Astrophotography:
A Guide & Personal Journey

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INTRODUCTION

- About Me
- Agenda
- Types of Astrophotography

About Me

- General background
- Photography
- Astrophotography

Agenda

- Types of astrophotography
- Astrophotography methods
- Light
- Telescopes
- Imaging
- Cameras
- Image Capture
- Processing
- Post processing

TYPES OF ASTROPHOTOGRAPHY

- Widefield

Types of Astrophotography

- Planetary

Types of Astrophotography

❖ Deep Space Objects (DSO)

ASTROPHOTOGRAPHY METHODS

- Afocal
- Prime focus - DSLR
- Prime focus – CCD
- Webcam

- What are they used for ?
- Pros & Cons ?

Afocal

- Camera held to the telescope eyepiece, either manually or using a clamp
- Works for large objects, such as the Moon and widefield images
- But:

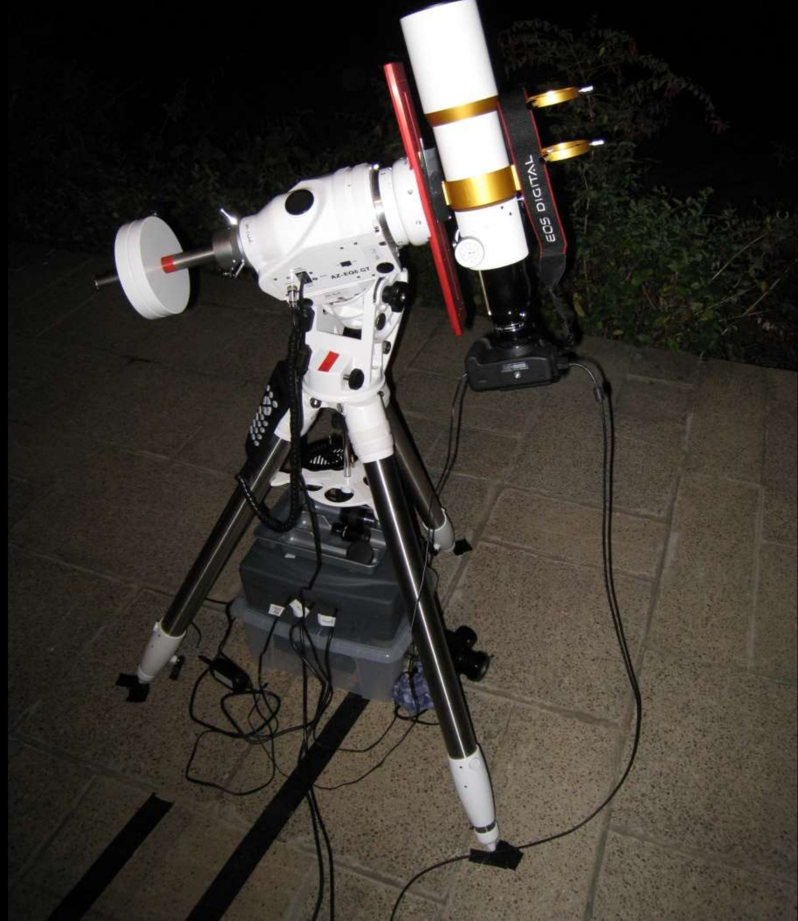
- Focussing is difficult;
- Limited magnification;
- Difficult to hold steady;
- Short exposures only;
- Suitable for compact or smartphone cameras.

Afocal

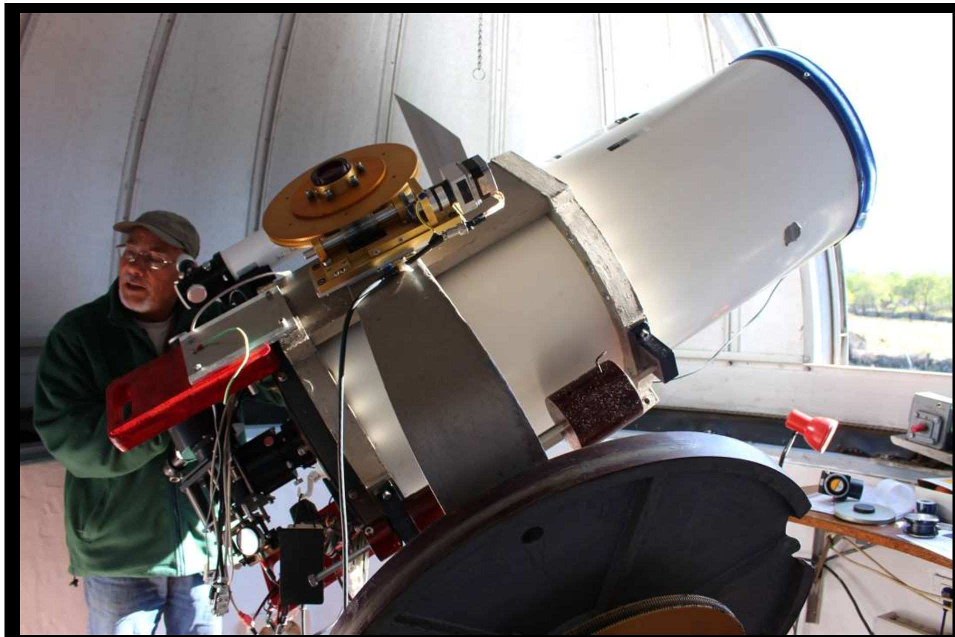
- Depending on the telescope, generally unsuitable for smaller planets & DSO objects

Prime Focus - DSLR

- Camera uses the telescope as the lens
- Long exposures possible with tracking
- Good for DSO objects
- Can be difficult to match with telescope to achieve focus
- Mostly used for RGB images



Prime Focus - CCD

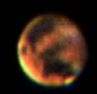


- Similar set-up to DSLR
- Using filters increased data captured to produce LRGB FITS images and thus greatly improved detail
- Cooling used to reduce image noise

- Camera operation & control requires computer
- Longer total imaging time for LRGB images
- Image capture and post processing complicated
- Very expensive

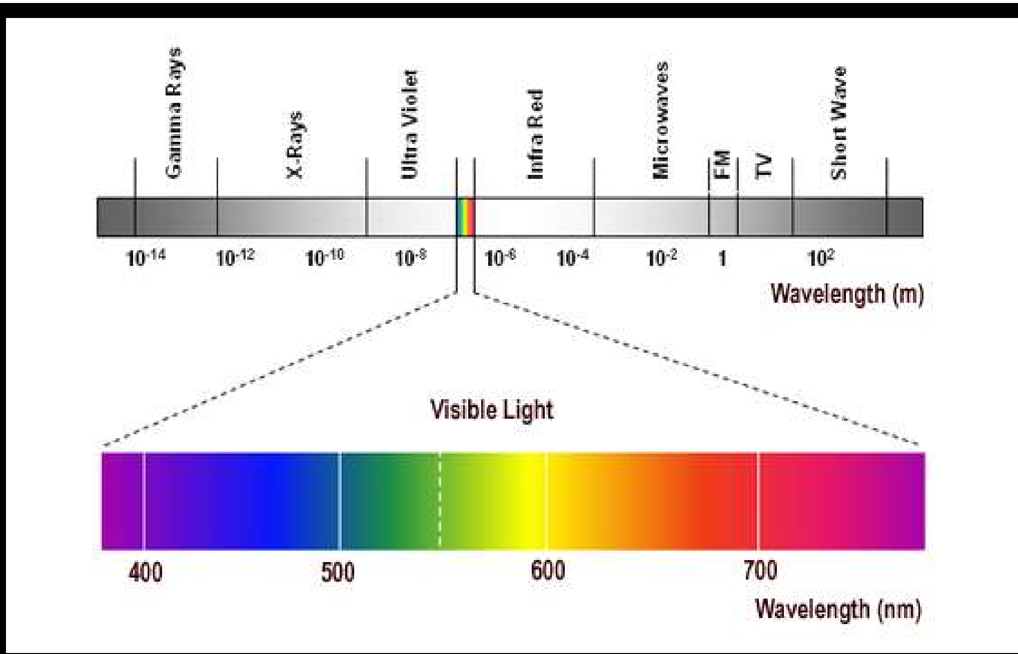
Webcam

- Similar to CCD but produces video
- Mainly used for planetary imaging
- Of limited other use
- Requires significant computer power for processing



