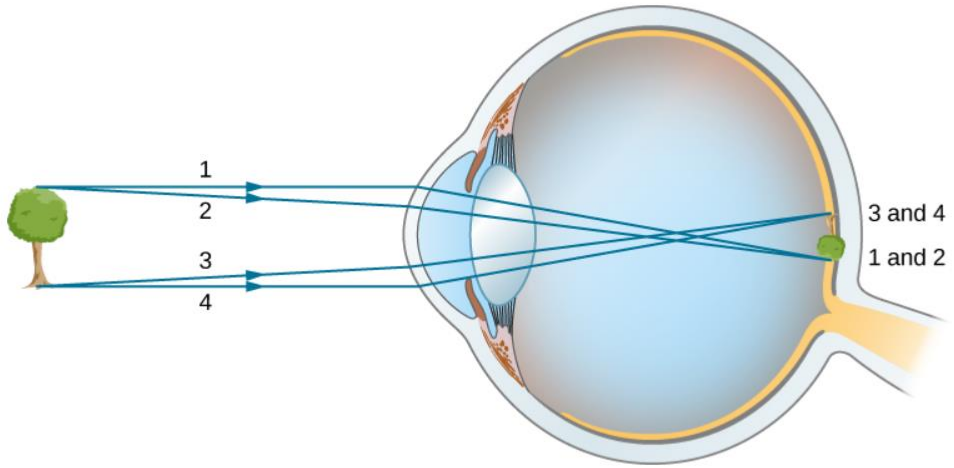
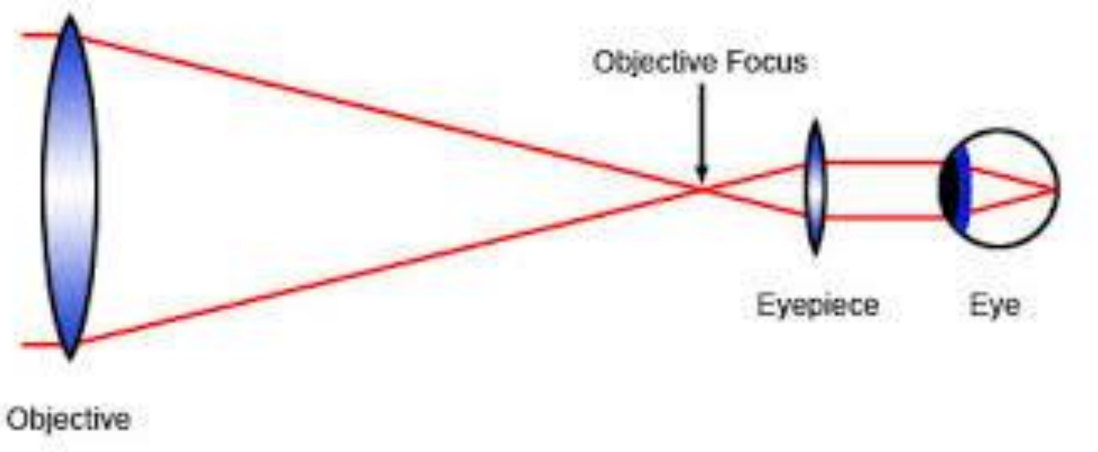
Astronomy field trips 2022

Prof. Ravit Helled
Prof. Ben Moore

Your task is to learn how to use the astrophotography equipment you will be given and take an image of a cosmic structure that you can not see with your eye.

Telescopes and a spinning Earth





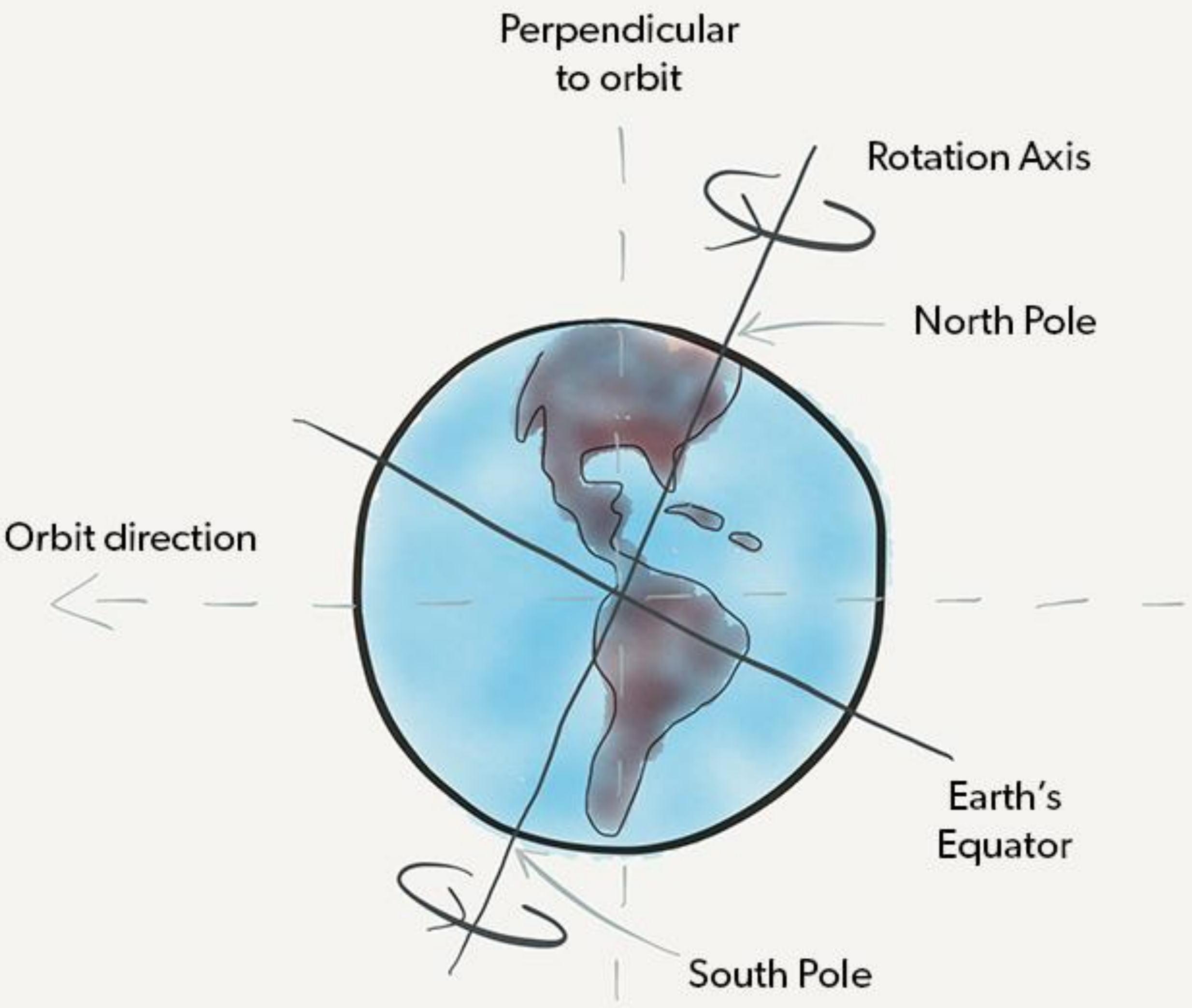
Number of photons collected by the lens is proportional to its area. A 22cm telescope lens will gather ~2,000x as many photons as a 5mm eye pupil.

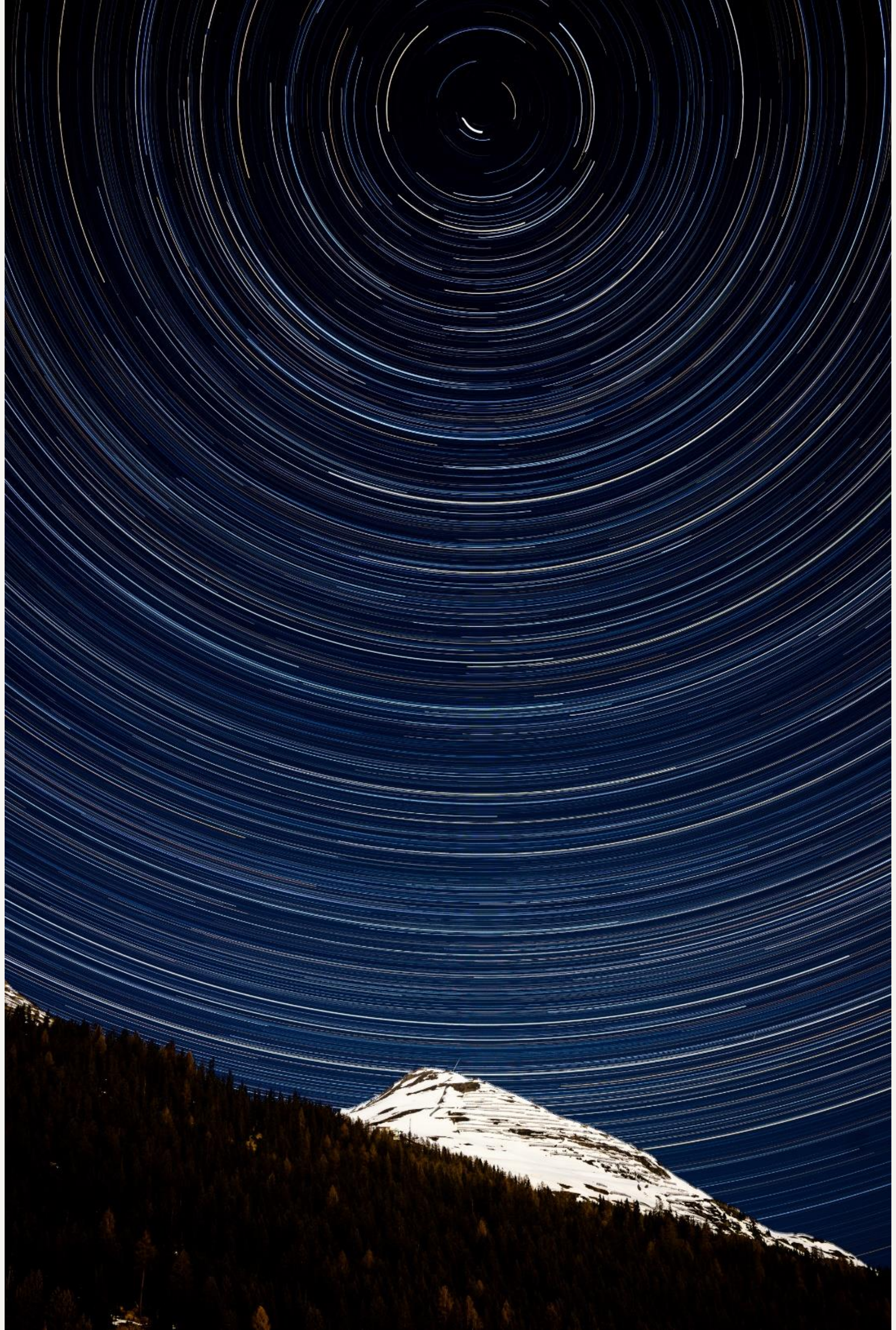
Your eye is like a video camera seeing the world at ~30 frames per second. With a long exposure of 10 minutes we can capture 18,000x as many photons.

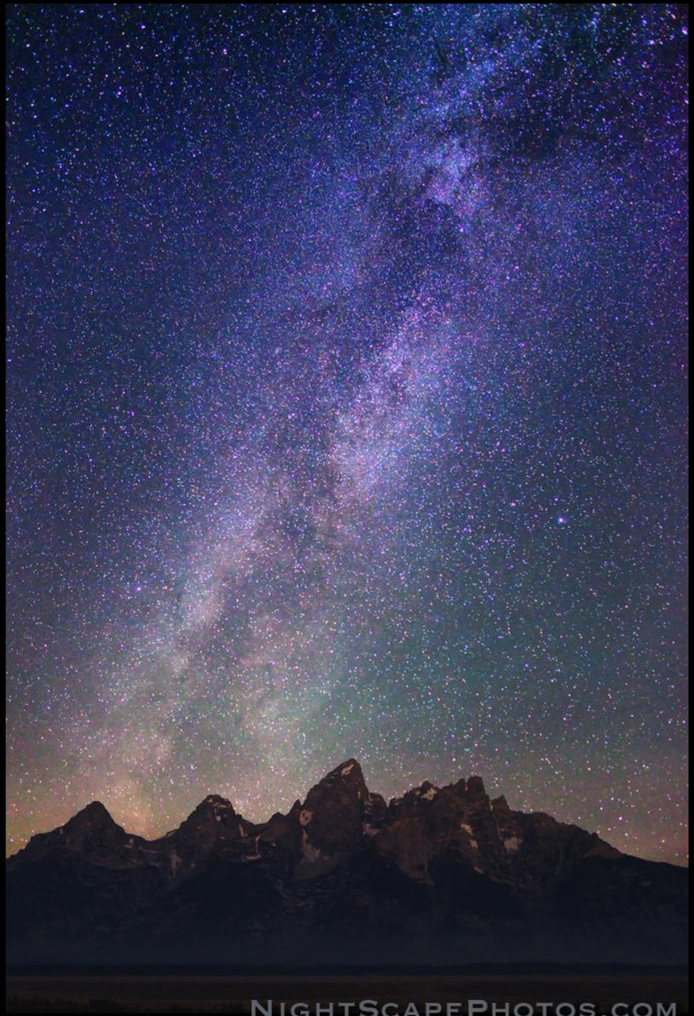
That's 18,000x2,000 = 36 million x photons as the eye.

Resolution is proportional to the lens diameter. The 22cm telescope can resolve things 44x smaller than your eye. Planets can be resolved with the telescope but to your eye they are like points of light. Stars can only be resolved with the worlds largest telescopes.

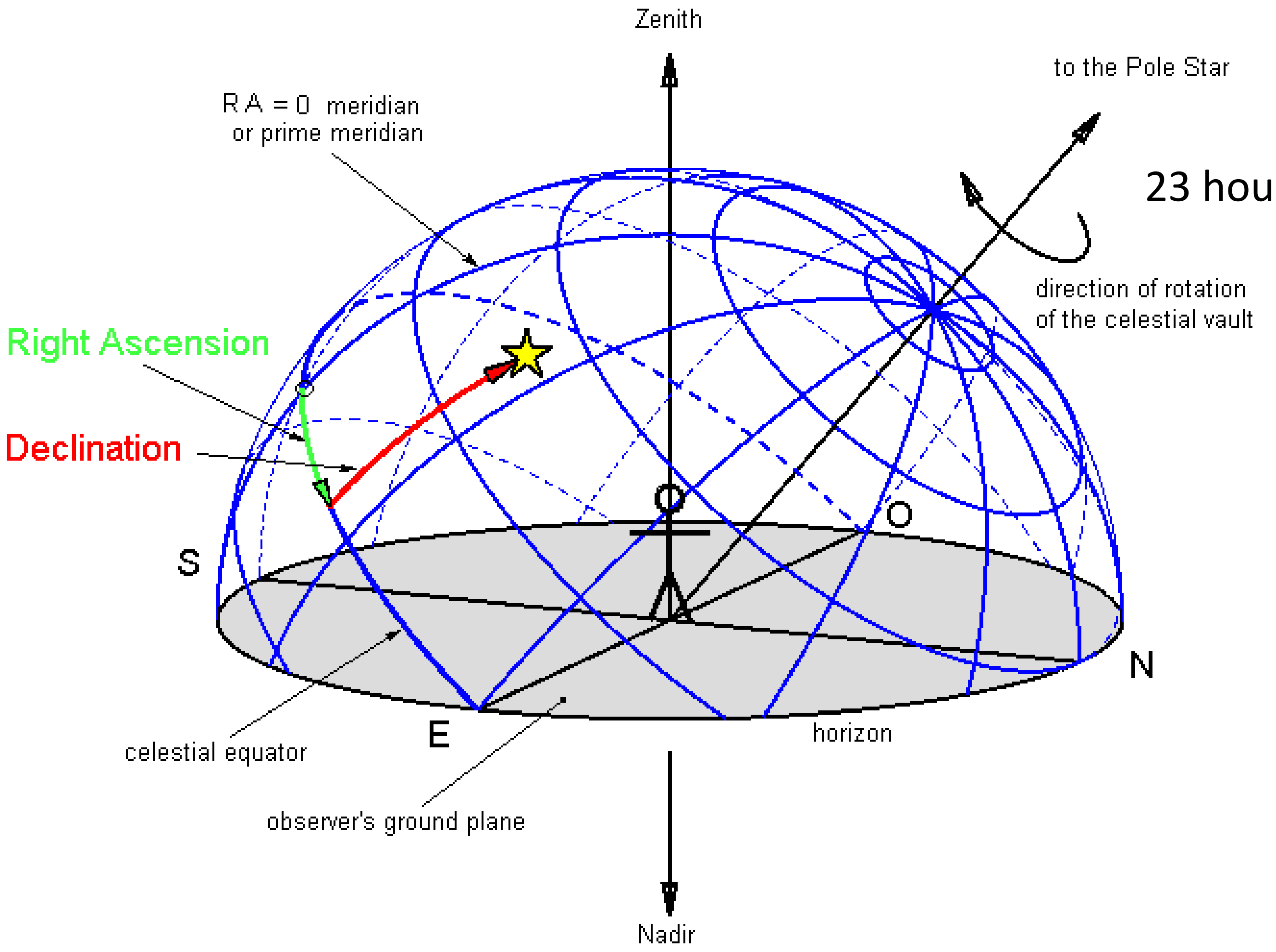
In practise resolution is limited by atmospheric motions.


