idea is that they spread the legs out and keep them ridged. This increases the stability of the mount.

The last thing is usually attaching the slow motion controls if the mount includes them (most lower end and all manual mounts include them, most go-to mounts do not). These normally slip over a shaft and have a bolt that tightens against a flat spot on the shaft they are slipped onto. This allows them to be turned either direction without slipping.

Some mounts will have a polar scope which is an accessory and is therefore not already installed. While the installation on these can vary all of the ones I have had to install so far simply thread into the hole at the rear of the mount. These do not need to be very tight, just thread them in (clockwise to tighten just like a typical bolt or screw) and turn until the scope is snug enough to not fall out by itself.

What all do I need to do, and when?

This book will discuss a wide array of things you can do to improve the accuracy, stability and usefulness of your mount. Do you really need to do them all in order to view the moon? Absolutely not!

Here I will discuss the sections that follow, and let you know which ones are important for which activity. You can then incorporate the sections you need for what you want to do.

Equatorial setup and the home position levels the mount and has you mark what we call the home position on your mount. This is not required to use the mount for any purpose but can make setup out in the field easier and faster.

With a level mount when you put it in the home position your mount should be very close to roughly polar aligned. This makes it easier to manually find objects and for computerized mounts, makes the first slews to alignment stars more accurate. This saves time and effort.

The section Aligning the polar scope only applies to mounts which have a polar scope, and then only to ones where you want maximum accuracy such as for astrophotography. Since this is something that you really only do once for each mount, I would recommend doing it if you have a polar scope in your mount.

Following that we have the section on Attaching a telescope tube. This is important for any use if you plan on using a telescope.

Next we have the section on Adjusting for cone error. I recommend you perform at least a quick and basic form of this adjustment because if your setup has a severe problem with cone error it can make slews to targets substantially off. This is really only has to be done once for each telescope tube you plan on using as long as the tube rings and rail are never removed from the tube.

Balancing the mount and telescope is an important section for any use. If your setup is not balanced correctly you can damage the motors and/or gears in the mount as well as cause a situation where the mount could move unpredictably. This could wind up being unsafe and cause injuries. Since this takes only a few short minutes I recommend you do this every time you setup your mount.

How accurately you balance is a different story. For quick visual observations your balance can be substantially rougher than if you plan on doing long exposure astrophotography. The latter should have a balance that is quite accurate.

Finder alignment is not required for use of your mount at all. I will tell you however that very little will irritate you nearly as much as a finder that is not aligned. It only takes a minute and is done in the daylight before you start a night's observing so I recommend you align your finder for any use.

Polar alignment is done to get your mount as accurate as possible in regards to both slews and tracking (if you have a motorized mount). Doing anything more than a rough pointing towards the north (or south) celestial pole is not required for a quick visual observation of bright objects.

The harder to find or see the object is, the more important this becomes. There is little more frustrating than straining to see an object in your eyepiece for half an hour only to find out it was never in your field of view to begin with.

With astrophotography, the polar alignment should be treated as a critical component. You can have a pretty bad polar alignment and still take some nice images if you are using short exposures (30 seconds or so) and don't mind throwing away a good percentage of the images you take due to defects. It is much easier however to just get the polar alignment accurate to start with.

Computer alignments are required for all computerized mounts if you want the mount to be able to locate objects or track them. You certainly do not have to do a computer alignment to point the scope at the moon and view it for a minute or two but you will for much more than that.

The final section we talk about is the All Star Polar Alignment section. Depending on who made and sold your mount it could have a different name. Basically, this is a method in your mount's hand controller for adjusting the mount for the correct polar alignment without using a polar scope or even being able to see your celestial pole at all.

I generally prefer to use my polar scope as it is faster and easier once you get used to it. That said, if you do not have a line of sight to the celestial pole this software can perform miracles.

My experience has been that this is roughly as accurate as using my polar scope but not as accurate as a good drift alignment or alignment using a laptop and good ASCOM polar alignment software.

Equatorial setup and the home position

To get the mount ready to use, we start by leveling the tripod. Place the tripod on a flat level surface with the legs extended to an appropriate height. Now place a level on the top flat portion and work at getting that piece as level as possible by adjusting the leg extensions. I use a two axis level like this one:

Figure 16:Dual axis level being used to level the tripod.

One word of caution, some mounts have a level built into them, and many of these are very incorrect in their readings. Before you rely on a built-in level, be absolutely sure it is correct by checking it with other levels.

You can use a single straight level but be sure you level on at least two axes (different directions) if not three. Once the mount is level make sure all the leg extensions are fully locked and place the mount without counterweights on the tripod and secure it. To make things much easier, use your altitude adjustment screws and set the mount to the smallest declination you can while allowing the mount to rotate freely with the counterweight bar fully extended.

Let’s look at an EQ mount, in particular, the Orion Sirius EQ-G (as shown). The first thing we need to understand is the controls for declination and right ascension. Note in the following image there are two light colored levers:

Figure 17:Declination (top left) and right ascension (lower right) clutch levers.

The upper left lever is the declination; the lower right lever is the right ascension. Note that the position of these levers can and will be different on different mounts. An easy way to know what you are moving is that if the weights move, you are moving right ascension, if the weights do not move, you are moving declination.

The first thing we need to know is where our 'home' position is. Having a marked home position allows us to set up in the field fast and accurately. Let's start by releasing the right ascension lock and rotating the mount head so that the counterweight shaft is straight out to the left side as seen from behind. Now place the level on the shaft and make sure it is completely level, then lock the right ascension lock. Double check the counterweight shaft to make sure it is still level.

Figure 18:Making sure the counterweight bar is level.

