An introduction to

Telescope Optics

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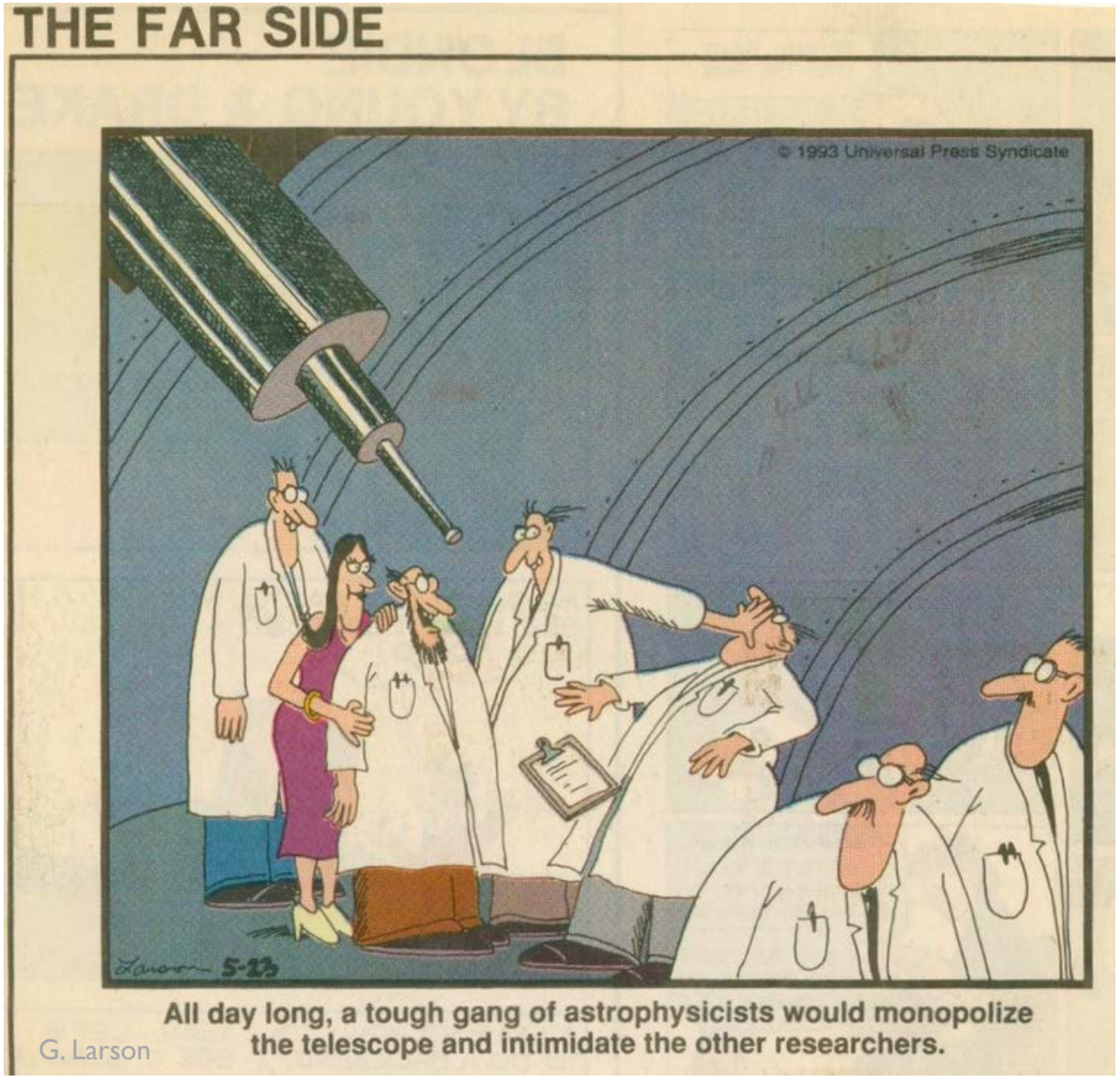
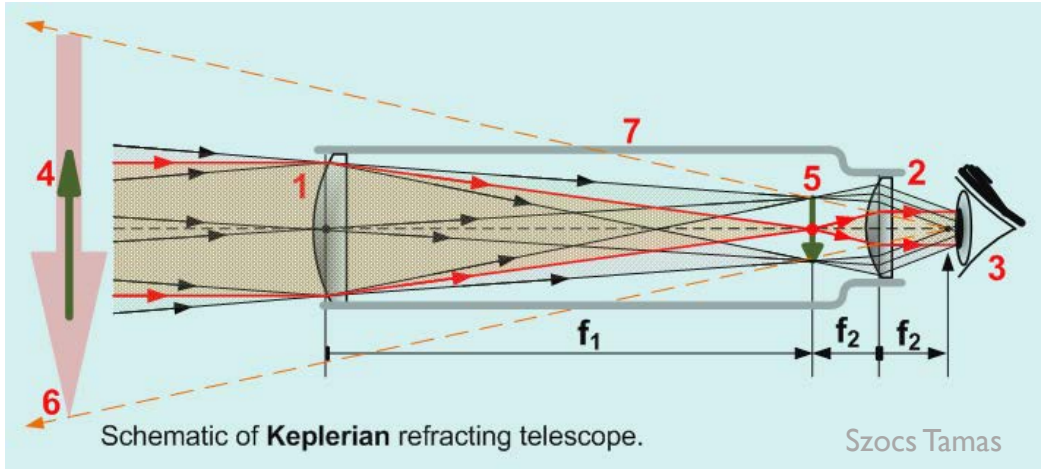
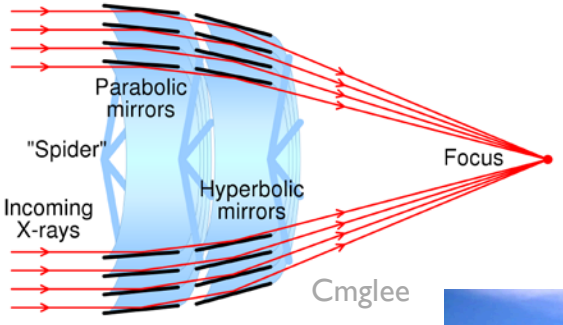
Lots of telescope types out there



