Precise Polar Alignment (Drift Alignment)

OCA AstroImagers Boot Camp

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Overview

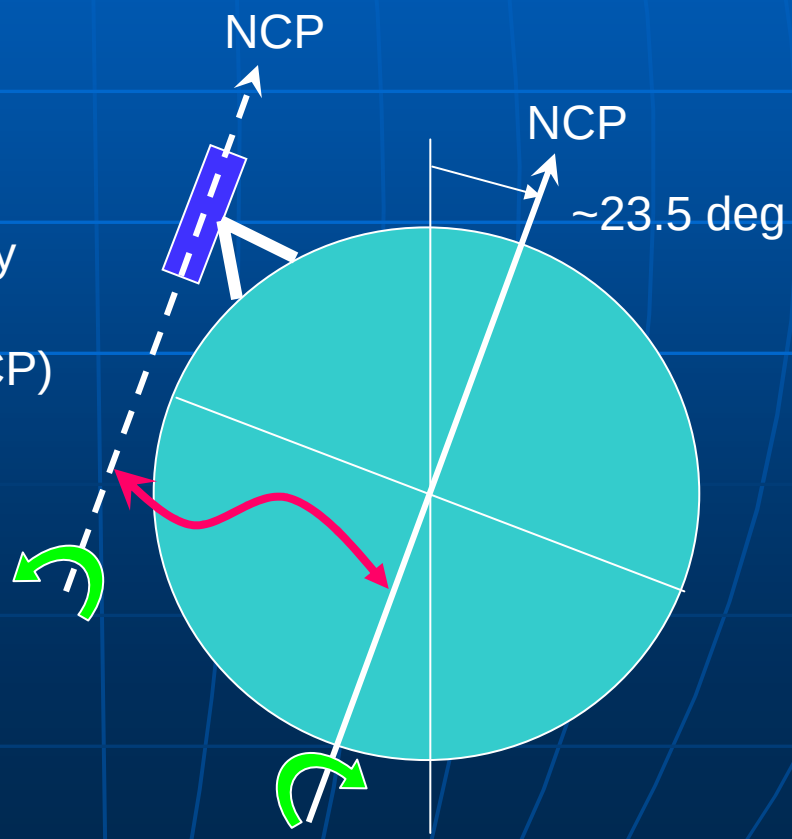
- Basics
  - Definition
  - Why drift align?
  - Basic polar alignment methods
  - Error sources
- Precise polar alignment
  - Drift correction method
- Case study – SCT Fork Mount
  - Meade 10” f/10 LX200 GPS

Basics

Basics

- Polar (equatorial) alignment
  - Mount's axis of rotation (in Right Ascension - RA) is exactly in line with the earth's axis of rotation
    - Approximate polar alignment is OK for visual observing
    - Precise polar alignment is required for astrophotography

Mount's Axis of Rotation is precisely aligned with Earth's axis of rotation pointing at North Celestial Pole (NCP)



Basics cont'd

- Why Polar Align?
  - Simplified tracking
    - Drive required in only one-axis (RA)
  - Eliminate field rotation during astrophotography
    - Long focal lengths
    - Large image areas (e.g. large CCD chip or film camera)
    - High resolution images
    - Long exposures or stack of many short exposures
    - Tracked star/object will not move
    - Stars near edge of field will not appear as short arcs

Basic Polar Alignment Methods

- Alignment using Compass and Bubble
  - Limited to accuracy of compass and bubble level readings and altitude markings on your mount.
  - Be sure to correct for magnetic deviation from true north when using a magnetic compass.
- Align on pole using Main Scope
  - Requires a clear (and reasonably dark) view of the sky near the pole.
  - Mostly useful to northern hemisphere observers.
  - Requires attention to accurate alignment between the scope's optical axis and the mount's mechanical axis.
  - Watch out for optical "flop" in movable mirror systems such as SCTs. Use a mirror lock if possible.
  - Take refraction into account at low latitudes.
  - Calculate celestial pole's offset from reference stars or use a special polar finder reticle.

Basic Polar Alignment Methods, cont'd

- Polar Finder Scope
  - May not be available in some mounts.
  - Requires good alignment between the optical axis of the polar finder scope and the mount's mechanical axis.
  - Requires a clear (and reasonably dark) view of the sky near the pole.
  - Mostly useful to northern hemisphere observers.
  - Take refraction into account at low latitudes.
  - Calculate celestial pole's offset from reference stars or use a special polar finder reticle.

Basic Polar Alignment Methods, cont'd

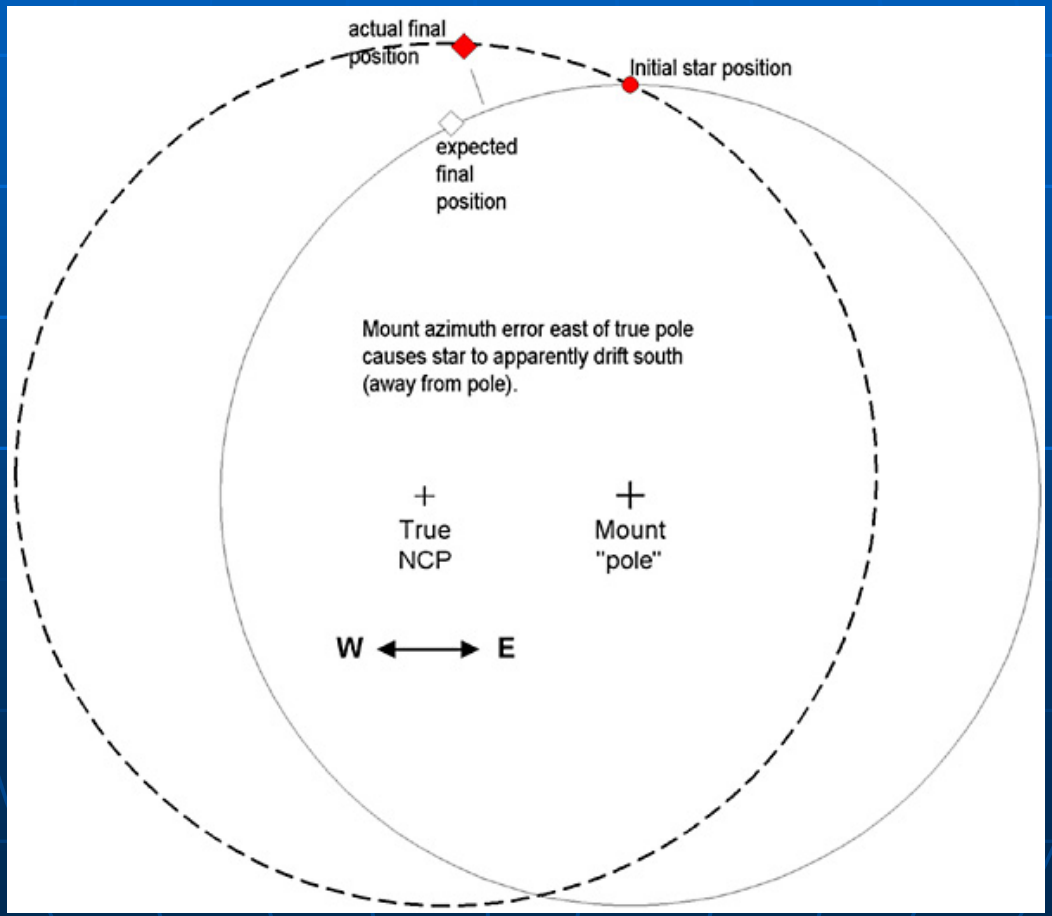
- Reference Star Iteration
  - Depends on setting circle accuracy (highest accuracy on computer-driven scopes with motor encoders)
  - Watch out for optical "flop" in movable mirror systems such as SCTs. Use a mirror lock if possible.
- GPS – Polar Auto Alignment
  - Automatic align
  - One Star align (in addition to Polaris)
  - Two Star align (in addition to Polaris)