LIGHT – A scarce resource

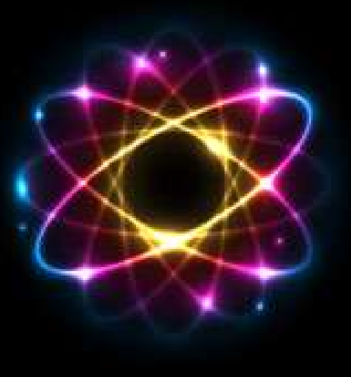
- Objects in the Universe emit wavelengths across the entire electromagnetic spectrum
- Unfortunately on Earth we can only image a very narrow band of visible light
- Imaging from space removes the additional problem caused by Earth's atmosphere which distorts light and reduces or removes wavelengths outside the visible spectrum
- For the first time the new James Webb telescope, due for launch in 2018, will capture wavelengths in infrared



Animal	Spectrum	Wavelength
Human	Visible	400-700 nm
Rattlesnake	Infra Red and visible	480-850 nm
Bee	Ultraviolet	as low as 360 nm
Fly	Ultraviolet	500-600 nm

Light – Across the Universe

Light – Time Travel

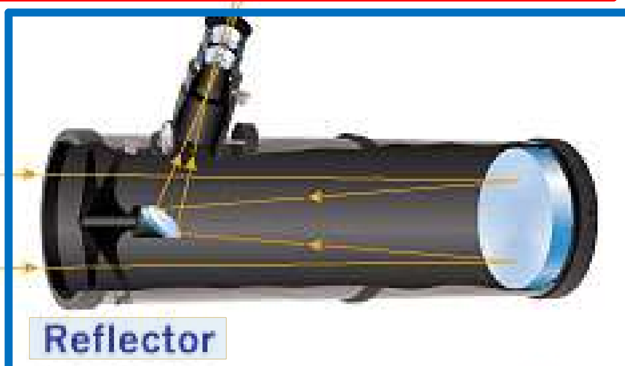


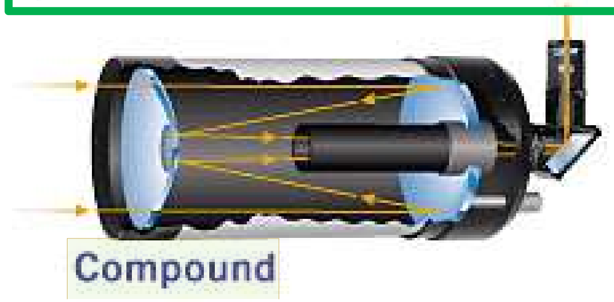
Travelling as photons, light travels at 670 million miles per hour or 6 trillion miles a year

- Light from the galaxy NGC 7331 (top right) reached my camera sensor **50** million years later in October 2014
- From the Stephan's Quintet group of galaxies (bottom left), light made a similar journey over **300** million years
- For **400** million years light travelled from a group of galaxies just above NGC 7331 called the Deer Lick Group
- The ammonite collected from Somerset in 2015 was alive about **180** million years ago

- Catching this light is the challenge for astrophotographers!

TELESCOPES





- Horses for Courses

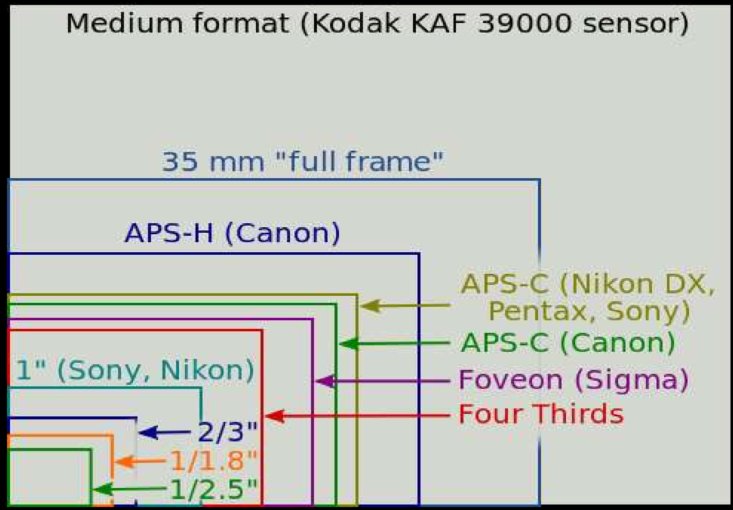
<u>Considerations</u>

- Objective / target
- Viewing v imaging
- Conditions
- Focal Length
- Aperture
- Camera

DSLR CAMERAS – Which camera?

- **Mainly Canon & Nikon**
- **A matter of personal preference, but……**
- **The majority of software works best or is written for Canon & MS Windows, which have *de facto* therefore become the most commonly used**

DSLR Cameras: APS-C v Full Frame



- **For most people APS-C works well producing RGB images**
- **Full frame provides a larger sensor area but very few telescopes cover the area**
- **To go to the next level of DSO imaging cooled CCD & colour filters are best, producing separate LRGB images; <u>more than 50% of the detail is contained in the Luminance image</u>**

DSLR: Sensor Comparison

Camera	Sensor			Telescope	Aperture	Focal Ratio	Focal Length	Focal Ratio *	Focal Length *	FOV *	Resolution *
	Type	Size	Pixel Size Microns		mm	f	mm	f	mm	Degrees	arcsec / pixel
Canon 550D	APS-C	22.3 x 14.9	4.30	William Optics GT81	81	5.90	478	4.72	382	3.34° x 2.23°	2.32"
Canon 5D II	CMOS	36.0 x 24.0	6.41							5.39° x 3.59°	3.45"
Canon 550D	APS-C	22.3 x 14.9	4.30	Skywatcher 150PL	150	8.00	1,200	8.00	960	1.06° x 0.71°	0.74"
Canon 5D II	CMOS	36.0 x 24.0	6.41							2.15° x 1.43°	1.38"

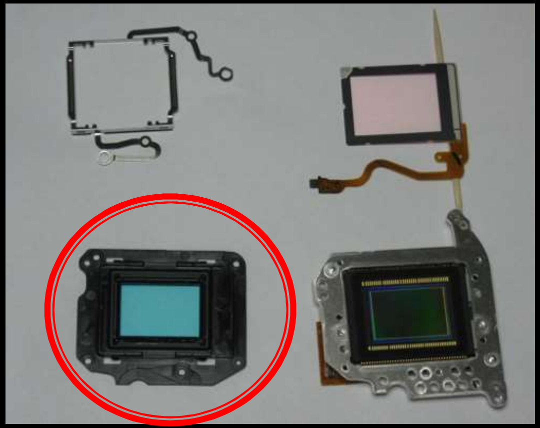
**WO using field flattener*

Minimum resolution of at least 1.0"~ to 2.0" preferred

DSLR CAMERAS: Issues

Camera Modification	• For terrestrial use all cameras come with infrared filters • Many DSO objects contain Ha and OIII light • For serious DSO imaging the infrared filter is removed
Telescope Attachment	• A basic nosepiece works well but is inevitably is less sharp at the image edge resulting in coma errors etc. • Use of a coma corrector of field flattener is preferred.

DSLR Cameras - Modification

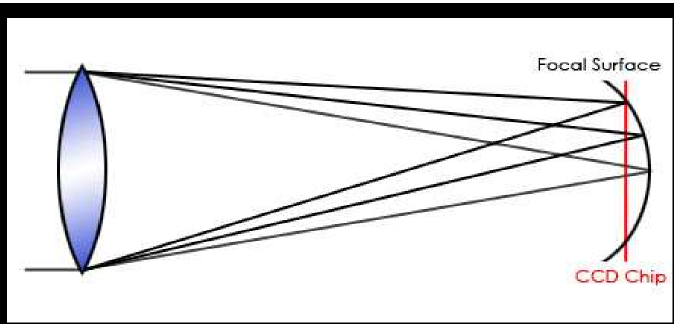


- All cameras come with an IR filter
- Many DSO objects contain Ha and OIII light which is therefore lost
- For serious DSO imaging removal of the IR filter increases the detection of red Ha-light by a factor of x4

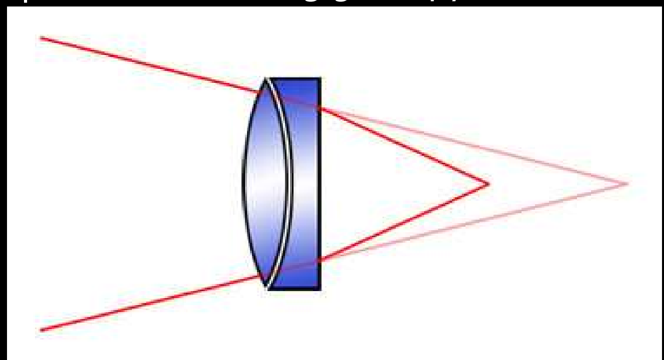
Without IR filter removal

With IR filter removal 'Modded'

