

Astronomy 350: Lecture 2 - Telescopes

- Observational Astronomy deals with the collection and analysis of light. Thus it is important to understand some basic physical principles about collecting this light: telescopes.
- A telescope's light collecting area is $\propto (\textit{aperature})^2$, where *aperature* is the size of the primary mirror or lens.
- Angular resolution is the smallest angle at which two stars are observed to be distinct: the human eye has an angular resolution of about 1 arcminute ($1/60^\circ$). Angular separation is equal to $\textit{physicalseparation} \times 360^\circ/2\pi \times \textit{distance}$.
- The HST Telescope (2.4m aperature) has an angular resolution of about 0.05 arcseconds which is higher than most ground based telescopes with 10m mirrors since anular resolution is affected by the Earth's atmosphere.
- The interference of light causes a blurring of light that limits a telescope's angular resolution even when all other conditions are perfect.
- The lowest angular resolution that a telescope could achieve is called the diffraction limit and depends on the both the wavelength of light and the diameter of the telescope's primary mirror:

$$\textit{diffractionlimit} \approx 2.5 \times 10^5 \times \left(\frac{\textit{wavelengthoflight}}{\textit{diameteroftelescope}} \right),$$

where this is in arcseconds.

- Refracting telescopes operate with lenses whilst reflecting telescopes operate with mirrors. Reflecting telescopes are much more common in Aastronomy.
- Most reflecting telescopes have a primary mirror which reflects light to a secondary mirror which reflects the light to a focus.
- Parallel rays from a distant source will focus to an on-axis point in the focal length a distance f_L (focal length) beyond/in front of the lens/mirror.
- The light from the target depoits energy per unit area

$$E_p \propto (d/f_L)^2,$$

where d is the diameter of the aperature and f_L is the focal length of the primary mirror/lens.

- The quantity $F = f_L/d$ is defined to be the focal ratio of the telescope.

- A focal ratio of "6" is written as " $f/6$ "
- The "speed" of an optical system just depends on the focal ratio, F .
- Large/Small F ratio implies bigger/smaller fainter/brighter image.
- F ratio is inversely proportional to the "speed" of the telescope.
- Large F ratio implies a slower speed and longer exposure times for the detector.
- Small F ratio implies faster speed and shorter exposure times for the detector.
- The eyepiece magnifies and refocuses light from the focal plane of the primary for the human eye.
- The magnification power equals the focal length of the primary divided by the focal length of the eyepiece.
- The Celestron 8 inch has a F ratio of $f/10$, a mirror of 8" diameter and a primary focal length of 2023mm.
- The Meade GOTO has a 8" primary mirror, an F ratio of $f/10$ and a primary focal length of 2030mm.
- The Meade GOTO has a 5.4" primary mirror, an F ratio of $f/14$ and a primary focal length of 1900mm.