

ASTROPHOTOGRAPHY III

TO INFINITY AND BEYOND!

By

Dale A. Chamberlain

February 19, 2020

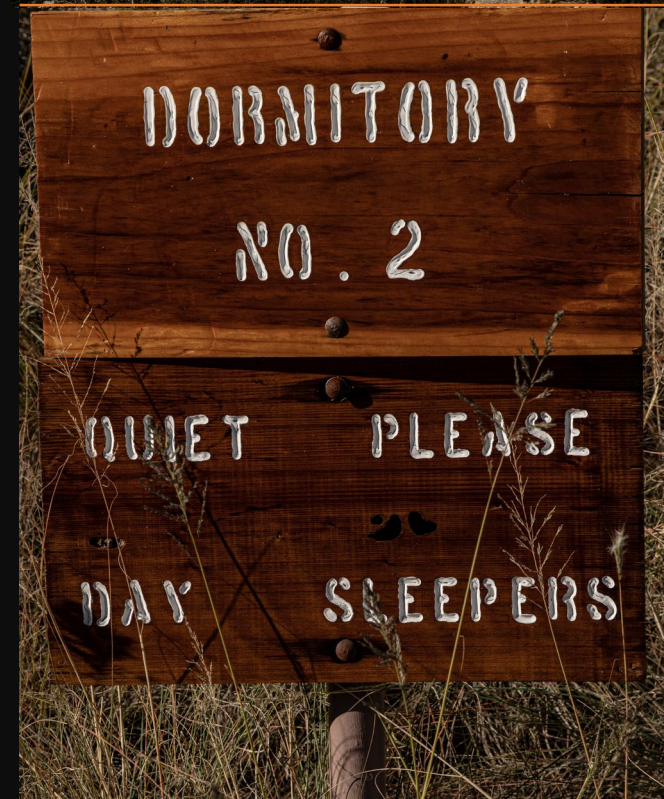
What will be covered tonight

- ❖ Kitt Peak workshop and new workflow
- ❖ Finalized Technologies/Techniques
- ❖ Astrophotography Images
- ❖ Future endeavors



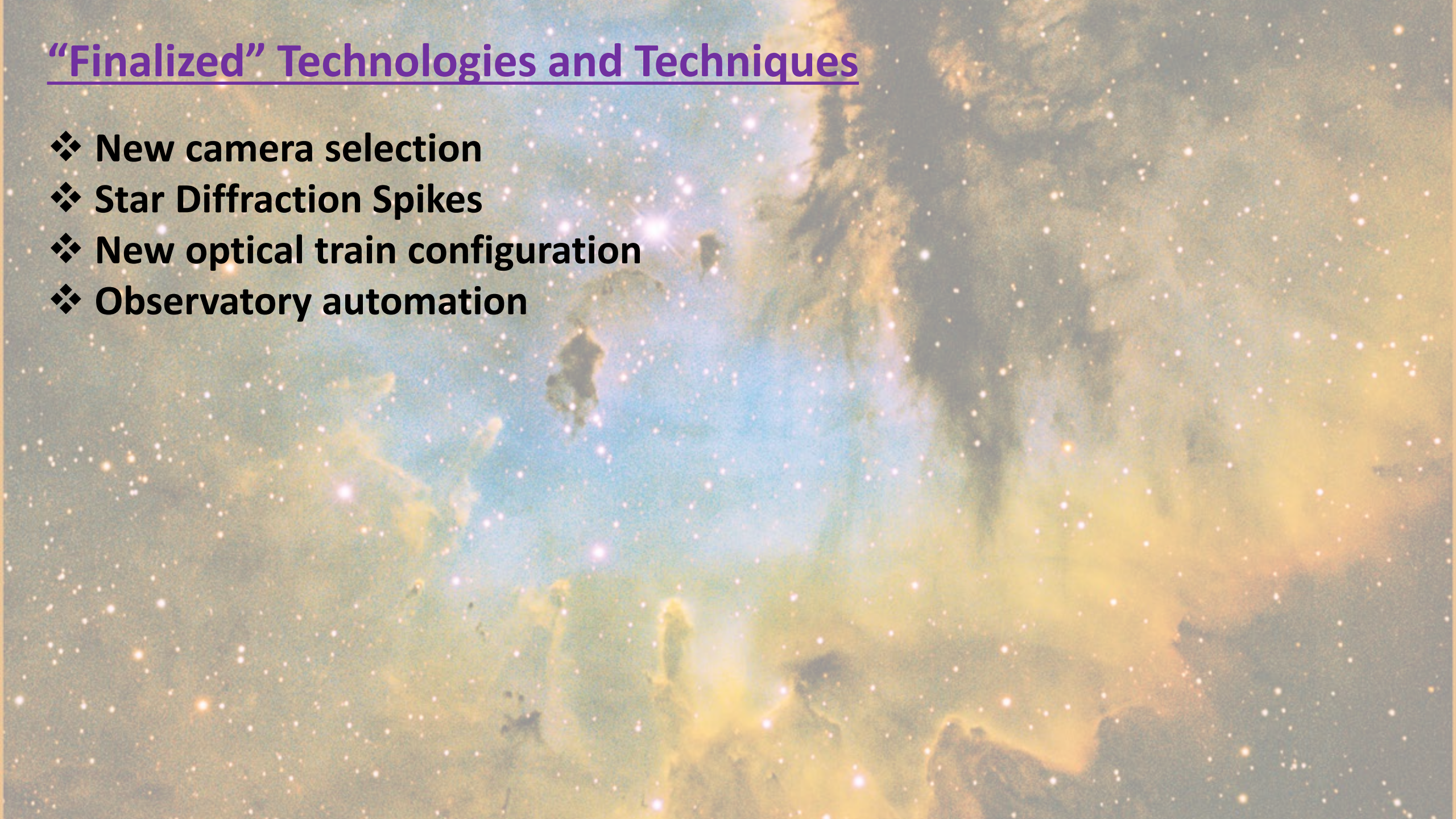
Kitt Peak National Observatory Workshop

- ❖ Attended a 3-day/2-night workshop on astrophotography at Kitt Peak National Observatory on the Tohono O'odham Nation, 56 miles outside of Tucson, Arizona on October 25-27, 2019.
- ❖ Validated equipment setup (not done spending money yet)
- ❖ Observatory automation using Sequence Generator Pro software
- ❖ Learned additional image processing steps with PixInSight astroimaging software
- ❖ Took some Milky Way photos



“Finalized” Technologies and Techniques

- ❖ New camera selection
- ❖ Star Diffraction Spikes
- ❖ New optical train configuration
- ❖ Observatory automation



