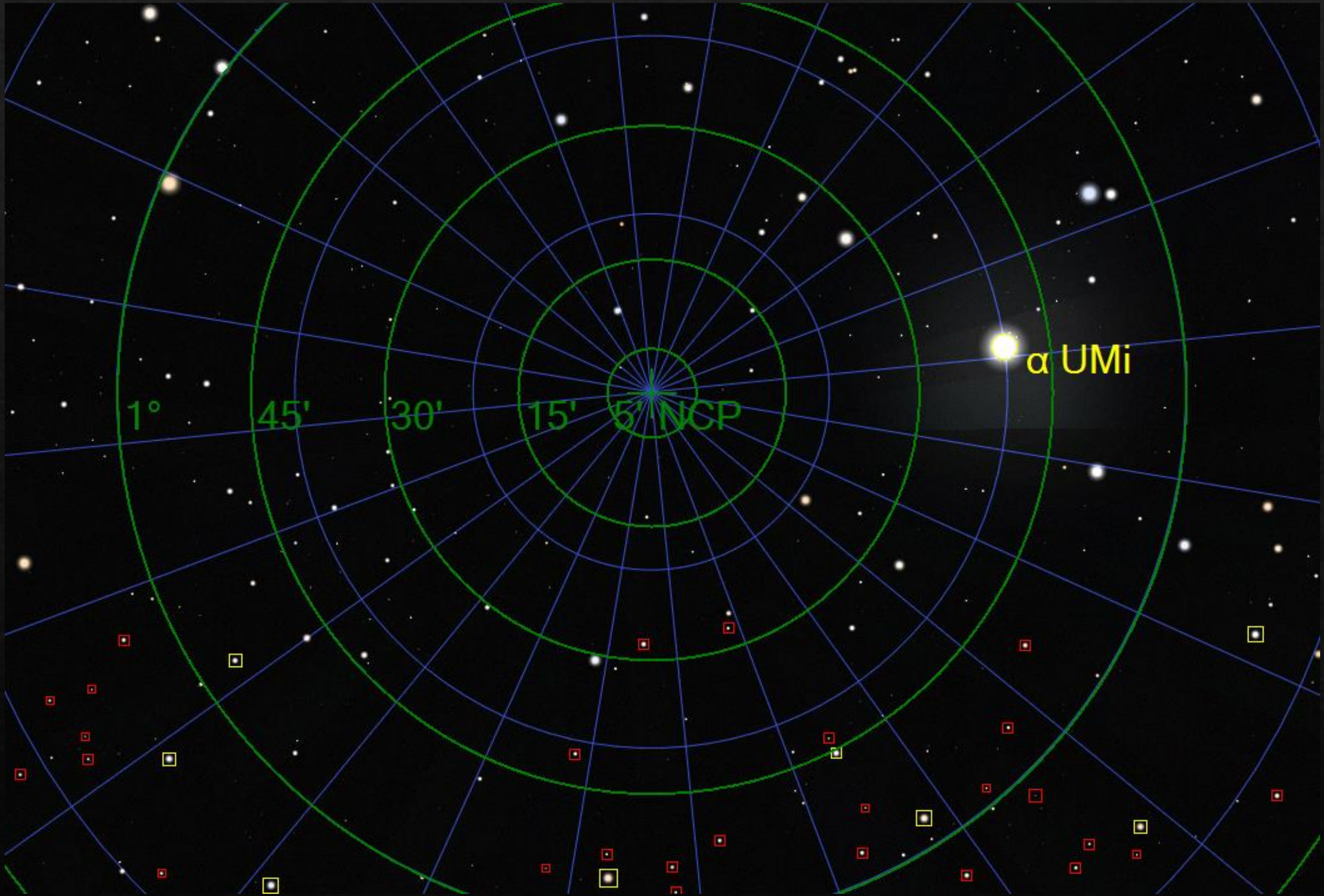


Good Polar Alignment and its Benefit to your Astrophotography

John Nagy

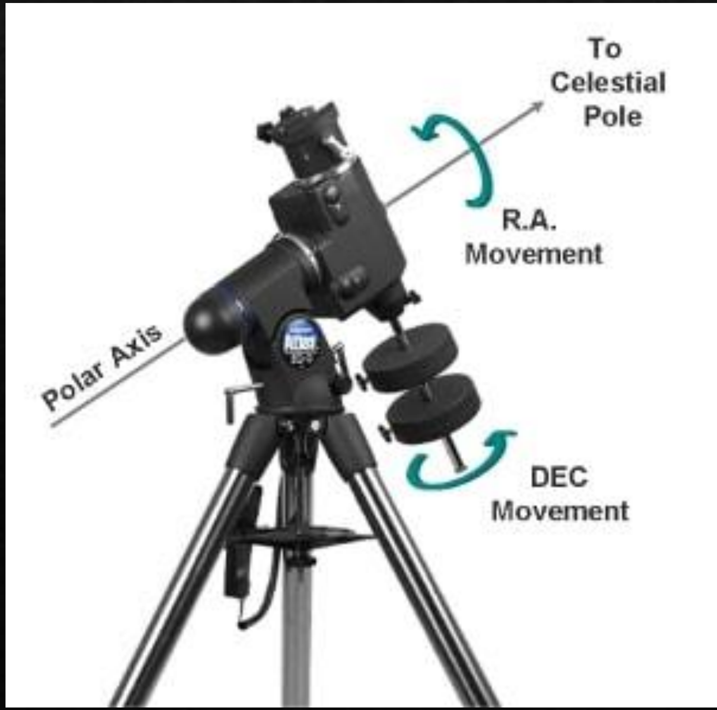
Agenda

- What is polar alignment and why do we do it?
- Guide for the methods I used.
- Present multiple (7) examples of star images and how they were achieved with a particular focus on Polar Alignment (PA) and Polar Alignment Error (PAE).
- Each step or level has a successively finer level of Polar Alignment.
  - The last two examples have an intentionally induced large PAE to see how autoguiding handles it.
- Each step or level may require additional equipment, software, and or skill.
- Conclusions drawn from this experiment.