DSLR Cameras – Field Flattner

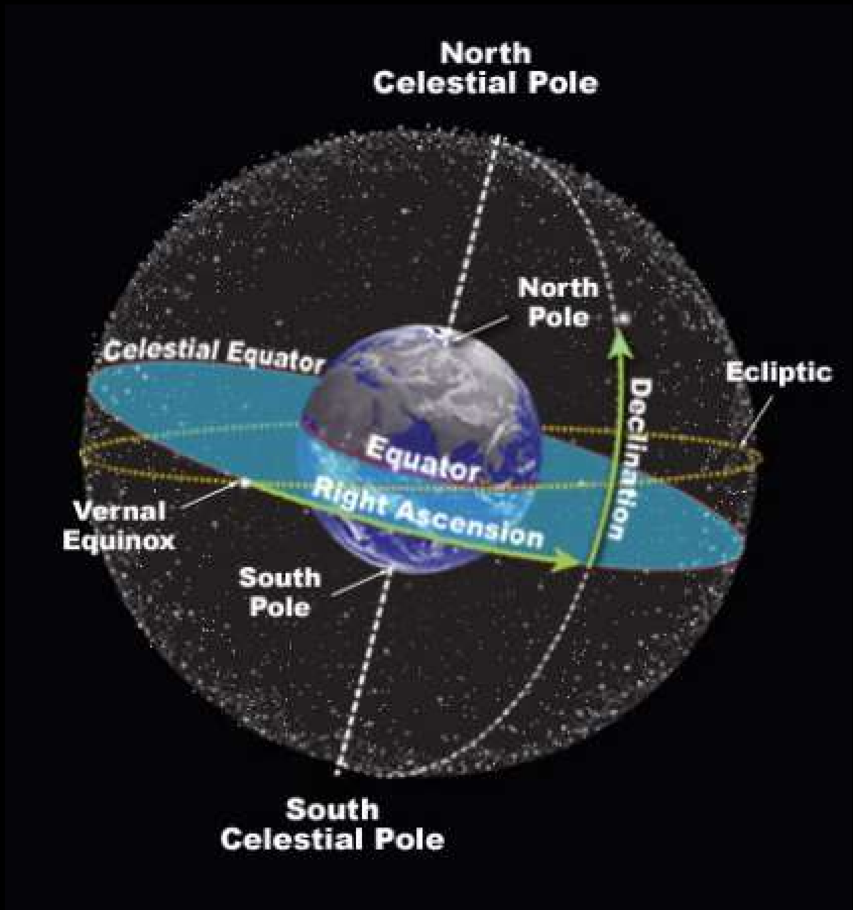


- The focal plane of most telescopes is not flat
- Field curvature is a problem for astrophotography as the camera sensor is flat
- As a result it is impossible to get sharp stars across the entire field-of-view
- Use of a field flattner optically corrects for this problem
- Furthermore, the flattener will increase the speed of the telescope (focal ratio) and field-of-view e.g. for the William Optics GT81 from f5.9 to f4.72 (x 0.8)



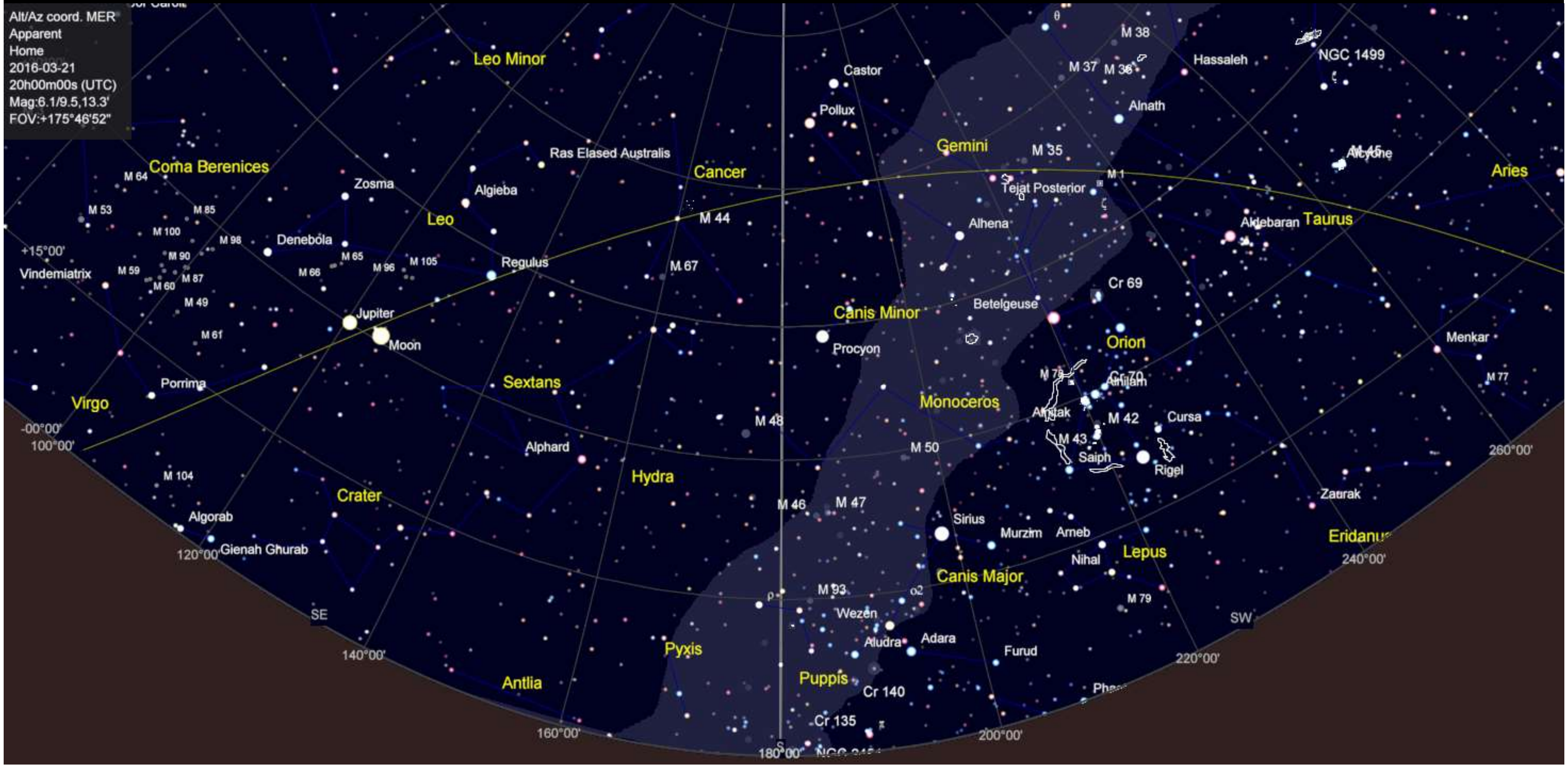
IMAGING ISSUES

- **Problem-1: Movement relative to the celestial sphere**



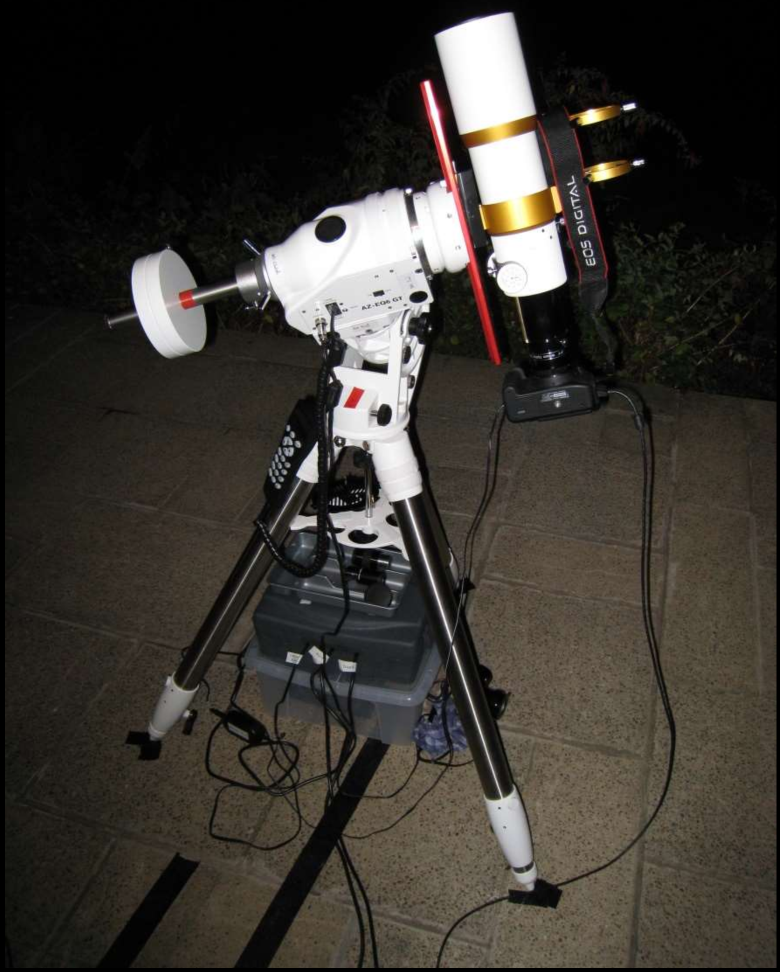
Imaging Issues - 1

- Ecliptic trace 21st March 2016 @ 20.00h



Imaging Issues-1

- **Solution: Tracking**
  - **The Mount**
  - **Alignment – Polar & Star**
  - **Control**
  - **Autoguiding**



