Beginning Astrophotography

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Beginning Astrophotography

- Types of Astrophotography
- Cameras and attaching
- Field of View
- Filters, Light Pollution
- Calibration Frames
- Processing, Stacking
- Hints & Tips
- References

Types of Astrophotography

- Intentional Star Trails
- DLSR and tripod
- Guided DLSR
  - “Door-hinge”
  - “Piggy-back”
- Telescope Imaging
  - Planetary vs Deep Sky

Camera Types

- DSLR vs Monochrome
- CCD vs CMOS
  - Expense vs Lower Bits/Pixel
- Phone or Tablet?

Specs

- Pixel size and dimensions (resolution)
  - 3.8um, 4656 x 3520 (16megapixels)
- Frame size and dimensions (FOV)
  - 17.7mm x 13.4mm
- Full well (saturation level)
  - 20 Kev
- Read Noise (background noise of camera)
  - 1.2-3.6e
- Bits per Pixel (color depth)
  - 16 bpp (65535 max ADU)

Attaching Your Camera

- Need a way to mount it
  - T-adapter, phone adapter, etc.
- Make it secure
  - Screw threads best, Safety clip
- 3 Ways: A-focal, Prime, Projection

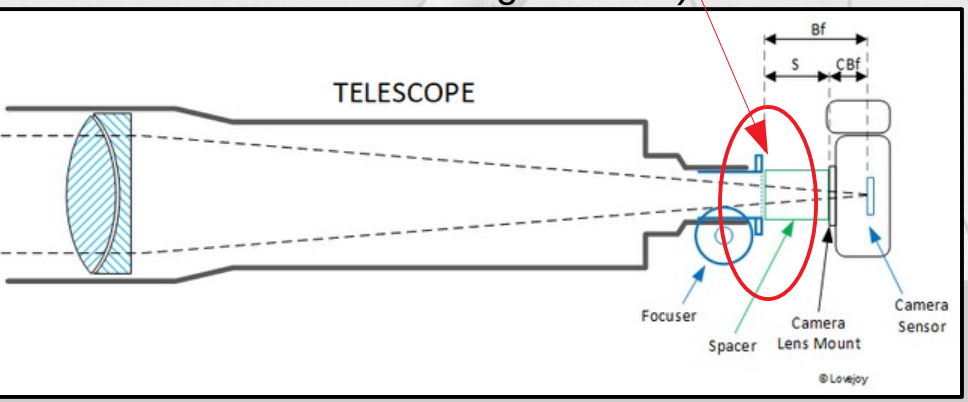
A-Focal Projection

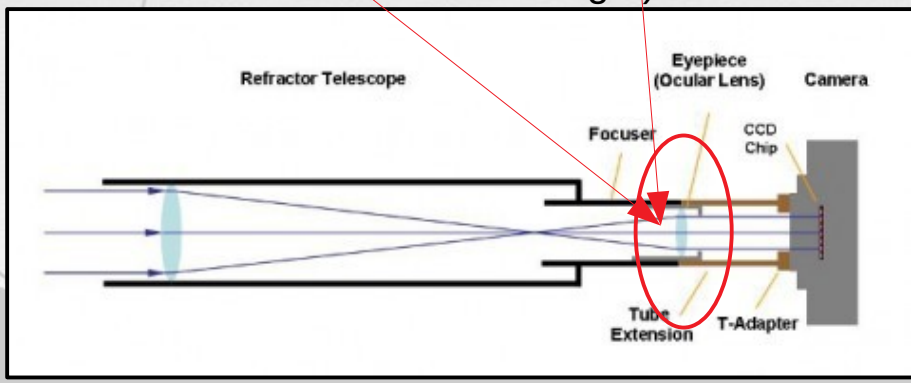
(Difficult to align, vignetting)

Prime Focus, Eyepiece Projection

Prime Focus
(Good for Deep Sky,
Reduced magnification)

Eyepiece Projection
(Good for Planets,
Reduced light)





Field Flatteners, Focal Reducers, and Barlows

- Flattener
  - Mirrors esp have a curved focal plane – not good as a camera expects a flat focal plane. This corrects it.
    - Image will be sharp in the center, out of focus at edges
- Reducer
  - Usually .8x, reduces magnification, gives larger FOV and brighter intensity
- Flattener and Reducer can be purchases as one unit
  - These insert (usually screw threads) into the imaging stack
- Barlow
  - 2x or 3x magnification, at the expense of light intensity and FOV
  - For eyepiece projection, inserted with or without eyepiece

FOV: Reducer, Normal, Barlow

.8x Reducer

Targets | Mode | Image | Options | Help

Explore Scientific
AR152 f/6.5
- Aperture: 152mm
- Focal length: 988mm
- Focal ratio: f/6.5
- Barlow/Focal reducer: .8x

ZW Optical
ASI1600M
- Pixel size: 3.8 µm
- Image size: 4656 x 3520
- Sensor size: 17.7 x 13.4mm
- Binning: 1x1

