ASTR705 ISM
HW #9
Due Friday, 4/21 in class

1) a) (2 pt) Compare the Strömgren sphere radii for stars of spectral type B0, O6, and O3. Make any relevant assumptions. Use data from Table 4 here (you want Q_0): https://www.aanda.org/articles/aa/pdf/2005/24/aa2386-04.pdf
b) (2 pt) Plot the evolution of these H II region radii as a function of time, beginning when they reach their Strömgren radii. State all assumptions.
c) (2 pt) Repeat the calculations in a) for He (you want Q_1 in the same table).

2) The observed spectrum of an H II region has

$$\frac{I([\mathrm{O\,III}]4364.4\mathring{A})}{I([\mathrm{O\,III}]5008.2\mathring{A})} = 0.003 \quad (1)$$

$$\frac{I([\mathrm{O\,II}]3729.8\mathring{A})}{I([\mathrm{O\,II}]3727.1\mathring{A})} = 1.2 \quad (2)$$

a) (1pt) What are the ionization potentials of neutral and singly ionized oxygen?
a) (3 pt) Assuming reddening is negligible, what are the electron temperature and electron density in the H II regions?
b) (3 pt) Bad news: now there is reddening, of 0.5 magnitudes at a wavelength of 5008Å. Using the same intensity ratios given in c), assume an extinction law to derive the electron temperature and density.

3) Let's talk about electron temperatures! Both the free-free intensity and the radio recombination line intensity depend on the emission measure. Since n_e is often unknown, this reduces the utility of intensity measurements alone. We can still use them in a ratio, however.
a) (4 pt) Use Draine Equation 10.23 for free-free optical depth and the following equation derived for radio recombination line optical depth in "Tools of Radio Astronomy" (their 14.27):

$$\tau = 1.92 \times 10^3 \left(\frac{T_e}{\mathrm{K}}\right)^{-5/2} \left(\frac{\mathrm{EM}}{\mathrm{cm^{-6}\,pc}}\right) \left(\frac{\Delta\nu}{\mathrm{kHz}}\right)^{-1} \quad (3)$$

to derive a line-to-continuum intensity ratio (you'll want to assume that both emission processes are optically thin). Then solve this equation for the electron temperature.
b) (2 pt) For a line-to-continuum intensity ratio of 0.25 at $\nu = 20$ GHz and a radio recombination line width of 25 $\mathrm{km\,s^{-1}}$, what is the electron temperature?