- Other notes:
- Wide field refractor and Equatorial mount used to acquire images.
- All images are of NGC 1960 (Pinwheel Cluster)
- All equipment, software, and test procedure steps are detailed in the backup slides

What is polar alignment?

- Polar alignment is the act of aligning the rotational axis of a telescope's equatorial mount with a celestial pole to parallel Earth's axis.
- Polar alignment is an essential first step towards a night of visual observation or astrophotography. Why is it so important? By aligning the axis of your telescope mount with the motion of the sky you can accurately track objects across the night sky. It's a rather simple process for equatorial mounts.
- I'm not going to go into great detail on the many ways of "how" to polar align your mount. I'll explain the methods I've used and present the results of an experiment I performed using various methods and tools.
- Your results will vary based on your own equipment and skills but this should give you a rough idea of what can be achieved and what is necessary.



Polar Alignment Challenge

Polar aligning in the northern hemisphere requires pointing to the Polaris or North Central Pole area of the sky. Polaris is an easy star to find just after the sun sets because it's so bright. This makes our PA relatively easy.

Our friends in the southern hemisphere don't have it quite as easy. The closest equivalent to for alignment in the southern hemisphere is much dimmer in magnitude.

What about those who live near the equator? Well, for every degree of latitude you move toward the equator, your right ascension axis moves closer to level. Our very own Victor Sanchez sent me this picture (this morning) of his rig Polar Aligned while in Tanzania. The location was just 2.3 degrees from the equator. Note that the Celestron mount adjustments only allow for polar adjustment between 15 and 65 degrees (or so) latitude and so he had to have this special triangular fixture made to support the tripod in what would normally be an unbalanced and unstable position.

Guide for this Experiment

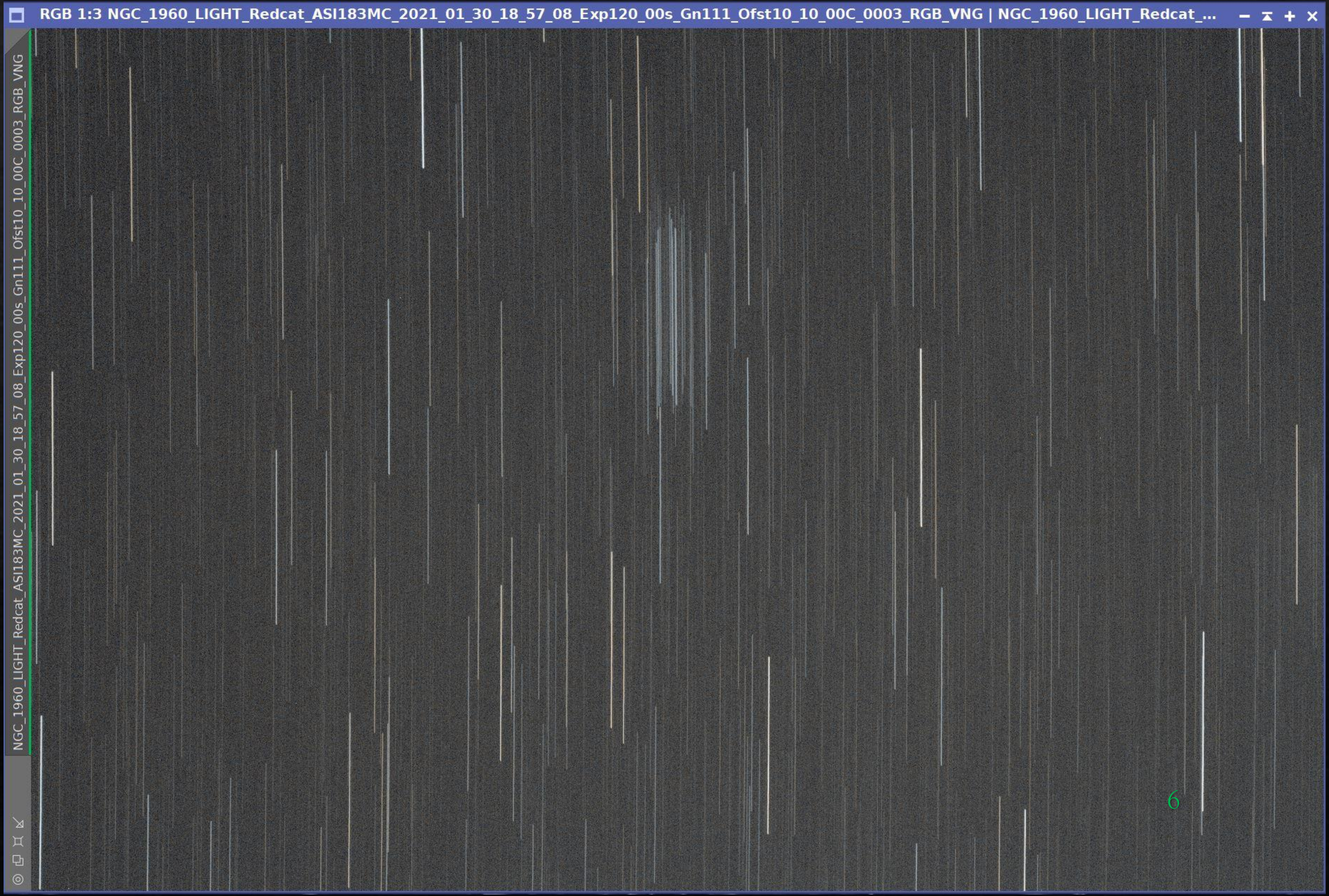
1. No tracking mount. 120 second exposure (slide 5).
2. Basic Polar Alignment looking through the hole in the mount. Engaged RA motor tracking at sidereal rate (slide 6).
3. Next level Polar Alignment employing a polar scope w/ reticle to lower the error. RA motor still tracking at sidereal rate (slide 7 and 8).
4. Polar Scope alignment and further refined using SharpCap. RA motor still tracking at sidereal rate (slide 9 and 10).
5. Polar Scope + SharpCap alignment and then auto-guiding from Push Here Dummy 2 (PHD2) during the exposures (slide 11 and 12).
6. Used SharpCap to induce 15 arc-minute PAE. Auto-guiding from PHD2 during the exposure (slide 13 and 14).
7. Used SharpCap to induce 30 arc-minute PAE. Auto-guiding from PHD2 during the exposure (slide 15 and 16).