Results
FOV: 1.28° x 0.97°
Resolution: 0.99"/pixel
Area: 1.24 sq°
Focal length: 790mm
Focal ratio: f/5.2

M42

1x Prime Focus

Targets | Mode | Image | Options | Help

Explore Scientific
AR152 f/6.5
- Aperture: 152mm
- Focal length: 988mm
- Focal ratio: f/6.5
- Barlow/Focal reducer: 1x

ZW Optical
ASI1600M
- Pixel size: 3.8 µm
- Image size: 4656 x 3520
- Sensor size: 17.7 x 13.4mm
- Binning: 1x1

Results
FOV: 1.03° x 0.78°
Resolution: 0.79"/pixel
Area: 0.80 sq°
Focal length: 988mm
Focal ratio: f/6.5

M42

2x Barlow

Targets | Mode | Image | Options | Help

Explore Scientific
AR152 f/6.5
- Aperture: 152mm
- Focal length: 988mm
- Focal ratio: f/6.5
- Barlow/Focal reducer: 2x

ZW Optical
ASI1600M
- Pixel size: 3.8 µm
- Image size: 4656 x 3520
- Sensor size: 17.7 x 13.4mm
- Binning: 1x1

Results
FOV: 30.78' x 23.27'
Resolution: 0.40"/pixel
Area: 0.20 sq°
Focal length: 1976mm
Focal ratio: f/13.0

M42

ES152 vs C14-Edge

6”

Targets | Mode | Image | Options | Help

Explore Scientific
AR152 f/6.5
- Aperture: 152mm
- Focal length: 988mm
- Focal ratio: f/6.5
- Barlow/Focal reducer: 1x

ZW Optical
ASI1600M
- Pixel size: 3.8 µm
- Image size: 4656 x 3520
- Sensor size: 17.7 x 13.4mm
- Binning: 1x1

Results
FOV: 1.03° x 0.78°
Resolution: 0.79"/pixel
Area: 0.80 sq°
Focal length: 988mm
Focal ratio: f/6.5

M42

14”

Targets | Mode | Image | Options | Help

Celestron
C14-A XLT
- Aperture: 355.6mm
- Focal length: 3910mm
- Focal ratio: f/11.0
- Barlow/Focal reducer: 1x

ZW Optical
ASI1600
- Pixel size: 3.8 µm
- Image size: 4656 x 3520
- Sensor size: 17.7 x 13.4mm
- Binning: 1x1

Results
FOV: 15.56' x 11.76'
Resolution: 0.20"/pixel
Area: 182.9 sq'
Focal length: 3910mm
Focal ratio: f/11.0

M42

Field of View

- Excellent online calculator
  - http://www.12dstring.me.uk/fovcalc.php
    - Has most telescopes and cameras included
- Create a table for your equipment
  - Telescopes/Eyepieces/Cameras/Barlow/Reducer…

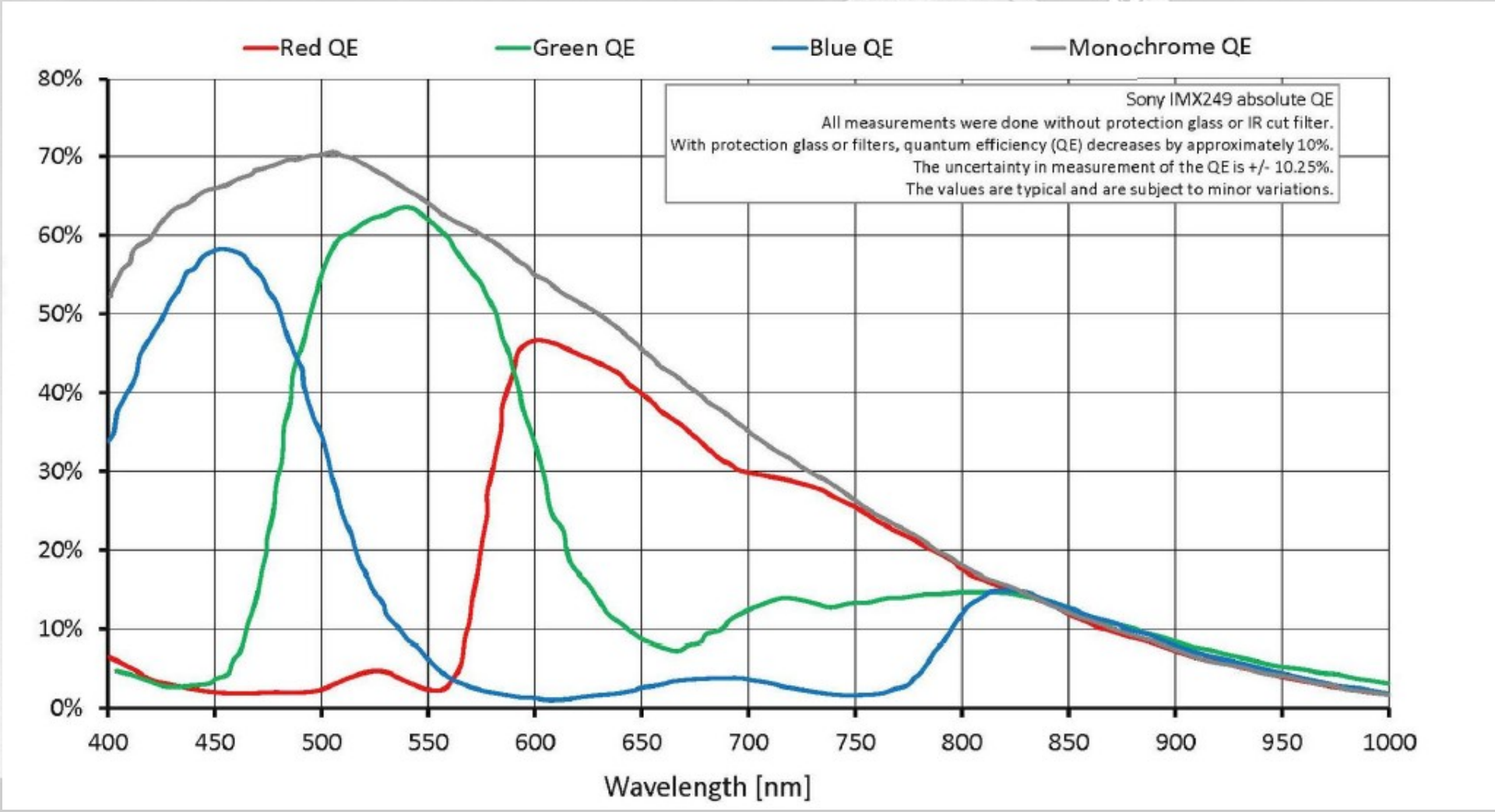
OTA	FOV	Pixel	Mag
ES	60.90 x 45.58 arcmin	0.78 arcsec	45.20
C11	21.49 x 6.08 arcmin	0.28 arcsec	128.09
C14	15.39 x 11.52 arcmin	0.20 arcsec	178.87

