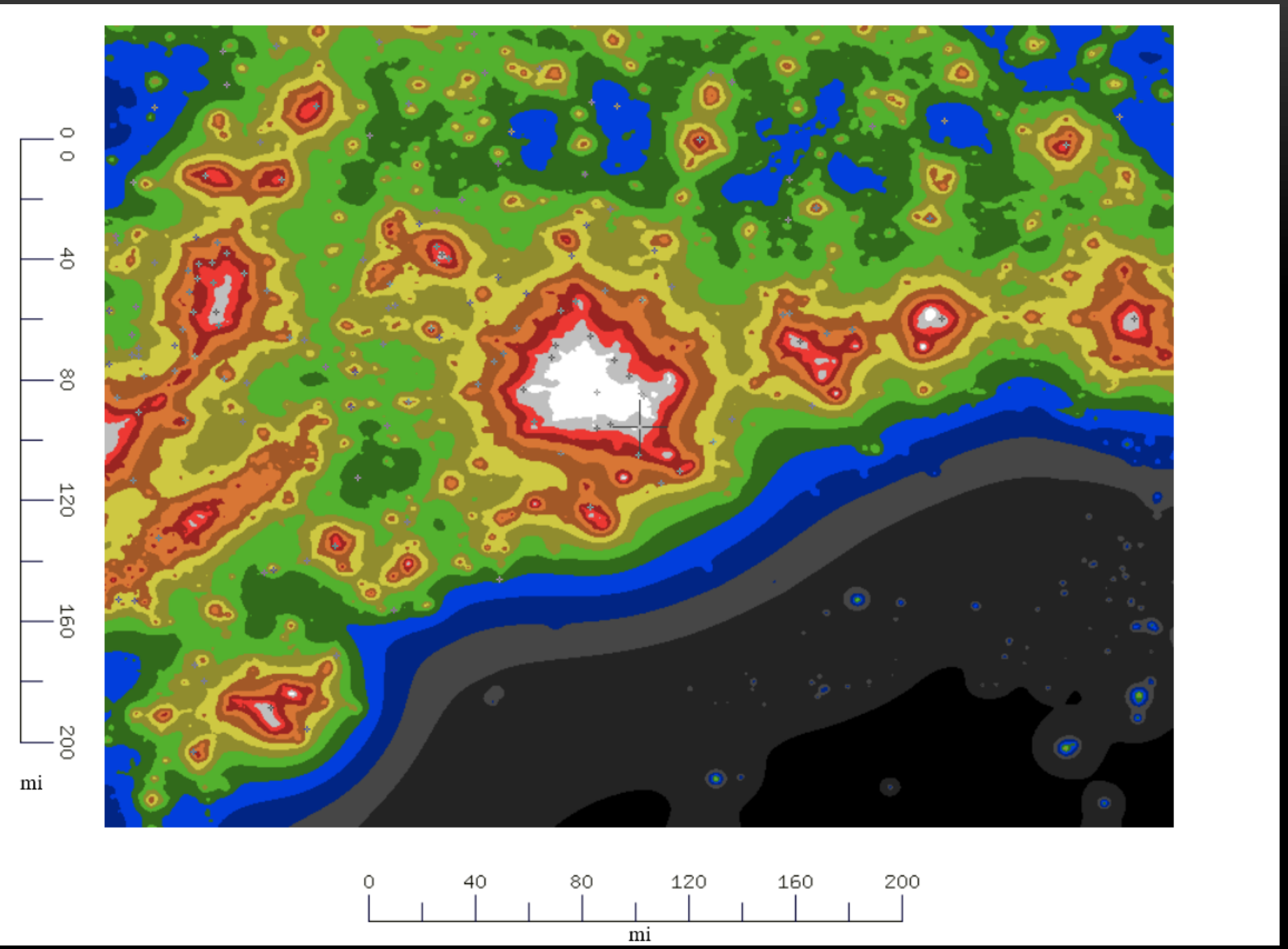
What Astronomy Can We Do from Here?

Doug Holland

What is the problem with doing astronomy from here?

Light Pollution -

Light Pollution Map of Our Area



The Bortle Scale

Conditions at Zenith				
Color	Artificial / Natural Sky Brightness	Sky Brightness mags / sq arcsec V Band	Bortle Scale approx	Description (Descriptions are approximate. Your sky may vary.)
	< 0.01	22.00 to 21.99	1	Theoretically darkest sky limited by airglow and starlight
	0.01 to 0.06	21.99 to 21.93	2	Gegenschein visible. Zodiacal light annoyingly bright. Rising milkyway confuses some into thinking it's dawn. Limiting magnitude 7.6 to 8.0 for people with exceptional vision. Users of large dobsonian telescopes are *very* happy. [-ad]
	0.06 to 0.11	21.93 to 21.89	2	Faint shadows cast by milkyway visible on white objects. Clouds are black holes in the sky. No light domes. The milky way has faint extentions making it 50 degrees thick. Limiting magntiude 7.1 to 7.5. [-ad]
	0.11 to 0.19	21.89 to 21.81	3	
	0.19 to 0.33	21.81 to 21.69	3	The sky is crowded with stars, extending to the horizon in all directions. In the absence of haze the M.W. can be seen to the horizon. Clouds appear as black silhouettes against the sky. Stars look large and close. [-Richard Berry] Low light domes (10 to 15 degrees) on horizon. M33 easy with averted vision. M15 is naked eye. Milky way shows bulge into Ophiuchus. Limiting magnitude 6.6 to 7.0. [-ad]
	0.33 to 0.58	21.69 to 21.51	4	21.6: ... a glow in the direction of one or more cities is seen on the horizon. Clouds are bright near the city glow. [-Richard Berry]
	0.58 to 1.00	21.51 to 21.25	4	Zodiacal light seen on best nights. Milkyway shows much dark lane structure with beginnings of faint bulge into Ophiuchus. M33 difficult even when above 50 degrees. Limiting magnitude about 6.2 to 6.5. [-ad]
	1.00 to 1.73	21.25 to 20.91	4.5	21.1: The M.W. is brilliant overhead but cannot be seen near the horizon. Clouds have a greyish glow at the zenith and appear bright in the direction of one or more prominent city glows. [-Richard Berry] Some dark lanes in milkyway but no bulge into Ophiuchus. Washed out milkyway visible near horizon. Zodiacal light very rare. Light domes up to 45 degrees. Limiting magnitude about 5.9 to 6.2. [-ad]
	1.73 to 3.00	20.91 to 20.49	4.5	
	3.00 to 5.20	20.49 to 20.02	5	20.4: To a city dweller the M.W. is magnificent, but contrast is markedly reduced, and delicate detail is lost. Limiting magnitude is noticeably reduced. Clouds are bright against the zenith sky. Stars no longer appear large and near. [-Richard Berry] Milkyway washed out at zenith and invisible at horizon. Many light domes. Clouds are brighter than sky. M31 easily visible. Limiting magnitude about 5.6 to 5.9.[-ad]
	5.20 to 9.00	20.02 to 19.50	5	
	9.00 to 15.59	19.50 to 18.95	6	19.5: M.W. is marginally visible, and only near the zenith. Sky is bright and discoloured near the horizon in the direction of cities. The sky looks dull grey. [-Richard Berry] Milkyway at best very faint at zenith. M31 difficult and indestinct. Sky is grey up to 35 degrees. Limiting magntidue 5.0 to 5.5. [-ad]
	15.59 to 27.00	18.95 to 18.38	7	
	27.0 to 46.77	18.38 to 17.80	8	Entire sky is grayish or brighter. Familliar constellations are missing stars. Fainter constellations are absent. Less than 20 stars visible over 30 degrees elevation in brigher areas. Limiting magntude from 3 to 4.CCD imaging is still possible. But telescopic visual observation is usually limited to the moon, planets, double stars and variable stars. [-ad]
	>46.77	>17.80	9	18.5: Stars are weak and washed out, and reduced to a few hundred. The sky is bright and discoloured everywhere. [-Richard Berry] Most people don't look up.[-ad]

We may wish we were on a mountain top in Chile…

But, there are things we can do from here =>

One thing we can do from here:

The Sun

https://uamshealth.com/wp-content/uploads/2019/03/staring-at-the-sun.jpg

Note – all astroimages are those of the author unless designated

The Sun

The Venus transit: 6/5/12

Mylar Solar Filter – visual & imaging

The Sun

Solar Eclipse:
8/21/17
from Houston

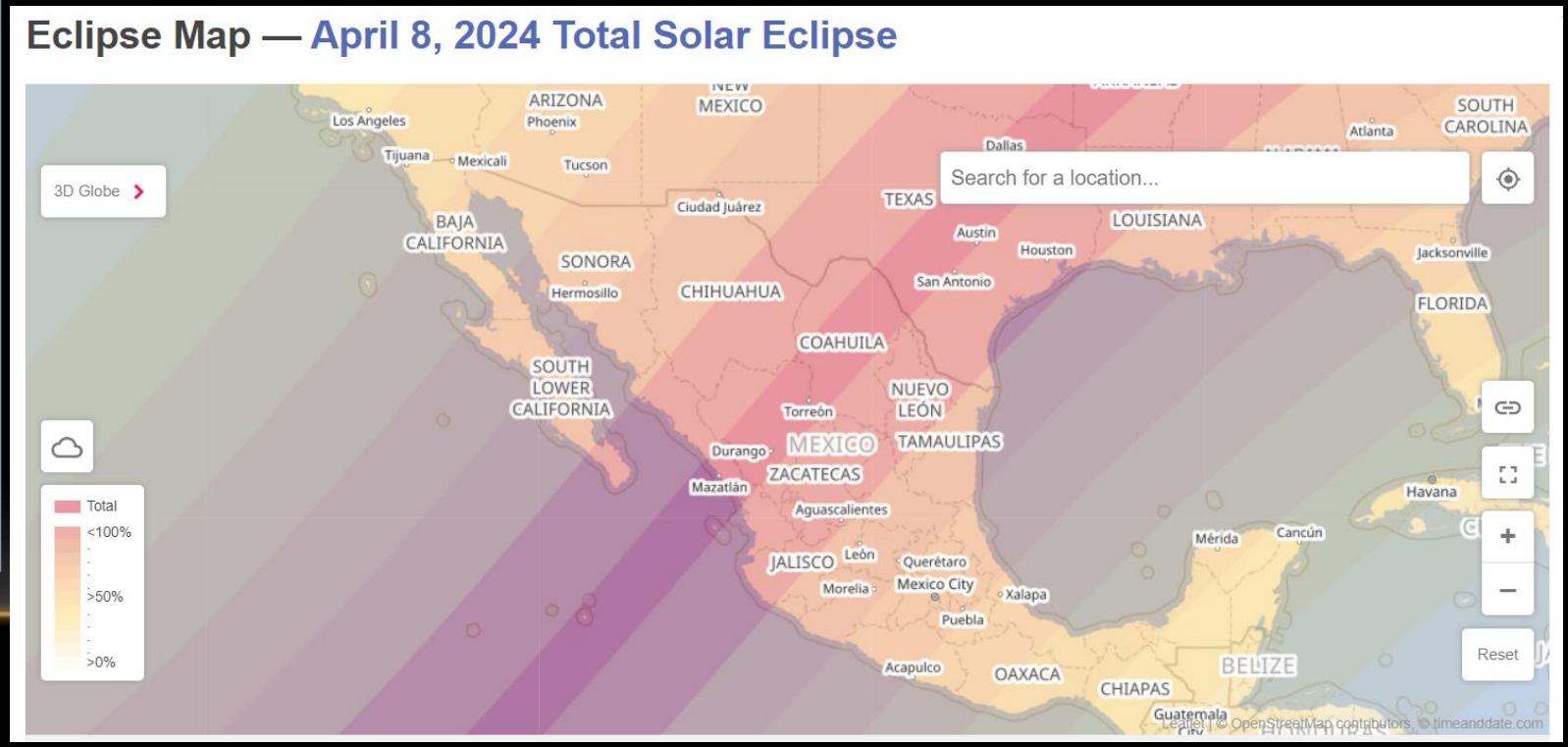
Solar Eclipse, 8/21/17

200mm Canon lens at f/22, 1/4000th Sec, Mylar Solar Filter, Canon 300D Camera

The Sun
Upcoming Eclipses:

Annular Solar Eclipse during ESP
Eldorado Star Party (ESP)
Saturday October 14, 2023
Peak 11:46 – 11:51 AM, over 5 minutes!

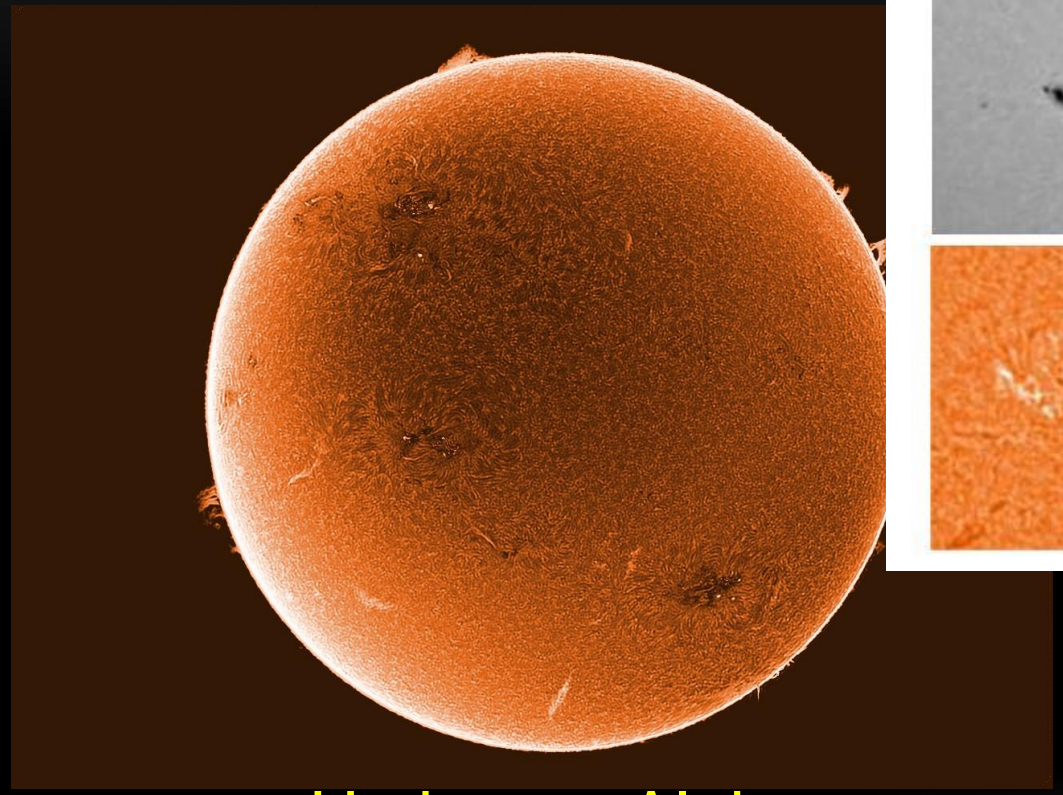
https://preview.redd.it/mijj7gg4q2h01.jpg?auto=webp&s=7b826d279da2b30f6825f93a8f01a30fb6360d90



The Sun

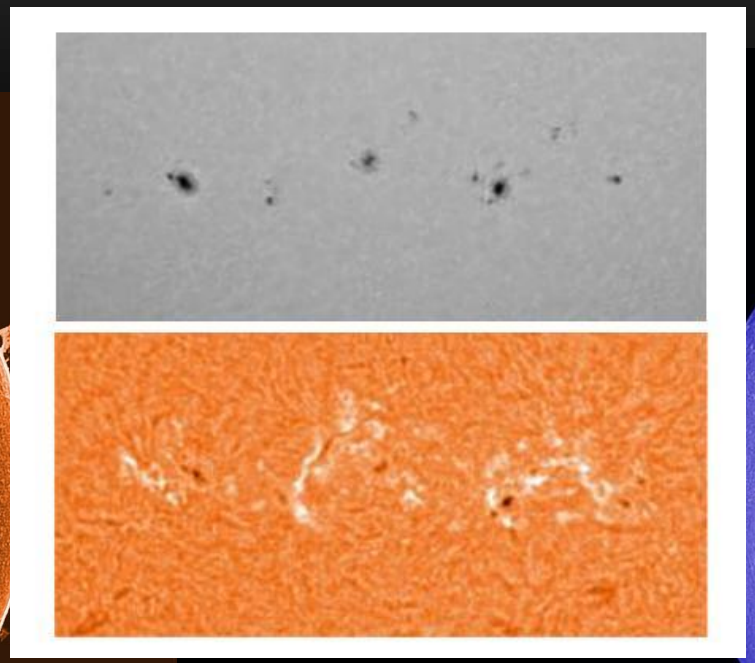
Solar Telescopes:

Solar sunspots and prominences



Hydrogen Alpha

656nm



White light vs.
Hydrogen Alpha
(granulation)

Calcium-K

393nm

Images from Lunt Solar System User Gallery

Another thing we can do from here:

The Moon

1. Lunar Geography
2. Eclipses
3. High Res Imaging
4. Impacts

The Moon
2. Eclipses

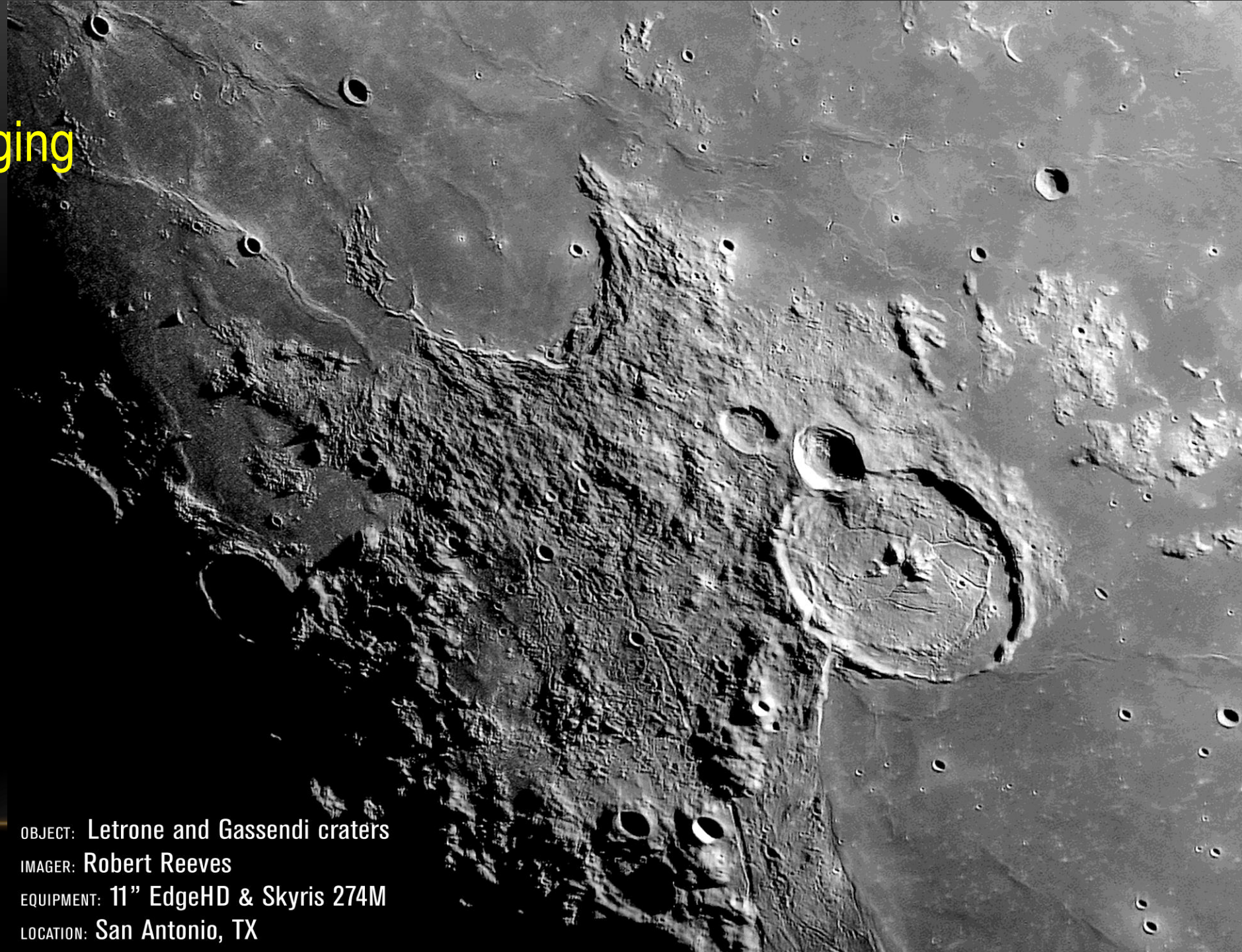
Total Lunar Eclipse
December 20th - 21st, 2010
The Holland Observatory
200mm Newtonian at f/5
Canon Digital Rebel w/ MPCC


Total Lunar Eclipse
January 20-21, 2019
The Holland Observatory
200mm Newtonian at f/5
Modified Canon 450D w/ MPCC
1/4 Sec.
2 Sec.
8 Sec.


