ASTR 3730: Astrophysics 1 – Problem Set #1
Due in class Friday 29th September

1. (a) Neutral hydrogen emits radio waves with a wavelength of 21 cm. What is the frequency of this radiation?

(b) What is the wavelength (in nm) of an X-ray photon with an energy of 6.4 keV?

2. (a) A binary star system in the star forming region of Taurus (at a distance of 150 pc) has a separation between the two stars of 50 au. Can we resolve the binary (i.e. detect the two stars individually) using a ground-based telescope with a resolution of 1 arcsecond?

(b) Improved observations show that what was previously thought to be a single 16th magnitude star is actually a close binary consisting of two identical stars. What is the magnitude of each individual star?

3. An Active Galaxy (i.e. a supermassive black hole accreting gas from a surrounding galaxy) at a distance of 1 Gpc produces a luminosity in X-rays of $L_X = 10^{41}$ erg s$^{-1}$.

(a) What is the X-ray flux at Earth from this source?

(b) The Chandra X-ray observatory observed the source for $10^6$ s (one of the longest exposures made with Chandra). Assuming for simplicity that all the X-ray photons from the source have an energy of 5 keV, how many photons does Chandra collect during the exposure? (You will need to know that the effective area of the Chandra telescope for detecting 5 keV photons is 400 cm$^2$.)
4. The Crab Nebula is observed to emit X-rays having an energy of at least 100keV from an extended region. Compute the energy, lifetime, and Larmor radius of the electrons producing this radiation. Assume it is due to synchrotron radiation in a magnetic field of $10^{-4}$ Gauss.

The nonthermal spectrum of the Crab exhibits a downward turn above $10^{15}$ Hz. Assuming this bend is due to lifetime losses, use the known age of the Crab (supernova in 1054 AD) to estimate the magnetic field strength.