- Match to target
  - Use the best combination to ‘just’ include the object you are trying to photograph

Filter Wheel

- Monochrome cameras are more sensitive and have a larger dynamic range
  - DLSR's have cut-off filters
- You will want a filter wheel to switch between Luminance, Red, Green and Blue filters
  - Perhaps Oiii, Sii and H-Alpha

Light Spectrum

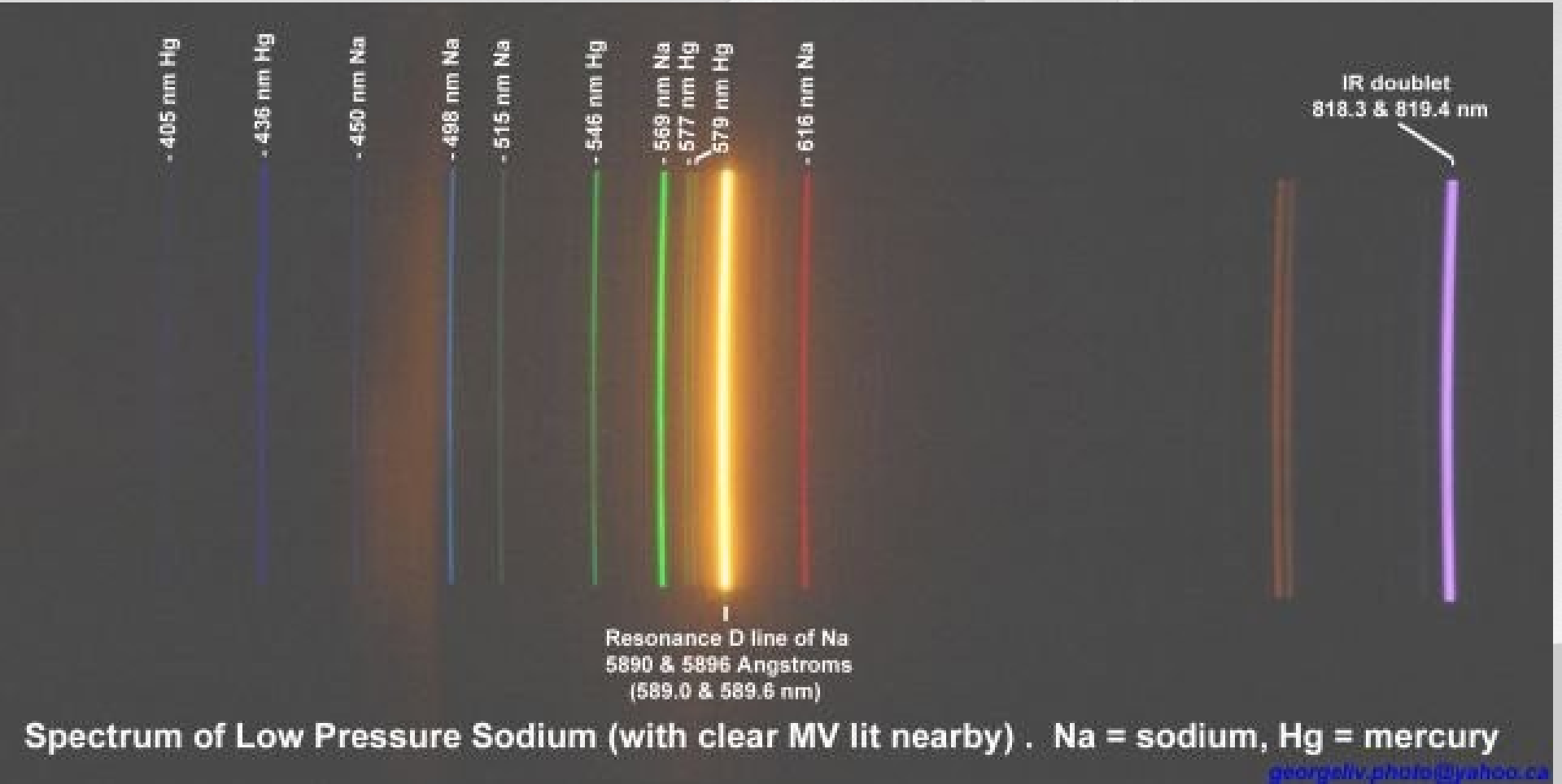


Filters

- RGB
- Use of Luminance
  - Establishes baseline for intensities
- Special filters: Oiii, Sii, H-alpha
  - Detect older stars or extent of nebulae
  - Use false colors when combining with RGB
- Chromatic aberration filters
  - Removes blue blooming around bright stars
    - Most notable in doublet refractors
- Matched filters are expensive
  - Different transmission/focus

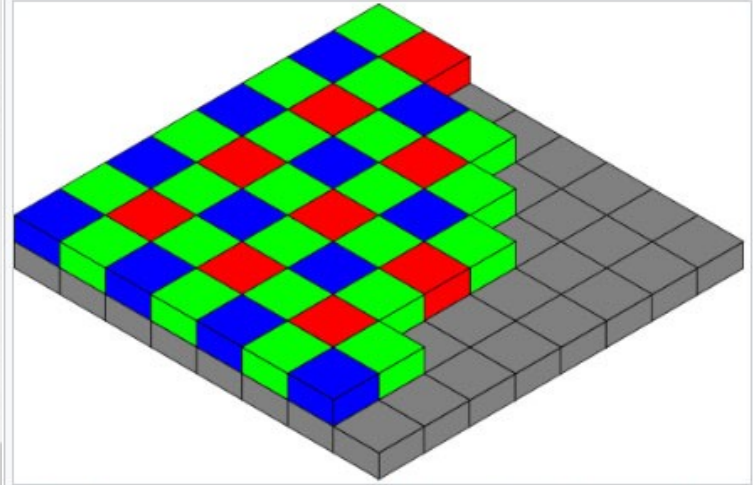
Street Lights

- LPR/UHC light pollution filters
  - Light Pollution Reduction/Ultra High Contrast

