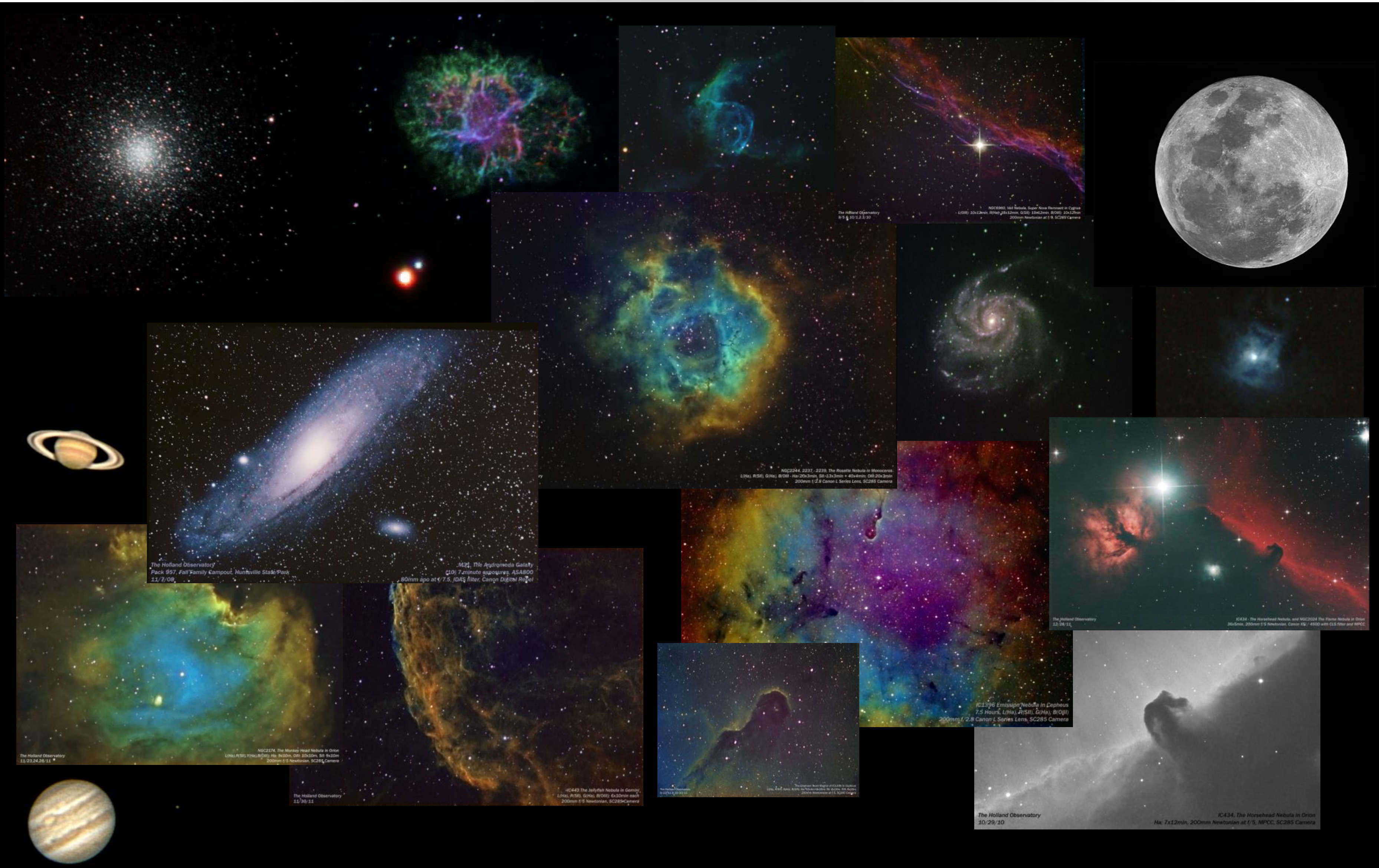
Astroimaging - Tutorial



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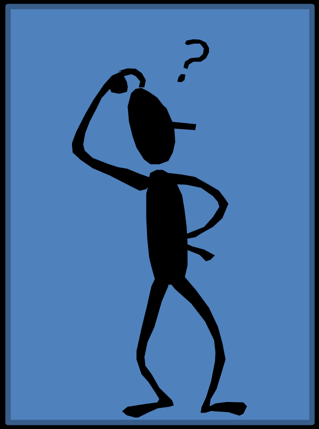

Who am I

&

Why am I up here talking?

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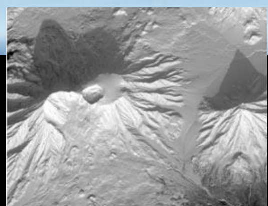
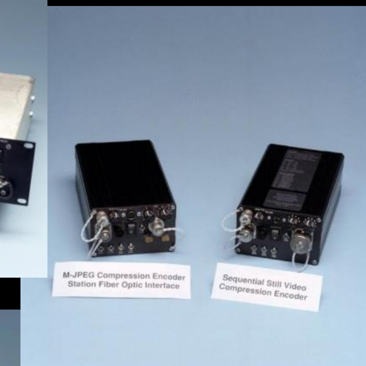
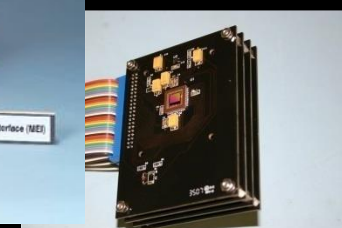
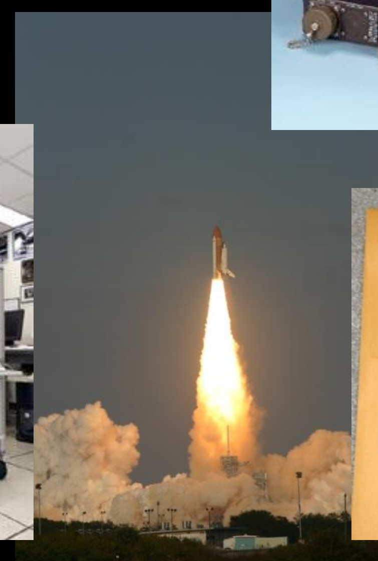


By day…

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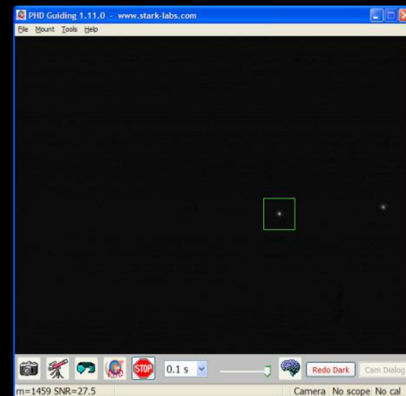

But, by night…

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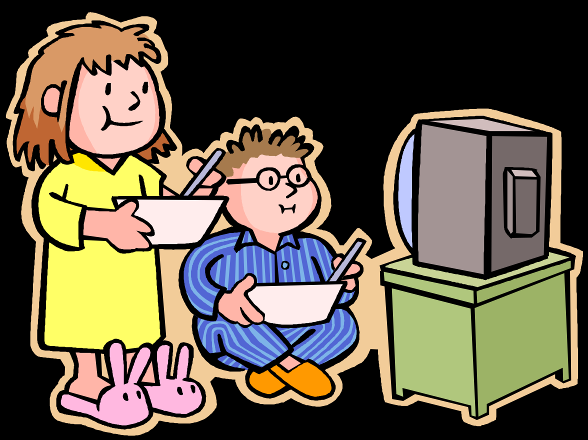
FIRST -

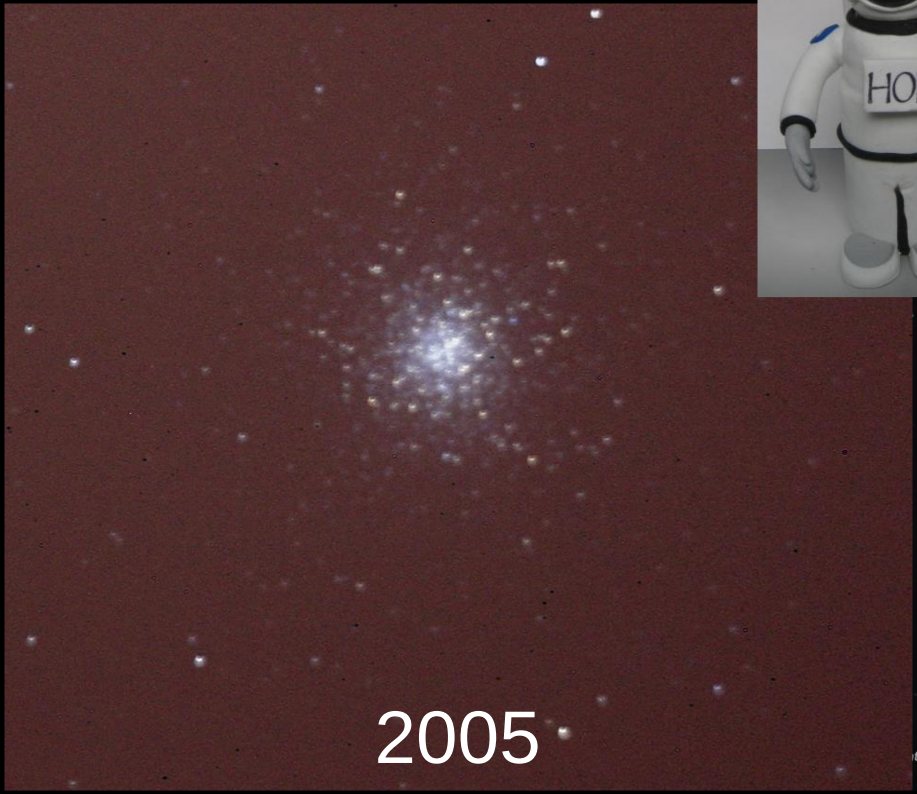
Astronomy ::



Watching TV?

Playing the Piano?

SECOND -



2005

2012

They say that

'hope'

is the most powerful word in the English language…

THIRD -

How bad do you want the shot….?

Astroimaging - Tutorial

Outline

- What You Can Expect
- The Elements of an Astroimaging System, and Signal Flow
- Tracking
- Setting up Your Equipment
- Focus
- Finding Your Target
- Camera Options
- Filter Options
- Calibrating the Images
- Creating Color Images
- Post Processing
- What Else Will Effect Your Astroimaging Session
- A Collection of Images (and how they were taken)
- References

Astroimaging - Tutorial

- What You Can Expect: Types of celestial objects within reach

Planets



Galaxies


Nebulae


Comets

Star Clusters


Constellations

Astroimaging - Tutorial

- What You Can Expect: Proportional to how much effort you put in –

Easiest

- The Moon

- Bright
  - Short exposure, easy to find
- Can be shot with most any system

Moderate

- Planets

- Bright
  - Easy to find
  - Short exposures – many taken, stacked and combined
- Minimal tracking
- Increased image processing difficulty

Difficult

- Bright DSO & Comets

(Deep Sky Object)
- More difficult to find
- Accurate tracking
- Exposure times around 4 minutes
- Calibration images needed
- Complicated image processing

Most Difficult

- Dim DSO

- Difficult to find
- Accurate tracking
- Exposures > 4 minutes
- Accurate calibration images needed
- Most complicated image processing

Astroimaging - Tutorial

- The Elements of an Astroimaging System, and Signal Flow

Imaging Scope

Imaging Camera

Guide Scope

Guide Camera

Telescope Mount Hand Controller

Telescope Mount Motor Control

Computer

Target Locating Software (The Sky, Cartes du Ciel, etc.)

Guiding Software (PHD Guiding or other)

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- Tracking – required to follow the movement of the sky
  - Problem: Image pixel size corresponds to approx. 1 arc second (1”) of angle
  - It is difficult to get a mechanical telescope mount to track accurately for long exposure pictures within around 1” of accuracy. Otherwise, pixels are smeared due to tracking errors. Good optics are of no use with a bad mount.
  - First step: Mount selection (periodic error PE figure of merit) –

Celestron ASGT
$575
35 lbs load
Light weight
Inaccurate
PE ~ 40”pp

Celestron CGEM & Orion Atlas
$1,400
40 lbs load
Smoother PE, still ~ 30”pp

Losmandy G-11
$3,200
60 lbs load
High quality
Users get ~ 10”pp

Astro Physics AP900
$8,750
70 lbs load
Guaranteed accuracy (7”pp)

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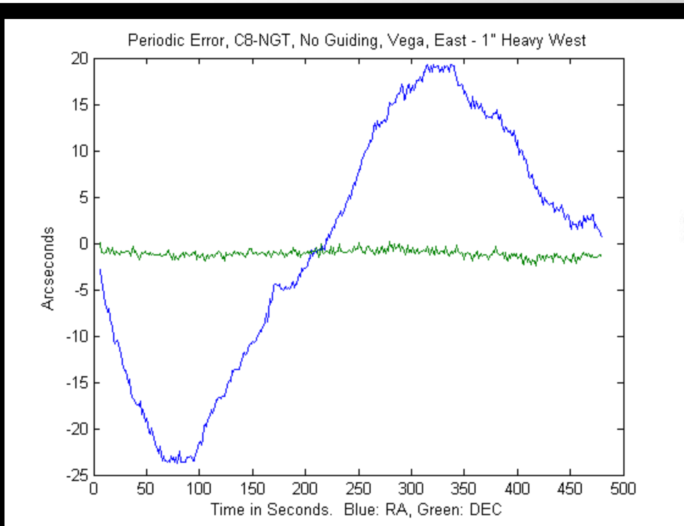
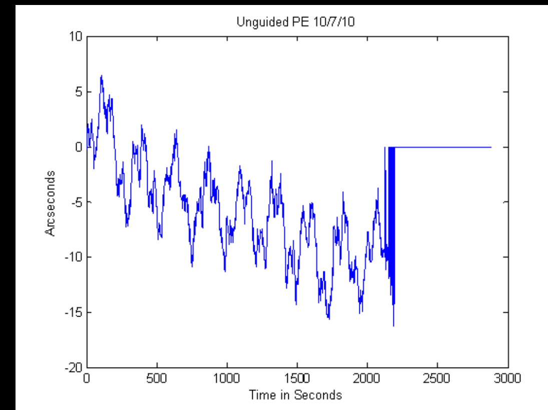


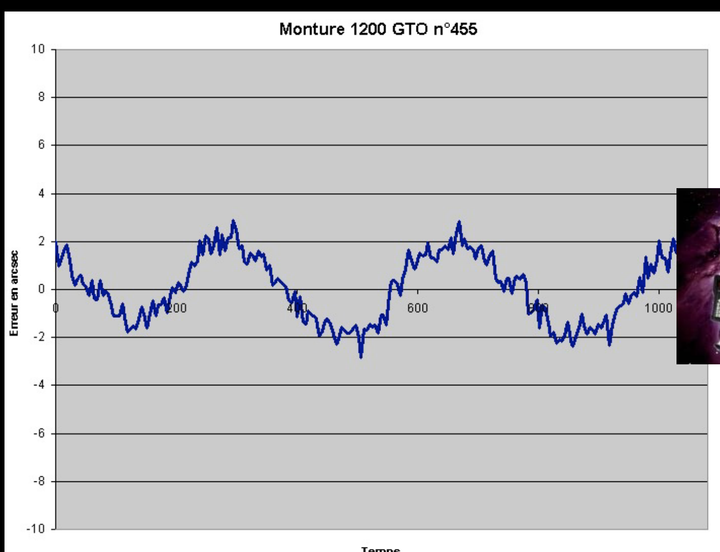
Celestron ASGT
$575
35 lbs load
PE ~ 40”pp



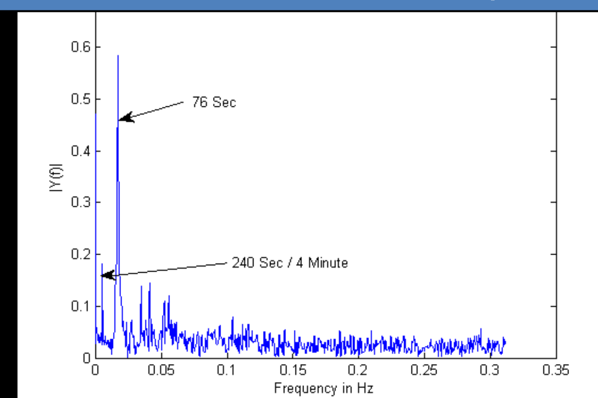
Losmandy G-11
$3,200
60 lbs load
Users get ~ 10”pp

Why is this happening???

Note – Not all RA errors are periodic!