G. Larson



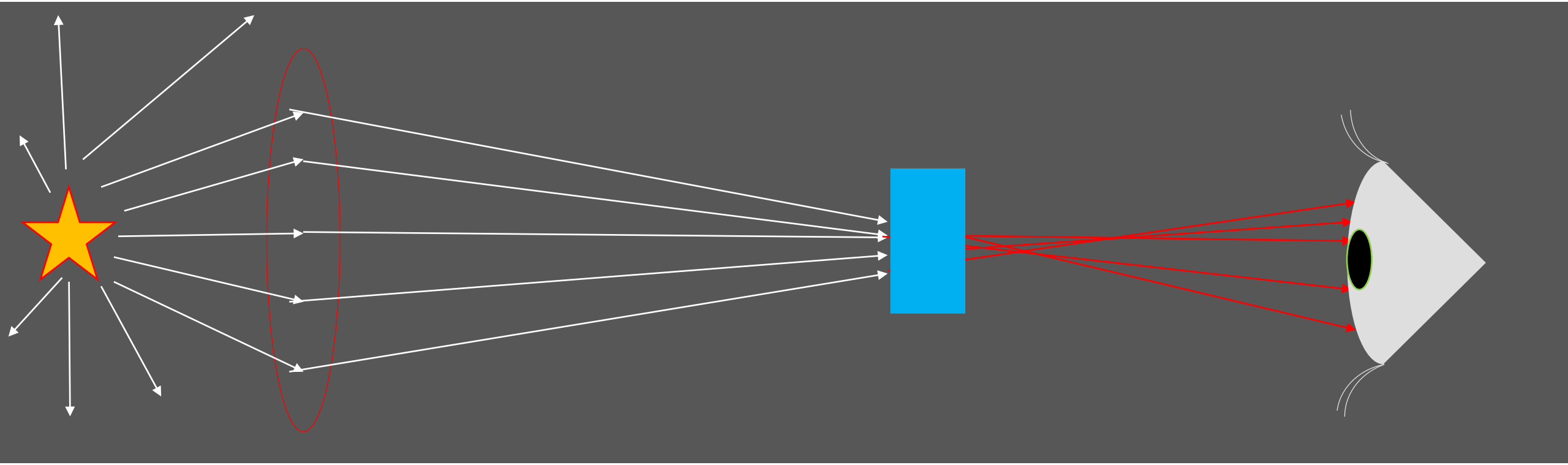
Schematic of **Keplerian** refracting telescope. Szocs Tamas



