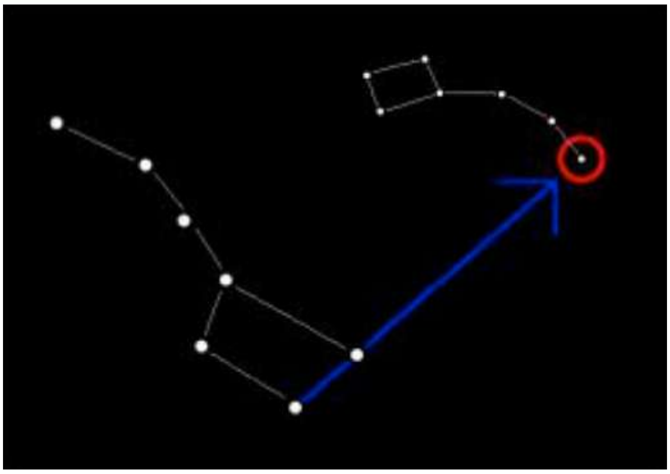
POLAR ALIGNMENT

Polar alignment is the procedure of aligning the rotational axis of a telescope's equatorial mount in parallel with that of the Earth to track the night sky with your telescope. When polar aligned, the Right Ascention (RA) motor on the equatorial mount will move the telescope in motion with the stars, nebulae or galaxies so that they remain stationary relative to the eyepiece. There are various ways to achieve this. For normal observing with an equatorially mounted telescope, only rough polar alignment is necessary. This will generally be enough for visual work but it is also a necessary step to make the accurate polar alignment phase easier.

Rough Polar Alignment (for the Northern Hemisphere)

Polar alignment in slightly different for Northern and Southern Hemispheres. The usual procedure for the polar alignment in the Northern Hemisphere is sighting on Polaris, the North Star. For the polar alignment in the Southern Hemisphereis the telescope is pointed to Octantis, the South Star.



- Identify your telescopes declination axis and note there is a scale around it.
- Rotate the telescope around this axis until it is at 90 degrees. It should now be pointing along the polar axis.
- Adjust the latitude scale of your mount to equal the latitude of your observing site.
- Identify Polaris in the sky which is easy to find by following the two pointer stars in the bowl of the Plough (part of the constellation Ursa Major). `
- Move the entire telescope mount and the telescope so that the tube is pointing toward Polaris. Polaris should be visible in the field of view of the finder telescope.
- Make minor adjustments to the mount by adjusting its left-right position and your latitude setting to centre Polaris. Assuming your finder telescope is aligned well, then you should now see Polaris in the field of view of an eyepiece.

Your telescope is now roughly polar aligned and will be enough for visual observing. If you want to take

Accurate Polar Alignment

To align the finderscope with the telescope polar axis:

- Set up your mount as you would do for rough polar alignment. Adjust the mount in altitude and azimuth until Polaris is in the field of view of the finder and centered in the cross hairs.
- Now, while looking through the finderscope, slowly rotate the telescope 180° around the polar axis (i.e. 12 hours in RA) until the finder is on the opposite side of the telescope.
  - If the optical axis of the finder is parallel to the polar axis of the mount, then Polaris will not have moved, but remain centered in the cross hairs.
  - If Polaris has moved off of the cross hairs, then the optical axis of the finder is skewed slightly from the polar axis of the mount. If this is the case, you will notice that Polaris will scribe a semi-circle around the point where the polar axis is pointing. Take notice how far and in what direction Polaris has moved. Using the screws on the finder bracket, make adjustments to the finderscope and move the cross hairs halfway towards Polaris' current position. Once this is done, adjust the mount itself in altitude and azimuth so that Polaris is once again centered in the cross hairs.
  - Repeat the process by rotating the mount back 180°, and adjusting the finder bracket screws until the cross hairs are halfway between their current position and where Polaris is located, and then centering Polaris in the cross hairs by adjusting the mount in altitude and azimuth. With each successive adjustment the distance that Polaris moves away from center will decrease. Continue this process' until Polaris remains stationary in the cross hairs when the mount is rotated 180º.

So far we have accomplished aligning the polar axis of the telescope with the North Star (Polaris), but the true North Celestial Pole (NCP) lies about 3/4° away from Polaris, towards the last star in the Big Dipper (Alkaid). To make this final adjustment, the telescope mount will also need to be moved away from Polaris towards the actual NCP:

- While looking through the finderscope, adjust the latitude and azimuth of the mount up and to the left until Polaris also moves up and to the left in your straight through finderscope (a straight through finder inverts the image, so Polaris will appear to move in the same direction as the mount is moved). How far to move Polaris will depend on the field of view of the finderscope. If using a finderscope with a 6° field of view, Polaris should be offset approximately 1/3 of the way from center to edge in the finder's view, which gives 1°.
- The mount's setting circles can now be used to determine just how close the polar axis is to the NCP. First, aim the telescope tube at a bright star of known right ascension near the celestial equator. Turn the right ascension setting circle to match that of the bright star. Now, rotate the telescope tube until it reads 2 hours 30 minutes (the right ascension of Polaris) and +89¼° declination. Polaris should fall in the center of the finder's cross hairs. If it doesn't, once again move the mount in latitude and azimuth to center Polaris.