New Cameras

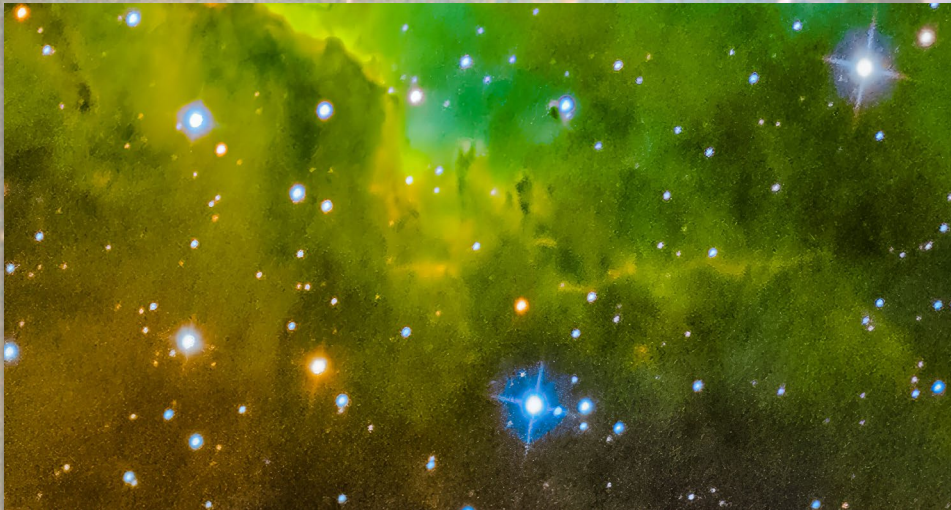
- ❖ Began using Canon 6D DSLR but soon moved to dedicated CMOS (complementary metal-oxide semiconductor) astroimaging cameras
 - ✓ Could not get desired dynamic range and noise reduction with a DSLR
 - ✓ ZWO ASI224MC – CMOS camera for planetary images
 - Uses Sony IMX224 Exmor and NIR technology
 - ✓ ZWO ASI1600MC – CMOS camera for one shot color (OSC) deep space images
 - ✓ ZWO ASI1600MM – CMOS monochrome camera used with a filter wheel
 - ✓ Both cameras use Panasonic 4/3 MN34230 sensor
- ❖ CCD (Closed Coupled Device) cameras were popular in astrophotography after the film days
 - ✓ The last company to make CCD sensors announced discontinuation on September 26, 2019
 - ✓ CMOS cameras less expensive than CCD
 - ✓ CCD camera makers are buying up the last of these sensors before switching to CMOS
- ❖ CMOS astrophotography cameras have coolers to keep sensor temperatures low during long exposures
- ❖ CMOS cameras have a deep “well depth”
 - ✓ Pixels can absorb a lot of photons before “blowing out”



Star Diffraction Spikes

What are diffraction spikes?

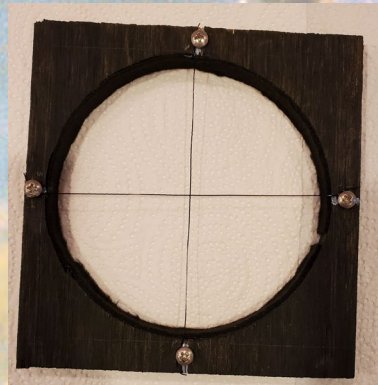
- ❖ When you see stars in an image with a cross-like spike of light
- ❖ Not a natural appearance of the star in real life
- ❖ A photographic effect caused by light bending or diffracting around an object
 - ✓ Support beams in a reflecting telescope's secondary mirror
 - ✓ Spikes not present with refractor telescopes due to a lack of a secondary mirror



Star Diffraction Spikes

Making a star diffraction spike mask for a refractor telescope

- **Cut out a square piece of plywood**
- **Cut a circle that fits the diameter of the telescope (in this case 80mm)**
- **Attach black coated 24 gauge wire to make a set of crosshairs**
- **Put the mask over the opening of the telescope**
- **Similar process can be done with a DSLR lens**



Optical Trains

- ❖ Optical train is an arrangement of optical components from the telescope to the imaging sensor
 - ✓ Distance between the last piece of glass or lens to the imaging surface is called “backfocus”
 - ✓ It is important to achieve correct backfocus for the equipment being used
 - ✓ Prevents “egg shaped” stars around the edges
 - ✓ Improves overall focus ability
- ❖ Focal reducers will speed up a telescope, i.e. from an f/8 to an f/5.2
- ❖ Correctors or flatteners will flatten the curvature of an image caused by mirrors or lenses

Astro-Tech 14" RC with ZWO Monochrome Optical Train and Starizona ApexED L 0.65x Reducer/Corrector



1. Astro-Tech 14" RC
2. Midnite Nitecrawler Focuser
3. Starizona ApexED L Reducer/Corrector
4. Starizona coupler (16.5mm)
5. ZWO 8 position filter wheel (20mm)
6. Gosky T2-T2 12mm coupler
7. ZWO ASI1600MM-Pro CMOS camera (or ZWO ASI1600MC-Pro when used with luminosity filter only) (6.5mm)

Backfocus: Telescope: 288mm; Starizona ApexED L Reducer/Corrector: 55mm (items in blue are in the backfocus field)

Focal ratio: **f/5.2** Focal length: **1849mm**

Image scale:
.4238 (Bin 1x1)
.8477 (Bin 2x2)
1.2716 (Bin 3x3)
1.6955 (Bin 4x4)

Revised 01/19/2020

Skywatcher Esprit 80 APO with ZWO Monochrome Optical Train



1. Sky-Watcher Esprit 80 APO Triplet Refractor
2. Focuser
3. Optec Pyxis LE Camera Field Rotator
4. PreciseParts Optec Pyxis LE to Skywatcher Esprit Field Flattener coupler (Custom)
5. Skywatcher Field Flattener with 11mm M62-M42 adapter
6. ZWO T2-T2 16.5mm coupler
7. ZWO 8 position filter wheel (20mm)
8. Gosky T2-T2 12mm extension ring
9. ZWO ASI1600MM-Pro CMOS camera (6.5mm backfocus)

Backfocus: 66mm/2.4 inches (items in blue are in the backfocus field)

Focal ratio: **f/5** Focal Length: **400mm**
Image Scale:
1.9595 (Bin 1x1)
3.9190 (Bin 2x2)
5.8785 (Bin 3x3)

Revised 1/19/2020

Astroimaging Process with automation

❖ Image acquisition starts with automation

- ✓ A choice is made as to which object to image
- ✓ A schedule is created that controls all equipment in the observatory, including the dome.
- ✓ The number of exposures and duration of exposure by filter is set (light frames)
- ✓ Desired orientation is set for the object
- ✓ The schedule can be set to start at a predetermined time (i.e. when the object is at a desirable altitude in the night sky)
- ✓ Run the schedule. This can take many hours to complete.
- ✓ Afterwards, several flat frame and dark frame images are taken for calibration of light frames (several more hours)

❖ Preprocessing steps

- ✓ Review and selection of light frames (throw out frames with airplanes, meteors, clouds, etc.)
- ✓ Calibrate light frames using flat and dark frames
- ✓ Weight light frames (computer analyzes the quality of each image and scores it)
- ✓ Register light frames (align them all together)
- ✓ Integrate light frames (create a stacked master for each filter)

❖ Post-Processing

- ✓ Combining master images for each filter together to create a color image.
- ✓ Apply techniques to balance background and color, and enhance the structure of the object
- ✓ Smooth and sharpen the image

My journey through the cosmos

The following images were taken from my observatory in 2019 & 2020

Taken with a one-shot color (OSC) camera or a monochrome camera with a filter wheel

A word about “palettes”

Many objects are too faint to trigger the “cones” in our eyes

Narrowband filters allow photons that can't be seen by our eyes to register on the monochrome camera sensor

These images must be mapped to colors (“palettes”) in the RGB spectrum (aka “false color”)

Typically these images are:

Ionized Hydrogen-alpha (H) [most dominant in the universe, basis behind nuclear fusion]

Doubly-Ionized oxygen-III (O)