Polar Alignment Error Sources

- Error sources in all alignment methods
  - Azimuth error
    - Mount's polar axis points Right or Left of true pole
  - Elevation error
    - Mount's polar axis points Above or Below true pole
- Basic idea behind drift alignment is to correct each error, one at a time.
  - Observe the path of a star such that the observed mis-tracking is entirely due to one of these errors

Azimuth Errors

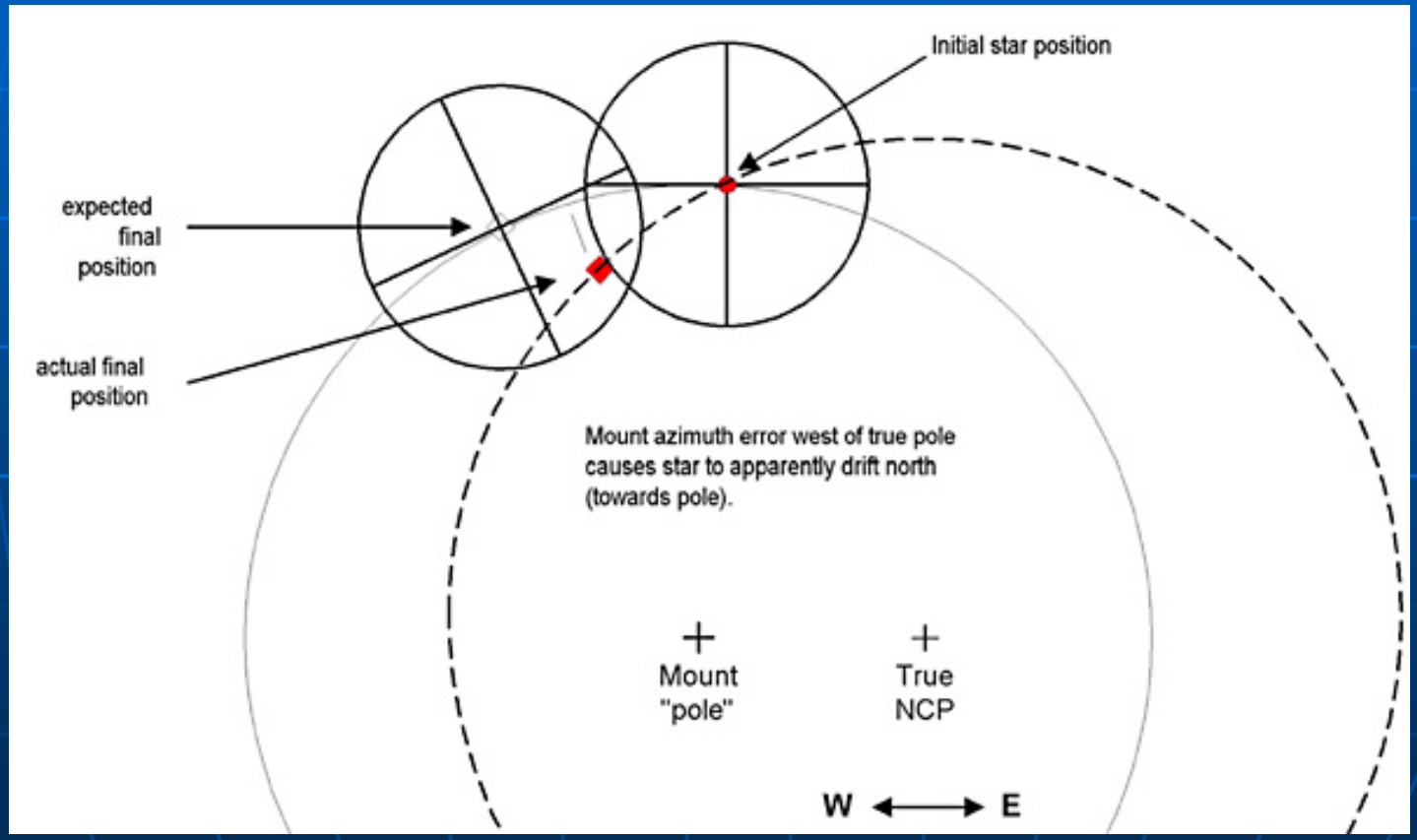
- Pick a star in the South, near or slightly north of the celestial equator, and near the meridian
- Example below assumes Mount's polar axis points East of North Celestial Pole (NCP)



(Figure by Dave Kodama)