Perpendicular to orbit
Rotation Axis
North Pole
Orbit direction
Earth's Equator
South Pole

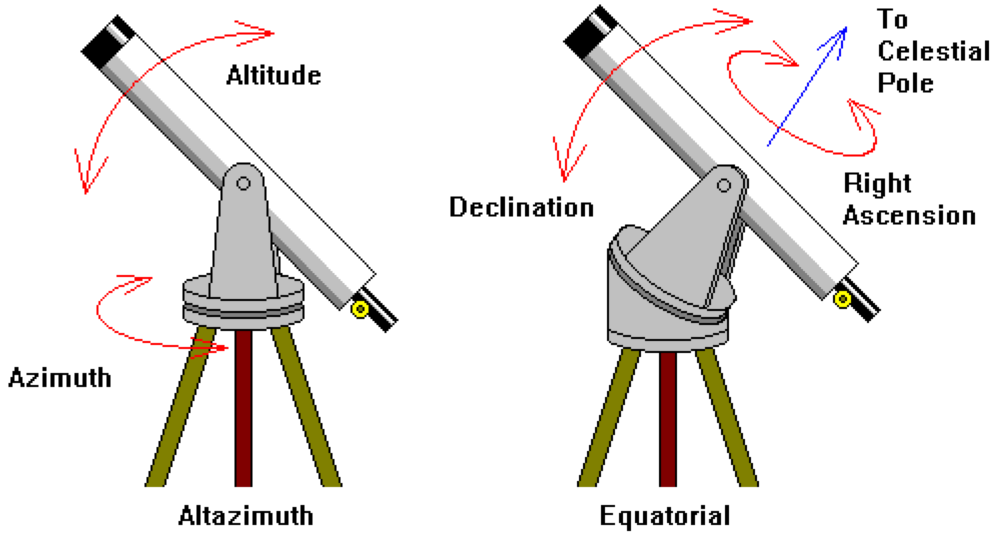


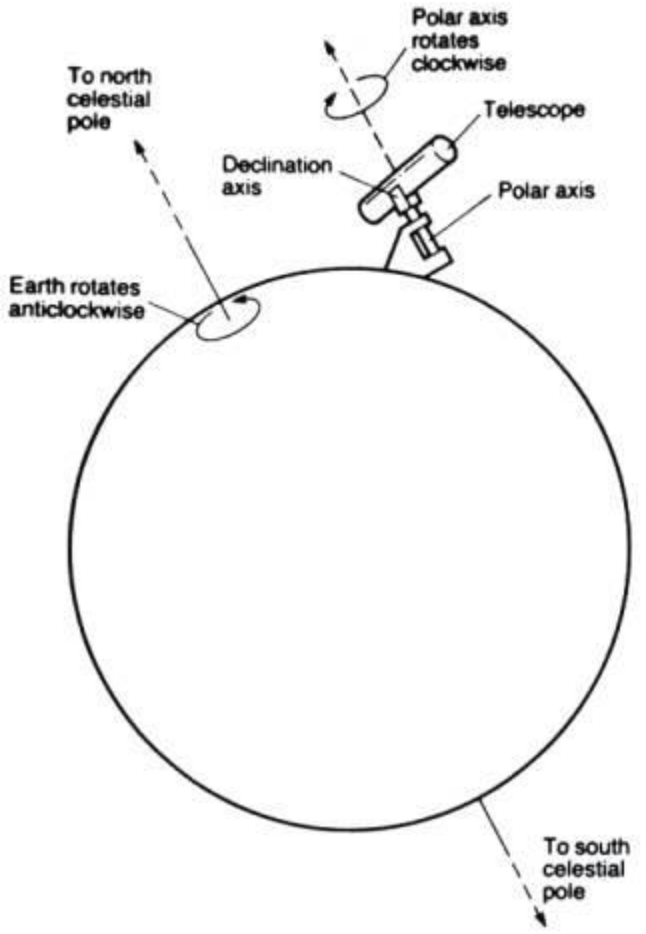


Royce Bair

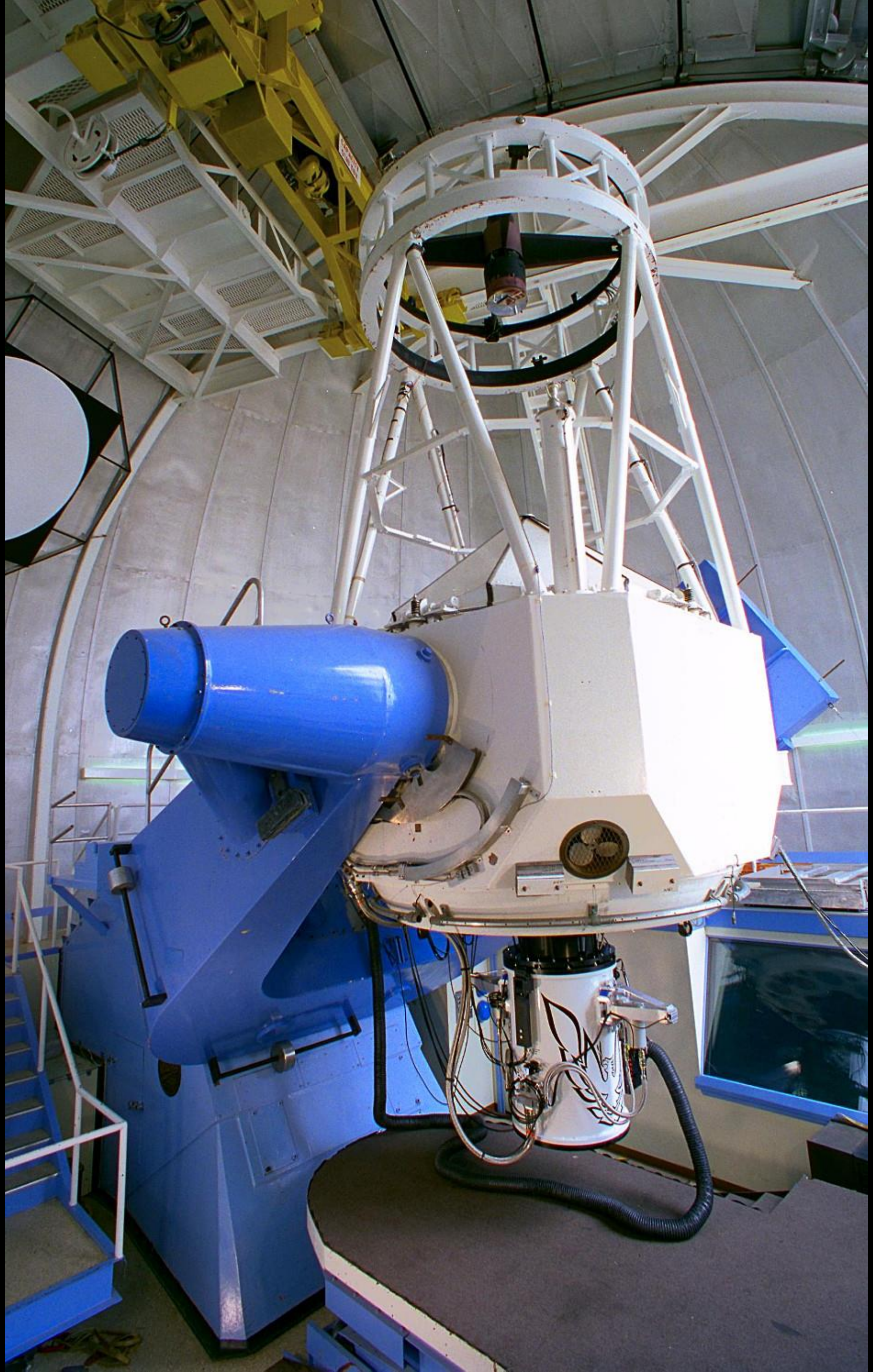


23 hours 56 minutes and 4.1 seconds


Altitude
Azimuth
Altazimuth
Declination
To Celestial Pole
Right Ascension
Equatorial

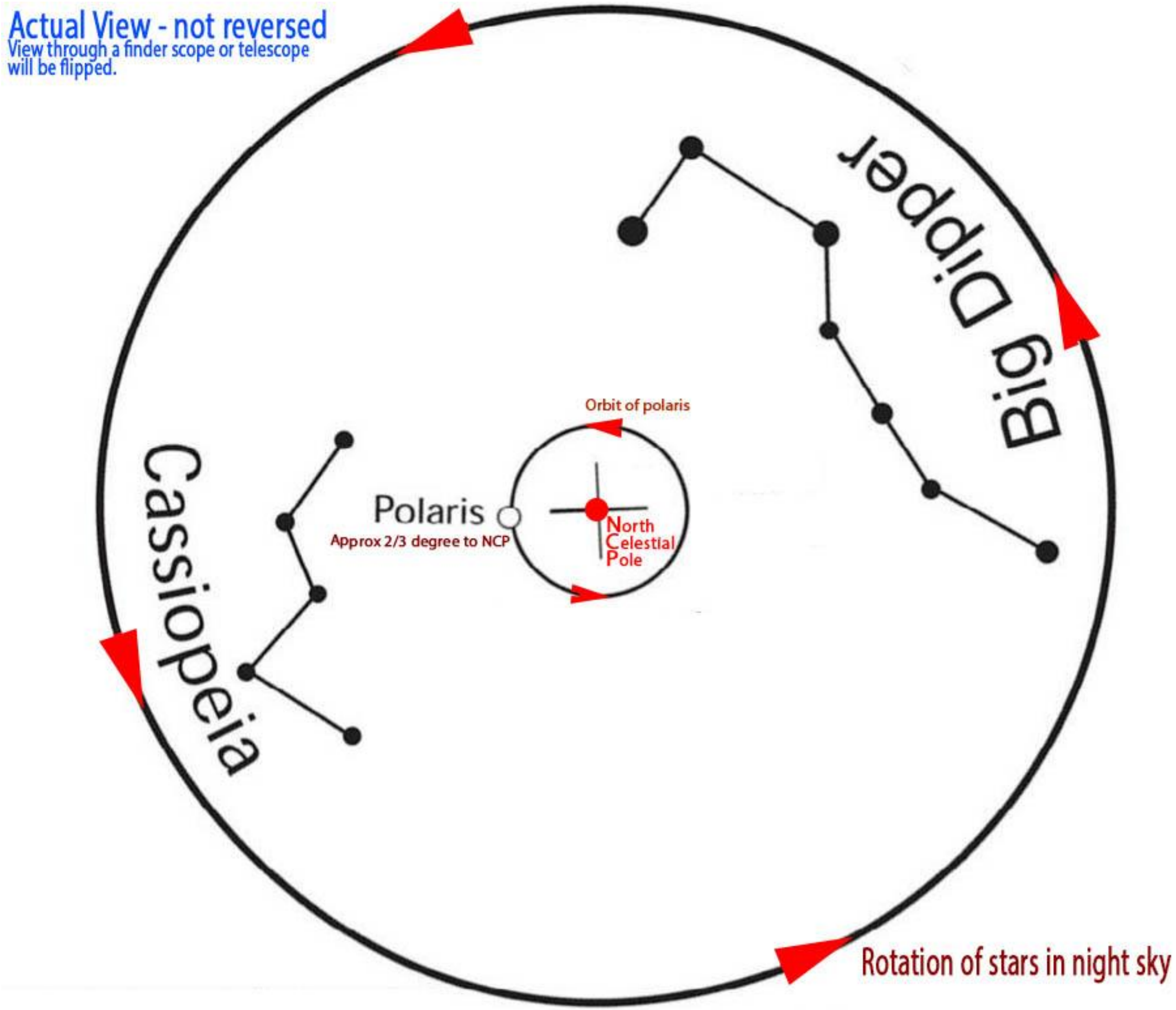

Polar axis rotates clockwise
To north celestial pole
Telescope
Declination axis
Polar axis
Earth rotates anticlockwise
To south celestial pole