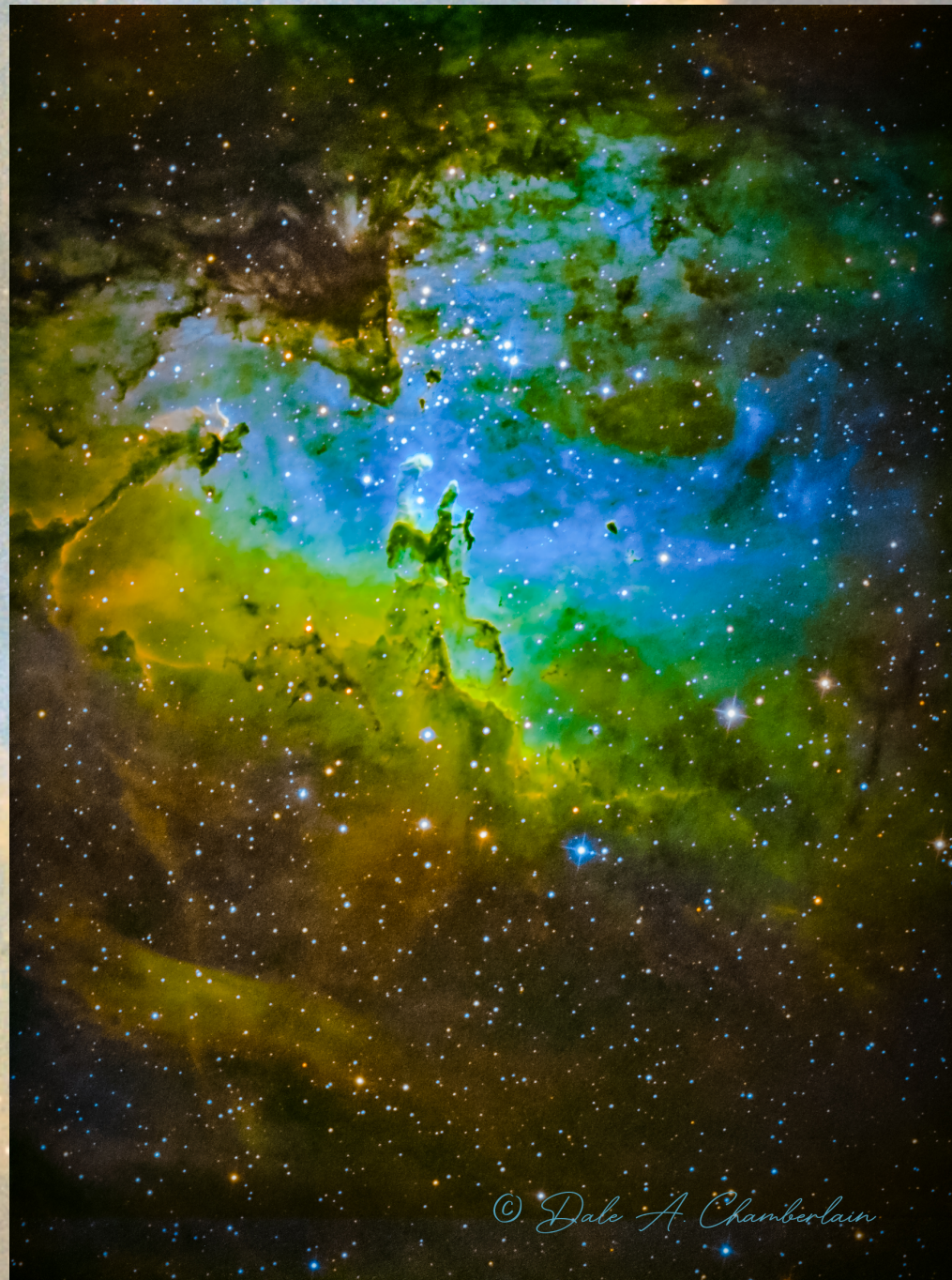
Singly-Ionized Sulphur-II (S)

Hubble uses the SHO palette, which means S is red, H is green and O is blue.

Typical and popular is the HOS palette, where H is red, O is green and S is blue

Object:The Eagle Nebula (catalogued as Messier 16 or M16, and as NGC 6611, and known as the Star Queen Nebula and The Spire) is a young open cluster of stars in the constellation Serpens, discovered by Jean-Philippe de Chéseaux in 1745–46. Both the "Eagle" and the "Star Queen" refer to visual impressions of the dark silhouette near the center of the nebula, an area made famous as the "Pillars of Creation" imaged by the Hubble Space Telescope. The nebula contains several active star-forming gas and dust regions, including the Pillars of Creation.

It is approximately $5,700 \pm 400$ light years away from Earth.



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Taken: July 23, 2019

Telescope: Astro-Tech 14" RC with 0.65x focal reducer

Mount: Paramount ME II unguided

Camera: ZWO ASI1600MM-Pro (cooled to -15C; unity gain) Bin 2x2.

Focuser: Moonlite Nitecrawler

Filters used: H-a, O-III and S-II on a ZWO 8 position filter wheel

Exposures: Ha: 25x60 sec. O-III: 23x60 sec; S-II: 22x60 sec for a total exposure time of 70 minutes; calibrated with 100 bias frames, 25 dark frames, 32 flat frames with 32 dark-flats. This image was processed in the Hubble (SHO) palette.

Seeing Conditions: Average. Bortle 5 region.

**Processed with PixInsight and Photoshop
CC 2019**

Object: The Orion Nebula Messier 42, M42 is a diffuse nebula situated in the Milky Way Galaxy, south of Orion's Belt in the constellation of Orion. M42 is located 1344 light years away and is the closest region of massive star formation to Earth. It is one of the brightest nebulae and is visible to the naked eye in the night sky. M42 is located at a distance of $1,344 \pm 20$ light years.

Taken: March 31, 2019

Telescope: Skywatcher Esprit 80 ED Triplet APO Refractor

Mount: Paramount ME II unguided

Camera: ZWO ASI1600MC-Pro (cooled to -15C; unity gain) Bin 1x1.

Focuser: Manual

Exposures: 30x100 sec. for a total exposure time of 50 minutes; calibrated with 100 bias frames, 25 dark frames, 32 flat frames with 32 dark-flats

Seeing Conditions: Above average. Bortle 5 region.

Processed with PixInsight and Photoshop CC 2019



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M42 The Orion Nebula and Running Man Nebula Sh2-279 in High Dynamic Range

Taken on January 26, 2020

Example of how HDR techniques can be applied to astrophotography

Exposures: 200x5sec., 200x10sec., 200x15sec., 156x30sec., for a total exposure time of 178 minutes (nearly 3 hours); Calibration: 40 darks per exposure time; 100 flats with 100 dark/flats. No bias frames.

Each set of exposure times stacked with the resulting stacks then stacked together (5 sec, 10 sec, 15 sec and 30 sec)

All taken with a one-shot color camera and a dual-band light pollution filter

All taken with the same f/5 telescope

5 second exposures prevent "blow out" of the central core

30 second exposures provide details of the nebula gases and dust



© Dale A. Chamberlain



Object:The Pleiades, also known as the Seven Sisters and Messier 45, are an open star cluster containing middle-aged, hot stars located in the constellation of Taurus. It is among the nearest star clusters to Earth and is the cluster most obvious to the naked eye in the night sky.

The cluster is dominated by hot blue and luminous stars that have formed within the last 100 million years.

Reflection nebulae around the brightest stars were once thought to be left over material from the formation of the cluster but are now considered likely to be an unrelated dust cloud in the interstellar medium through which the stars are currently passing.

Computer simulations have shown that the Pleiades were probably formed from a compact configuration that resembled the Orion Nebula. Astronomers estimate that the cluster will survive for about another 250 million years, after which it will disperse due to gravitational interactions with its galactic neighborhood.

It is approximately 444 light years away.

Taken: April 2, 2019

Telescope: Skywatcher Esprit 80 ED Triplet APO Refractor

Mount: Paramount ME II unguided

Camera: ZWO ASI1600MC-Pro (cooled to -15C; unity gain)
Bin 1x1.

Focuser: Manual

Exposures: 24x300 sec. for a total exposure time of 2 hours; calibrated with 100 bias frames, 25 dark frames, 32 flat frames with 32 dark-flats

Seeing Conditions: Average. Bortle 5 region.

