Problem Set 1

Astro 1

Due Friday, October 4 by 4:30 pm

1. (U 1.19) Suppose your telescope can give you a clear view of objects and features that subtend angles of at least 2 arcsec. What is the diameter in kilometers of the smallest crater you can see on the Moon?

   Sol: We will use the small-angle formula $D = \alpha_{\text{rad}} d$, where D and α_{rad} are the linear size and angular size (in radians) of a crater, and d is the distance between the observer and the crater (Earth-Moon distance, 384,000 km).

   We want to first convert arcsec to radians. 1 arcsec is 1/3600 degrees, and 360° is 2π radians. So to convert the angular size in arcsec (α_{arcsec}) to radians (α_{rad}), we have

$$\begin{aligned} \alpha_{\text{rad}} &= \alpha_{\text{arcsec}} \times \frac{1 \text{ degree}}{3600 \text{ arcsec}} \times \frac{2\pi \text{ rad}}{360 \text{ degree}} \\ &\approx \frac{\alpha_{\text{arcsec}}}{206265} \text{ rad} \end{aligned}$$

   Using the small-angle formula (Box 1-1 of your textbook),

$$\begin{aligned} D &= \alpha_{\text{rad}} d \\ &\approx \frac{\alpha_{\text{arcsec}}}{206265} d \\ &= \frac{2}{206265}(384,000 \text{ km}) \\ &\approx 3.72 \text{ km} \end{aligned}$$

2. (U 1.31) When the Voyager 2 spacecraft sent back pictures of Neptune during its flyby of that planet in 1989, the spacecraft's radio signals traveled for 4 hours at the speed of light to reach Earth. How far away was the spacecraft? Give your answer in kilometers, using powers-of-ten notation.

   Sol: The distance d traveled by the radio signals, which is also the distance of the spacecraft from Earth, is the speed of light c times the time t required for the signals to make the journey:

$$\begin{aligned} d &= ct \\ &= (3.00 \times 10^8 \text{ m s}^{-1})(4 \text{ hr}) \\ &= \left(3.00 \times 10^8 \text{ m s}^{-1} \times \frac{1 \text{ km}}{10^3 \text{ m}}\right)\left(4 \text{ hr} \times \frac{60 \text{ min}}{1 \text{ hr}} \times \frac{60 \text{ s}}{1 \text{ min}}\right) \\ &\approx 4.32 \times 10^9 \text{ km} \end{aligned}$$

Note that this is also about thirty times the Earth-Sun distance (1 AU $\approx 1.5 \times 10^8$ km).

3. (U 1.38) In the original (1977) *Star Wars* movie, Han Solo praises the speed of his spaceship by saying, "It's the ship that made the Kessel run in less than 12 parsecs!" Explain why this statement is obvious misinformation.

   Sol: Han Solo refers to 12 parsecs as if it were a unit of time. However, a parsec is a unit of distance. The definition of a parsec is "the distance at which 1 AU subtends an angle of 1 arsec" (Universe p. 13). So Han Solo is mixing up distance and time, which are two different physical quantities.

4. (U 1.47) Look up at the sky on a clear, cloud-free night and note the positions of a few prominent stars relative to such reference markers as rooftops, telephone poles, and treetops. Also note the location from where you make your observations. A few hours later, return to that location and again note the positions of the same bright stars that you observed earlier. How have their positions changed? From these changes, can you deduce the general direction in which the stars appear to be moving?

   Sol: All stars should appear to be moving from east to west (if you are in the northern hemisphere and facing north, the stars should move from your right to your left), but for Polaris and other stars near the north celestial pole one may not observe obvious changes in positions.