TOA
EM-400

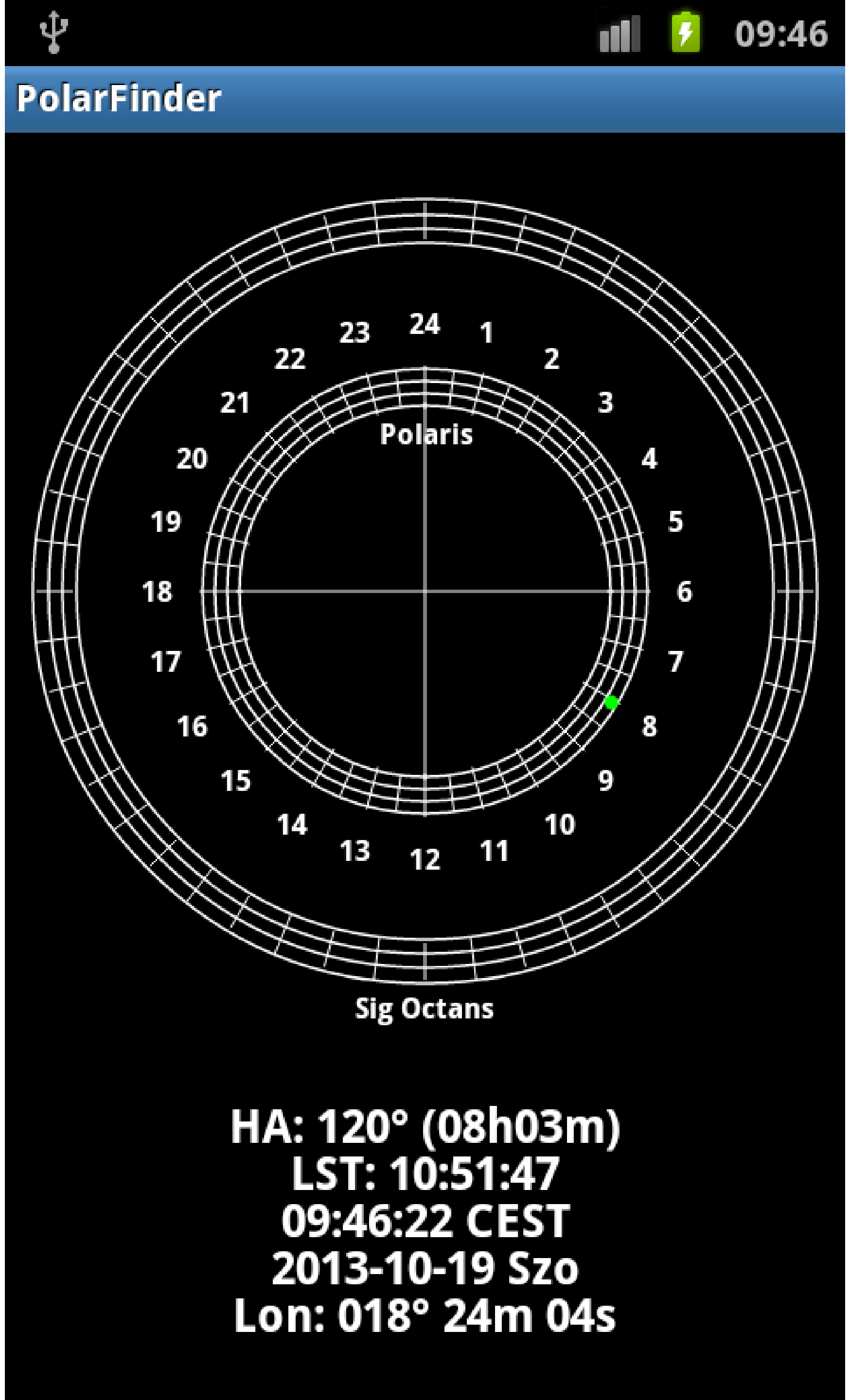


7 minute instruction video:
https://www.youtube.com/watch?v=ZR20U1dbdm8

34 minute instruction video:
https://www.youtube.com/watch?v=jssf2ffHYbc



Actual View - not reversed
View through a finder scope or telescope will be flipped.
Big Dipper
Cassiopeia
Orbit of polaris
Polaris
Approx 2/3 degree to NCP
North Celestial Pole
Rotation of stars in night sky


09:46
PolarFinder
24
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Polaris
Sig Octans
HA: 120° (08h03m)
LST: 10:51:47
09:46:22 CEST
2013-10-19 Szo
Lon: 018° 24m 04s


USB

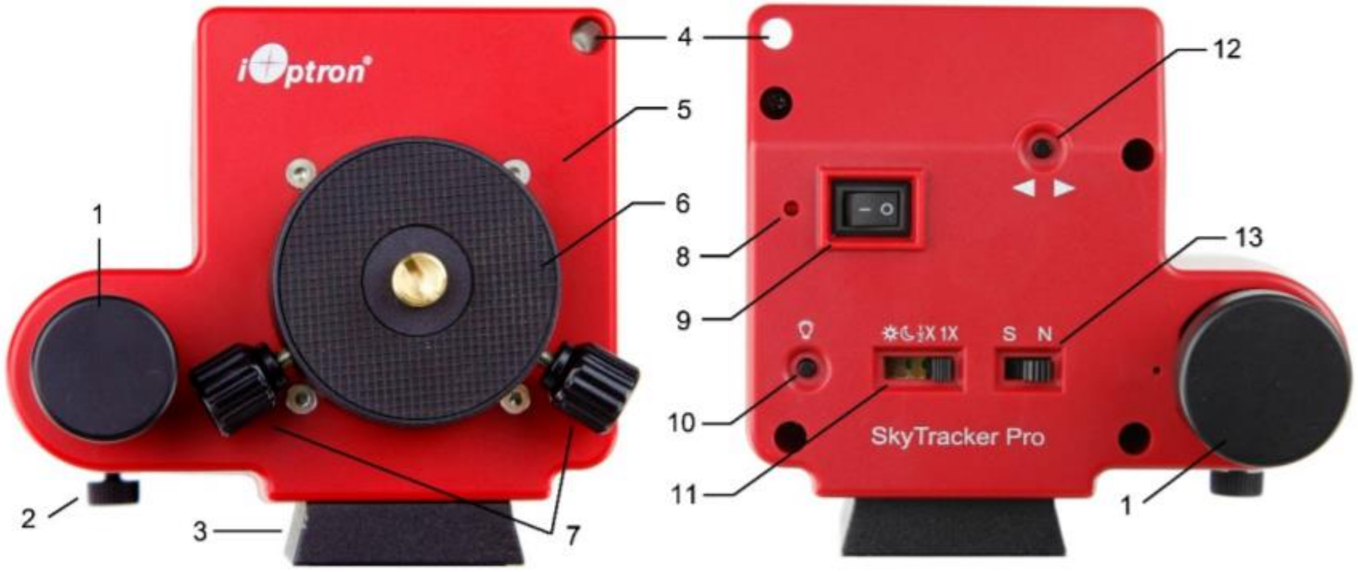


Figure 3. Front and back view of a SkyTracker™ Pro mount head

1- Polar scope
2- Polar scope locking screw
3- Dovetail base
4- Polar sight hole
5- Single axis equatorial mount body
6- Camera mounting block
7- Camera mounting block locking screw
8- Battery status indicator
9- Power switch
10- Polar scope illumination adjustment button
11- Tracking speed switch
12- RA fast slew button
13- South/north switch

Figure 4. Alt-azi adjusting base

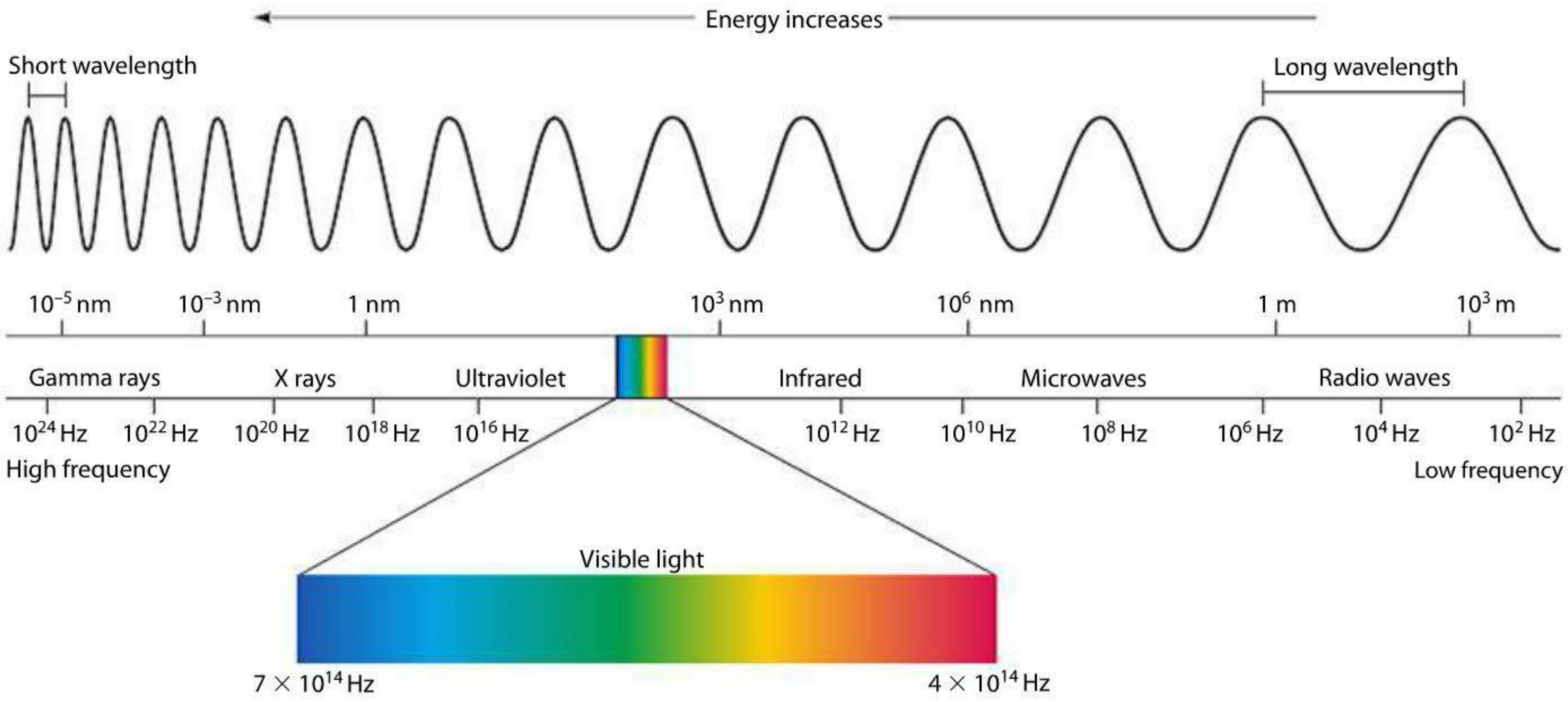
14- Dovetail saddle
15- Latitude lock
16- Azimuth adjusting knob
17- Dovetail locking knob
18- Azimuth locking knob
19- Base
20- Latitude adjustment knob
21- Latitude scale
22- Leveling bubble

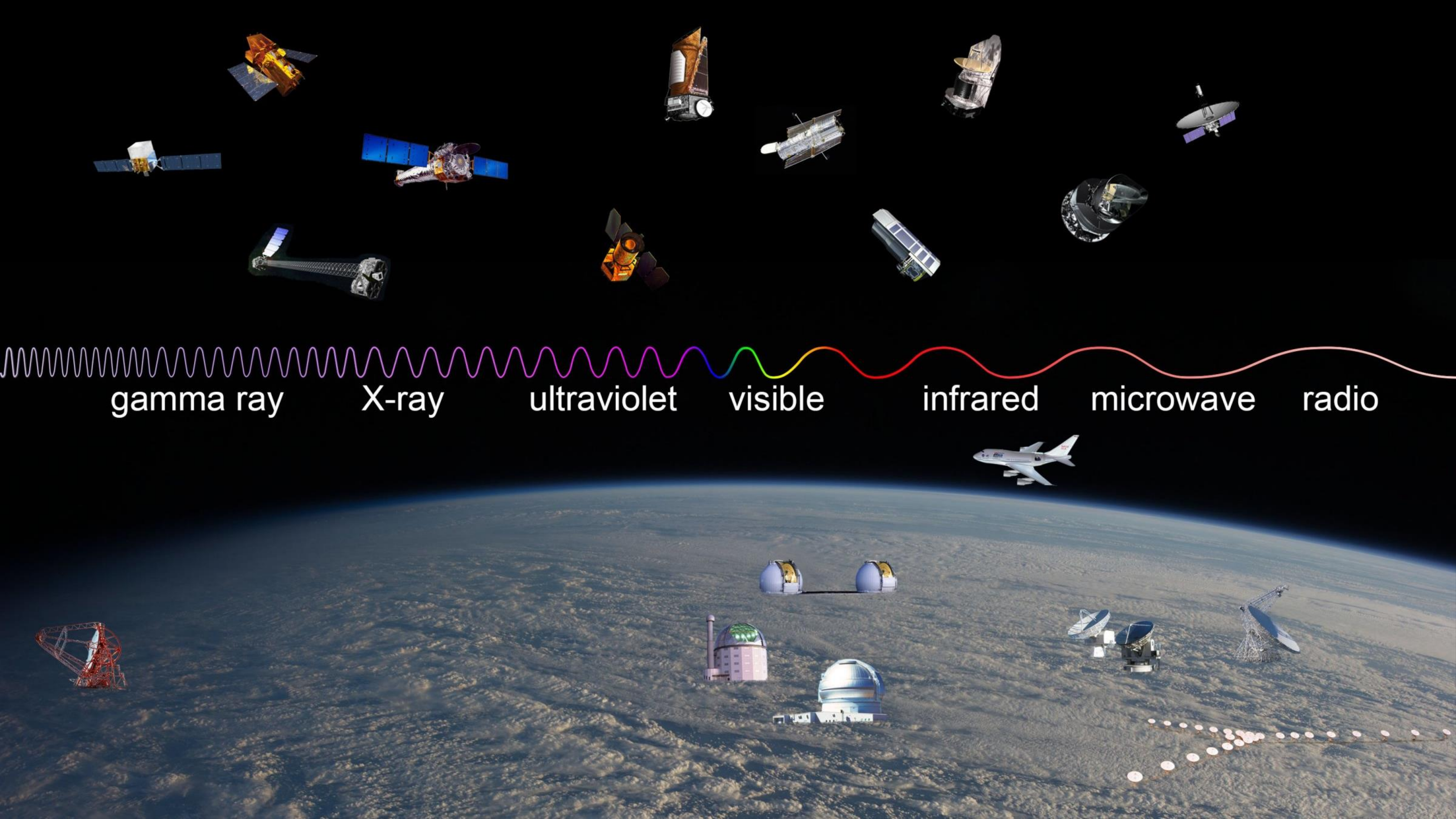
Basics of light & colour

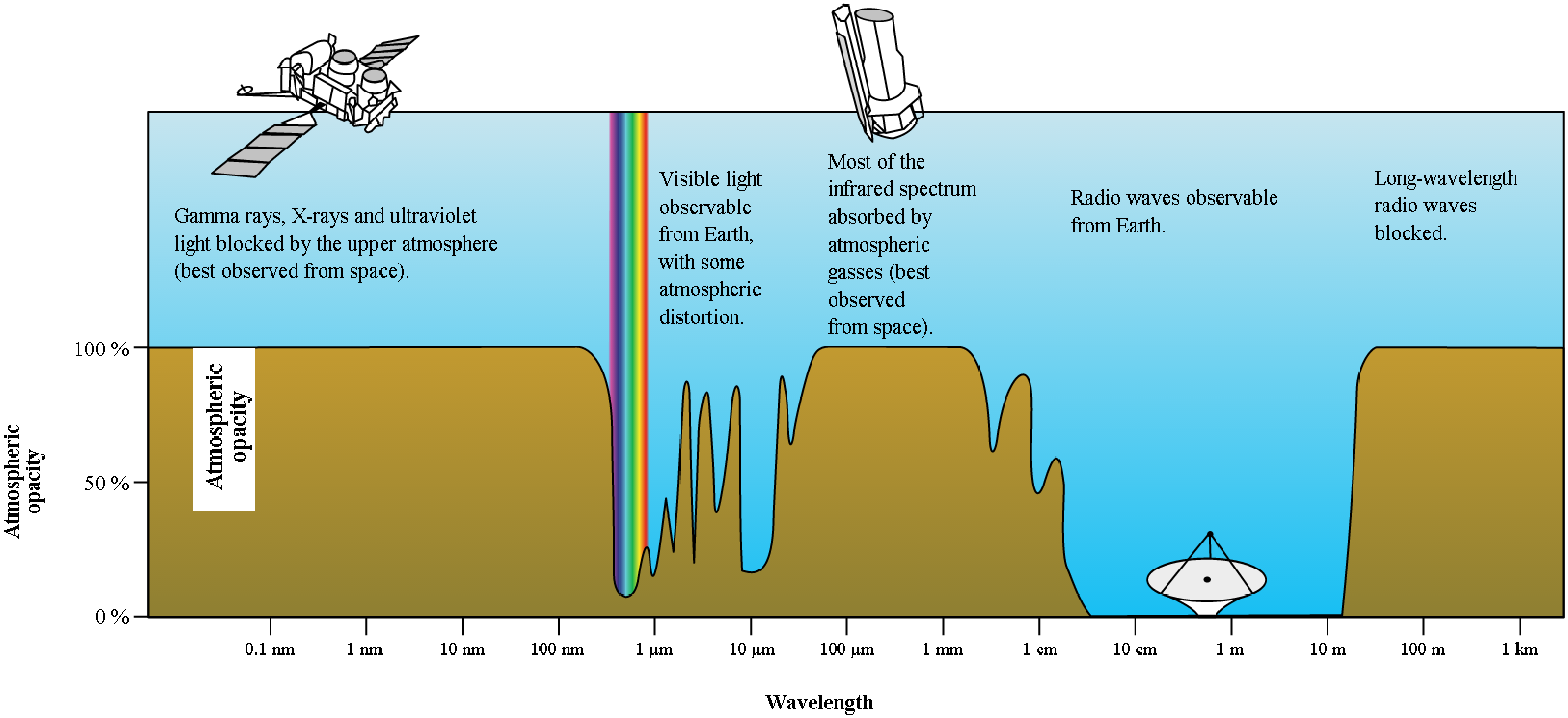
Ben Moore, Davos 09/2016 – Nikon d7100, 10mm f2, 60s

