ASTR705 ISM
HW #1
Due Friday, 1/27 in class or over email

1) The total mass of gas in the Galaxy is $\sim 7 \times 10^9\ M_\odot$. Assume that it is uniformly distributed in a disk of radius $R_{\rm disk} = 15\,{\rm kpc}$ and thickness $h = 200\,{\rm pc}$.

   (a) What is the mean free path between hydrogen atom scattering events, assuming that all the gas is atomic hydrogen? State all relevant assumptions. (3 pt)

   (b) Now assume that 30% of the gas and dust mass is in spherical molecular clouds of radius 15 pc and mean molecular density $n(H_2) = 100\ {\rm cm}^{-3}$. What is the mass of one such cloud (3 pt)? How many such molecular clouds would there be in the Galaxy (1 pt)? How do these numbers change if the gas is instead a mixture of H and He with He/H=0.1 (by number) (2 pt)?

2) The "very local" interstellar medium has $n(H) = 0.22\ {\rm cm}^{-3}$ (Lallement et al. 2004: Astr. & Astrophys. 426, 875; Slavin & Frisch 2007: Sp. Sci. Revs. 130, 409). The Sun is moving at about 26 $\rm km\,s^{-1}$ relative to this local gas (Mobius et al. 2004: Astr. & Astrophys. 426, 897). Suppose that this gas has He/H=0.1, and contains dust particles with total mass equal to 0.5% of the mass of the gas. Suppose these particles are of radius $a = 0.1\,\mu$m and density of $2\,{\rm g\ cm}^{-3}$, and we wish to design a spacecraft to collect them for study. How large a collecting area A should this spacecraft have in order to have an expected collection rate of 1 interstellar grain per hour? Neglect the motion of the spacecraft relative to the Sun, and assume that the interstellar grains are unaffected by solar gravity, radiation pressure, and the solar wind (and interplanetary magnetic field). (3 pt)

3) Assume that the ISM has three phases, one with $T_k = 10^6$ K, one with $T_k = 10^4$ K, and one with $T_k = 10^2$ K, and that these three phases are in pressure equilibrium. If the density of the 10^2 K component is 30 ${\rm cm}^{-3}$, what are the densities of the other phases (2 pt)?

4) STERADIANS!!!!!!!!!!!!!!!! How many steradians does the star Alpha Centauri cover in the sky? Compare your results using the exact and approximate expressions for the steradian. (2 pt)