Next you need to find the right ascension clock ring on the rear of the mount and unlock it so it freely rotates. For the northern hemisphere,set this ring to 6 on the scale of the ring.Some designs have two scales on the ring; however it should be obvious that only one will work. Now unlock the right ascension lock and rotate the mount head until the ring reads 0, then relock it. This is your RA home position. Now we need to mark this with a scribe, tape, paint, magic marker, whatever. You need to have a line that goes from the mount head to the rest of the mount so that you can return to the RA home position easily and quickly.

Figure 19:Line marking the right ascension home position.

With the mount in the locked RA home position, it is time to find your declination home position. Release your declination clutch and rotate the head until it is roughly at 90 degrees. Place the level in the slot where your dovetail would go facing left and right as seen from behind your mount.

Figure 20:Making sure the declination axis is level.

Once the level shows level, release the lock on your declination clock ring and set it to 0 degrees. Now rotate the mount head until it reads 90 degrees paying particular attention to which side the locks for your scope’s dovetail are on (on mine, the locks are on the right so I rotated the head until the declination clock ring read 90 degrees and the locking screws for the dovetail were on the right) and lock the declination clutch. Now you need to make a line marking this as your declination home position.

Figure 21:Marking the declination home position.

Marking your home position is not really required to use the mount. If it were, they would be marked from the factory. The reason you mark them is to speed up your setup process out in the field. A few minutes work once right now will save you time, every time, in the field under dark skies.

Aligning the polar scope

The next problem we run into is our polar scope if we have one. On rare occasions the polar scope is aligned correctly, but more often than not we have to adjust it. You can do this indoors on a rainy day. Place the scope as far from one wall as you can get it (down a hallway is great) but leave plenty of room behind it because that is where you will be working).

Figure 22:Location of the polar scope on an EQ mount.

Still working without counterweights or telescope, make sure that your counterweight bar is fully extended and that the declination is turned to 0 degrees. Remove any covers for the polar scope and note the three allen head screws around the circumference of the polar scope. Now look through the polar scope and make sure you can see a wall, not a ceiling. If you cannot see a wall, you can prop the rear legs of the tripod up on books or something to raise the rear enough to point the polar scope at a wall. Now get a piece of paper and put a large (about the size of a pea) dot in the center. You need to have the scope in the RA home position and place the piece of paper on the wall in such a way that the dot is right in the center of the polar scope crosshairs.

Unlock the right ascension clutch and slowly rotate the mount head until the counterweight shaft is straight up in the air. If your polar scope is perfectly lined up, you will still see the dot right in the center of the crosshairs. If it is not, you need to adjust the three screws until you bring it back HALF THE DISTANCE to the center. Do this process slowly, carefully, and you may never have to do it again.

Do not loosen the screws more than one half turn at a time or the glass for the polar scope could fall out. It is very time consuming to get this piece back in should it fall out.

Figure 23:One of the three polar scope adjustmentallen head screws.

Assuming that you made an adjustment, move the paper on the wall until the dot is again in the crosshairs and rotate the mount head back to home. It should still be right in the middle of the crosshairs. If not, repeat the process until you can rotate the mount head anywhere you like and the dot stays right in the center.

I will tell you I have never gotten this perfect, meaning no movement of the dot at all, but at no time does the dot not touch the exact center of the crosshairs, there is just a slight wobble to the dot. Now make sure all three of the allen screws are snug but do not over tighten them. They need to be tight enough to stop them from coming loose but no more.

Now we will use the altitude bolts to dial in your approximate declination. For example, my latitude is 30.48 so in theory I should set my declination to 30 ½ or so. Unfortunately these stickers that mark the declination are rarely placed correctly so all we are worried about is getting it in the ballpark. We will fine tune this later.

Attaching a telescope tube

While the mount is a fantastic piece of equipment, it really is not that useful without something attached. This can be a telescope tube or a camera. For our discussions we will concentrate on the telescope tube.

There are two basic ways to mount a telescope tube; scope rings and direct. Either method usually mounts the telescope tube to a rail,that rail then attaches to the mount.

Direct is exactly what you would expect. The mount will bolt directly to the telescope tube. This can be done with a plate or an arm.

Tube rings can also be used with either a plate or a rail. A tube ring is simply a strap, usually metal, which goes around the telescope tube and has a place to bolt it to the plate or rail.

Using a rail makes it easy to move a telescope tube from one mount to another, attach and detach the tube quickly, and allows for a wide variety of different telescope tube types to all be attached easily to a mount.

These rails come in two basic types; Losmandy and CG5. The Losmandy types are larger, wider and more appropriate for large and heavy setups. The CG5 style are smaller and more suitable for low-end to midrange setups (150mm refractor or smaller will work easily).

Less expensive mounts may have a setup where it uses a proprietary mount for a specific telescope tube and may or may not use rings. These work fine but make it difficult if not impossible to replace the telescope or to use the telescope on another mount without purchasing other equipment.

Figure 24: A proprietary telescope mount plate with rings attached.

There is a solution to the proprietary mount plate with an aftermarket adapter. These adapters bolt to the manufacturer-supplied plate and provide for the attachment of a standard (usually CG5) rail.

Adjusting for cone error

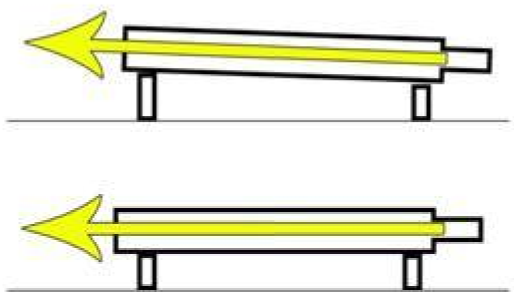


Figure 25: An example of cone error.

The next thing on our list is adjusting the telescope for cone error. We need to start by understanding what cone error is. Let's think of something silly to get an understanding. In your mind (not in reality!) picture your scope with the dovetail mounted except you put a 6" block of wood under the front scope ring attachment to the dovetail. Yes, that's right, the rear of the scope will be a little lower than it is now but the front of the scope will be pointing way up in the sky.

