ASTR 515 – ISM and Star Formation – Fall 2015
Assignment I on Radiative Transfer and Processes
Due Date: Friday October 2

1. Suppose the source function is to be represented by a power-series expansion about the point τ_*; i.e., $S(\tau) \approx S(\tau_*) + S'(\tau_*)(\tau - \tau_*) + \frac{1}{2}S''(\tau_*)(\tau - \tau_*)^2$. Calculate the emergent intensity and show that the choice of $\tau_* = \mu$ is "optimum" in the sense that it eliminates the contribution of S' and minimizes the contribution of S'' to $I(0, \mu)$.

2. A distant source emits blackbody radiation at temperature T_s. There is an intervening nebula at temperature $T_n < T_s$. Calculate the specific intensity of the radiation you would observe by looking at the source through the nebula as well as along a line of sight to the nebula that does not intersect the source. You may assume that the frequency of observation is smaller than both kT_s and kT_n so that you may work in the Rayleigh-Jeans limit. Can you use these two observations to infer the optical depth through the nebula at that wavelength?

3. There are very roughly 10^{38} hydrogen atoms in the solar photosphere. They are in LTE, so the distribution of their speeds follows a Maxwellian. Using this, first make a plot of their speed distribution. Then estimate
   1. The typical speed of a hydrogen atom
   2. The total number of hydrogen atoms within a percent of that speed
   3. The Doppler shift in an H_α line due to this motion
   4. The total number of hydrogen atoms within a percent of the speed that would cause a Doppler shift twice as large
   5. The total number of hydrogen atoms within a percent of the speed that would cause a Doppler shift four times as large and compare your answer to part 2.

4. See the attached scanned problem from Shu's "The Physics of Astrophysics".