Astrophotography II

Capturing the Final Frontier

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Overview

1. *Building an Observatory*
2. *Equipment*
3. *Image Acquisition*
4. *Image Pre processing*
5. *Image Post Processing*
6. *A few images of heavenly bodies*

Building An Observatory

- Materials for the POD MAX observatory shipped from Canada and arrived on June 27, 2017
- First POD MAX erected in the United States
- Construction began July 13, 2017 and ended November 6
- Dome automation system arrived December 18, 2017 and installed in March 2018.
- Observatory is 12 ½ feet around, 12 ½ feet high

Building An Observatory

… Not for the faint of heart!

- Delays due to waiting for building instructions and weather
- First adopter woes:
  - Missing parts
  - Finding errors in instructions
  - Some components modified after shipment
- Fortunately had help from people with construction/engineering background and excellent support from tech vendors
- New technology learning curve
- New technology not working as designed
  - *First dome control smoked when turned on!*

Equipment

Mount

- Paramount ME II - 240 lb total instrument capacity
- The mount controls the movement of the telescope
- It is attached to the steel pier and the telescope attaches to the mount
- It must be calibrated and polar aligned before use
- A computer controls the mount using TheSkyX Pro software

Equipment

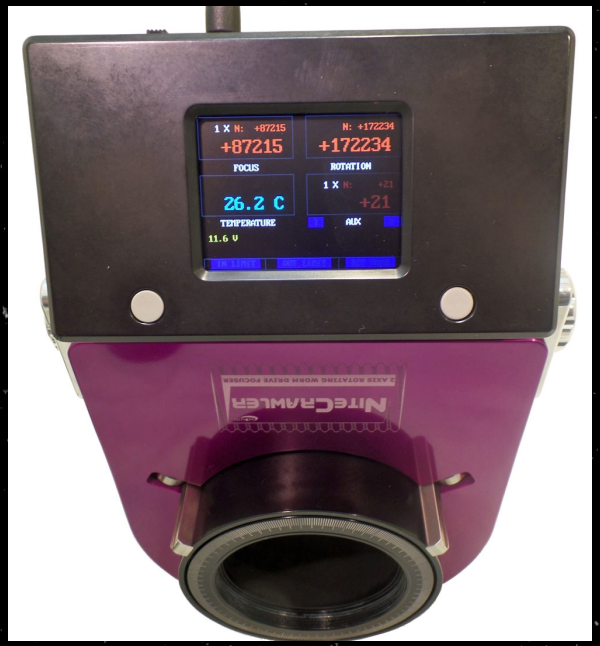
Telescope

- Astro-Tech 14” RC (Ritchey-Chrétien)
- Optical specifications: 14” aperture, 2850mm focal length, f/8 focal ratio prime lens
- Carbon fiber truss-tube design
- Hyperboloid primary and secondary mirror

Equipment

Focuser

- Moonlite Nitecrawler model WR25
- Extreme position accuracy that is repeatable down to .26 microns
- Provides focus and optics rotation by manual or computer control