Now imagine you rotate the mount on the RA axis. This is cone error to the extreme! The scope will never be pointed where it should be, and if you align on one star, when you slew to another star it will be way off.

So how do we test for cone error? Simple! With the scope in the home position, release the RA clutch and rotate the scope until it is at the side and level with the counterweights.

Now either using a star or a faraway object like the top of a telephone pole, using only the declination axis to move the nose of the scope up/down or the azimuth bolts on your mount to move the scope left/right.Center the object in the middle of your eyepiece (this works MUCH better if you have an eyepiece with crosshairs in it). Once you have it centered lock your azimuth bolts (by making sure both are tight) and lock your declination clutch.

Now release your RA clutch and rotate the scope 180 degrees so that it is on the other side of the mount level with the counterweights and lock the RA clutch. Using ONLY your declination adjustment find the point again. If you can line it up in the center of the crosshairs using only declination then you have no cone error. If not, you need to either use your cone error adjustment screws on either end of the dovetail bar or install shims between your scope tube ring and the dovetail bar. Just like when working with our polar scope you only want to correct HALF the error.

If you have an error, make your adjustments and then repeat the process until you have no more cone error.

Balancing the mount and telescope

Now you need to balance the scope. There are three axes you need to balance on an EQ mount.

The mount usually comes with a weight or two. It is entirely possible that the payload (telescope, rings, finder, eyepiece, etc.) is heavier than the supplied counterweights will balance. Should this happen additional counterweights can be purchased. I have seen these counterweights come in 2.5lb, 5lb, 7.5lb and 11lb weights in the US with only certain sizes being available depending on the specific mount.

Counterweights are sometimes interchangeable such as between the SkyView Pro and Sirius mounts. The deciding factor is usually the diameter of the counterweight shaft. If the counterweight fits and tightens then there should be no problem using it.

Figure 26: Balancing the scope's declination axis.

First turn the scope on its side by loosening the right ascension release then locking it at 90 degrees. This will result in the scope being on one side of the mount and the weights on the other side. Then loosen the declination release and pivot one end of the scope up and down to see if it is balanced. To balance it, either loosen the scope ring knobs and slide the scope towards the lighter end and recheck, or carefully slide the entire assembly by loosening the dovetail clamps and sliding the dovetail on the mount head (this is also how you would balance a SCT or MCT that has no scope rings). Once finished, tighten the scope ring knobs or dovetail clamps back down and move to the front of the scope.

When using the dovetail method be sure not to loosen the clamp on the dovetail while the scope is tilted on its side as it could fall out of the mount onto the ground and do a lot of damage to the scope and your feet.

Figure 27: Balancing the scope's right ascension axis.

Now we need to balance the second axis just like we did the first one. First turn the scope on its side by loosening the right ascension release then locking it at 90 degrees. This will result in the scope being on one side of the mount and the weights on the other side. Now loosen the right ascension lock and pivot the scope and weight up and down. You can slide the weight left and right (as it appears in the figure above) until it balances the scope. Lock everything down, return the scope to its home position.

Figure 28:Balancing the nose of a reflector.

The third axis is just pointing the nose of the scope straight up in the air and making sure that the nose does not tip one direction or the other. This is primarily to see if you have too much weight strapped to one side or the other such as on a Newtonian with a heavy eyepiece hanging off one side. This is a critical step for Newtonians that many people miss and failure to complete this setup can cause alignment issues.This is not nearly as important for a refractor unless you have something unusual bolted to the side of it.

Finder alignment

The first piece of a telescope that needs to be aligned in the field is your finder. Finders have some method of adjusting where they point such as adjustment screws on the finder mount.

Figure 29: A typical optical finder mounted to a telescope with adjustment screws.

This process is far easier before dark. Pick a distant object that is easy to see with your naked eye (I like to use power poles). Using a low power eyepiece (an illuminated centering eyepiece is best if you have one) center the object in your telescope and lock the mount so that the telescope cannot move.

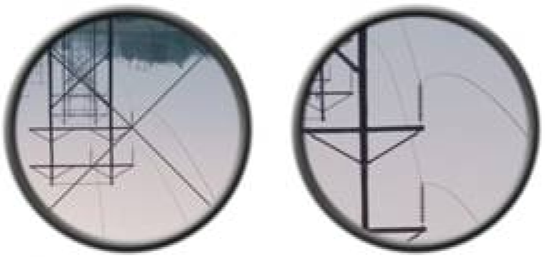


Figure 30: View through the finder on the left, telescope on the right.

Now adjust the finder until the crosshairs (or dot if you are using a red dot finder) is precisely centered where it should be.

Figure 31: Adjustment screws for an optical finder.

To move the finder there are several methods in use. The primary adjustments for most visual finders are by using setscrews. To move the finder you tighten one screw and loosen another to move it. Depending on the desired direction of motion you may have to loosen two screws and tighten one, or tighten two and loosen one.

Figure 32: An optical finder with one set of adjustment screws.

Originally finders used two sets of setscrews; one to adjust the front of the finder and one to adjust the rear. You will also see some designs where the front or rear of the finder is supported by the bracket and the setscrews are on the opposite end. This design is especially popular with the larger optical finder designs.

You may also see either of these designs with a spring pin in place of one of the setscrews. This makes it easier to adjust as one of the three setscrews always applies tension against the tube which can be overpowered by the other two if needed.

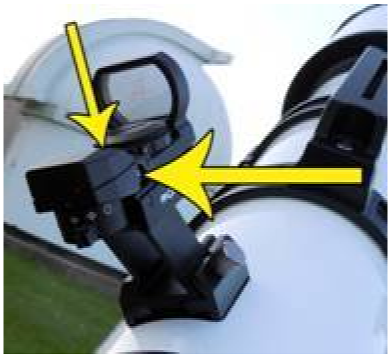


Figure 33: An Orion EZ Finder Deluxe

Other finder types such as red dot finders usually have much different adjustment procedures which still operate on the same basic principles.