No Right Ascension (RA) tracking or guiding

As you can see… 120s is pointless without some sort of tracking mount. You can't even tell this is NGC 1960 – Pinwheel Cluster. This is essentially what you'd get with a camera on a tripod at this exposure length.

Polar Alignment Error measured 3 deg 38m 10s.

This image was debayered, "de-greened", and stretched using Pixinsight (PI).



Polar Alignment “through mount” using only Polaris and Tracking

What a difference a little motor can make! The stars are still very enlongated but this is 120s with a poor polar alignment.

Polar Alignment Error measured 3 deg 38m 10s.

This image was debayered, “de-greened”, and stretched using PI.

Polar Alignment using Polar Scope and Polaris

Now we're getting somewhere with the 120s exposures. The little polar scope and an accurate hour angle time can make a big difference. These stars are passable. See next page for zoomed core.

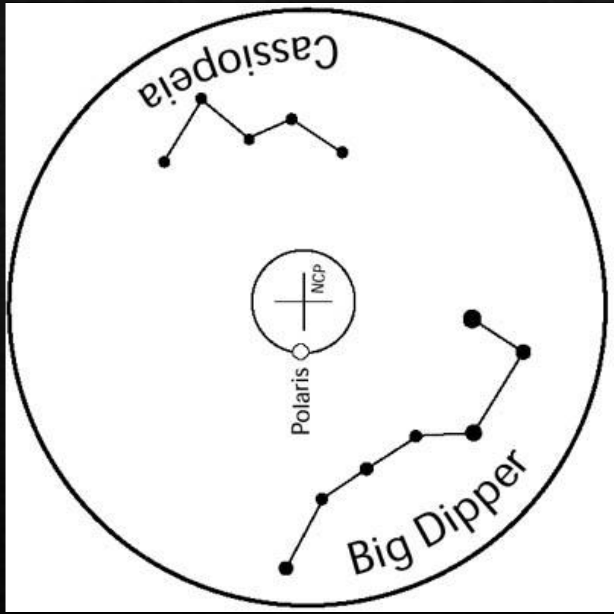
Polar Alignment Error measured 0 deg 1m 01s.
I think I was a little lucky.
I'm typically about 3-8 arc-minutes off.

This image was debayered, "de-greened", and stretched using PI.