Imaging Issues-2

- **Problem-2: 'Seeing'** (the atmosphere)

Imaging Issues-2

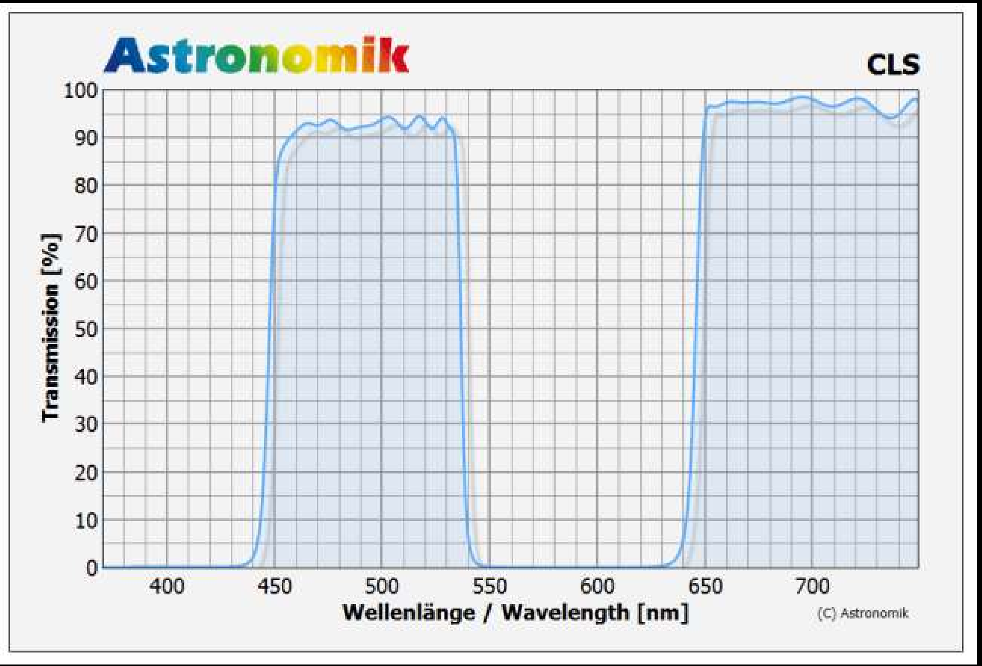
- **Solutions:**
  - Target location: Meridian, high DEC
  - Match pixel size with sampling size

Imaging Issues-3

- **Problem-3: Darkness**

Imaging Issues-3

- **Solutions:**
  - Location
  - Timing
  - Light Pollution Filter



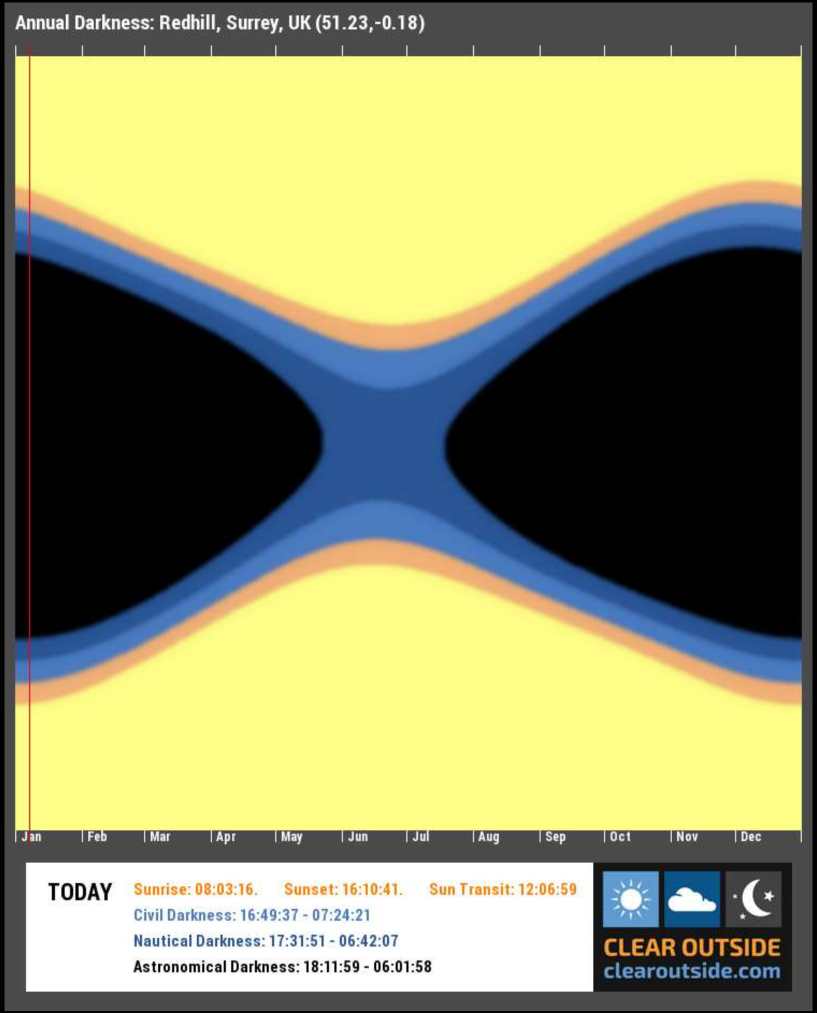
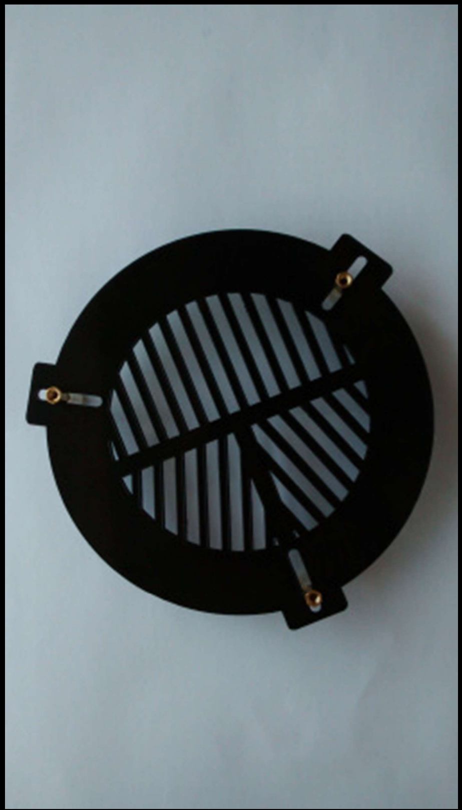


IMAGE CAPTURE

- Operate in Manual mode
- Format: it's all about the data JPG, RAW, FITS
- ISO settings: a balancing act
- Exposure times: as long as possible