Many red dot finders have two setscrews to raise the front or rear up and down, and left and right. They may also have a rail system which can be similarly adjusted.

More advanced models may have a piece of glass or clear plastic with a dot or crosshair projected onto the surface so that the dot appears to float in space where your telescope is pointed.

Many of these have features such as brightness controls, different types of pointers and some even project in different colors (although I would stick with red, as you will learn later).

These are easily my favorite type of finder.

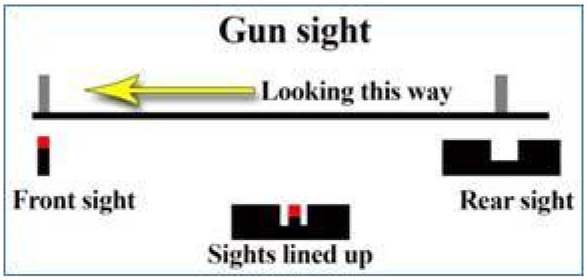


Figure 34: Diagram of a typical gun sight.

Gun sights are very similar to red dot finders except there is no red dot, or usually any lights at all (although the tip of the center sight is usually painted). It is simply a metal or plastic set of pointers that you look down to aim the telescope.

Gun sights are usually adjusted much like a red dot finder in that there is one screw for left and right, and another for up and down.

I have even run into a combination gun sight and red dot where the site is designed exactly like a typical gun sight except instead of just a painted tip on the front sight there is a red LED.

Finders are fairly personal and there is no one that is really better than the other. I prefer a nice red dot finder such as the Orion EZ Finder Deluxe and have a difficult time with optical finders.

Polar alignment

In order to track an object for an extended time, even with a great mount, you need to align it correctly. EQ mounts need to be polar aligned, or aligned with the north celestial pole (or south celestial pole if you are in the southern hemisphere). This is just about pointed to the star Polaris in the northern sky for the northern hemisphere. In fact, if you are doing strictly visual for short amounts of time you can just about point the mount towards Polaris and be done.

Polar alignment means two things, moving the azimuth bolts so the scope moves left and right until it is perfectly in line with Polaris. Secondly moving the altitude bolts to raise and lower the scope until that, too, is perfectly in line with where Polaris needs to be in your polar scope.

Obviously your azimuth moves the mount left and right until you get it lined up right with Polaris since you probably will not place the tripod down exactly facing celestial north, but why exactly are you changing the elevation if Polaris is more or less fixed in the sky? Good question! It is because Polaris appears at different points in the sky depending on where you are on the earth. Use this illustration to help you with the concept:

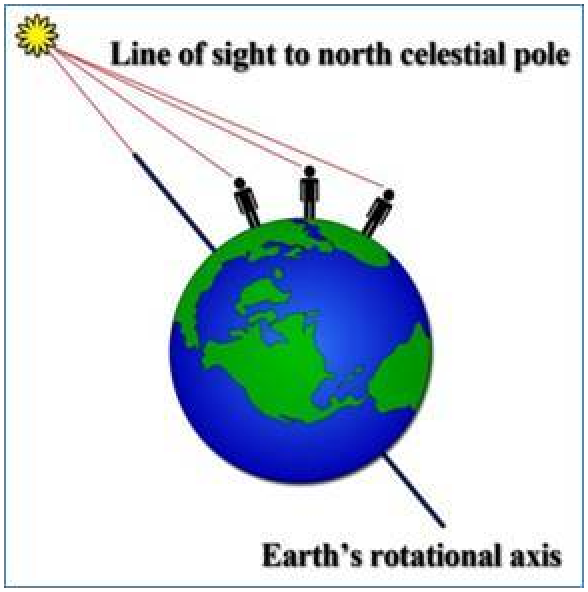


Figure 35:Different points of view on earth result in apparent changes to Polaris' position in space.

A person near the North Pole will see Polaris directly overhead while someone near the equator will see it very low in the sky to the north.

Alignment problems cause tracking problems. Minor misalignments will probably go unnoticed while larger ones will cause go-to and push-to systems to navigate incorrectly as well as tracking systems to allow objects to move out of your view.

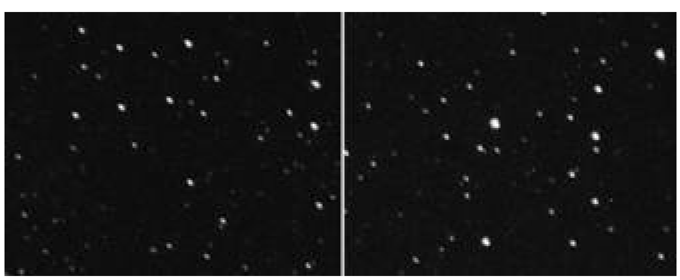


Figure 36:Results of bad alignment in astrophotography.

For the first method of polar alignment you need to have the scope outside at night with a clear view of the star Polaris (for the northern hemisphere). Start by leveling the mount. Now get the mount roughly pointed at Polaris by either sighting along the axis or using the polar scope.

Look around Polaris and find the constellation Cassiopeia. Look in your polar scope to put Polaris in the small circle on the outside of the slightly larger central circle with Cassiopeia roughly in the same position in the polar scope as it is in the sky.

For the second method of polar alignment you need to have the scope outside at night with a clear view of the star Polaris (for the northern hemisphere) just like last time. Again, get your mount level, then point your mount roughly north. You will need a free piece of software called Polar FinderScope (PC) from:

http://MyAstroImages.com

Download this and enter your longitude (available from the compass app in most smartphones, on your car's GPS, or by looking it up online) and look at the charts it gives you. This will show you where Polaris should be in your polar scope. Rotate your mount on the RA axis which will rotate your polar scope until the little circle on the larger circle is where Polar FinderScope says Polaris should be (it will be the large dot somewhere on the middle circle), then use your altitude and azimuth bolts to put Polaris right in the same position in the reticle of your mount's polar scope.