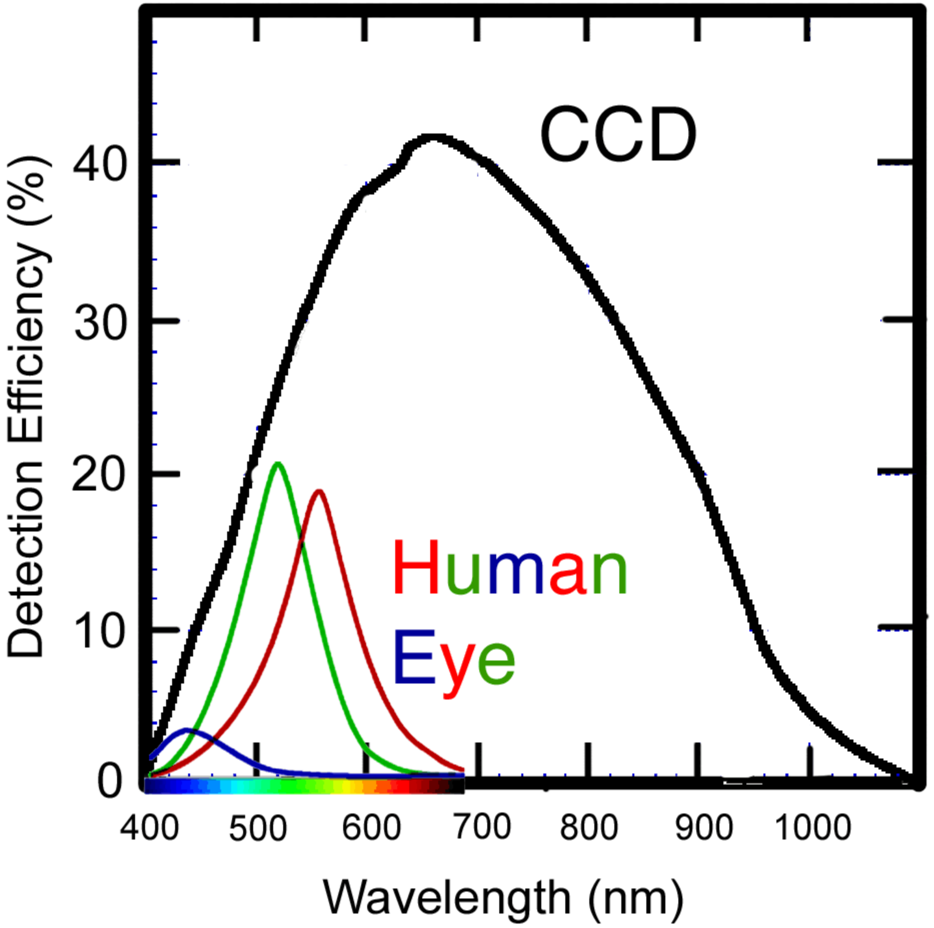
Wavelengths shorter than gamma rays take too much energy to produce

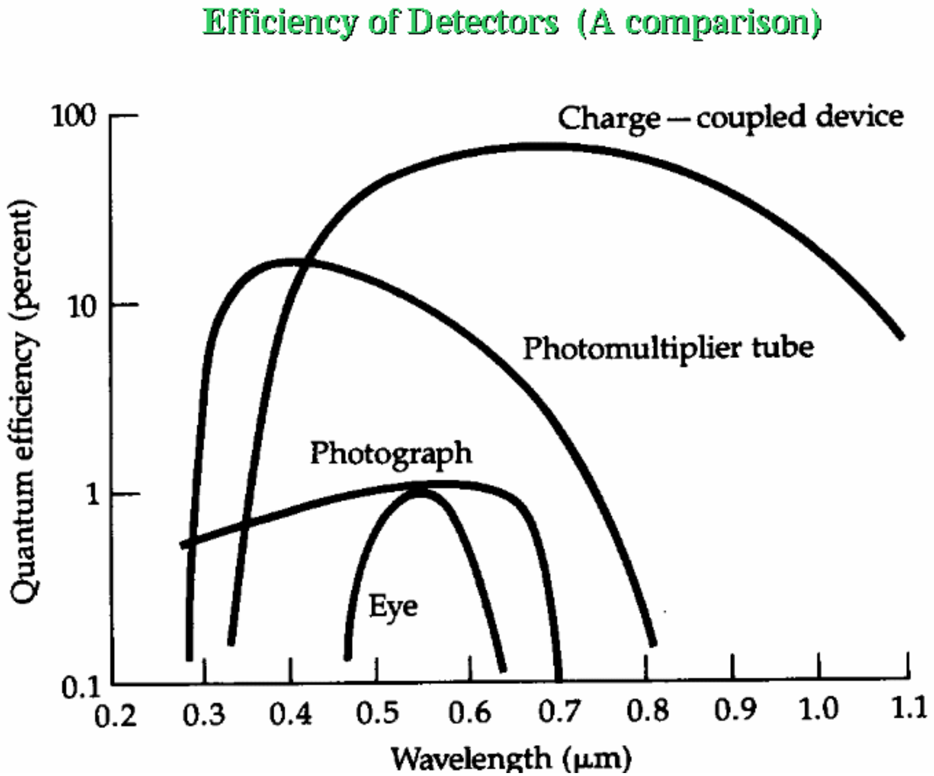
Very long wavelengths contain too little energy to be detected

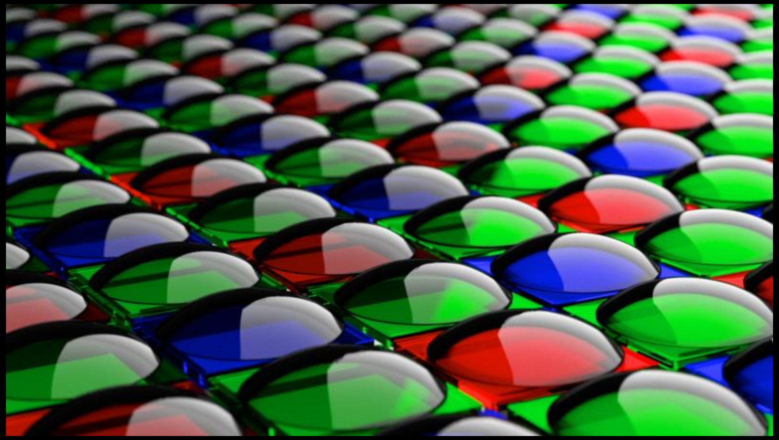



gamma ray
X-ray
ultraviolet
visible
infrared
microwave
radio


Gamma rays, X-rays and ultraviolet light blocked by the upper atmosphere (best observed from space).
Visible light observable from Earth, with some atmospheric distortion.
Most of the infrared spectrum absorbed by atmospheric gasses (best observed from space).
Radio waves observable from Earth.
Long-wavelength radio waves blocked.
Atmospheric opacity
100 %
50 %
0 %
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1 km
Wavelength

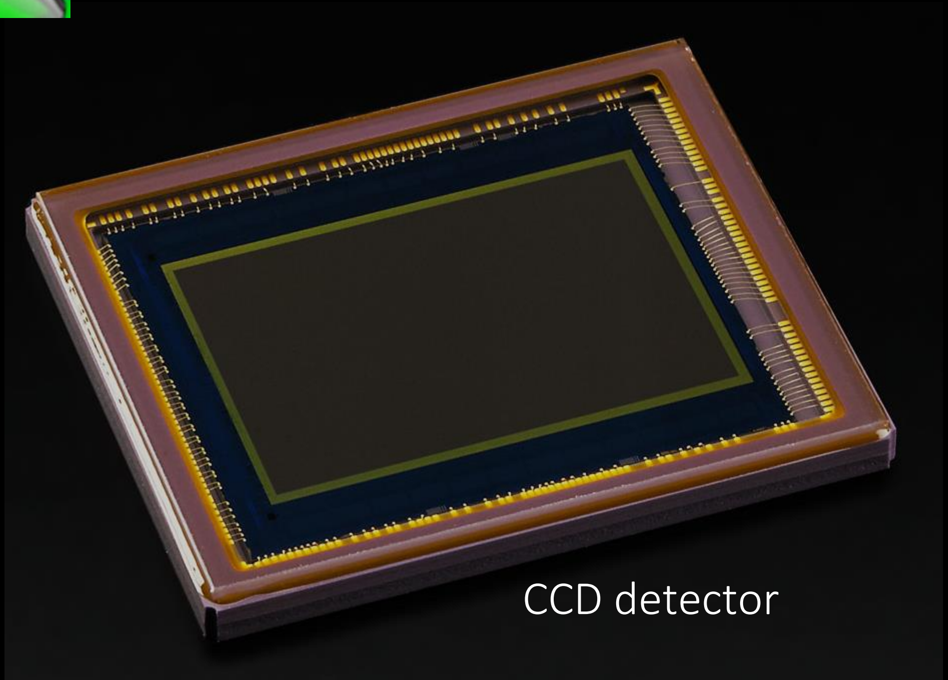

CCD
Human
Eye
Detection Efficiency (%)
40
30
20
10
0
400
500
600
700
800
900
1000
Wavelength (nm)


Efficiency of Detectors (A comparison)
Charge — coupled device
Photomultiplier tube
Photograph
Eye
Quantum efficiency (percent)
100
10
1
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
Wavelength (μm)