Processed with PixInsight and Photoshop CC 2019

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Object: Messier 3 (M3 or NGC 5272) is a globular cluster of stars in the northern constellation of Canes Venatici. It was discovered on May 3, 1764 and was the first Messier object to be discovered by Charles Messier himself.

Many amateur astronomers consider it one of the finest northern globular clusters, following only Messier 13. M3 has an apparent magnitude of 6.2, making it a difficult naked eye target even with dark conditions. With a moderate-sized telescope, the cluster is fully defined.

One of the largest and brightest clusters it has around 500,000 stars. Estimated to be 8 billion years old and is located at about 33,900 light-years away from Earth.

Taken: May 31, 2019

Telescope: Astro-Tech 14" RC

Mount: Paramount ME II unguided

Camera: ZWO ASI1600MC-Pro (cooled to -15C; unity gain) Bin 2x2.

Focuser: Moonlite Nitecrawler

Filters used: Luminosity on a ZWO 8 position filter wheel

Exposures: Luminosity: 24x60 sec. for a total exposure time of 24 minutes; calibrated with 100 bias frames, 25 dark frames, 32 flat frames with 32 dark-flats

Seeing Conditions: Average. Bortle 5 region.

Processed with PixInsight and Photoshop CC



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Object: Messier 13 or M13, also designated NGC 6205 and sometimes called the Great Globular Cluster in Hercules or the Hercules Globular Cluster, is a globular cluster of several hundred thousand stars in the constellation of Hercules. It is 22,180 light years from Earth.

Taken: June 13, 2019

Telescope: Astro-Tech 14"

RC (2850mm focal length)

Mount: Paramount ME II unguided

Camera: ZWO ASI1600MC-

Pro (cooled to -15C; unity gain) Bin 2×2.

Focuser: Moonlite Nitecrawler

Filters used: Luminance on a ZWO 8 position filter wheel

Exposures: 10×60 sec. for a total exposure time of 10 minutes calibrated with 100 bias frames, 25 dark frames, 32 flat frames with 32 dark-flats

Seeing Conditions: Average with an 81% illuminated moon. Bortle 5 region.

Processed with **PixInsight** and Photoshop CC 2019

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Object: The Iris Nebula, also known as NGC 7023 and Caldwell 4, is a bright reflection nebula and Caldwell object in the constellation Cepheus. NGC 7023 is the cluster within the nebula, LBN 487, and the nebula is lit by a magnitude +7 star, SAO 19158. It shines at magnitude +6.8. It is located near the Mira-type variable star T Cephei, and near the bright magnitude +3.23 variable star Beta Cephei (Alphirk). It lies 1,300 light-years away and is six light-years across.



Taken: July 26, 2019
Telescope: Astro-Tech 14" RC with 0.65x focal reducer
Mount: Paramount ME II unguided
Camera: ZWO ASI1600MM-Pro (cooled to -15C; unity gain) Bin 2x2.
Focuser: Moonlite Nitecrawler
Filters used: Luminance, Red, Green, Blue on a ZWO 8 position filter wheel
Exposures: Each filter: 25x60 sec. for a total exposure time of 1.67 hours; calibrated with 100 bias frames, 25 dark frames, 32 flat frames with 32 dark-flats
Seeing Conditions: Above average. Bortle 5 region. Processed with PixInsight and Photoshop CC 2019

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Object: NGC 281 also known as The Pacman Nebula is a cosmic cloud of space gas located in the constellation Cassiopeia and is part of the Milky Way's Perseus Spiral Arm. NGC 281 gets its name from the classic video game character it resembles. Many people think that this nebula resembles a heart. It is approximately 9,200 light years from Earth and 48 light years in circumference.

Taken: August 9, 2019

Telescope: Astro-Tech 14" RC with 0.65x focal reducer

Mount: Paramount ME II unguided

Camera: ZWO ASI1600MM-Pro (cooled to -15C; unity gain) Bin 2x2.

Focuser: Moonlite Nitecrawler

Filters used: H-a, O-III and S-II narrowband on a ZWO 8 position filter wheel

Exposures: 21x100 sec H-a; 20x100 sec O-III and 25x100 sec S-II, for a total exposure time of 1.833 hours; calibrated with 100 bias frames, 25 dark frames, 32 flat frames with 32 dark-flats. Image was processed in the Hubble (SHO) palette.

Seeing Conditions: Average. Bortle 5 region.

Processed with PixInsight and Photoshop CC 2019

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Object: The Andromeda Galaxy also known as Messier 31, M31, or NGC 224 and originally the Andromeda Nebula, is a spiral galaxy approximately 2.5 million light-years from Earth, and the nearest major galaxy to the Milky Way. The galaxy's name stems from the area of the Earth's sky in which it appears, the constellation of Andromeda.

The Milky Way and Andromeda galaxies are expected to collide in ~4.5 billion years, merging to form a giant elliptical galaxy or a large lenticular galaxy. With an apparent magnitude of 3.4, the Andromeda Galaxy is among the brightest of the Messier objects making it visible to the naked eye from Earth on moonless nights, even when viewed from areas with moderate light pollution.

Taken: September 4, 2019

Telescope: Skywatcher Esprit 80 ED Triplet APO Refractor

Mount: Paramount ME II unguided

Camera: ZWO ASI1600MC-Pro (cooled to -15C; unity gain) Bin 1x1.