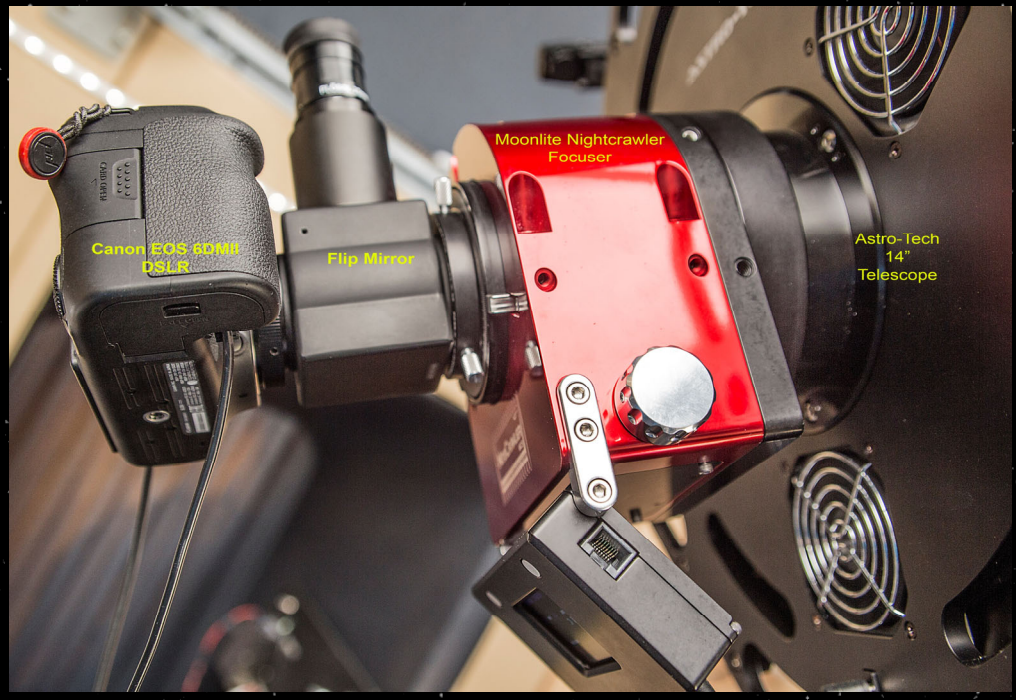


Equipment

Dome Control

- Kendrick Astro Instruments PODMAX CRM-114 control
- 2 separate computers interfaced via Bluetooth control dome rotation and slot cover opening and closing
- Interfaces to PC to keep the observatory slot opening where the telescope is pointing

All Together



The optical train---From celestial object to camera sensor

What do you see when you look through the eyepiece? (Camera sees things your eye doesn't)

The Orion Nebula – Messier 42

Image Acquisition

1. Image Acquisition software is TheSkyX Pro from Bisque
2. My camera: Canon EOS 6D Mark II
3. Camera set to BULB mode if exposure time is greater than 30 seconds
4. Camera set to MANUAL mode if exposure time is 30 seconds or less
5. Turn on Long Exposure Noise Reduction in camera
6. There are 4 types of exposures that need to be taken: LIGHT, DARK, FLAT and BIAS
7. Use TheSkyX Pro software running on the computer to control the camera settings and shutter release, as well as telescope, dome and focuser control
8. LIGHT frames are the images of the object in the sky you are photographing
9. DARK frames are images taken with the lens opening covered (only time it is acceptable to not remove the lens cap before taking pictures!)
10. FLAT frames are taken while it is still light outside using a light box or light diffuser. I use the translucent slot cover of the observatory.
11. BIAS frames are like LIGHT frames except you are using the fastest shutter speed capable of the camera (1/4000 for the Canon 6D)

Image Acquisition

LIGHT frames

1. Actual image data of the object you are photographing
2. Light frames straight out of the camera have imperfections that must be removed
3. Vignetting, dust, thermal noise, bias signal, hot pixels, etc.
4. Problems with light frames can be remedied by calibrating with dark, bias and flat frames.
5. Light frames can be stacked into a single image once calibrated

Example of a LIGHT frame

Image Acquisition

DARK frames

1. A way to minimize image noise for long exposure images
2. Fixed-pattern noise is the same from shot to shot, dead or hot pixels
3. Take a series of shots with the cap on (no light getting to the sensor from the outside)
4. Each shot should be the same ISO and exposure time as your LIGHT images
5. Ideally, they are taken at the same ambient temperature as the light images.
6. DARK frames are subtracted from the light frames during calibration.

Example of a DARK frame

Image Acquisition

FLAT frames

Why FLAT frames?

1. We need to correct optical imperfections (i.e. caused by telescope, instead of ones with the camera sensor).
2. Telescopes do not distribute light evenly across the sensor (vignetting)
3. Any dust on the sensor must be removed
4. Must be taken with the same focus, camera orientation and optical setup as the light frames

Image Acquisition

FLAT frames

1. To be taken while there is still light in the sky if using a light box or observatory slot cover. Computer screen can be used too http://whitedisplay.com/
2. Camera mode is set to Aperture Priority
3. Set exposure compensation to +2EV
4. ISO is set low (100,200) to minimize noise
5. Try to get images where the histogram is close to the center
6. Camera is connected to the scope
7. Maintain same focus as you would use for the LIGHT frames
8. Shoot a minimum of 30-50 FLAT frames
9. FLAT frames will be stacked together and divided into the light frames
   - ✓ Illumination of the LIGHT frame is evened out

Example of a FLAT frame

Image Acquisition

BIAS frames

1. Used to remove the readout signal from your sensor
2. Variations in how the camera reads data from the sensor
3. Each shot is taken as close to zero exposure length as possible for the camera (i.e. the fastest shutter speed for my Canon 6D Mark II is 1/4000 second.)
4. Each shot is taken at the same ISO as the DARK and LIGHT images.
5. It is not necessary to take these at the same ambient temperature as the DARK and LIGHT images.
6. Will be subtracted from all other images before stacking begins