Double check where the constellations in the polar scope are versus where they really are in the sky to make sure they match.

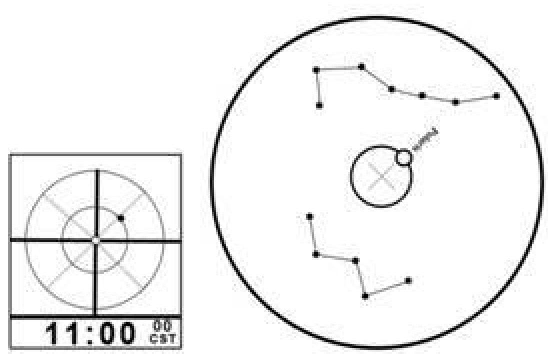


Figure 37:Illustration of Polar Finder software showing Polaris' position (left) and the matching view through a polar scope (right).

You are now polar aligned! Here we are at a crossroads.You can use your hand controller to do an alignment or you can use other software. I will assume you are going to use your hand controller.With the hand controller do a three star alignment now by selecting it on your hand controller's menu if it does not automatically come up after entering your date, time and location information.

Using the computerized alignment procedure is covered in more detail later in the book.

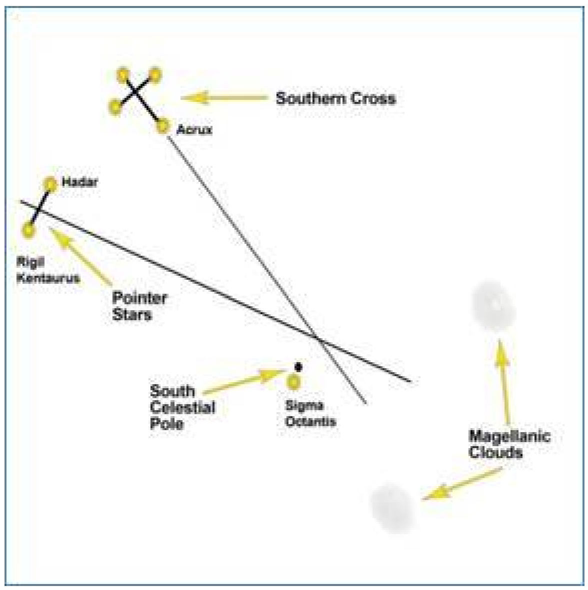


Figure 38:Illustration of the south celestial pole.

If you are in the southern hemisphere you could probably just point your scope right at Sigma Octantis just like we can up north at Polaris for a short visual session. Unfortunately, Sigma Octantis is far dimmer than Polaris so you really need to use the pointer stars.

There are two ways to perfect our polar alignment and we will start with the old school method of drift alignment. It seems that this method has frightened a lot of people because they think it is overly complex, but it is actually pretty simple albeit time consuming.

Perfect polar alignment is primarily for astrophotography but can also allow an EQ mount to visually track accurately for hours. You certainly don’t have to get the polar alignment this accurate, but it sure is nice. Let’s get started.

Once the telescope is set up, aligned with the polar scope (if we have one) and aligned with the computer or hand controller, we need to find a star near the meridian (the line that runs from north to south just overhead), north of the celestial equator (the line that runs from east to west directly over the earth’s equator). The star should be roughly 65 degrees or so in height and no brighter than Polaris (magnitude 2) and no dimmer than around magnitude 4.

At this point we need an illuminated reticle eyepiece that will provide over 100-150x which we can compute by taking the focal length of the telescope and dividing it by the eyepiece focal length.

If the eyepiece gives you insufficient magnification you can use a Barlow and center the star in the eyepiece.

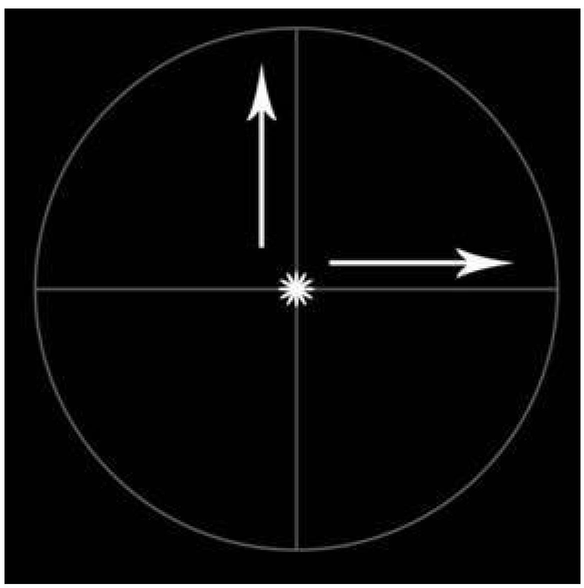


Figure 39:Centering a star for drift alignment.

Our next objective is to move the telescope using the hand controller one direction and then another making sure that when we move the telescope the star moves along one of the lines in our eyepiece exactly. Rotate the eyepiece until this is done and then lock the eyepiece down. Make sure the star moves exactly down the line all the way to the end.

Now put the star directly in the center of the eyepiece and let it track for about five minutes.

First we want to worry about north/south drift and ignore any east/west drift. As the star drifts away from center (assuming you do not have perfect alignment) we need to adjust the azimuth knobs on the base of the mount. It is worth noting that if you are using a Newtonian style reflector you need to reverse these directions. If the star moves up (north) then adjust the azimuth knobs so that the star moves down and then use the hand controller to recenter the star and repeat the test until there is no up/down (north/south) drift.