Cmglee


Hajor

Basic concept for a telescope:



Collector

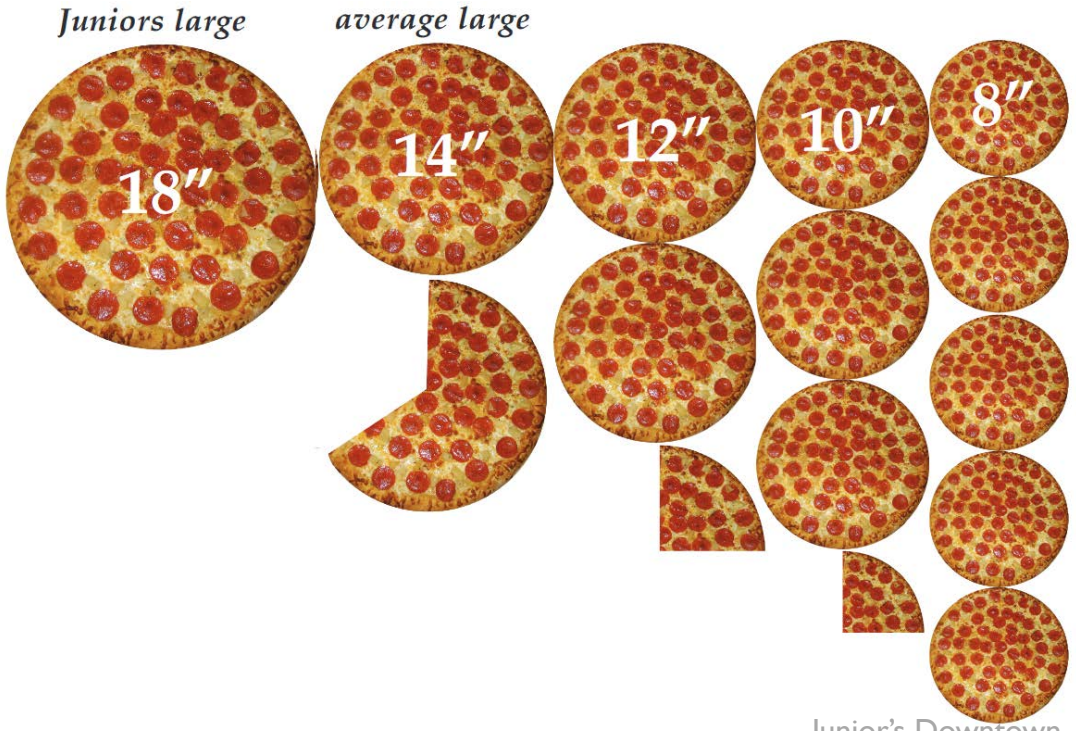
Filter/Separator (optional)

