Stellar - HW3
September 5, 2024, Due September 12, 2025
2 pt for each question part

1a) A star collapsing from initial radius to r_0 to radius r will gain potential energy and will lose potential energy. Conserve total energy using a test mass to set up an integral in dr/dt (this is v). You can integrate this expression to determine the free-fall time.

b) What is the free-fall time for the Sun?

c) How about for a white dwarf (assume typical values)?

2) The Maxwell-Boltzmann distribution is

$$f(v) = \sqrt{\left(\frac{m}{2\pi kT}\right)^3}\, 4\pi v^2 \exp^{-\frac{mv^2}{2kT}}, \tag{1}$$

but, in one dimension the function is

$$f(v_x) = \sqrt{\frac{m}{2\pi kT}}\exp^{-\frac{mv_x^2}{2kT}}\ . \tag{2}$$

a) Plot these functions for reasonable assumed values. What function does the 1D M-B distribution look like?

b) Based on your answer above, what is a typical value for the standard deviation of the Hα line from the Solar photosphere? Use whatever unit you like.

c. (Grad students only) What fraction of Hydrogen is ionized in the Solar photosphere? Compute the quantity $n_{\rm HII}n_e/n_{\rm HI}$.

d. (Grad students only) What fraction of all Hydrogen atoms are in the $n = 1$ ground state in the Solar photosphere? The degeneracy of principle quantum number n is $2n^2$.(Hint: for this question, you do not need to compute the entire partition function.)