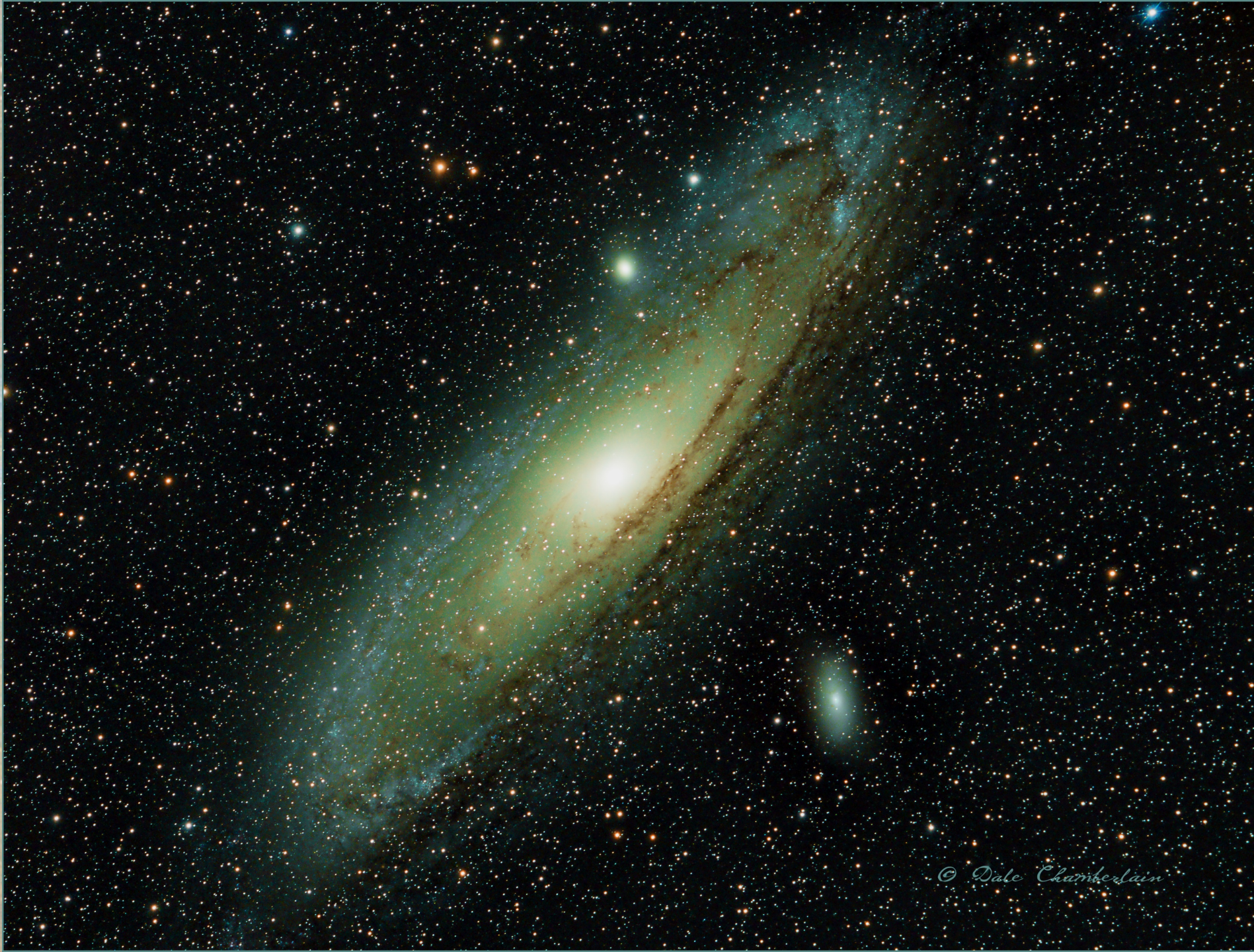
Filter: Astronomik IR Blocker

Focuser: Manual

Exposures: 30x300 sec. for a total exposure time of 2.5 hours; calibrated with 100 bias frames, 25 dark frames, 32 flat frames with 32 dark-flats

Seeing Conditions: Average. Bortle 5 region.

Processed with PixInsight and Photoshop CC 2019



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Object: Messier 20 (M20), also known as the Trifid Nebula, is a famous star-forming region located in the constellation Sagittarius.

The nebula's designation in the New General Catalogue is NGC 6514. The name Trifid refers to its three-lobed appearance. Messier 20 consists of several different objects: an emission nebula, a reflection nebula, a dark nebula and an open star cluster.

The dark nebula, catalogued as Barnard 85, consists of dust clouds that absorb and block light from the bright objects behind them. It is responsible for the apparent gaps in the larger emission nebula that give M20 its trifurcated look.

The other two types of nebulae – emission and reflection – make M20 glow in different colors in images.

Messier 20 is a popular target for amateur astronomers as it is quite bright, even when seen through a small telescope. It has an apparent magnitude of 6.3 and lies at an approximate distance of 5,200 light years from Earth. M20 has a linear diameter of over 40 light years and is only 300,000 years old.



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Taken: August 18, 2019

Telescope: Astro-Tech 14" RC with f/5.2 focal reducer. (1850 mm focal length)

Mount: Paramount ME II unguided

Camera: ZWO ASI1600MM-Pro (cooled to -15C; unity gain) Bin 2x2.

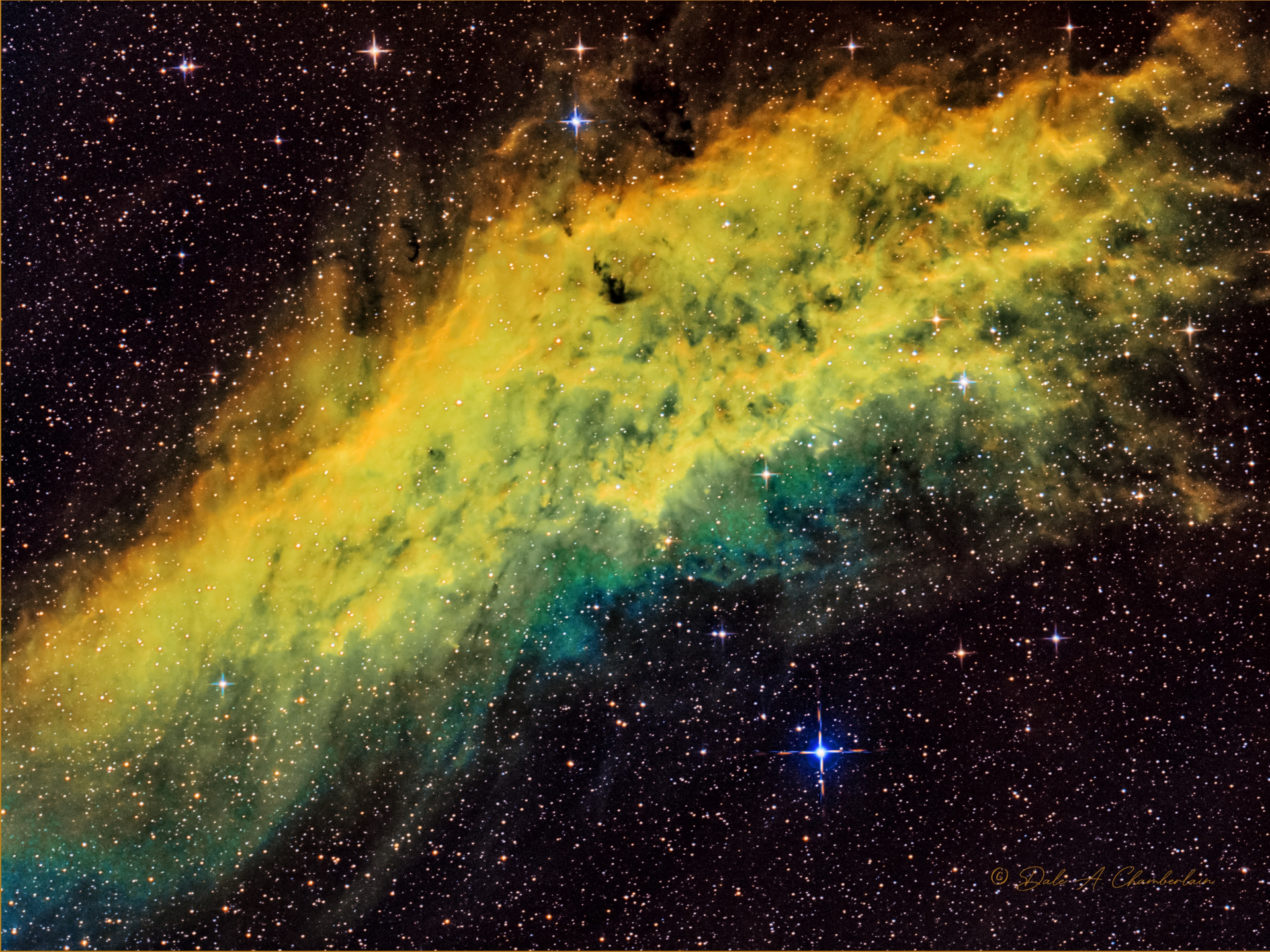
Focuser: Moonlite Nitecrawler

Filters used: H-a, O-III and S-II narrowband on a ZWO 8 position filter wheel

Exposures: 23x100 sec H-a; 21x100 sec O-III and 21x100 sec S-II, for a total exposure time of 1.8 hours; calibrated with 100 bias frames, 25 dark frames, 32 flat frames with 32 dark-flats

Seeing Conditions: A little below average. Bortle 5 region. A lot of humidity!

Processed with PixInsight and Photoshop CC 2019



Object: The California Nebula (NGC 1499) is an emission nebula located in the constellation Perseus. It is so named because it appears to resemble the outline of the US State of California on long exposure photographs. It is almost 2.5° long on the sky and, because of its very low surface brightness, it is extremely difficult to observe visually.

It lies at a distance of about 1,000 light years from Earth. Its fluorescence is due to excitation of the H β line in the nebula by the nearby prodigiously energetic O7 star, Xi Persei (also known as Menkib, seen at center below it in the inset at right).