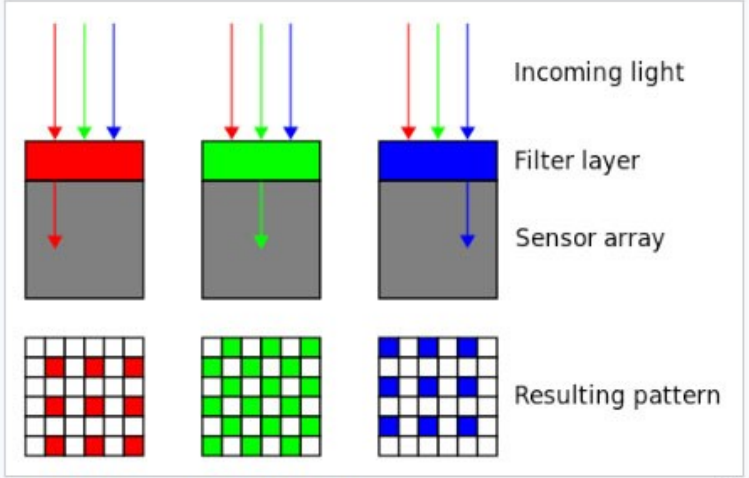


DSLR's and De-Bayering

- All pixels are black and white – period
  - They measure intensity
- A Bayer pattern of colored filters are arranged 'on-top' the pixels
  - The extra green is used for luminance
- The raw image must be 'de-bayered' into separate channels in order to be processed



The Bayer arrangement of color filters on the pixel array of an image sensor



Profile/cross-section of sensor

FITS Files

- All astronomical software uses the .fits file types
  - Camera ‘RAW’ images are converted to .fits
- Consists of a header and multiple image/data sections
  - This is good, lots of detail can be kept in the header
    - Camera data, date, telescope, weather, pointing info, who the observer was, etc.
  - The de-bayered color channels can be kept together in one file, each in it’s separate section
- Like the RAW image – all detail is kept
  - Eg: these can get large