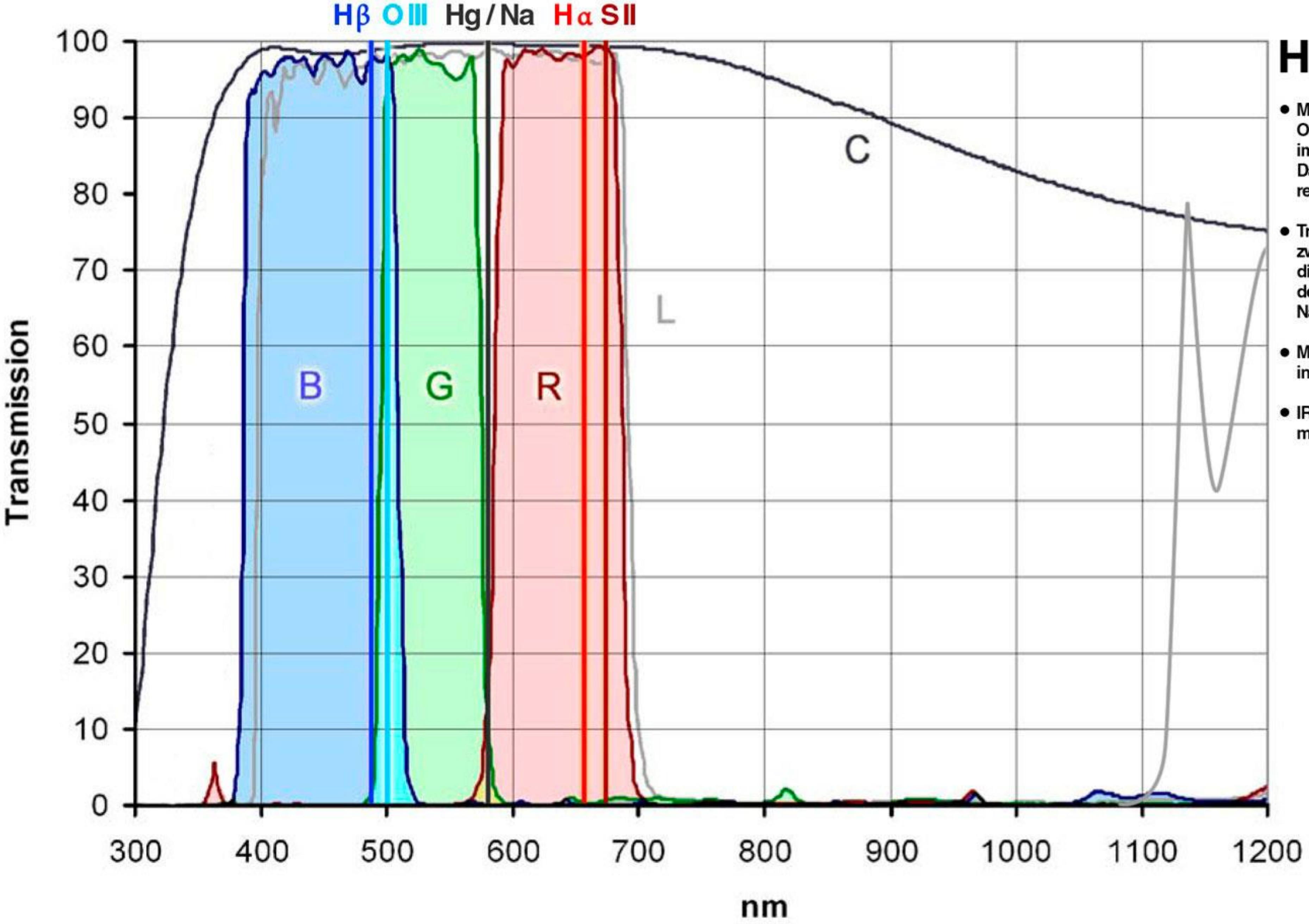
Bayer filter used in DSLR cameras

Filter wheel for astrophotography



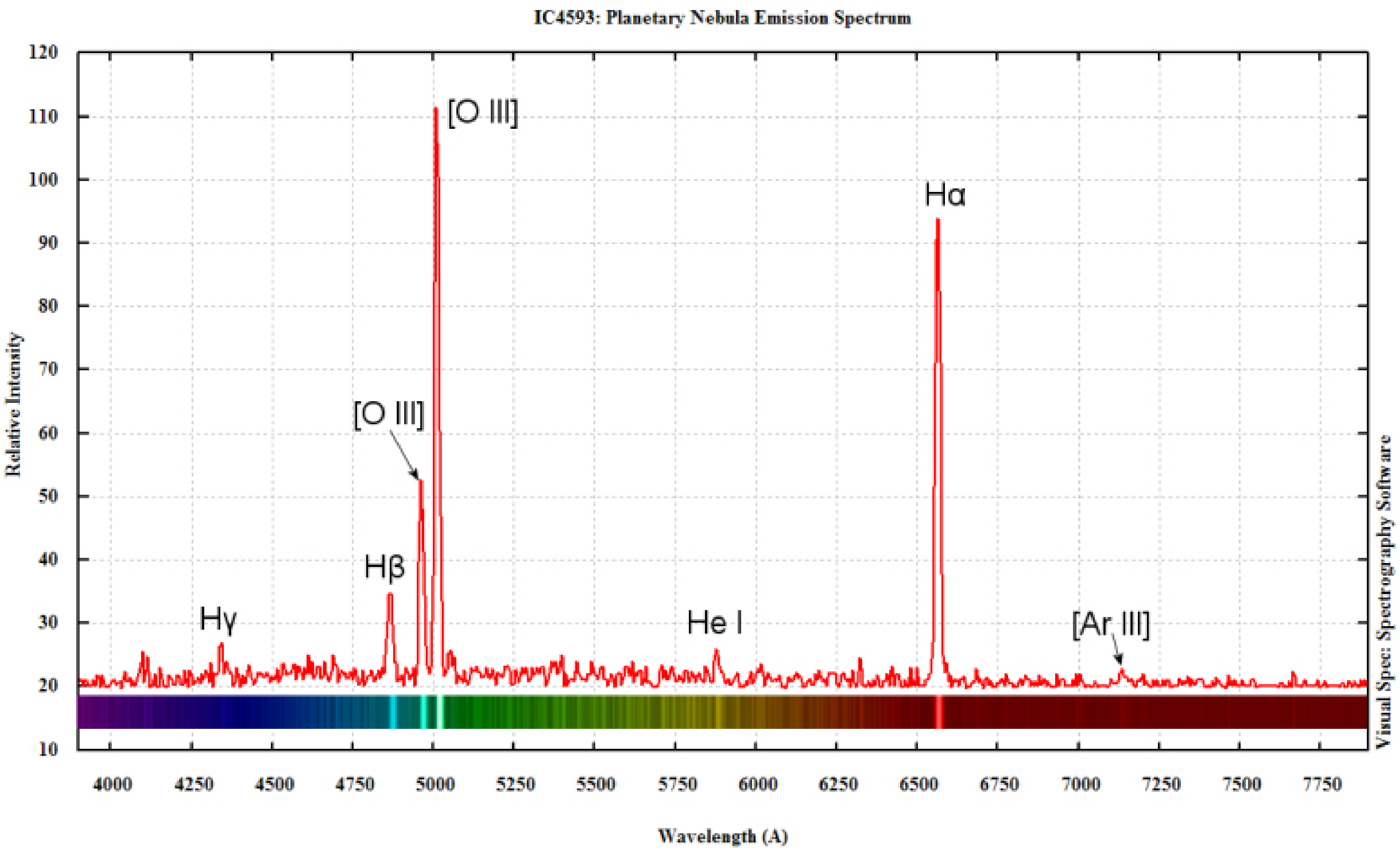
CCD detector

BAADER L-RGB-C CCD-Filter



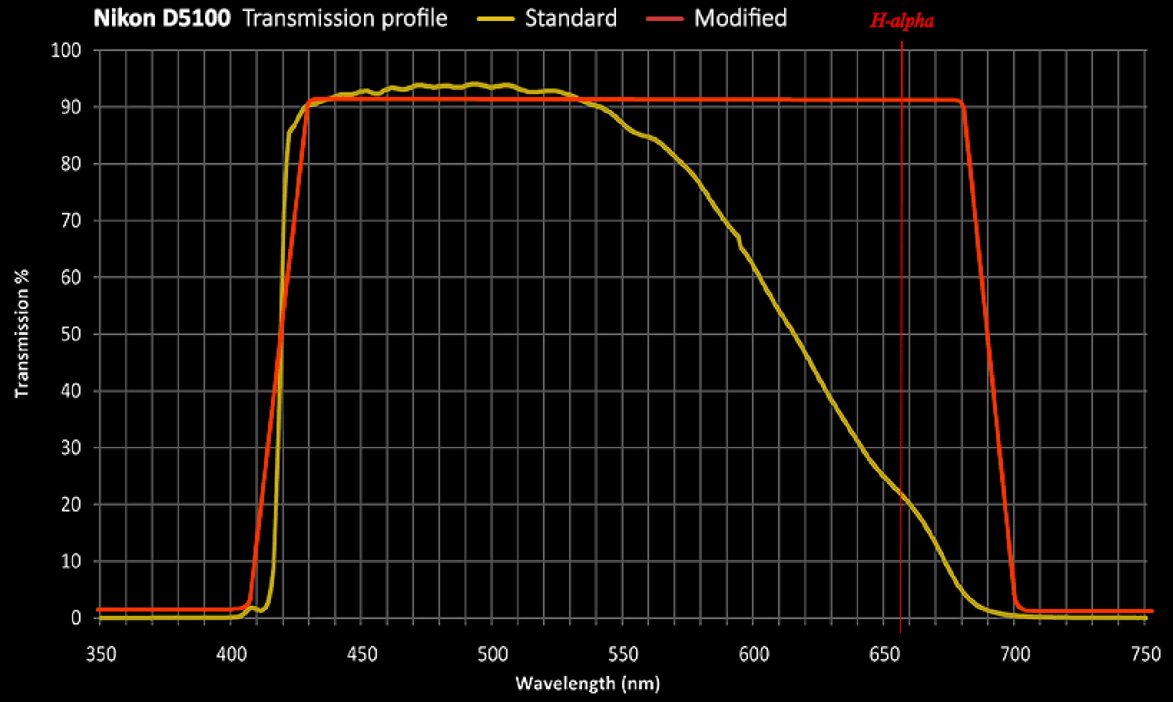
Highlights:

- Maximale Gewichtung der O III Linie durch Nutzung im B- und G-Band. Daraus resultiert eine realistische Farbgebung
- Transmissionslücke zwischen G/R blockiert die Hauptemissionslinien der Quecksilber- und Natriumdampflampen
- Maximale Effizienz in H-α und SII
- IR-Blockung mit höchstmöglichem Kontrast



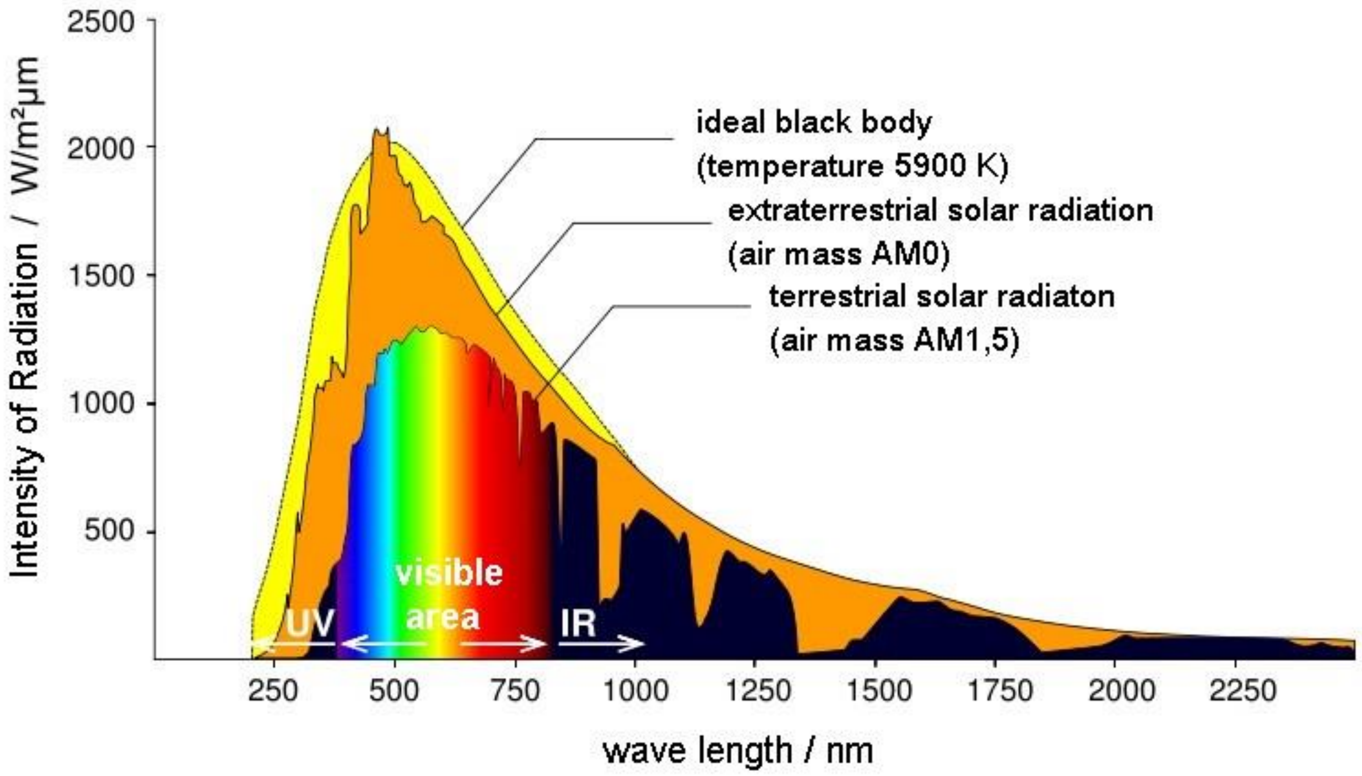
Emission lines from stars & nebula

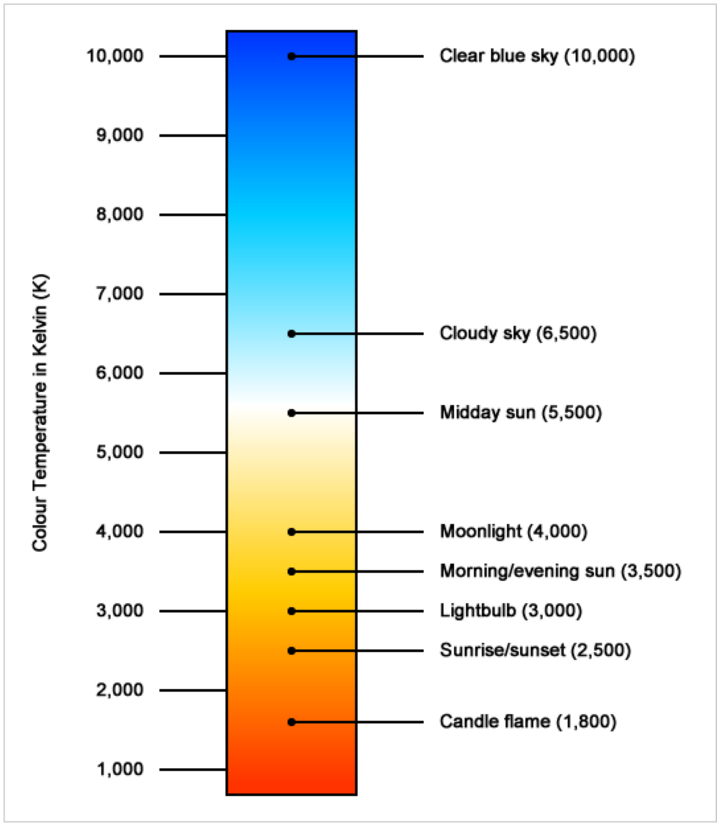
https://www.e-education.psu.edu/astro801/content/l5_p2.html


Nikon D5100 Transmission profile
Standard
Modified
H-alpha
100
90
80
70
60
50
40
30
20
10
0
Transmission %
350
400
450
500
550
600
650
700
750
Wavelength (nm)

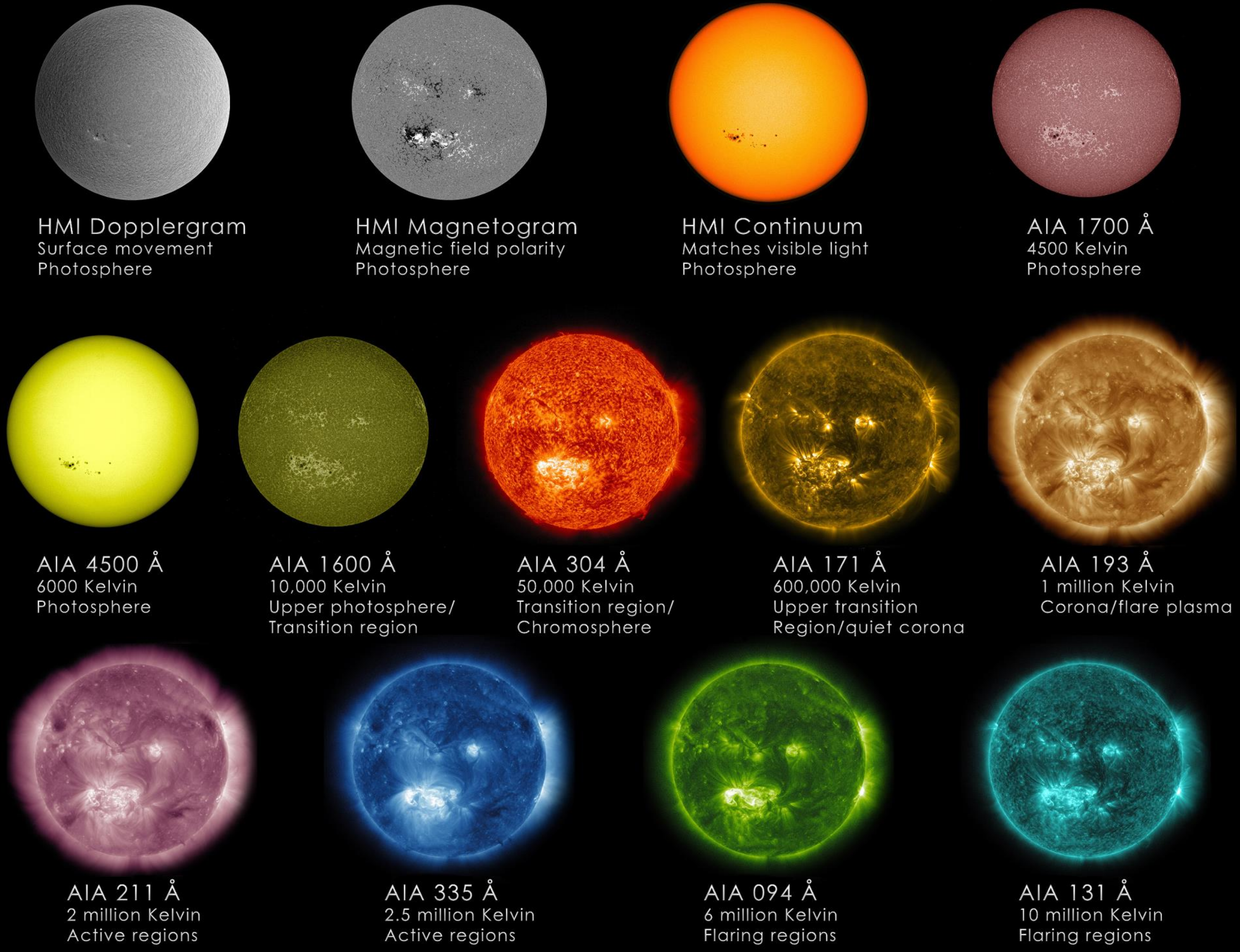

1
2
3
4
5
6


M8 Lagoon Nebula, Nikkor 200-400mm 1:4G ED VR
@400mm f/4 30s ISO 800
Nikon D90 astromod
Nikon DF