Now we need to select a second star somewhere between 20-30 degrees high in the east about the same distance and direction from the celestial equator as our last star.

We repeat the steps to make sure that the star moves directly down the lines of our reticle when we move the scope north/south and east/west just like before, rotating the eyepiece as needed.

Using the hand controller, recenter the star exactly in the center and let it drift until you clearly see it move off the line or for five minutes.

If the star moves up, adjust your altitude bolts to move it back down. If the star moves down, adjust the altitude bolts to move it back up.

Recenter the star using the hand controller and try again until you have adjusted the altitude bolts to keep the star right in the center.

The second method of perfecting our polar alignment is a better, faster and easier way to do it if you control your telescope with your laptop or desktop computer. Unfortunately this will cost you roughly what you would spend on a delivery pizza but it is well worth it.

You need a piece of software called AlignMaster (PC, $19)available from:

www.alignmaster.de

He offers a free 30 day trial so you can try before you buy. Download and install the software and use it to perform your precise polar alignment. This will save you a ton of time and get you just as accurate as drift alignment. Unlike drift alignment it also tells you exactly how close you are to perfect alignment.

It is important to remember that if you have used the altitude and/or azimuth adjustments since you did an alignment with your hand controller, then you must turn off the mount, return it to the home position, turn it back on and redo the alignment process.

This is required because you physically moved the direction the mount was pointing after you did the alignment.

Could you just do another alignment? Possibly. The problem is that you need to make sure that the mount completely forgets the previous star positions and does not just add the new alignment data to the old.

Do mounts do this? Possibly. It takes a minute longer to turn the mount off and then back on to make absolutely sure. Why take the chance?

Computer alignment

Figure 39: Hand controller display.

If you have a go-to or push-to mount and everything is attached and it is polar aligned if necessary, you will need to align the computer. What follows is a typical sequence of events which may not follow your handset's procedure exactly but should be close.

The first thing most mounts want to know is where on the planet you are. Here you will enter your longitude and latitude. If you do not know this information you can get it from most smartphones, GPS units, navigation systems or online with most mapping sites.

Figure 40: Hand controller display.

Be sure you enter the E/W or N/S identifiers correctly. Failing to enter the correct identifier will completely confuse the mount and cause you to not be able to find any targets.

Also make sure you are entering your longitude and latitude in the correct places. Attempting to reverse the placement of these numbers will not make you a happy person. If the computer even accepts your data, it will never be able to find any targets much less track them.

The next thing you will need to know is your time offset. This little piece of information is the number one mistake I see novices make when it comes to setting up their new telescope.

This number is based off of your UTC (Universal Time Coordinates) time (or Zulu time) and is known as a UTC offset. If you do not know your UTC offset you can use the chart on the following page to locate it.

Note that this number does not change based on daylight savings time. It remains the same all year long.

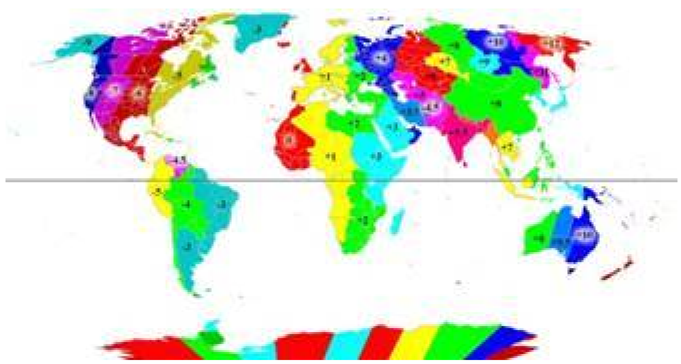


Figure 41: World UTC time zone map.

Figure 42: Hand controller display.

Next we have to enter the date. There is nothing special to remember here except that the date is in U.S. format so if you are across the pond do not forget to reverse the month and day as shown.

Figure 43: Hand controller display.

After entering the date we need to enter the time. Most hand controllers I have dealt with use twenty four hour time instead of the normal AM and PM twelve hour time. Since you will most likely be out in the evening just add twelve to the time and you should have it.

For example, if it is 7pm just add 12 + 7:00pm = 19:00:00. It is not critical to exact to the second.

Figure 44: Hand controller display.

The next question is for daylight savings. This is probably the second biggest mistake I see novices make. If you are on daylight savings time, select yes. If not, enter no.

If you are not sure, you can check online to see. For me here in the central United States in 2014 daylight savings time runs from March 9th to November 2nd. Between those two dates I select "yes", after November 2nd and before March 9th I select "no".

Here we have a fork in the road. When I am doing my normal visual without a laptop computer connected to my mount I select "1)YES" and allow the handset to do an alignment. When I have my laptop hooked up to the handset and want to use it to control the mount, I select "2)NO".

Figure 45: Hand controller display.

Connecting your computer to your mount is beyond the scope of this book but I did want to mention where the fork occurred just so you would be aware.

For the purposes of this book, I will assume you selected "1)YES".

Figure 46: Hand controller display.

The handset now wants to know which method you want to use to align the mount. There are usually several options: 3-Star Align, 2-Star Align and 1-Star Align.

The most accurate alignment is achieved when you use the three star alignment. When using this method you should use three stars that are widely spaced apart making sure one star is on the opposite side of the meridian from the other two.

Once you are finished with this alignment routine you are set up and ready to start observing!

All Star Polar Alignment

This function allows you to polar align your mount using the hand controller with no polar scope and even with no ability to see the celestial pole.

You will still need to have your mount pointed as close to the celestial pole as possible. A compass works well for this.

Depending on your mount's manufacturer and distributor, this routine could be called a different name. Regardless of its nomenclature, the idea is the same.

The software will use whatever star you last aligned with. If you have moved the scope since you had that alignment star in your eyepiece, the telescope should slew back to that star. Once you have that star centered in your eyepiece you hit a button which causes the mount to move away from that star (unless you are already well polar aligned). You then use the mount's altitude and azimuth adjustment bolts to recenter the object in your eyepiece.

