Polar Aligning A Telescope For Astro-imaging

Roger Powell

Accurate polar alignment of an equatorial mount is essential for astro-imaging.

Good polar alignment is a pre-requisite for accurate auto-guiding; and accurate auto-guiding is the prerequisite for long exposure astro-photography. They go hand in hand together. Without guiding, your camera cannot accurately track the stars and your long exposures will not be satisfactory.

In practice, an accurate polar alignment will make your auto-guiding easier to manage. Conversely, if your polar alignment is poor, then you are more than likely to have trouble with your auto-guiding.

In this article I describe the principles of polar aligning and the steps that I have taken to improve and ultimately achieve a good alignment of my mount, every time.

I write this from a Southern Hemisphere perspective but my description can be equally applied in the Northern Hemisphere.

Celestial Poles

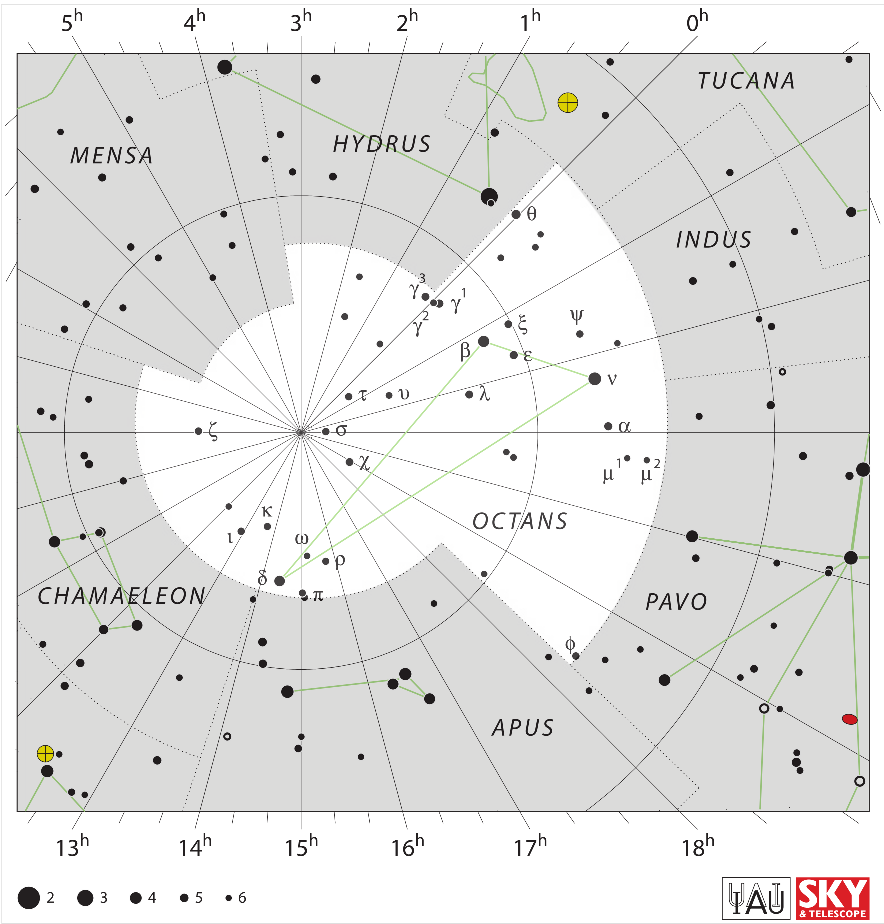
The north and south celestial poles are the two points on the imaginary celestial sphere which are intersected by lines extended from the Earth's rotation axis. They represent points in the sky that are directly above the Earth's two Poles and from our perspective on the surface of a rotating Earth, the surrounding stars all appear to rotate around the celestial poles.

Star trails around the South Celestial Pole.
Image: Roger Powell

The angular height above the horizon of the celestial pole which is visible from your location is exactly the same as the latitude of your location. Here in SW Sydney, our latitude is approximately 34º and consequently the South Celestial Pole is 34º above the horizon when looking towards true south.

Southern Polar Region

The South Celestial Pole (SCP) is located in an otherwise insignificant part of the sky in the constellation of Octans, just over one degree from Sigma Octantis (σ) a fifth magnitude star.



The South Celestial Pole and σ Octans.
Image attribution: IAU and Sky & Telescope magazine (Roger Sinnott & Rick Fienberg).
Wikimedia Commons.