Image Capture - Focus

- Achieving focus is surprisingly difficult
- Solution – Bahtinov Mask



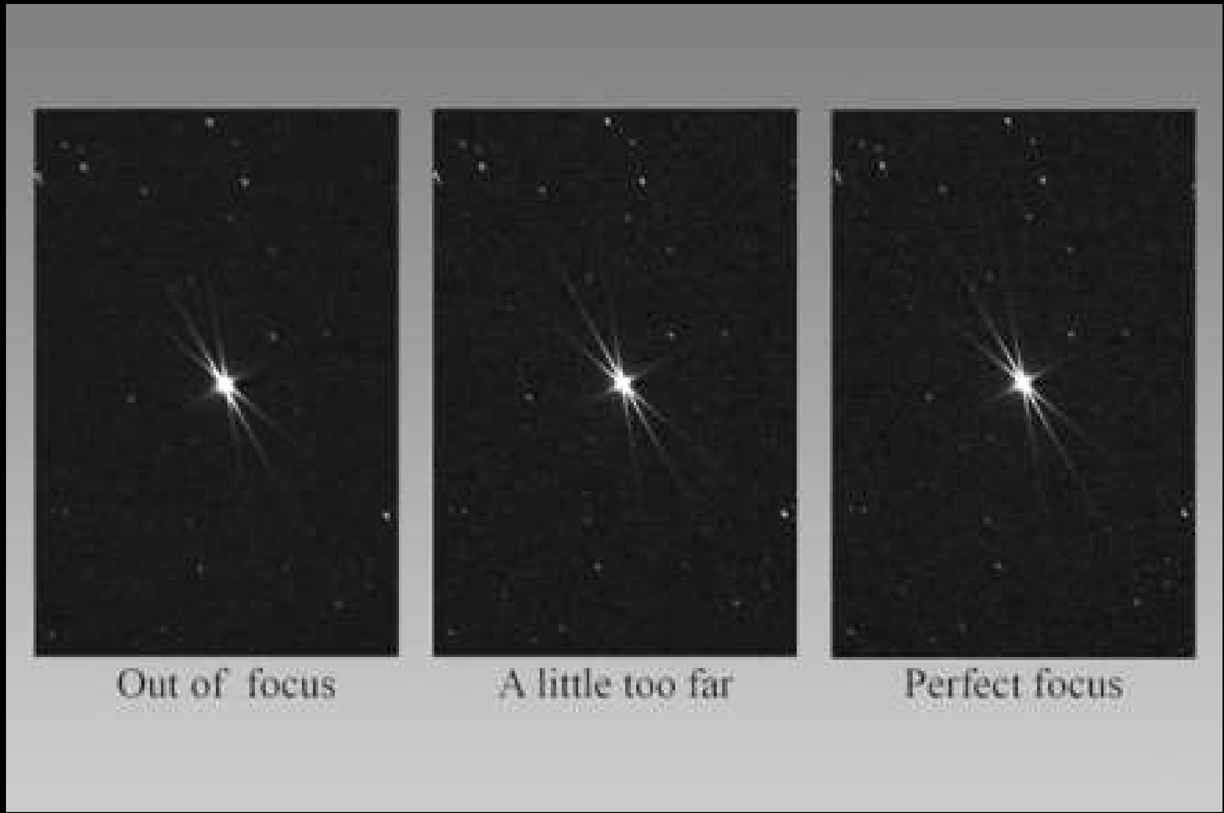
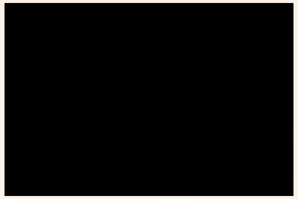


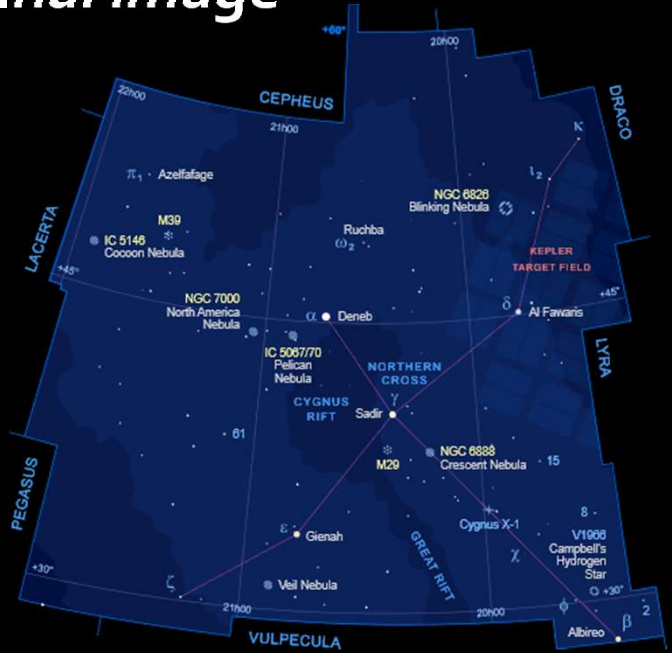
Image Capture - Calibration

- Required to remove & correct stuff

Image Type	Description	Process	Example
Subs or Light Frames	Images containing real object information	Prime focus RGB image with camera & telescope	
Dark Frames	Used to remove dark signal from the light frames	Shoot as above (same ISO & exposure) but with cap over telescope	
Bias Frames	Used to remove sensor readout signal from the light frames	As darks but at the shortest possible exposure e.g. ¼,000 s	
Flat Frames	Used to correct vignetting & uneven field illumination	Using AV mode shoot a bright light with even light distribution	

PROCESSING

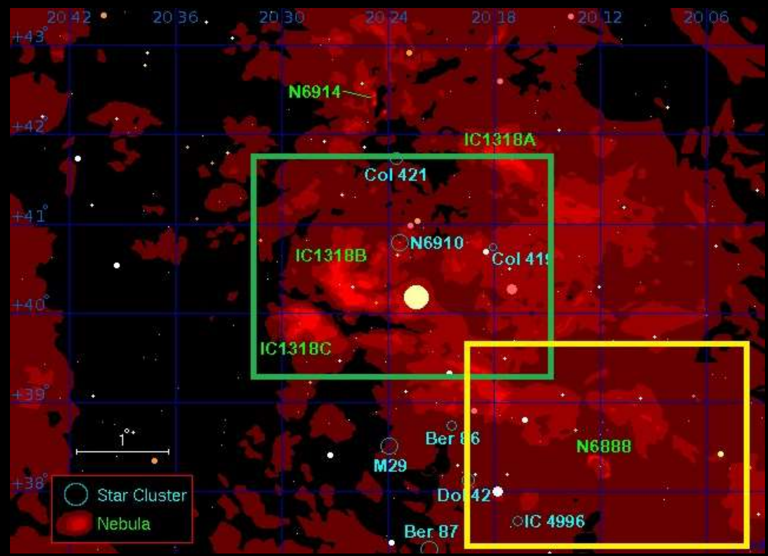
- Stacking subs + calibration
- Stacked picture in Photoshop
- Histogram before stretching
- Picture after stretching
- Other processes
- Final image



Processing Example:

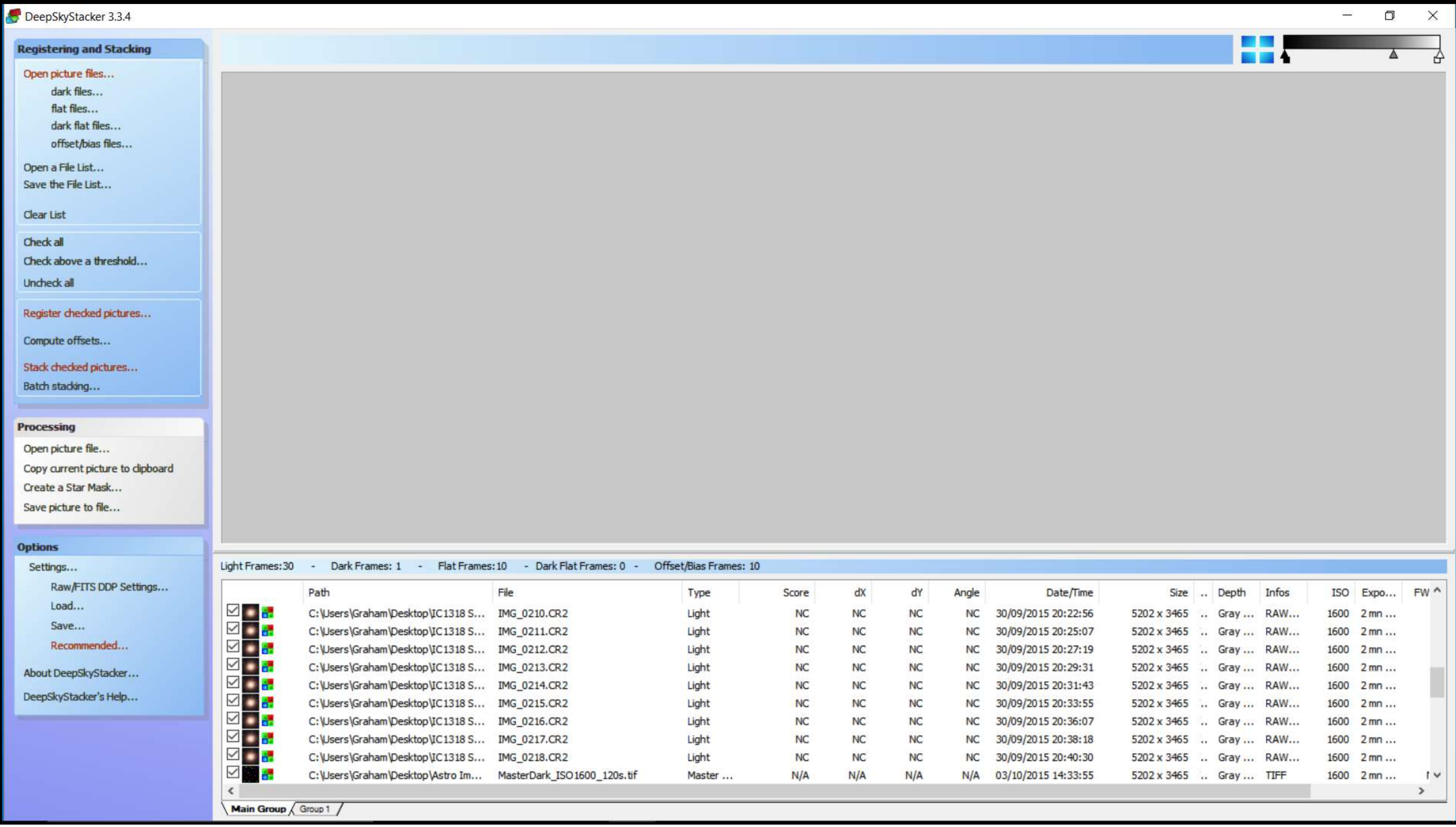
The Sadr region IC 1318 nebula surrounds the star Gamma Cygni, located in the Cygnus constellation in the Orion arm of the Milky Way and spans an area of about 200 light years or 4°