Astro Physics AP1200
$9,950
140 lbs load
Guaranteed accuracy (5”pp)



Also DEC Errors –
Backlash, Stiction!!!

http://demeautis.christophe.free.fr/ep/ap1200gto.htm

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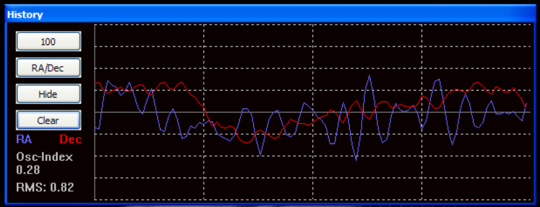
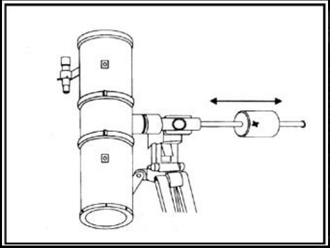
Astroimaging - Tutorial

- Tracking (cont'd)
  - How accurate tracking is accomplished: Autoguiding



Set counter weight heavy East



1. Guide camera is selected in guiding software
2. Guide camera with guide scope focuses on star
3. Telescope mount is selected in guiding software
4. Software calibrates mount
5. Autoguiding starts

<u>Camera options:</u>

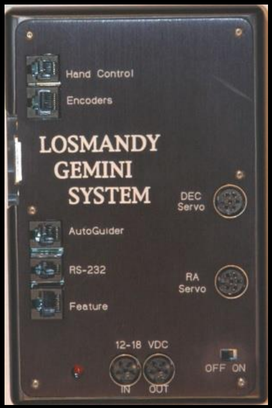
Webcam style ::: or :::

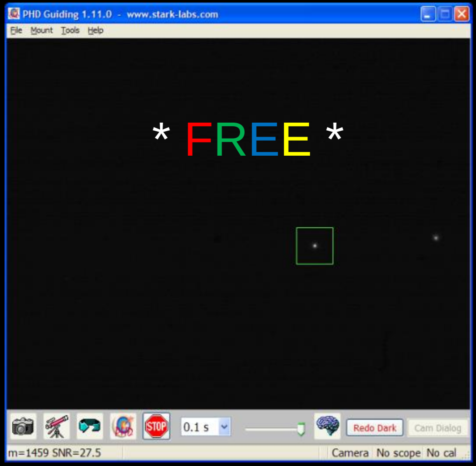
Dedicated autoguide camera

<u>Mount interface options:</u>

RS-232 port (ASCOM drivers) ::: or :::

Mount Autoguiding Port (ST4)





- Tracking (cont'd)
  - How accurate tracking is accomplished: Autoguiding (cont'd)

What are the guiding optical options?

Guidescope:

Pros –

Easy to find stars

Cons –

Flexing

Different optical axis (field rotation)

Self Guiding:

Pros –

Same optical axis

Cons –

Limits available stars

Behind filters

Off Axis Guider:

Pros –

Same optical axis

Cons –

Limits available stars

Behind filters

Astroimaging - Tutorial

- Tracking (cont'd)

- OR -

Barn Door Tracker

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Astroimaging - Tutorial

- Setting up Your Equipment

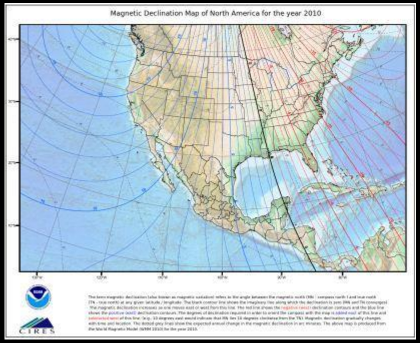
Daytime Setup: It is much easier to set up in the daylight!

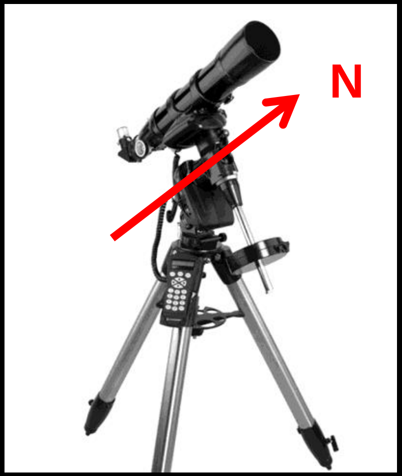
Step 1 – Point your telescope mount North.

Compass

\+

Magnetic Declination

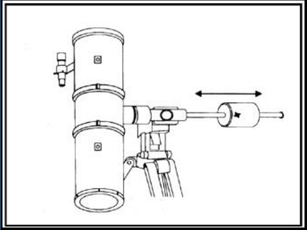


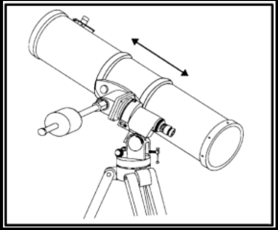


Step 2 – Set latitude scale

Step 3 – Level mount: For setting up in same location

Step 4 - Mount and balance optical tube





Step 5 – Verify collimation

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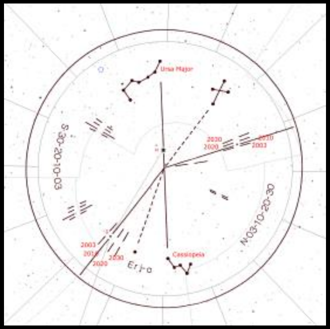
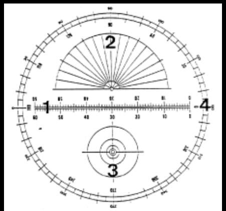
Astroimaging - Tutorial

- Setting up Your Equipment (cont'd)



Nighttime Setup:

- Polar Alignment Options:
  - North Celestial Pole Polar Alignment Scope
    - Quick, easy. Good enough for many targets
  - Declination Drift
    - More difficult, takes time. Best method

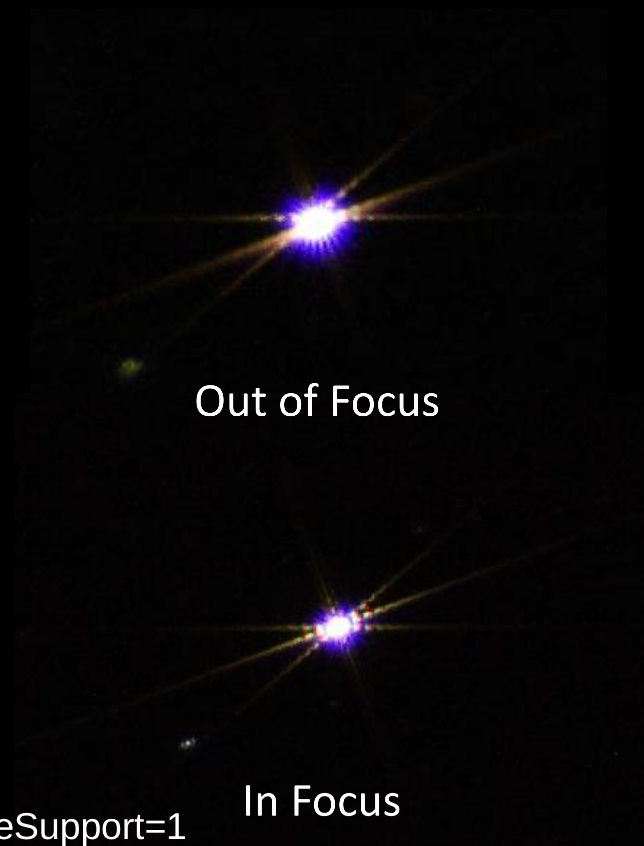


- GoTo Alignment
  - User will center 2 or more bright stars allowing scope computer to create an accurate map of the sky.
    - Afterwards, targets can be entered into scope computer and scope will slew to them.
    - Some scopes have 'Accurate GoTo' features that aid in finding faint objects

- Dew
  - Dew can form on scope, camera, filters, etc.
    - Just extending the length of the end of the scope will combat dew.
    - Raising optics above dew point prevents dew from forming (heater).
- Stray Light
  - You will need to address any sources of stray light (same dew extensions help). Filter selector is a source of light leaks.

Astroimaging - Tutorial

- Focus
  - There are many methods to obtain focus:
    - Hartman Mask, Measuring the Point Spread Function, Visual, Bahtinov Mask
      - Recommend Bahtinov Mask **
        - Can make your own



http://astrojargon.net/MaskGen.aspx?AspxAutoDetectCookieSupport=1

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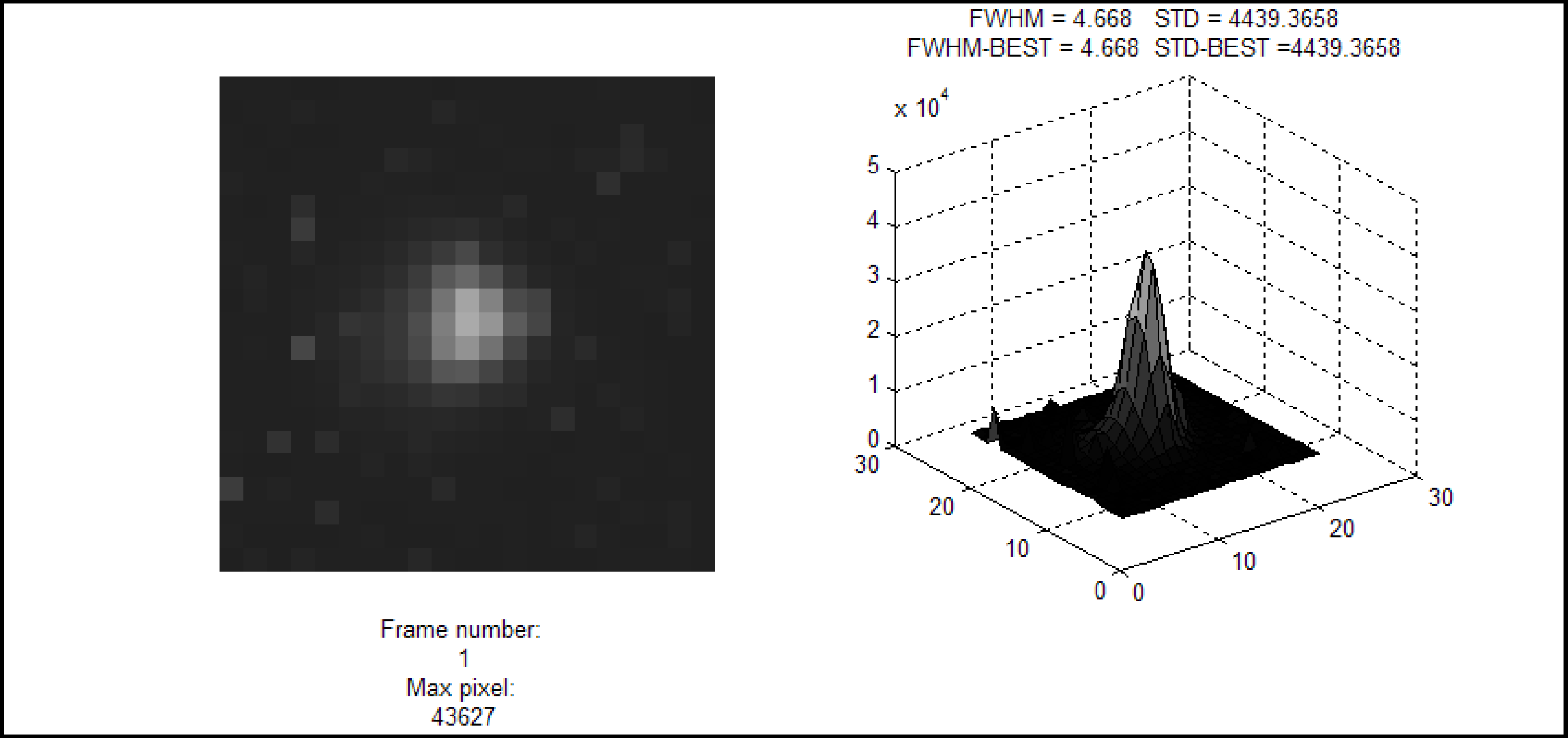
- Focus (cont'd)

  Another method – Measuring Point Spread Function:

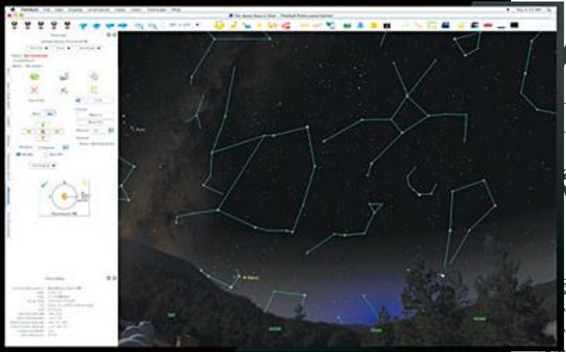
  Full Width Half Max – minimum

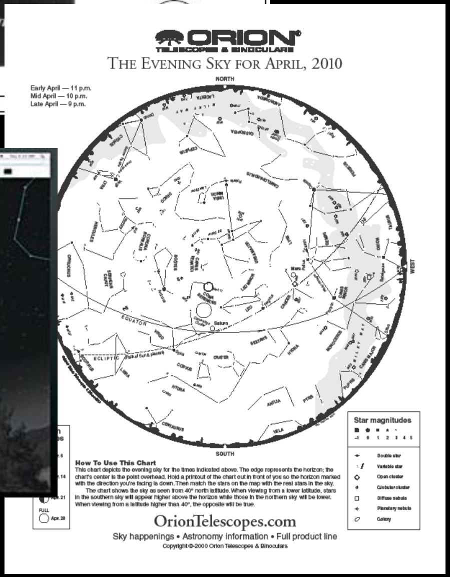
  Standard Deviation – maximum



Astroimaging - Tutorial

- Finding Your Target
  - At Least Three Options
    - GoTo Scope – select from list
      - Accurate GoTo function
    - Computer Control
      - Via scope RS-232 interface
      - ASCOM drivers
      - Planetarium Programs
        - » The Sky
        - » Cartes du Ciel
    - Star Hopping
      - Star charts
        - » Free Monthly charts:
        - » www.telescope.com
        - » www.skymaps.com
      - Planetarium Programs
        - » The Sky
        - » Cartes du Ciel
  - Note: Best results when target near Zenith due to atmosphere





Astroimaging - Tutorial

- Camera Options

1. Planetary Camera

Celestron Skyris

Orion Star Shoot Solar System Color Imager

Celestron NexImage

What can be accomplished?

1. Planetary imaging
2. Use as guide camera (but noisy)

How it is done:

1. Focus is critical
2. Mounts in place of eyepiece
3. Use high magnification (barlow lens)
4. Nights of good seeing (low air turbulence) are required
5. Hundreds of images taken, best selected, stored as video
   - Note – limited by planet rotation
6. Aligned and stacked (e.g. Registax software)
7. Enhanced in Photoshop, or other

Astroimaging - Tutorial

- Camera Options (cont'd)

2. Digital Single Lens Reflex (DSLR)

What can be accomplished?