Azimuth Errors, cont'd

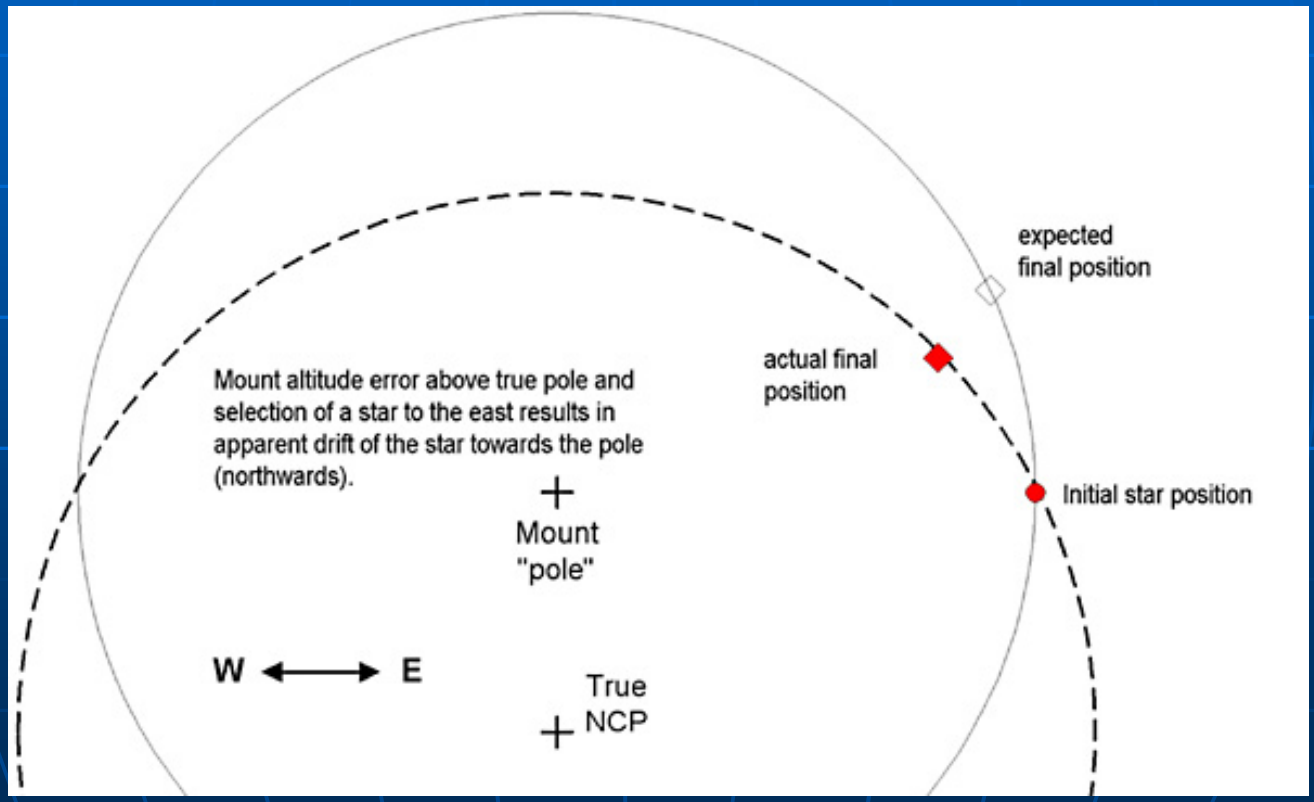
- Pick a star in the South, near or slightly north of the celestial equator, and near the meridian
- Example below assumes Mount's polar axis points West of NCP



(Figure by Dave Kodama)

Elevation Error

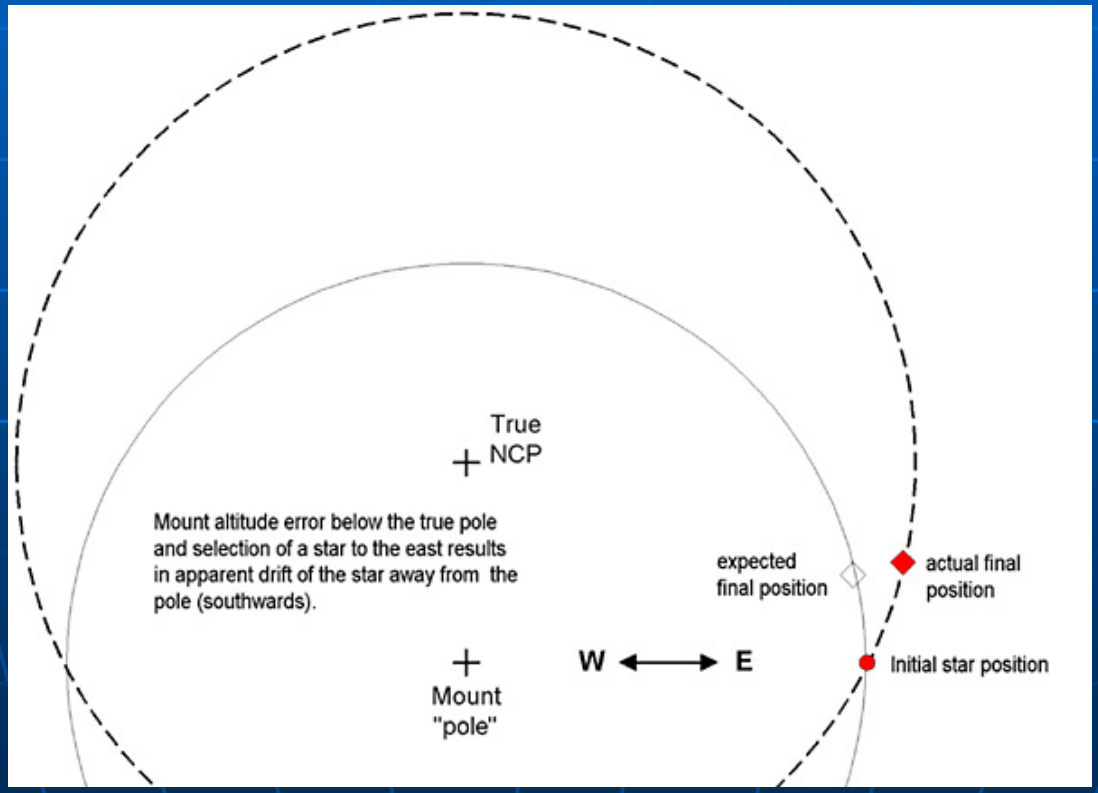
- Pick a star in the East, near or slightly north of the celestial equator, and 20°- 30° above the horizon
- Example below assumes Mount's polar axis points <u>Above</u> true NCP