Lunar Eclipse - 5/15/22
10:21 PM
11:11 PM
12:01 AM
The Holland Observatory
80ED Refractor at f/7.5
AT2FF Field Flattener
Modified Canon 450D Camera

The Moon

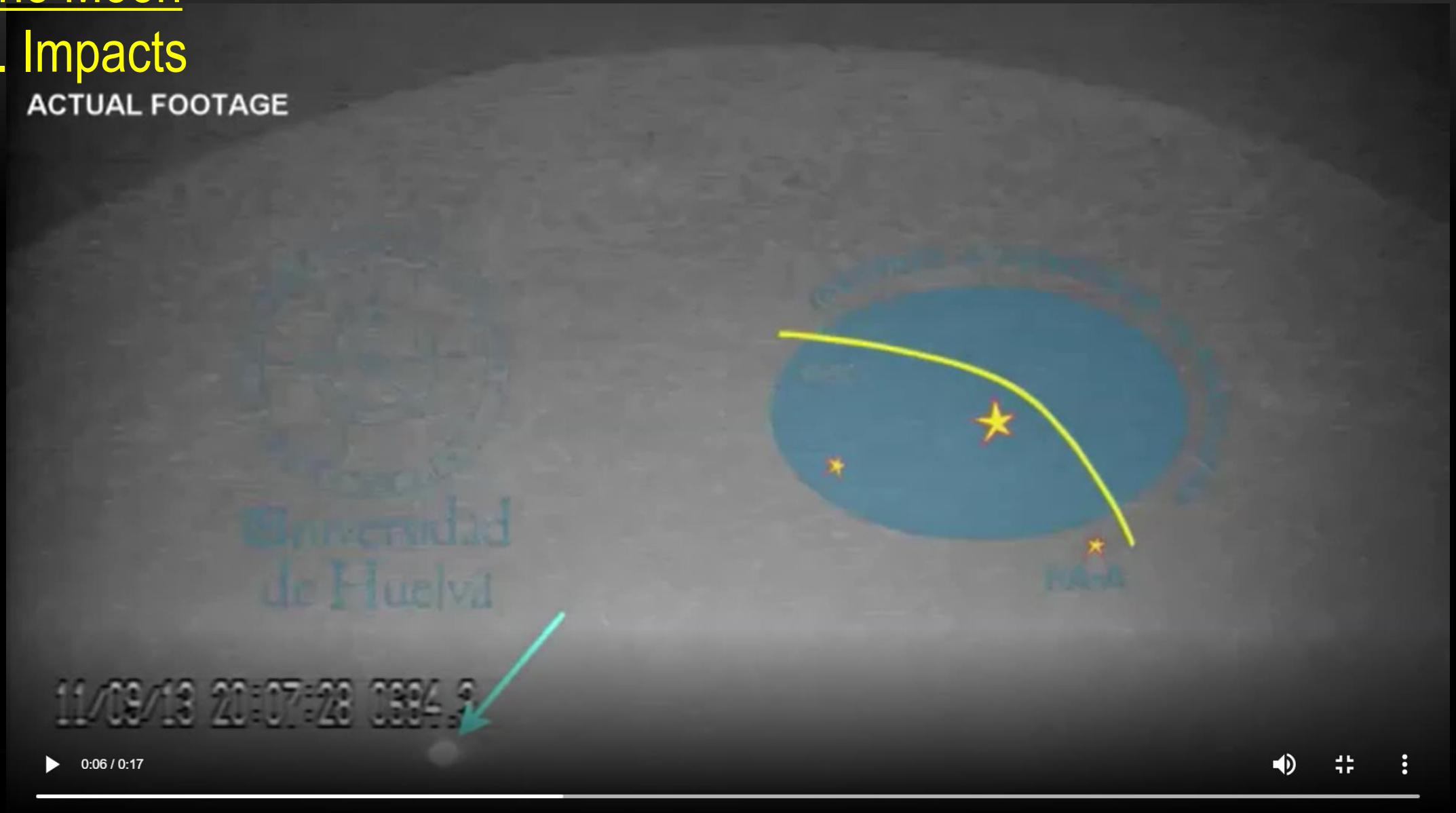
3. High Res Imaging



OBJECT: Letrone and Gassendi craters
IMAGER: Robert Reeves
EQUIPMENT: 11” EdgeHD & Skyris 274M
LOCATION: San Antonio, TX

The Moon

4. Impacts



https://www.theguardian.com/science/video/2014/feb/24/meteorite-hits-moon-lunar-impact-video

What else can we do?

Our Solar System Planets

1. Visual observing
2. Imaging
3. Phenomena of solar system planets

Our Solar System Planets

1. Visual observing

Even with small telescope:

- All planets visible
- Rings of Saturn
- Moons of Jupiter & Saturn
- High brightness – able to see in light polluted areas: Haak Winery Uranus example

Our Solar System Planets

2. Imaging

- Planetary Camera
- Hundreds of images
- Stacked and processed

*** In general – seeing is better here than other places in country, including West Texas !! Good seeing is key to planetary imaging.

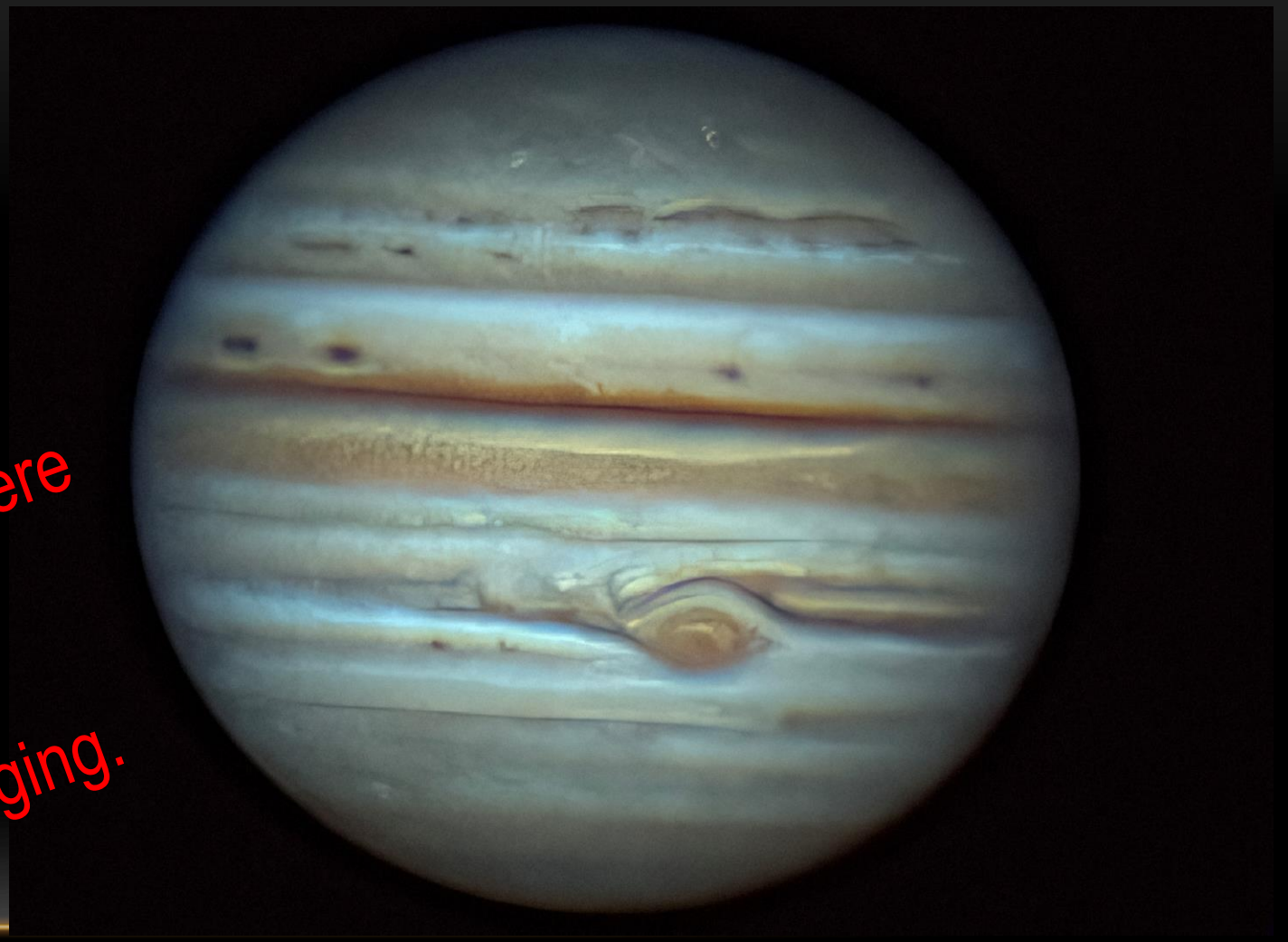


Image produced by Treavor Quinn

Our Solar System Planets

3. Phenomena of solar system planets

Many examples – a few here:

- Tilt of Saturn's rings
- Movement of Jupiter's Moons
  - Able to see IO disappear and reappear in one night
- Venus phases, similar to Moon
- Ice caps on Mars, changing with season
- Impacts on Jupiter

What about other solar system objects?

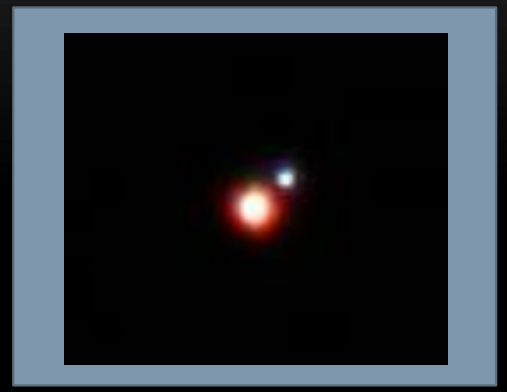
Meteor showers, comets, asteroids

=> Can be viewed & imaged but generally much better in dark sky areas

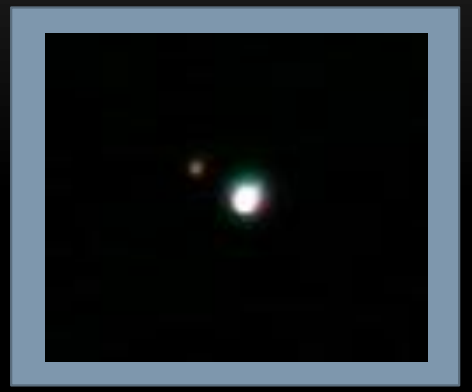
What else can we do?

Moving outside our Solar System =>

Multiple Star Systems (double stars)



Almach
in Andromeda



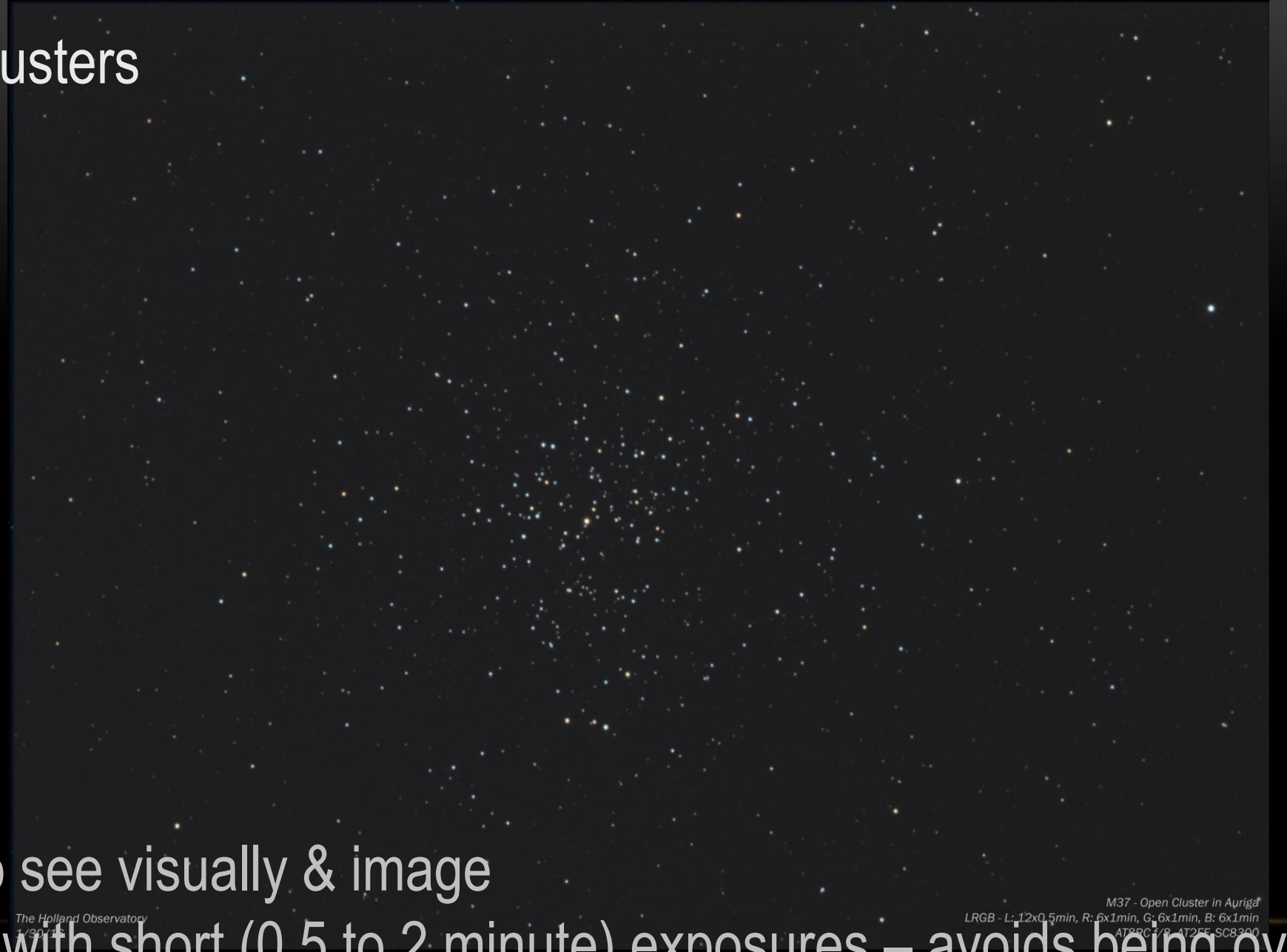
Eta Cassiopeiae

- Most star systems in the Milky Way are multiple star systems
- One celestial object that exhibits color with visual observing
- Many in view throughout the year
  - UHCL Star Party 11/16/22

Globular Clusters

- Able to see visually
- Image with short (1 to 2 minute) exposures – avoids being overwhelmed by light pollution

Open Clusters



- Able to see visually & image
- Image with short (0.5 to 2 minute) exposures – avoids being overwhelmed by light pollution