Detector

Light collection: the aperture

- A bigger light collector will collect more light, *(deep, I know)* so the light collector ("aperture") size is an important metric
- Apertures are generally circular, so the area is $A = \pi r^2$
- As such, light collecting area scales as the square of the radius (or equivalently the square of the diameter over 4)

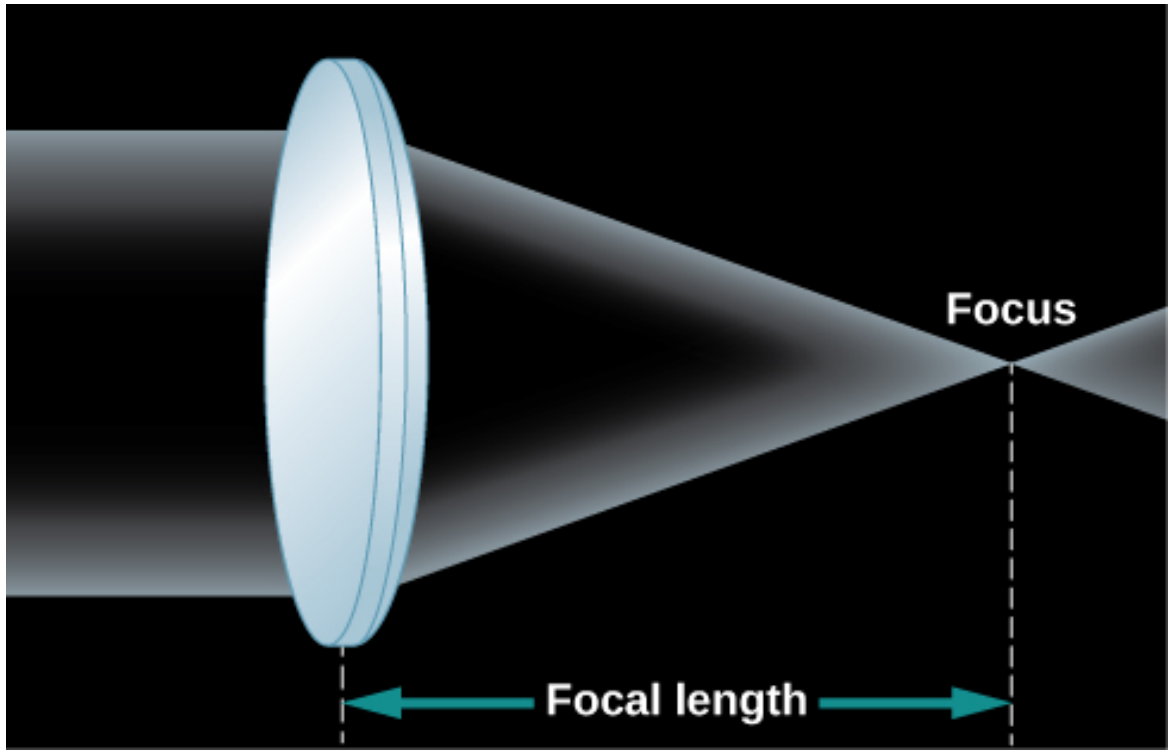

Meldy Tamenge



