Observational Technics

Krištof Skok

3rd IWAA
1. - 8. 9. 2018, Zanka, Hungary

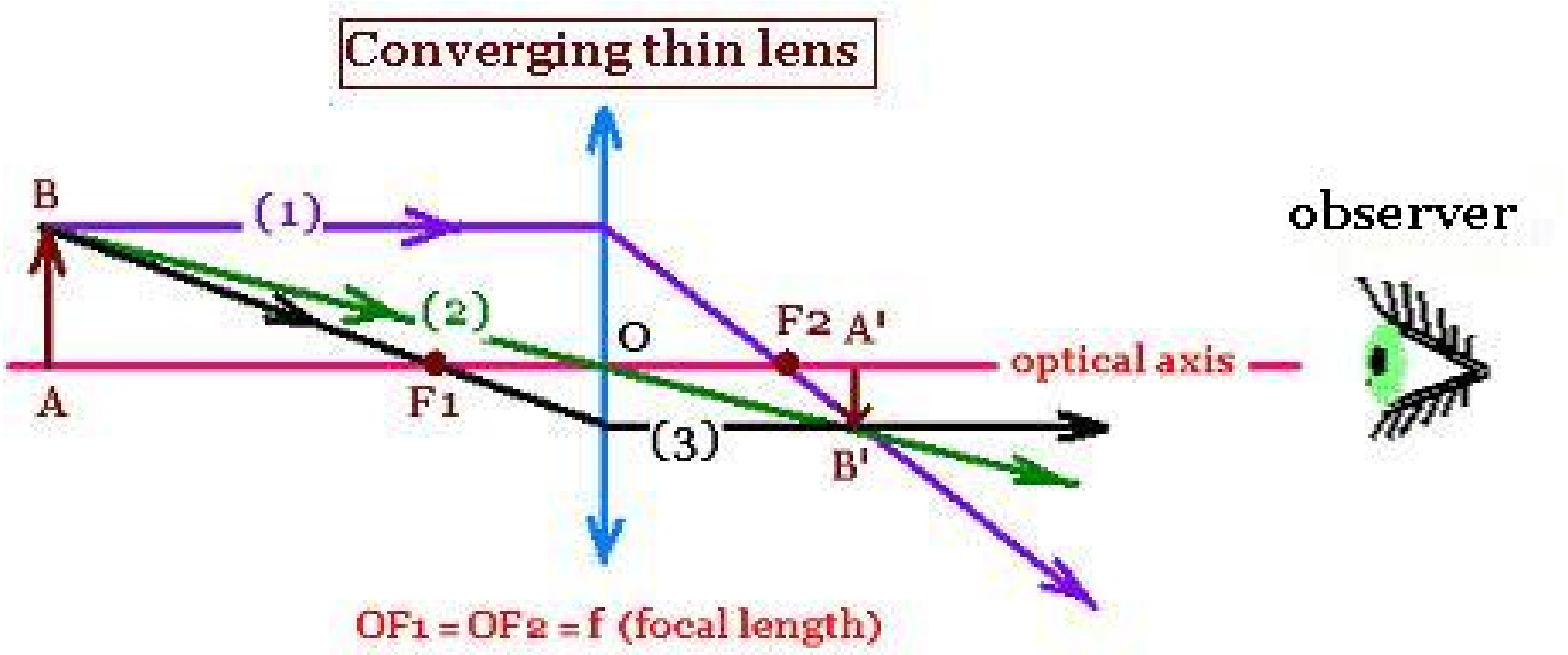
Telescopes

- Different types: refractors, reflectors (Newtonians), catadioptics
- Different mountings: alt-azimuthal, equatorial (german or fork)
- One goal: collect more light and achieve better resolution!

Geometrical optics

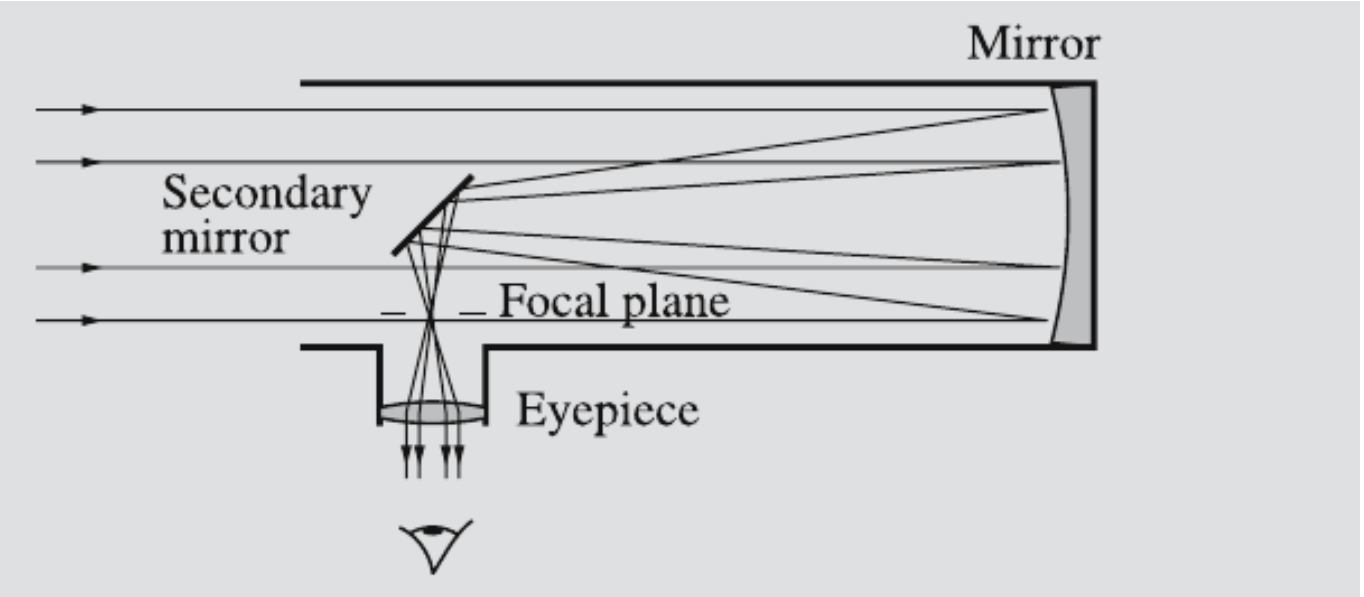
$1 / f = 1 / a + 1 / b$

Celestial objects: $a = \infty$, $b = f$

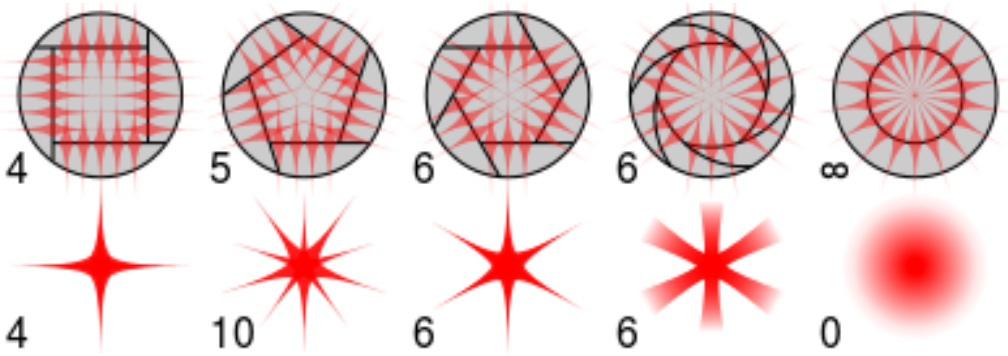


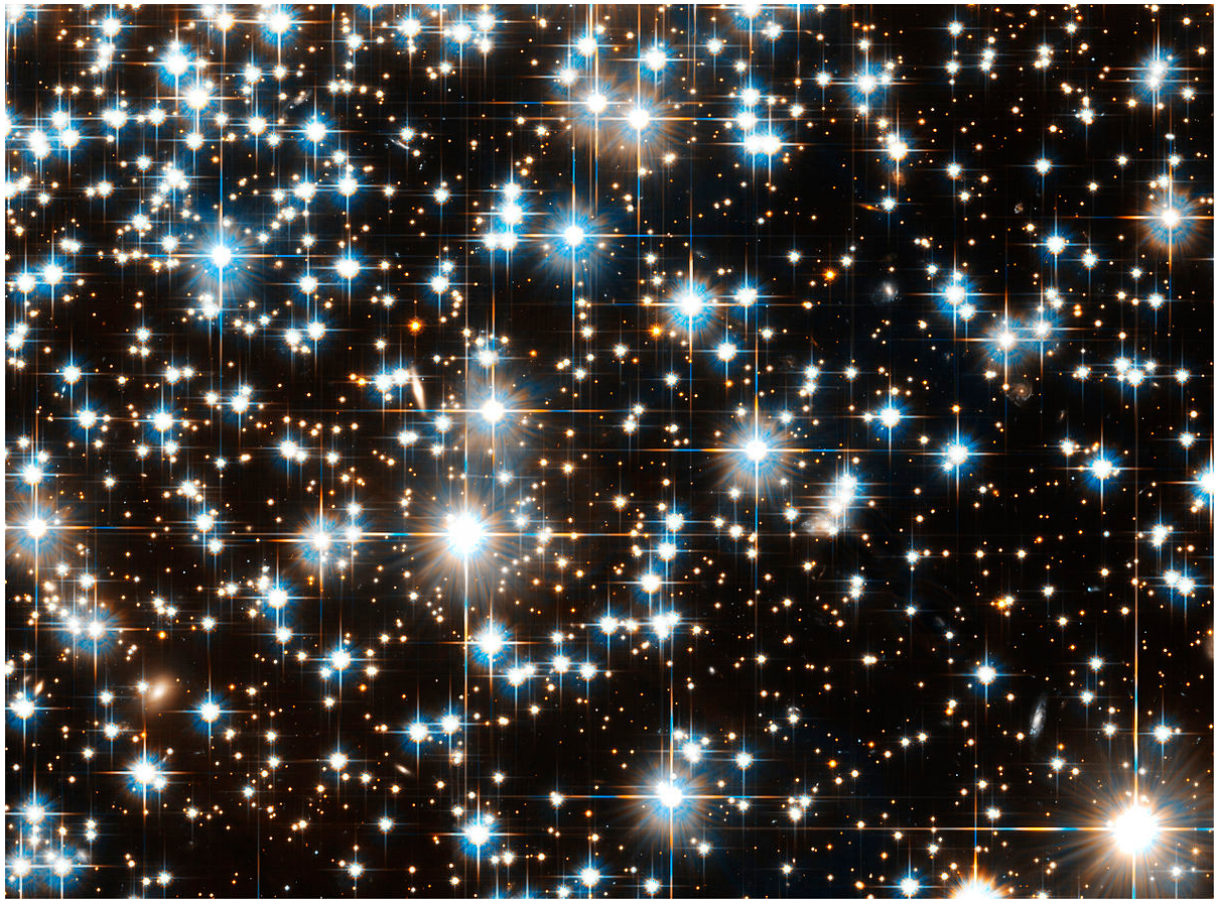
Ray-tracing method to construct the image A'B' of the object AB