1. Images of the Moon
2. Bright Deep sky objects (DSO): Nebulae, Galaxies, Super Nova Remnants, Star Clusters, etc.
3. Not optimal for planetary (unless movie mode)
   a) Vibrations from shutter
   b) Long download time (planet features move)

How it is done:

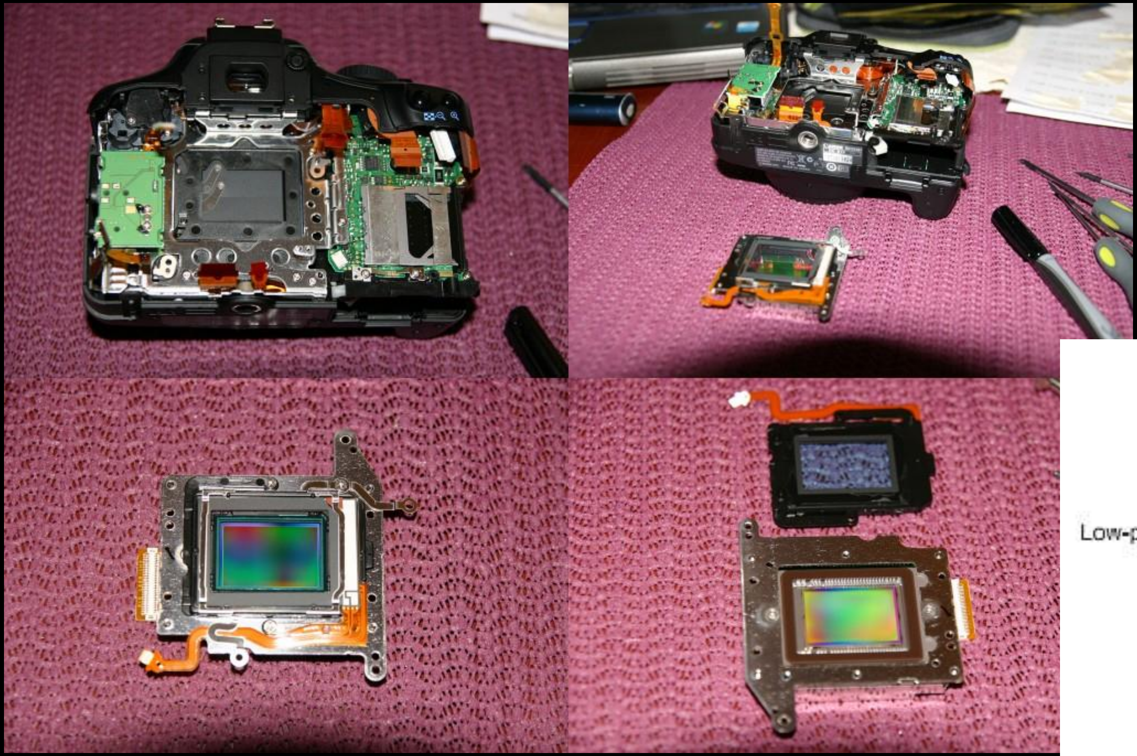
1. T adapter acquired for specific DSLR
2. Shutter release cable required for specific DSLR or control via USB
   - Note – mirror lockup requires shutter release cable
3. Long exposures can be taken (miraculously)
4. Calibration frames are required (more later)
5. Exposure control manual or software controlled (EOS Utility, Backyard EOS, APT)
6. Remote image capture and download (e.g. EOS Utility, Backyard EOS, APT)
7. Images calibrated, aligned and stacked (e.g. Deep Sky Stacker)
8. Final processing in Photoshop or other (more later)

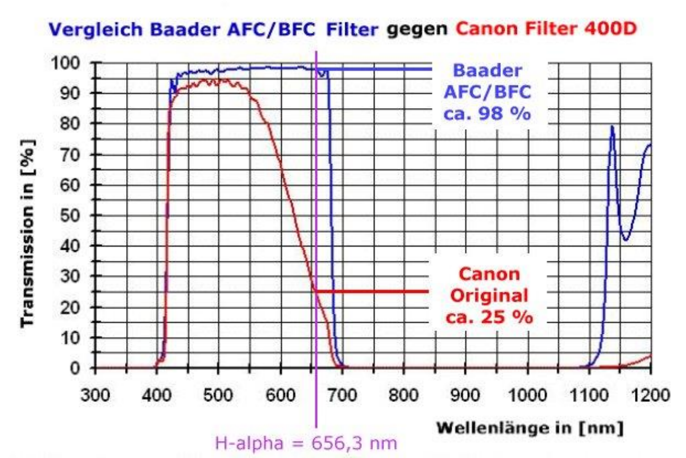
The Holland Observatory

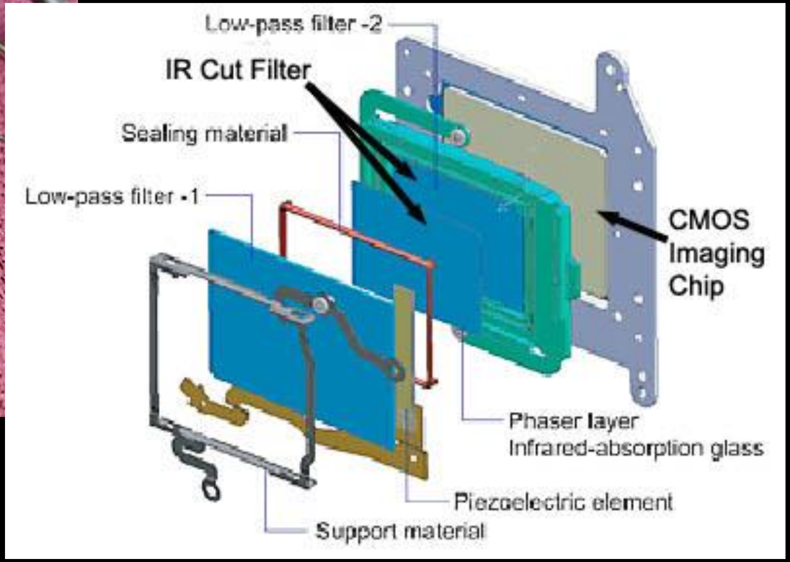
M42, The Orion Nebula Center, NGC1977, Running Man Nebula Right

- Camera Options (cont'd)

2. Digital Single Lens Reflex (DSLR) (cont'd)





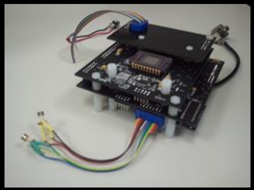


Replacing IR Cut Filter improves performance for Astrophotography.

Astroimaging - Tutorial

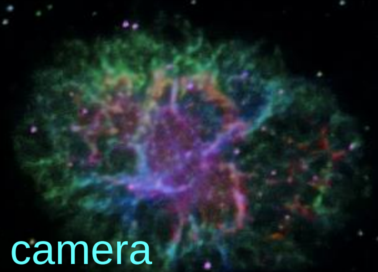
- Camera Options (cont'd)

3. Dedicated Astroimaging Camera



What can be accomplished?

1. Best for: Bright & Dim DSOs
2. Advantages: highest quality, meaningful scientific data
3. Disadvantages: most complicated



How it is done:

1. T adaptor required between scope and camera
2. Some cameras are monochrome so filters and filter exchanging mechanism is required
3. Cameras are cooled to reduce thermal noise (2x for each 6°C)
4. Images are taken along with closely matched calibration frames (more critical than DSLR)
5. Images are calibrated, aligned and stacked (Deep Sky Stacker)
6. The individual color channels preprocessed (e.g. AIP4WIN – deconvolution, background smoothing, gradient, etc.)
7. The individual channels are combined into a color image (e.g. Photoshop) and then post processed (Photoshop)

Astroimaging - Tutorial

- Camera Options (cont'd)

What are the trade offs?

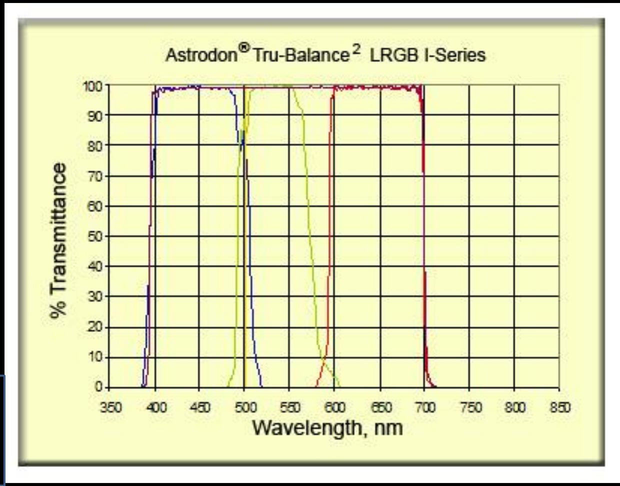
CAMERA	EASE OF USE	EXPOSURE TIME	SINGLE SHOT COLOR	NOISE	DARK CURRENT	SKY REQUIRED	WIDE SPECTRAL RANGE
Planetary	Easy	Short	Yes	High	High	Any	No
DSLR	Moderate	<= 10 min	Yes	Moderate	Moderate	Dark skies best	No Yes – if modified
Astronomical CCD	Difficult	Very long	Yes or No	Very low (down to 1 electron)	Very low	Any (narrrowband)	Yes

Astroimaging - Tutorial

- Filter Options

For dark sky areas or moderate light pollution, Luminance, Red, Green, Blue (LRGB) filters work well

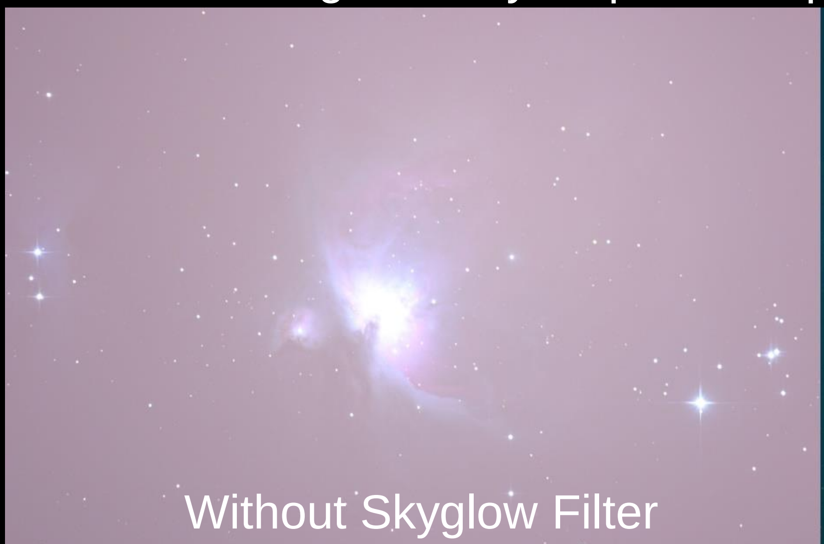
Note - Good coatings required to reduce reflections



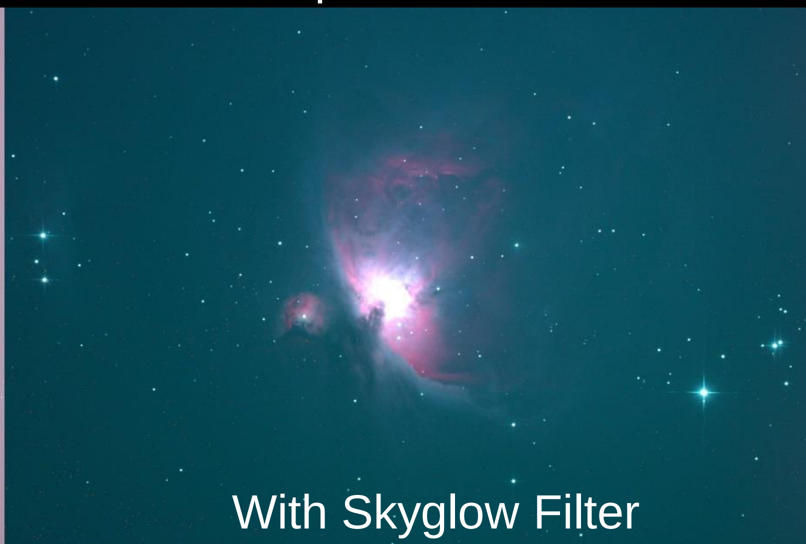
Some type of filter exchange mechanism is needed.

Astroimaging - Tutorial

- Filter Options (cont'd)
  - Light pollution reduction filters
    - Can significantly help – example 4 minute exposures



Without Skyglow Filter



With Skyglow Filter

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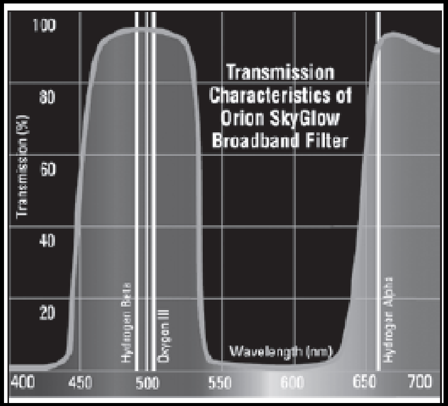
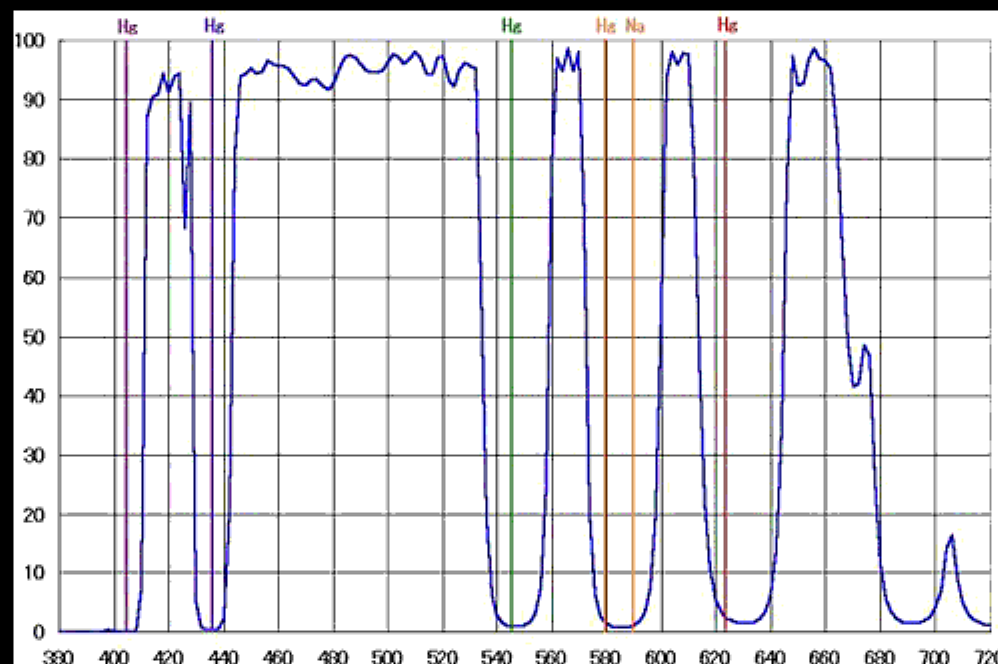


Astroimaging - Tutorial

- Filter Options (cont'd)
  - Other light pollution filters like the Hutech IDAS filter pass more total light, and have narrow rejection bands for specific light pollution wavelengths.
  - Results in truer colors, than filters that cut larger sections out of spectrum



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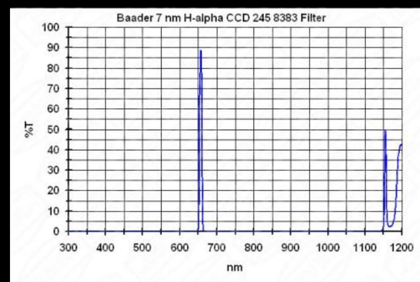
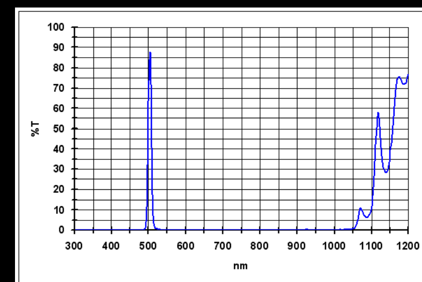
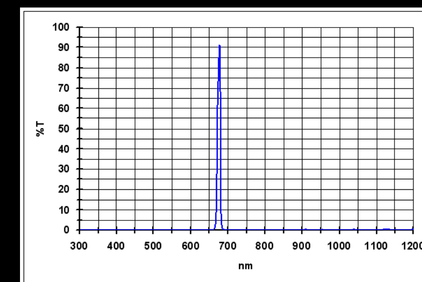
- Filter Options (cont'd)

  Narrowband Imaging – Cuts all wavelengths except narrow bandwidth around desired wavelength.

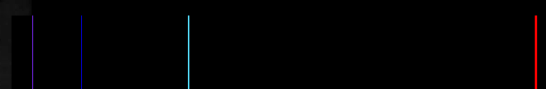






Most common: Hydrogen Alpha (Ha), 656.3nm; Sulfur (SII), 672.4nm; Oxygen (OIII), 500.7nm.

Filters are very effective against light pollution – can even image during full Moon.



Hydrogen Spectral Series
{ Ha: red line at right}

Requires LONG integration time..

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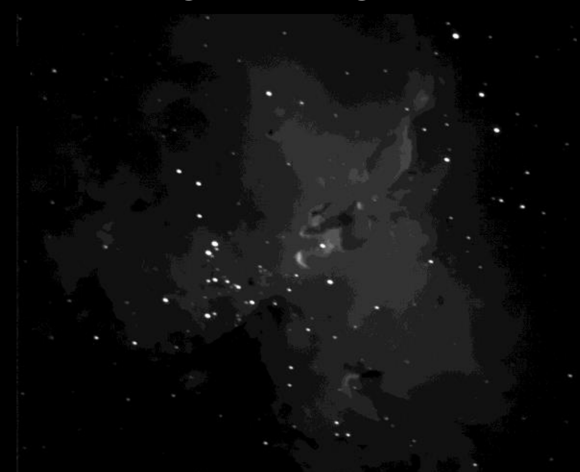


- Filter Options (cont'd)

  Narrowband Imaging – Many targets show more features in narrowband than in RGB / regular visible light images.