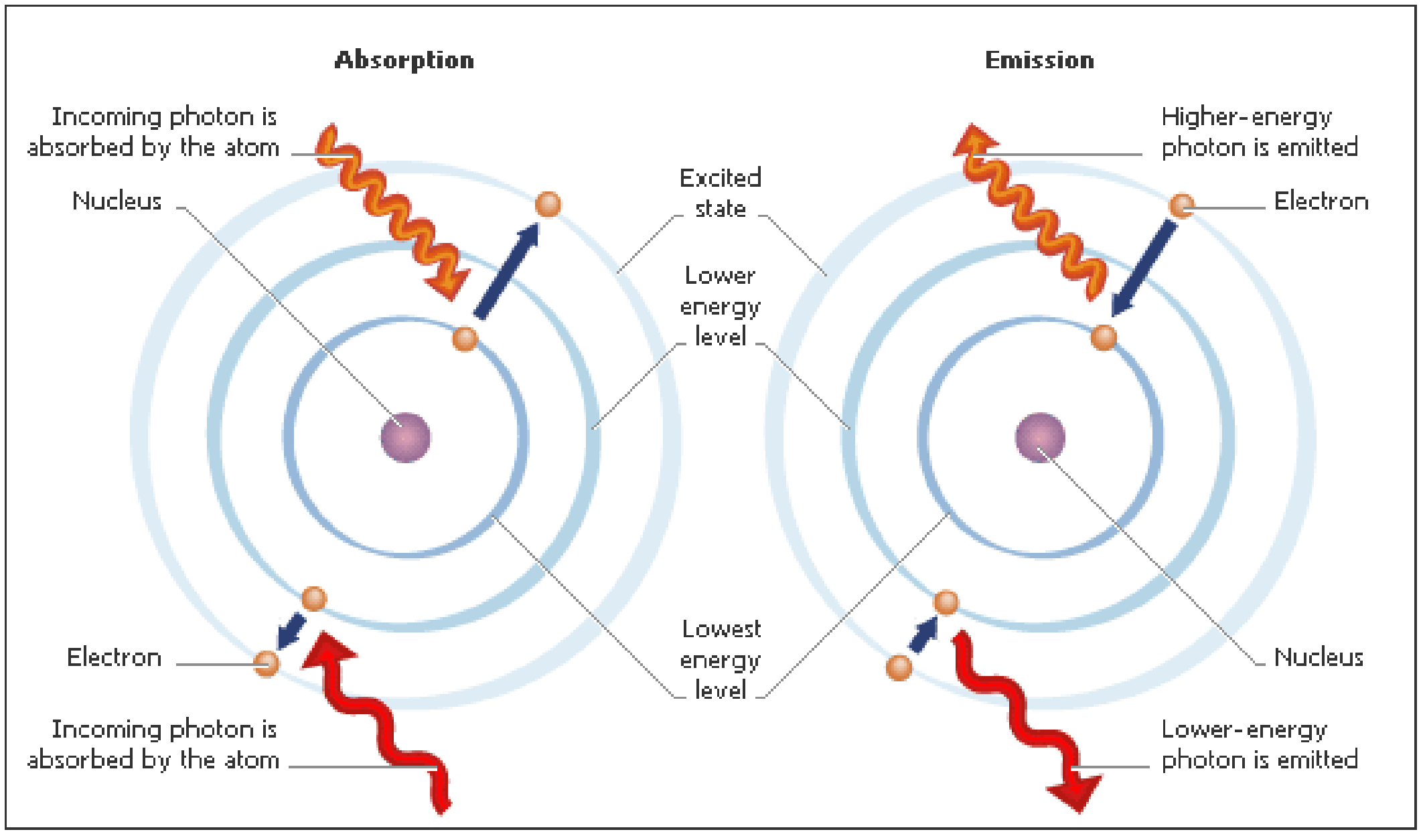
But ---

Deep images of Open Clusters with nebulosity requires a dark sky…

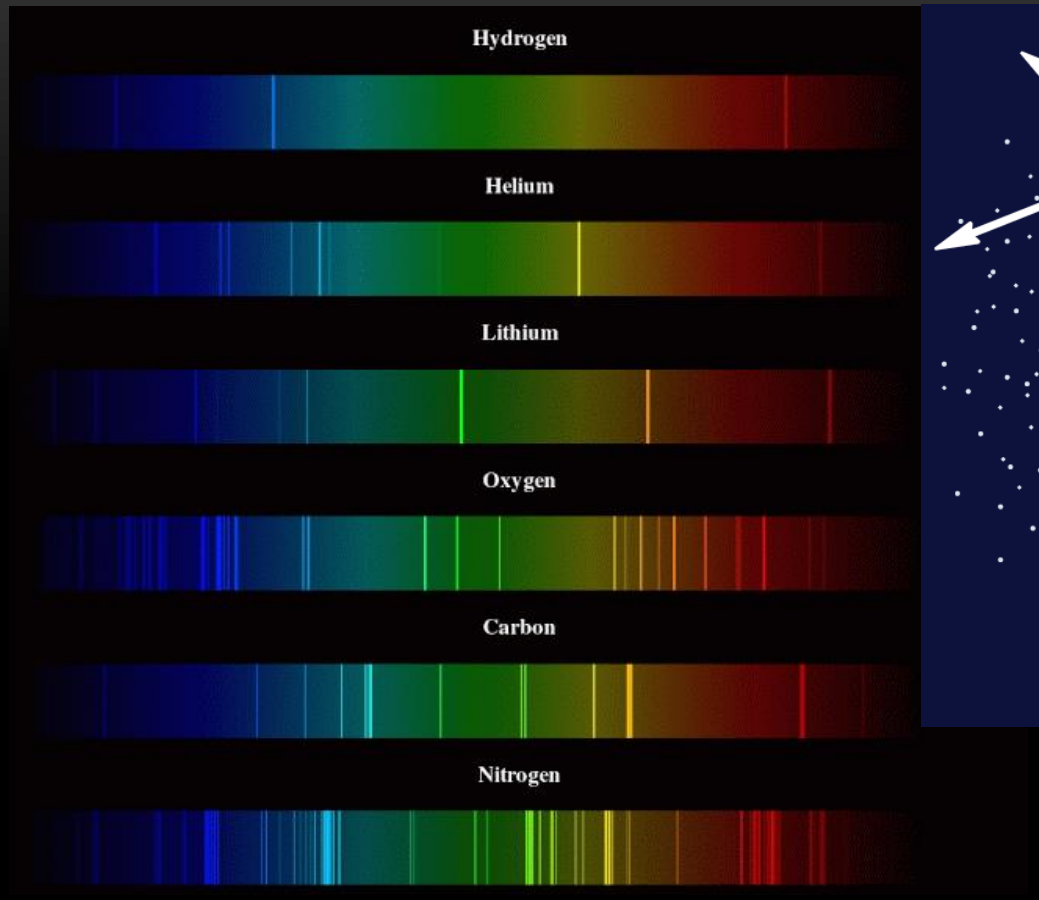
What else can we do?

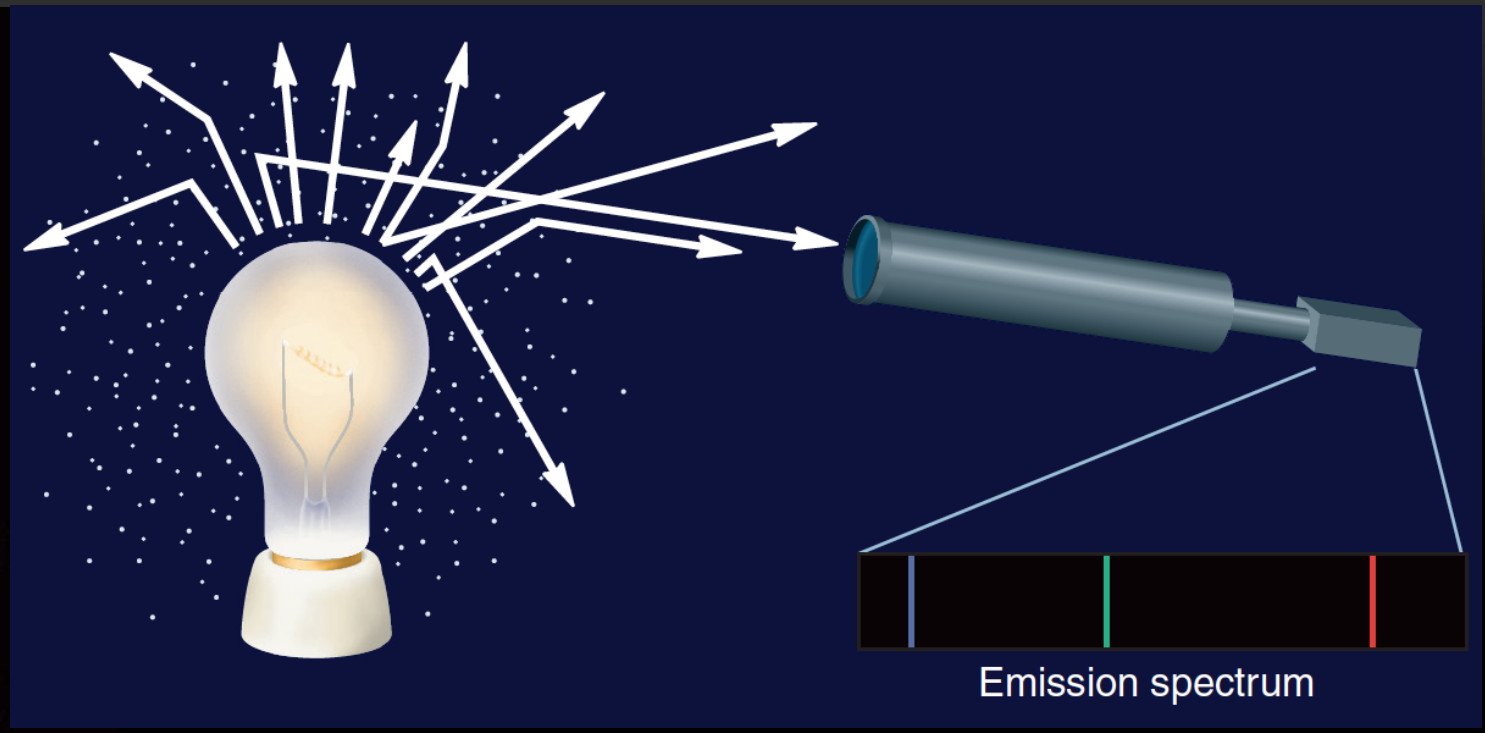
Emission Nebulae

What is an Emission Nebula?



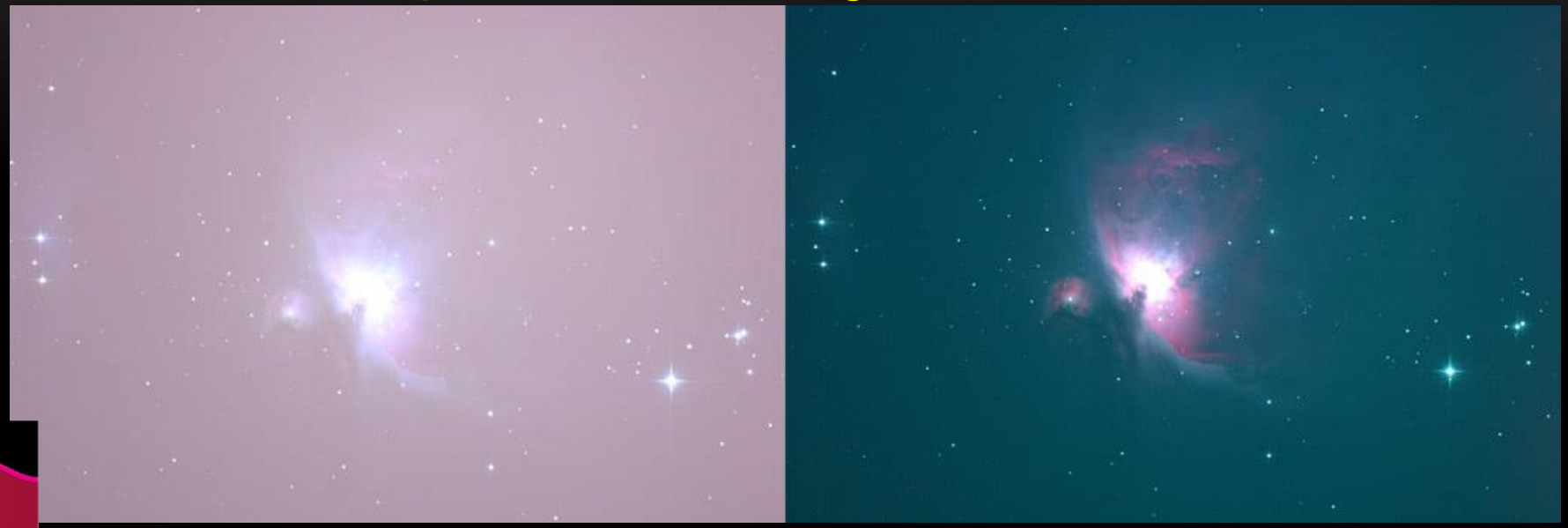
Foundations of Astronomy (Seeds & Backman)


Hydrogen
Helium
Lithium
Oxygen
Carbon
Nitrogen

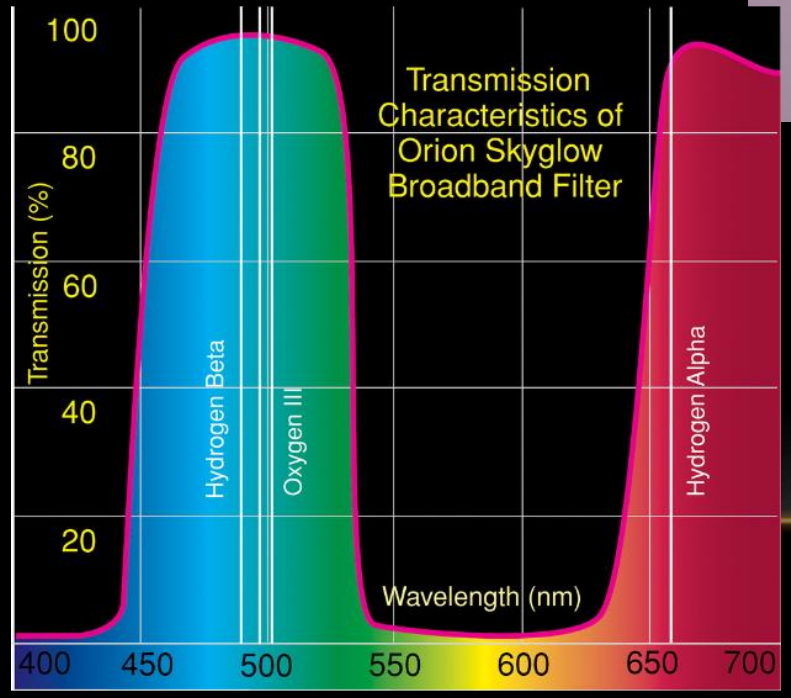

Emission spectrum

How can Emission Nebula be imaged in light polluted areas?

Since Emission Nebula emit at specific wavelengths => Filters



Orion Nebula with and without Skyglow Filter

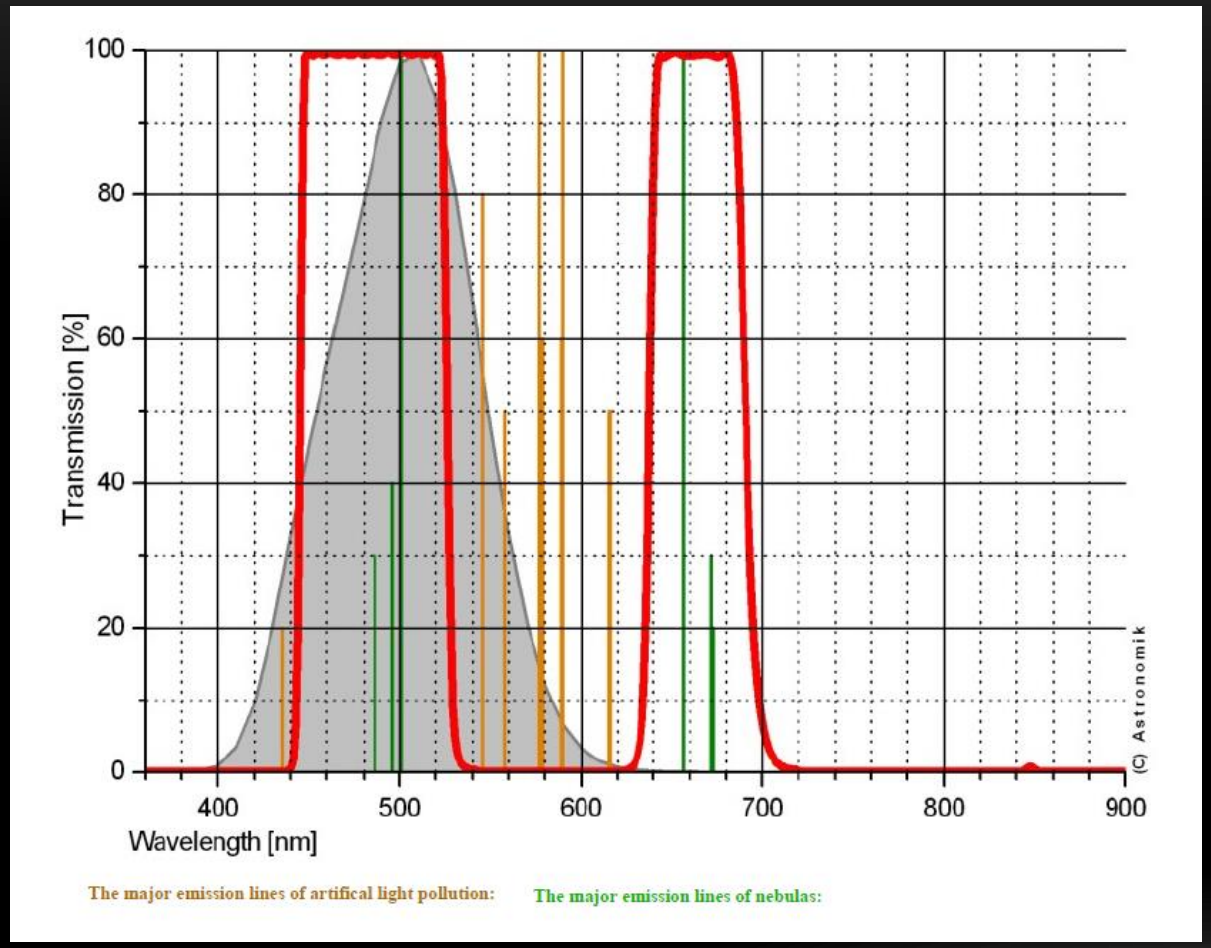


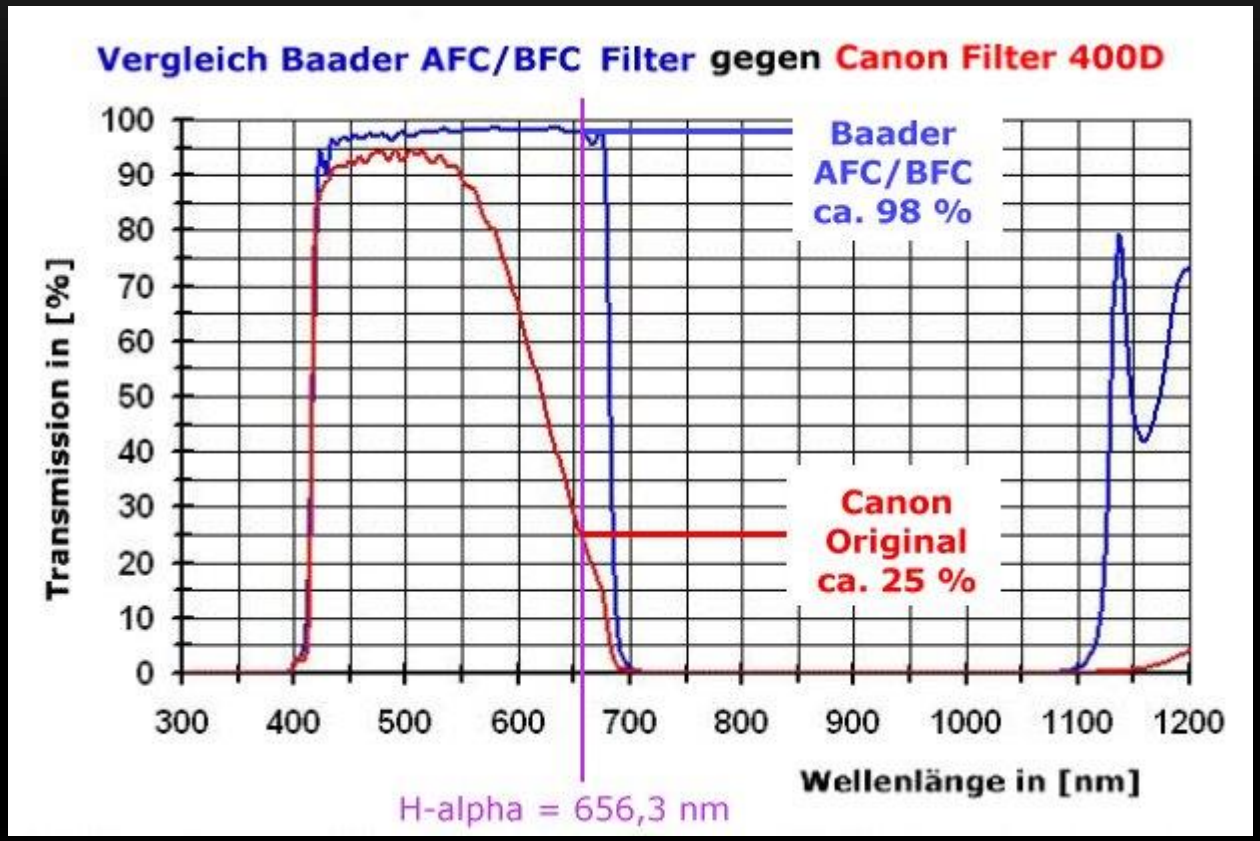
<= Pass emission wavelengths, block others