Reflectors

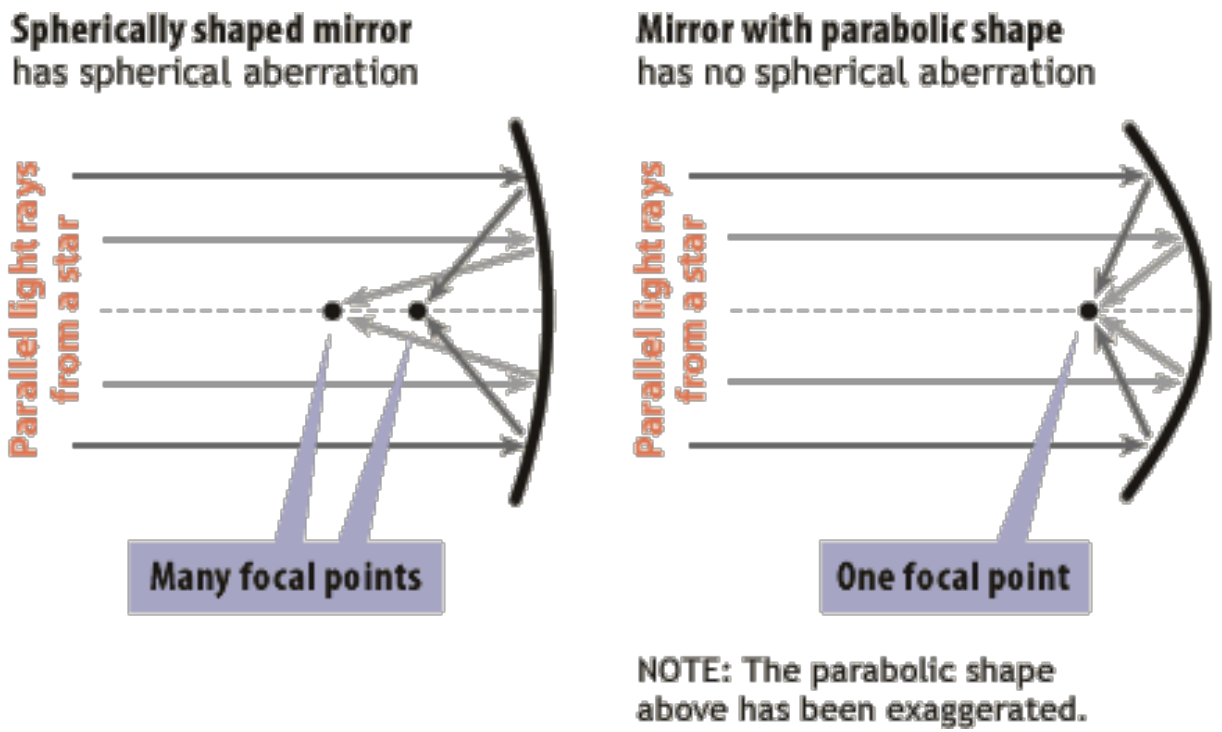


Diffraction spikes



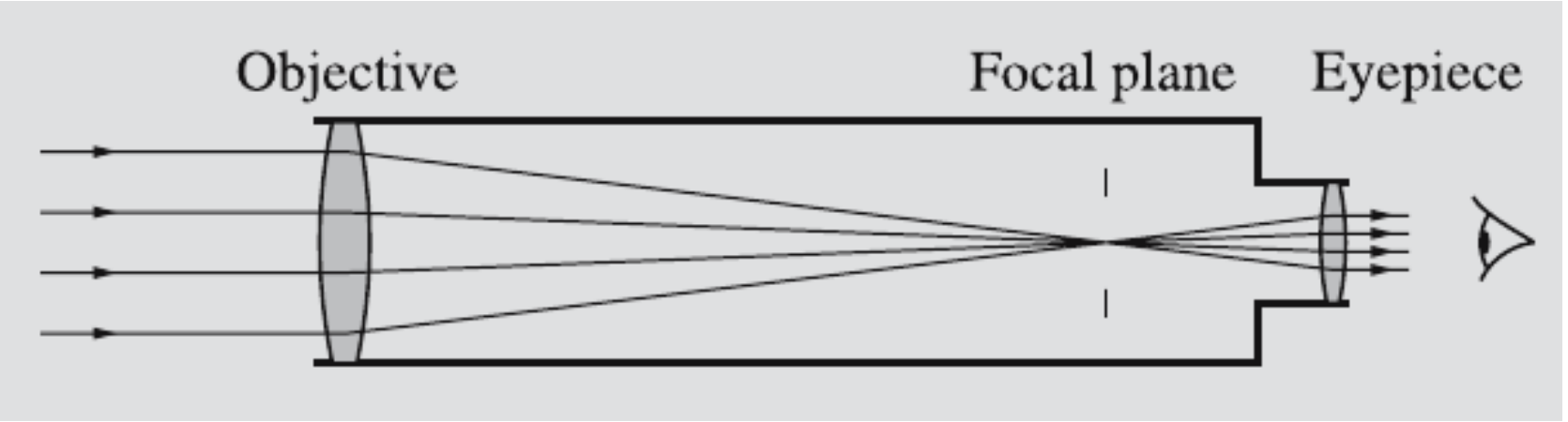


Spherical aberration

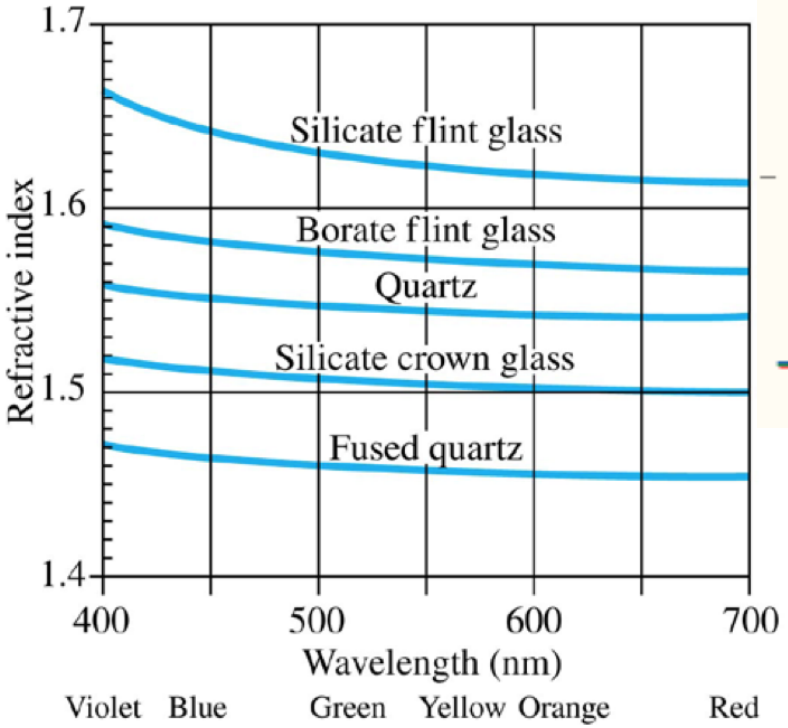


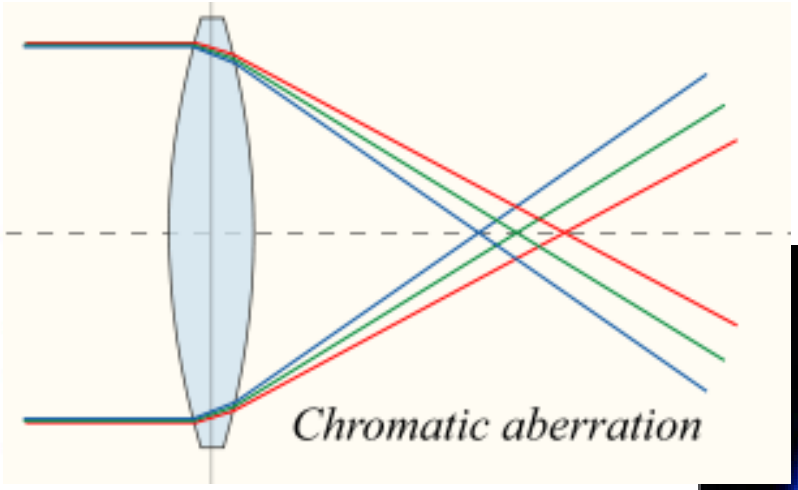
Refractors

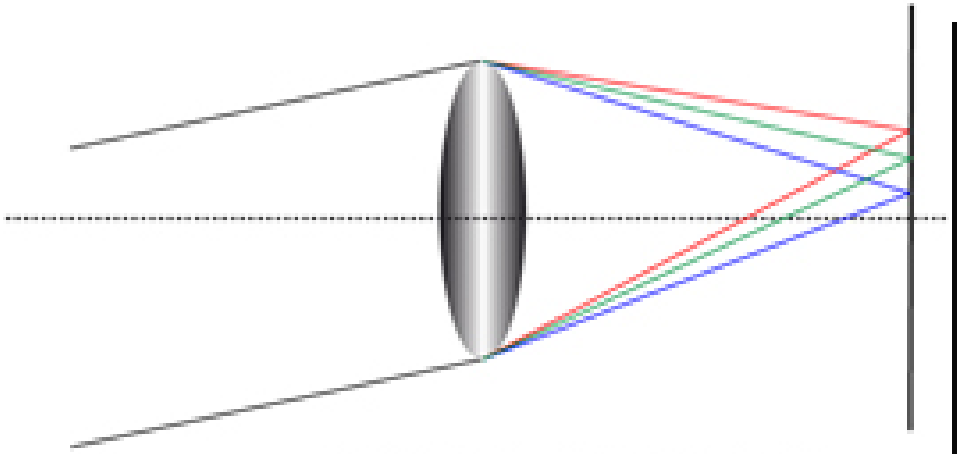
- Achromats & apochromats



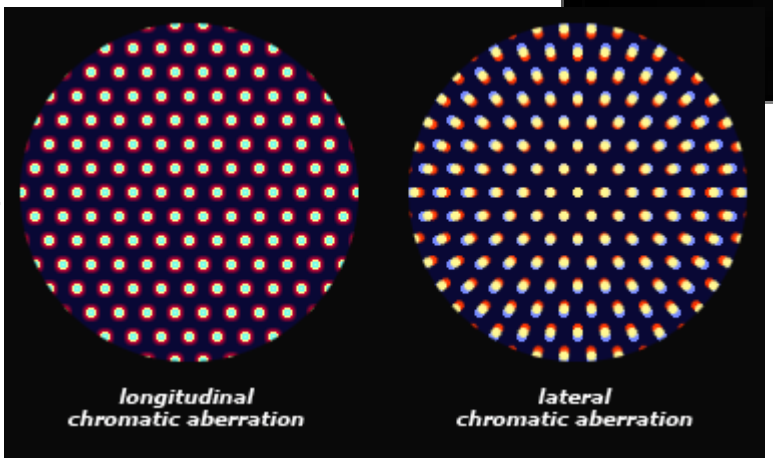
Chromatic aberration



