ASTR 3730: Problem Set 1
(due Tuesday September 6th)

(1) The *FERMI* space telescope has recently detected flares from the Crab Nebula in gamma-rays with an energy of around 100 MeV. Suppose that the quiescent flux from the Crab in photons of this energy is 10^{-10} erg cm^{-2} s^{-1} at Earth.

(a) What is the frequency and wavelength of 100 MeV photons?
(b) If the effective collecting area of *FERMI* for photons of 100 MeV energy is 10^3 cm^2, how many photons from the Crab does the telescope collect per day, on average?

(2) Estimate the *theoretical* resolution of the human eye, assuming a pupil diameter of 0.5 cm and a wavelength corresponding to that of green light ($\lambda = 0.5$ μm). Express the answer in arcminutes.

(3) A globular cluster has 10^5 stars distributed within a sphere of characteristic radius of 1 parsec (1 pc). *Estimate* the distance, in kpc, out to which the *Hubble Space Telescope* ought to be able to resolve individual stars within the cluster. Assume that the *HST* has a mirror of diameter 2.4m, and works at a wavelength of $\lambda = 0.5$ μm.

State clearly any assumptions you make about the distribution of stars within the cluster!

(4) The supermassive black hole at the Galactic Center (distance 8 kpc) has a characteristic size given by the Schwarzschild radius:

$$R_s = \frac{2GM}{c^2}.$$

The mass of the black hole is about 4 x 10^6 M_{Sun}. Estimate the diameter, D, of a radio telescope that would be needed to resolve structure on the scale of the Schwarzschild radius, if the telescope works at a wavelength of 0.1 mm.