NGC2174 - RGB

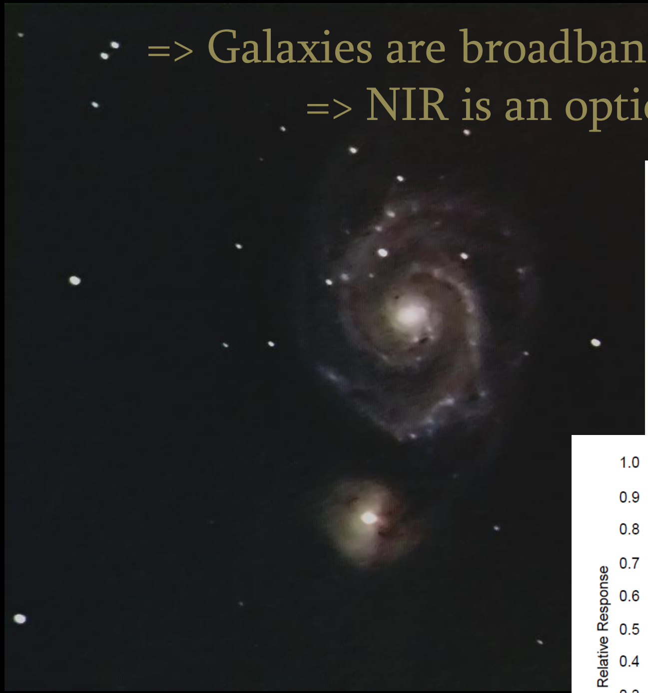
NGC2174 - Narrowband

Astroimaging - Tutorial

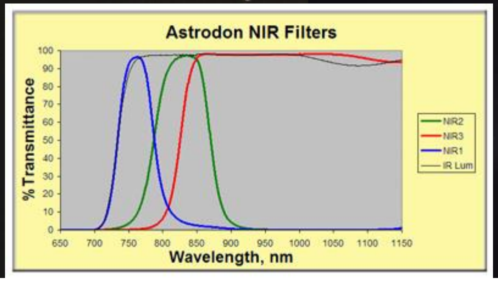
- Filter Options (cont'd)

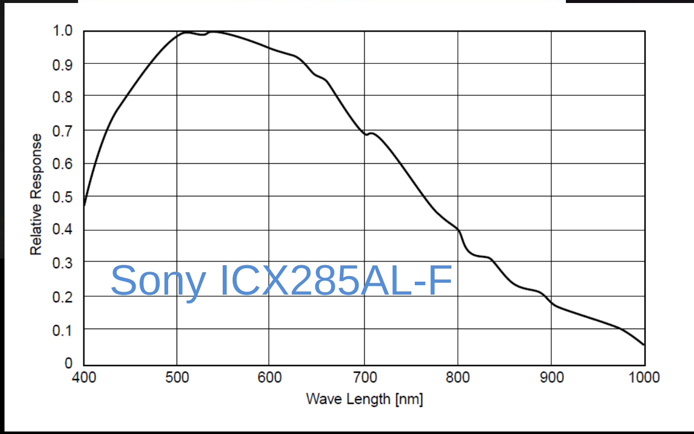
Near Infrared Imaging – Most light pollution is in visible spectrum. Celestial objects emit in other wavelengths like near infrared (NIR).

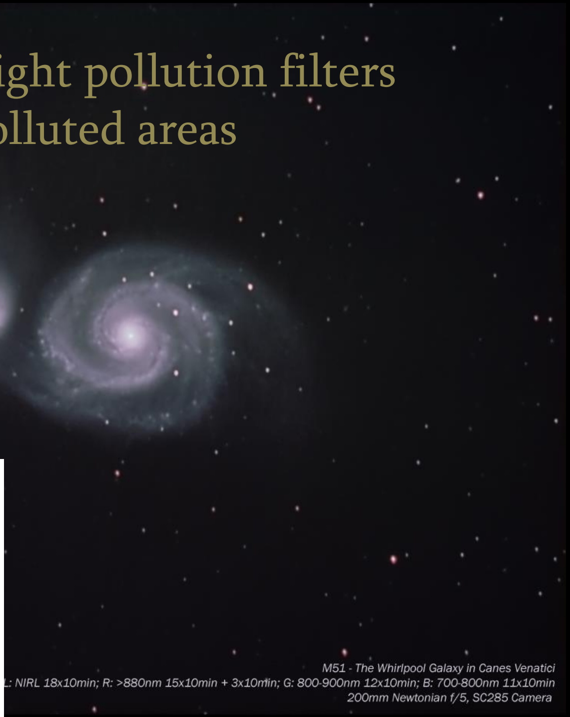
=> Galaxies are broadband, don't improve much with light pollution filters
=> NIR is an option to image galaxies in light polluted areas



M51 – Visible Light
Yuck!







M51 – NIR Light
Better!

Astroimaging - Tutorial

Flame Nebula

RGB

Narrowband

Near Infrared

Nebula do well in NIR too!

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Astroimaging - Tutorial

Desired Wavelengths (nm):		Undesired & Light Pollution Wavelengths (nm):	
OII	372.7	Hg	405
Hγ	434	Hg	436
Hβ	486.1	Airglow Auroras	463
OIII	495.1	Hg	546
OIII	500.7	High Pressure Sodium, Na	466, 475, 498, 515
C2	511	Hg	546
C2	514	O (skyglow)	557
NII	654.8	NaII / Hg	570
Hα	656.3	Hg	579
NII	658.4	High Pressure Na(D) / NO_2	583
SII	671.6	Na	600
SII	673.1	NaII / Hg	617
		O (skyglow)	630
		O (skyglow)	636

Astroimaging - Tutorial

- Calibrating the Images

Thermal noise present in both light & dark frames

1 light frame (1 minute exposure)

1 dark frame (1 min)

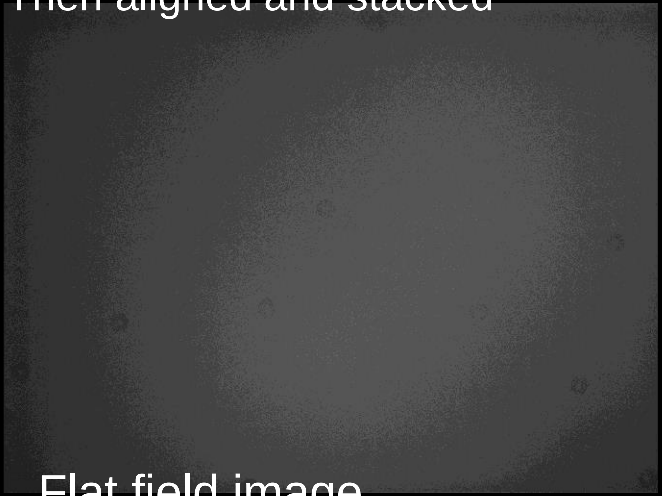
With dark frame subtraction only, Imperfections remain (dust donuts, vignetting)

(42 x 1 minute lights) – (10 x 1 minute dark), Then aligned and stacked

Astroimaging - Tutorial

- Calibrating the Images (cont'd)

(42 x 1 minute lights) – (10 x 1 minute dark),
Then aligned and stacked



Flat field image

((42 x 1 minute lights) – (10 x 1 minute dark))
7 flat field images

- Calibrating the Images (cont'd)

Multiple images are combined to improve the signal -

Why does aligning and stacking images increase the signal to noise ratio?

Answer – The signal adds linearly, the noise (being uncorrelated / orthogonal) adds as the square root of the sum of the squares.

Example: Take an image that has a signal of 2 and a noise level of 2. Its initial signal to noise ratio (SNR) is 2/2 = 1.

When we combine (2) images: signal = 2 + 2 = 4, noise = sqrt $(2^2 + 2^2)$ = 2.828, SNR = 4/2.828 = 1.414.

When we combine (4) images: signal = 2 + 2 + 2 + 2 = 8,
noise = sqrt $(2^2 + 2^2 + 2^2 + 2^2)$ = 4,
SNR = 8/4 = 2.

*** So, the more images we combine, the better the signal to noise ratio.
=> Works for lights, darks, flats, flat darks, and bias.

Astroimaging - Tutorial

- Calibrating the Images (cont'd)

Do you believe it?

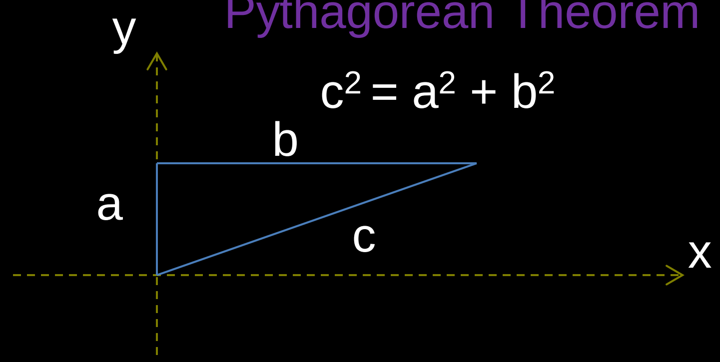
Answer - The signal adds linearly, the noise (being uncorrelated / orthogonal) adds as the square root of the sum of the squares.

Why is this true?

UNCORRELATED NOISE

Pythagorean Theorem

$$c^2 = a^2 + b^2$$



Noise a has no x value
Noise b has no y value

uncorrelated

CORRELATED NOISE

Note – there is correlated noise!!

- Combining images does NOT decrease correlated noise.
  - Example: Fixed Pattern Noise
    - Use dithering

What is the scoop on calibration -

All require Dark Frames
(optional for planetary)

Flat Lights and **Flat Darks** ?? - Needed mostly when sky background is evident. (Vignetting shows up, Dust donuts more obvious)

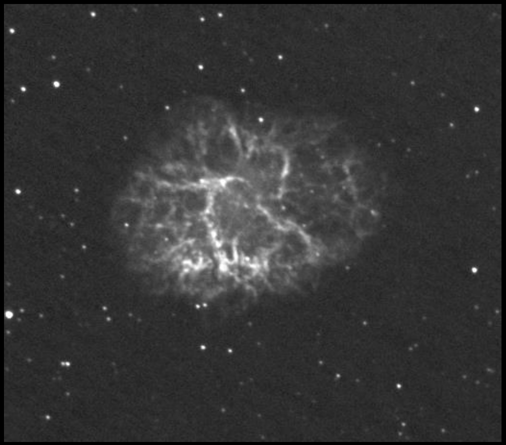
- DSLR, LRGB CCD

➢ Narrowband & NIR typically do not require Flats
➢ Bias Frames – depends, sometimes improvement
=> Short exposures to subtract offset up from zero

Astroimaging - Tutorial

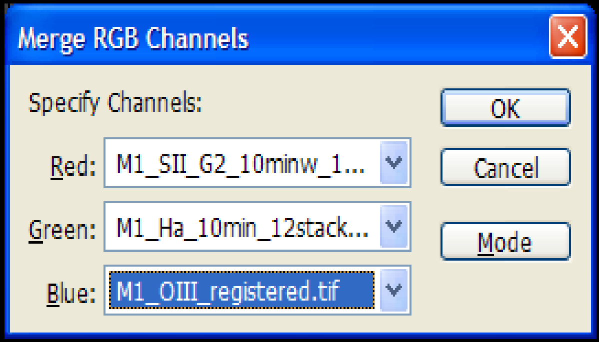
- Creating Color Images – using Photoshop

SII, 672nm, Red

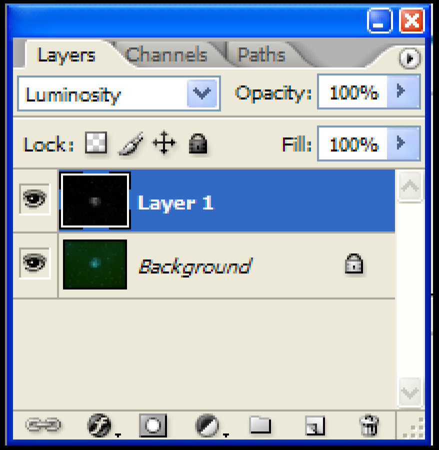


Ha, 656nm, Green & Luminance

OIII, 501nm, Blue



Combined: SII, Ha, OIII: LRGB Image



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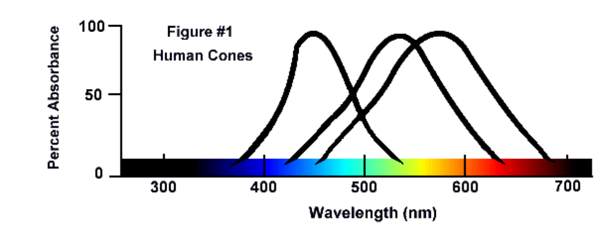
Astroimaging - Tutorial

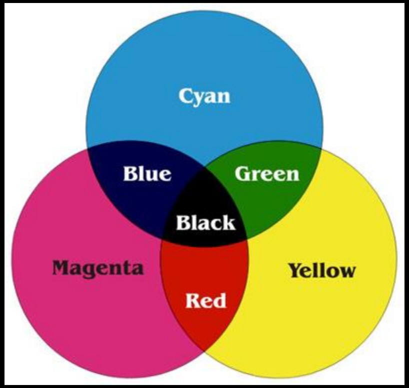
- Creating Color Images – using Photoshop (cont'd)

Alternate Color Mapping

SII, 672nm: Red
Ha, 656nm: Green
OIII, 501nm: Blue



SII, 672nm: Magenta
Ha, 656nm: Gold
OIII, 501nm: Turquoise



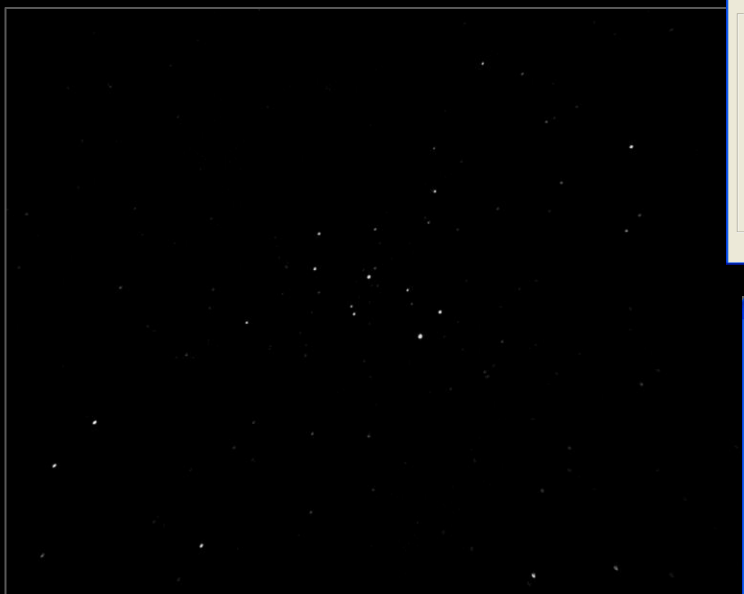
RGB Color Space
(Red, Green, Blue)

CYM Color Space
(Cyan, Yellow, Magenta)

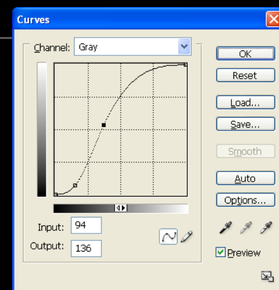
http://bf-astro.com/hubbleP.htm

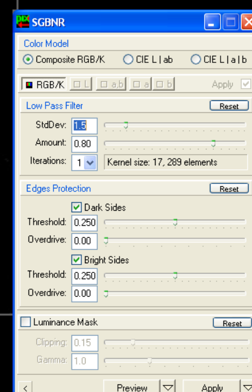
Astroimaging - Tutorial

- Post Processing
  - A very large field. Example tools: Photoshop, Matlab, AIP4WIN, GIMP, PixInsight



NGC2244 / NGC2237 (7 x 10 min) Ha Original





NGC2244 / NGC2237 (7 x 10 min) Ha Processed

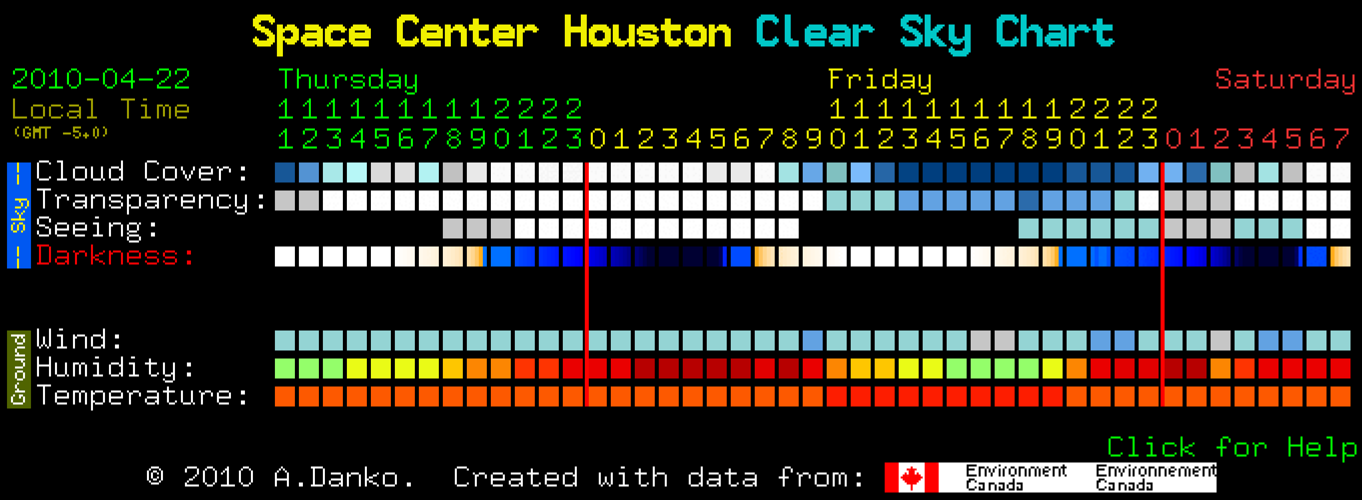
Example of the power of image processing –
• Image on left has had its dynamic range stretched via Photoshop curves, and noise reduced using Selective Gaussian Blur Noise Reduction (SGBNR) in PixInsight.