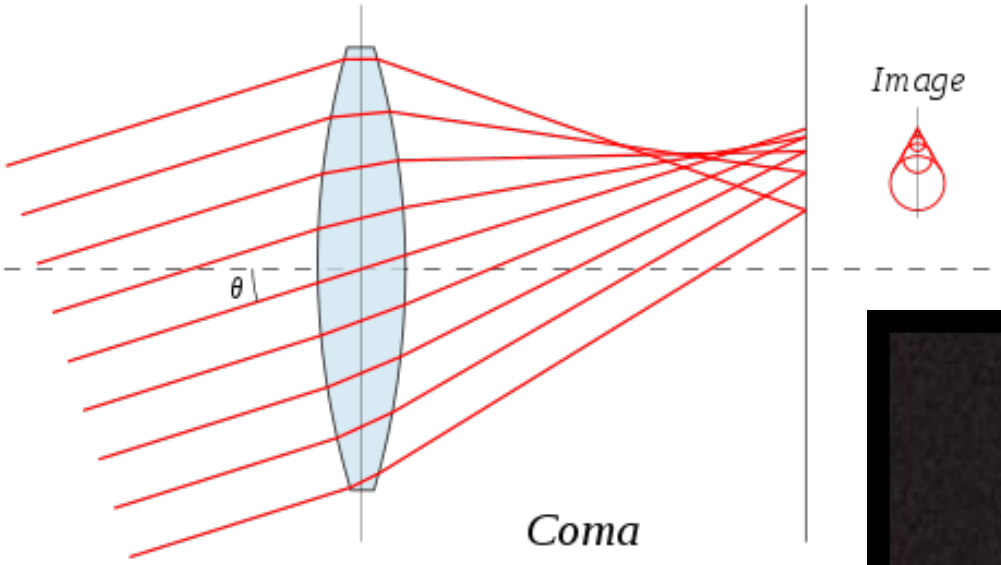




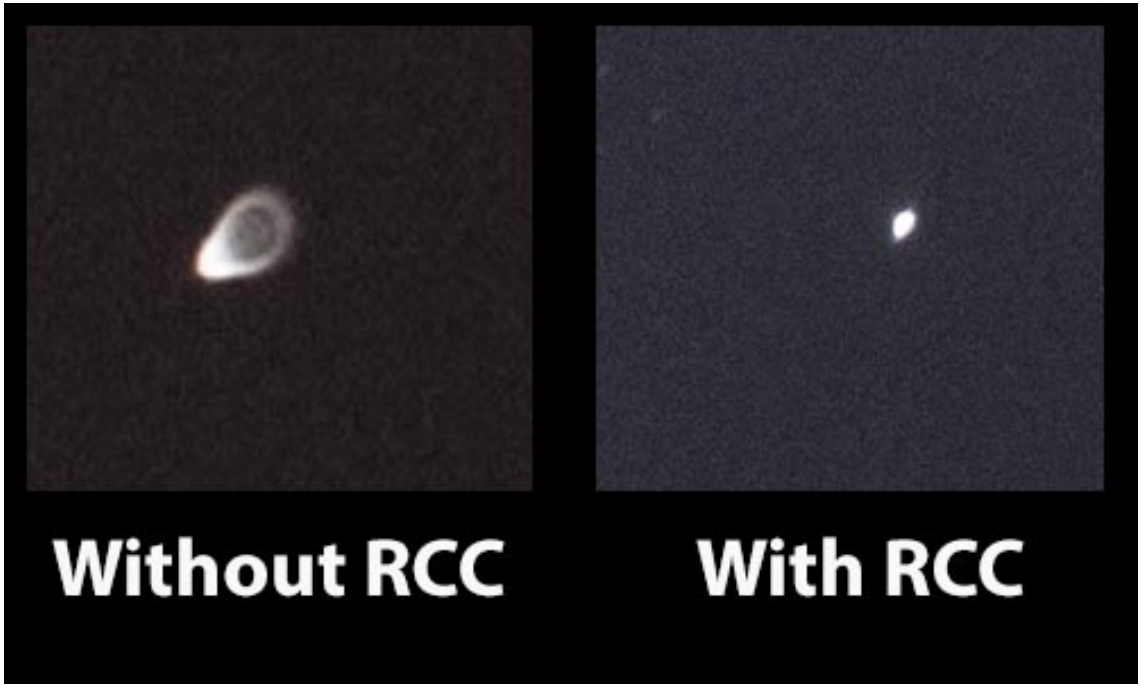
lateral chromatic aberration



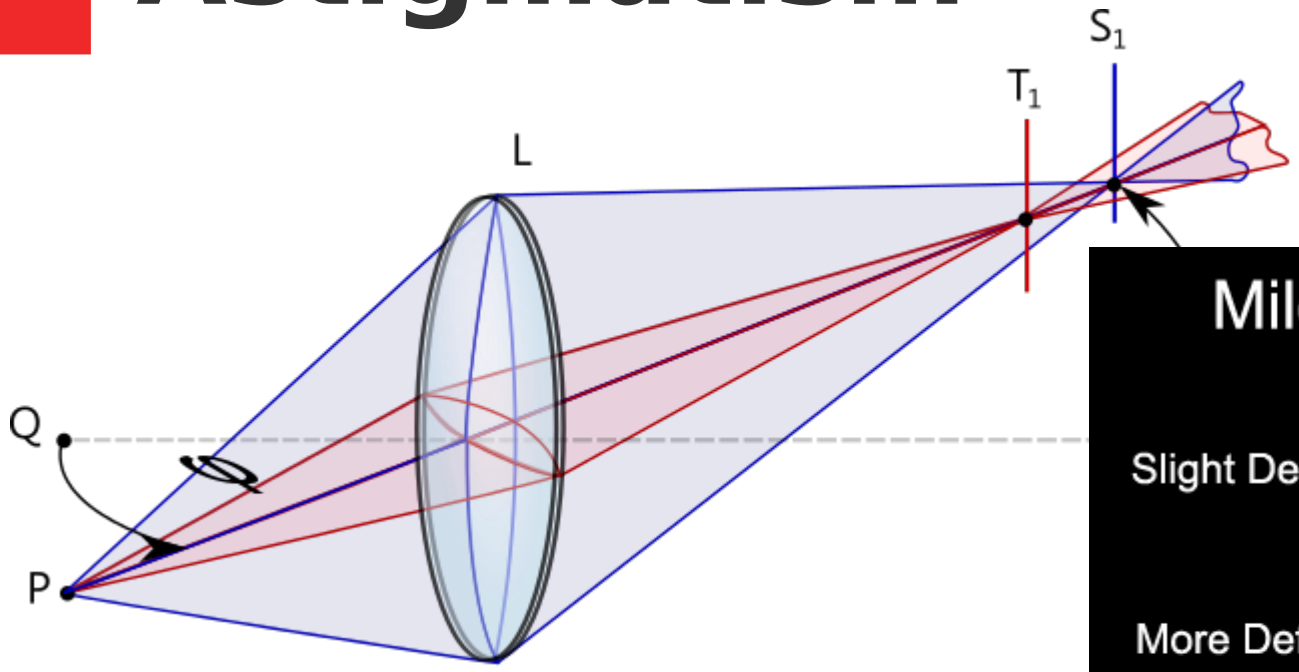
Coma

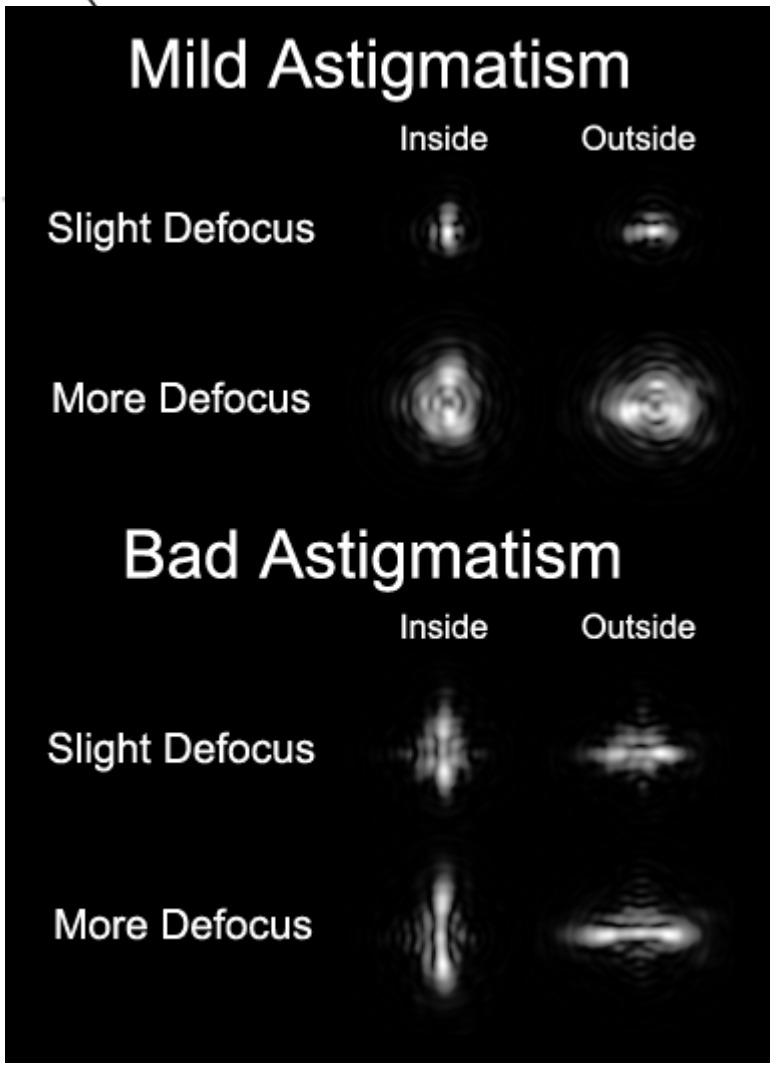


Use coma corrector!



Astigmatism

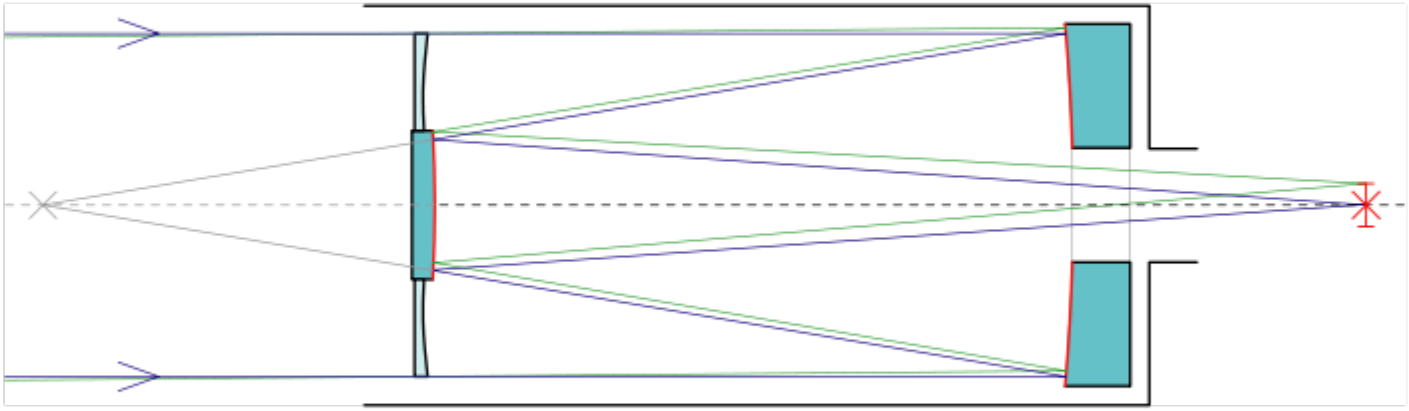


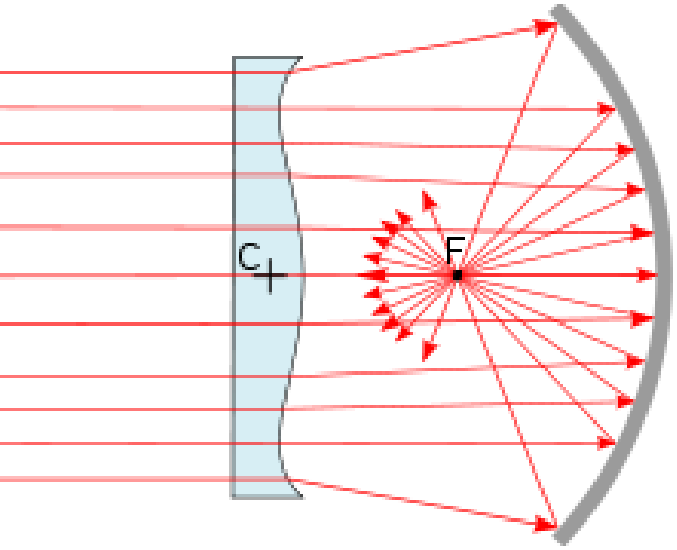


Show the photographs!