(Figure by Dave Kodama)

Elevation Error, cont'd

- Pick a star in the East, near or slightly north of the celestial equator, and 20°- 30° above the horizon
- Example below assumes Mount's polar axis points <u>Below</u> true NCP



(Figure by Dave Kodama)

Precise Polar Alignment

Drift Alignment Method

Reticle Eyepiece Decisions

- Reticle eyepiece focal length
  - Shorter focal length = higher magnification
    - Typical focal lengths: 12mm, 9mm, 5mm
- Reticle eyepiece eye relief
  - Greater eye relief reduces effort to watch guide star
- Reticle pattern
  - Various styles for differing purposes
    - Single or Double cross hair
    - Concentric Rings Target
- Power source
  - Wireless (battery)
  - Wired
- Steady or pulsing LED

Drift Alignment Method

- Get scope approximately aligned using one of the basic methods (e.g. polar finder).
- Use a high magnification eyepiece to reduce the drift time and increase your accuracy.
  - Do not use a focal reducer during drift alignment
- Lock your mirror if possible if you are using a scope with a movable mirror in order to avoid false drift movement.

Drift Alignment Method, cont'd

- Align the reticle eyepiece so that the cross-hairs are aligned with the mount's RA and Dec axes, not along the path of drift of a star when the mount is not running!
  - Slew in RA and set the direction of the crosshair to this direction as closely as possible.
  - Once this is done, lock it in place for the rest of the testing.

Drift Alignment Method, cont'd

- Determine N vs. S by nudging the scope toward the pole while looking in the eyepiece.
  - You may find it helpful to put some tape on the eyepiece or mount to indicate north for drift observations.
- Familiarize yourself with your altitude and azimuth adjustment screws
  - Labeling them with N, S, E, W, if necessary will avoid the frustration of adjusting in the wrong direction.

Azimuth Error Summary

- Track a star near the intersection of the meridian and equator to see azimuth errors.
- Drift in RA should be ignored.
- If the star appears to drift southwards in the eyepiece, the mount is pointing too far east.
- If the star appears to drift northwards the mount is pointing too far west.

Elevation Error Summary

- Track a star to the east near the equator to see elevation errors.
- Drift in RA should be ignored.
- If the star appears to drift northwards the mount is pointing above the true pole.
- If the star appears to drift southwards the mount is pointing below the true pole.

Case Study

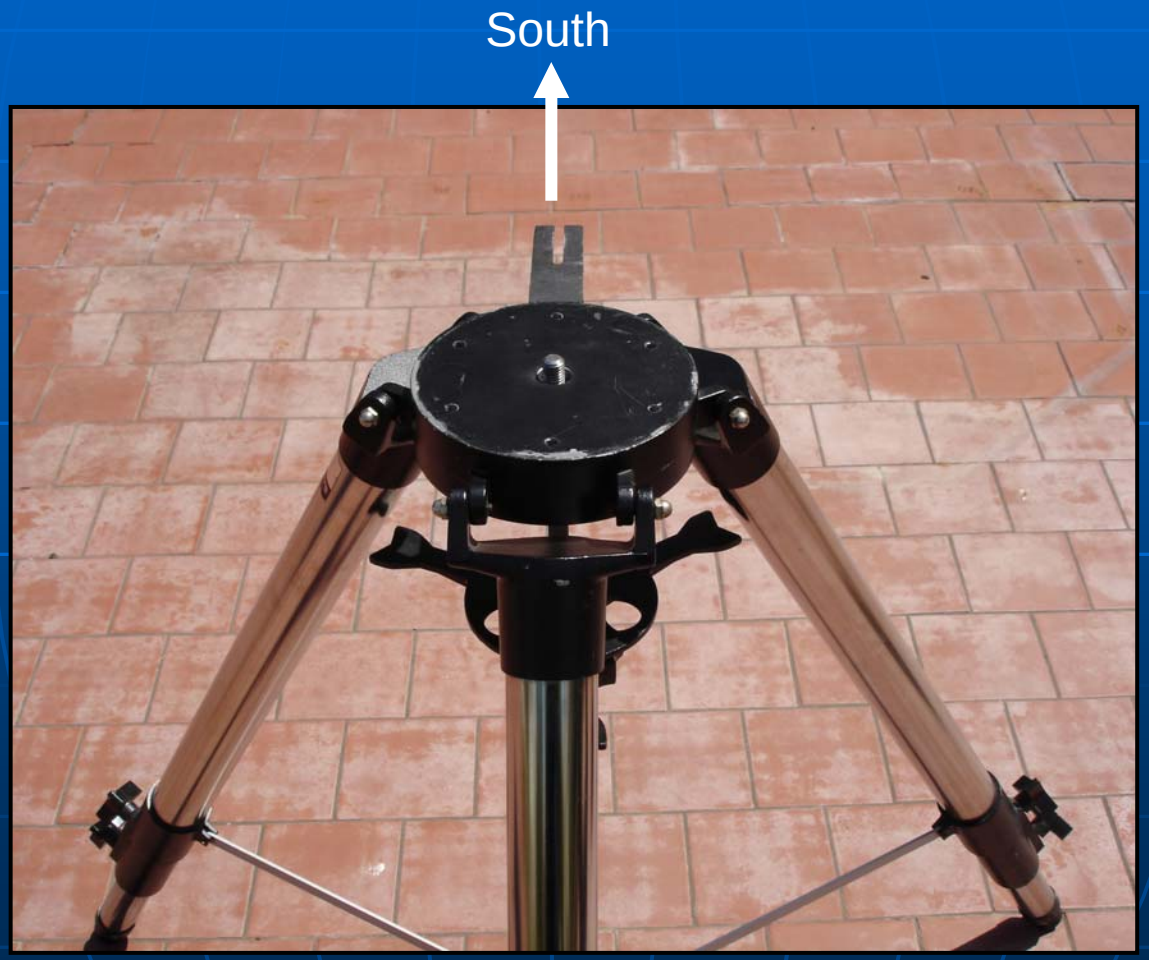
Meade 10” LX200 GPS

Basic Equipment

- Meade 10” f/10 LX200 GPS SCT (focal length 2450mm)
- Meade standard tripod
- Meade Super-wedge Equatorial adapter
- Televiewe 27mm Panoptic lens (~91X)
- Parks 12.5 mm illuminated reticle (~200X)
- Clock, watch, or timer