The California Nebula was discovered by E. E. Barnard in 1884.

By coincidence, the California Nebula transits in the zenith in central California as the latitude matches the declination of the object. (Courtesy of Wikipedia)

Taken: January 1, 2020

Telescope: Skywatcher Esprit 80 ED Triplet

APO Refractor

Mount: Paramount ME II unguided

Camera: ZWO ASI1600MM-Pro (cooled to -15C; unity gain) Bin 1x1.

Focuser: Starizona Micro Touch Autofocuser

Rotator: Optec Pixys LE camera field rotator

Filters used: Hydrogen-alpha, Oxygen-III and Sulphur-II on a ZWO 8 position filter wheel

Exposures: 33x300 sec. Hydrogen-alpha,

27x300 sec. Oxygen-III and 23x300 sec.

Sulphur II for a total exposure time of 6.92 hours; calibrated with 40 dark frames, 40 flat frames with 40 dark-flats

Palette: SHO (Hubble)

Seeing Conditions: Average 3/5. Bortle 5 region.

Processed with PixInsight and Photoshop CC 2019

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Object: The Horsehead Nebula (also known as Barnard 33) is a small dark nebula in the constellation Orion. The nebula is located just to the south of Alnitak, the easternmost star of Orion's Belt, and is part of the much larger Orion Molecular Cloud Complex. It appears within the southern region of the dense dust cloud known as Lynds 1630, along the edge of the much larger, active star-forming H II region called IC 434.

The Horsehead Nebula is approximately 1375 light years from Earth. It is one of the most identifiable nebulae because of its resemblance to a horse's head. (Courtesy of Wikipedia)

Taken: January 7-8, 2020

Telescope: Skywatcher Esprit 80 ED Triplet APO Refractor

Mount: Paramount ME II unguided

Camera: ZWO ASI1600MM-Pro (cooled to -15C; unity gain) Bin 1x1.

Focuser: Starizona Micro Touch Autofocuser

Rotator: Optec Pixys LE camera field rotator

Filters used: Hydrogen-alpha, Oxygen-III and Sulphur-II on a ZWO 8 position filter wheel

Exposures: 32x300 sec. Hydrogen-alpha, 32x300 sec. Oxygen-III and 20x300 sec. Sulphur II for a total exposure time of 7 hours; calibrated with 40 dark frames, 40 flat frames with 40 dark-flats

Palette: SHO (Hubble)

Seeing Conditions: Poor 2/5 with a 92% illuminated waxing gibbous moon. Bortle 5 region.

Processed with [PixInsight](#) and Photoshop CC 2019



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Object: The Rosette Nebula (also known as Caldwell 49) is a large spherical hydrogen II region (circular in appearance) located near one end of a giant molecular cloud in the Monoceros region of the Milky Way Galaxy. The open cluster NGC 2244 (Caldwell 50) is closely associated with the nebulosity, the stars of the cluster having been formed from the nebula's matter.

The cluster and nebula lie at some 5,000 light-years from Earth and measure roughly 130 light years in diameter. The radiation from the young stars excites the atoms in the nebula, causing them to emit radiation themselves producing the emission nebula we see. The mass of the nebula is estimated to be around 10,000 solar masses.

On April 16, 2019 the Oklahoma Legislature passed HB1292 making the Rosette Nebula as the official state astronomical object. Oklahoma Governor Kevin Stitt signed it into law April 22, 2019.

Taken: February 1&2, 2020

Telescope: Skywatcher Esprit 80 ED Triplet APO Refractor

Mount: Paramount ME II unguided

Camera: ZWO ASI1600MM-Pro (cooled to -15C; unity gain) Bin 1x1.

Focuser: Starizona Micro Touch Autofocuser

Rotator: Optec Pixys LE camera field rotator

Filters used: Hydrogen-alpha, Oxygen-III and Sulphur-II on a ZWO 8 position filter wheel

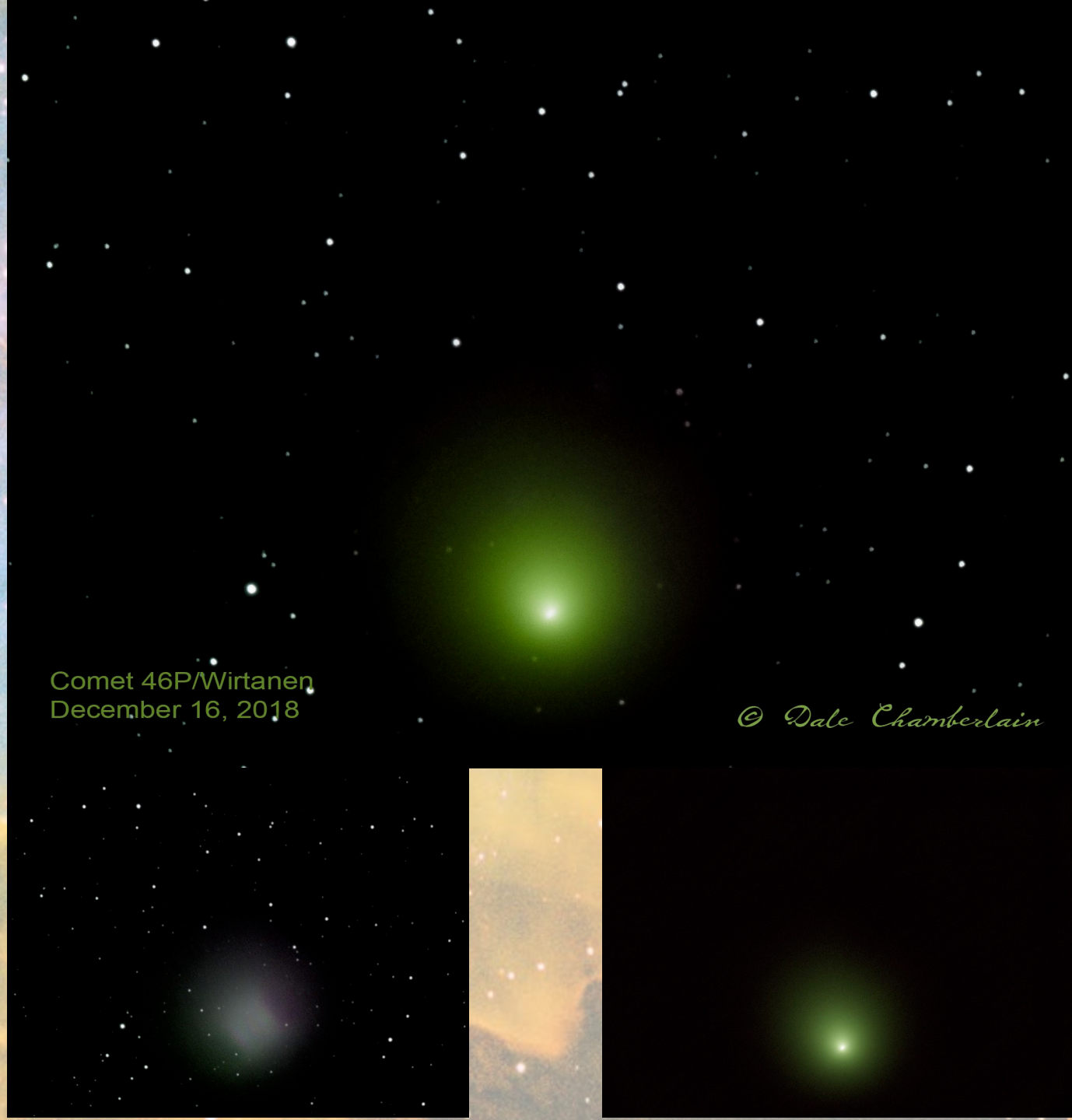
Exposures: 34x300 sec. Hydrogen-alpha, 35x300 sec. Oxygen-III for a total exposure time of 5.75 hours; calibrated with 40 dark frames, 40 flat frames with 40 dark-flats

Palette: HOO (Clouds interrupted getting more data)

Seeing Conditions: Poor 2/5 with a 50% illuminated first quarter moon. Bortle 5 region.