The Holland Observatory
12/23/13

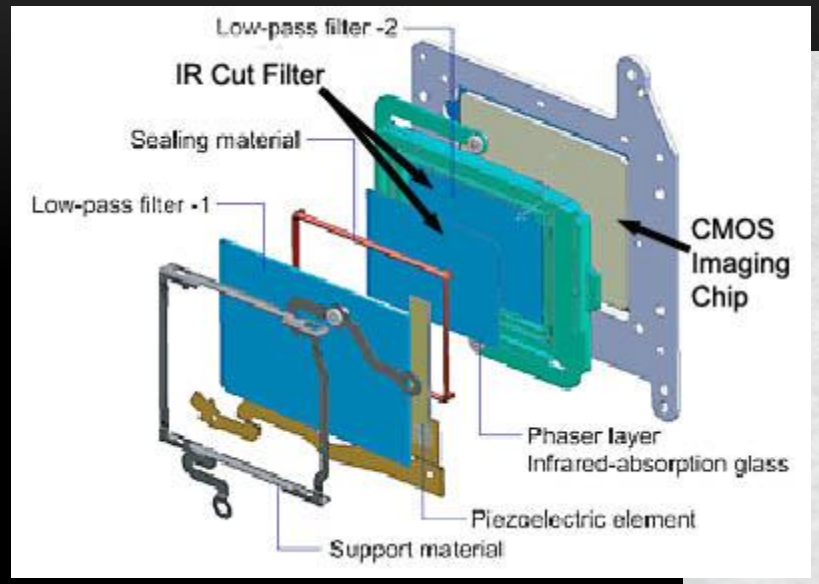
Orion's Belt Star Alnitak, Emission Nebula IC434 surrounding Dark Nebula B33 - The Horsehead Nebula, Emission Nebula NGC2024 - The Flame Nebula, Blue Reflection Nebula NGC2023 under Horsehead: all in Orion
40x5min, 200mm f/5 Newtonian, Baader MPCC, CLS Filter, Baader Filter Modified Canon 450D Camera

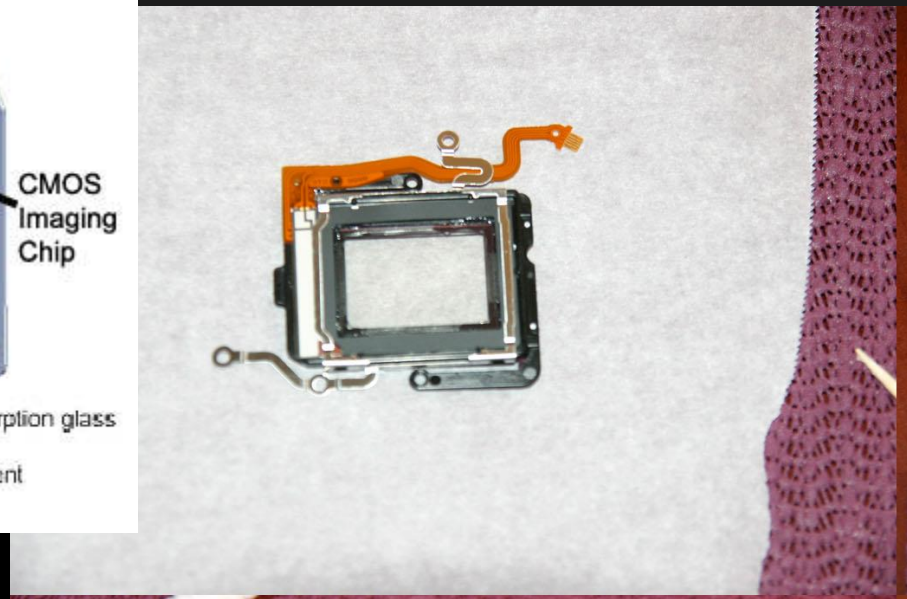
Previous image taken with Astronomik CLS Filter & Modified Canon DSLR





A quick detour => Modified Canon DSLR??





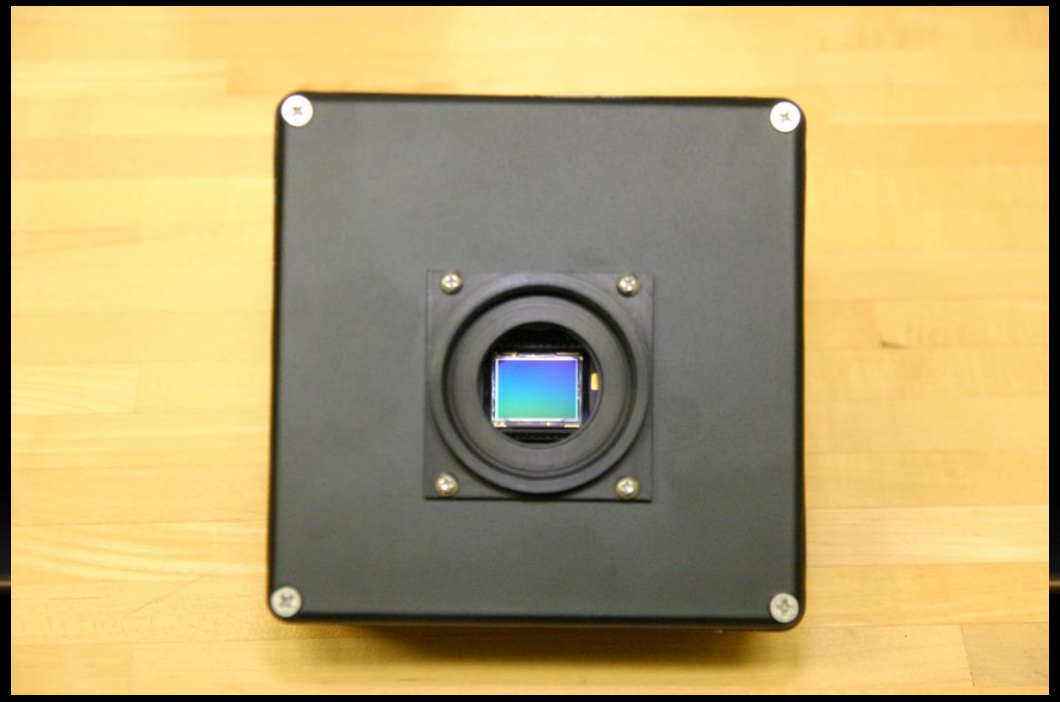
Replace IR Cut & Low Pass Filter #2 with new Baader UV / IR Filter

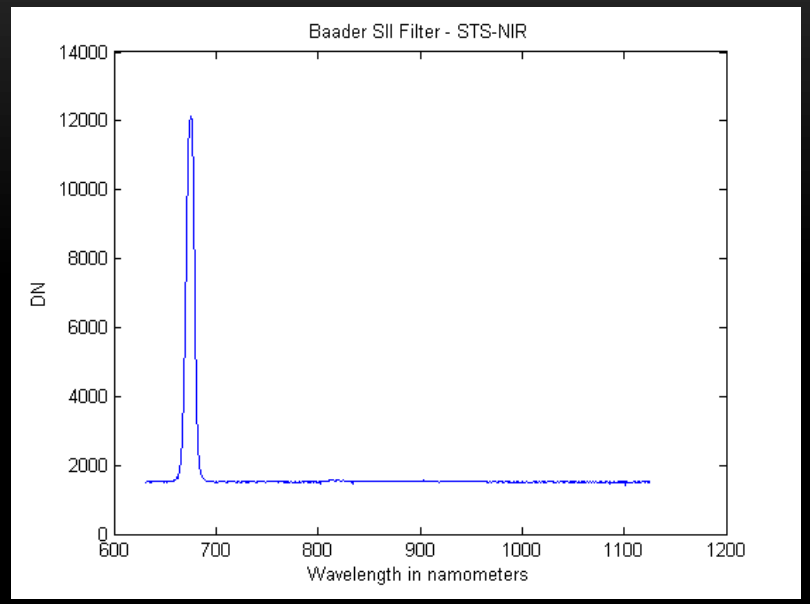
What else can we do?

Narrowband Imaging

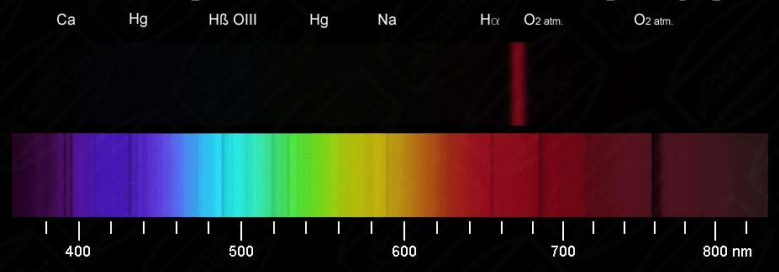
Note - Previous filters are considered “broadband” filters

Generally done with dedicated astronomical camera, rather than DSLR

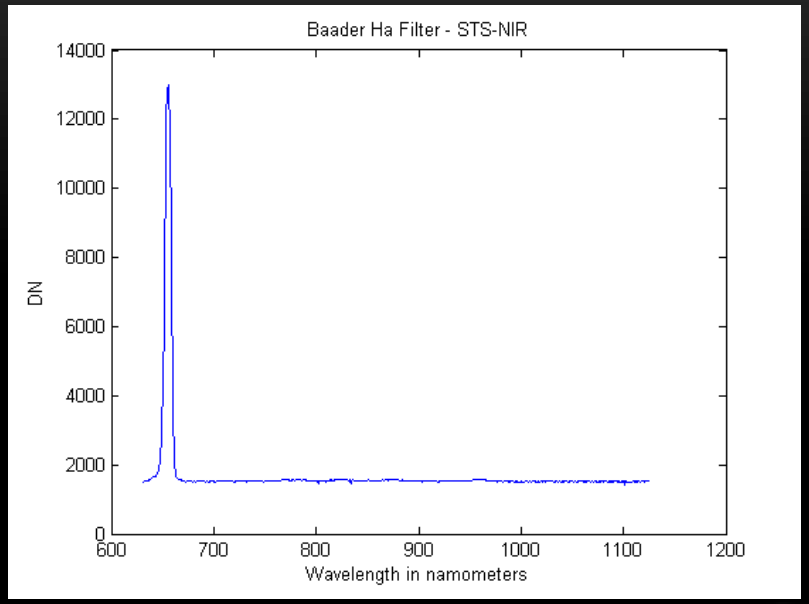




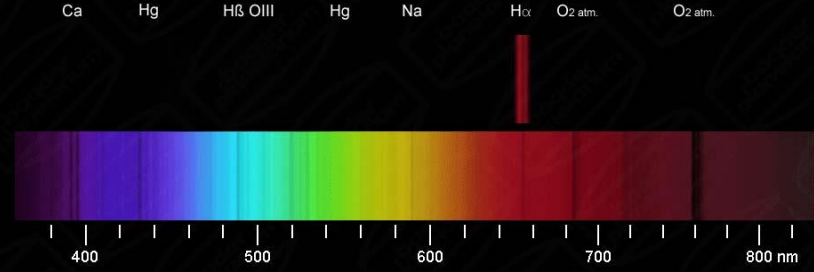
Baader S II-CCD 2458432 Narrowband-Filter 8nm
Real Filter-Spectrum, taken with MPI-DADOS-Spectrograph



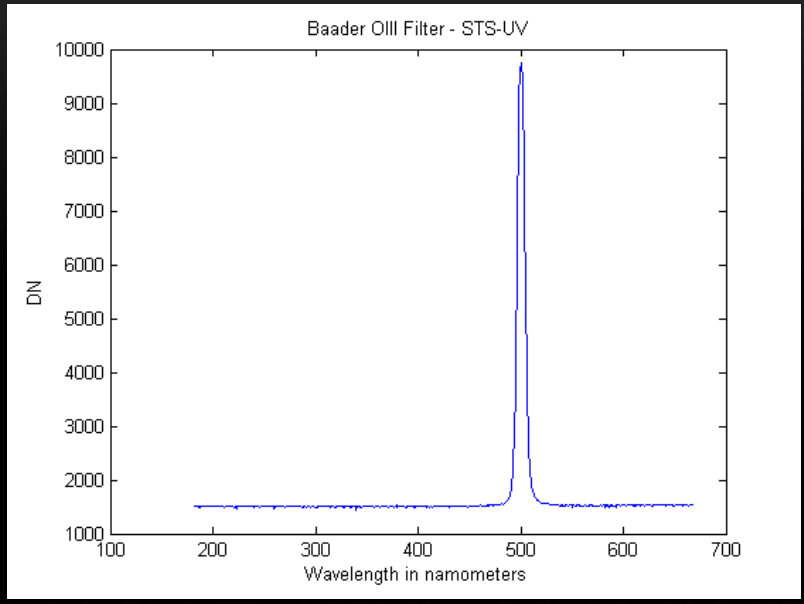
Comparison Solar-Spectrum



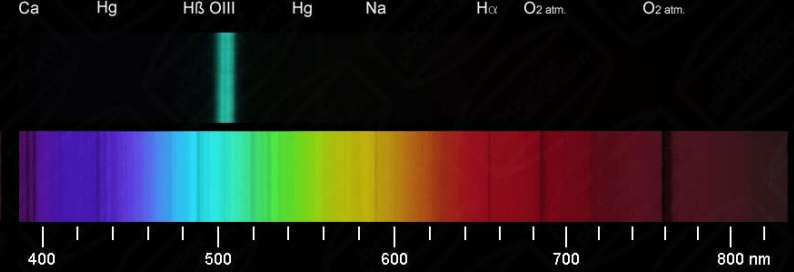
Baader 7nm H-alpha CCD 2458383 Filter
Real Filter-Spectrum, taken with MPI-DADOS-Spectrograph



Comparison Solar-Spectrum

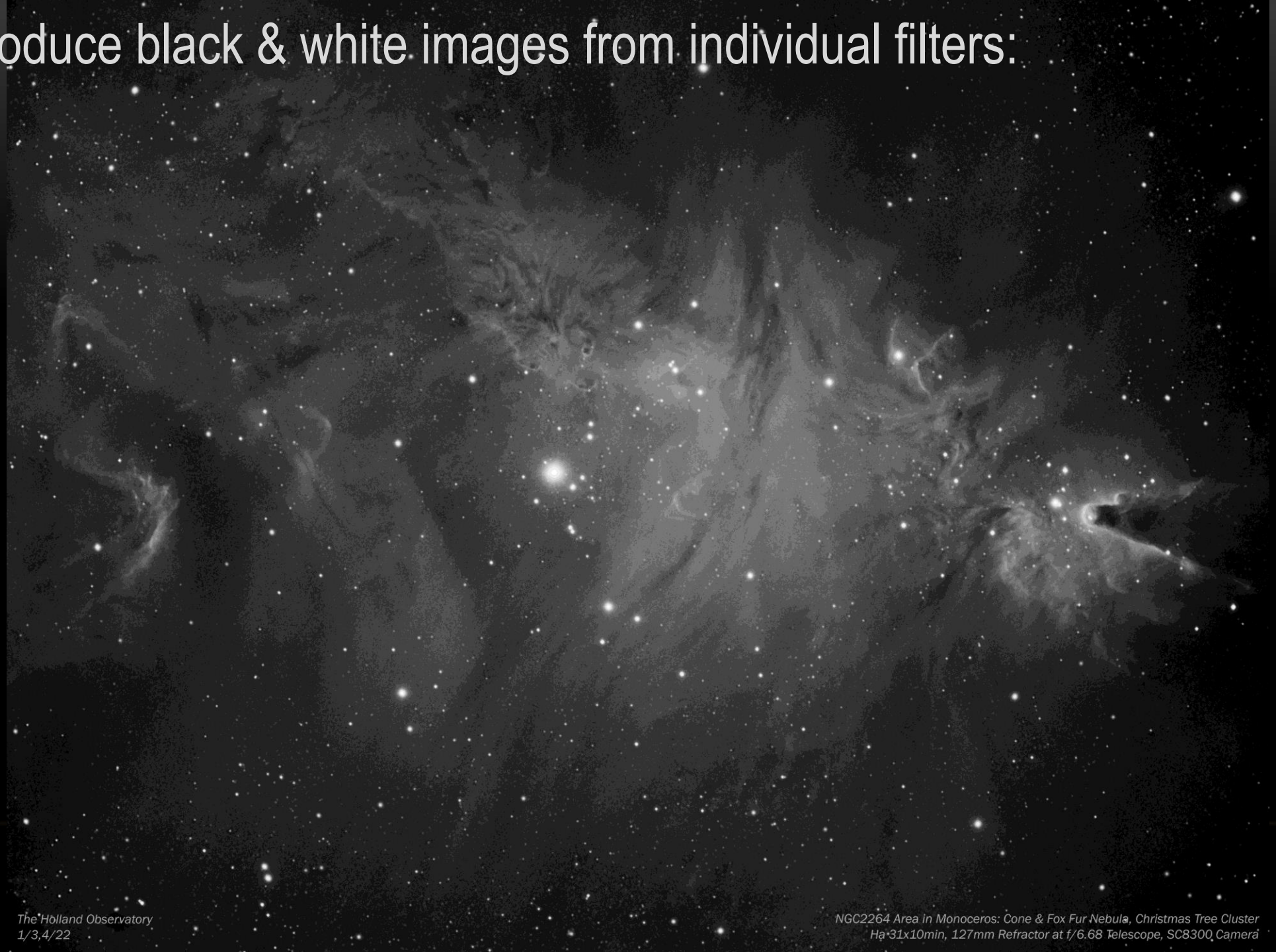


Baader OIII-CCD 2458437 Narrowband-Filter 8,5nm
Real Filter-Spectrum, taken with MPI-DADOS-Spectrograph



Comparison Solar-Spectrum

Can produce black & white images from individual filters:



The Holland Observatory
1/3,4/22

NGC2264 Area in Monoceros: Cone & Fox Fur Nebula, Christmas Tree Cluster
Ha 31x10min, 127mm Refractor at f/6.68 Telescope, SC8300 Camera


The Holland Observatory
5/5-6/21
M16 - The Eagle Nebula in Serpens
Pseudo Luminance - Ha: 18x5min + OIII: 24x5min
AT8RC at f/8, SC285 Camera

The Holland Observatory
10/29,30/16

NGC7380 - The Wizard Nebula in Cepheus
Ha: 44x15min, AT8RC Telescope f/8, AT2FF, SC8300 Camera