Astroimaging - Tutorial

- What Else Will Effect Your Astroimaging Session?

Cloud cover, transparency (humidity + particles in atmosphere), seeing (turbulence), phase of the Moon

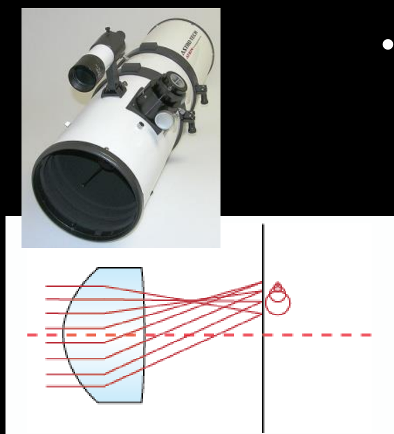
How can you find the conditions for your area?
=> Clear Sky Clock home page: http://cleardarksky.com/csk/



Astroimaging - Tutorial

- What Else Will Effect Your Astroimaging Session? (cont'd)

In general, telescopes perform better on axis (middle) than off axis (edges).

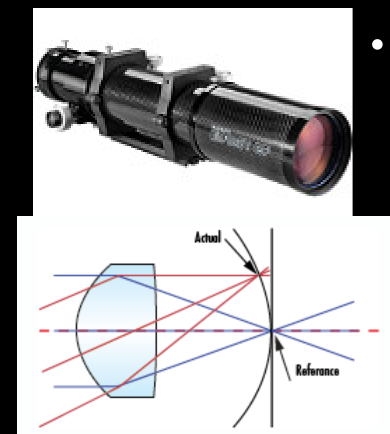


- Newtonians have issues with coma

Coma Corrector

WITHOUT

WITH



- Refractors have issues with field curvature

Field Flattener

WITHOUT

WITH

Astroimaging - Tutorial

- What Else Will Effect Your Astroimaging Session? (cont'd)

How to fit target within image –

- Field of View: the angle subtended by an image sensor's horizontal and vertical dimensions
    - Example: ICX285 sensor measures 8.98mm x 6.71mm. With a 1000mm fl telescope has a horizontal field of view of .50° , and a vertical field of view of .38°.
- How can I change the field of view?

⇒Focal reducer

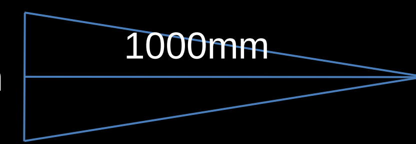
⇒ Will decrease f-stop thus allowing shorter exposure times

⇒ Can cause vignetting (bright in middle, dark on edges)

⇒Will change where scope comes into focus

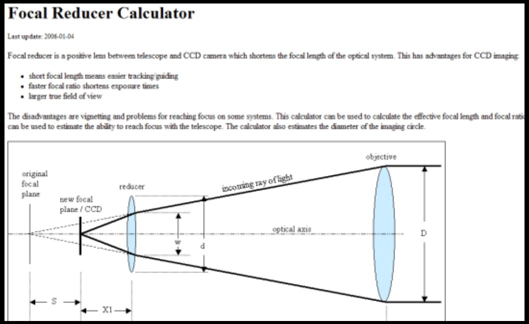
⇒ Or just use scope with shorter focal length

How to calculate field of view:



$$2 \bullet \arctan\left(\frac{8.89mm/2}{1000mm}\right)$$

Focal Reducer



Focal Reducer Calculator

Last update: 2006-01-04

Focal reducer is a positive lens between telescope and CCD camera which shortens the focal length of the optical system. This has advantages for CCD imaging:

- short focal length means easier tracking/guiding
- faster focal ratio shortens exposure times
- larger true field of view

The disadvantages are vignetting and problems for reaching focus on some systems. This calculator can be used to calculate the effective focal length and focal rati can be used to estimate the ability to reach focus with the telescope. The calculator also estimates the diameter of the imaging circle.

http://timosastro.1g.fi/tools/focalreducer.html

Astroimaging - Tutorial

- What Else Will Effect Your Astroimaging Session? (cont'd)

Scope Focal Length –

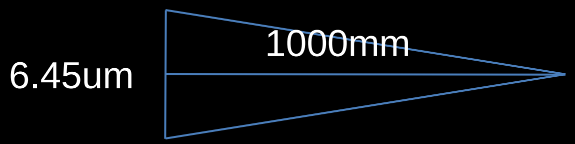
- Image Scale: the angle subtended by one pixel
  - Example: a 6.45um pixel (ICX285) with a 1000mm fl telescope has an image scale of 1.33".
- Image Scale – vs. – Tracking Accuracy – vs. Seeing
  - Seeing limits results to be between 2" to 4"
  - It is challenging to get a telescope mount to track to 1" and below.
  - Without good polar alignment, image will rotate around guide star – field rotation.

⇒So, what is the point?

⇒ A shorter focal length telescope:

1. Leads to a lower f-stop, short exposure (f-stop = fl/ aperture)
2. Does not show seeing effects as much
3. Is more forgiving of guiding errors
4. Is more forgiving of polar alignments
5. Is in general easier to image with

How to calculate image scale:



$$2 \bullet \arctan\left(\frac{6.45um/2}{1000mm}\right)$$

Astroimaging - Tutorial

- What Else Will Effect Your Astroimaging Session? (cont'd)

f stop – vs. – aperture – vs. – focal length – vs. – tracking accuracy – vs. – seeing conditions – vs. – exposure length – vs. – polar alignment – vs. – wind – vs. planes flying through your picture – vs. – a large truck driving down your street – vs. – etc., etc., etc.

Exposure Length –

- For planets, shorter is better - capture during moments of good seeing
- DSOs, in general longer is better to bring out subtle detail

⇒Trade offs:

⇒ Lower f-stop allows shorter exposure times

⇒ f-stop = focal length / aperture

⇒ Example: At f/5.6, only half the exposure time is required as compared to f/8 for the same resulting image brightness

⇒ Longer exposure lengths require accurate mount tracking for longer periods of time

⇒ Periodic and non-periodic error due to quality of mount

⇒ Field rotation due to poor polar alignment

⇒ Longer exposures require other ideal conditions

⇒ Wind vibrating scope, airplanes, meteors, trucks

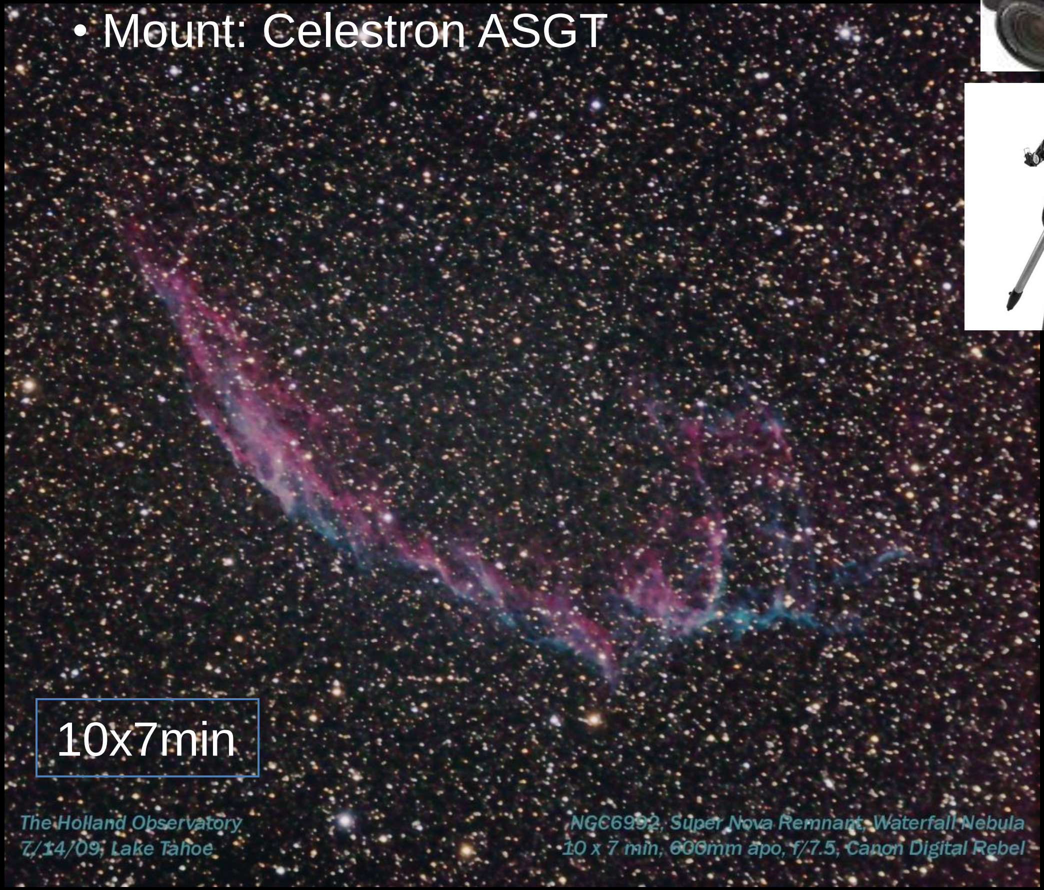
- A Collection of Images

➢ *And how they were taken*

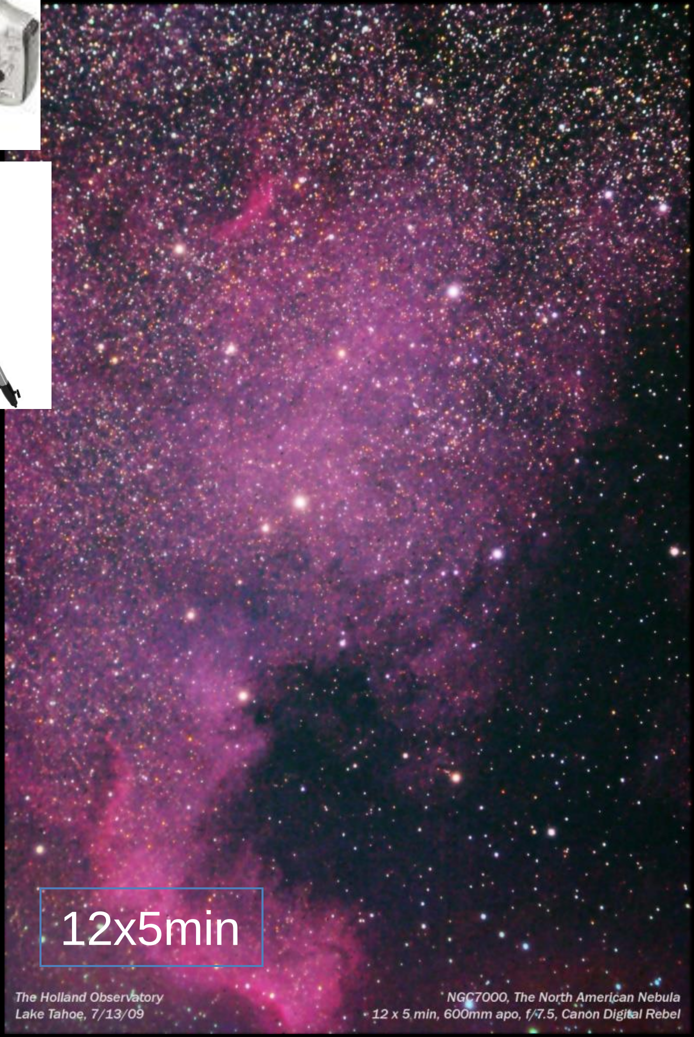
- Unmodified Canon DSLR -

Astroimaging - Tutorial

- Camera: Unmodified Canon 300D
- Telescope: Celestron 80ED Refractor
- Mount: Celestron ASGT



NGC6992: The Waterfall Nebula (Super Nova Remnant)

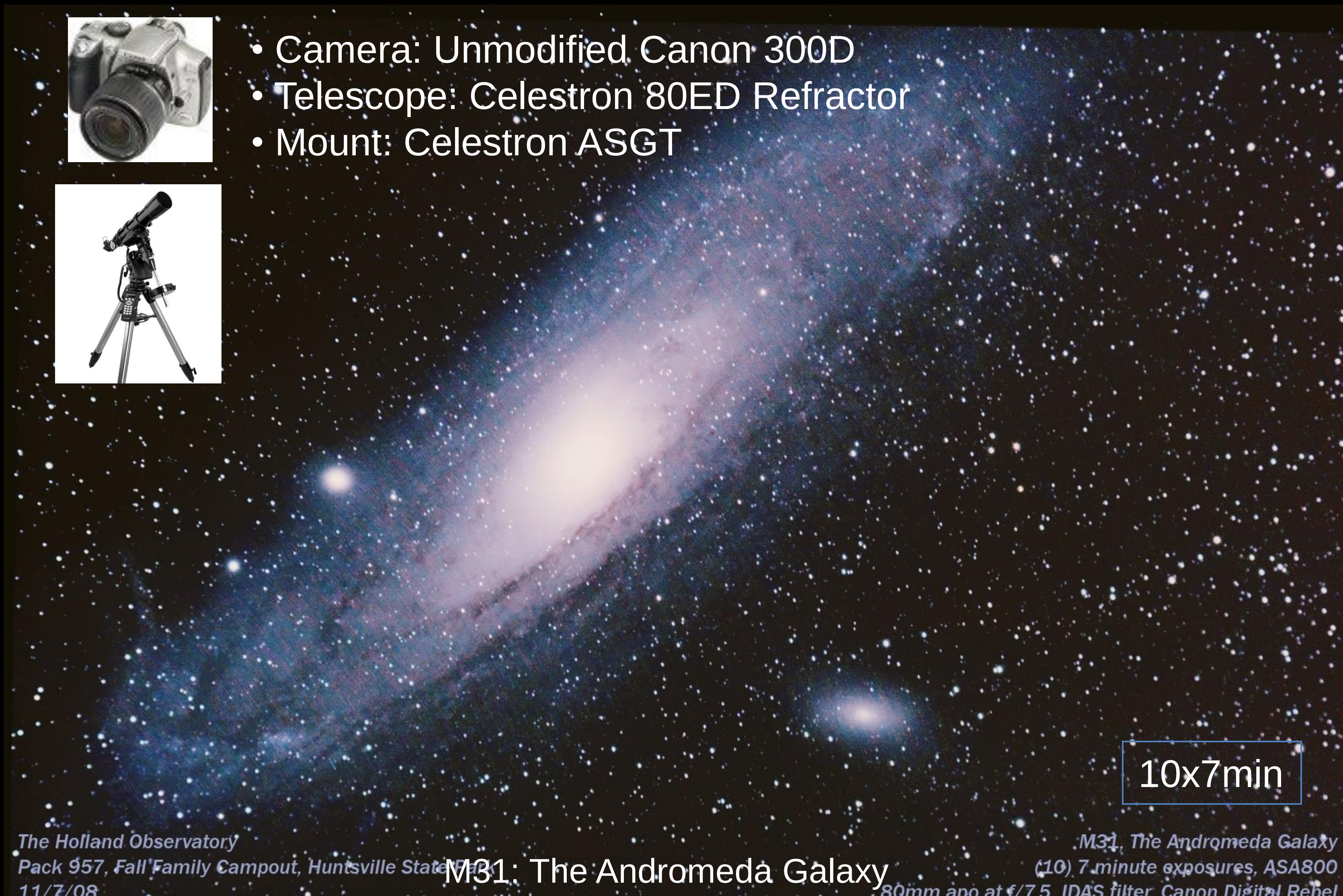


NGC7000: The North American Nebula

S. Douglas Holland

Astroimaging - Tutorial

- Camera: Unmodified Canon 300D
- Telescope: Celestron 80ED Refractor
- Mount: Celestron ASGT