Comets

- ❖ Late in 2018, a comet was in the area called 46P/Wirtanen. It was about 7.2M miles away.
- ❖ This image was the result of 30 separate exposures, 40 seconds each
- ❖ The comet moves significantly during the course of 30 exposures (20 minutes)
- ❖ Doing a single merge would be inadequate
 - Either the stars would be blurred or the comet
- ❖ One merge for the stars is performed
- ❖ Another merge for the comet is performed
- ❖ The stars are removed from the comet aligned image
- ❖ The two images are blended together
- ❖ This is accomplished in PixInSight and Photoshop



Comet 46P/Wirtanen
December 16, 2018

© Dale Chamberlain

Comets

- Comet photos can be taken with a DSLR and a tripod
- Stars will elongate with longer exposure time without a motorized mount
- Courtesy of Madi Hawn, taken the same night (200mm/f/2.8/0.4 secs/ISO-3200):



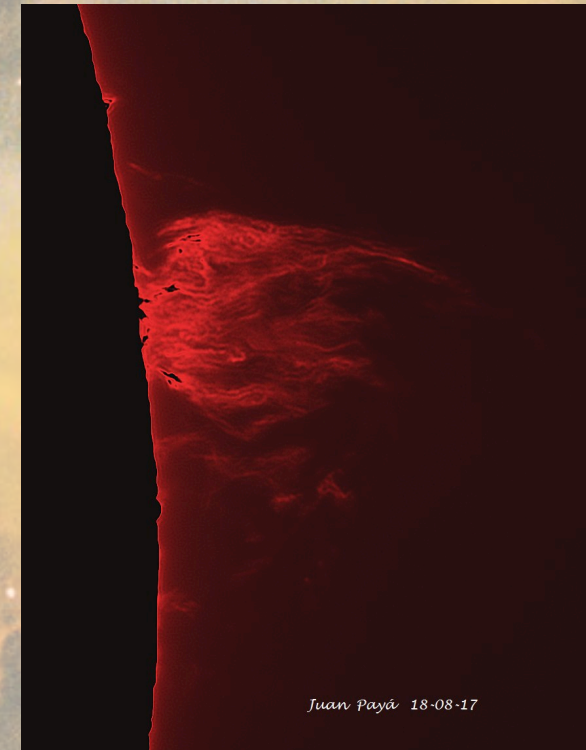
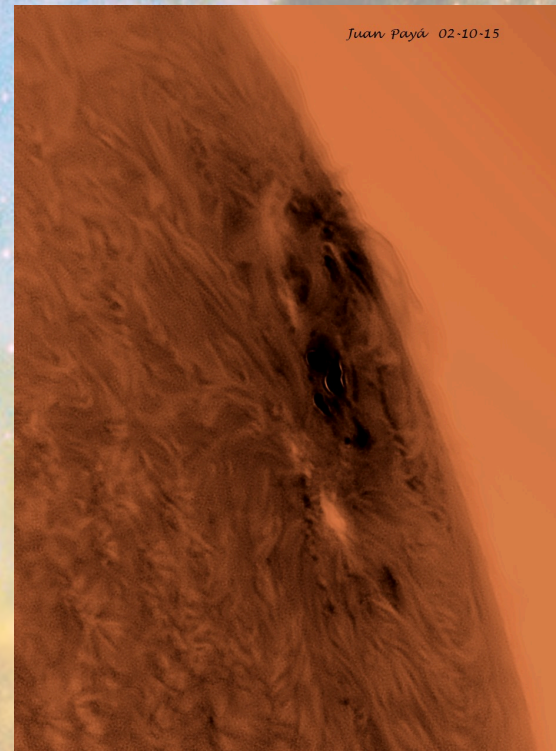
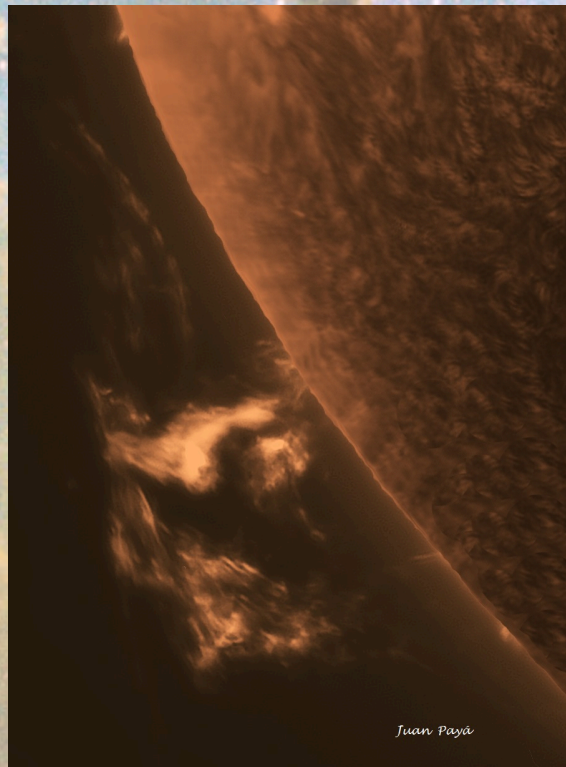
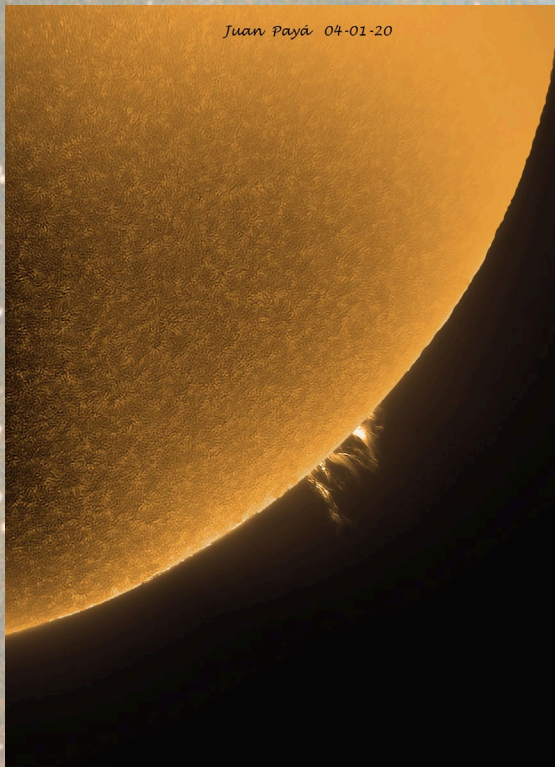
What's Next?