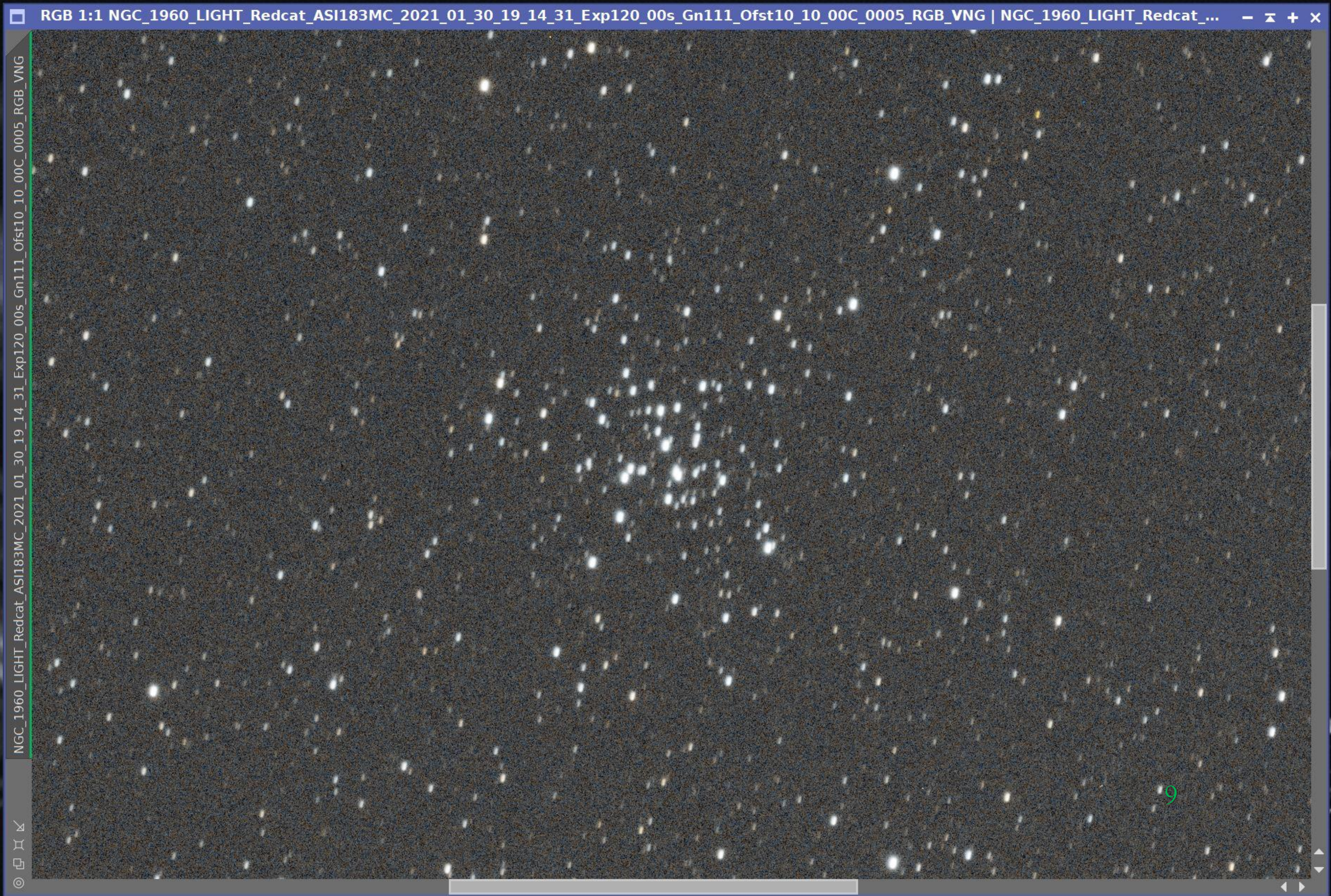
Polar Alignment using Polar Scope and Polaris

1:1 zoom of the core of the Pinwheel Cluster.

This little reticle and scope make quite a big difference.



This image was debayered, “de-greened”, and stretched using PI.

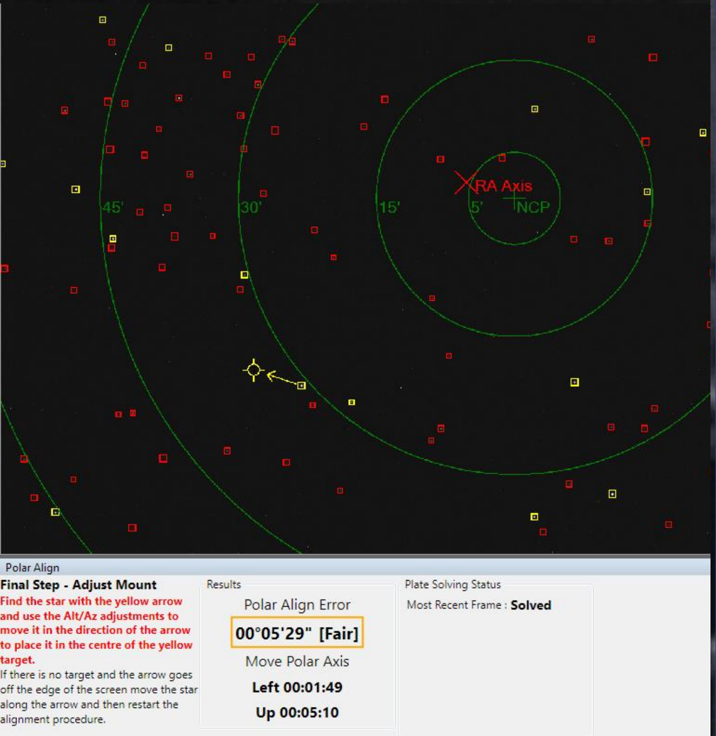


Polar Alignment using Polar Scope and then Refined with SharpCap Software

Note: Software used can be replaced by dedicated Polar Alignment camera like an iPolar or PoleMaster

This is a very usable 120s exposure and I'm not even guiding yet. See next page for zoomed core.

Polar Alignment Error measured 0 deg 00m 13s.
It took a few minutes to dial the PAE this low. Seeing makes it jump around considerably.