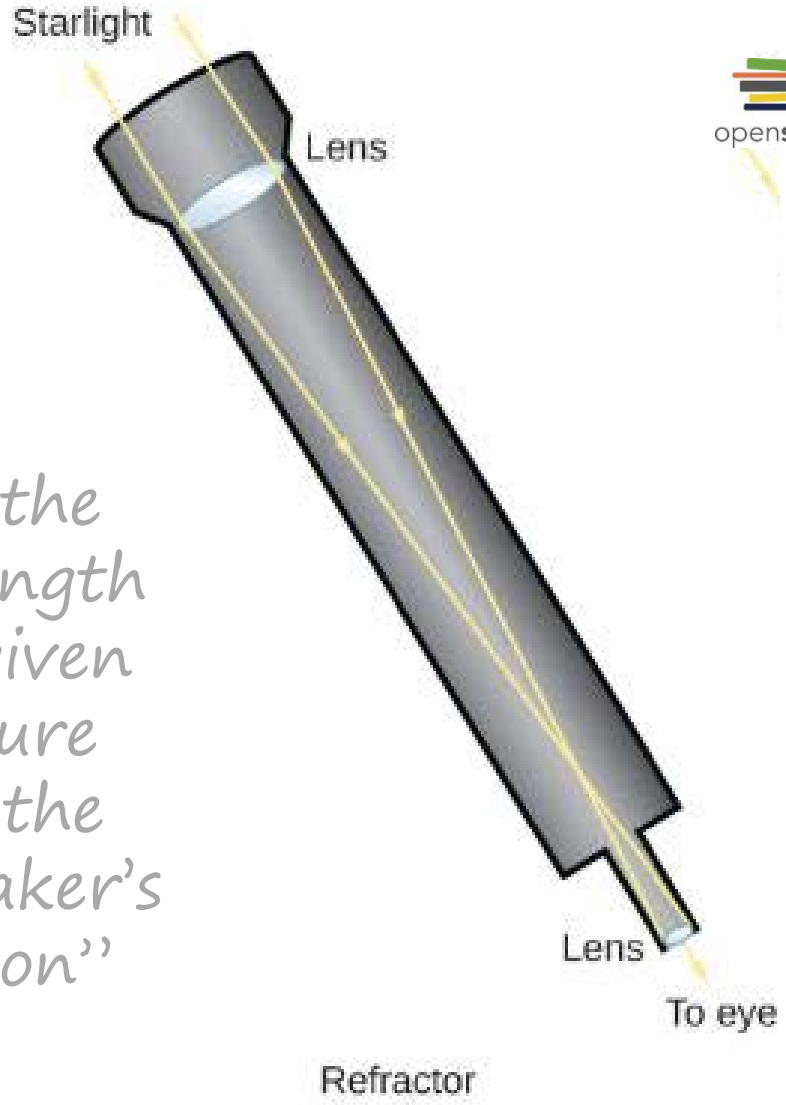
Junior's Downtown

Classic optical telescope: *the refractor*

- A good telescope takes light from a large aperture and concentrates it down to a smaller detector (e.g. our eye)
- A refractor bends light using a large lens toward a smaller lens, which bends the light toward the detector

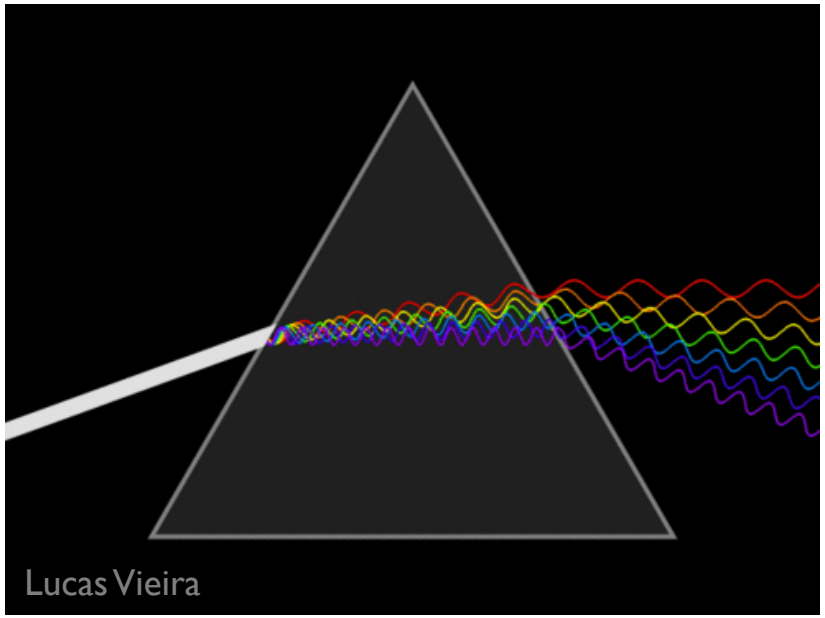


Tune the focal length for a given aperture using the "lensmaker's equation"



