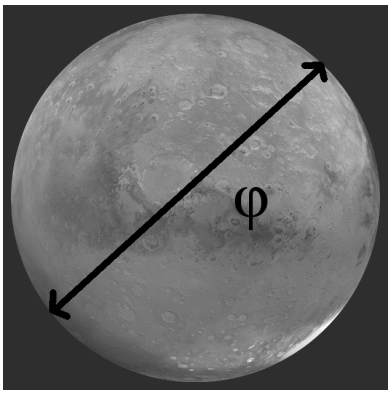
ASTR469: Homework #1.

Due 20 Jan

Note: with all assignments in this class, show enough of your work and/or include explanations so I can follow how you got your answer. Simply writing the right answer will not get you full credit, and a wrong answer that shows a mostly right explanation can get you partial credit! Give answers in SI units unless otherwise specified.

1. Let's say you observe the astronomical object shown below (it's Mars!). Mars' physical diameter is 6.78×10^6 m.



(It's Mars!)

   a) (2 pt) How many arcseconds across is Mars?
   https://in-the-sky.org/graphs.php

   b) (4 pt) Using the angular and physical sizes, w hat is the distance to Mars?

   c) (4 pt) Use the small angle approximation to estimate the solid angle subtended by Mars (give answer in steradians).

   d) (1 pt) Give the solid angle from (c) in deg^2.

   e) (4 pt) What is the actual solid angle subtended by Mars, if you do not use the small angle approximation? Give the answer in deg^2.

   f) (1 pt) **Brief self-reflection**: Consider the usage of the small angle approximation here; how accurate was it? (e.g. What factor difference from the actual solid angle?)

2. (2 pt) The faintest stars seen by the Hubble Space Telescope have a visible band magnitude $m_V \approx 28$. What is the flux ratio between these stars and the brightest star visible in the sky (Sirius A, $m_V = -1.46$)?

3. (2 pt) The Sun has an apparent visual magnitude of $m_V = -27$ and is 150×10^6 km from the Earth. If the Sun were instead at a distance of 3 pc, what would its apparent magnitude be? Recall that one parsec (pc) is 3.09×10^{16} m.

4. (4 pt) You are observing a galaxy in X-rays at an energy of 10 keV, and you know the galaxy is at a distance of 2 Mpc. Around this galaxy, you discover an X-ray "halo" that appears to subtend a solid angle of 0.1 sr and has an average spectral intensity of $I_{10\,\mathrm{keV}} = 10^{24}\,\mathrm{W\,Hz^{-1}\,m^{-2}\,sr^{-1}}$ across the halo. What is the 10 keV spectral luminosity of the entire halo?

5. Use any plotting program (gnuplot, matlab, mathematica, or even an online tool like https://www.desmos.com/calculator) to make a plot that shows both the spectral intensity given by the Planck function, and by the Rayleigh-Jeans approximation; both should be as a function of wavelength. Assume a temperature $T = 6 \times 10^4\,\mathrm{K}$ (about the temperature of a young, class O star).

   a) (2 pt) Show the plot; be sure to zoom in enough so that the Planck function's shape and the RJ approximation are clear and visible. Also be sure to label your axes (numbers, words).

   b) (4 pt) Calculate the peak wavelength of the emission, and mark the peak wavelength on the plot as a vertical line. As a sanity check for yourself: it should agree with your curve!

   c) (6 pt) Determine at what wavelength the Rayleigh-Jeans approximation is within 5% agreement of the Planck function. Mark this on your plot as a vertical line.

   d) (1 points) **Brief self-reflection**: Consider what general waveband(s) the much simpler Rayleigh-Jeans approximation is suitable for (if, say, you want to calculate the brightness of a source within 5% accuracy, as determined in (c)).

6. (3 pt) Without looking it up online, prove that intensity is independent of distance. Hint: Think about how the surface area of a source changes with distance for a given solid angle, and how the number of photons received also changes with distance.