Homework Set #4

(1) Compliments of G. Blumenthal; 10pts
The oscillator strength for the emission of Lymanβ in Hydrogen is $f(3p \rightarrow 1s)$. If an optically thin slab of atomic hydrogen having thickness X and density n_H has incident upon it a flux of continuum radiation with flux F (photons/s/cm^2/Hz), how many Lyβ photons are absorbed in the slab per cm^2 per second?

(2) Numerical fun; 30pts
Consider a Hydrogen gas cloud with ionization fraction $x \equiv \mathrm{H}^+/\mathrm{H} = 0.5$, density $n_H = 1\,\mathrm{cm}^{-3}$, and volume 100 pc^3. Assume there is a radiation field incident on the gas cloud which holds the ionization fraction constant in time. [Astrophysical units only, please!!]

(a) Ignoring line emission, plot the Flux from the cloud that you would observe at 1kpc distance as a function of frequency for gas temperatures $T = 10^4, 10^5, 10^6, 10^7$K. Note: (i) present a separate plot for each temperature, (ii) plot the Flux in

$$\mu\mathrm{Jy} = 10^{-29}\ \mathrm{ergs/s/cm^2/Hz} \quad , \tag{1}$$

and (iii) only consider frequencies $\omega = 10^{12.5} - 10^{17.5}$.

(b) Explain the the spectra you have just plotted.

(c) Calculate the mass of a star (solar metallicity, main sequence) with comparable luminosity to the gas cloud for each temperature in part(a). Compare these masses with the mass of the gas cloud.

(3) Molecular estimate; 10pts
Consider an electrically neutral medium of diatomic molecules (nuclear mass M_A and M_B) in thermal equilibrium with temperature T. [**Note**: Portions of this problem are discussed in the Solutions to Rybicky & Lightman. You are on your honor to ignore these solutions.]

(a) Derive an expression for the temperature of the gas where you would expect purely rotational emission lines from a substantial fraction of the molecules.

(b) What range of temperatures would be appropriate for the CO molecule which has rotational constant $B = 2.77$K?