Initial Mount Setup

- Place tripod in north-south direction

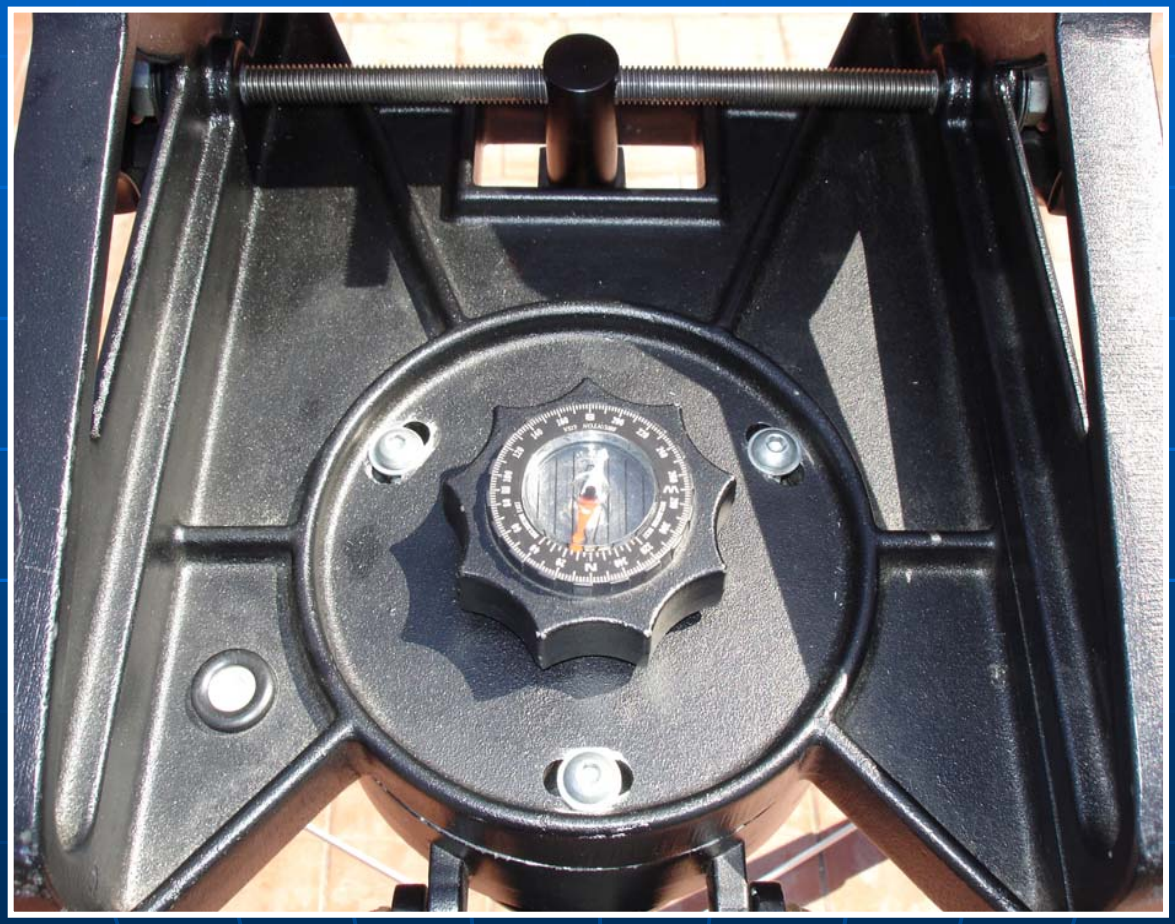


Initial Mount Setup, cont'd

- Place Super-wedge on tripod.
  - Alignment pin fits in slot
  - Tripod screw fits through center hole in wedge