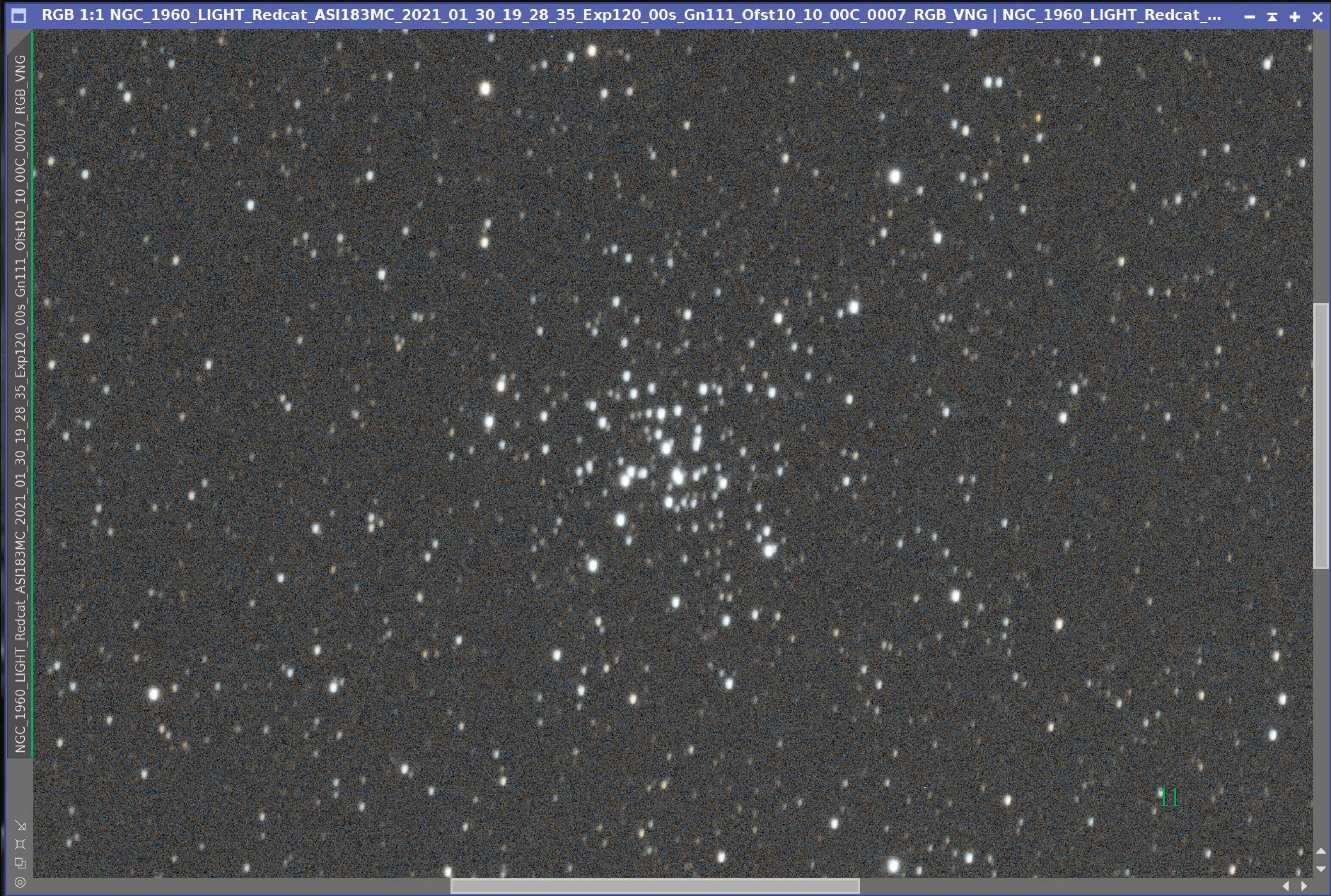


Polar Alignment using Polar Scope and then Refined with SharpCap Software

1:1 zoom of the core of the Pinwheel Cluster.

Not a huge difference between the zoom of the core two slides ago. The PAE was only improved by ~45 seconds.

This image was debayered, “de-greened”, and stretched using PI.



Polar Aligned w/ SharpCap and Autoguiding w/ PHD2

At this point… 120s isn't any sort of limit. With guiding this could very well be a 600 second exposure. See next page for zoomed core.

Polar Alignment Error measured 0 deg 00m 13s.