Example of a BIAS frame

Image Preprocessing

Calibrate, Integrate (stacking) and Registration

1. Software used is PixInSight from Pleiades Astrophoto
2. Calibrate and integrate BIAS frames to create a Super BIAS
3. Calibrate and integrate DARK frames using Super BIAS to create a Master DARK image
4. Calibrate and integrate FLAT frames using Super BIAS and Master DARK
5. Super BIAS, Master DARK and Master FLAT all will be used in processing each LIGHT frame
6. LIGHT frames are calibrated, and registered (aligned with each other) and finally stacked to create one final image

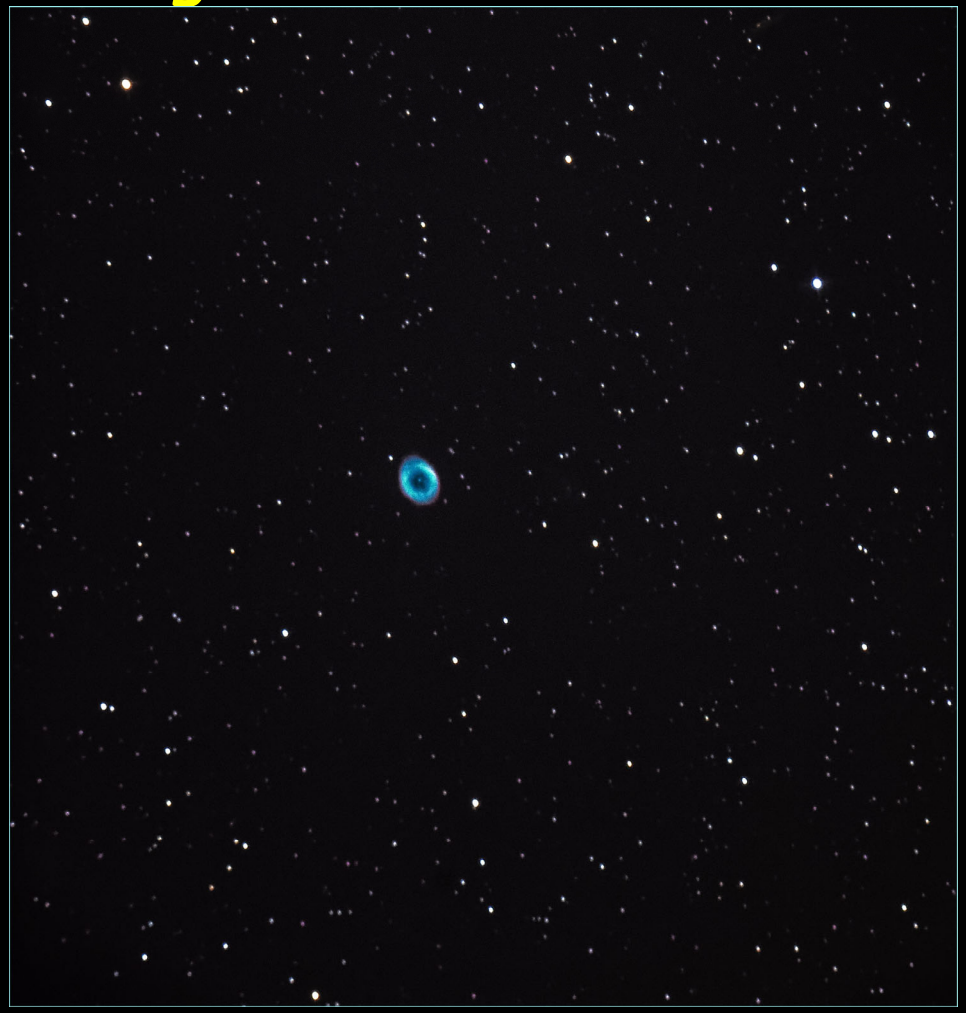
Image Post processing

1. Software used: Adobe Photoshop CC
2. Making adjustments to the stacked, calibrated and registered image
3. No set workflow since objects vary in size and light intensity
4. Typical adjustments to white balance, shadows, highlights, sharpness, contrast etc.
5. No color changes except saturation. Colors as detected by camera sensor are natural.
    - Hydrogen shows as red, oxygen shows as green/teal

First visit: The Moon

- Taken October 26, 2017
- Single exposure, 1/80 sec, ISO 100
- 248,467 miles away
- No computer used, telescope aimed by hand