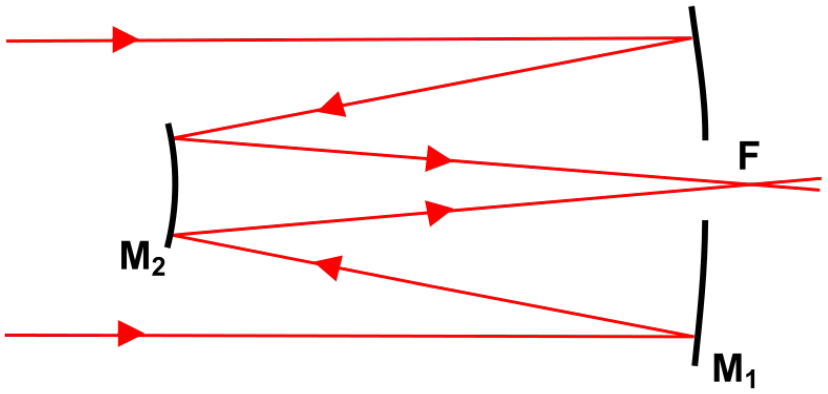
Catadioptics

- Schmidt-Cassegrain – spherical primary
- Maksutov

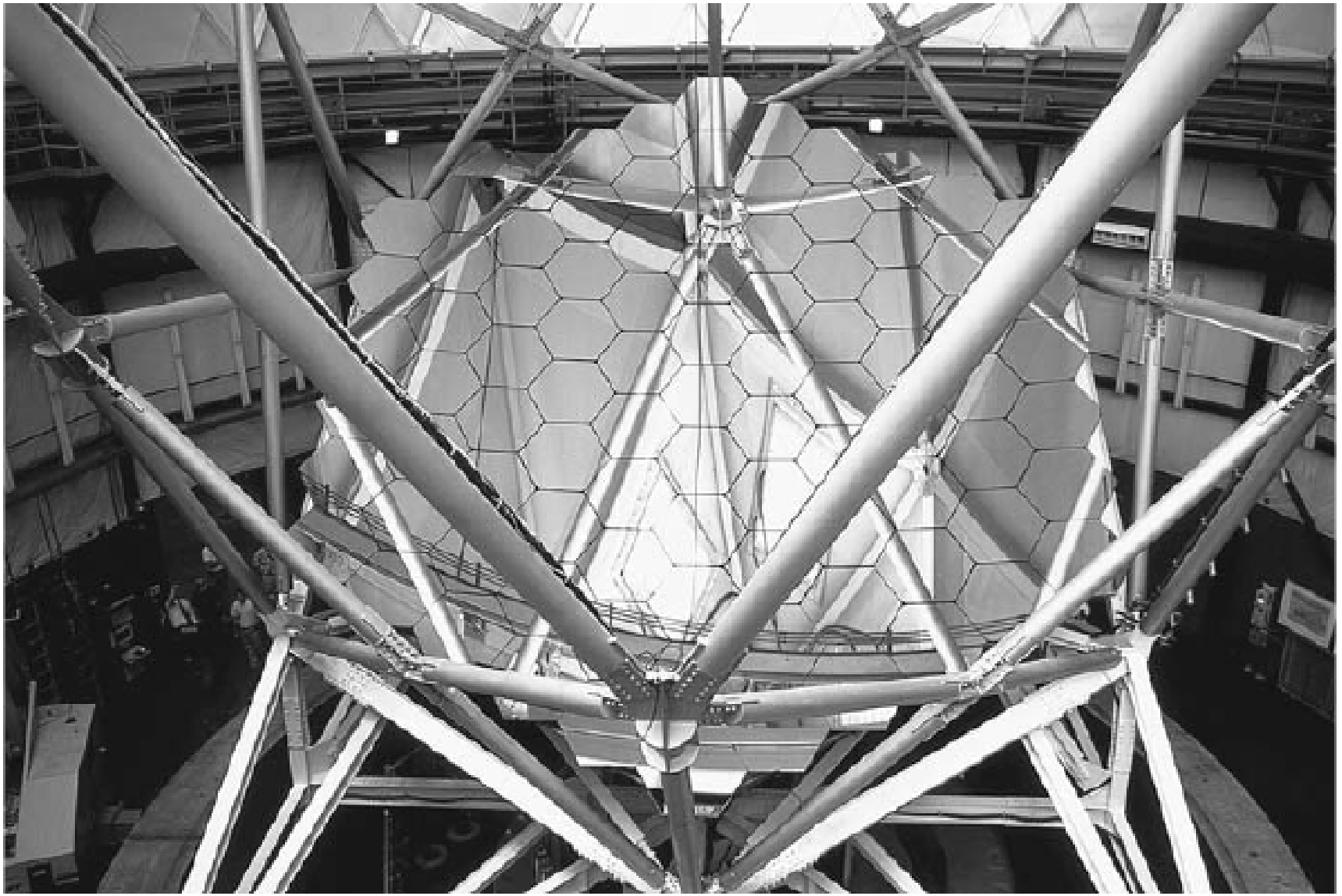




Ritchey-Chretien



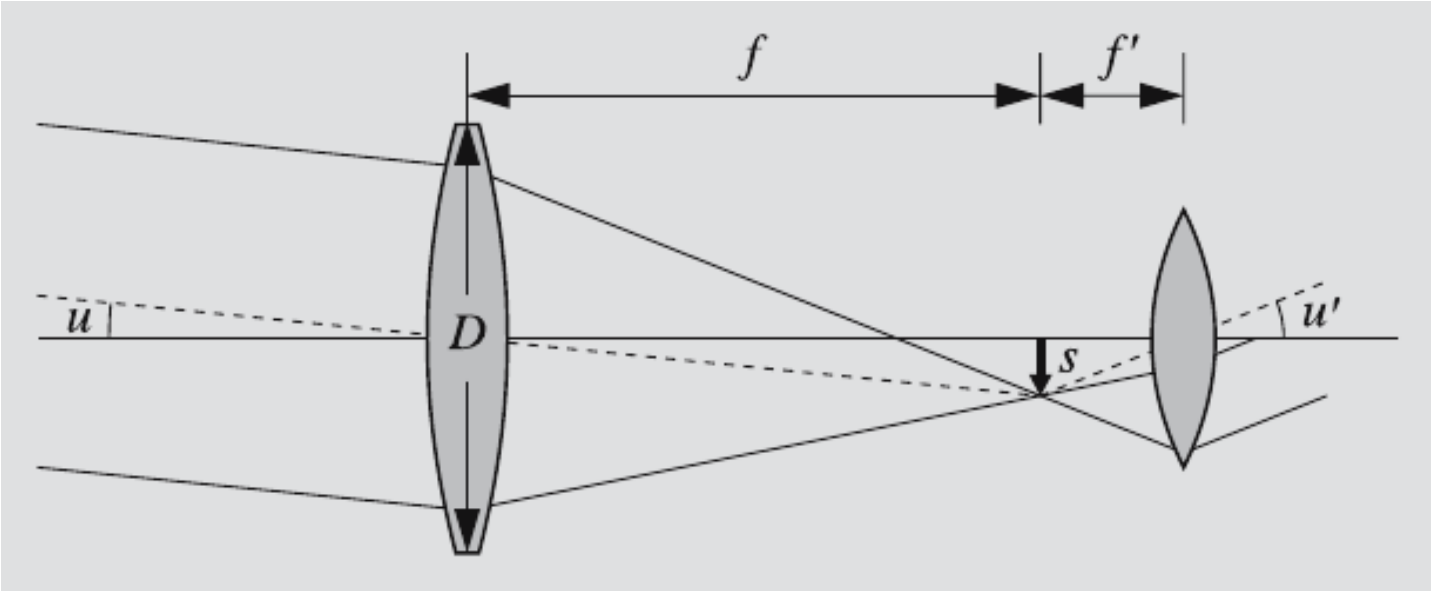
Ritchey-Chrétien



Basic characteristics

- Diameter D
- Focal length f
- Aperture ratio F = f/D. eg. f/5
- “slow” and “fast”
- Rule of Thumb: Less than f/5 = Fast.... f/6 - f/10 = mid-range.... over f/10 = Slow
- Light gathering power proportional to F^-2

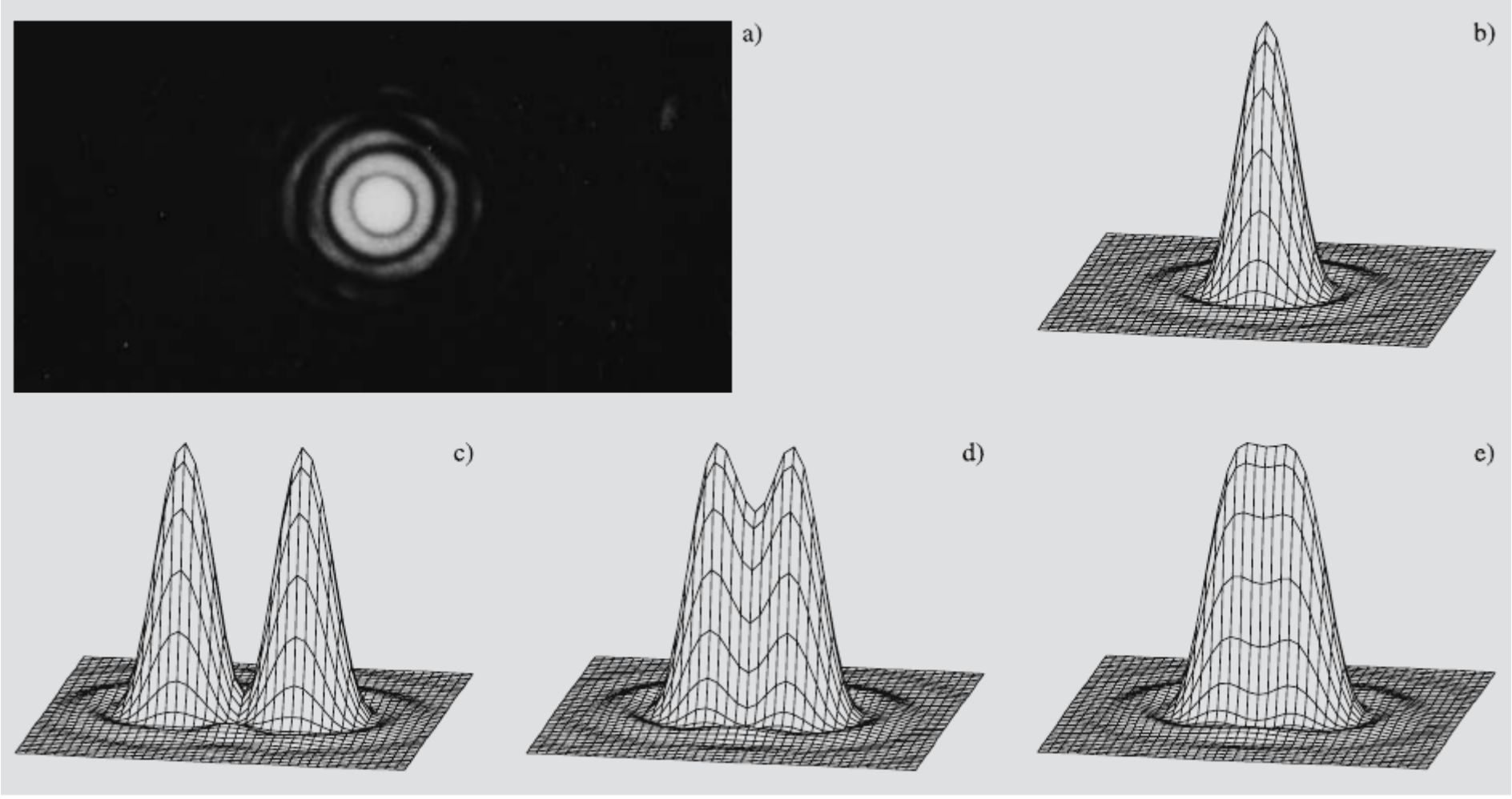
Magnification



- s = f * u = f' * u'
- M = u' / u = f / f'
- Change the eyepiece!