SII
29x15min

Ha
31x15min

OIII
33x15min

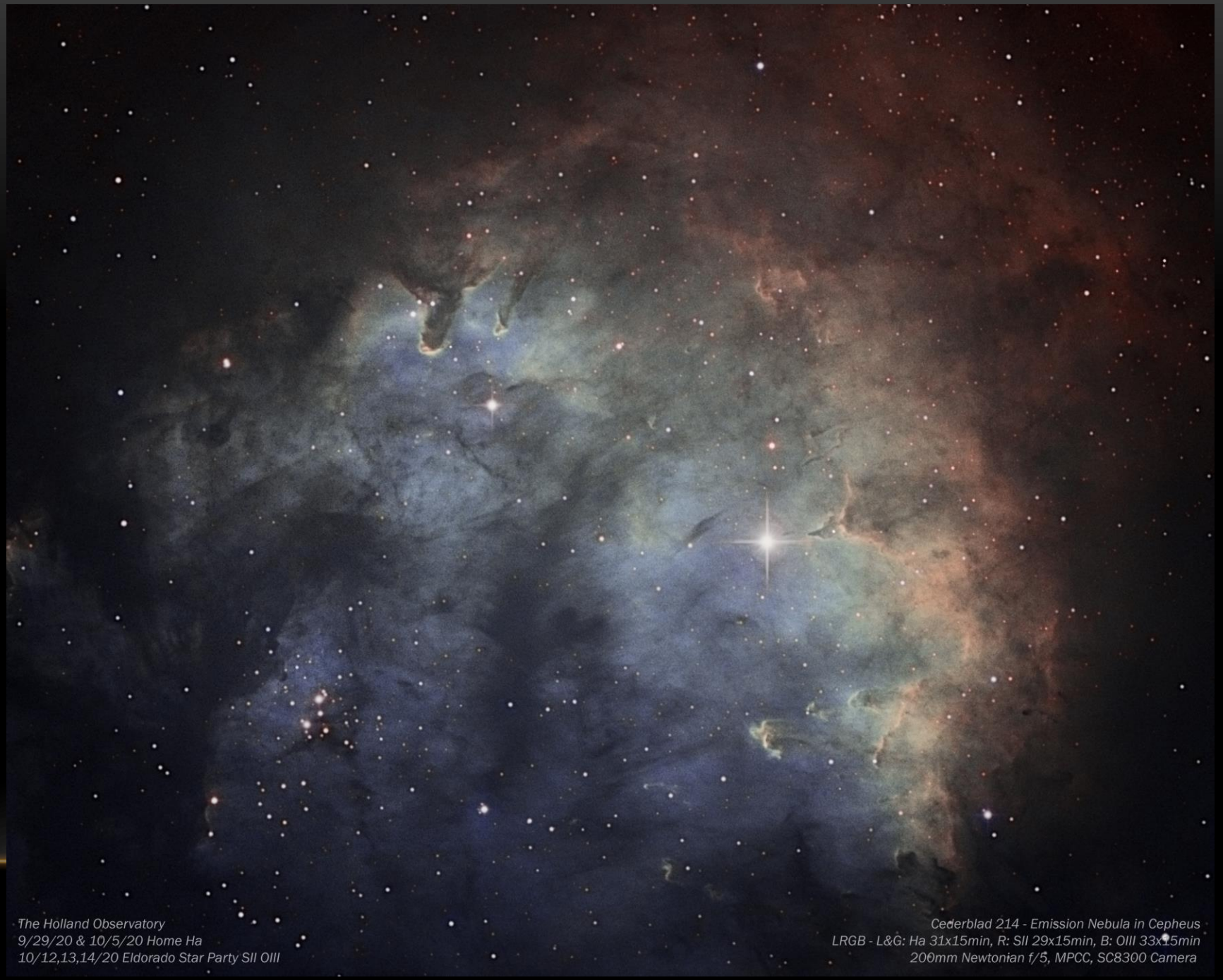
Total 93x15min => 23hours, 15 minutes

Narrowband Imaging

Can produce color images from individual filters by assigning filters to different colors

Processing

- Calibration: DSS (Deep Sky Stacker) [Provided better results than PixInsight (PI)]
- PI Dynamic Crop
- PI MultiScale Linear Transform (MLT) noise reduction for SII & OIII
- Photoshop (PS) Levels & Curves, Ha Smart Sharpen with star mask
- PS LRGB combine
- PI Correct Magenta Stars script
- PS Star blur w/ star mask
- PS Reduce Color Noise
- PS Dust & Scratches
- PI Subtractive Color Noise Reduction (SCNR) 87% + Color Mask script 13% to fix colors



The Holland Observatory
1/27 - 28/12

NGC2244, 2237 - 2239, The Rosette Nebula in Monoceros
L(Ha), R(SII), G(Ha), B(OIII - Ha: 20x3min, SII:13x3min + 40x4min; OIII:20x3min
200mm f/2.8 Canon L Series Lens, SC285 Camera

The Holland Observatory
10/15/14 & 11/18/14

Melotte 15 / IC1805 Heart of the Heart Nebula in Cassiopeia
Narrowband - Ha: 14x12min, SII: 15x12min, OIII: 11x12min
200mm Newtonian at f/5, MPCC, SC285 Camera

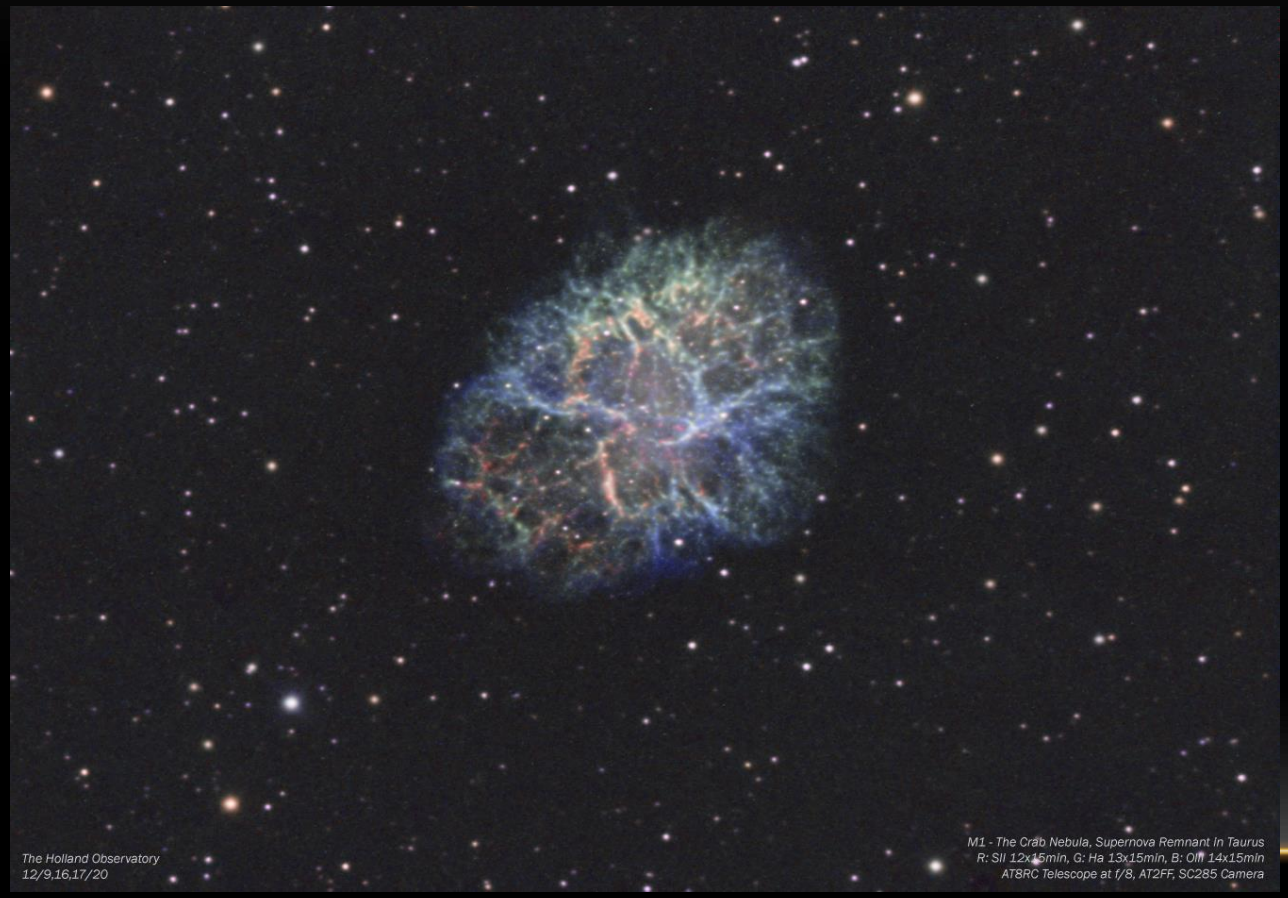
The Holland Observatory
10/21,22,24,26,27,28/16

NGC281 - Pacman Nebula in Cassiopeia
LRGB - L Ha: 44x15min, R SII: 41x15min, G Ha: 44x15min, B OIII: 35x15min
AT8RC Telescope f/8, AT2FF, SC8300 Camera

What else can we image with Narrowband Filters?

1. Supernova Remnants
2. Planetary Nebulae
3. Wolf-Rayet Stars

1. Supernova Remnants



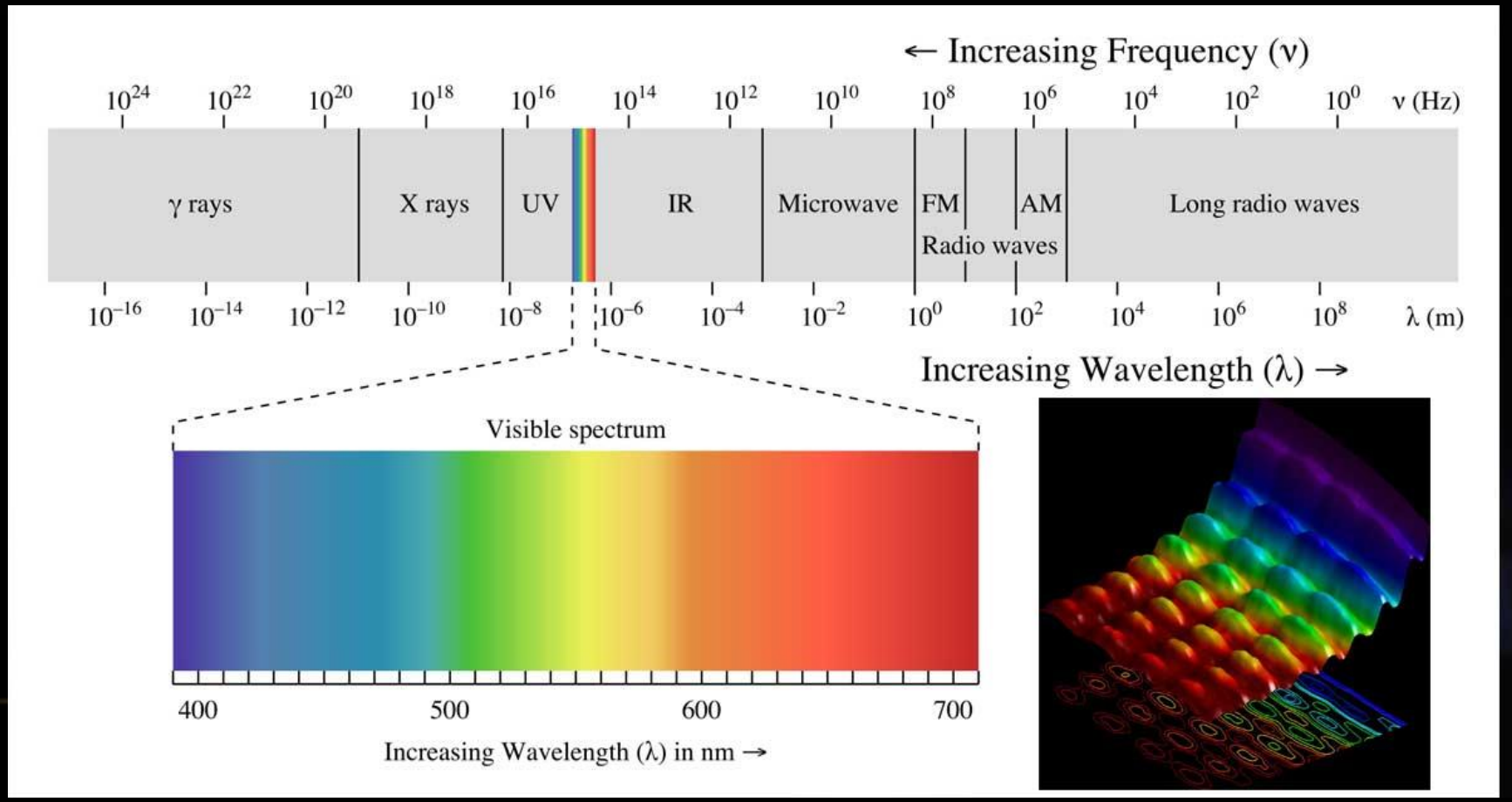
2. Planetary Nebulae

3. Wolf-Rayet Stars (First noted in 1867 by French Astronomers Charles Wolf and George Rayet, the spectra of Wolf-Rayet stars are characterized by broad band emission lines predominantly of helium. Massive, luminous, and hot (likely decended from stars of spectral class O), they develop intense radiation pressure and winds. A Wolf-Rayet's violent behavior results in tremendous mass-loss, making the star unstable. It's hydrogen-rich atmosphere is stripped away. Intense radiation from the exposed helium core expels gas at high-velocity that collides into a previously ejected envelope to create the shell.)

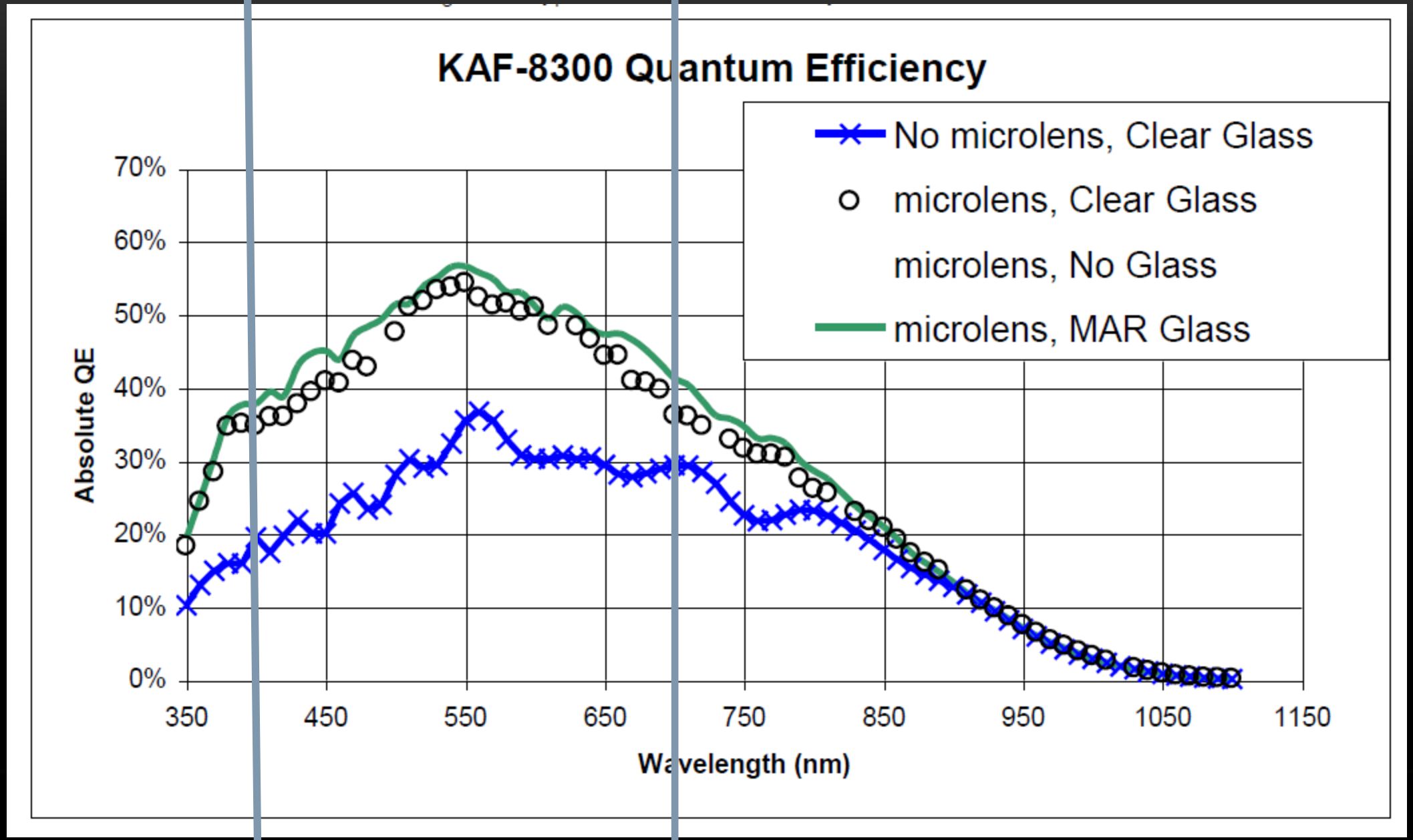
What else can we do?

What about other types of filters?

It turns out that most light pollution occurs in Visible portion of spectrum



Ultraviolet Visible Spectrum Near Infrared (NIR)



NIR displays different features than visible range

NIR makes imaging galaxies possible from light polluted areas

The Holland Observatory
1/17/13 and 2/13, 14, 16/13

M51 - The Whirlpool Galaxy in Canes Venatici
NIR - L: NIRL 18x10min; R: >880nm 15x10min + 3x10min; G: 800-900nm 12x10min; B: 700-800nm 11x10min
200mm Newtonian f/5, SC285 Camera

What have we done so far?