Ring Nebula – Messier 57

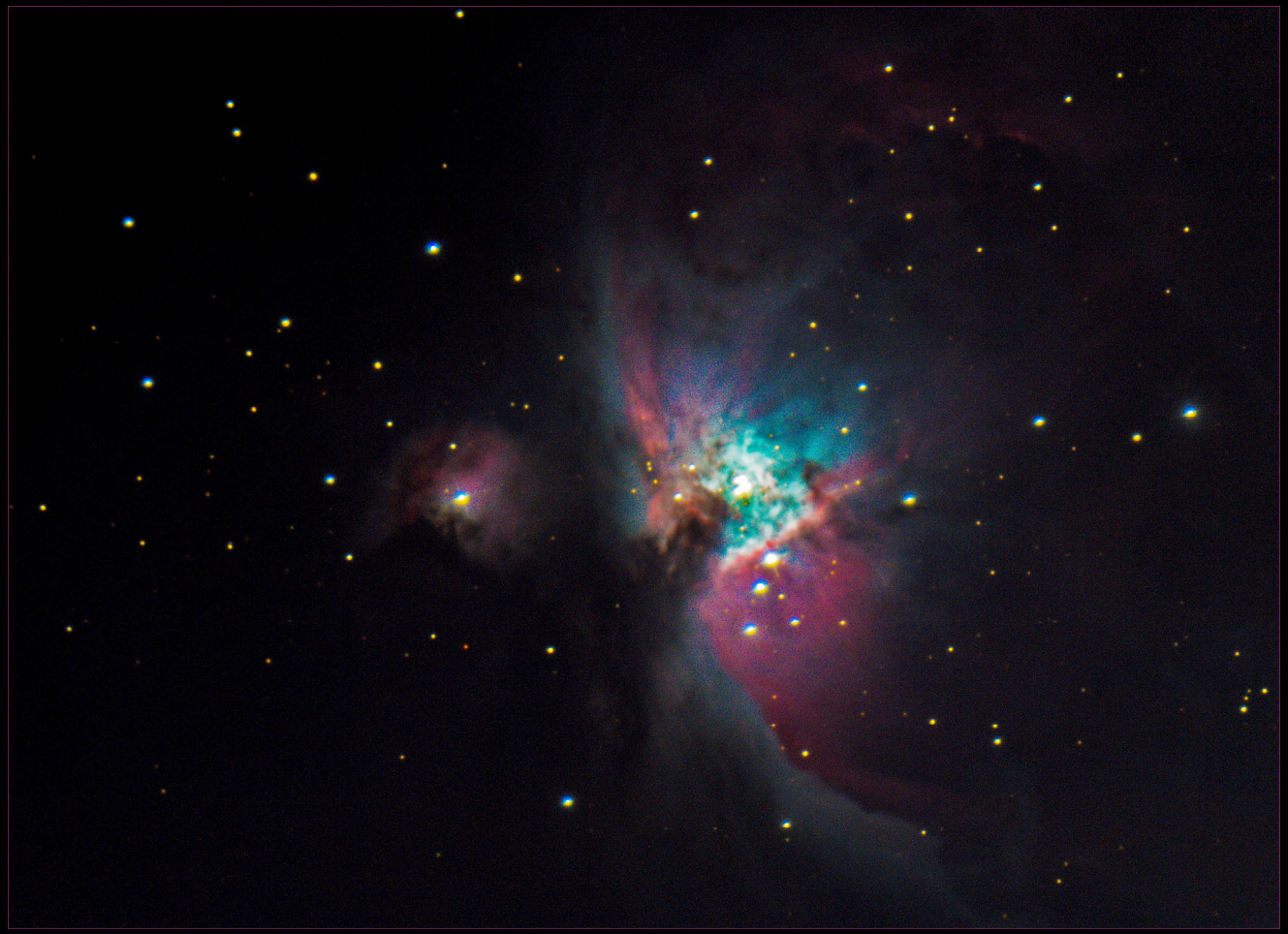


- Taken November 8, 2017
- Single exposure, 30 seconds, 3200 ISO
- 2,283 light years away