x30 subs 120 sec @ ISO 1,600 + x5 darks , x10 bias, x10 flats



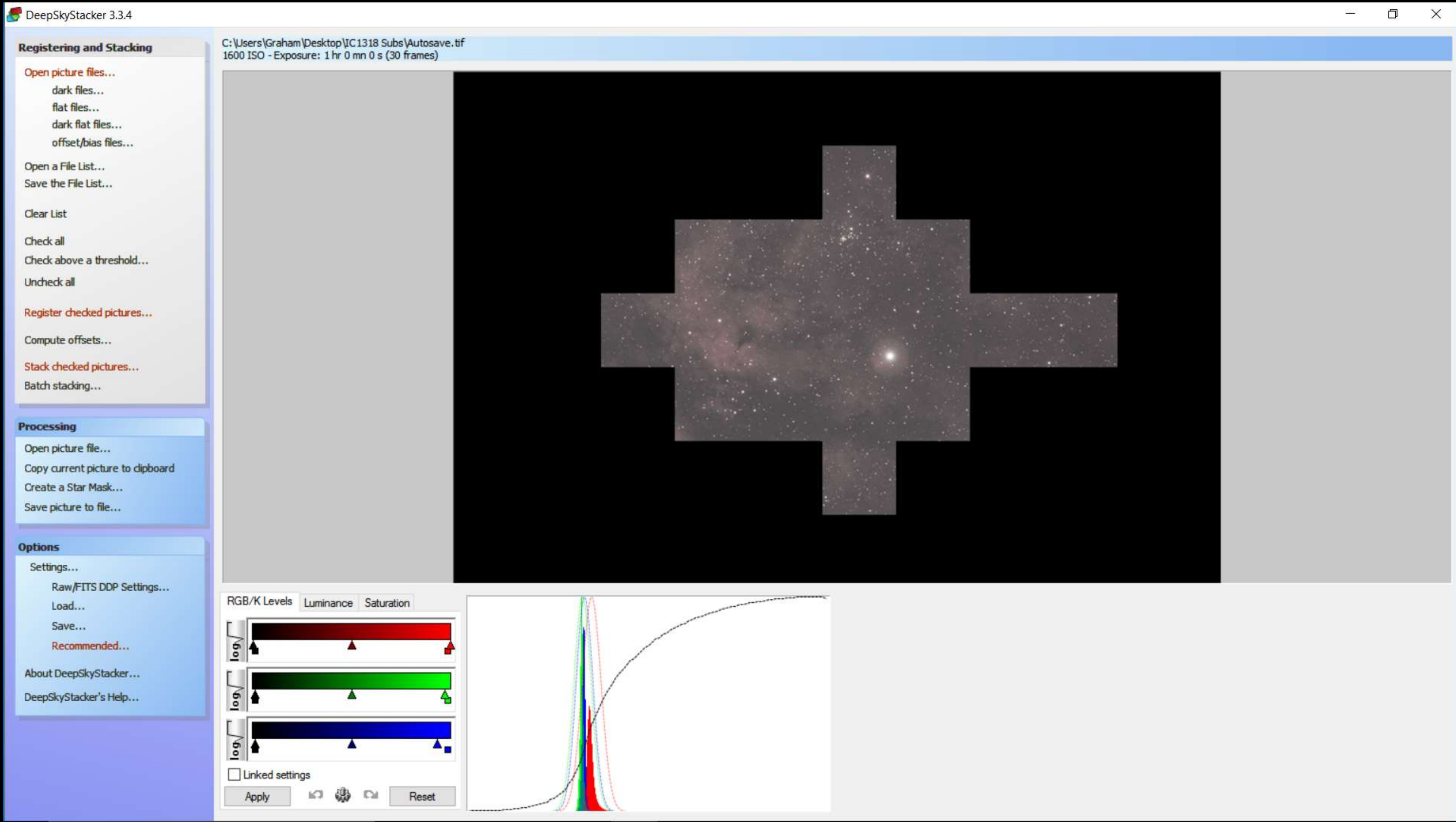
Processing: Stacking

- **Load images & calibration files into Deep Sky Stacker & run**



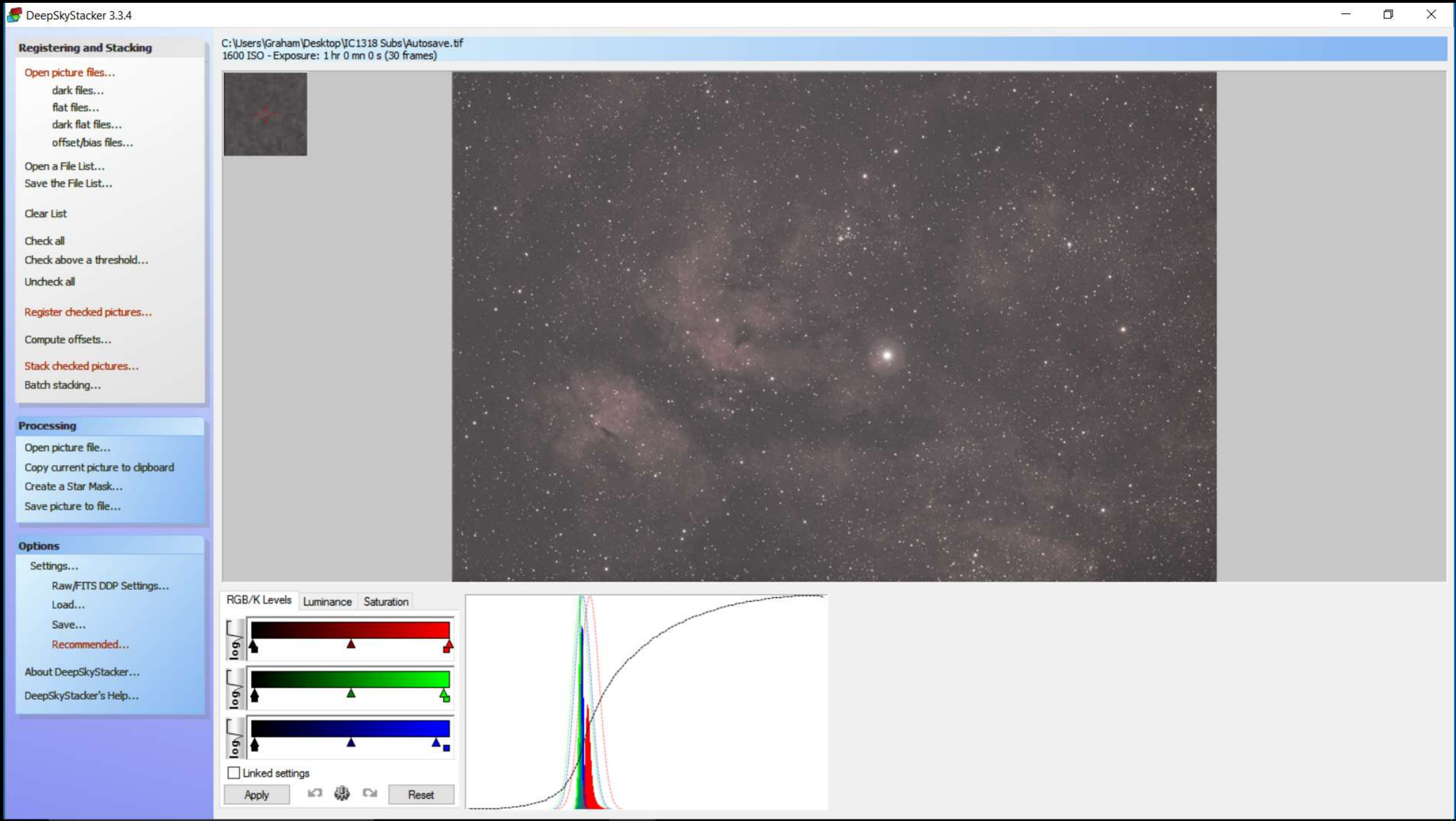
Processing: Compiling

- At the end DSS compiles a final stacked image



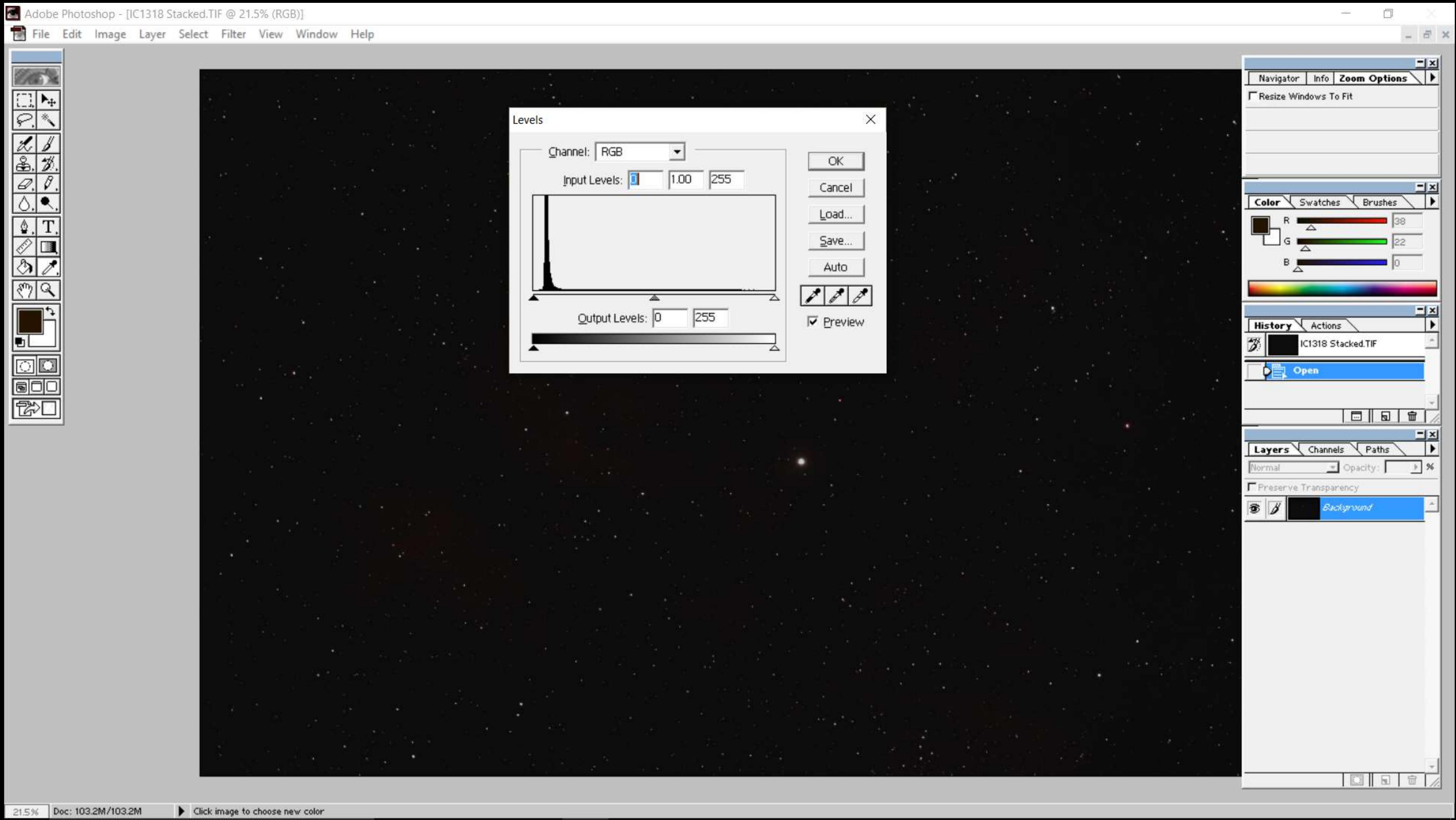