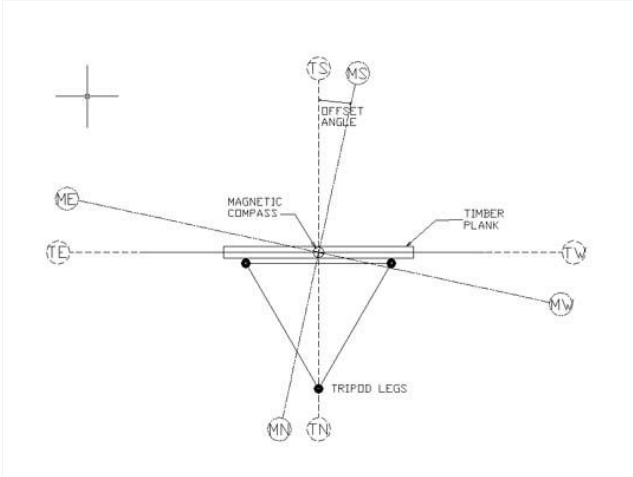
Rough Alignment by Magnetic Compass

When setting up before an imaging session, it is important to align the tripod fairly accurately, so that when it gets dark a more accurate alignment can be easily carried out using the stars.

All telescope mounts have adjustment knobs for fine tuning of azimuth and altitude after the mount and telescope have been set up. The popular EQ6 mount has an azimuth adjustment range of about 9º which means that if your rough alignment is in error by more than 4.5º, then you will be unable to fine tune the alignment later without the hazardous task of moving the tripod legs.

It is advisable to use a magnetic compass to position the tripod facing towards true South. One way of doing this is to place the compass on a piece of straight timber placed against the tripod legs and moving the timber until it it is aligned directly East-West, then butting two of the tripod legs up to it.

Beware of any magnetic field distortion which may occur from nearby objects e.g. your motor vehicle.



Rough polar aligning.
Use a magnetic compass to find magnetic South and offset to true South (TS).
Image: Roger Powell

You need to know the exact angle of offset between magnetic South and true South for your location. Here in Macarthur that angle is approximately 12.5º anti-clockwise from (or to the left of) magnetic South. South is 180º and I therefore need to align my tripod to 180º - 12.5º = 167.5º.

Magnetic compass pointing to to 167.5º.

Altitude set to local geo-latitude.

Using this method, the tripod should be set up within a degree or two of true South. Once you have done this, you can level the mount, attach the telescope, have a snack and wait for the stars to come out before the important task of fine tuning the alignment.

Polar-scope

The traditional method of fine tuning the polar alignment is to use the polar-scope which often comes packaged with new telescopes. To use it can be a real struggle. This can be true even in both hemispheres but a lot of astronomers in the Northern Hemisphere still successfully use this method, because fortunately for them they have a bright (magnitude 2.0) pole star, just 44 arc-minutes from the North Celestial Pole (NCP).

It is much more difficult here in the Southern Hemisphere, where the “pole star” is the unremarkable (magnitude 5.4) Sigma Octantis (σ). It is inconspicuous and it is a significant 1º 8’ away from the South Celestial Pole (SCP).

Kneeling on the ground, in the darkness, neck tilted backwards by 34º, trying to recognise faint inverted star formations which are probably not even in the narrow field of view was not my idea of fun and this abandoned method gave me nothing but grief.

Drift Aligning

I was using a DSLR at the time and I moved on to the drift align method because it made some some sort of sense to me. It consisted of first selecting a star close to 0º DEC and due South, locating it in the camera monitor and watching how far it drifted from its starting point, adjusting the azimuth bolts and repeating again and again until there is no drift.

You can observe the drift by taking images (pictured) and slewing the ‘scope slowly west for thirty seconds and then back again, by which time the star has drifted and traced a “V”. The concept is to close the "V" until the star returns to the exact same spot and the outward and return lines are indistinguishable.