FITS Header

```
BITPIX  =                   16                  / number of bits per data pixel
INSTRUME= 'ZWO CCD ASI1600MM Pro' / CCD Name
TELESCOP= 'ES 152'                  / Telescope name
OBSERVER= 'Sifan Kahale'            / Observer name
OBJECT  = 'M_99    '                / Object name
EXPTIME =         3.000000E+01  / Total Exposure Time (s)
CCD-TEMP=            -1.40E+01    / CCD Temperature (Celsius)
XPIXSZ  =         3.800000E+00    / X binned pixel size in microns
YPIXSZ  =         3.800000E+00    / Y binned pixel size in microns
FRAME   = 'Light   '              / Frame Type
FILTER  = 'Red     '              / Filter
FOCALLEN=            9.88E+02   / Focal Length (mm)
APTDIA  =            1.52E+02     / Telescope diameter (mm)
SCALE   =         7.934615E-01    / arcsecs per pixel
SITELAT =         4.487806E+01   / Latitude of the imaging site in degrees
SITELONG=        -1.230381E+02 / Longitude of the imaging site in degrees
AIRMASS =         2.021975E+00 / Airmass
OBJCTRA = '12 18 46.26'           / Object J2000 RA in Hours
OBJCTDEC= '14 25 02.97'           / Object J2000 DEC in Degrees
RA      =         1.846928E+02      / Object J2000 RA in Degrees
DEC     =         1.441749E+01          / Object J2000 DEC in Degrees
EQUINOX =                 2000      / Equinox
DATE-OBS= '2020-02-21T06:20:09.151' / UTC start date of observation
GAIN    =                60.           / Gain
OFFSET  =                 10.         / Offset
SKYTEMP =              -17.35     / Sky Temperature
OTATEMP =               36.86     / OTA Temperature
OTADPDEP=                2.70    / OTA Dew Point Depresion
OTAHUM  =               90.0      / OTA Humidity
OTADP   =              34.16       / OTA Dew Point
```

Exposure vs Gain (ISO)

- The longer the exposure, the more likely you will get star trails (and capture micro-sats, space junk, cosmic rays, shooting stars …)
  - Taking multiple shorter images allow you to delete the bad ones (and stack)
- The higher the gain, the more noise will be in the image from the camera
  - At some point stacking software will start counting noise as stars and give up
- Need to strike a balance – usually the longest exposure possible at the lowest gain.
  - This is where stacking comes in …
- For Planetary – take fast video and select best frames and stack those