One critical piece of information is that once you have completed this procedure, you need to turn off the mount, return it to the home position, turn it back on and then do another standard computerized alignment (not a second All Star Polar Alignment).

Automatic computer alignment

Today we are starting to see more telescopes and telescope accessories that can align themselves such as the Meade LightSwitch andCelestronStarSense.

With the Meade LightSwitch the mount (not an EQ mount) can automatically align itself with the flip of a switch in about three minutes.

The StarSense from Celestron is a little more involved but has the distinct advantage of being able to work with a variety of mounts including the Celestron CG-5 and Advanced VX (the CG-5's replacement).

As of this writing, the Meade system is built into a couple of their mounts while the Celestron system is available as a separate purchase for a couple of their mounts.

These work by having a small camera that takes an image of the sky which is then compared to an internal database of star maps. Once a match is found, the scope is aimed at a different part of the sky and the process is repeated. This process continues until the mount has a sufficient number of matches so that it knows exactly where it is pointing.

It should be noted that this process only replaces the computerized alignment and in no way is a substitute for accurate polar alignment.

That being said, if you are doing visual work for bright objects you could just point the mount roughly at the celestial pole, activate the automatic alignment and be done. This sure makes things nice for a quick evening out under the stars!

Common problems and solutions

Problem: No matter what you do, you cannot get your computerized mount to do its alignment correctly.

Solution: There are three very common mistakes with setting up the computerized alignment in your mount's hand controller.

Entering the wrong value for daylight savings time will cause everything to be off but still in the right area of the sky.

Entering the wrong value for UTC offset will cause everything to be substantially off. For example, if I entered +6 instead of -6 in my hand controller here in the Central time zone of the United States. Not like I have ever done that or anything, heh.

Reversing the direction of your longitude or latitude by entering N when it is really S, or E when it is really W will cause everything to be substantially off as well. Yes, I have done that too.

Problem: What is the easiest way to do a meridian flip with a computerized go-to mount?

Solution: Wait until your mount has tracked the object just past the meridian (make sure your telescope does not hit your mount). Now reselect the object in your hand controller and it should perform the flip for you.

Problem: I look through my polar scope and all I see is blackness. I cannot see any stars at all. I can't even see though it in daylight!

Solution: Turn your telescope all the way to the left or right on the declination axis until it is pointed ninety degrees from straight ahead. There is a hole drilled through the shaft that drives the declination axis to look through.

Problem: When tracking an object the mount sometimes tracks well and sometimes seems to just stop.

Solution: Check to make sure that your cables do not catch on anything as the mount turns. You can also ensure that the weights do not hit the mount as they swing past the legs. Lastly, make sure the declination and right ascension locks are firmly locked.

Problem: I have a Celestron mount and it seems to track strangely ever since I bought the AC adapter for it.

Solution: Unfortunately I have heard of several CG-5 mounts from Celestron with this issue. The only solution I have heard that works is to run the mount off its 12V DC adapter instead of the 110V AC adapter. You can easily enough get an inverter which will plug into your 110V household socket and provide a 12V cigarette adapter plug to plug the Celestron DC adapter into.

Problem: You are using software to assist in your polar alignment but you can never seem to get it right. Every time you recheck the polar alignment it is still off.

Solution: This can happen when you start out with a mount that is not level. The software assumes that your altitude adjustment will move the mount perpendicular to the horizon and that the azimuth adjustment will move it perfectly parallel to the horizon. If the mount is not level this will not be the case and the software can not compensate for that.

Where to get more information

Oh boy, are there a lot of places you can go so here are some suggestions:

Astronomy equipment:

Orion Telescopes	-www.telescope.com
AgenaAstro	-www.agenaastro.com
Oceanside Telescope	-www.optcorp.com
Astromart (used)	-www.astromart.com
ScopeStuff	-www.scopestuff.com
Hayneedle	-www.telescopes.com

Online forums:

Astronomy Magazine	-www.astronomy.com
Stargazers Lounge	-www.stargazerslounge.com
Cloudy Nights	-www.cloudynights.com
Ice In Space	-www.iceinspace.com
Astromart	-www.astromart.com/forums/
Telescope Junkies	-www.telescopejunkies.com
Allan’s AP Forums	-www.allans-stuff.com/forum/

Specializations:

Spectroscopy	-www.rspec-astro.com
Radio Astronomy	-www.radio-astronomy.com
Photometry	-www.citizensky.org
Astrophotography	-www.allans-stuff.com

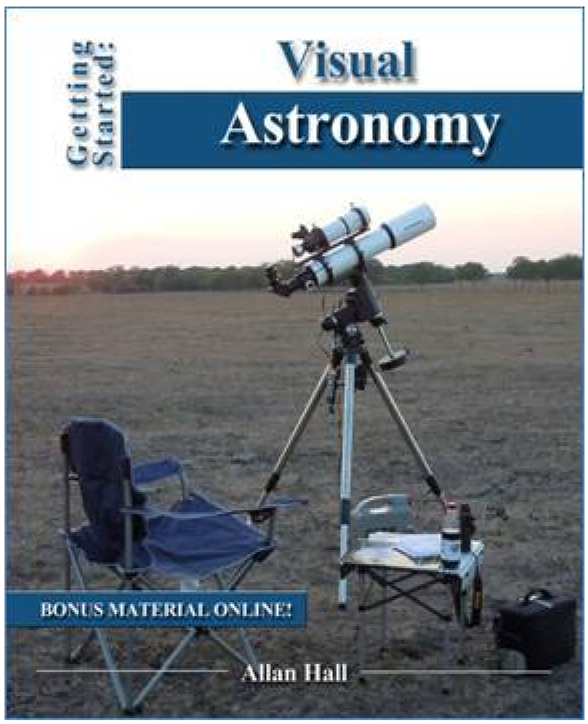
Planetarium software:

TheSkyX	-www.bisque.com
Starry Night	-www.starrynight.com
Stellarium	-www.stellarium.org

Cartes du Ciel	-www.ap-i.net
C2A	-www.astrosurf.com

Session planning software:

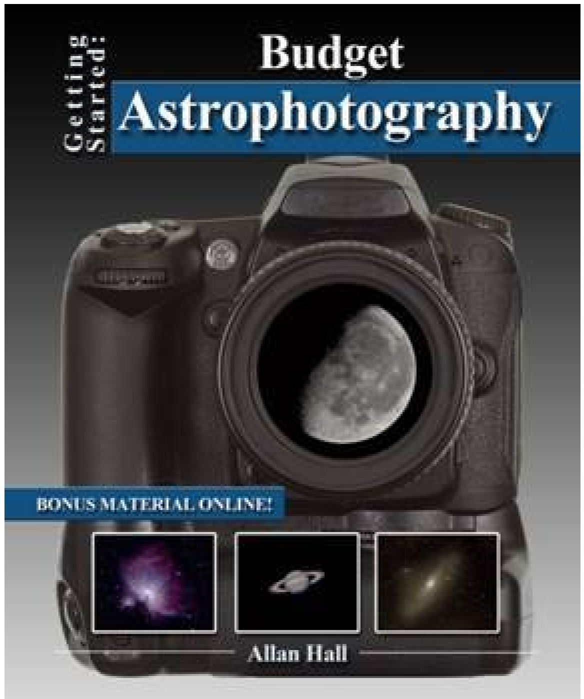
Astroplanner	-www.astroplanner.net
Skytools	-www.skyhound.com
Deep Sky Planner	-www.knightware.biz



https://tinyurl.com/olfvsp2

Now that you know how to set up your telescope and use it, why not learn what all you can see in the sky? *Getting Started: Visual Astronomy* is the perfect companion to this book and includes tons of information, star charts, and dates for special celestial events through 2025.

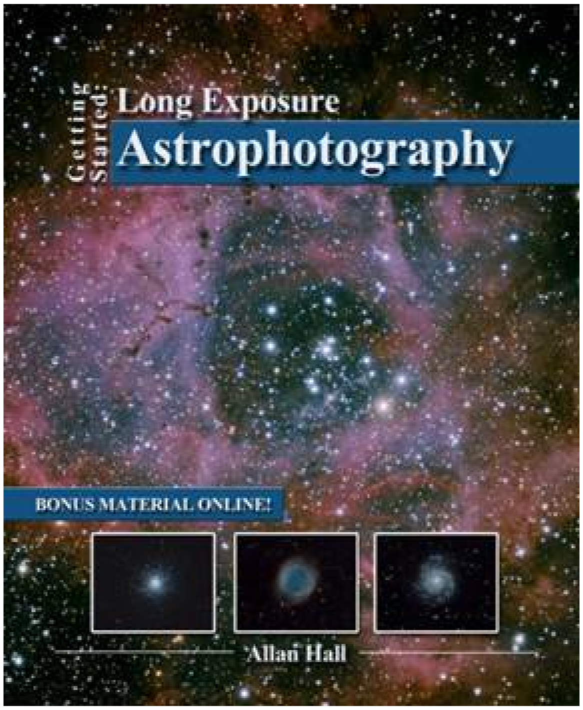
Like most of my books it is available from Amazon.com in both print and Kindle editions.



https://tinyurl.com/qewdlgo

Want to take a few snapshots of the beautiful objects you are viewing without spending a small fortune? Already have a camera but you can't seem to get a good image and want to know why?

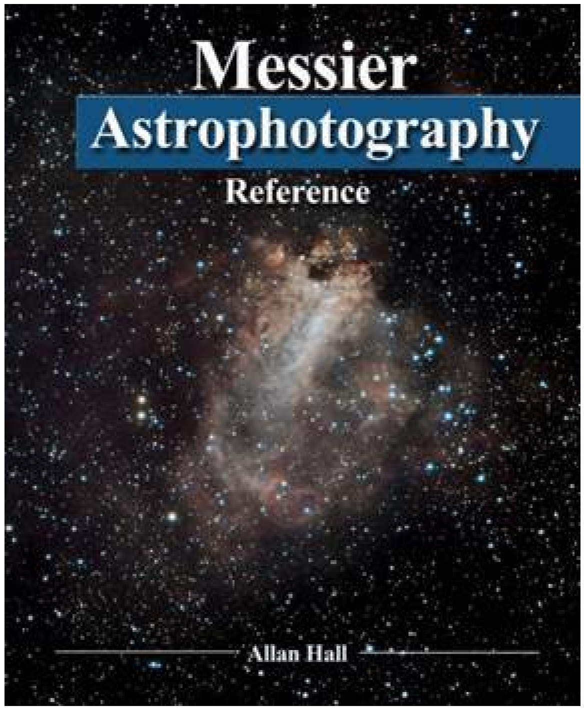
This book will answer those and many other questions while giving you a quick and reasonably easy introduction to budget astrophotography. In addition, save more money by seeing how to make a lot of items you may find useful.



https://tinyurl.com/og5zlge

If you decide that you want more than quick snapshots, you want big beautiful prints to hang on your wall, this is the book for you.

From required and optional equipment, through the capture process and into the software processing needed to create outstanding images, this book will walk you through it all.



https://tinyurl.com/o67sg6r

You decide that you want to take images of celestial targets, but need a little help with the targets? This book discusses all 110 Messier targets and includes descriptions, realistic images of each target, star charts and shoot notes to help you image all 110 of the objects yourself.

If you have enjoyed this book please take a moment to leave a review on Amazon. Thank you!