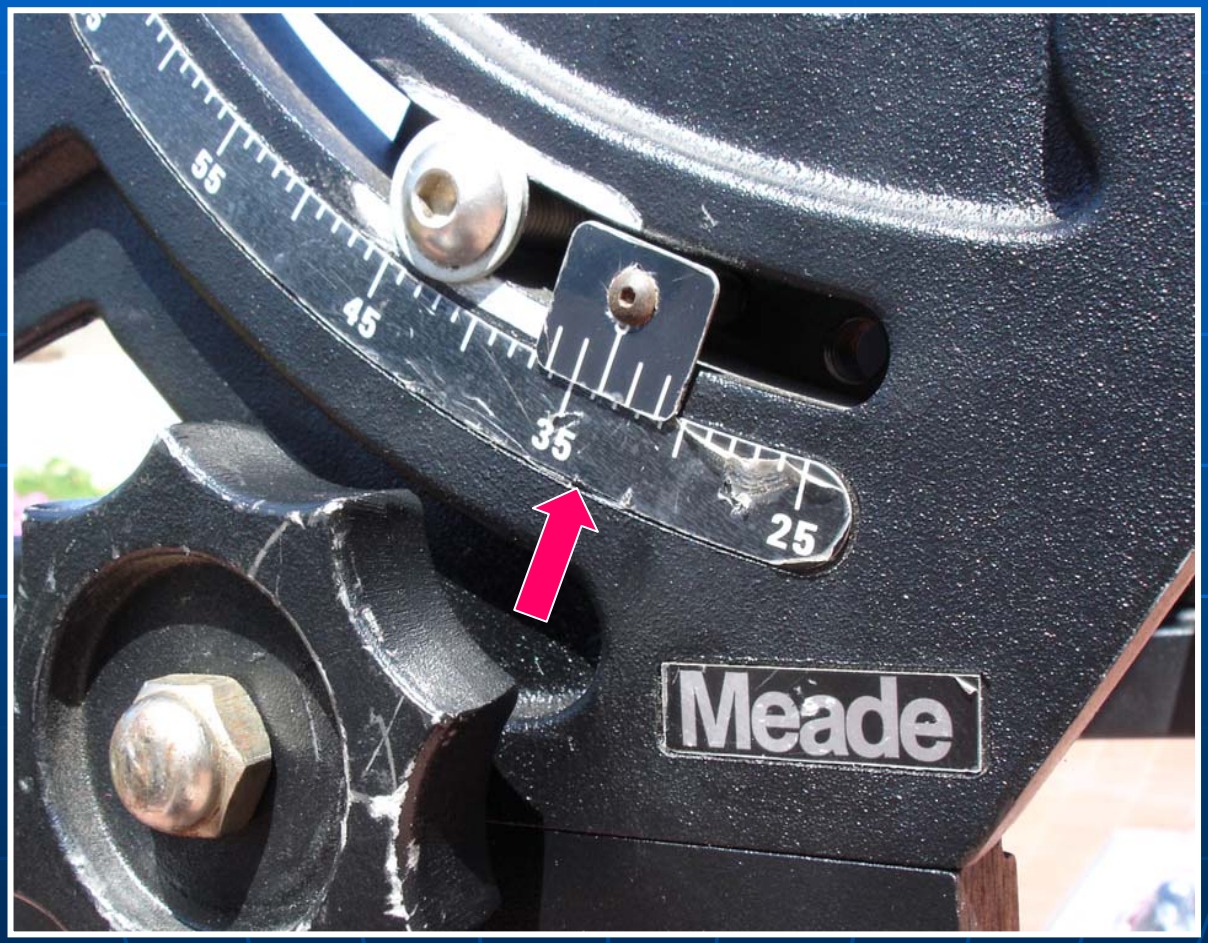
Initial Mount Setup, cont'd

- Fasten Super-wedge to tripod snuggly



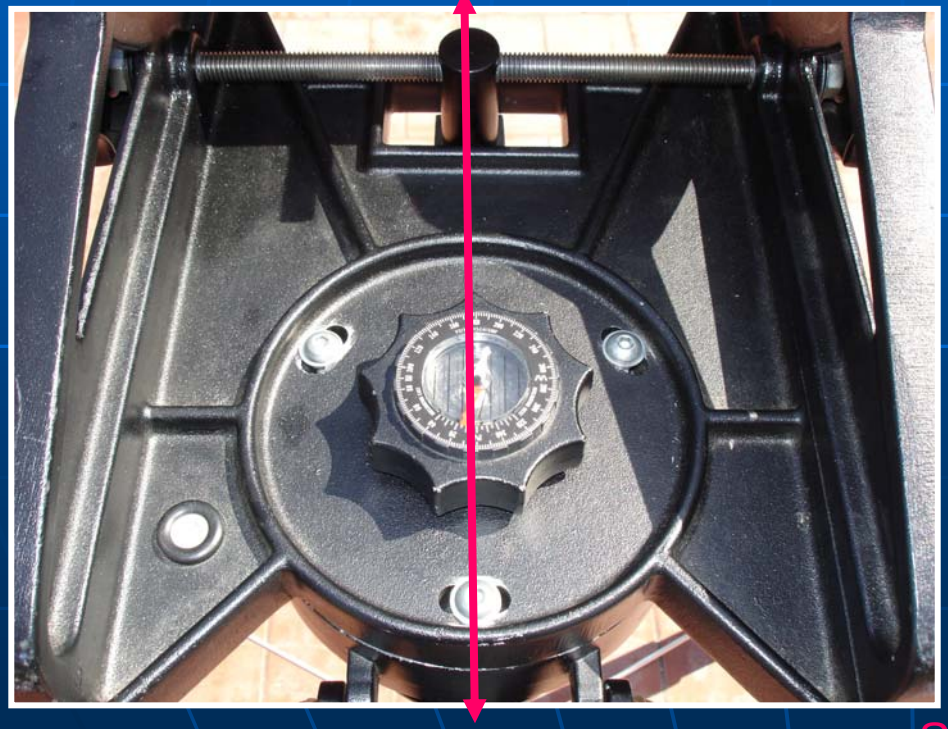
Initial Mount Setup, cont'd

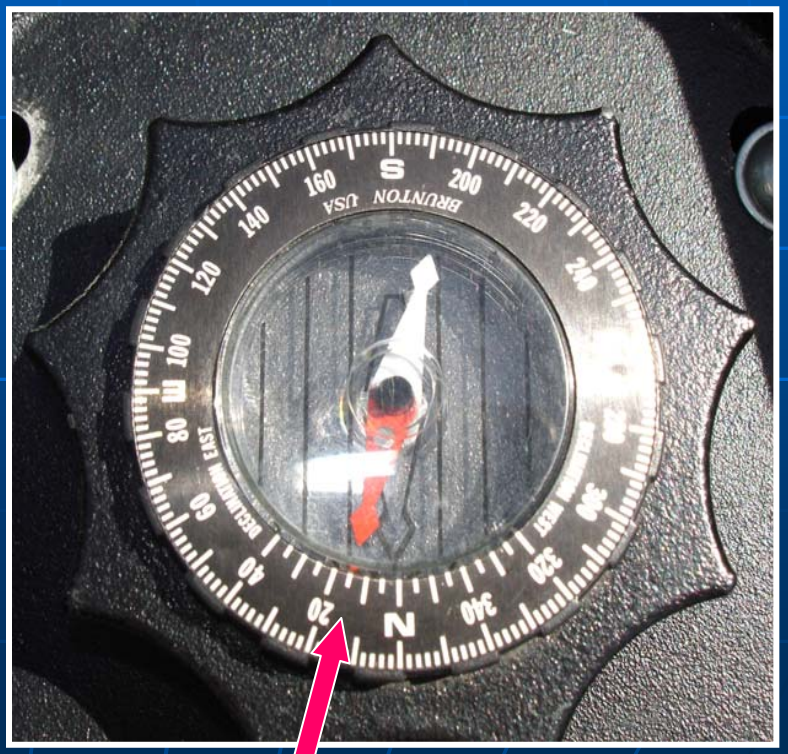
- Set approximate plate elevation to declination