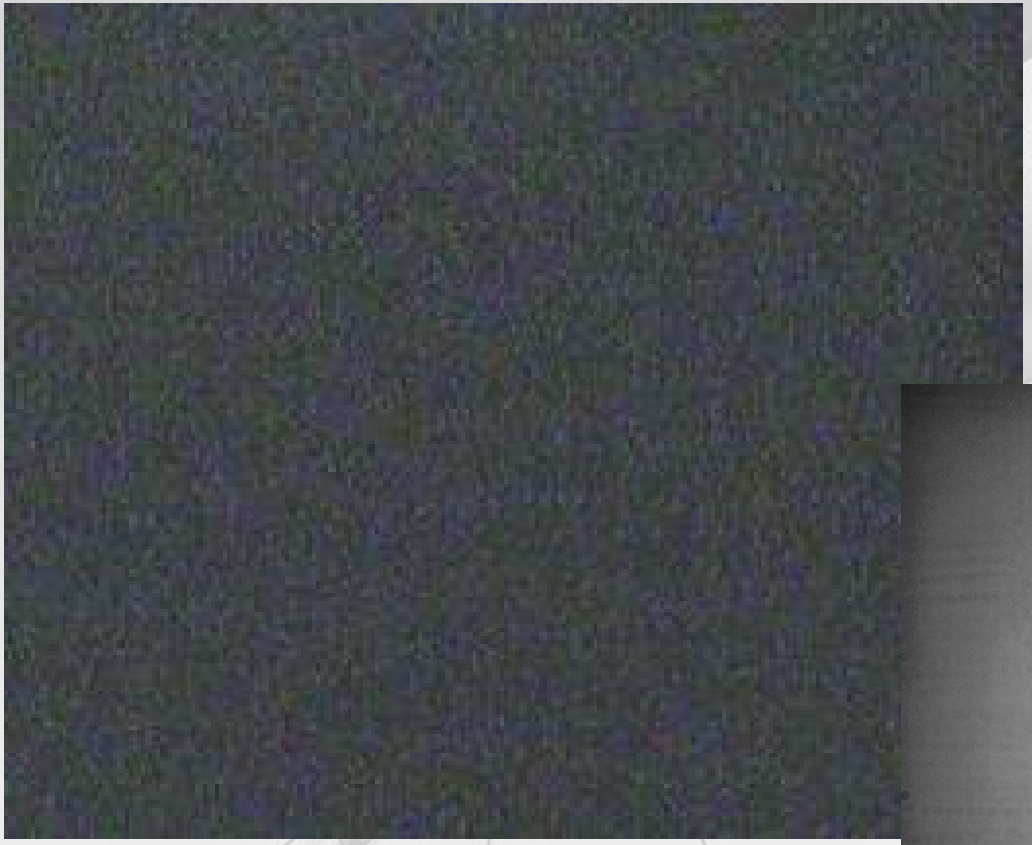
Advantages of Stacking

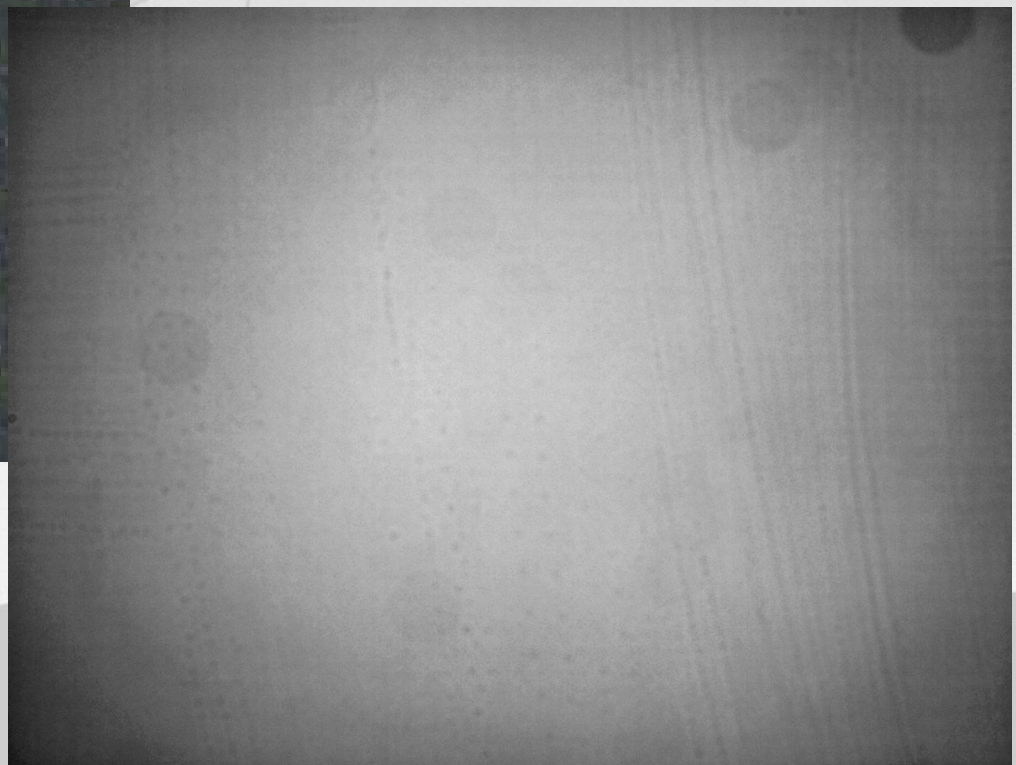
- Take 10, 1 minute exposures instead of 1, 10 minute one
  - Allows you to use a lower gain
  - Can throw away bad images
    - Micro-satellites, tracking errors, shooting stars, etc
- Reduces SNR (signal to noise ratio)
  - Noise is random, does not add up
  - A faint star will ‘add-up’ and pop out of the noise

Bias, Darks and Flats – oh my ...

- Calibration Frames: Improving SNR
  - Bias:
    - Shortest dark exposure possible
    - Tells us the fixed noise pattern of the camera
  - Dark:
    - Dark exposure at the same exp and gain as images
    - Thermal camera noise
  - Flat:
    - Taken looking at a flat white area (t-shirt over telescope)
    - Same gain as images, but exp set to ¾ max ADU
    - Shows vignetting, uneven illumination and dust motes
  - Darks and flats need to be taken at same camera temperature and rotation as images