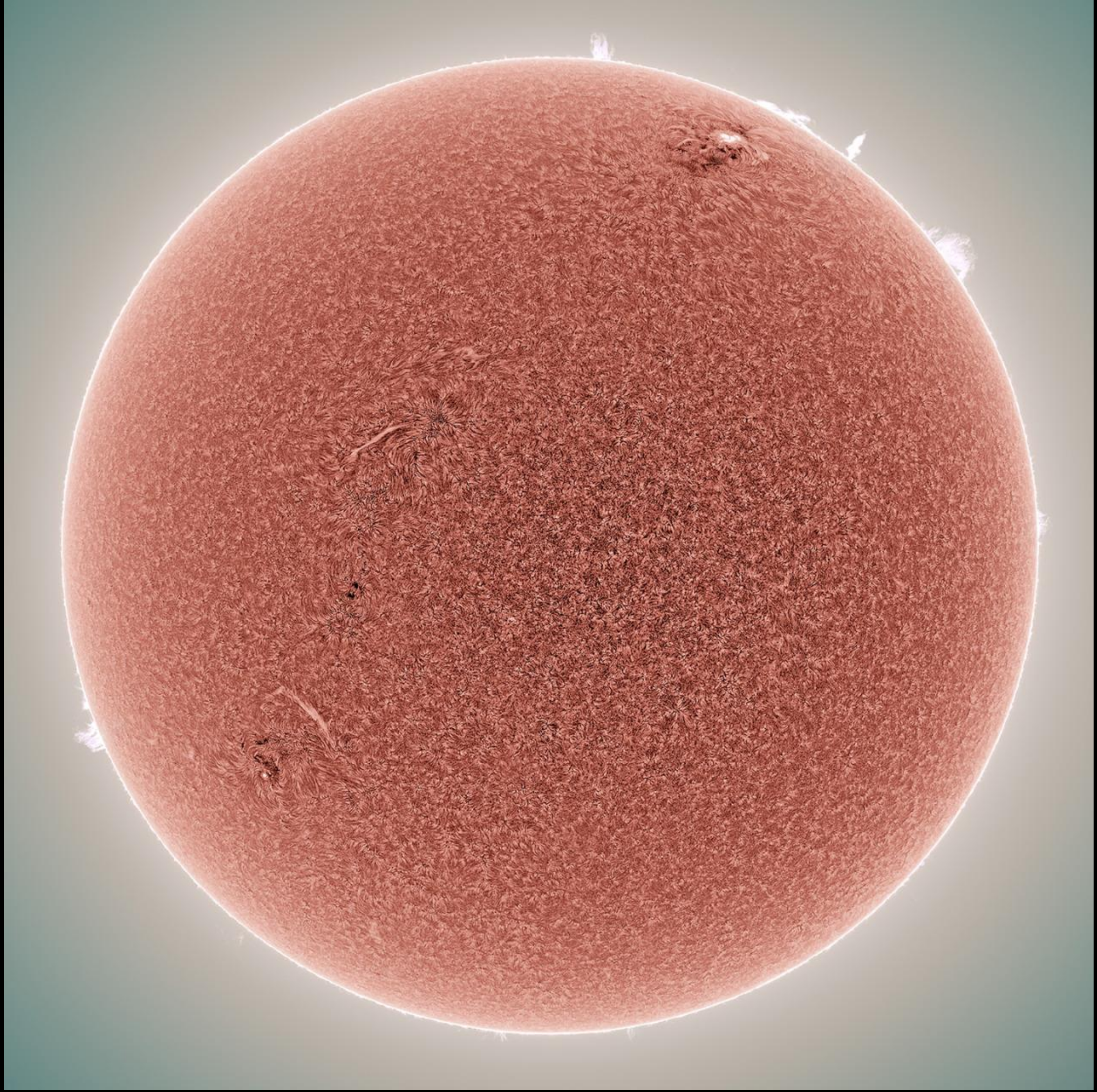




Temperature of Sun surface 5780 K

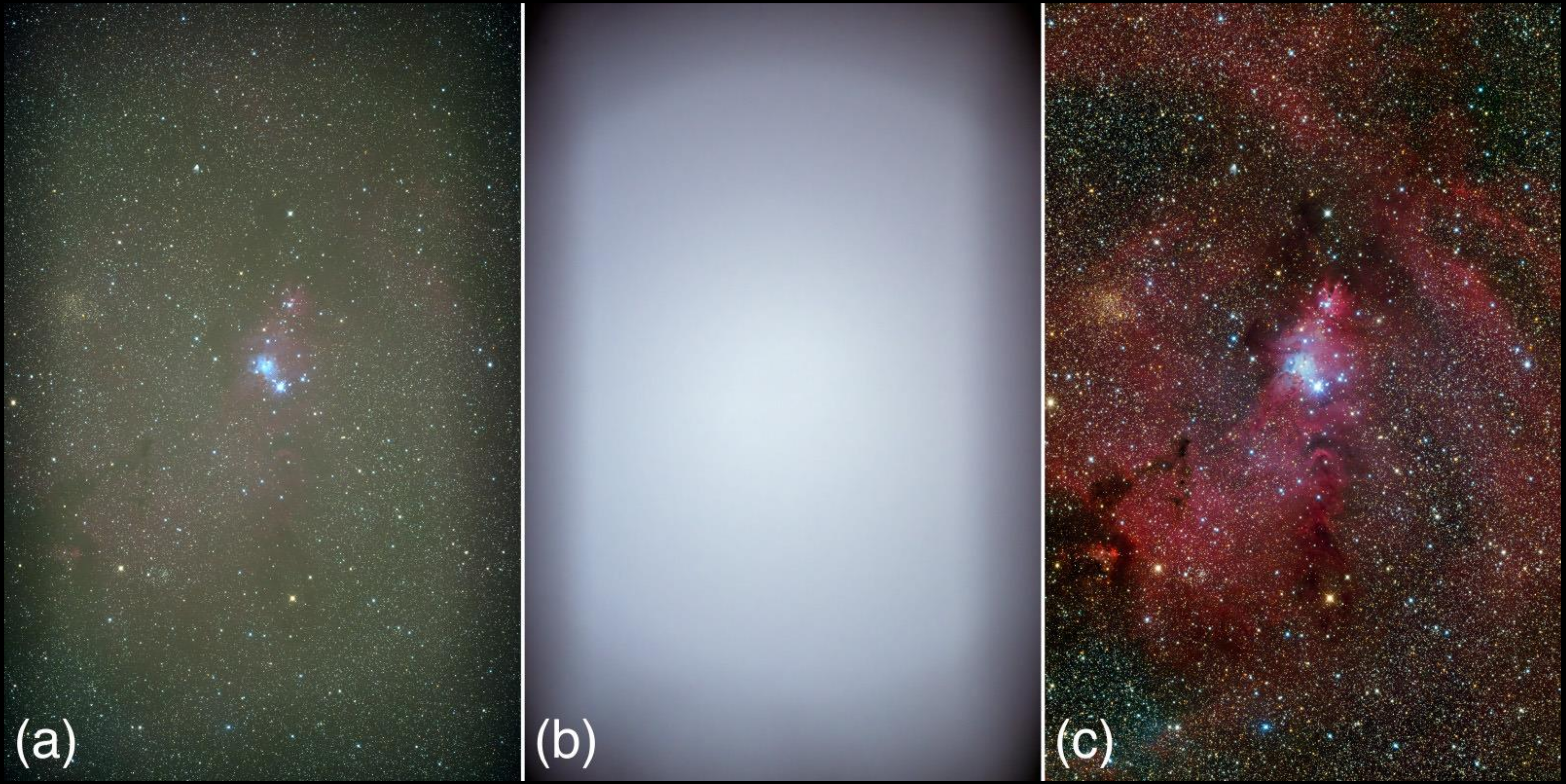

HMI Dopplergram
Surface movement
Photosphere
HMI Magnetogram
Magnetic field polarity
Photosphere
HMI Continuum
Matches visible light
Photosphere
AIA 1700 Å
4500 Kelvin
Photosphere
AIA 4500 Å
6000 Kelvin
Photosphere
AIA 1600 Å
10,000 Kelvin
Upper photosphere/
Transition region
AIA 304 Å
50,000 Kelvin
Transition region/
Chromosphere
AIA 171 Å
600,000 Kelvin
Upper transition
Region/quiet corona
AIA 193 Å
1 million Kelvin
Corona/flare plasma
AIA 211 Å
2 million Kelvin
Active regions
AIA 335 Å
2.5 million Kelvin
Active regions
AIA 094 Å
6 million Kelvin
Flaring regions
AIA 131 Å
10 million Kelvin
Flaring regions

True colour image of the Sun



Alan Friedman 3.5in, ND8192 + narrow band filter, webcam

Flat fields, darks and bias frames

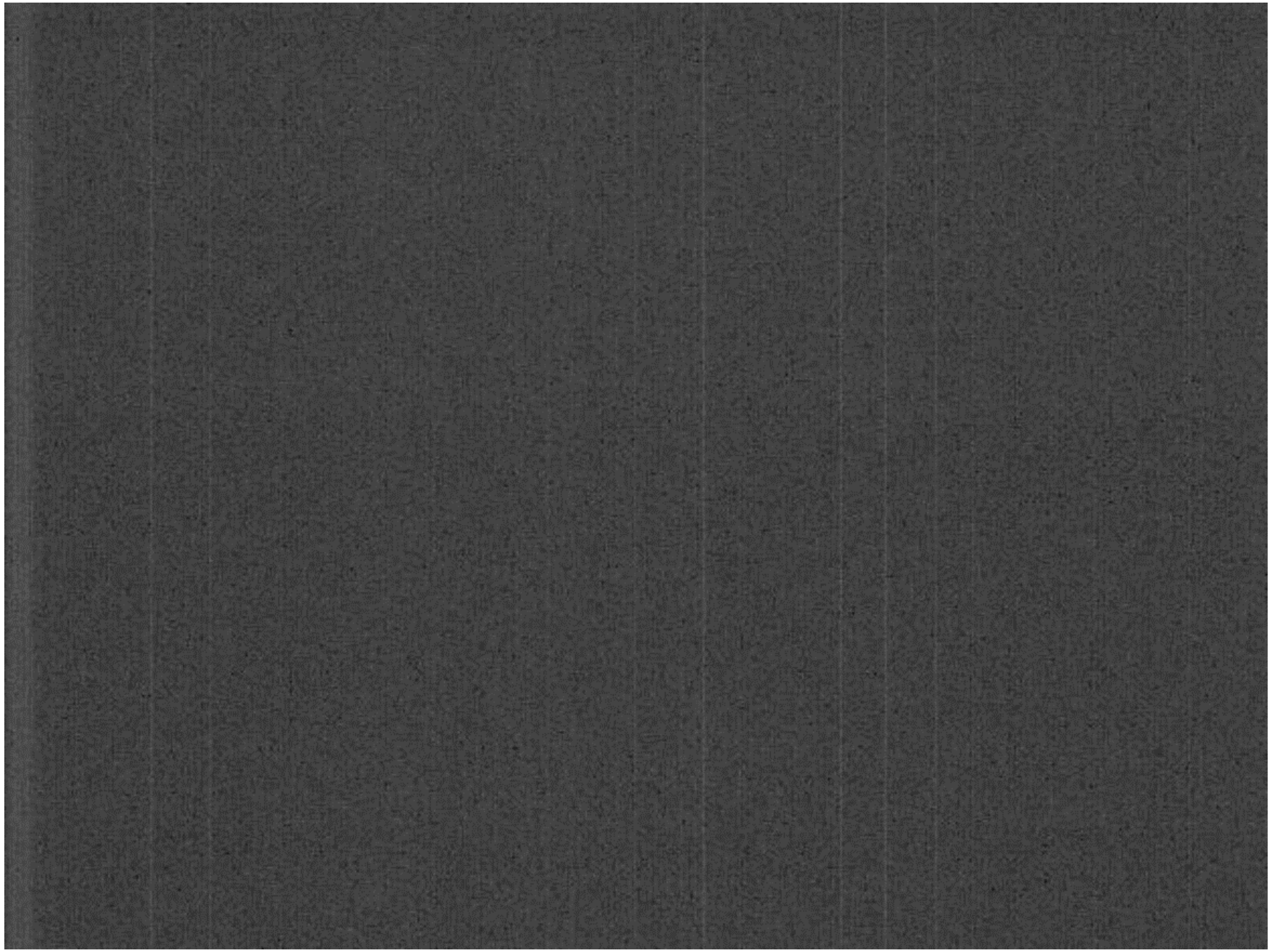


(a)
(b)
(c)

Flat field frames are used to correct problems in the optical path, including dust on the lens, vignetting and internal reflections. Any change in the optical path, such as changing the focal length of the lens, will require a new flat field frame. To obtain the best possible flat field frames would mean taking them at the same conditions as the light and dark frames. To take flat field frames, first focus (at infinity) and then point the camera to an evenly illuminated surface. Flat field frames can be taken from the twilight sky, pointing at a white sheet of paper or with a clean white cloth over the lens. The exposure time has to be chosen in such a way that the intensity level reached approximately 50% of the maximum. Do not over expose - these typically need short exposure times. You should take several flat field images. Once stacked the master flat image may look something like the above (stretched).

Dark frames

The purpose of dark frames is to remove the non-image related thermal and electronic noise that the CCD generated when capturing photons. It also removes imperfections of the chip, such as dead pixels. Since we are capturing the build-up of thermal and electronic noise, it is important to match the dark frame to the same conditions as the light frame, this should include the same duration of exposure, temperature, gain, brightness and contrast. Dark frames can be taken by covering the lens with its lens cap and take several images with the same exposure length as the light frames. With these dark frames you can generate a master dark frame. You might see bad pixels and other defects when you stretch the image colour scale on your stacked dark frame.



Bias frames

CCD sensors have a base level of noise in the sensor, called bias. When averaged out, basically it's an inherent gradient to the sensor. Bias frames are meant to capture this so it can be removed. These are short exposures taken with the telescope lens cap on. Take several. Once stacked your master bias frame may look like the above.

Camera settings

Camera

You need a camera that you can set everything to manual.

Camera settings:

ISO: high (experiment, 400-4000)

Exposures: many & long i.e. 50 x 30 second exposures

Lens: see next slide

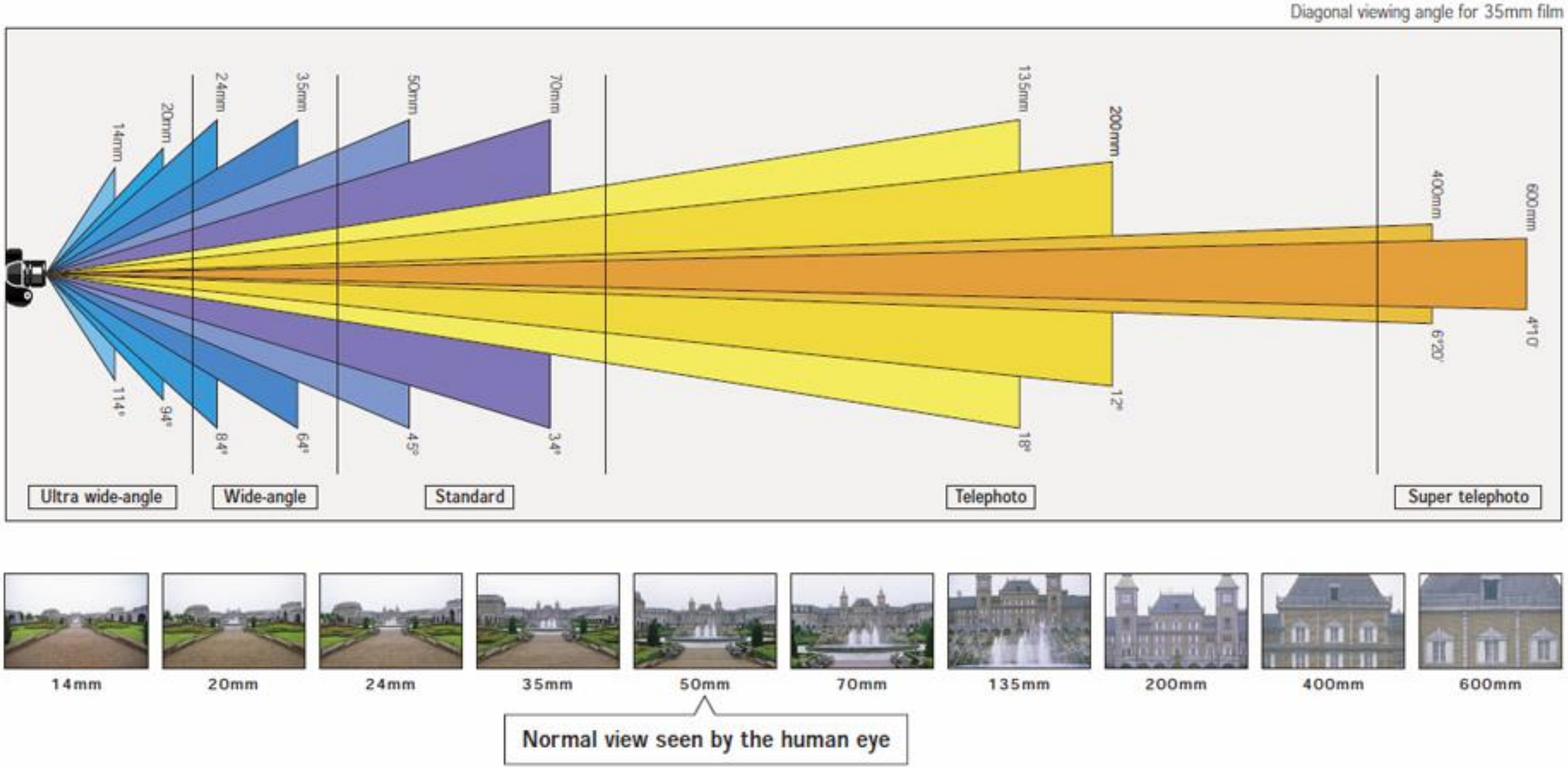
Aperture: widest (low f number as possible)

White balance: can modify afterwards if RAW, otherwise use ‘daylight’.