10x7min

M31: The Andromeda Galaxy

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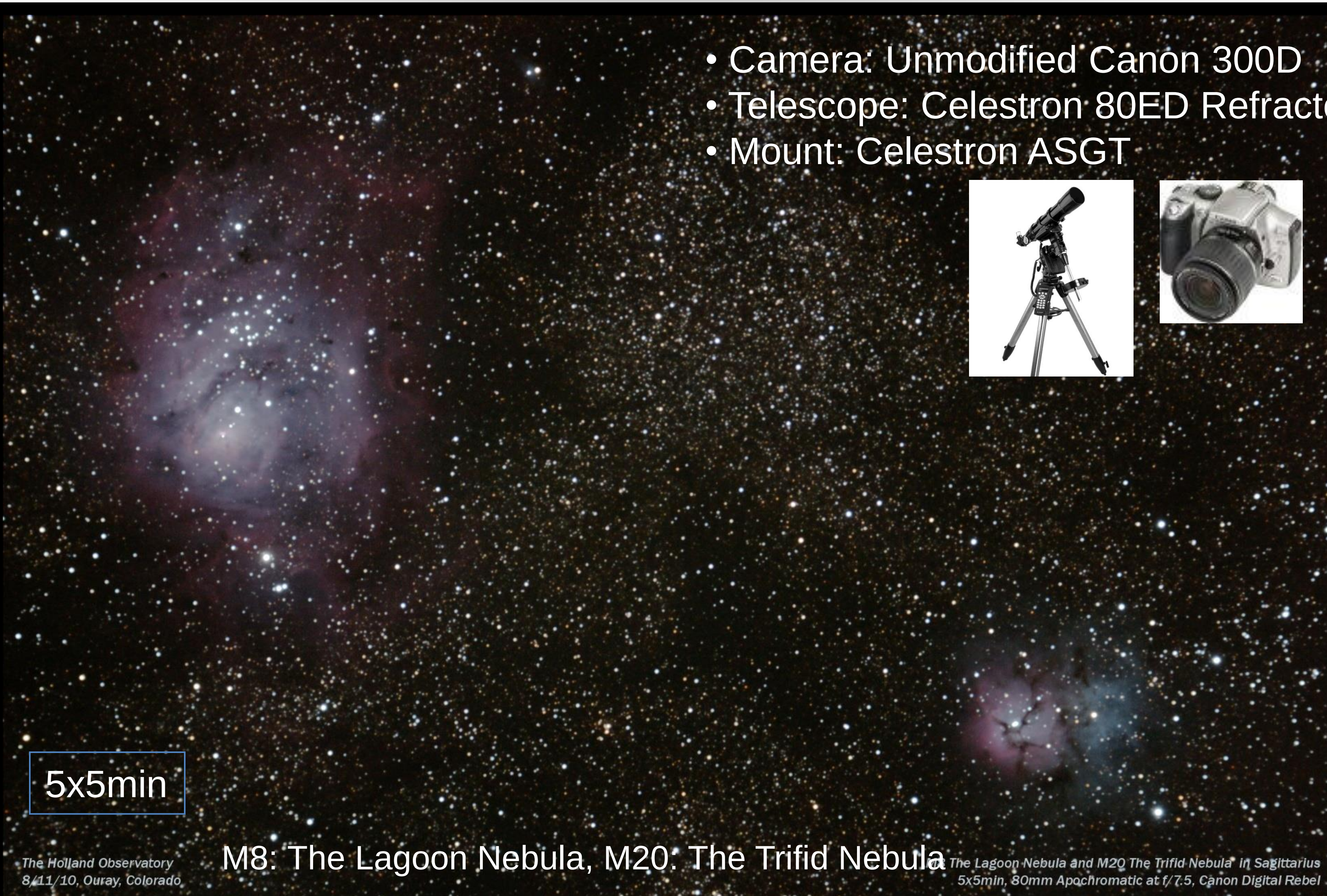
Astroimaging - Tutorial



- Camera: Unmodified Canon 300D
- Telescope: Celestron 80ED Refractor
- Mount: Celestron ASGT

5x5min

M8: The Lagoon Nebula, M20: The Trifid Nebula

Astroimaging - Tutorial

The Moon
Single Shot Image

- Camera: Unmodified Canon 300D
- Telescope: Celestron 8” Newtonian
- Mount: Celestron ASGT

Astroimaging - Tutorial

M42: The Orion Nebula, NGC1977 The Running Man Nebula

- Camera: Unmodified Canon 300D
- Telescope: Celestron 8” Newtonian
- Mount: Celestron ASGT

7x4min

Astroimaging - Tutorial

- Camera: Unmodified Canon 300D
- Telescope: 18-55mm kit lens
- Mount: Barn Door Tracker

1x4min

The Milky Way over Lake Tahoe

- Modified Canon DSLR -

Astroimaging - Tutorial

- Camera: Modified Canon 450D
- Telescope: Sigma 17-70mm lens
- Mount: Barn Door Tracker

1x3min

The Milky Way over Buffalo Trail Scout Ranch

Astroimaging - Tutorial

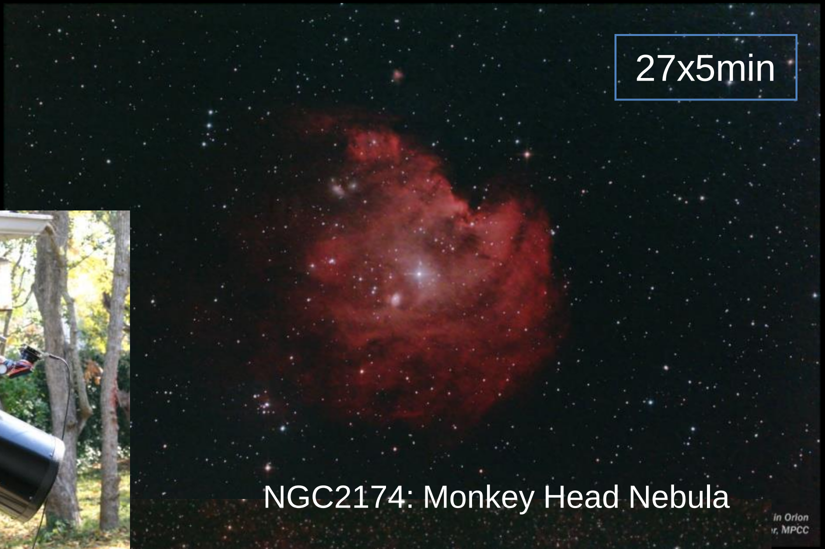
- Camera: Modified Canon 450D
- Telescope: Canon EF 200mm Lens
- Mount: Celestron ASGT
- Filter: None

5x3min

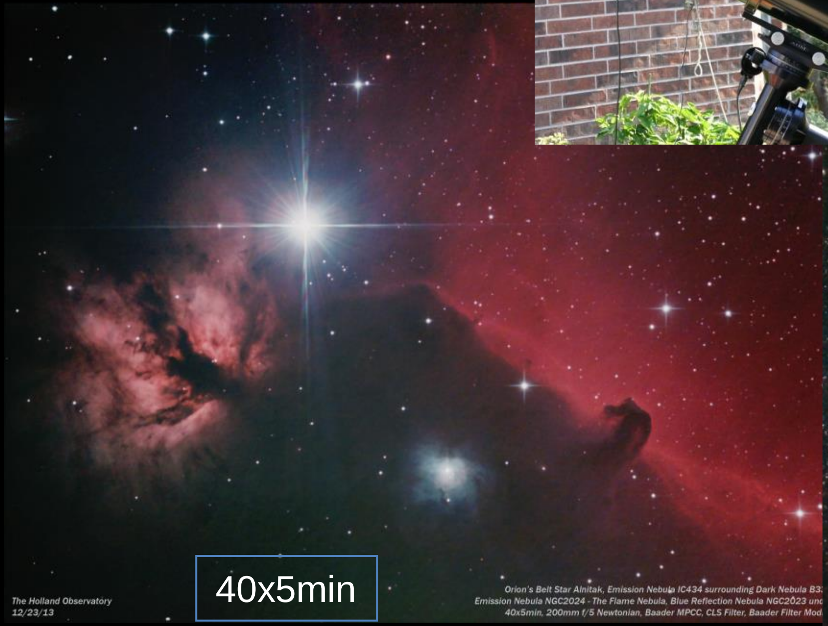
Antares / Scorpius Area

Astroimaging - Tutorial

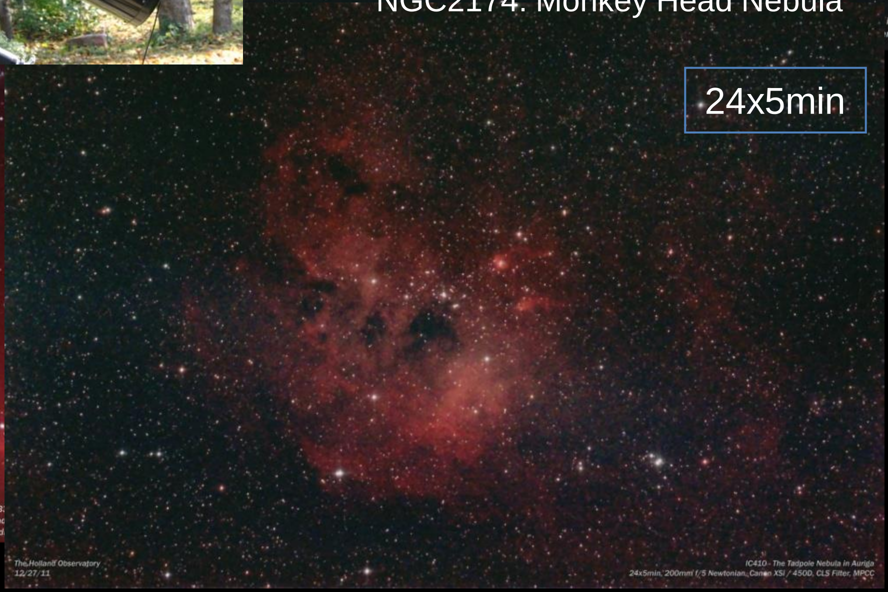
- Camera: Modified Canon 450D
- Telescope: Celestron 8” Newtonian
- Mount: Losmandy G-11
- Filter: Astronomik CLS



NGC2174: Monkey Head Nebula



IC434: Horsehead, NGC2024: Flame Nebula



IC410: The Tadpole Nebula

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- CCD LRGB -

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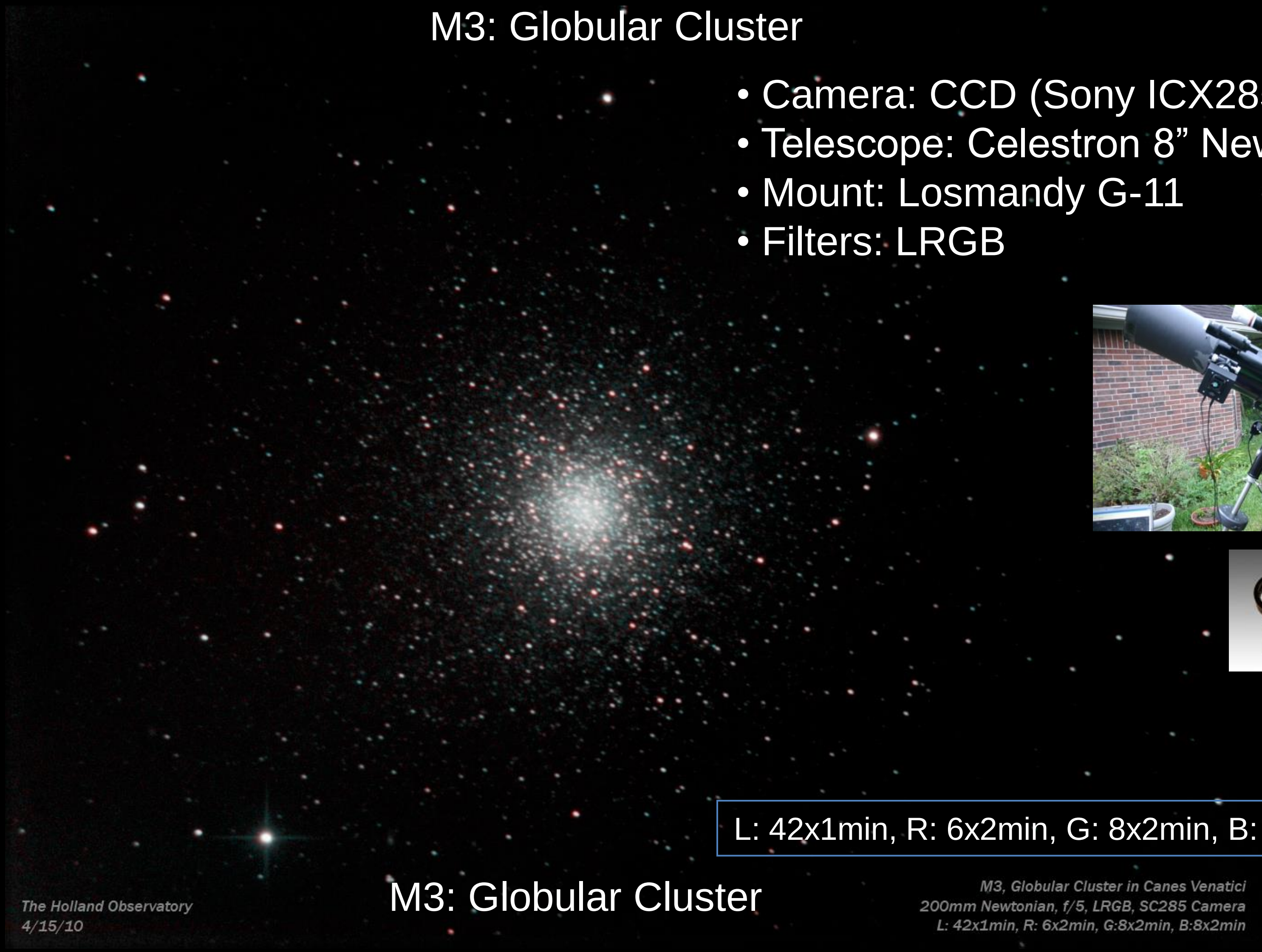
M3: Globular Cluster

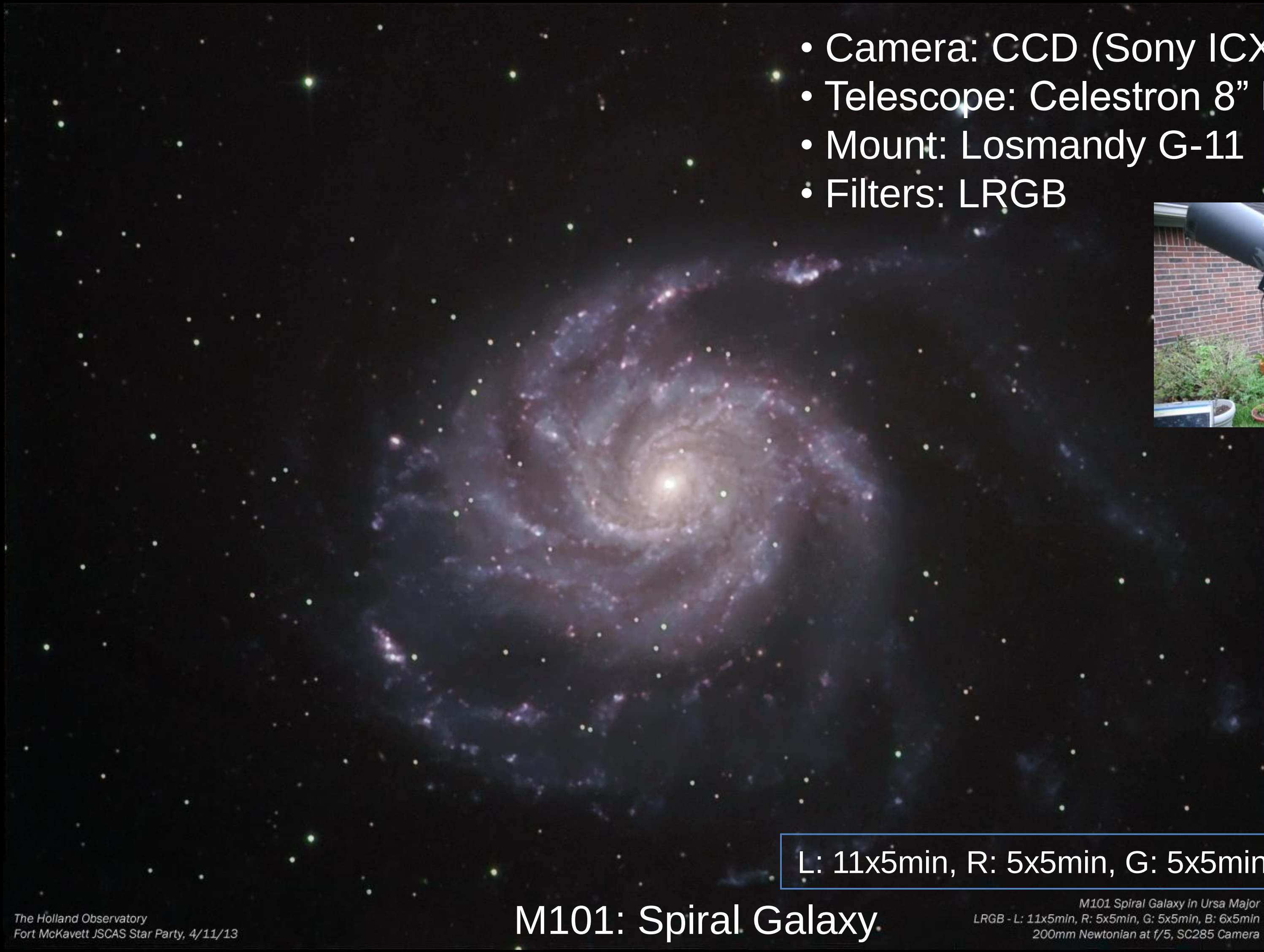
- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Celestron 8” Newtonian
- Mount: Losmandy G-11
- Filters: LRGB



L: 42x1min, R: 6x2min, G: 8x2min, B: 8x2min

M3: Globular Cluster

Astroimaging - Tutorial



- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Celestron 8” Newtonian
- Mount: Losmandy G-11
- Filters: LRGB