Initial Mount Setup, cont'd

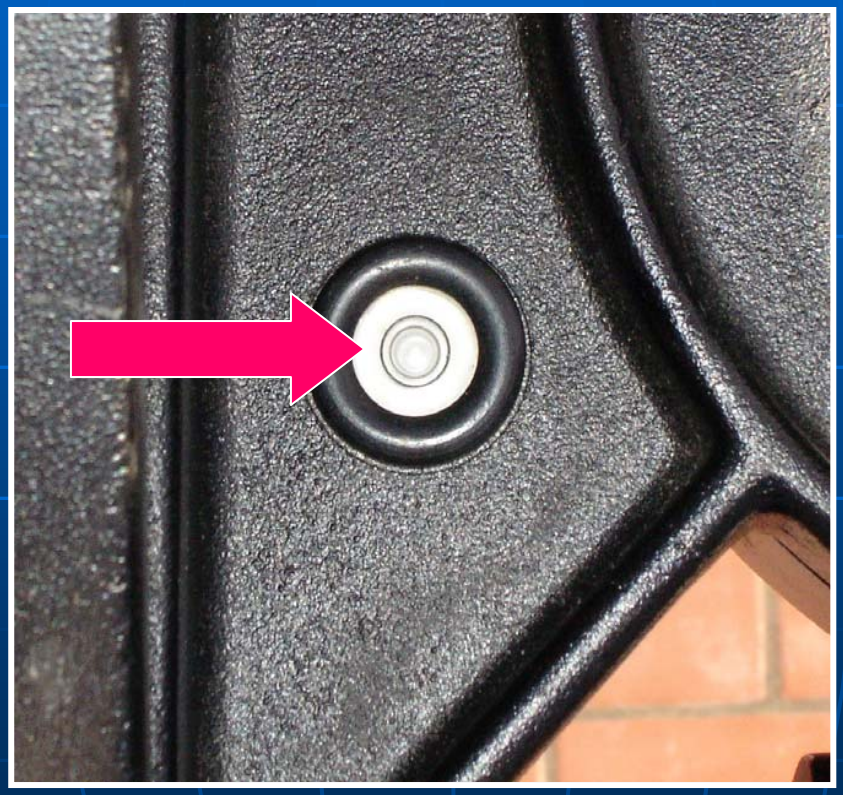
- Rotate tripod (legs) to true north using compass
  - Adjust Compass to line up with reference points shown
  - Needle points to magnetic north. Rotate tripod to local variation. (For So. Calif. currently approx. 14 deg East)





Initial Mount Setup, cont'd

- Level tripod using bubble
  - Accurate level will produce more repeatable results



Initial Mount Setup, cont'd

- Carefully place SCT on wedge and secure with bolts

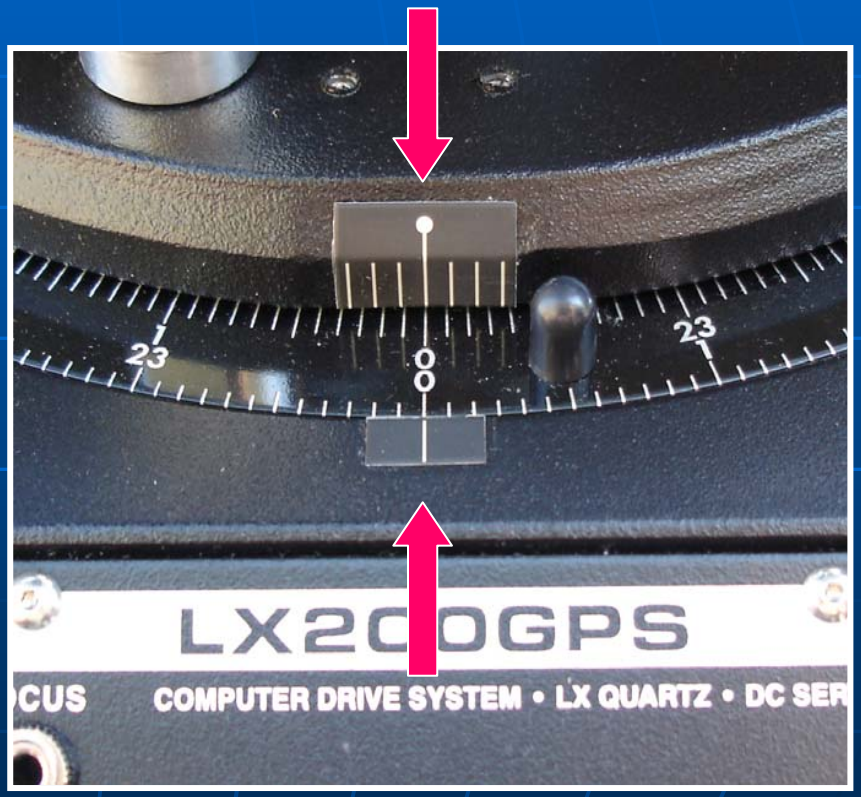
Initial Mount Setup, cont'd

- Adjust eyepiece to closely match mount axes

GPS Polar Alignment

- Power on GPS (let initialization complete)
- Manually move scope to 90° Dec and 00 RA (Polar “home” position)

Dec = 90 °



RA = 00

GPS Polar Alignment, cont'd

- Select Polar 1-Star alignment
- Computer takes a GPS fix
- Computer Positions scope to point at Polaris
- Accuracy of initial position dependent on sensor calibration, drive training, and backlash correction.

GPS Polar Alignment, cont'd

- Manually adjust azimuth and elevation knobs to center Polaris, first in finder, then center in medium power eyepiece (e.g. 27mm).
- Press enter when Polaris is centered in eyepiece. The closer the better, but reticle not necessary.

Manual Azimuth adjustment

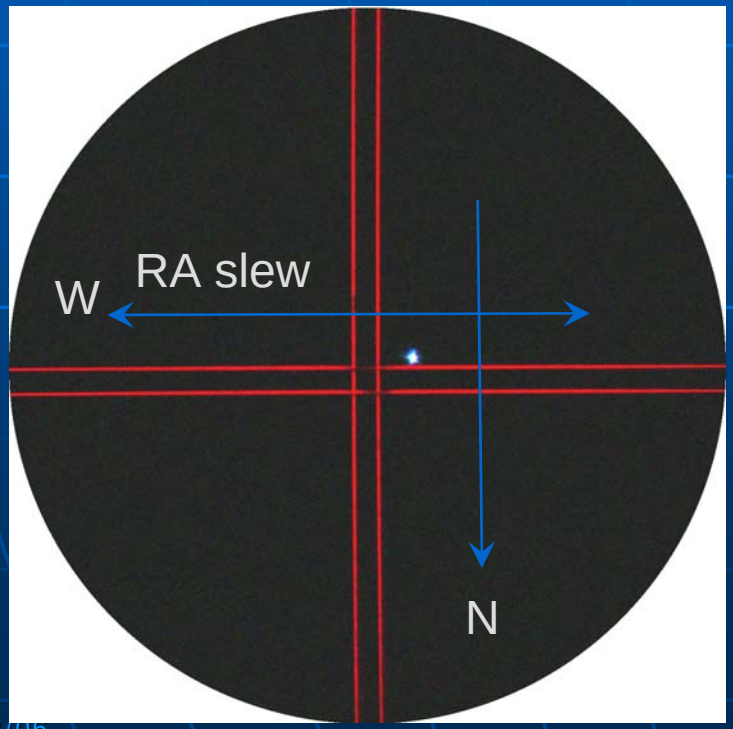
Manual Elevation adjustment

GPS Polar Alignment, cont'd

- Next, computer moves scope to a computer selected star
- Use paddle controls to center star in eyepiece
- Resulting alignment is usually good enough for visual work