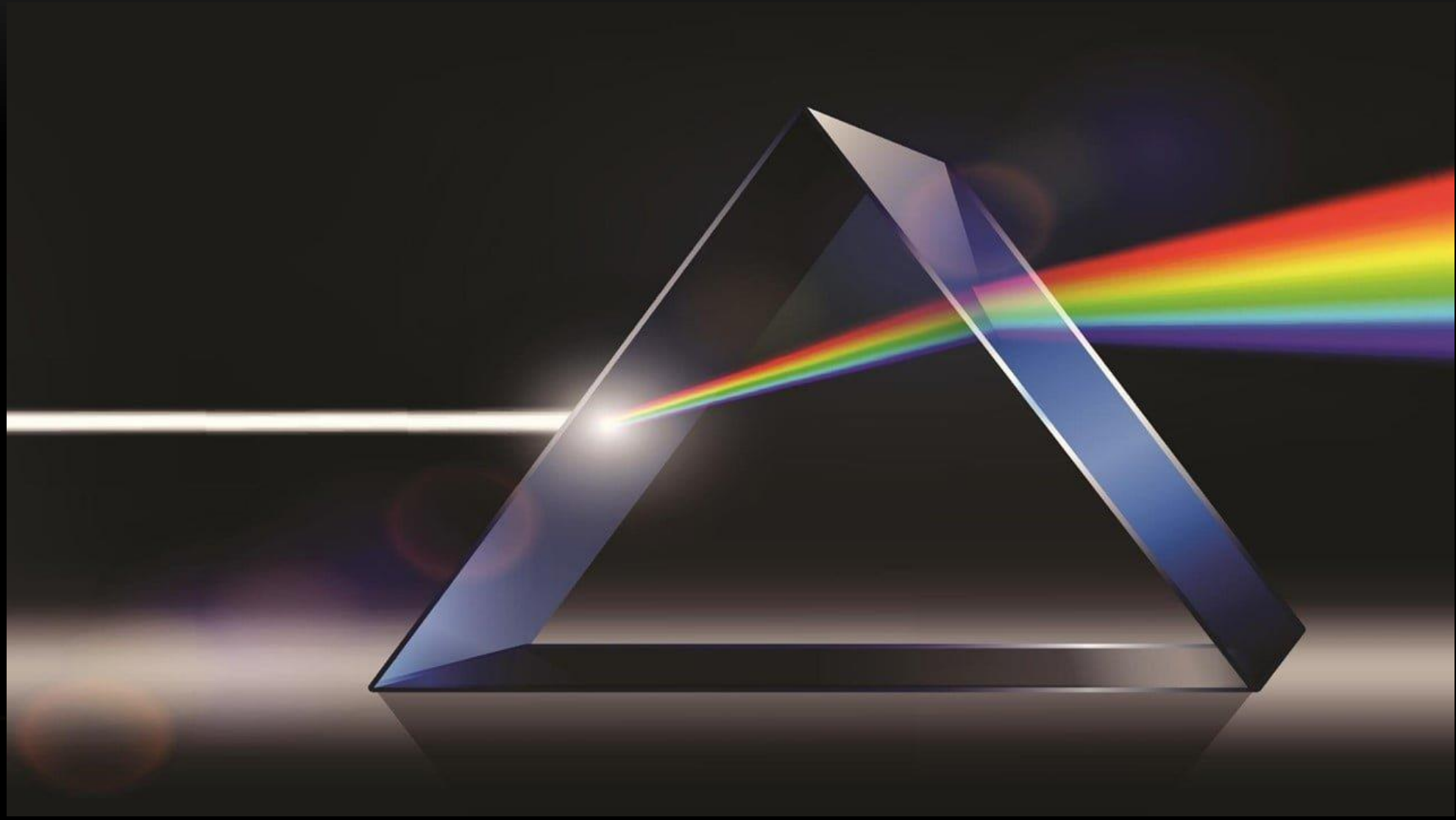
- Solar System: Sun, Moon, planets
- Double Stars, Globular Clusters, Open Clusters
- Emission Nebula – Broadband and Narrowband
- Supernova Nebula, Planetary Nebula, Wolf-Rayet Stars - Narrowband
- NIR Imaging

What else can we do?

How about something that is not imaging?

How about something more Sciencey?

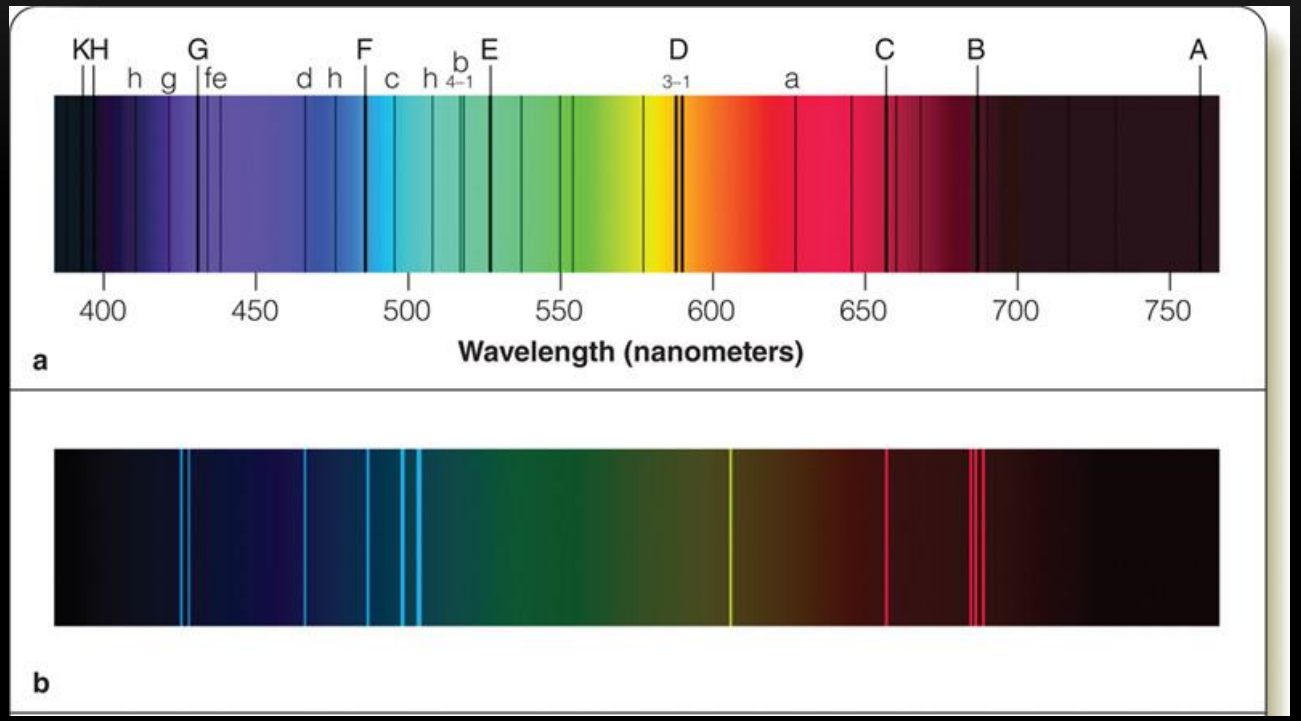
Spectroscopy



Spectrum of the Sun

Project STAR Spectrometer, $36
(Flame spectra, street lights, solar)

The Sun's Spectrum



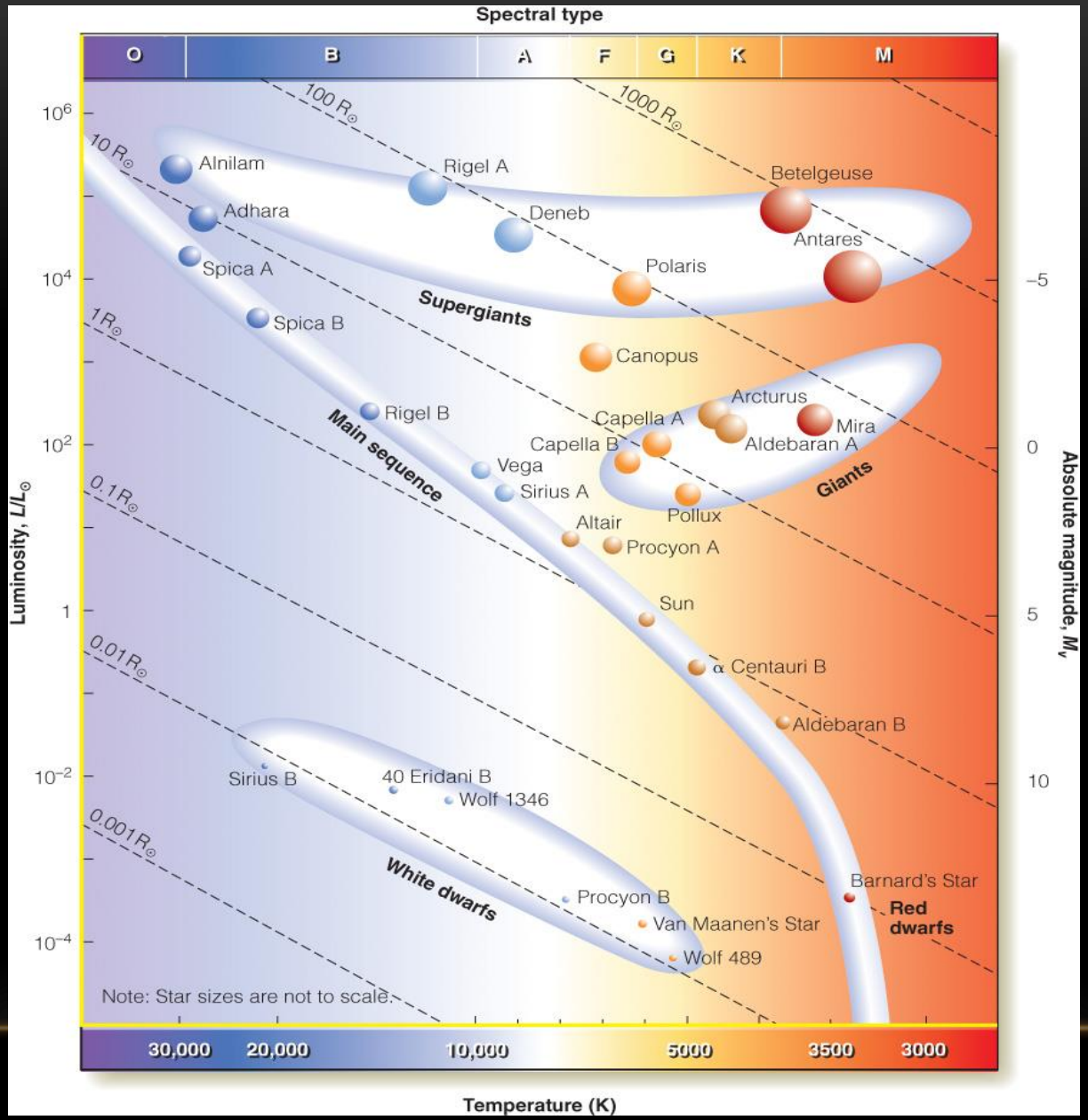
Foundations of Astronomy (Seeds & Backman)

Spectrum of Stars & Deep Sky Objects

Field Tested Systems - produces hardware & software which enables spectroscopy

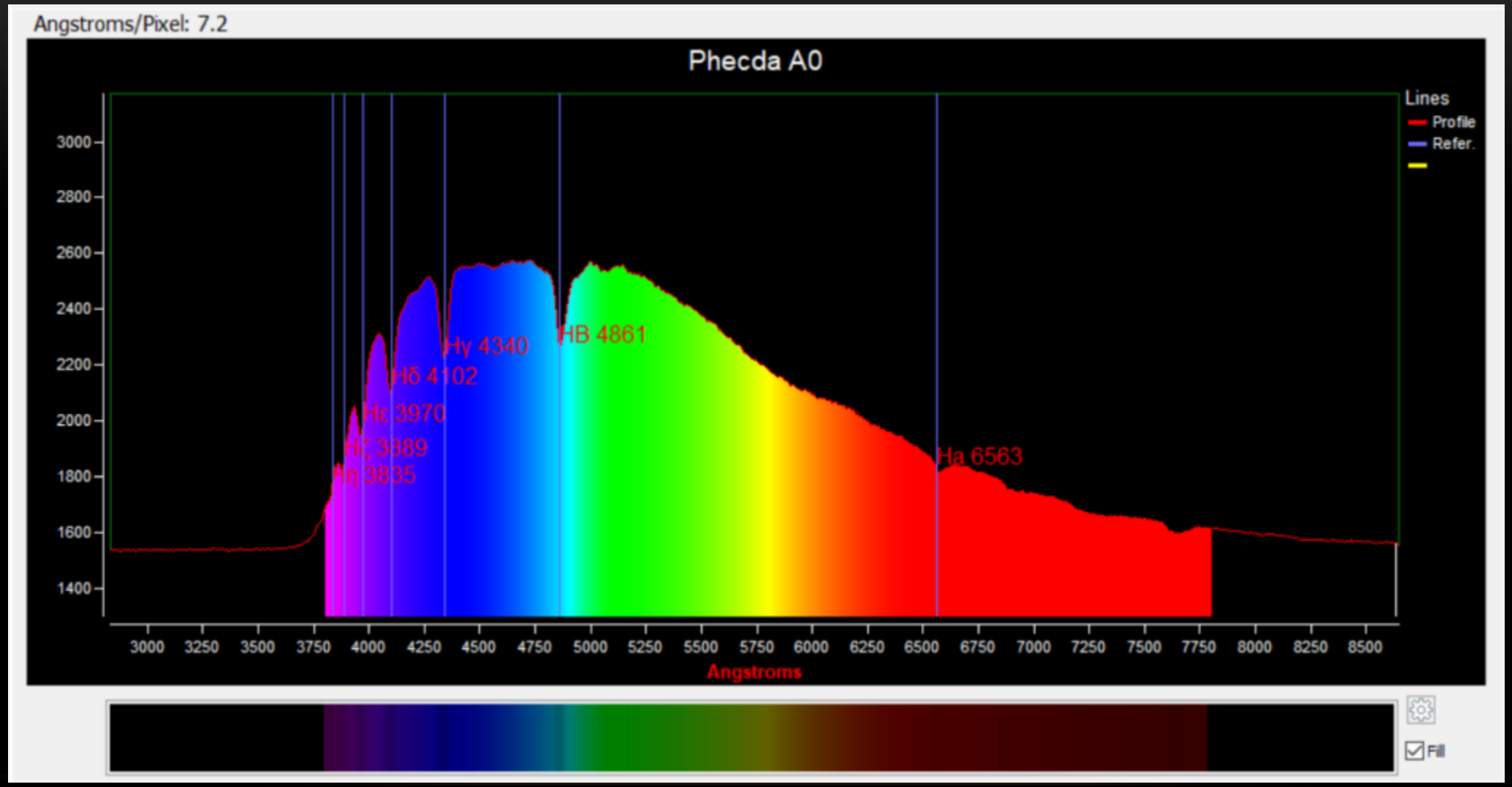
Rspec (Real-time Spectroscopy) at https://www.rspec-astro.com/

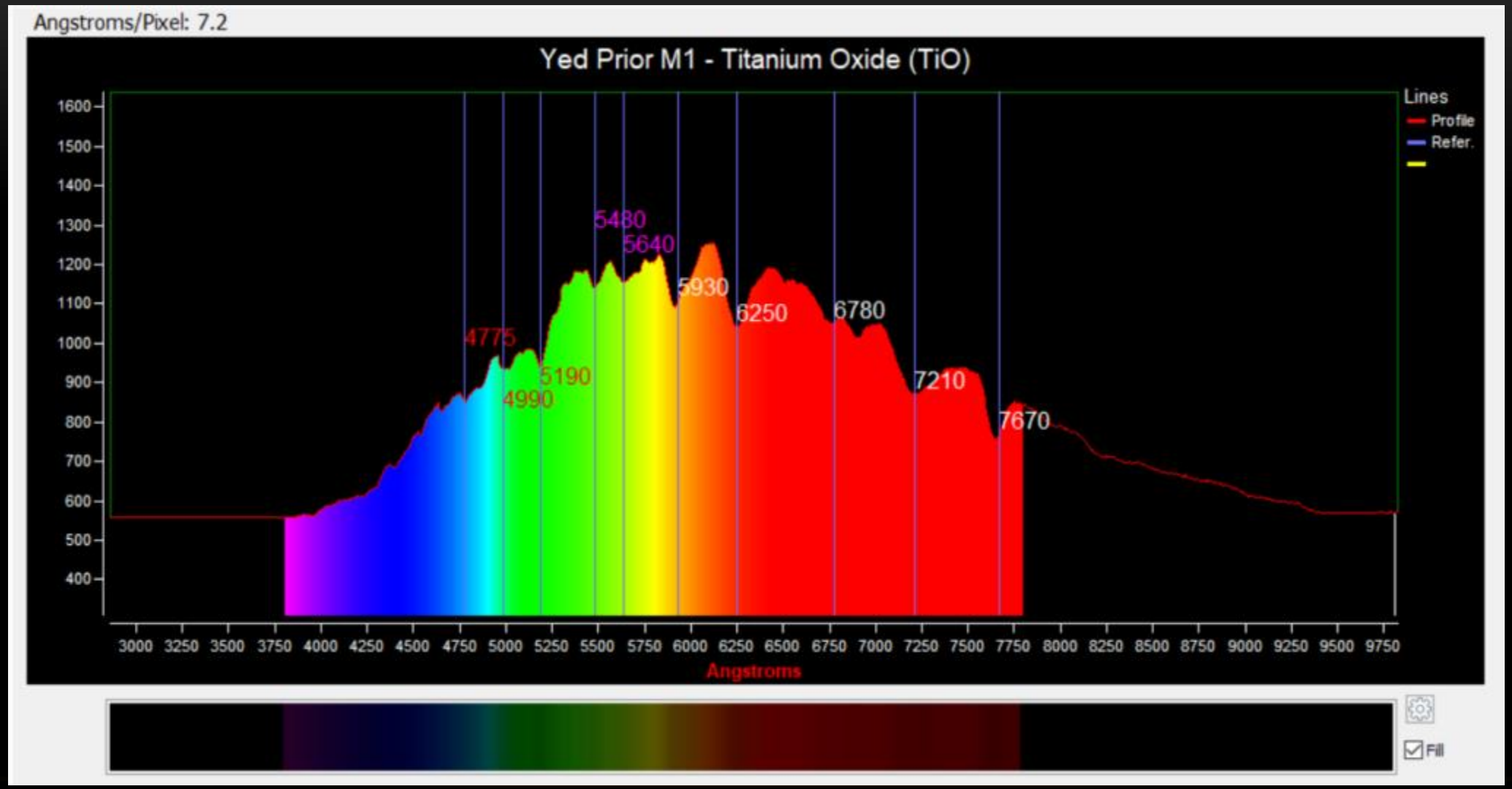
Hertzsprung-Russell (H-R) Diagram



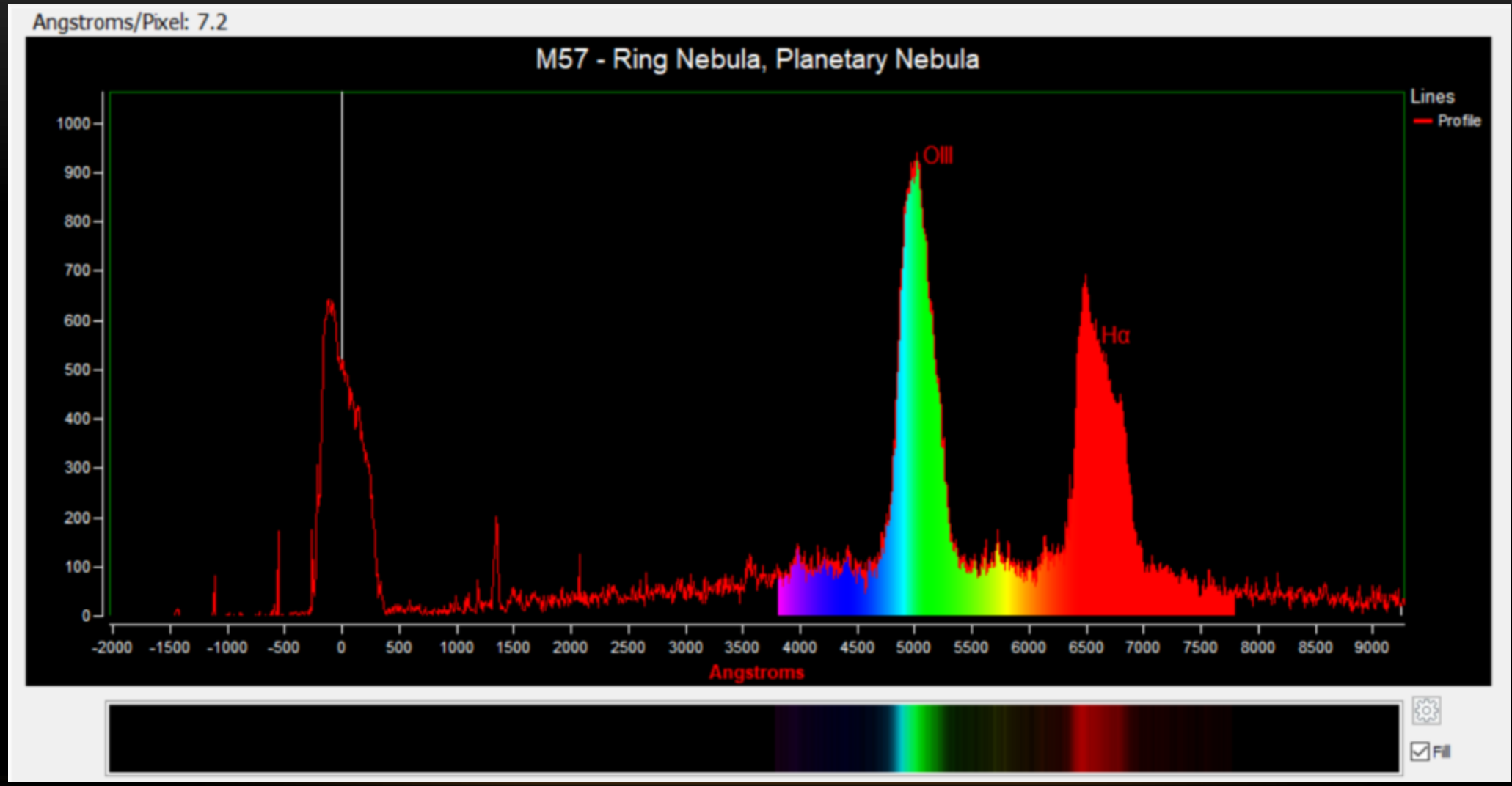
(Foundations of Astronomy – Seeds & Backman)