Auto-guiding with PHD2. Total RMS error: 0.61 arc seconds

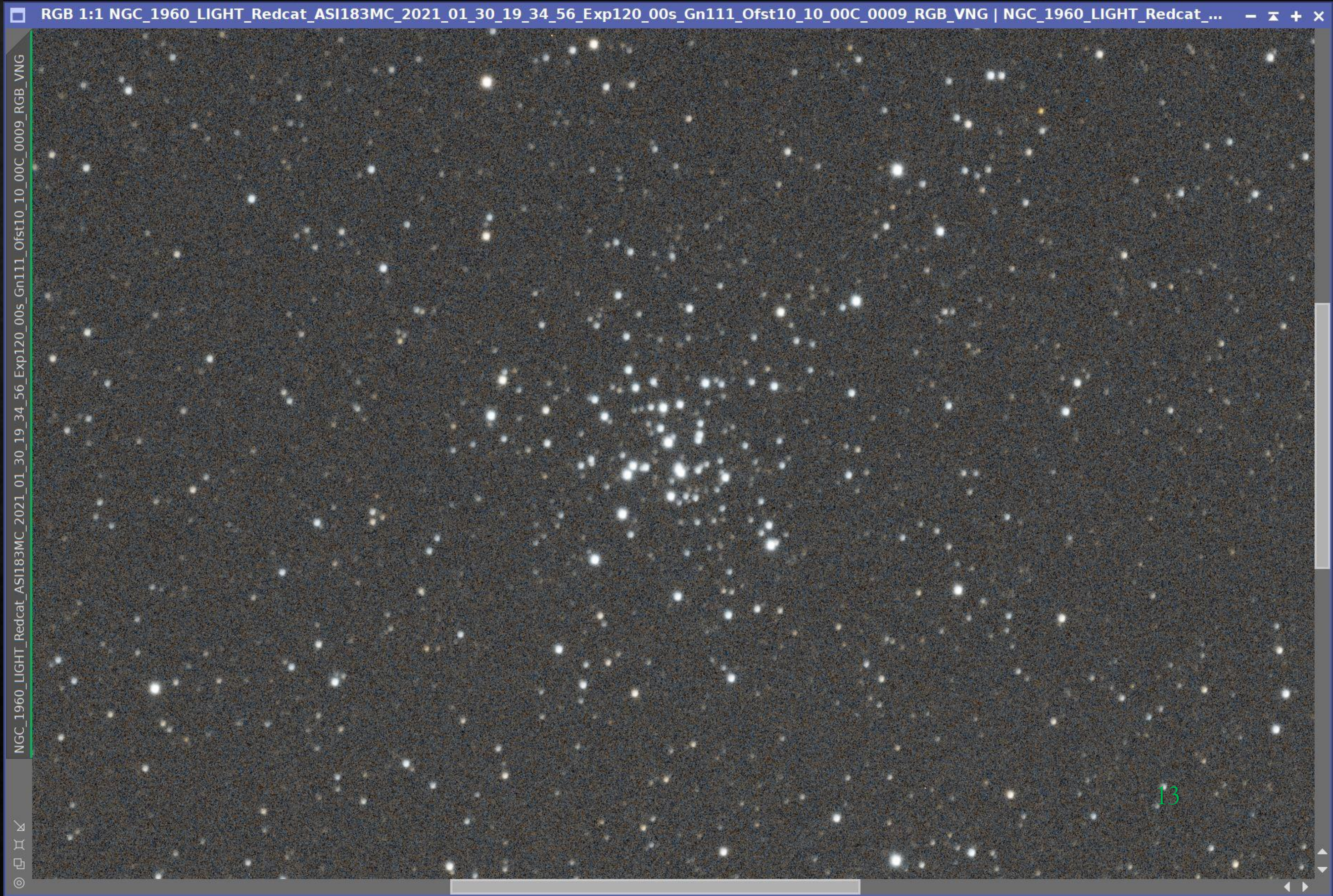
This image was debayered, "de-greened", and stretched using PI.

Polar Aligned w/ SharpCap and Autoguiding w/ PHD2

1:1 zoom of the core of the Pinwheel Cluster.

Stars are rounder and sharper now that guiding is being employed.

This image was debayered, "de-greened", and stretched using PI.



15 arc-min (0.25 deg) of PAE and Autoguiding w/ PHD2

At this point, I intentionally dialed in a 15 arc minute PAE to see if auto-guiding would be able to compensate. Surprisingly I didn’t notice much change in the guide graph or the stars. Judge for yourself. See next page for zoomed core.

Polar Alignment Error measured 0 deg 15m 02s.

Auto-guiding with PHD2. Total RMS error: 0.77 arc seconds

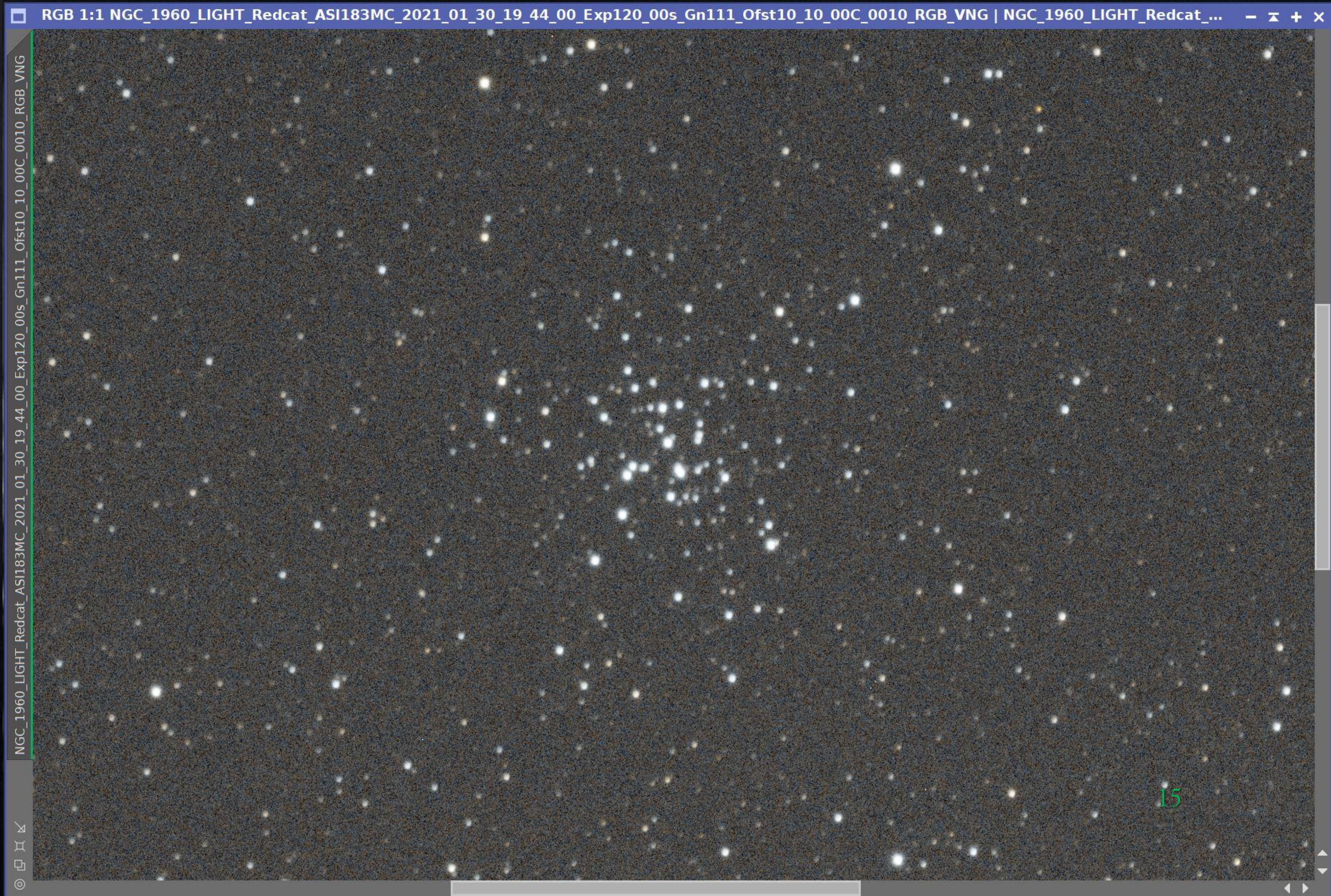
This image was debayered, “de-greened”, and stretched using PI.

