Telescopes
A Fundamental Tool of the Astronomer

1. Diagram the optical devices which can focus collimated light to a point.

2. What are the advantages and disadvantages of a
   a. refracting telescope
   Advantage: *highest optical contrast of all designs*
   Disadvantage: *highest cost per mm aperture of all designs*
   even small apertures produce long optical tube assemblies (OTAs)
   chromatic aberration can be minimized but not avoided

   b. reflecting telescope
   i) Newtonian configuration
   Advantage: *Lowest cost per mm aperture of all designs*
   No chromatic aberration
   Simple to design and construct, even for amateurs
   Disadvantage: *Not as optically contrasty due to central obstruction from secondary mirror*
   OTA nearly as long as focal length
   eyepiece may be uncomfortably high when pointed at zenith; eyepiece may be in awkward position when pointing either east or west.

   ii) Schmidt configuration (Schmidt-Cassegrain, Schmidt-Maksutov)
   Advantage: *No chromatic aberration*
   Eyepiece usually in convenient location except when pointing directly north (when equatorially mounted)
   Long focal lengths available in short OTA due to folded light path
   Disadvantage: *Difficult (expensive) to figure mirror with central perforation*
   Not as optically contrasty due to central obstruction from secondary mirror

3. a. What is the improvement in light-gathering power (LGP) of a 125 mm (5”) telescope over the dark adapted human eye (~5 mm aperture)?
   LGP $\propto$ *Area of aperture* $\propto r^2$

$$\frac{A_{125}}{A_{eye}} = \text{improvement} = \frac{(62.5\text{mm})^2}{(5\text{mm})^2} = 625\times \text{ more LGP}$$

   b. What is the improvement in LGP of a 30 cm (12”) telescope over a 25 cm (10”) telescope?

$$\frac{A_{12''}}{A_{10''}} = \text{improvement} = \frac{(15\text{cm})^2}{(12.5\text{cm})^2} = 1.44\times \text{ more LGP (that's 144\% more LGP)}$$

4. What is the Dawes Limit (diffraction limited angular resolution) at 600 nm of
   a. a 125 mm (5”) apochromatic refracting telescope?

      $\lambda = 600\text{ nm}\times\frac{10^{-9}\text{ m}}{\text{nm}} = 6.00\times10^{-7}\text{ m}$ $\quad D = 125\text{ mm}\times\frac{10^{-3}\text{ m}}{\text{mm}} = 0.125\text{ m}$

      $$\text{Resolution(arcsec)}, R = 2.5\times10^{5}\frac{\lambda}{D}$$

      $$R = 2.5\times10^{5}\frac{6.00\times10^{-7}\text{ m}}{0.125\text{ m}} = 1.2\text{ arcsec}$$

   b. a 30 cm (12”) Schmidt-Cassegrain telescope?

      $$D = 30\text{ cm}\times\frac{10^{-2}\text{ m}}{\text{mm}} = 0.3\text{ m}$$

      $$R = 2.5\times10^{5}\frac{6.00\times10^{-7}\text{ m}}{0.3\text{ m}} = 0.5\text{ arcsec}$$

   c. the Hubble telescope (2.4 m aperture)?

      $$R = 2.5\times10^{5}\frac{6.00\times10^{-7}\text{ m}}{2.4\text{ m}} = 0.0625\text{ arcsec}$$

5. What is the advantage of long-baseline interferometry in radioastronomy?

   Increases resolution of the radio observation (unfortunately, without increasing LGP)

6. Could the advantage of long-baseline interferometry be exploited in optical astronomy?

   Yes, and it is being used in the four 8.2 m telescopes of the Very Large Telescope at Cerro Paranal, Chile.

7. a. What is the Dawes Limit for a single radio telescope 25 m (82’) in diameter operating at 21 cm?

      $$\lambda = 21\text{ cm}\times\frac{10^{-2}\text{ m}}{\text{mm}} = 0.21\text{ m}$$

      $$R = 2.5\times10^{5}\frac{0.21\text{ m}}{25\text{ m}} = 2100\text{ arcsec}$$

      Notice that the resolution is extremely poor (over 0.5°-about the angular width of the moon). This is a limitation of radio telescopes.

   b. What is the Dawes Limit for the Very Large Array (VLA) where the 27 telescopes are arrayed at a maximum distance of 21 km?

      $$R = 2.5\times10^{5}\frac{0.21\text{ m}}{21000\text{ m}} = 2.5\text{ arcsec}$$

      The 21 km VLA has about the same resolution as a 60 mm (2.5”) optical telescope

   c. What is the resolution of two radio telescopes separated by 8000 km of baseline and operating at 21 cm?

      (0.00656 arcsec)