Processing: Stacked Image

- Final stacked DSS Tif format image



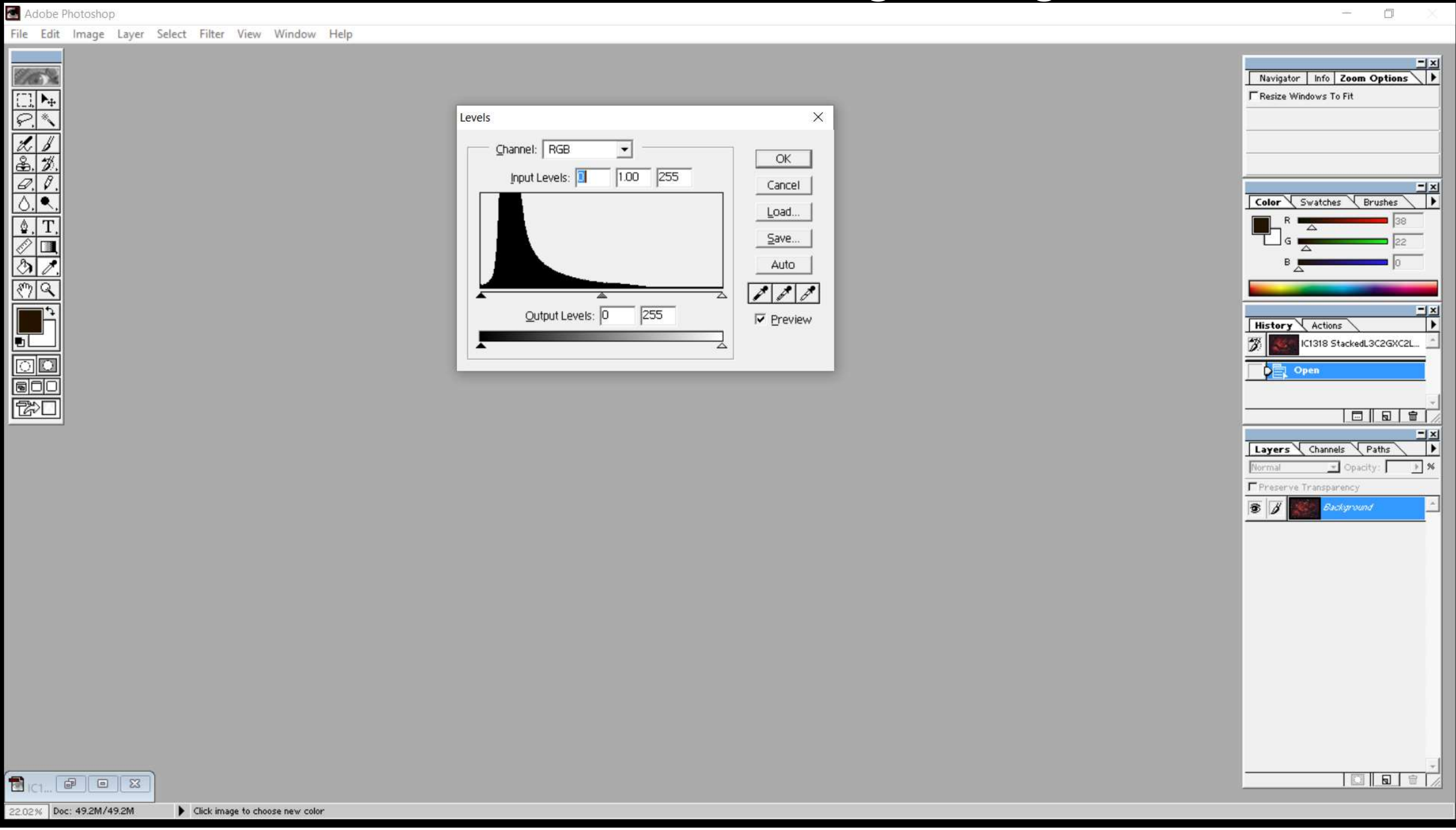
POST PROCESSING

- Pre-stretched DSS Tif image loaded into PS

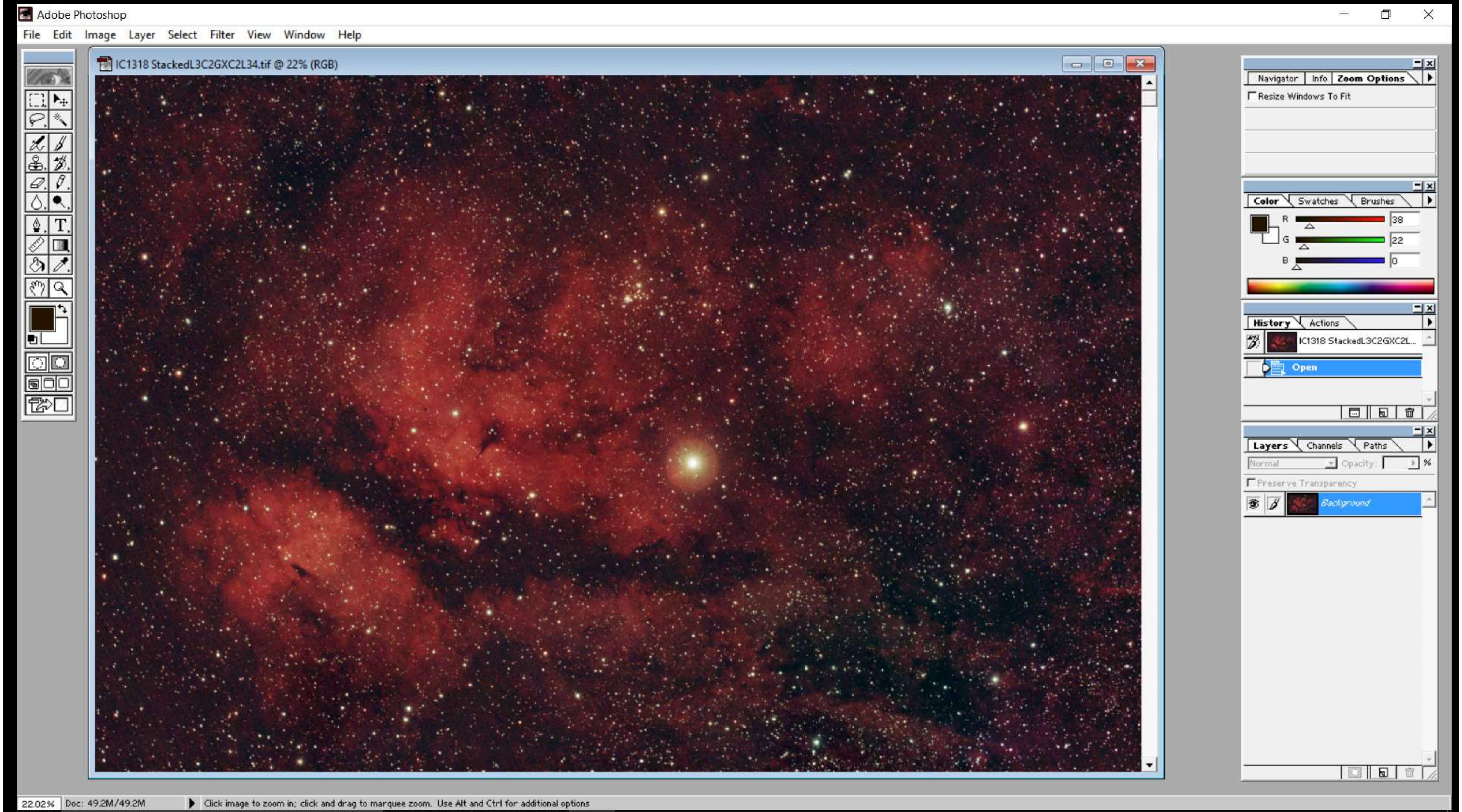


Post Processing

- Post stretched final image histogram



Post Processing: Final Image



PICTURES

Lunar Eclipse

Totality