15 arc-min (0.25 deg) of PAE and Autoguiding w/ PHD2

1:1 zoom of the core of the Pinwheel Cluster.

Stars are still round and sharp even with a “poor” polar alignment. Thank you PHD2!

This image was debayered, “de-greened”, and stretched using PI.



30 arc-min (0.50 deg) of PAE and Autoguiding w/ PHD2

At this point, I increased the PAE to 30 arc minutes to see if auto-guiding would still be able to compensate. Surprisingly I didn't notice much change in the guide graph or the stars. Judge for yourself. See next page for zoomed core.

Polar Alignment Error measured 0 deg 29m 51s.

Auto-guiding with PHD2. Total RMS error: 0.66 arc seconds

This image was debayered, "de-greened", and stretched using PI.

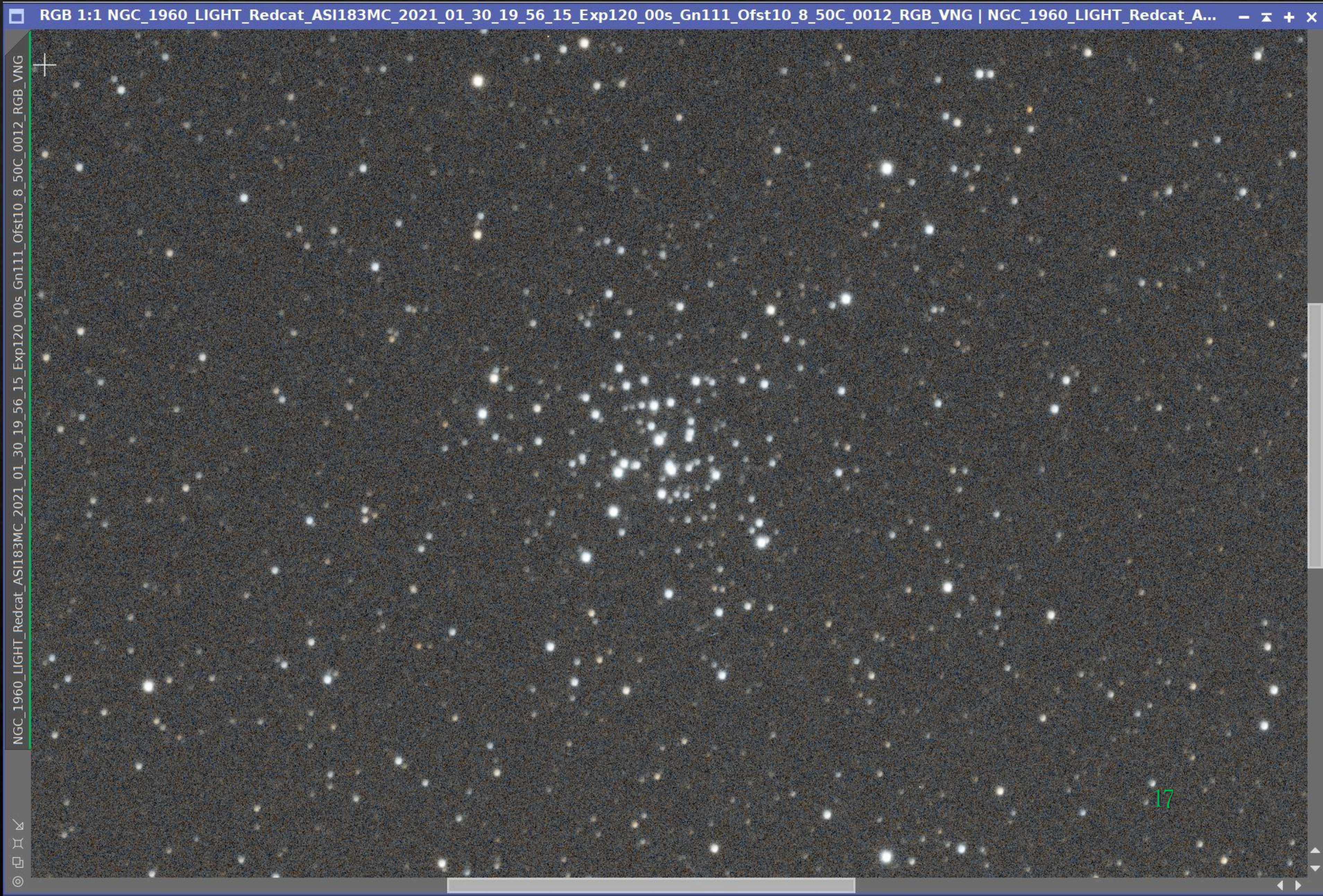
30 arc-min (0.50 deg) of PAE and Autoguiding w/ PHD2

1:1 zoom of the core of the Pinwheel Cluster.