Image format: RAW/Jpeg ~ RAW preferred

Focussing manual: zoom with +/- on bright distant object using live view

Everything set to manual, no image stabilising, no autofocus etc.


Diagonal viewing angle for 35mm film
14mm
20mm
24mm
35mm
50mm
70mm
135mm
200mm
400mm
600mm
114°
94°
84°
64°
45°
34°
18°
12°
6°20'
4°10'
Ultra wide-angle
Wide-angle
Standard
Telephoto
Super telephoto
14mm
20mm
24mm
35mm
50mm
70mm
135mm
200mm
400mm
600mm
Normal view seen by the human eye


SkyEyE Observatory / Ole Alexander Ødegård

Camera settings:

Camera: ideally a DSLR, Nikon/Canon etc. But must have manual settings and ability to take 30+s exposures, manual focus etc. Remote camera control to prevent camera vibrations

Lens:

Fisheye for entire Milky Way galaxy
Wide field, 10-20mm for Milky Way galaxy/star trails
~50mm for Milky Way centre/several stitched together for panorama
~100mm for Milky Way or large angle view of Orion and Horsehead nebulae
>100mm for Andromeda, Pleiades, any object from the Messier catalogue

Software

Stellarium (planetarium, Windows/MacOS): https://stellarium.org/
Professional star charts/planetarium: https://www.ap-i.net/skychart/en/start
Current configuration of the planets: https://theskylive.com/#brightest_planets
What is visible tonight, deep sky objects, nebulae, galaxies etc: www.telescopius.com
Polar finder scope app: www.polarfinder.com
Polar finder online:
https://takahashi-europe.com/support/softwares/polarisfinder/polarisfinder-1.5-en.htm
Deepskystacker: http://deepskystacker.free.fr/
SIRIL astronomical image processing tool (Windows/Linux/MacOS): https://siril.org/
AstroImageJ: https://www.astro.louisville.edu/software/astroimagej/
Gimp (free alternative to photoshop): www.gimp.org
Startrails software for stacking: https://www.startrails.de/
Startrails software for blending: https://markus-enzweiler.de/software/starstax/
Camera control software (APT): https://www.astrophotography.app/

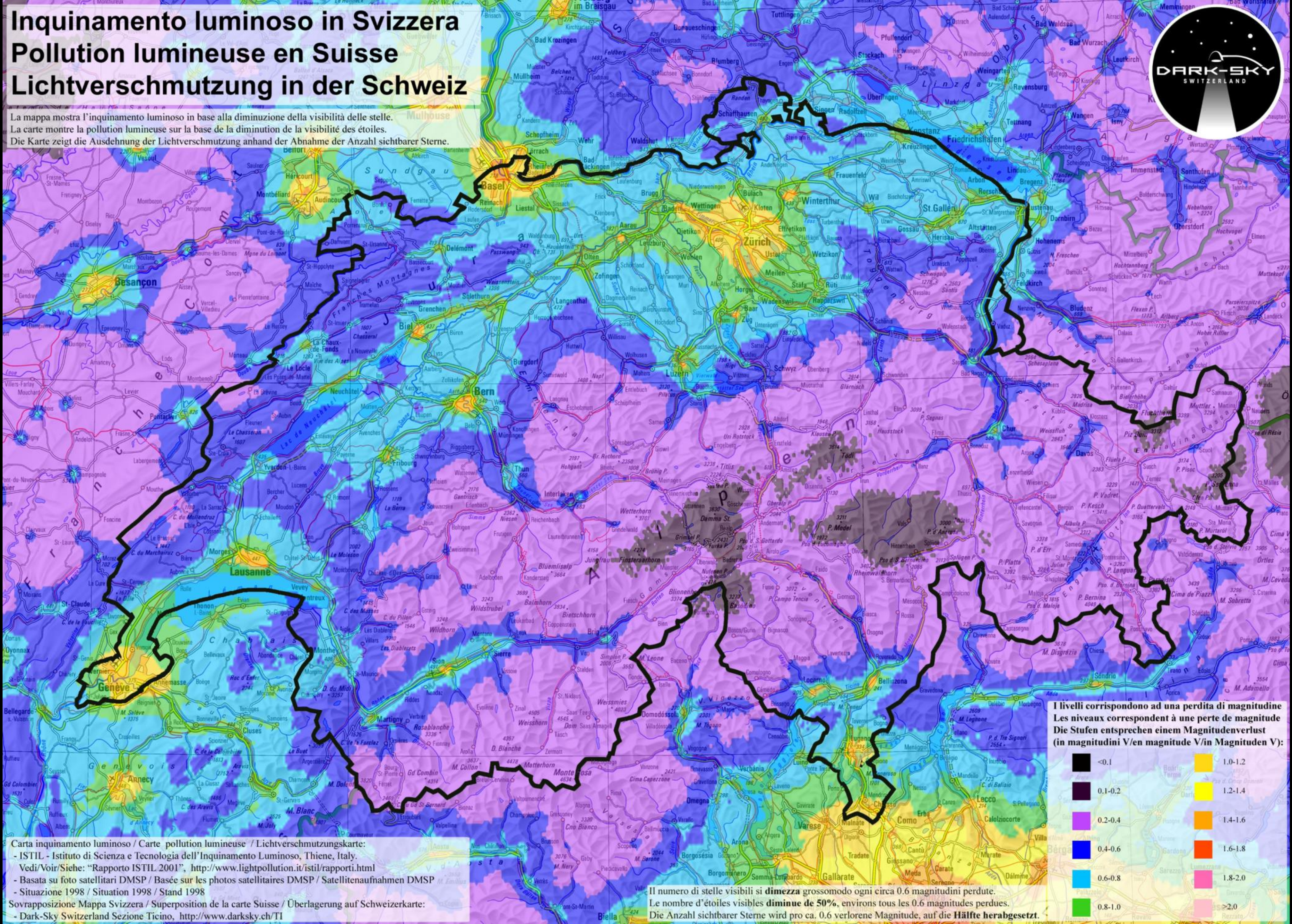
Software $$$ many: https://diffractionlimited.com/product/maxim-dl/
Tutorials: many online, search “DSLR astrophotography”

Preparations: finding charts and observing site

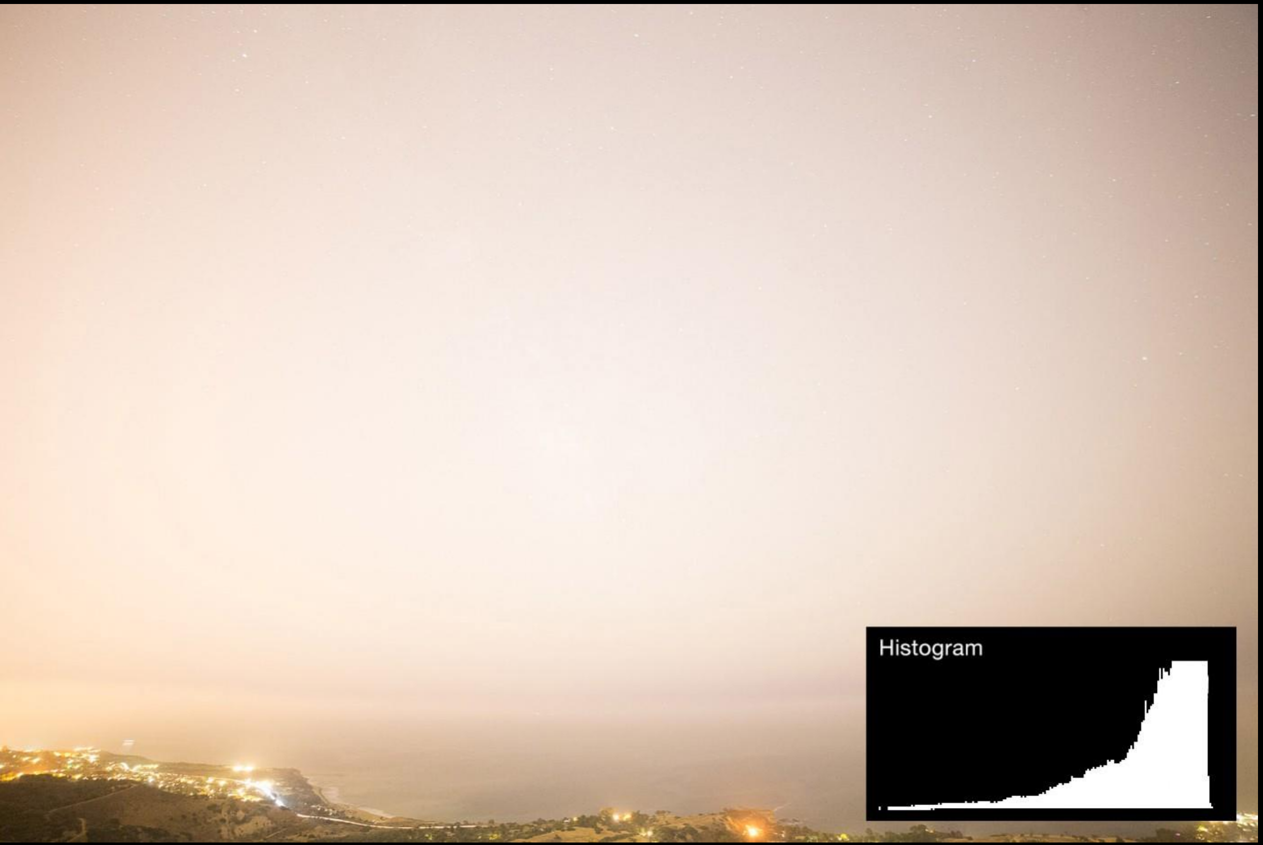

THE MOON
TARGET
(Orion Nebula)
S
January 14, 2017

Make a finding chart for your object – check moon phase, check date/time

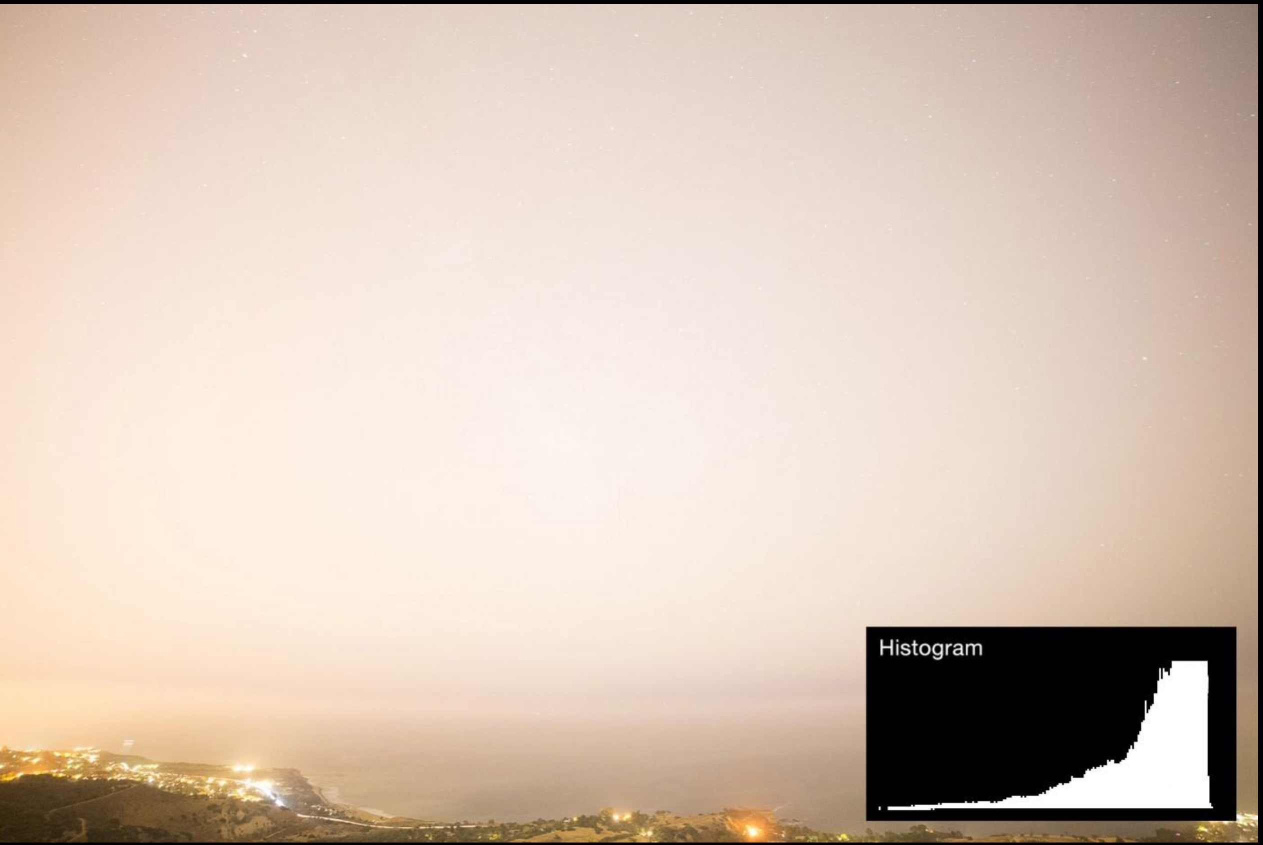
With stellarium or cartes du ciel you can also show the field of view of your camera/lens combination



Inquinamento luminoso in Svizzera
Pollution lumineuse en Suisse
Lichtverschmutzung in der Schweiz
La mappa mostra l'inquinamento luminoso in base alla diminuzione della visibilità delle stelle.
La carte montre la pollution lumineuse sur la base de la diminution de la visibilité des étoiles.
Die Karte zeigt die Ausdehnung der Lichtverschmutzung anhand der Abnahme der Anzahl sichtbarer Sterne.
DARK-SKY SWITZERLAND
Basel
Zürich
Bern
Lausanne
Genève
I livelli corrispondono ad una perdita di magnitudine
Les niveaux correspondent à une perte de magnitude
Die Stufen entsprechen einem Magnitudenverlust
(in magnitudini V/en magnitude V/in Magnituden V):
<0.1
0.1-0.2
0.2-0.4
0.4-0.6
0.6-0.8
0.8-1.0
1.0-1.2
1.2-1.4
1.4-1.6
1.6-1.8
1.8-2.0
>2.0
Carta inquinamento luminoso / Carte pollution lumineuse / Lichtverschmutzungskarte:
- ISTIL - Istituto di Scienza e Tecnologia dell'Inquinamento Luminoso, Thiene, Italy.
Vedi/Voir/Siehe: "Rapporto ISTIL 2001", http://www.lightpollution.it/istil/rapporti.html
- Basata su foto satellitari DMSP / Basée sur les photos satellitaires DMSP / Satellitenaufnahmen DMSP
- Situazione 1998 / Situation 1998 / Stand 1998
Sovrapposizione Mappa Svizzera / Superposition de la carte Suisse / Überlagerung auf Schweizerkarte:
- Dark-Sky Switzerland Sezione Ticino, http://www.darksky.ch/TI
Il numero di stelle visibili si dimezza grossomodo ogni circa 0.6 magnitudini perdute.
Le nombre d'étoiles visibles diminue de 50%, environs tous les 0.6 magnitudes perdues.
Die Anzahl sichtbarer Sterne wird pro ca. 0.6 verlorene Magnitude, auf die Hälfte herabgesetzt.