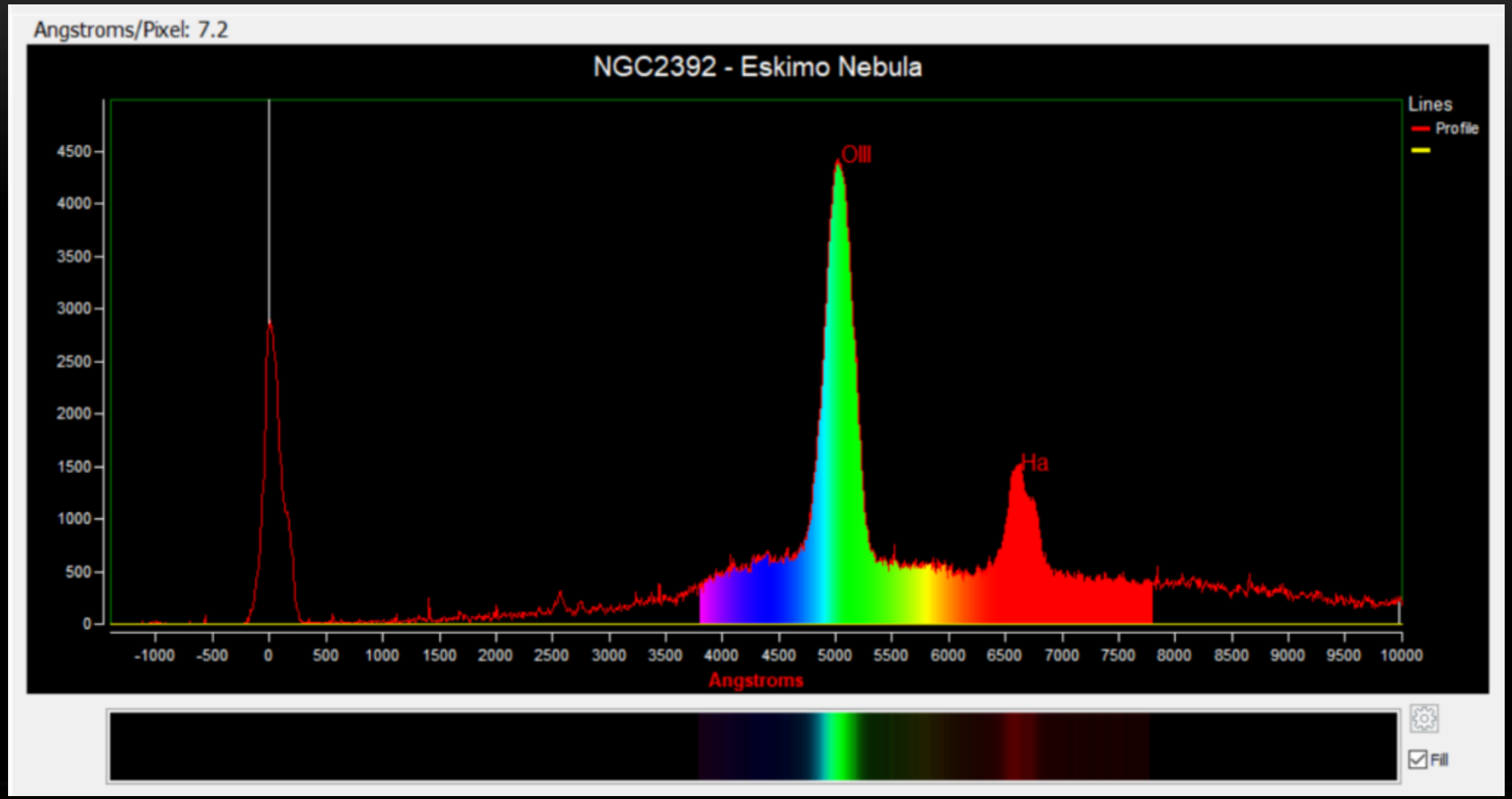
Stellar Spectra




Angstroms/Pixel: 7.2
Yed Prior M1 - Titanium Oxide (TiO)
Lines
Profile
Refer.
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
5480
5640
5930
6250
6780
4775
5190
4990
7210
7670
3000 3250 3500 3750 4000 4250 4500 4750 5000 5250 5500 5750 6000 6250 6500 6750 7000 7250 7500 7750 8000 8250 8500 8750 9000 9250 9500 9750
Angstroms
Fill

Planetary Nebula Spectra



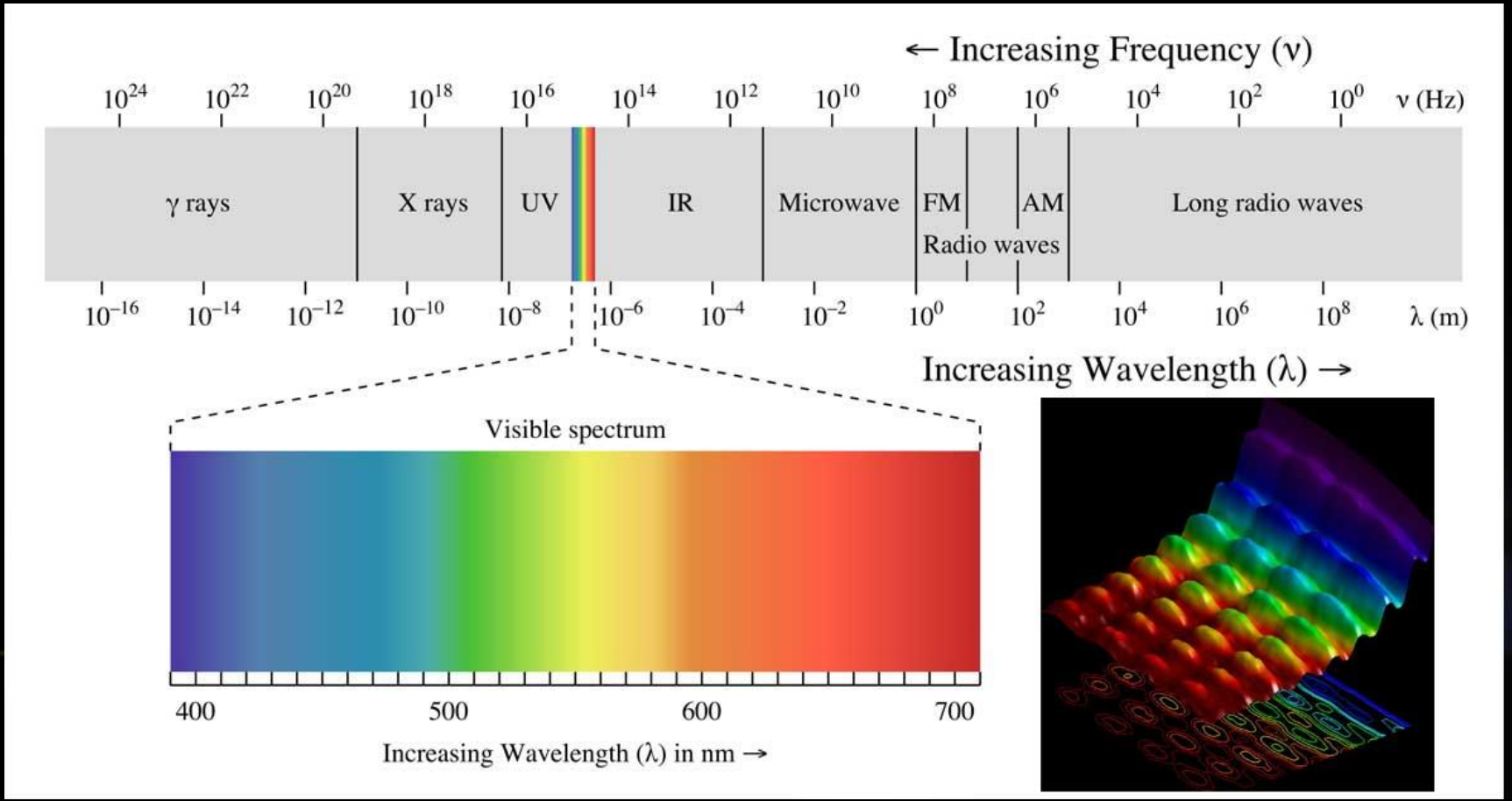

Angstroms/Pixel: 7.2
NGC2392 - Eskimo Nebula
Lines
Profile
OIII
Ha
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-1000 -500 0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000 8500 9000 9500 10000
Angstroms
Fill

What else can we do?

One more thing =>

Radio Astronomy

- Can be done day or night
- Light pollution plays no role
- Can be done with or without clouds



21cm Radio Telescope

(21cm => 1.42GHz)
Neutral Hydrogen Emission

WiFi Dish Antenna:
eBay

- 24dBi gain
- 2.4GHz but works at 1.42GHz
- 14ºx10º beam width

Low Noise Amplifier:
Amazon

- 40dB, Tuned for 21cm

Software Defined Radio:
https://www.rtl-sdr.com/

- USB interface

SDR# software -

21cm Radio Telescope
(21cm => 1.42GHz)
Hydrogen Emission

- Raspberry Pi Configuration

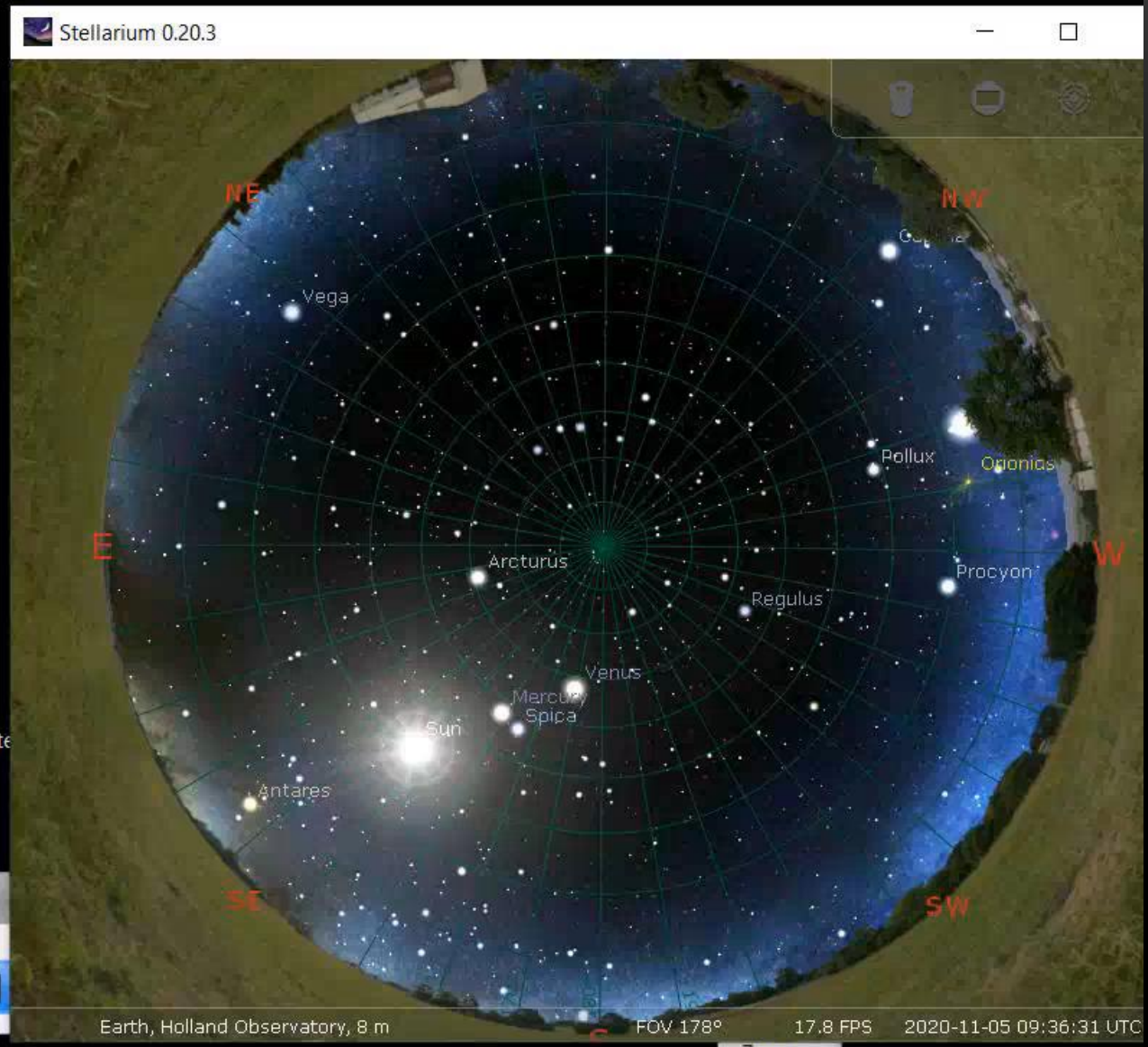
Sawbird Low Noise Amplifier with Hydrogen bandpass (1420MHz)

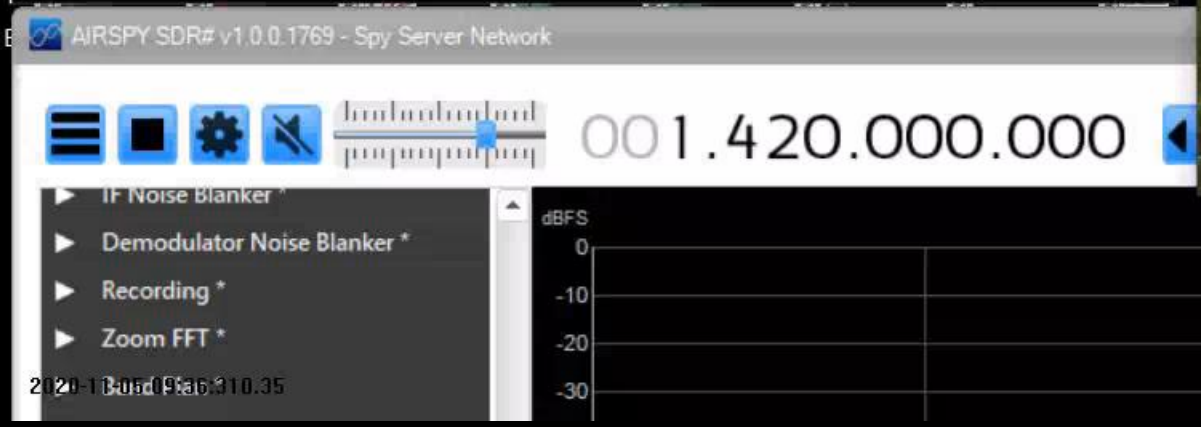
Software Defined Radio (SDR) receiver

Raspberry Pi 3B+

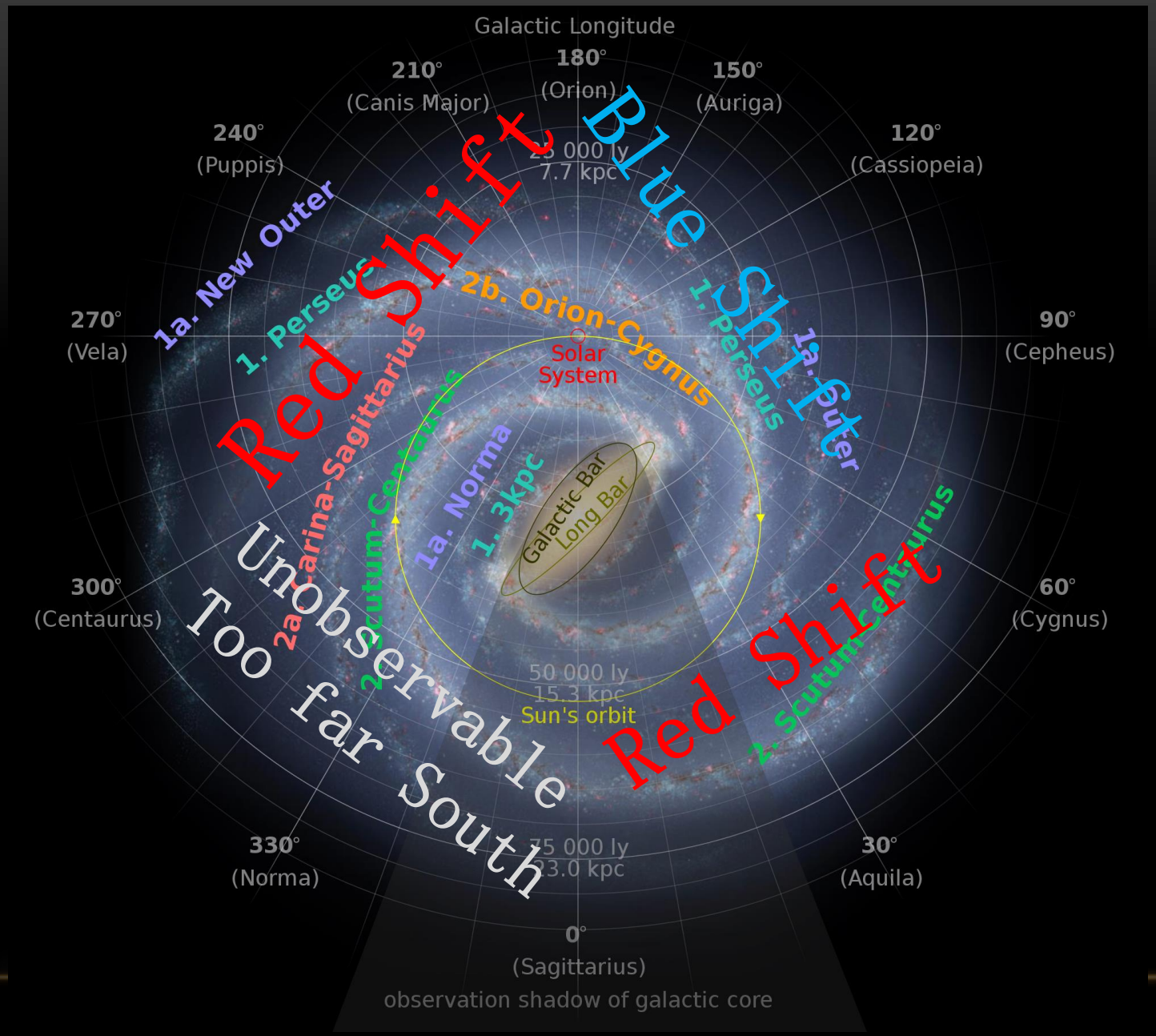
Project #1 – Create video of one day of Milky Way passing over