Dark and Flat Frames

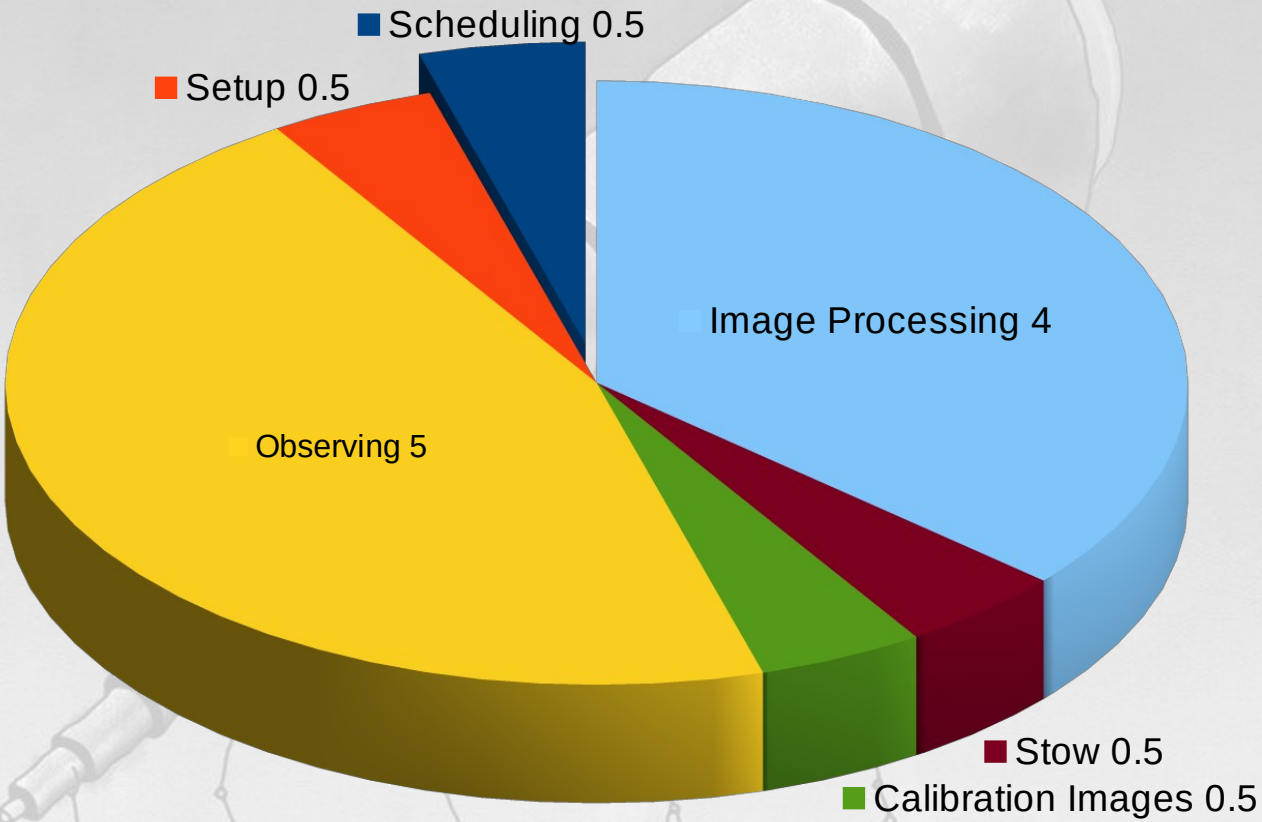




Processing

- If Stacking:
  - Need to align, normalize and apply calibration frames
    - Good idea to apply calib. frames even if not stacking
- Need to enhance images due to extended filter range in IR/UV
- FITS or RAW has data buried
  - Need to ‘stretch’ image to extract visual data
- Also need to adjust saturation, levels and color balance

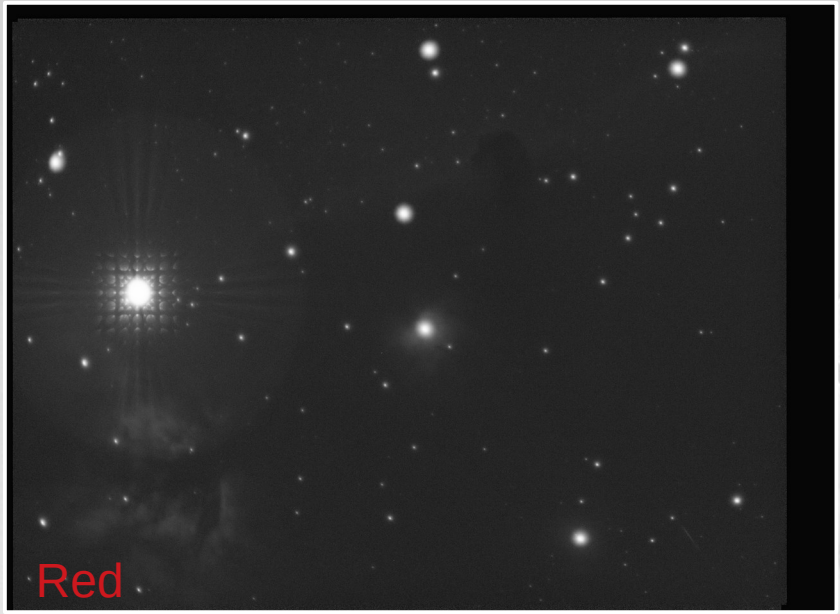
Can take as much time to process as it did to take the images!