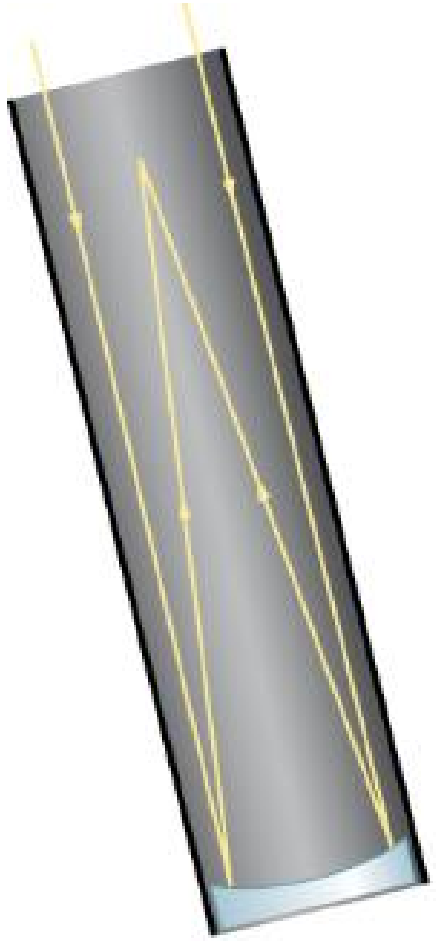
Fundamental issue of refractors: *aberration*

- Refraction is the bending of light in a transparent medium
- Light bends a different amount based on the wavelength
- This causes chromatic aberration, which blurs an image and creates a rainbow effect