Resolving power

- Rayleigh criteria: $\sin\theta \approx \theta = 1.22\,\lambda / D$

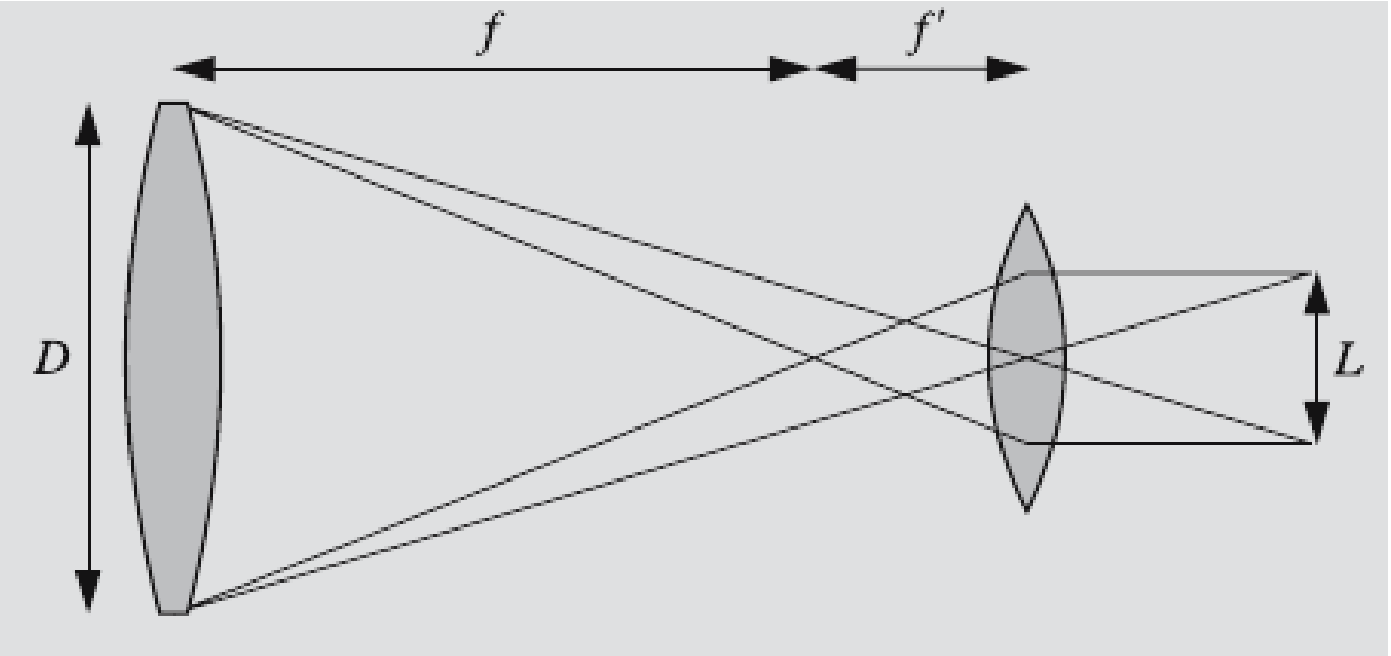


Exit pupil

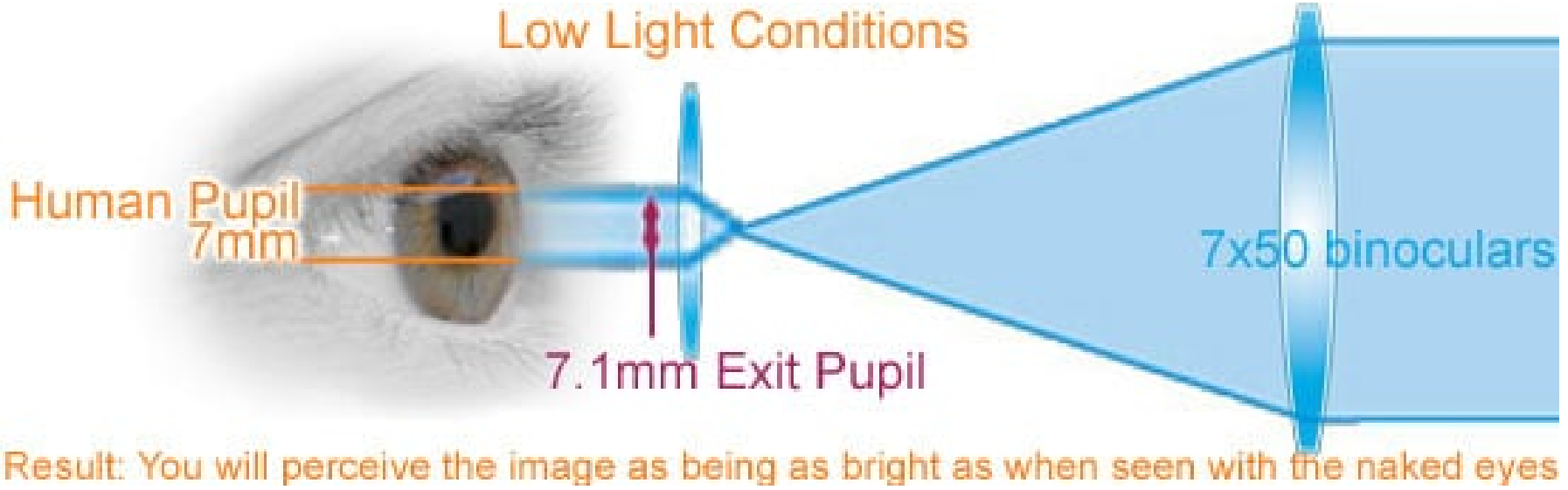

25mm / 8x = 3.125mm
42mm / 8x = 5.25mm
42mm / 10x = 4.2mm
Trailfinder 3 WP
8x25
Field 6.8°
EAGLE OPTICS
8x42
RANGER ED
EAGLE OPTICS
10x42
RANGER ED

Exit pupil

- L = D * f’ / f = D / M = f’ / F
- Binoculars have fixed magnification M: L = D / M



Why it matters?



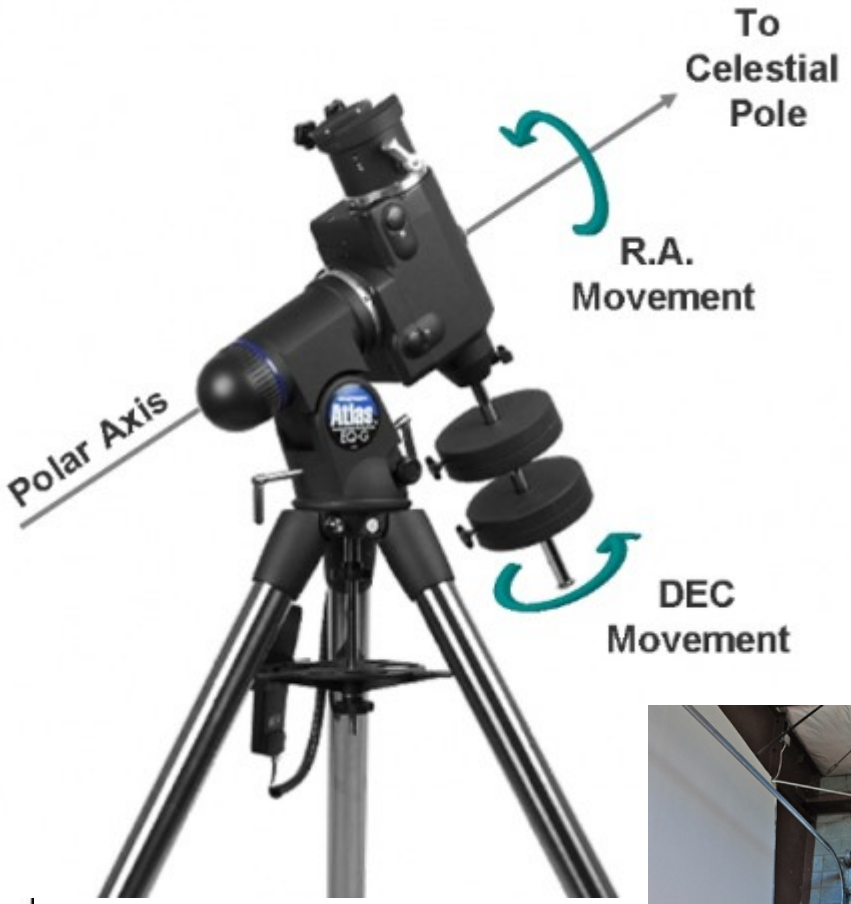
- For defining minimum usable magnification!
- EP_max = D / M_min = EP_eye
- M_min = D / EP_eye