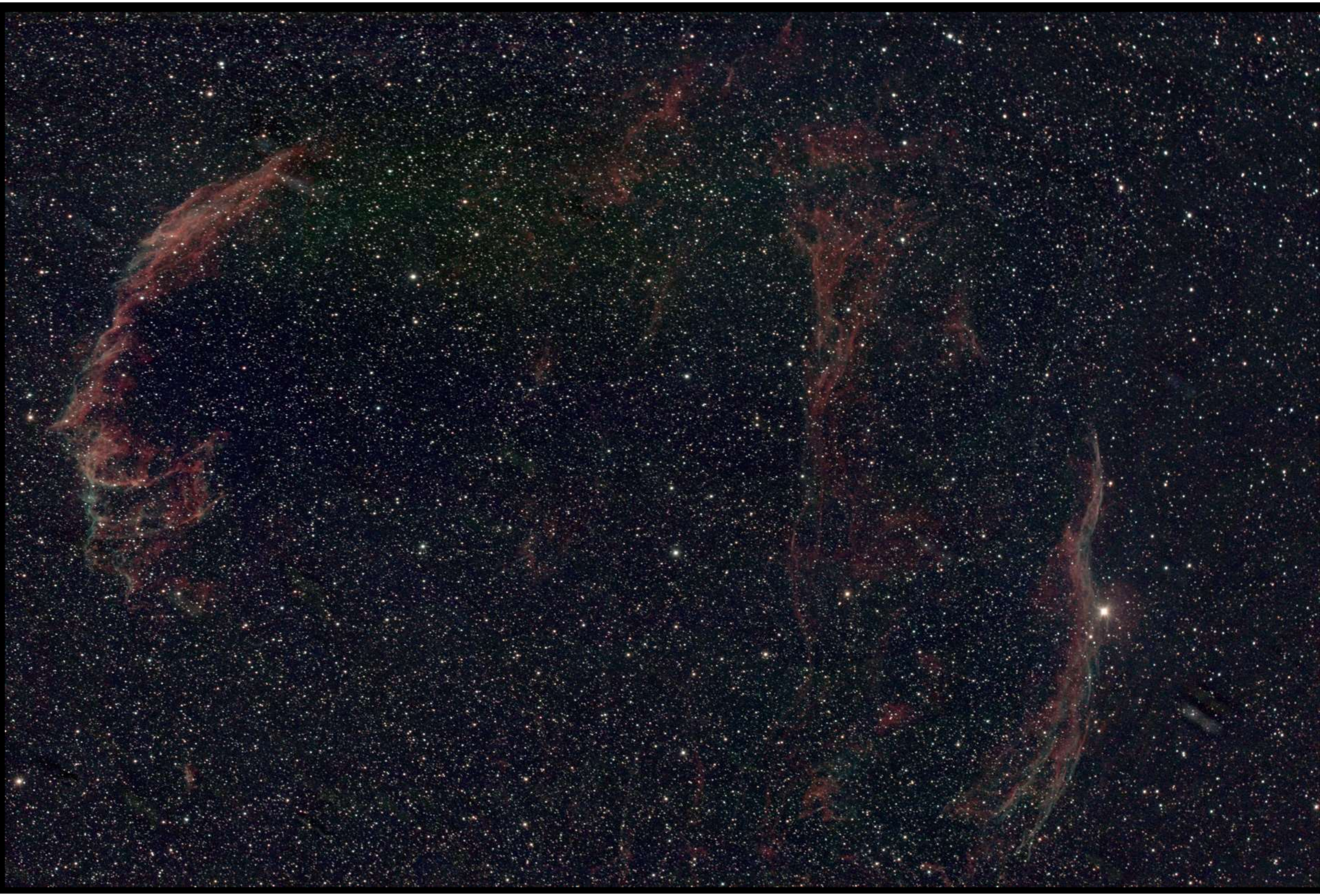
Comet Lovejoy

M15 Star Cluster

Pleiades

Pelican Nebula

Veil Nebula



California Nebula

Flaming Star & Tadpole Nebulae

Orion Constellation

M42 Great Orion Nebula etc.

Flame & Horsehead Nebulae

M84 Virgo Supercluster

M31 Andromeda Galaxy

THANK YOU

- **For more information go to:**
- **www.watchthispaceman.wordpress.com**