This procedure aligns the telescope mount to within a fraction of a degree of the NCP; good enough to track a star or planet in a medium power eyepiece without any noticeable drift. However, long exposure astrophotography is far less forgiving and film will easily reveal even the smallest amount of motion. At this point, you may be wondering why bother polar aligning any more accurately if you can use the slow motion controls or drive corrector to keep a guide star centered in the cross hairs of an eyepiece. Unfortunately, keeping the guide star centered in the cross hairs is only half the battle. Since, the polar axis is not perfectly in line with the Earth's axis, the stars in the field of view will slowly rotate as you guide. You will get a sharp image of the guide star, but the other stars on the photograph will appear to rotate around the guide star. This is also why you cannot accurately do guided photography with an Altitude-Azimuth (Altazimuth) style mount.

Precise Polar Alignment

The above method of polar alignment is limited by the accuracy of your telescope's setting circles and how well the telescope is aligned with the mount. The following method of polar alignment is independent of these factors and should only be undertaken if long-exposure, guided photography is your ultimate goal. The declination drift method requires that you monitor the drift of selected stars. The drift of each star tells you how far away the polar axis is pointing from the true celestial pole and in what direction. Although declination drift is simple and straight-forward, it requires a great deal of time and patience to complete when first attempted. The declination drift method should be done after the previously mentioned polar alignment steps have been completed.

To perform the declination drift method, you will need to choose two bright stars, one near the eastern horizon and one due south near the meridian. Both stars should be near the celestial equator (i.e., 0° declination). You will monitor the drift of each star one at a time and in declination only. While monitoring a star on the meridian, any misalignment in the east-west direction is revealed. While monitoring a star near the east horizon, any misalignment in the north-south direction is revealed.

As for hardware, you will need an illuminated reticle ocular to help you recognize any drift. For very close alignment, a Barlow lens is also recommended since it increases the magnification and reveals any drift faster. When looking due south, insert the diagonal so that the eyepiece points straight up. Insert the cross hair ocular and rotate the cross hairs so that one is parallel to the declination axis and the other is parallel to the right ascension axis. Move your telescope manually in right assention and declination to check parallelism.

Drift alignment
Drift alignment (shift)

- Choose your star near where the celestial equator (i.e. at or about 0º in declination) and the meridian meet. The star should be approximately 1/2 hour of right ascension from the meridian and within five degrees in declination of the celestial equator.
- Center the star in the field of your telescope and monitor the drift in declination. If the star drifts south, the polar axis is too far east. If the star drifts north, the polar axis is too far west.
- Using the telescope's azimuth adjustment knobs, make the appropriate adjustments to the polar axis to eliminate any drift. Once you have eliminated all the drift, move to the star near the eastern horizon. The star should be 20 degrees above the horizon and within five degrees of the celestial equator. If the star drifts south, the polar axis is too low. If the star drifts north, the polar axis is too high.
- This time, make the appropriate adjustments to the polar axis in altitude to eliminate any drift. Unfortunately, the latter adjustments interact with the prior adjustments ever so slightly. So, repeat the process again to improve the accuracy, checking both axes for minimal drift.

Once the drift has been eliminated, the telescope is very accurately aligned. You can now do prime focus deep-sky astrophotography for long periods.

If you have a PC controlled mount, use software to accurately align your mount within minutes.

Polar Alignment Software

Alignmrnt software Generally, polar alignment software works by one of two methods:

- Calculating alignment error based on the drift of a star, similar to conventional drift alignment
- Comparing the position of stars within an image to a known database.

The problem with the latter is that most, if not all software of this kind calculates alignment using the J2000 position of stars and does not take into account the present day position. Therefore, alignment using software of this kind can be inaccurate by several arc minutes. Software that uses drift alignment is likely to be more accurate, but a couple of arc minutes is accurate enough for most people's needs.

Software available as at October 2017

- **PoleAlignMax** - freeware that requires Maxim DL or CCD Soft, a CCD camera, ASCOM and star catalogue such as GSC1.
- **AlignMaster** - easy to use commercial software at a very reasonable price with 30 day free trial, compensates for the J2000/JNOW offset.
- **EQ Align** - a sophisticated freeware program capable of providing accurate polar alignment with the drift method.
- **PemPro** - rather expensive but excellent commercial software with free trial.
- **WCS (WebCamScheinern)** - reasonably priced commercial software with 30 day free trial for drift aligning with a webcam.
- **PolarFinder** - freeware that calculates the correct offset from Polaris and does not require a camera or a webcam.
- **K3CCD Tools** - commercial with 35 day free trial, it is a popular software toolkit for webcam imaging, which can also be used for polar alignment.
- **StarTarg** - commercial drift alignment software for GEMs.
- **TPoint** (used with TheSkyX) - TPoint provide polar alignment data which can be used to polar align the mount.