- ❖ Solar Photography
- ❖ Mosaics
- ❖ Autoguiding
- ❖ All Sky camera



Plans for future solar photography

- Use my Coronado Solarmax II 60 H-a telescope
- Can be used on a tripod with a DSLR
- Examples of solar images (courtesy and permission of Juan Payá of Spain)



Mosaics

- Using automation to take images of an area larger than a single field of view of the system
 - ✓ Necessary if taking detailed images of the moon, or deep space objects that are larger than the moon in the field of view (i.e. North American nebula)
- Images are adjacent to each other and then blended or “stitched” together in postprocessing to create a single high resolution image (this is not a composite)
- Very tedious process – requires taking the desired number of exposures for the desired exposure length each (i.e. 40x300 seconds) for each frame in the mosaic for each filter used.
- Very difficult to do beyond 4 frames in the mosaic
- Most likely this is a multiple night project
- Automation can return the mount to the exact frame to resume imaging on subsequent nights

Mosaics



Example of a 2 frame mosaic of The Orion Nebula, Running Man, Horsehead and Flame nebulas (author unknown)

Autoguiding

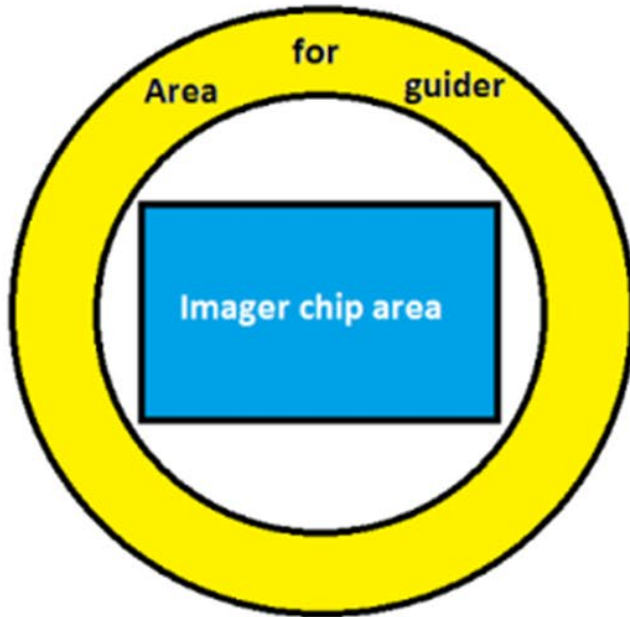
- Automation software monitors movement of a selected “guide” star
 - Computer makes adjustments to the mount’s tracking to stay on target
 - Compensates for imperfections in the mount’s worm gears and any polar alignment issues
- Guidescope
 - Can be effective, simpler solution, large field of view
 - “Differential flexure” is the main drawback
- OAG
 - No differential flexure, same optical train
 - Limited field of view, shadows in image, flats
- ONAG
 - No differential flexure, same train, no shadows, focus lock available
 - Dichroic mirror = Guider must to be sensitive in NIR (Very expensive option)

“Differential flexure” occurs when one part of the imaging system shifts slightly, while other parts do not.

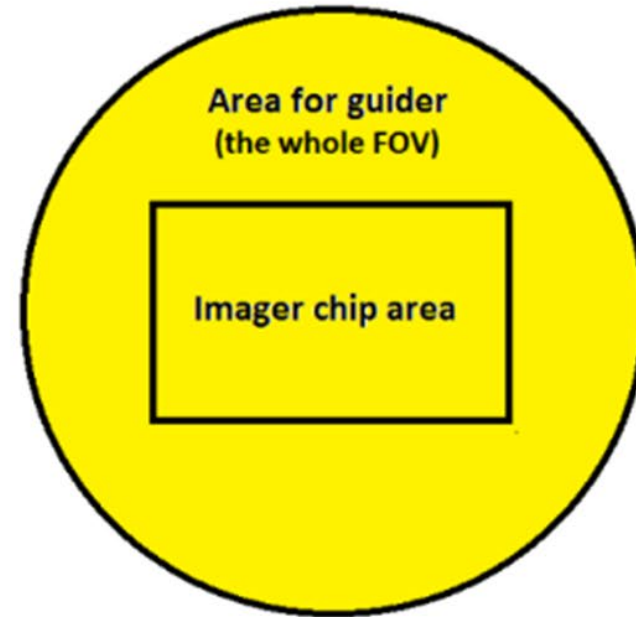
Autoguiding

Sketch of an ONAG v.s. OAG (off axis guider) available guiding field of view

OAG and Self-Guided Cameras

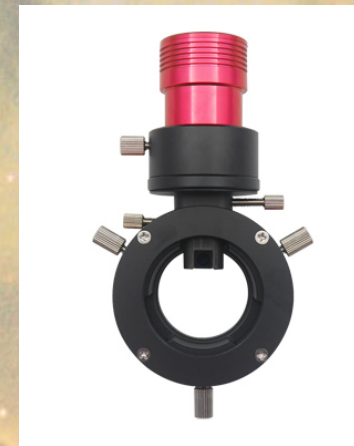


ON Axis Guider - ONAG



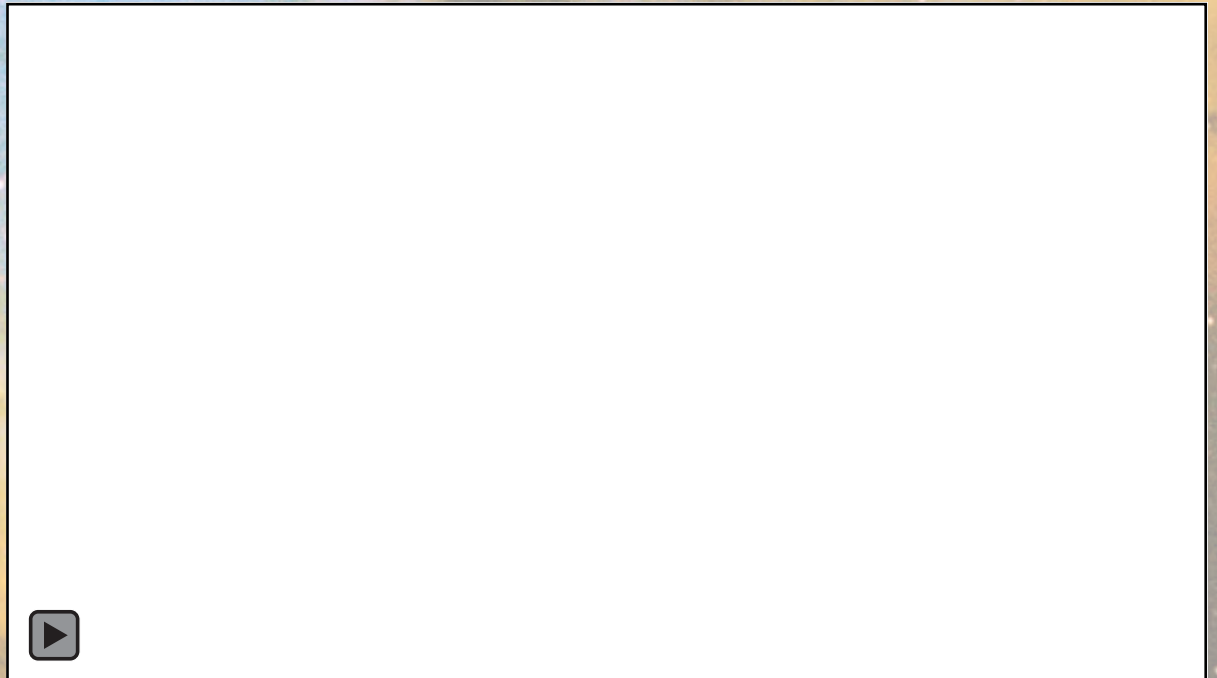
Autoguiding

- My guide camera (ZWO ASI290MM-Mini)
 - Monochrome (best for guiding)
 - Lightweight, not bulky
- ZWO Off-Axis Guider (OAG)
 - Connects main imaging camera and the guide camera
 - No guide scope, no differential flexure problems



All-Sky Camera

- An “All-Sky” camera is a camera with a fish-eye lens pointed at the open sky
- It can provide 24/7 views of sky conditions
- It can also capture meteor showers, fireballs, milky way, sky conditions and near earth events



Thank you !!

This presentation will be available on my observatory website at
<https://chamberlainobservatory.com>



Also please visit and follow my Facebook page
@chamberlainobservatory