Ian Norman, Los Angeles 2013, Canon EOS 6D, 14mm, f/2.8, 30s

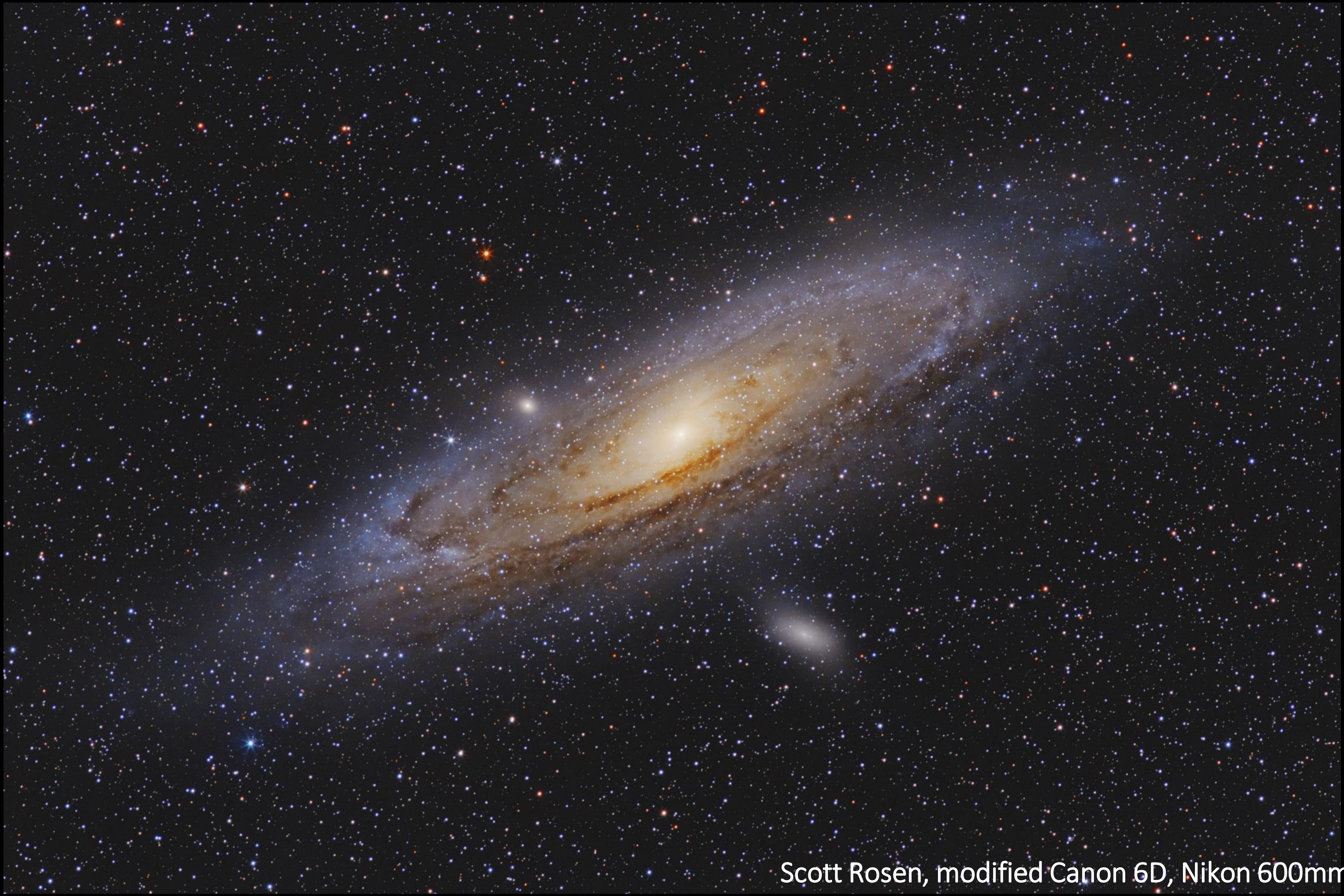


Ian Norman, Los Angeles 2013, Canon EOS 6D, 14mm, f/2.8, 30s

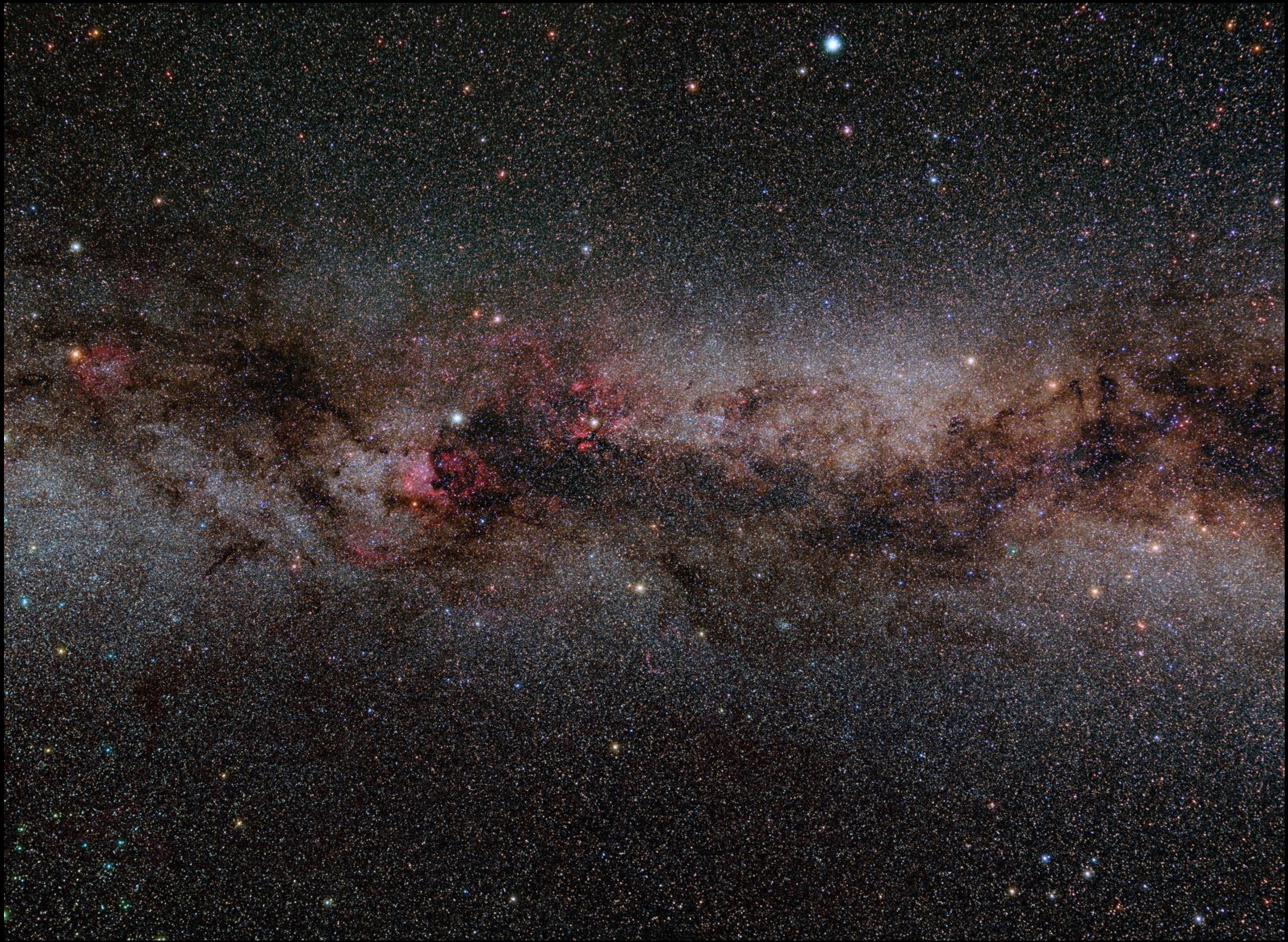
Example images

Ben Moore, Davos 11/2017, Nikon D7100, 300mm, f2.8, 180s

Josh Borup, Orion 80ed, Canon t3i unmodified, 25x600s



Scott Rosen, modified Canon 6D, Nikon 600mm, 44x600s



Wei-Hao Wang: A two-image mosaic taken with a Mamiya 645 45mm f/2.8 lens at f/4.0 and Canon 5D Mark II. Each individual mosaic frame contains 16 4-minute exposures at ISO 1600.

AST201, 2018

M81 and M82

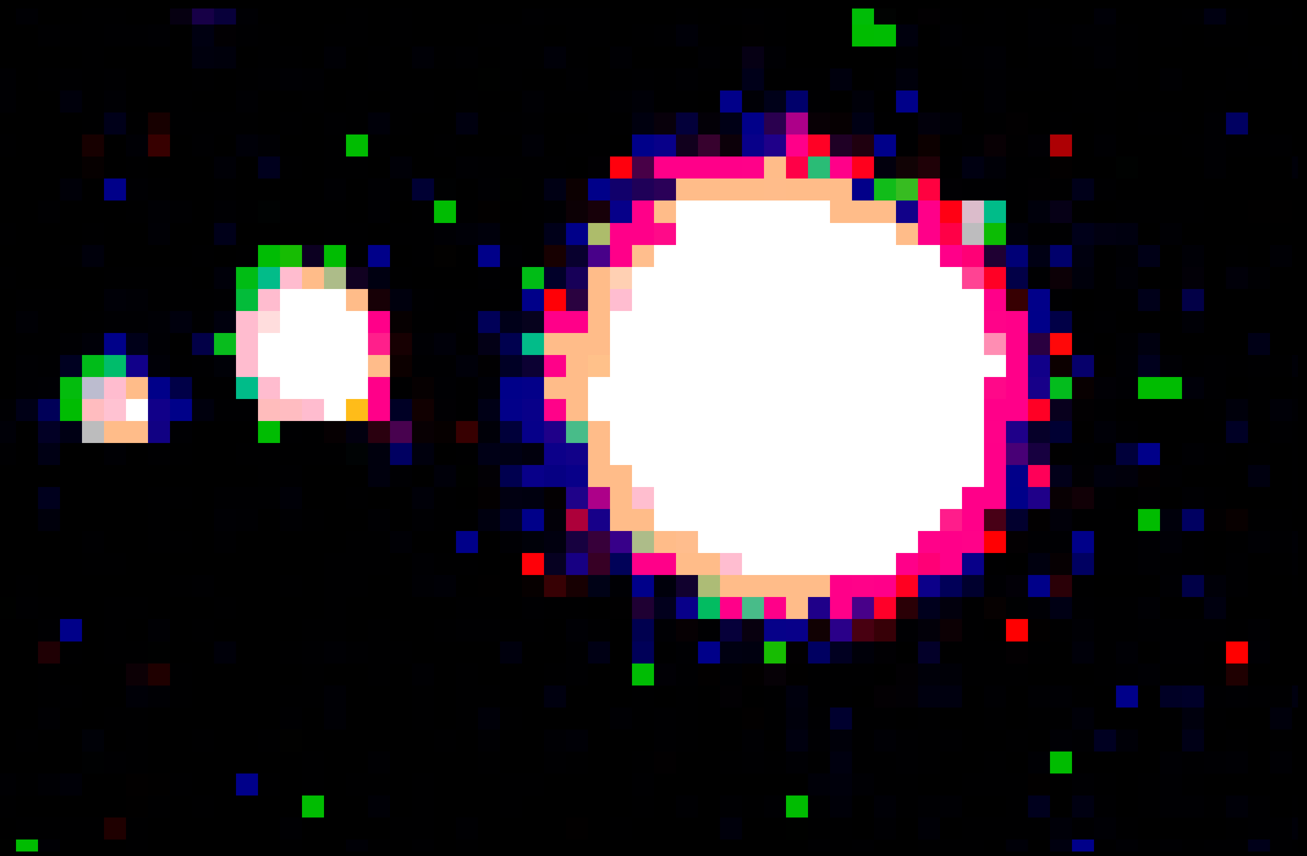
The pinwheel galaxy, M101: Nikkor 180mm f2.8 ED Ai-s, Nikon D7000, 30x1 minutes

Nikon D7000, Nikkor 180mm f2.8 at f4. 36 minutes (27 x 80 seconds) at iso 1600.

Orion and Horsehead nebula AST201, 100mm lens Nov 2019

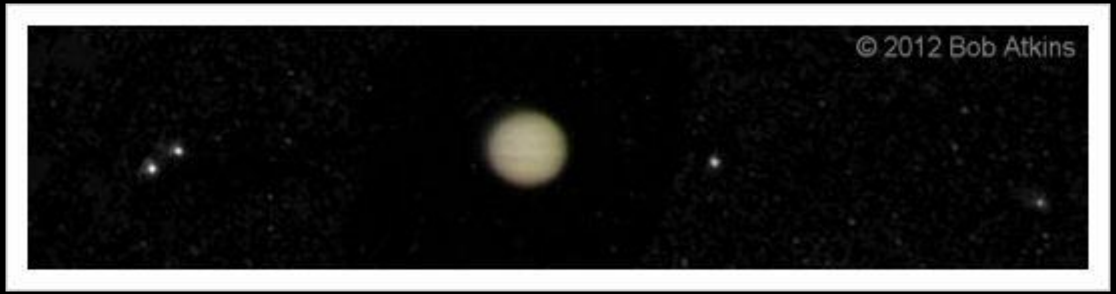
Orion AST201, 300mm lens apr 2020

California Nebula (NGC1499) AST201 Fall 2020



Flaming star nebula: Nikkor 180mm f2.8 ED Ai-s, Nikon D7000, 50x1minutes



1000mm lens (500mm + 2x), 1/50s at f9, ISO 400

Logistics:

- Collect the equipment from the TA, and read the HOWTO guide and practise before trip!
- Did you read that carefully? Make sure you know how to set up the camera and startracker before going out!!
- We will meet all together on one of the next clear nights.
- You must attend the field trip unless you have a very good excuse.
- Please note that the weather has been particularly bad in canton Zurich – only one or two clear nights last semester. Take advantage of every clear night, or spend time in the mountains where the weather can be better.
- You can keep the equipment until the end of semester.
- Work in teams of two/three, share equipment but not data – everyone within a group should choose a separate object to image.
- Take care of the equipment. Do not lose anything.
- Be careful with the screws that fix the small polar telescope
- Be careful with the USB charging port – do not force the cable
- Aim to write a short report detailing what you have observed, lens settings, camera settings/exposure times, software you used, how you made your final image etc. Should be about 10 pages. Include technical details as well as some science about what you have observed and why that object is interesting, what the colours represent etc.
- 6 points requires flat field/bias/dark frames.
- It’s 3 credit points = quite a lot of hours work, more than you think…
- Submit reports by end of January (fall) or end of June (spring).
- Deep sky objects or the Milky Way only, not planets/moon/stars!