L: 11x5min, R: 5x5min, G: 5x5min, B: 6x5min

M101: Spiral Galaxy

Astroimaging - Tutorial

- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Celestron 8” Newtonian
- Mount: Losmandy G-11
- Filters: LRGB

L: 7x5min, R: 4x5min, G: 3x5min, B: 2x5min

M20: Trifid Nebula

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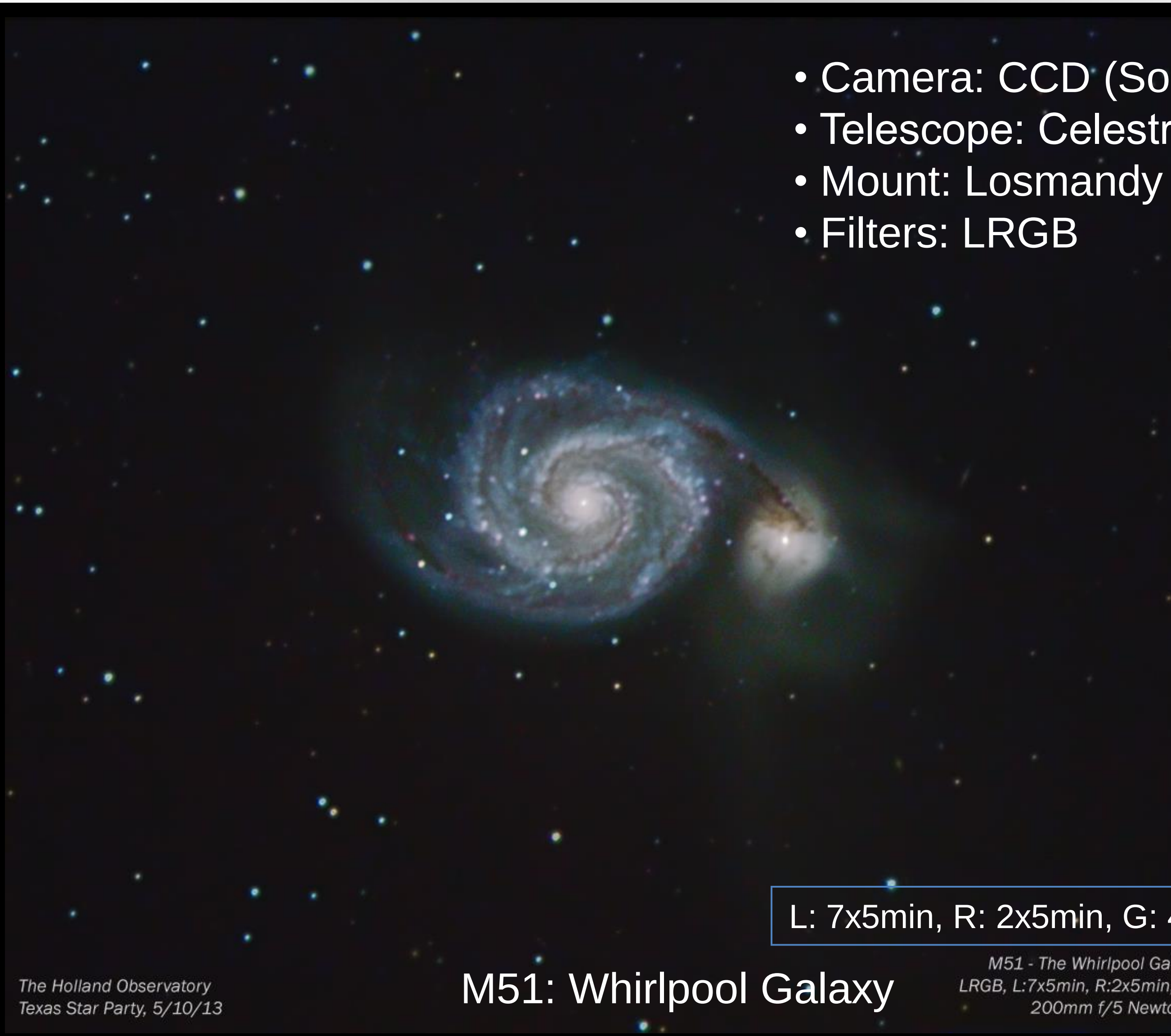
Astroimaging - Tutorial



- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Celestron 8” Newtonian
- Mount: Losmandy G-11
- Filters: LRGB

L: 7x5min, R: 2x5min, G: 4x5min, B: 2x5min

M51: Whirlpool Galaxy

Astroimaging - Tutorial

- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Celestron 80ED Refractor
- Mount: Celestron ASGT
- Filters: LRGB

L: 7x4min, R: 4x4min, G: 4x4min, B: 1x4min

NGC6992 / 6995: Veil Nebula

Astroimaging - Tutorial

- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Celestron 80ED Refractor
- Mount: Celestron ASGT
- Filters: LRGB

L: 3x4min, R: 5x4min, G: 4x4min, B: 4x4min

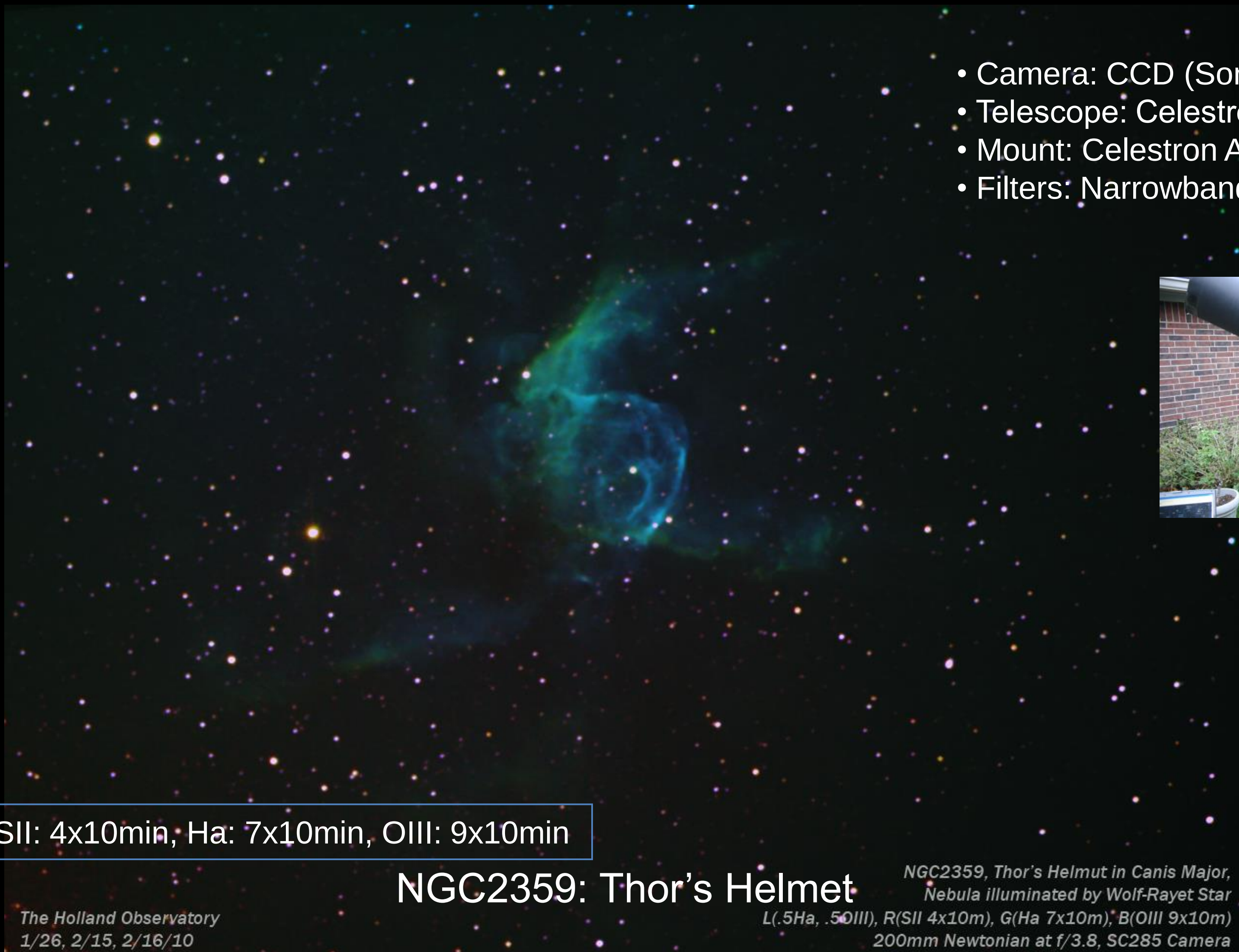
NGC7000: North American Nebula

S. Douglas Holland

- CCD Narrowband -

Astroimaging - Tutorial

- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Celestron 8" Reflector
- Mount: Celestron ASGT (pic G11)
- Filters: Narrowband (SII, Ha, OIII)

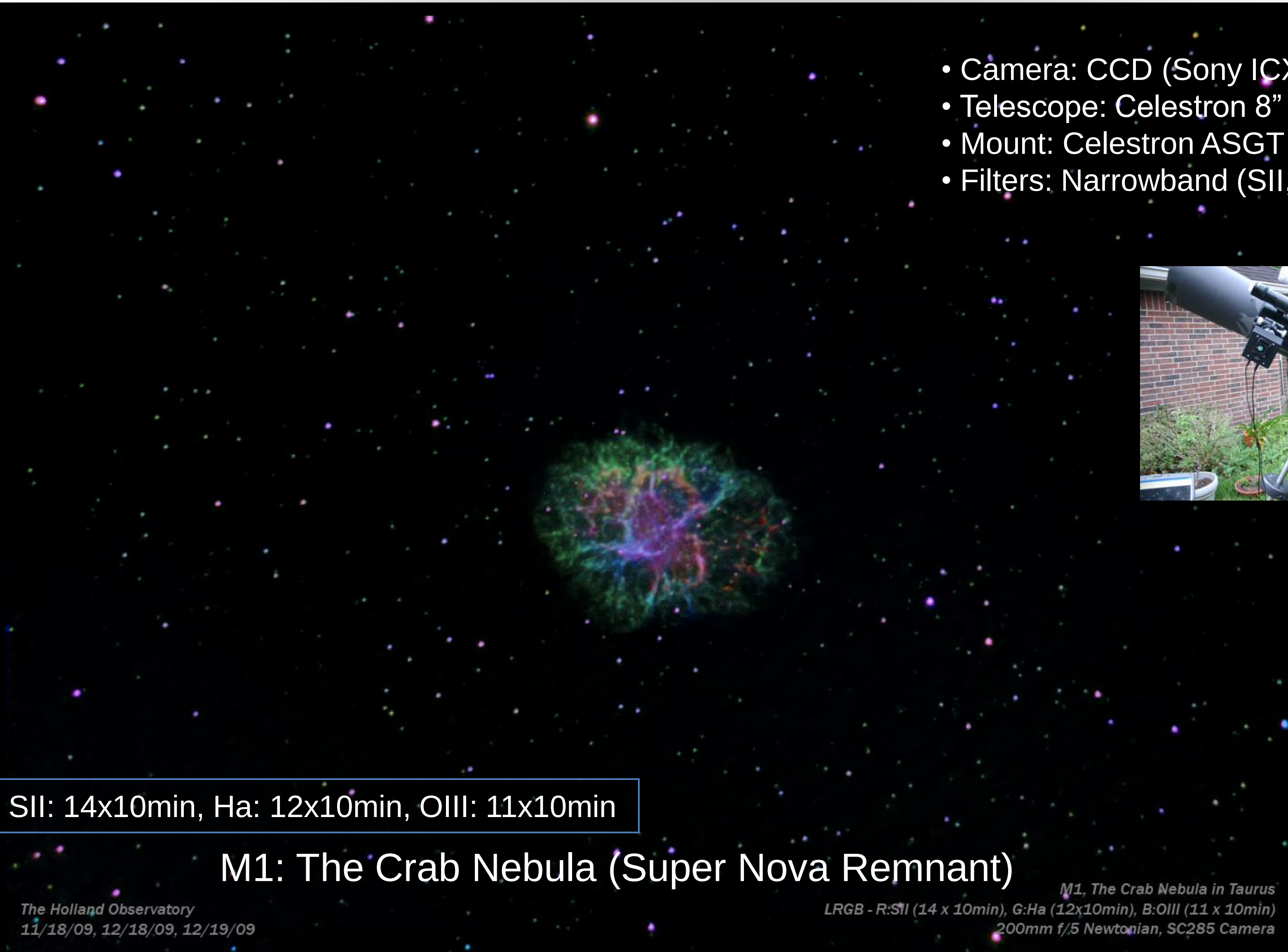


SII: 4x10min, Ha: 7x10min, OIII: 9x10min

NGC2359: Thor's Helmet

Astroimaging - Tutorial

- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Celestron 8” Reflector
- Mount: Celestron ASGT (pic G11)
- Filters: Narrowband (SII, Ha, OIII)



SII: 14x10min, Ha: 12x10min, OIII: 11x10min

M1: The Crab Nebula (Super Nova Remnant)

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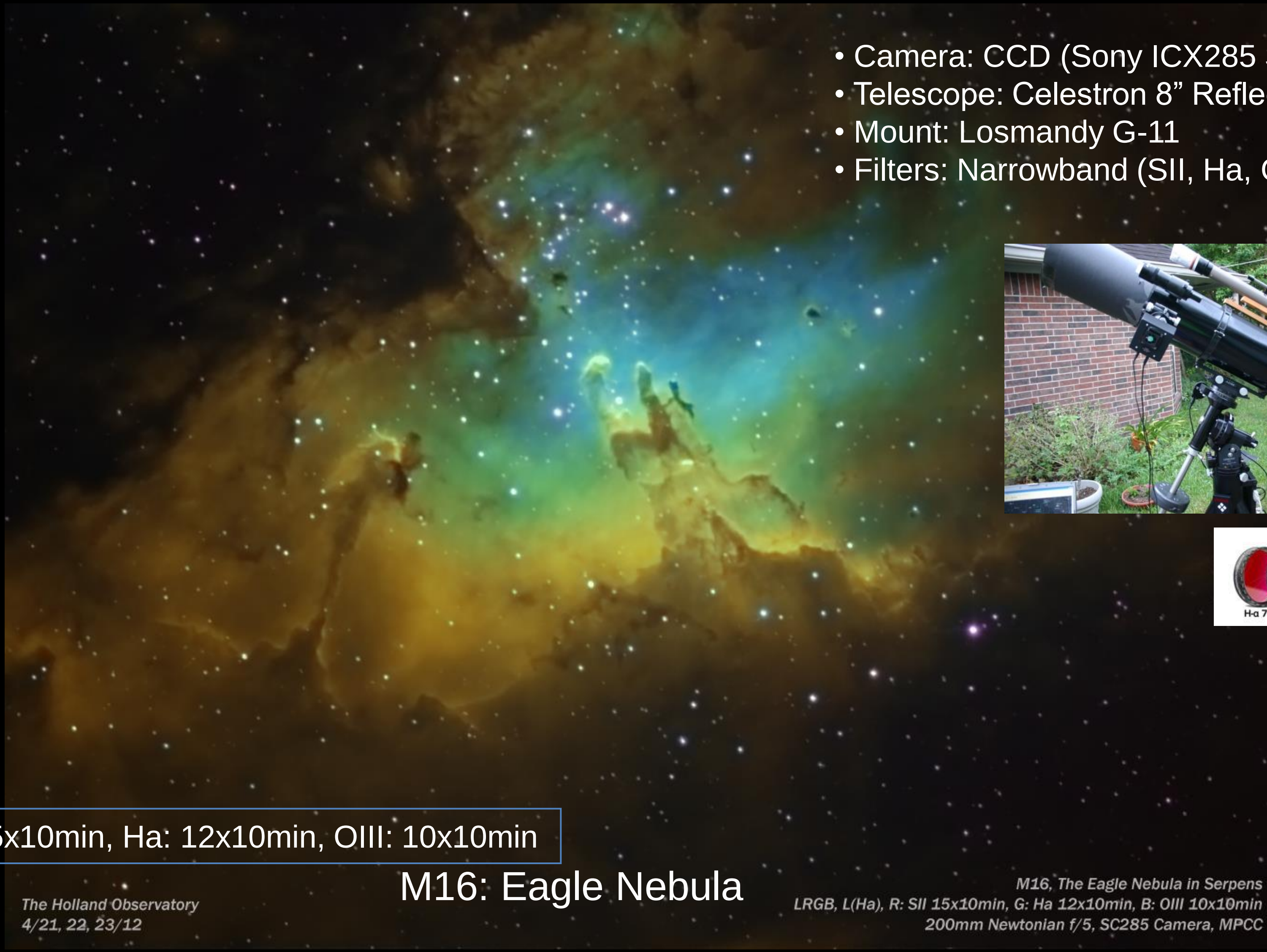
Astroimaging - Tutorial

- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Celestron 8” Reflector
- Mount: Losmandy G-11
- Filters: Narrowband (SII, Ha, OIII)