Stars are still round and sharp even with a "poor-er" polar alignment. Thank you PHD2!

Remember, this is only a 250 focal length. If this were a 2,000+mm SCT it might be different.

This image was debayered, "de-greened", and stretched using PI.



Conclusions

- Unless you like star trails (or are going for that effect) then you need some sort of tracking of the night sky for anything but a wide angle lens and/or very short exposures photography.
- You can do very well with just a polar scope alignment. The small boost in magnification, the reticle image for better placement, and an accurate hour angle will definitely get you in the ball park. Guiding may not even be necessary. I feel confident I could shoot up to 60 seconds this way.
- If you are autoguiding, the extra accuracy of a software (SharpCap) or hardware (iPolar or Polemaster) refined polar alignment aren't strictly necessary. They can't hurt though and will ultimately lead to less guiding corrections by PHD2 and consequently better images.

Backup

Equipment and Software

Hardware

- **Mount**: Orion Sirius EQ-G Computerized GoTo Telescope Mount
  - Motorized GoTo Pointing
  - 30 lb payload
- **Telescope**: William Optics Redcat Apochromat (APO) refractor
  - 51 mm aperture (F4.9) and 250 mm focal length
- **Imaging camera**: ZWO ASI183MC-Pro w/ ZWO UV/IR cut filter
  - 20Mp CMOS color sensor (5496x3672)
- **Guide Scope**: William Optics guide scope
  - 50 mm aperture (F4) and 200 mm focal length
- **Guide Camera**: ZWO ASI120mm-S
  - 1.2 Mp CMOS mono sensor (1280x960)
- Laptop for software control and image storage
- Dew-Not dew heaters (2)
- Pegasus Astro Pocket Powerbox
  - Power distribution, dew heater control, monitoring
- 4 port USB hub

Software

- EQMOD – mount interface
- ASCOM – equipment interface
- NINA – mount/target acquisition
- SharpCap Pro – polar alignment
- PHD2 – autoguiding
- ASTAP – plate solving

Detailed Test Procedure(s)

1. Set up the mount, scope, and laptop.
   a) Align the mount roughly north and level the mount.
   b) Balance the weight of the scope/camera/guide scope/guide camera in the Right Ascension (RA) and the Declination (DEC) axes
   c) Start software and connect to each piece of equipment.
   d) Focus the main scope.
   e) Measure the polar alignment with SharpCap.
   f) Slew to NGC 1960 (Pinwheel Cluster)
2. Untracked and unguided imaging – basic tripod or fixed camera imaging
   a) Take 120 second(s) image of the target with no tracking (sidereal rate=off) and no auto-guiding.
   b) Home the scope/mount.
3. Polar Alignment on basic EQ mounts – some mounts don't have polar scopes to assist with RA to North Celestial Pole (NCP) alignment
   a) Look through the EQ mount "hole" and center Polaris in the open view. No other alignment assistance.
   b) Slew to the target. Ensure mount is tracking at the sidereal rate (~0.25 deg/minute).
   c) Take 120s image of the target.
   d) Home the scope/mount.
4. Polar Alignment on EQ mount with manual polar scope – polar scope provides magnification and has stenciled image()s to help align RA to NCP
   a) Look through the EQ mount polar scope and place Polaris at the appropriate hour angle for the day and time. Time provided by PolarFinder app
   b) Measure polar alignment with SharpCap and the guide camera to see how much using the Polar Scope and app improved PA. No adjusting the RA/DEC axis.
   c) Slew to the target. Ensure mount is tracking at the sidereal rate (~0.25 deg/minute).
   d) Take 120s image(s) of the target.
   e) Home the scope/mount.

Detailed Test Procedure(s) - continued

5. Polar Alignment with polar scope and refined by SharpCap Pro – SharpCap polar align utility uses plate solving to more accurately align the mount axes to the NCP
    a) Use SharpCap Pro polar align utility to adjust the bolts on the mount axes and achieve better polar alignment than previous test.
    b) Slew to the target. Ensure mount is tracking at the sidereal rate (~0.25 deg/minute).
    c) Take 120s image(s) of the target.
6. Good Polar Alignment with SharpCap Pro with the benefit of auto-guiding in PHD2
    a) Ensure mount is tracking at the sidereal rate (~0.25 deg/minute).
    b) Enable guide corrections in PHD2.
    c) Take 120s image(s) of the target.
    d) Home the scope/mount.
    e) Record the PHD2 guiding errors/corrections.
7. Using SharpCap to induce PAE – 0.25 deg (15 arc minutes) and 0.5 deg (30 arc minutes) – how much can autoguiding overcome?
    a) Set PAE using SharpCap.
    b) Slew to the target. Ensure mount is tracking at the sidereal rate (~0.25 deg/minute).
    c) Enable guide corrections in PHD2.
    d) Take a 120s image(s).
    e) Home the scope/mount.
    f) Repeat steps 7a-d for 0.5 deg PAE.
    g) Record the PHD2 guiding errors/corrections.