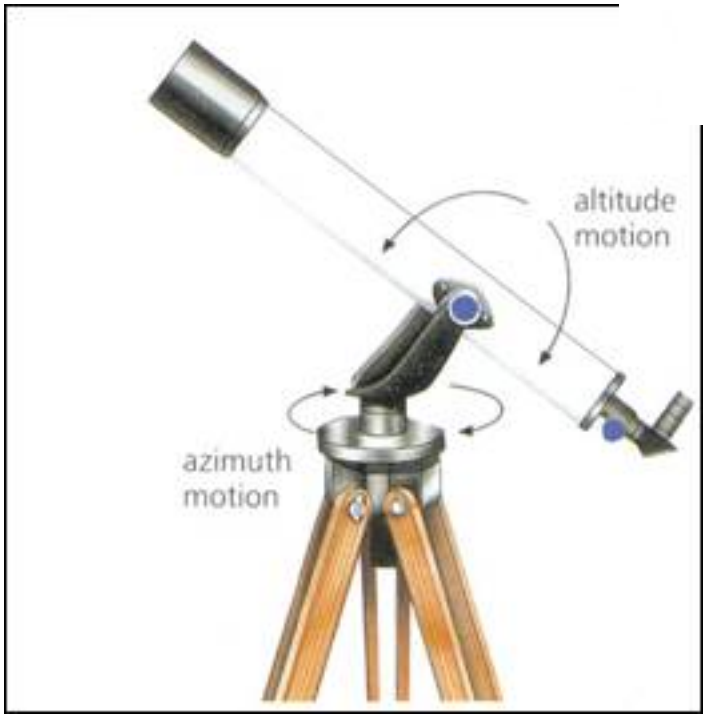
Maximum magnification

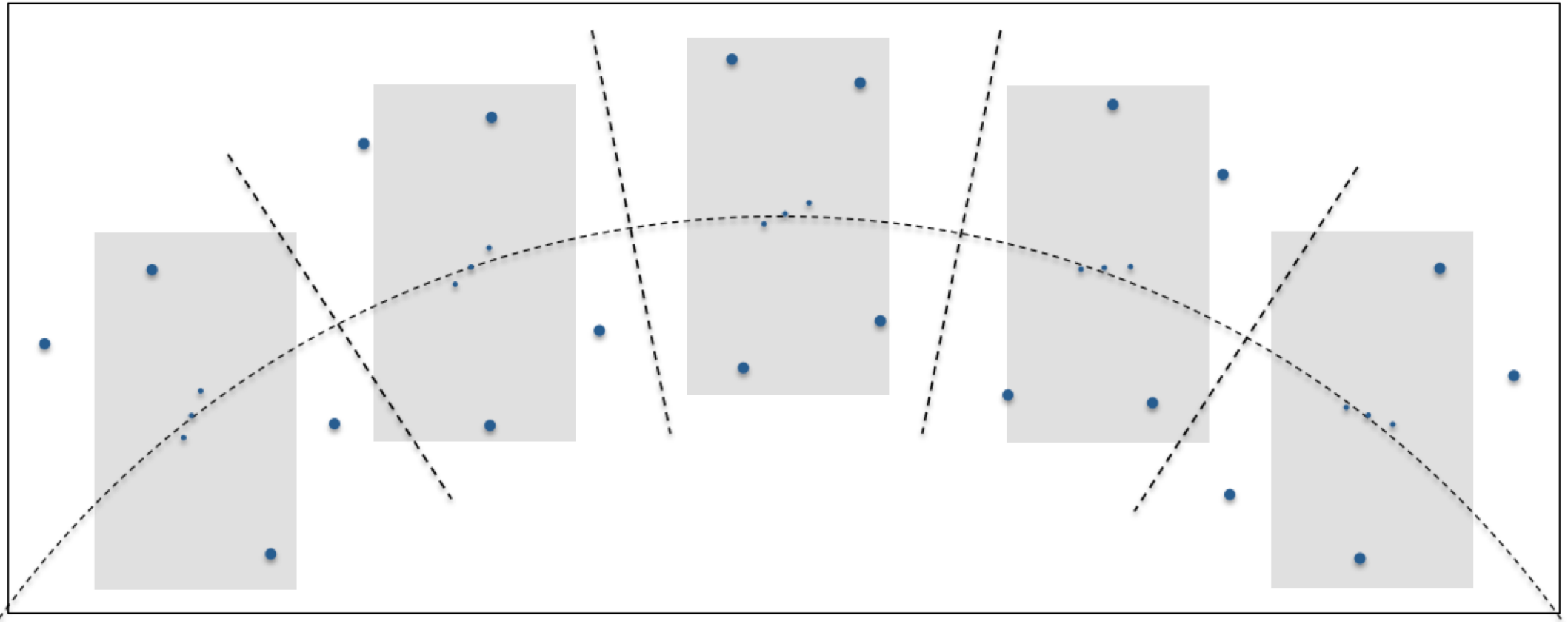
- the resolving capability of the human eye is about 2’
- $$\omega_{\max} = e/\theta \approx eD/\lambda = \frac{5.8 \times 10^{-4}\, D}{5.5 \times 10^{-7}\ \mathrm{m}}$$
$$\approx D/1\ \mathrm{mm}\ .$$

Mounts

- Alt-azimuthal
- German equatorial
- Fork

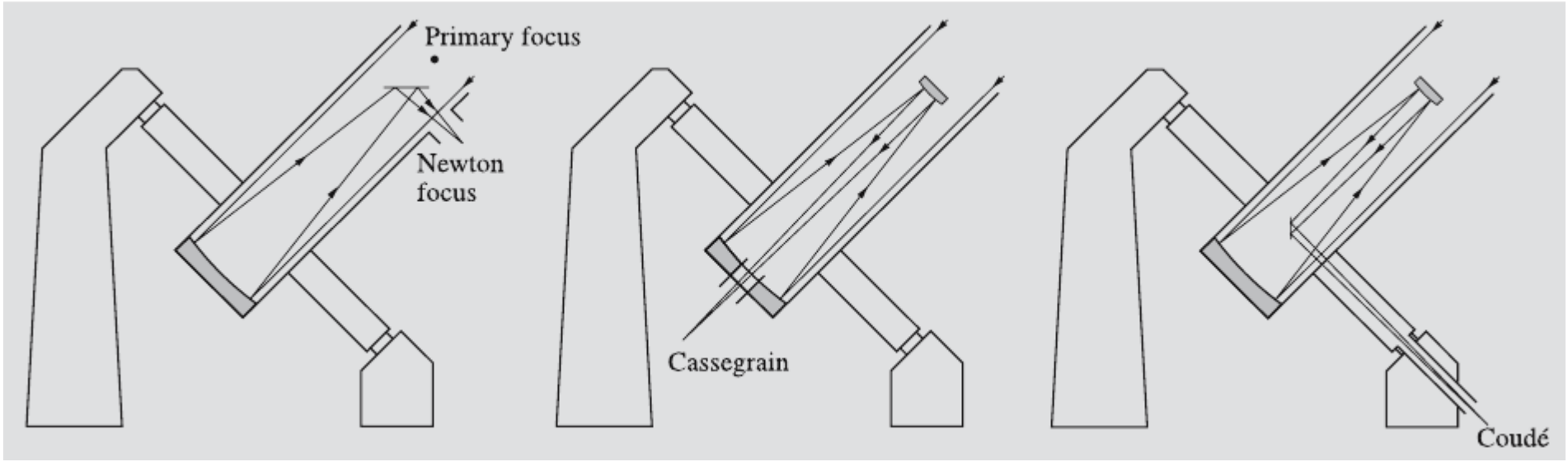




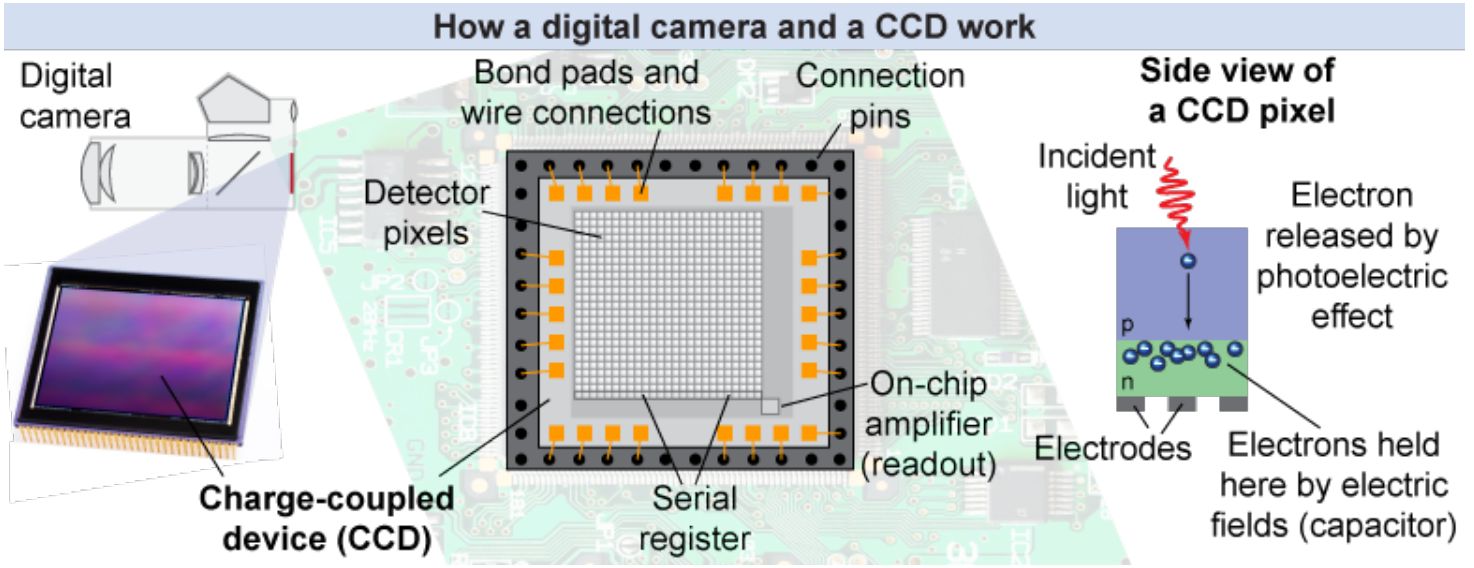


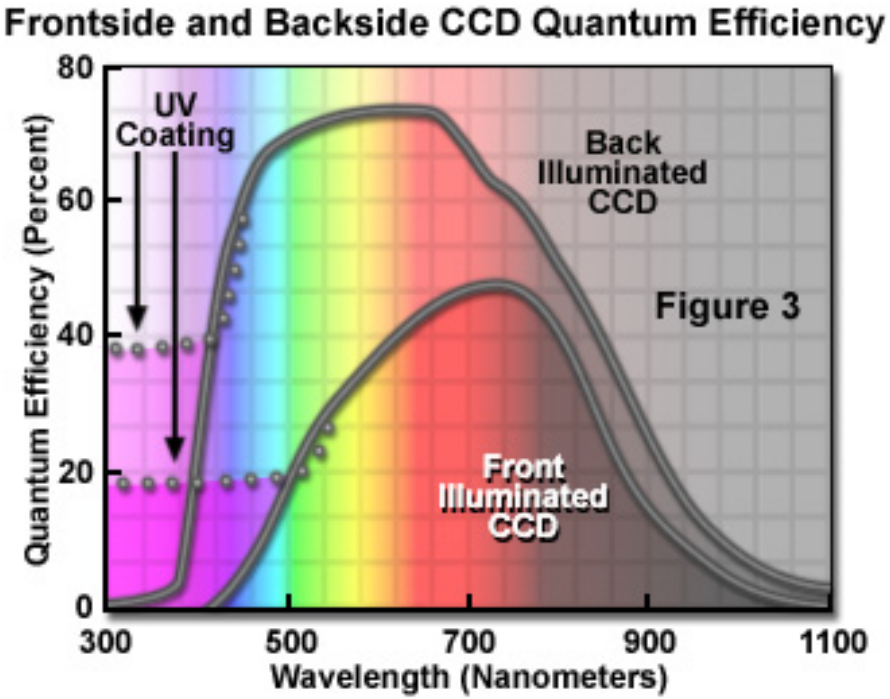
Field rotation!

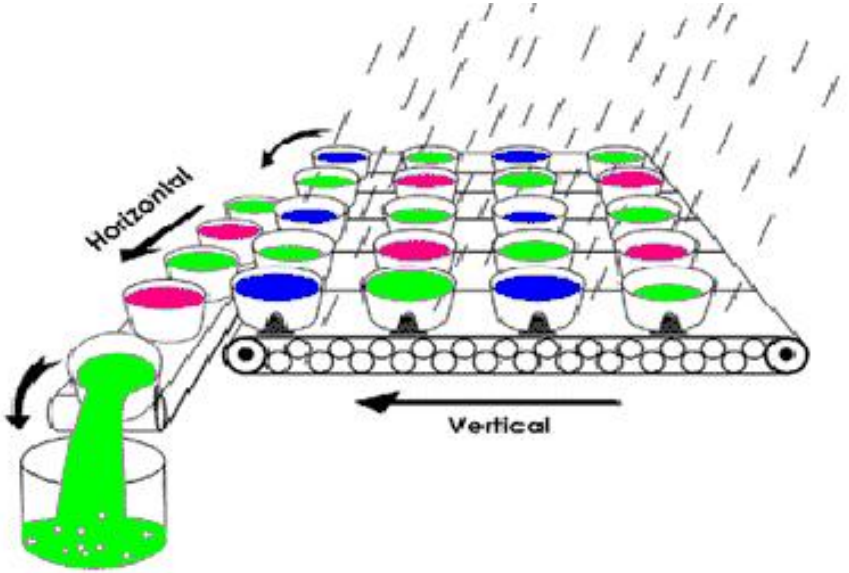
Focus point



CCD


How a digital camera and a CCD work
Digital camera
Bond pads and wire connections
Connection pins
Detector pixels
On-chip amplifier (readout)
Serial register
Charge-coupled device (CCD)
Side view of a CCD pixel
Incident light
Electron released by photoelectric effect
p
n
Electrodes
Electrons held here by electric fields (capacitor)