IF Average Window
1418.6623327 MHz Cumulations: 87000 of: 902000 Recording time: 37s
Corrected background!
-65
-67
-70
1419.00
1419.50
1420.00
1420.50
1421.00


Stellarium 0.20.3
NE
NW
E
W
SE
SW
Vega
Pollux
Orionids
Arcturus
Procyon
Regulus
Venus
Mercury
Spica
Sun
Antares
Earth, Holland Observatory, 8 m
FOV 178°
17.8 FPS
2020-11-05 09:36:31 UTC

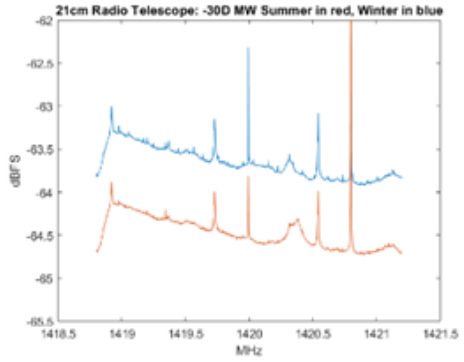

AIRSPY SDR# v1.0.0.1769 - Spy Server Network
001.420.000.000
IF Noise Blanker *
Demodulator Noise Blanker *
Recording *
Zoom FFT *
dBFS
0
-10
-20
-30
Zoom

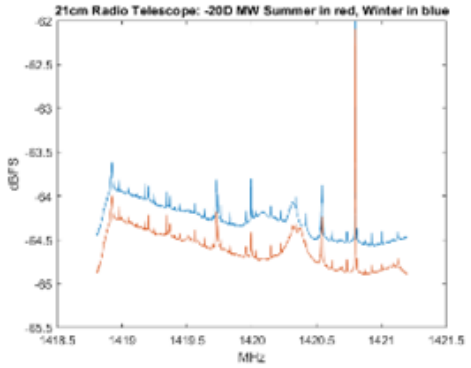
Project #2 – Measure relative location of our Solar System within Milky Way

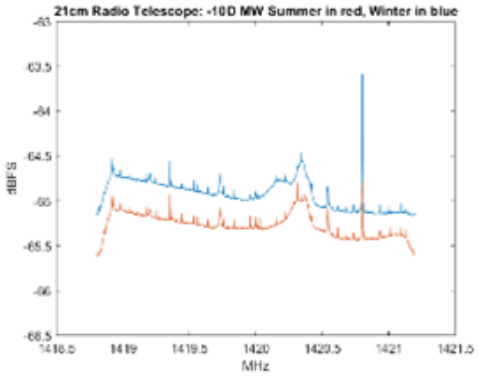


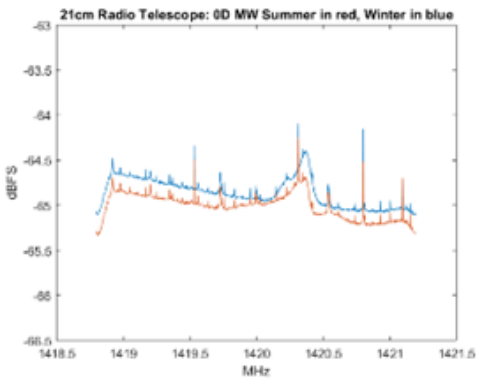
https://earthsky.org/upl/2020/01/milky-way-arms-suns-location-orion-cygnus-arm.png

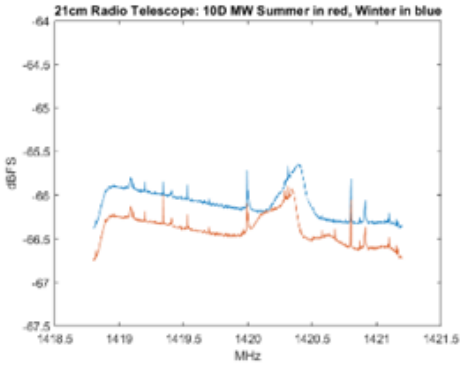
21cm Plots at Galactic Equator – Spaced at 10 Degrees Declination

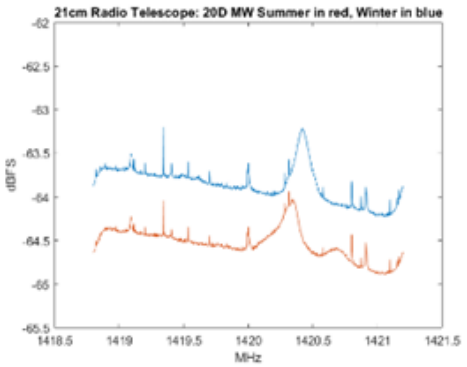


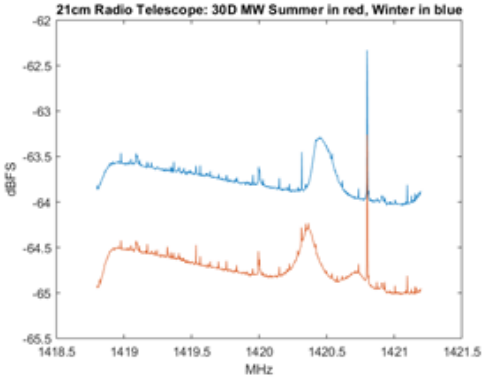


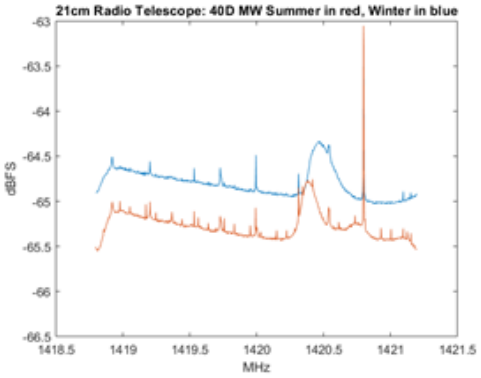


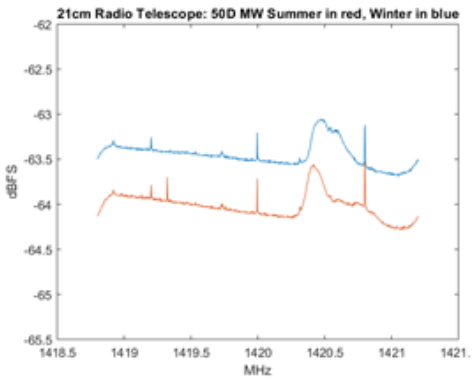


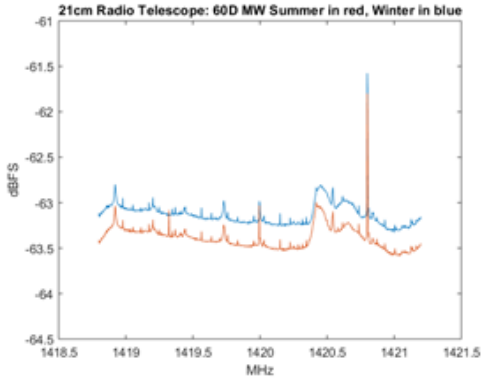




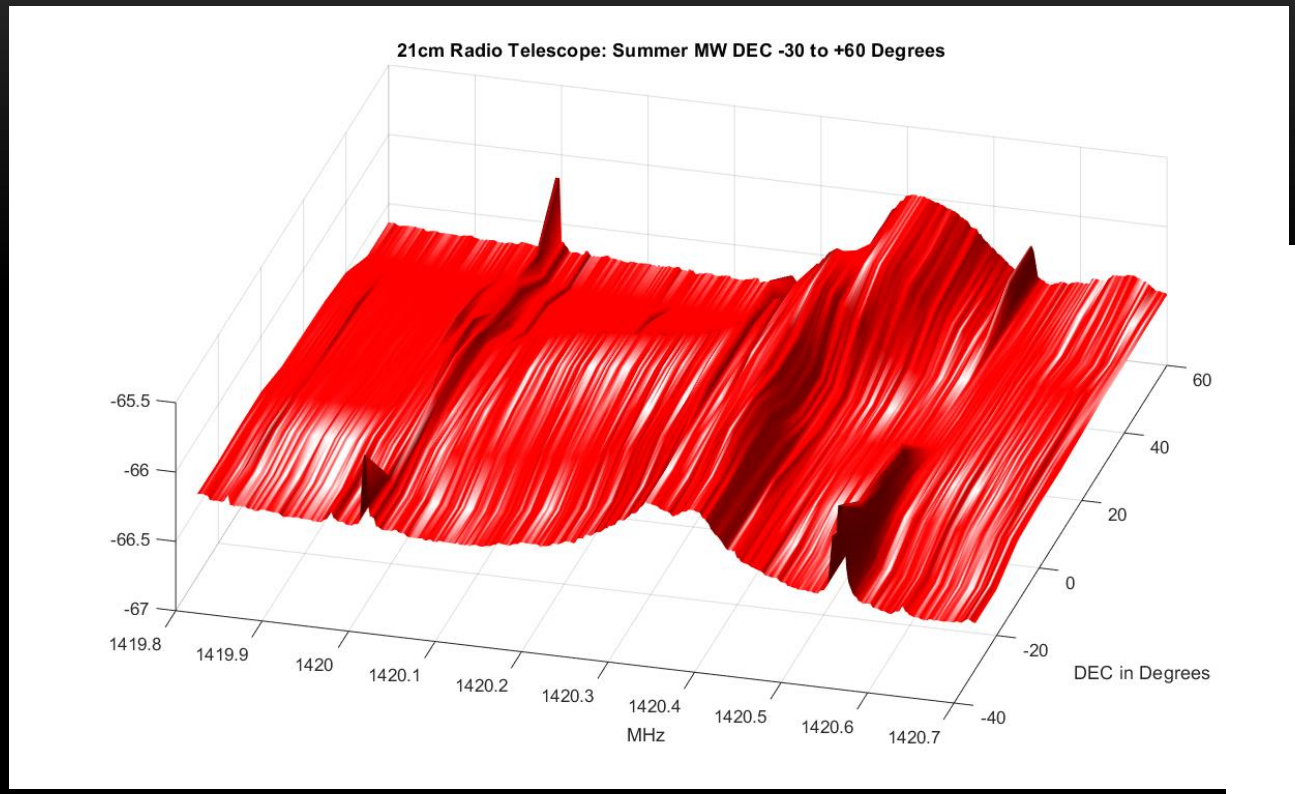




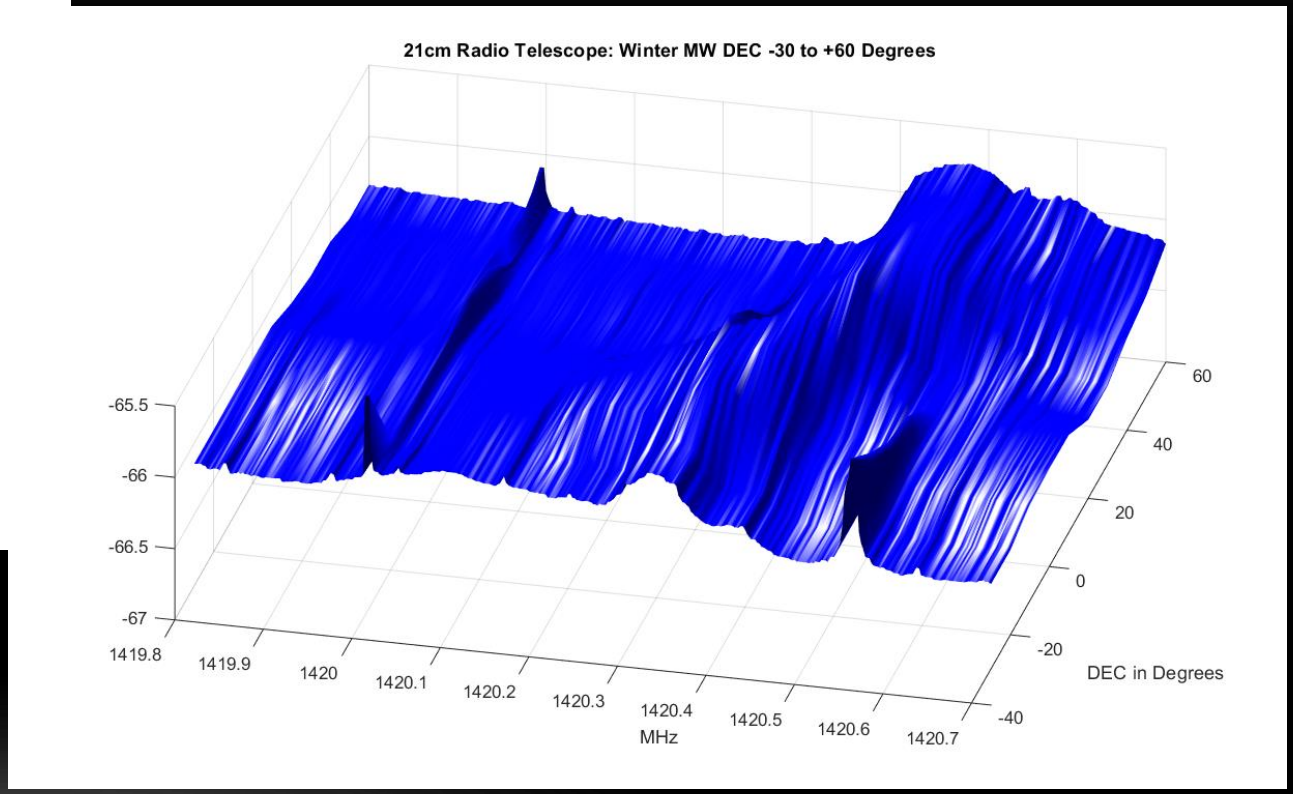




3D Surface Plots of Summer (Red) and Winter (Blue) Milk Way Data



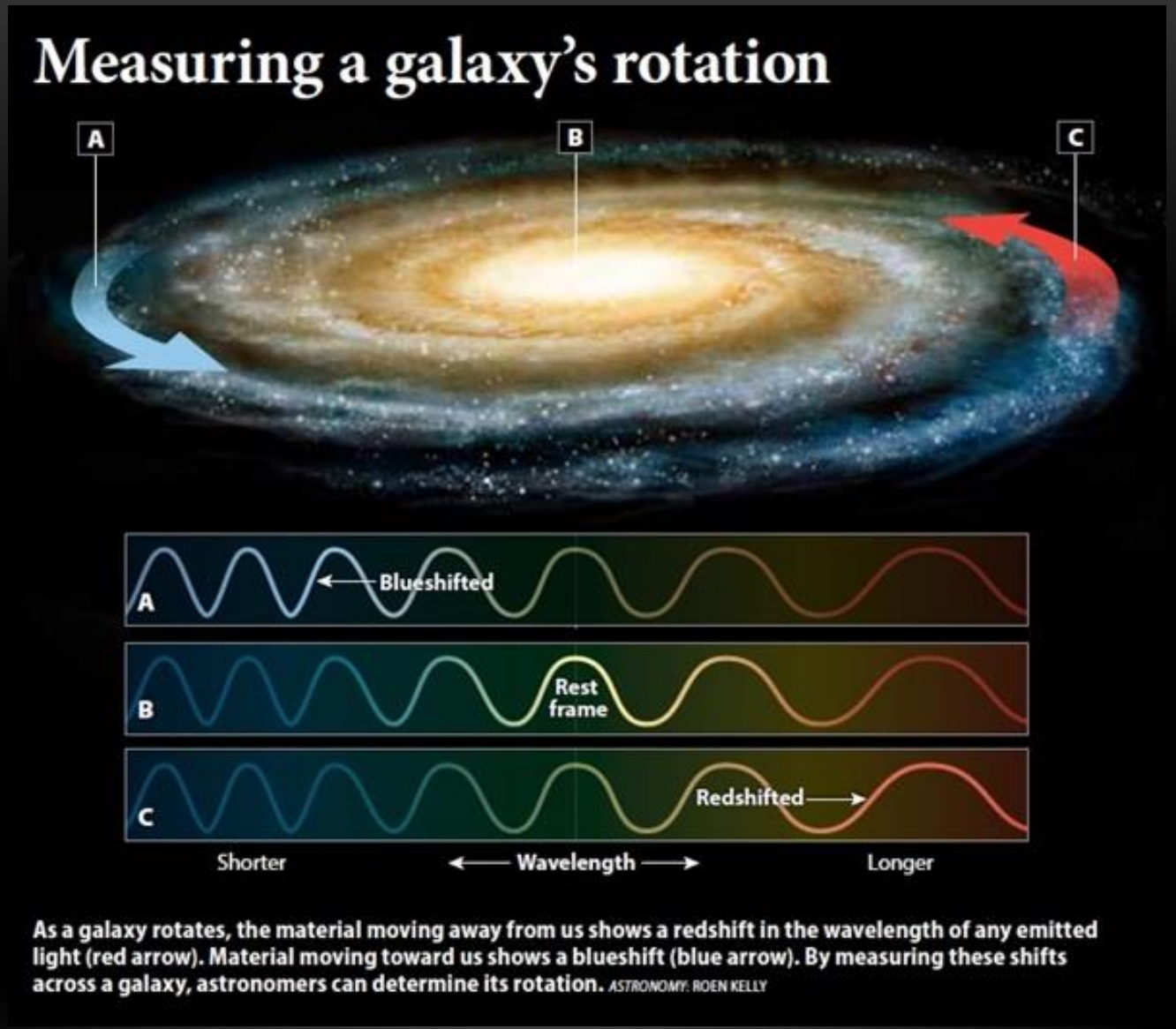
- The **diameter of** the luminous **Milky Way** is between 100,000 and 120,000 light years across.
- Sun (Solar System) is 1/2 to 2/3rds from center (www.universetoday.com)



Declination vs. Amplitude vs. Frequency
-30^0 DEC: Center of galaxy (Sagittarius)
$+60^0$ DEC: Most Northerly point of galactic equator (all data taken along galactic equator)

=> Transition between red shift and blue shift is approx. 1/2 to 2/3 from center of galaxy to most Northerly point

Project #3 – Measure the rotation of the Milky Way



https://astronomy.com/magazine/ask-astro/2018/05/rotational-speed-of-a-galaxy

To Summarize => What Astronomy Can We Do from a Light Polluted Area?

- Solar System: Sun, Moon, planets
- Double Stars, Globular Clusters, Open Clusters
- Emission Nebula – Broadband and Narrowband
- Supernova Remnant, Planetary Nebula, Wolf-Rayet Stars - Narrowband
- NIR Imaging
- Spectroscopy
- Radio Astronomy

The End

www.holland-observatory.net