Hercules Globular Cluster – Messier 13

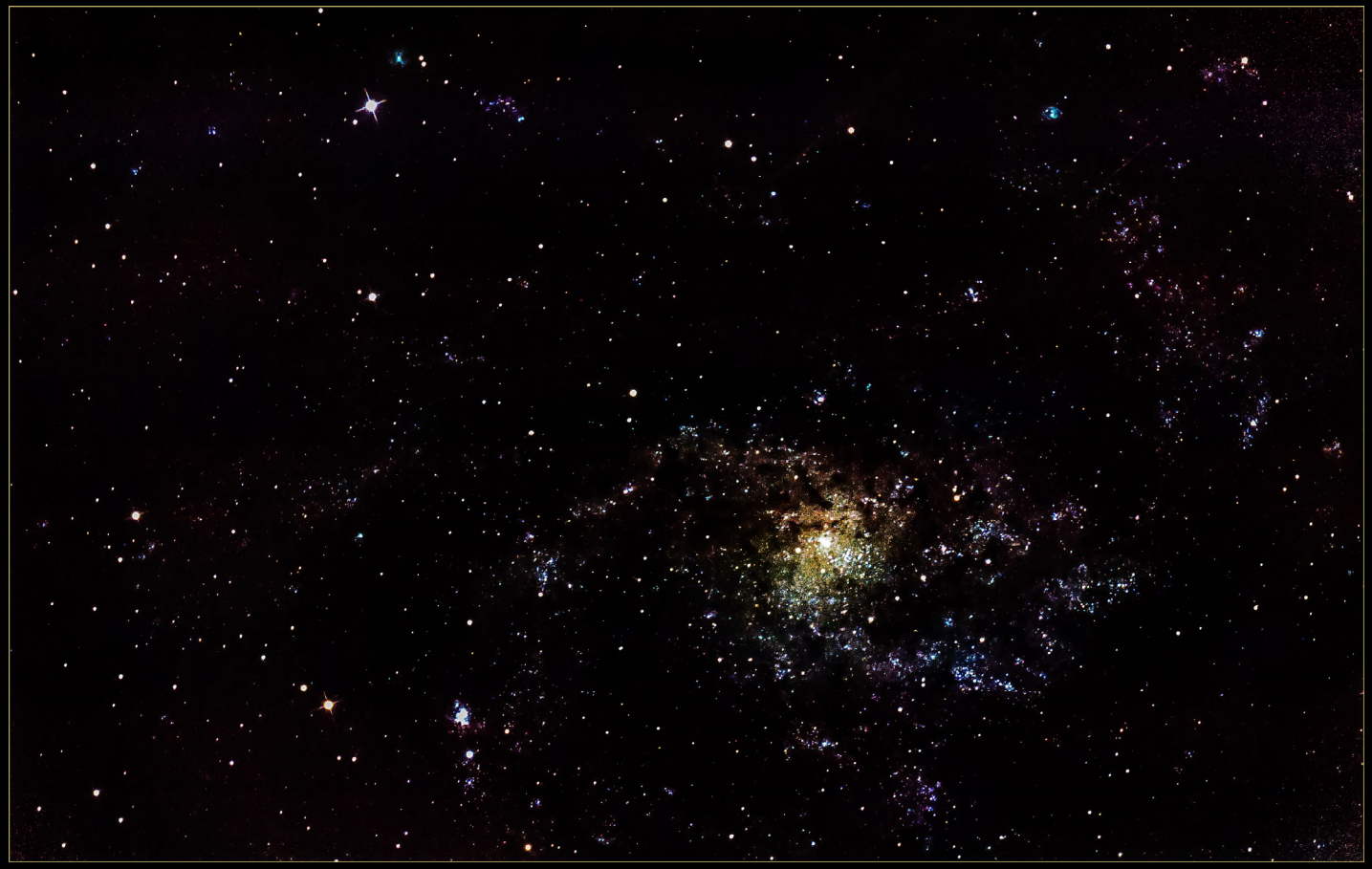
- Taken November 9, 2017
- Single exposure, 30 seconds, 1250 ISO
- 22,180 light years away
- Cluster of about 300,000 stars
- One of the oldest objects in the sky, about 12B years old

Orion Nebula – Messier 42



- Taken November 30, 2017
- 10 exposures, 10 seconds, 800 ISO stacked with BIAS, DARKs and FLATs
- 1,344 light years away

Triangulum Galaxy – Messier 33



- Taken December 10, 2017
- 46 exposures, 25 seconds, 800 ISO stacked with BIAS, DARKs and FLATs
- 3 million light years away

Rigel

- Taken March 13, 2018
- 1 exposure, 13 seconds, 800 ISO
- 864.3 light years away

In Conclusion

- Almost to the point of having a turnkey observatory
- Tweaks needed to the slot cover control, image preprocessing and telescope pointing accuracy
- Next steps:
  - ✓ Take more exposures (50 or more) of objects at longer shutter time and process them through PixInSight
  - ✓ Utilize the Nitecrawler focuser more
  - ✓ Take planetary and sun photos
  - ✓ Get over the learning curve!
  - ✓ Look into remote control operation (maybe)
- Need ***clear skies!***

The End

Links to websites:

- Chamberlain Observatory https://chamberlainobservatory.com
- Email: dale@chamberlainobservatory.com
- Bisque: http://www.bisque.com
- PixInSight: https://pixinsight.com/
- Moonlite: http://www.focuser.com/
- SkyShed POD MAX: http://www.skyshedpodmax.com/
- Kendrick Astro Instruments: http://www.kendrickastro.com/