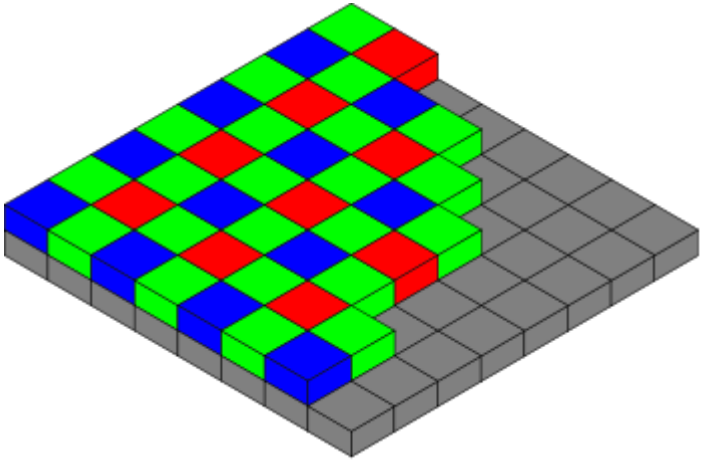

Frontside and Backside CCD Quantum Efficiency
Quantum Efficiency (Percent)
80
60
40
20
0
UV Coating
Back Illuminated CCD
Figure 3
Front Illuminated CCD
300
500
700
900
1100
Wavelength (Nanometers)

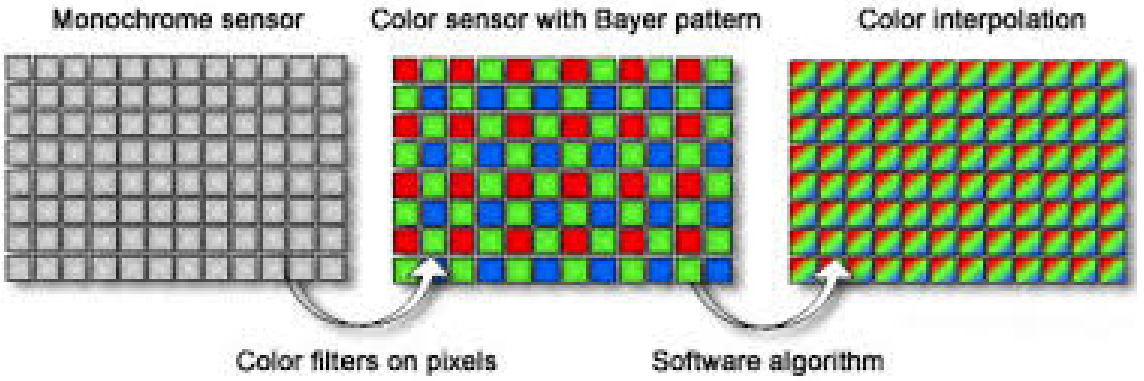

Horizontal
Vertical

Colors?

Use filters!

Use Bayer matrix!





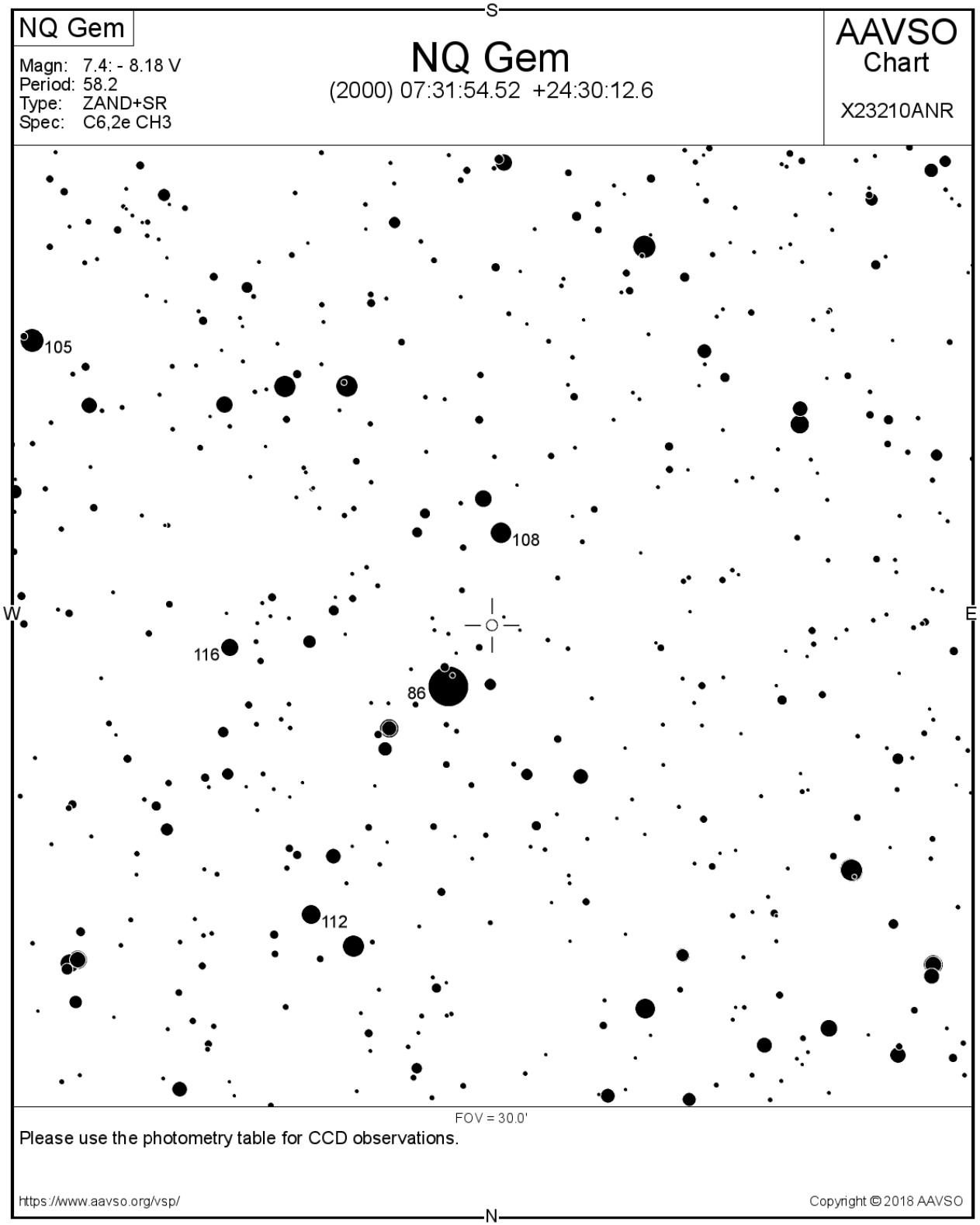
Task!

On April 2, 2008 a telescope (10 cm diameter, f /10) at the Bosscha Observatory was used to observe the Sun and found an active region 0987 (based on the NOAA number) at 8° South and 40° West from the center of the solar disk. The region was recorded with a SBIG ST-8 CCD camera ($1600 \times 1200 pixels$, ($9\ \mu$m $\times 9 \mu$m)/pixel) and size of the spot was 5×4 pixels. According to the Astronomical Almanac, the solar diameter on that day is 32'. How large is the corrected area of the active region in unit of millionth of solar hemisphere (msh)?

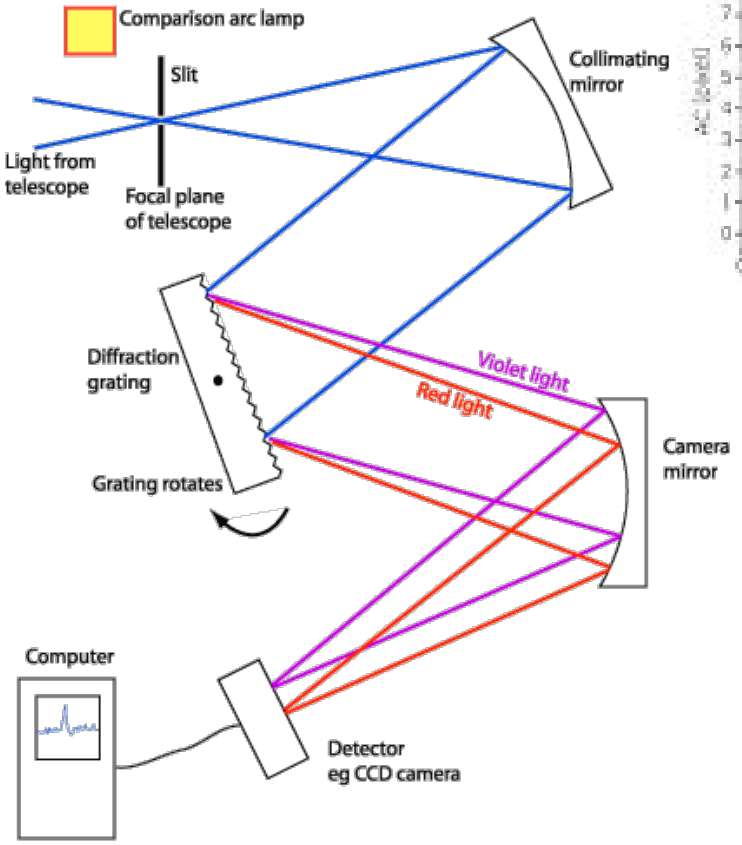
Another task!

Photometry

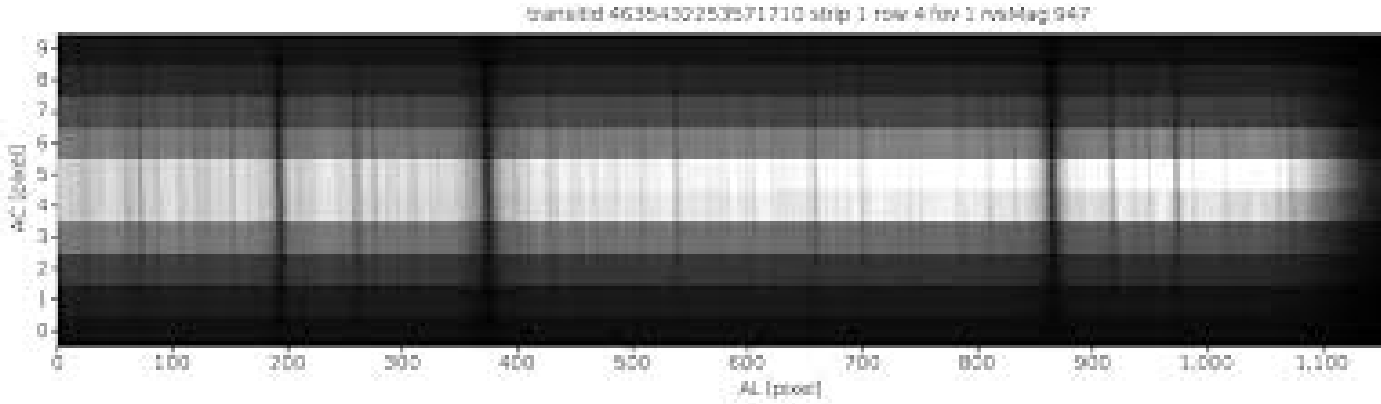

#2. H-064387. EHLibV_24 AB330
355.8'
355.7'
355.6'
+48.3'
N
E
-1'
-1'5"
20m
59mn
14h58mn40s