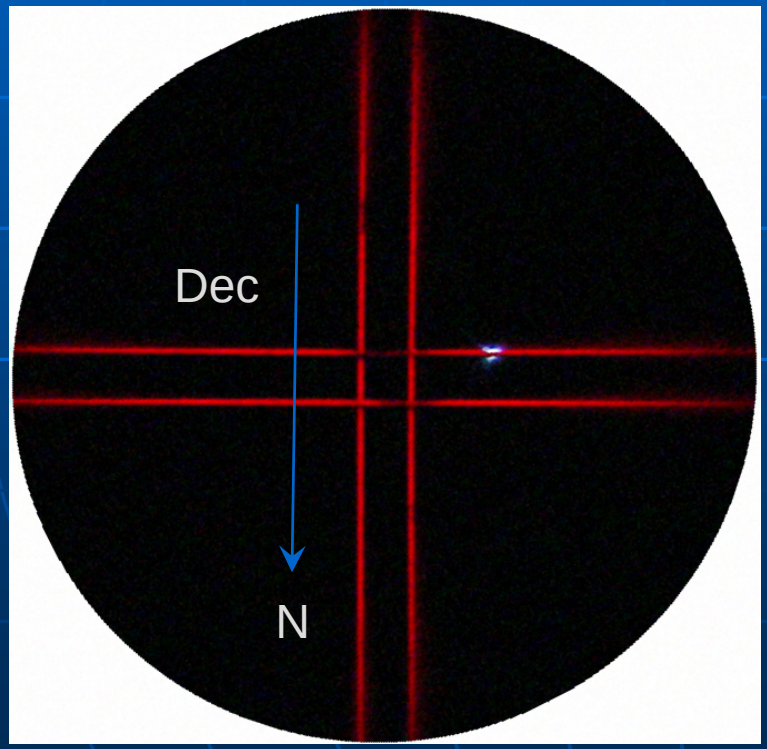
Azimuth Error Correction

- Insert reticle eyepiece and refocus.
- Pick a 2nd or 3rd magnitude star in the South, near or slightly north of celestial equator, and near meridian
- Adjust reticle rotation. Slew scope left and right in RA. Rotate eyepiece so star motion is parallel to horizontal reticle line.
- Lock eyepiece in place.



Azimuth Error Correction, cont'd

- Position star to eclipse horizontal reticle line.
- Make manual azimuth adjustments until there is no north or south drift in a 5 minute interval. Refer to previous slides.
- RA motion can be ignored

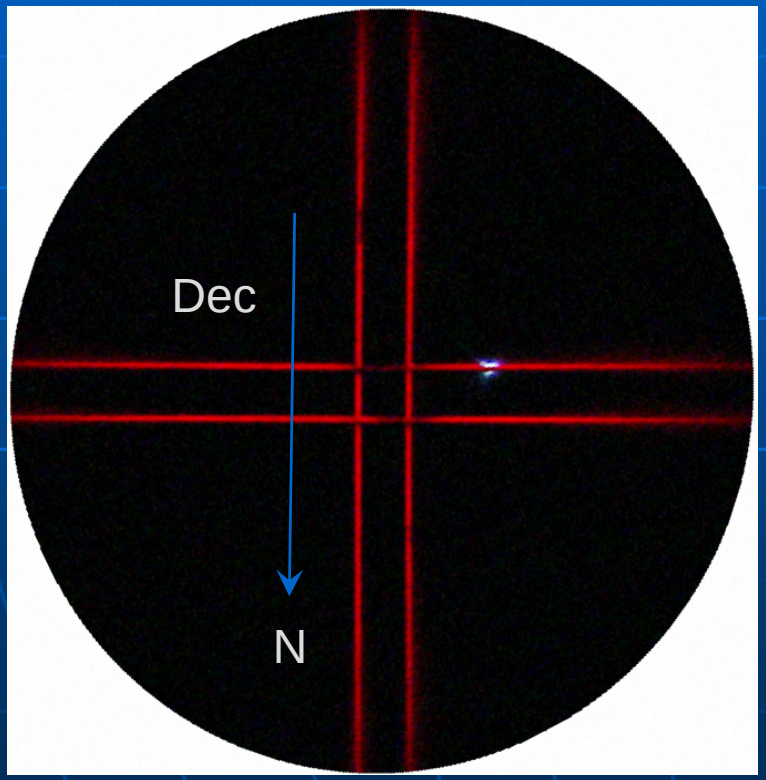


Elevation Error Correction

- Use drive motors to move telescope to point East in RA.
- Pick a 2nd or 3rd magnitude star in the East, near or slightly north of celestial equator, about 20° - 30° above horizon.

Elevation Error Correction, cont'd

- Position star to eclipse horizontal reticle.
- Make manual elevation adjustments until there is no star drift in a 5 minute interval.



Ready to Photograph

- When finished, remember to turn off reticle
- Insert focal reducer / field flattener if desired
- Change set-up for taking pictures – be careful not to disturb polar alignment!
- *Go for those deep sky shots!*

Tips

- Practice at home using brighter stars, even with the moon up
- Use a comfortable chair or stool
- Try not to kick the tripod legs
- Be patient, it is worth the effort
- Eventually you will be able to do other things while drift aligning (preparing camera, etc.)

References

- Dave Kodama's web site – Polar alignment tutorial
  - http://www.eanet.com/kodama/astro/
- Meade web site – LX200 Classic instruction manual
  - http://www.meade.com/manuals/TelescopeManuals/LXseries/LX200_Classic_Manual.pdf