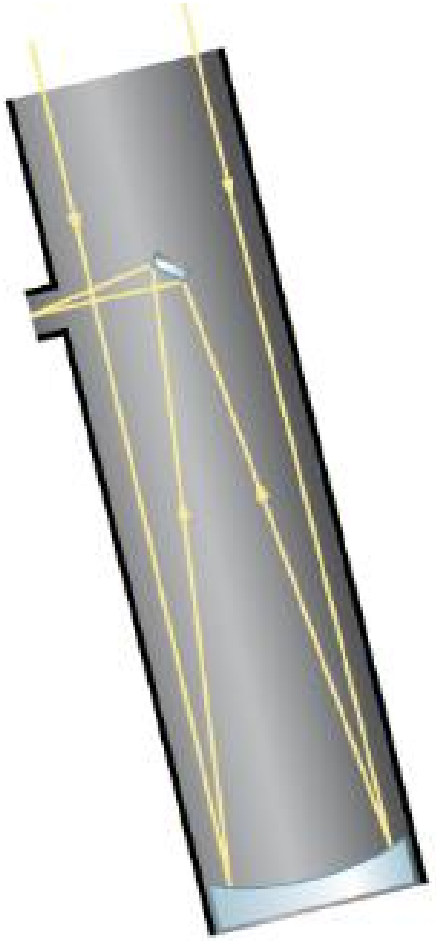


Classic optical telescope **upgrade**: *the reflector*

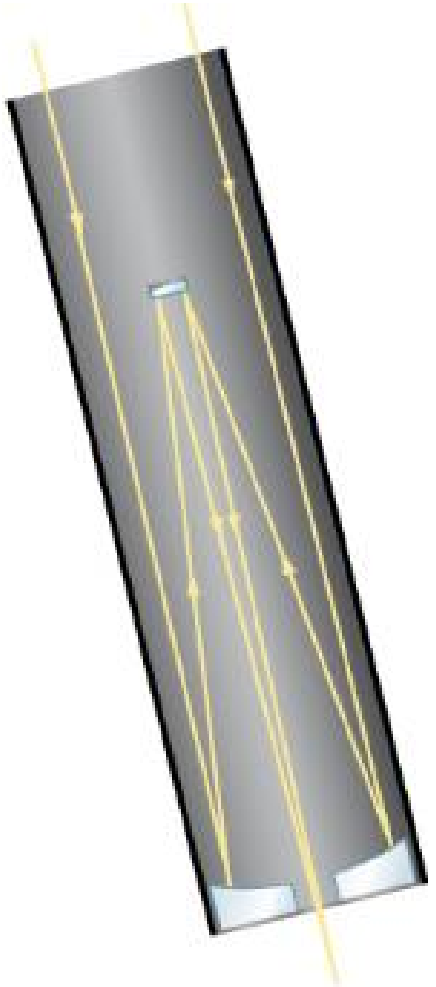
Aberration is avoided by re-directing light from the large aperture to the small detector using mirrors instead of lenses



Prime focus



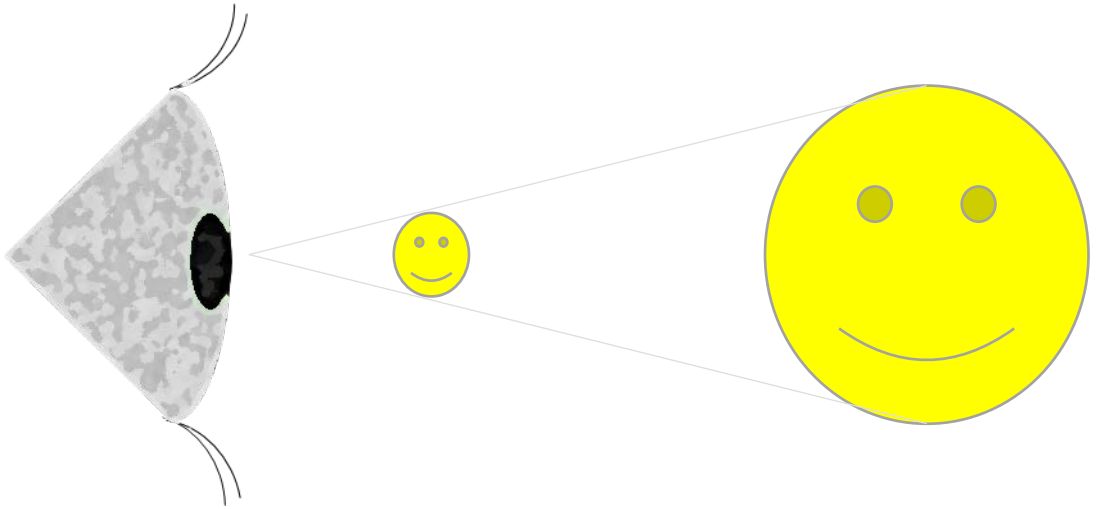
Newtonian focus



Cassegrain focus

Angular resolution

- The angular resolution indicates the size of something a telescope could see
- Of course, what it can see depends on the distance to the object
- So the relevant quantity is the angular size that can be seen
- An estimate of the resolution is:
  $R = \frac{\lambda}{d_{\text{aperture}}}$ (in radians … $\times \frac{180}{\theta}$ for degrees)



Longer wavelengths require larger telescopes!

- Check for Hubble: $d \approx 2.5m, \lambda \sim 500\ nm$, so $R = \frac{5\times10^{-7}m}{2.5m} \approx 2 \times 10^{-7}$ rad
- For context, a golf ball's text is ~5mm tall and is ~7km from HST, so the angular size is $\approx \frac{5\times10^{-3}m}{7\times10^{3}m} \sim 10^{-6}$ rad

On-paper resolution isn't accurate because of atmospheric effects