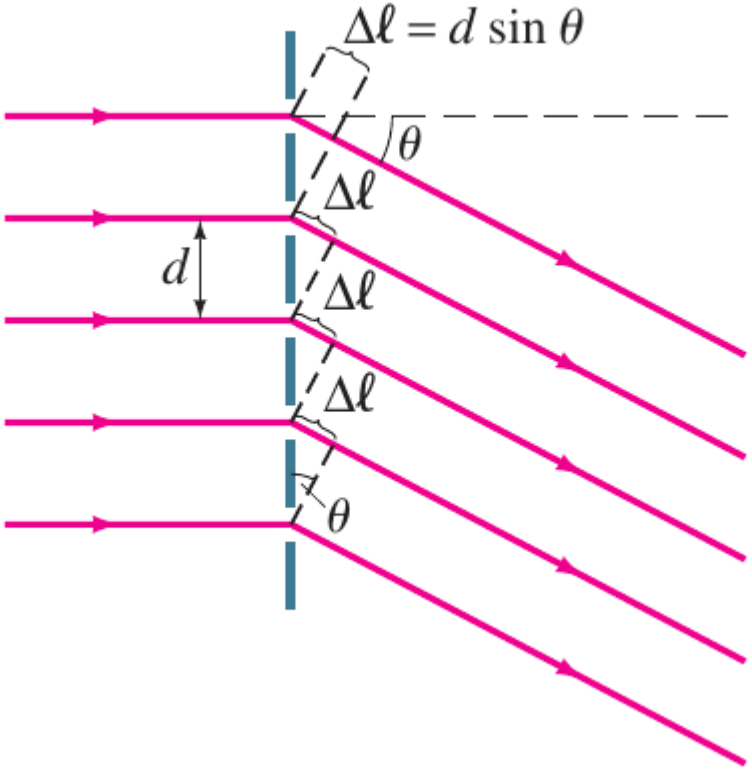

NQ Gem
Magn: 7.4: - 8.18 V
Period: 58.2
Type: ZAND+SR
Spec: C6,2e CH3
NQ Gem
(2000) 07:31:54.52 +24:30:12.6
AAVSO
Chart
X23210ANR
S
W
E
N
105
108
116
86
112
FOV = 30.0'
Please use the photometry table for CCD observations.
https://www.aavso.org/vsp/
Copyright © 2018 AAVSO

Spectroscopy



A Schematic Diagram of a Slit Spectrograph





$$d \sin\theta = m\lambda$$

$$(m = 0, \pm 1, \pm 2, \pm 3, \ldots)$$

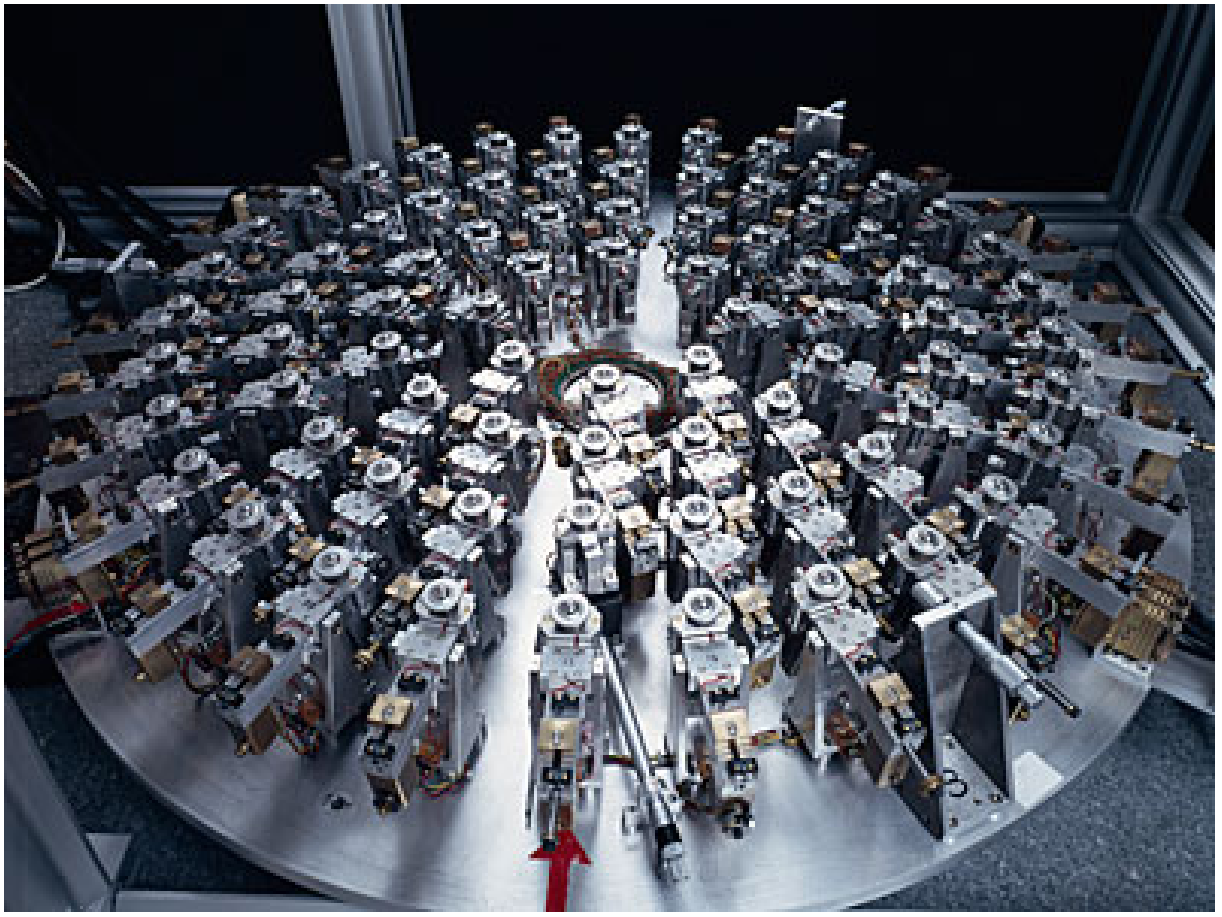
$$d \sin\theta = m\lambda$$

$$d\ \mathrm{d}(\sin\theta) = m\ \mathrm{d}\lambda$$

$$d\ \cos\theta\, \mathrm{d}\theta = m\ \mathrm{d}\lambda$$

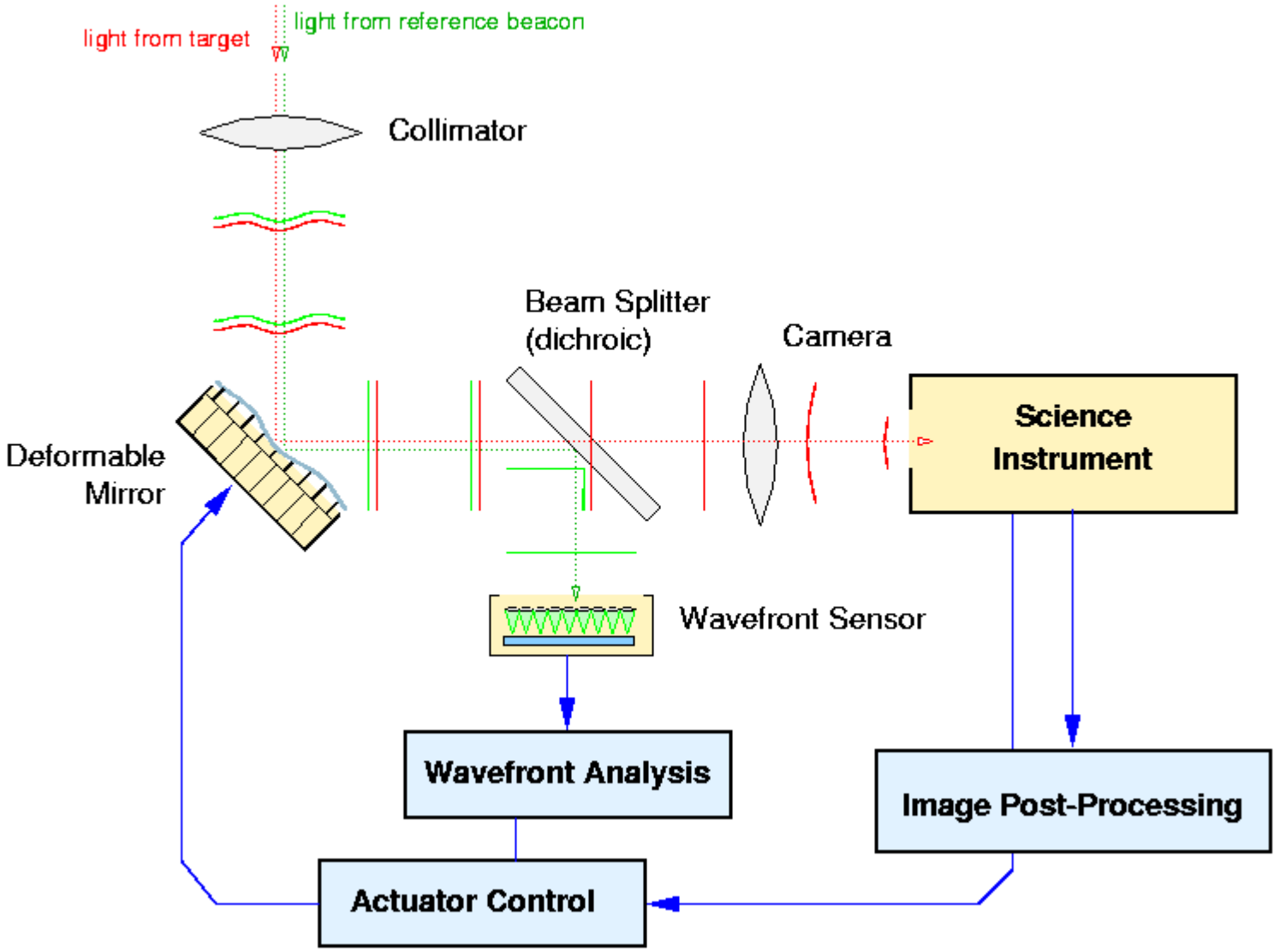
$$\frac{\mathrm{d}\lambda}{\mathrm{d}\theta} = \frac{d\cos\theta}{m}$$

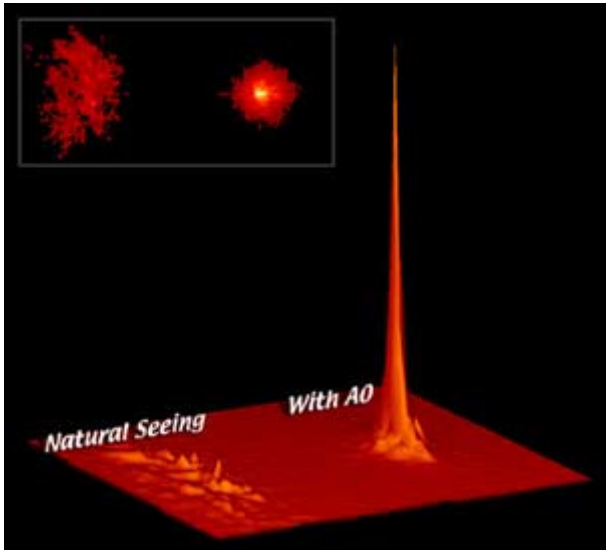
Active optics

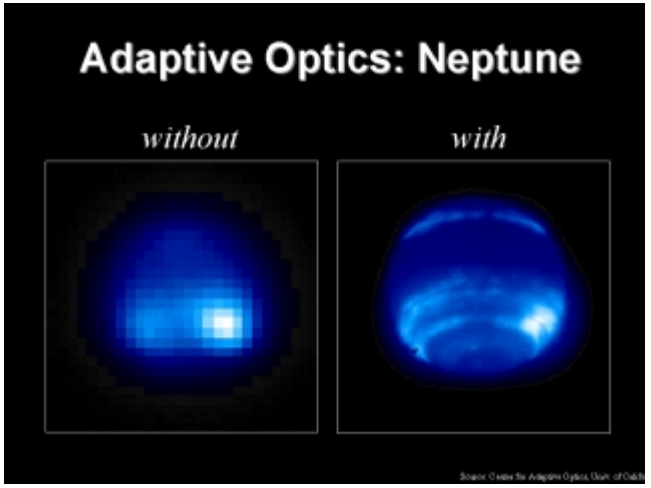


Adjusting shape

Adaptive optics




Natural Seeing
With AO


Adaptive Optics: Neptune
without
with