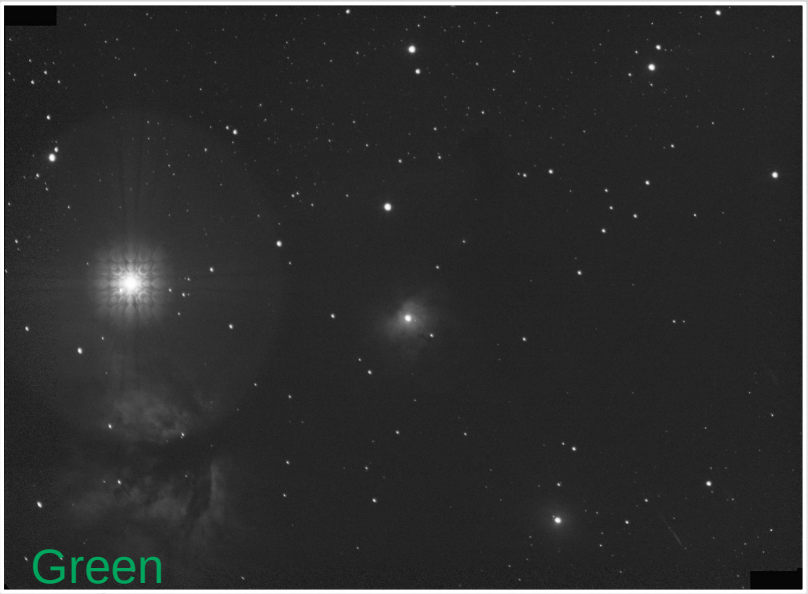


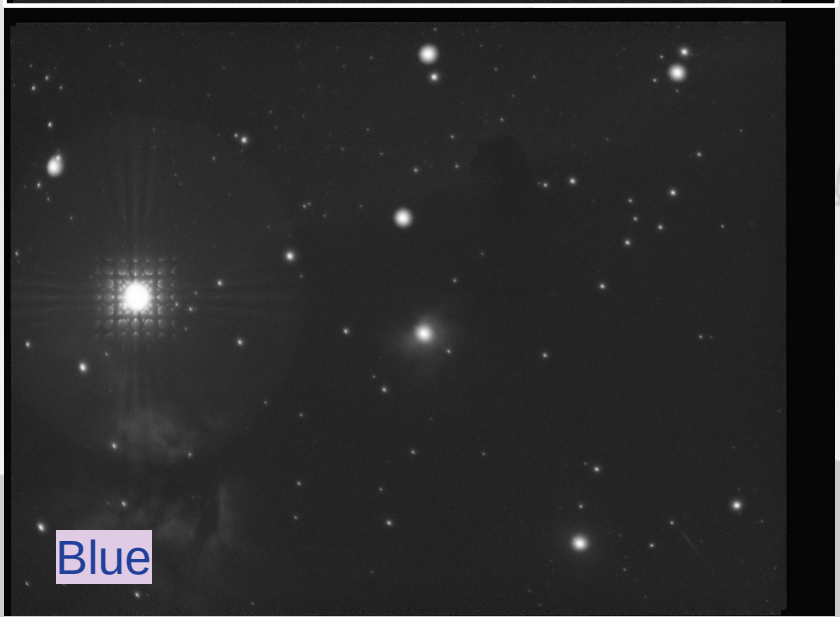
Example Processing an Image Stack

- Create Master Dark, Bias, Flat and Bad Pixel maps
- Apply the masters to each image
- Identify stars (calibration points)
- Register frames (locates sames stars in each of the images)
- Normalize frames (rotate/resize/stretch)
- Integrate (Adds them all together)
- RGB combine (Yay! Color)
- Saturation/Color Balance/Dynamic Stretch
  - Eg. “Photoshop” it …

What Do the Colors Mean?







Adding Them All Up

Luminance

Raw LRGB


Adjusting for ‘Humans’
Aka ‘Photoshoping’
Blasted Micro Satellites!

M42 – Great Orion Nebula
Raw Combined Image

M42 – Great Orion Nebula
Adjusted Saturation

Western Veil Nebula: Ha, Sii, Oiii

NGC-2175
Monkey Head Nebula

H-Alpha

LRGB

Software

- BackyardEOS $30, Camera control
- Siril $0
- Deep Sky Stacker $0
- ASTAP $0
- IRIS $0, Planetary and Deep Sky
- RegiStax $0, Planetary
- PIPP $0, Planetary (auto selects images from video)
- AstroArt $100
- Astro Pixel Processor $170
- CCDStack $200
- PixInsight $300
- MaximDL $600

Hints

- Do one thing at a time
  - Get that working before moving on
  - Only make ONE change at a time!
    - Don’t complicate with potential of multiple issues
- Don’t calculate by hand
  - Use WEB calculator (http://www.12dstring.me.uk/fovcalc.php)
- Get out there and try it
- Take notes!!
- Join an Astronomy Club – seek advice

References

- Cloudy Night forum: https://www.cloudynights.com/
- Rose City Astronomers: https://www.rosecityastronomers.net/
- https://www.skyandtelescope.com/
- http://www.astronomy.com/
- FOV calculator: http://www.12dstring.me.uk/fovcalc.php
- Excellent tutorial on pixels/noise/flats/darks/bias: https://cloudbreakoptics.com/blogs/news/astrophotography-pixel-by-pixel-part-1
- Google !!

OMG that sea captain is picking his nose!!

What We Covered

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Mahalo!
Sifan Kahale
Hōkū Wahine
(Star Woman)