SII: 15x10min, Ha: 12x10min, OIII: 10x10min

M16: Eagle Nebula

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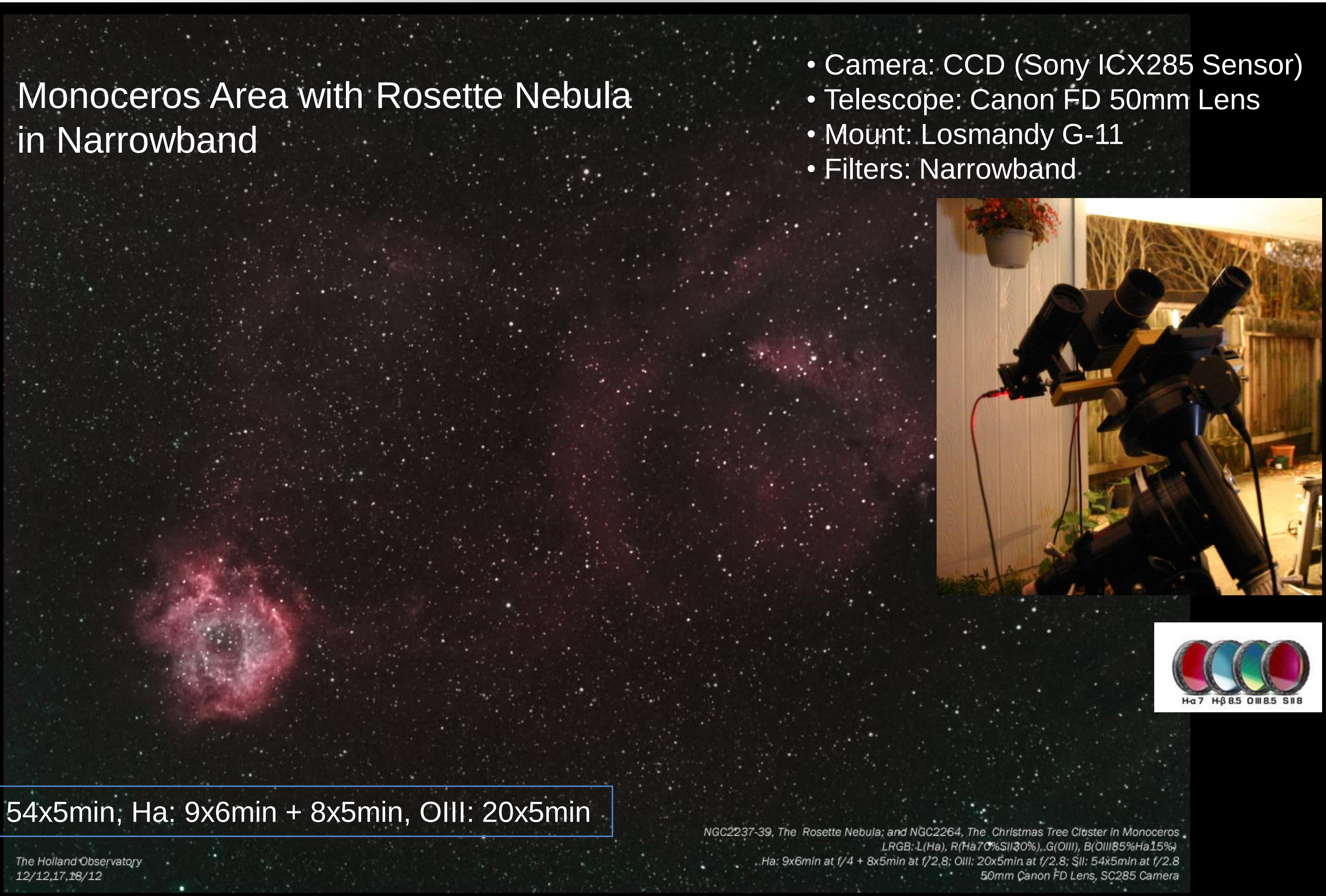
Astroimaging - Tutorial

Monoceros Area with Rosette Nebula in Narrowband

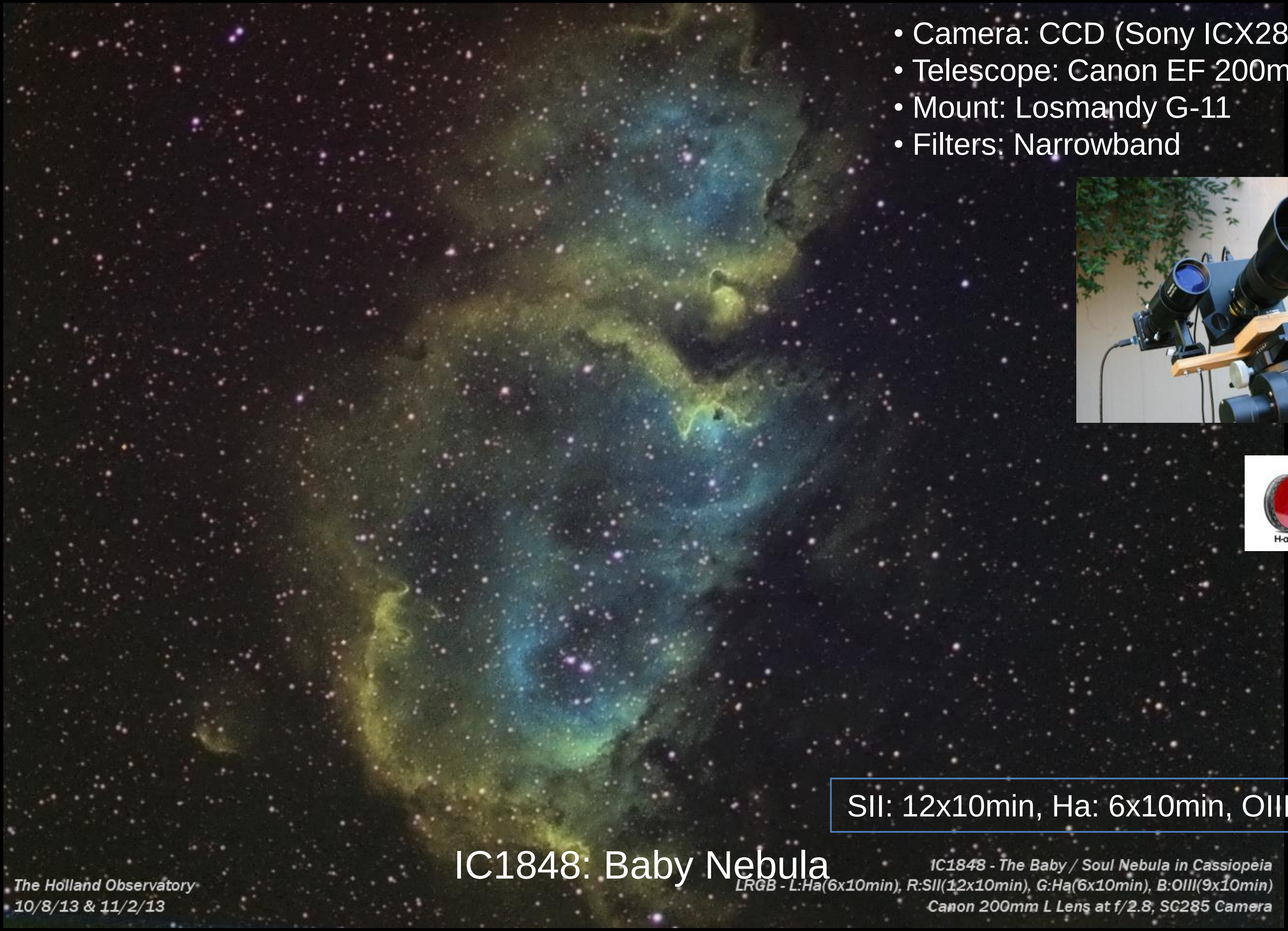
- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Canon FD 50mm Lens
- Mount: Losmandy G-11
- Filters: Narrowband



SII: 54x5min, Ha: 9x6min + 8x5min, OIII: 20x5min

Astroimaging - Tutorial

- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Canon EF 200mm Lens
- Mount: Losmandy G-11
- Filters: Narrowband



SII: 12x10min, Ha: 6x10min, OIII: 9x10min

IC1848: Baby Nebula

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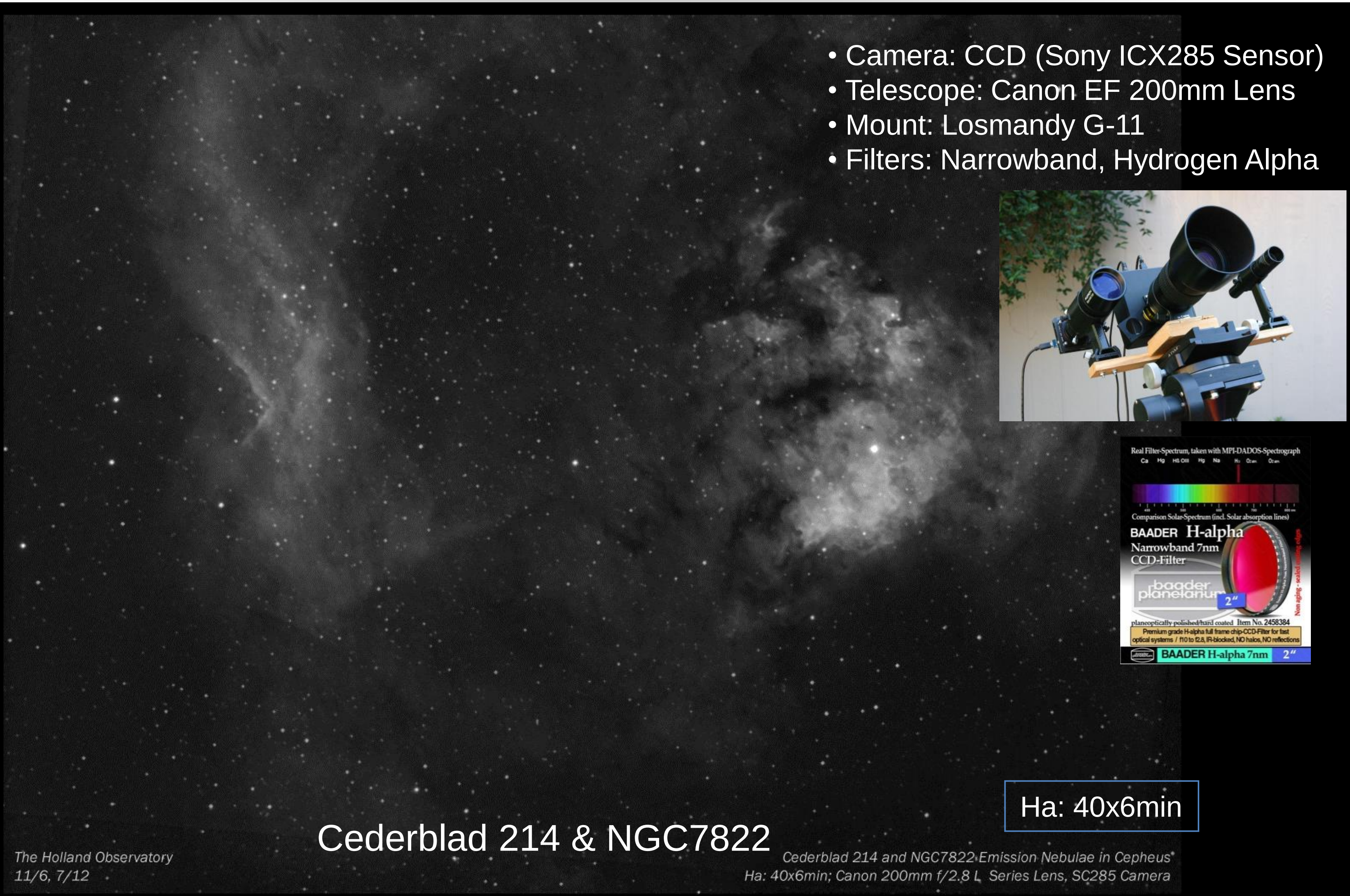
Astroimaging - Tutorial



- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Canon EF 200mm Lens
- Mount: Losmandy G-11
- Filters: Narrowband, Hydrogen Alpha

Ha: 40x6min

Cederblad 214 & NGC7822

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Astroimaging - Tutorial

- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Canon EF 200mm Lens
- Mount: Losmandy G-11
- Filters: Narrowband

SII: 16x10min, Ha: 6x10min, OIII: 15x10min

NGC7000: North American Nebula

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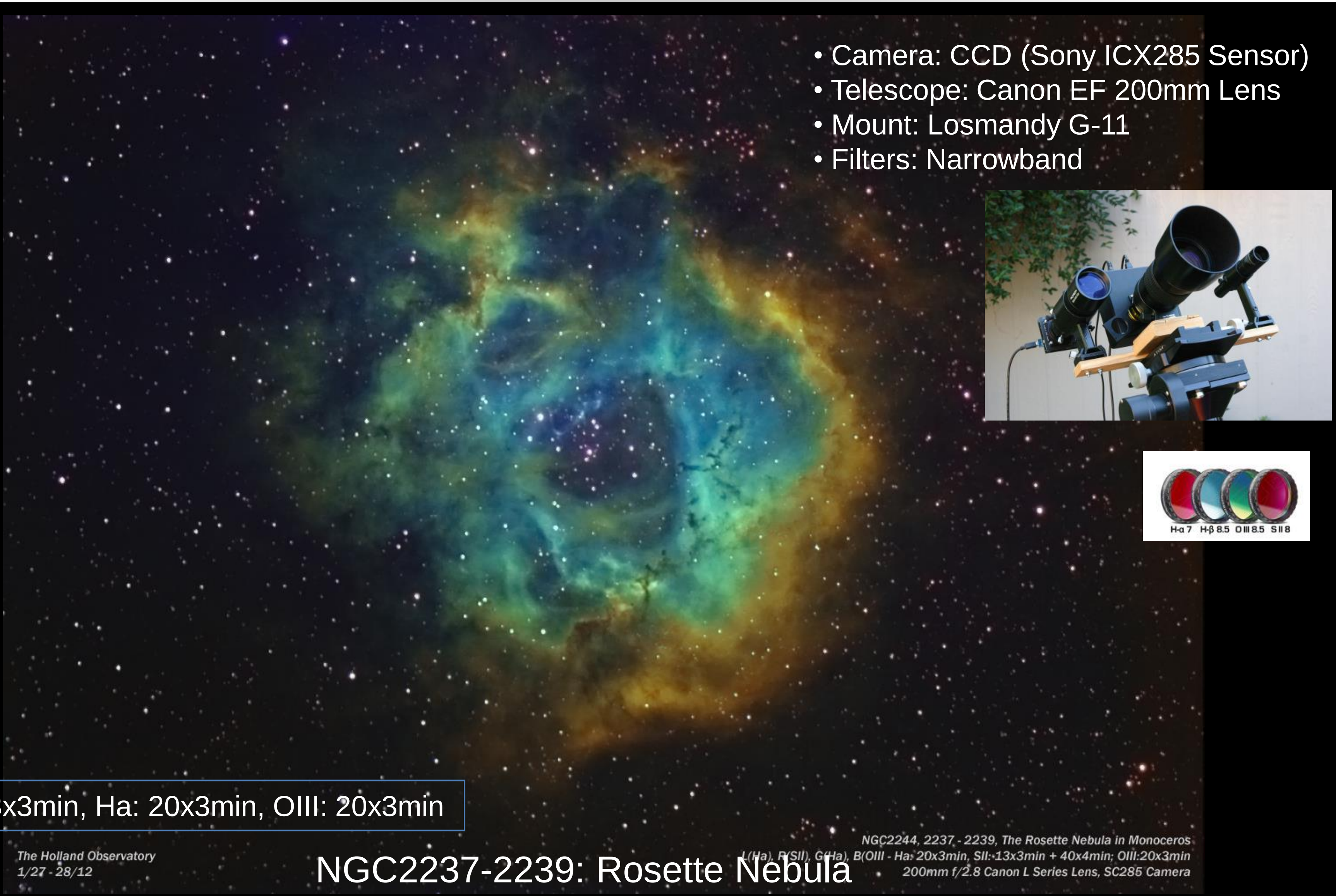
Astroimaging - Tutorial



- Camera: CCD (Sony ICX285 Sensor)
- Telescope: Canon EF 200mm Lens
- Mount: Losmandy G-11
- Filters: Narrowband

SII: 13x3min, Ha: 20x3min, OIII: 20x3min

NGC2237-2239: Rosette Nebula

Astroimaging - Tutorial

- References
  - The New CCD Astronomy by Ron Wodaski
  - The Handbook of Astronomical Image Processing by Richard Berry and James Burnell
    - Best book to understand theory of image calibration, comes with AIP4WIN software
  - The 100 Best Astrophotography Targets by Ruben Kier
  - Photoshop Astronomy by R. Scott Ireland
  - Telescopes, Eyepieces, Astrographs by Smith, Ceragioli & Berry
    - Tells the pros and cons of different telescope designs
- Visit my web page:
  - www.holland-observatory.net