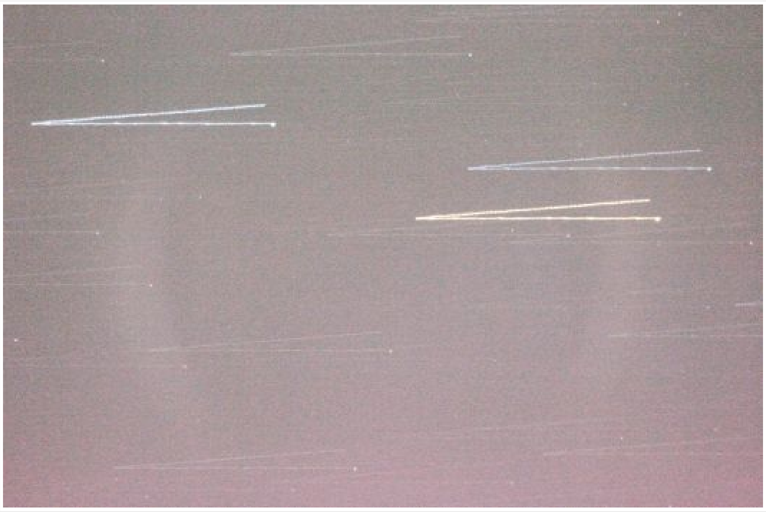


Image : Roger Powell

The whole process is then repeated with a star also close to 0º DEC but near the East or West horizon and moving north and back, again noticing how far it drifts and this time adjusting the altitude bolts. Repeat until satisfied.

This method is logical and simple but can take a lot of time, depending on the accuracy required. It did not provide me with the degree of accuracy which the guiding system required for smooth and accurate guiding – and I spent too much time attempting to do it.

For some it works well but I could easily have spent three quarters of the evening doing it properly.

After I bought my refractor telescope and Skywatcher EQ6 mount, I moved to a dedicated astro-camera and soon realised that I really needed to not only further improve my polar aligning technique but also to measure the achieved degree of accuracy.

PoleMaster

Next I discovered PoleMaster, which is claimed to be accurate down to 30 arc-seconds. It consists of a small camera fitted on the polar axis of the mount, in front of the polar scope, with a software routine which aligns the axis of the mount with the axis of the Earth within minutes.

The PoleMaster camera has a field of view of 11° x 8°, which has the great advantage of viewing a wide field around the pole which is very helpful if the rough aligning is a few degrees out. It certainly revolutionised my technique but the disadvantage I found was that due to the 88 square degree field of view, it rarely polar aligned to the degree of accuracy which the manufacturer advertised.

PoleMaster Camera: image copyright: Roger Powell

SharpCap

Several of the more advanced image capturing software packages contain polar aligning routines. SharpCap is the software of my choice for image capture and it has its own excellent polar alignment routine, so first I began using it just to check the accuracy of PoleMaster. Most of the results I got varied between one and four arc-minutes. Not impressive!

Realising there was still much room for improvement, I abandoned PoleMaster and switched to the SharpCap polar aligning routine. It is even simpler than the PoleMaster method - but much more precise because it can use the main camera attached to the telescope (my field of view= 1.5 square degrees) and after only a couple of nights I quickly nailed it.

The routine is based on the simple principle of measuring where the centre of rotation of the mount is located in the sky by plate solving the stars in the image and then issuing unambiguous instructions how to adjust the alt/az bolts to align it to the SCP. It is consistent and very quick.

SharpCap display

With this software I now consistently and quickly achieve a polar alignment accuracy between 0 and 10 arc-seconds. Once the error reaches less than 10 arc-seconds, I recommend you don't spend any more time on it, because you might end up chasing your tail and losing valuable imaging time for little or no gain.

With such a small polar alignment error, the guiding system usually averages a very acceptable average error of about half a pixel and rarely plays up, because polar alignment accuracy equals good guiding performance.

Footnote: not wanting to waste the money I spent on the PoleMaster, I discarded the software but left the camera attached, so that in the event of a significant rough alignment error (which can sometimes happen when using a magnetic compass), I could utilise the PoleMaster camera as a time-saving wide-angle tool to quickly re-centre the polar region, before beginning the SharpCap fine-tuning routine with my imaging camera.

Polar Alignment Summary

So this is now the procedure I use to polar align:

1. In daylight, set up the tripod facing true South using a magnetic compass, offsetting for magnetic deviation. Accuracy should be less than about 4°, typically much less.

2. Still in daylight, level the tripod as accurately as possible by using a spirit level in the North-South and East-West directions.

3. Make sure the mount is lightly lubricated before placing it in position on the tripod and securing it tightly.

4. Adjust the Azimuth bolts so that the mount is centrally aligned and set the Altitude pointer to the approximate latitude.

5. After dark, with the telescope fully set up and ready to use, wait for the first stars to appear.

6. Open SharpCap and select the PoleMaster camera. If the polar region is roughly centred move on quickly but if necessary, locate Sigma Octans and centre the SCP region.

7. In SharpCap, switch to the main imaging camera (or the guiding camera) and follow the on-screen instructions to get a near perfect alignment.

Roger Powell
September 2021