Homework Assignment 8 (due 12 noon, Fri Nov 4$^{\text{th}}$)

This assignment is composed of the following questions from Chapter 9 of *An Introduction to Modern Stellar Astrophysics*, plus some supplemental questions adapted from Frank Shu's textbook *The Physical Universe*:

- Q9.11
- Repeat the second part of problem 9.11, but assume a typical photon mean free path of 0.003 m instead. How does this estimate of the leakage time for radiative diffusion compare with the time for a photon to escape if it doesn't interact at all with matter and just flies straight through the Sun?
- We can form a crude estimate of the luminosity of the Sun as follows: we approximate the total energy in radiation inside the Sun as the volume of the Sun times the radiation energy density $u = aT^4$, using a typical interior temperature of $4.5 \times 10^6\,\mathrm{K}$. We then estimate the Sun's luminosity as this radiation energy over the leakage time from the previous (supplemental) problem. How does this estimated luminosity compare with the listed value $L_\odot = 3.839 \times 10^{26}\,\mathrm{W}$?
- We can calculate the (thermal) plasma energy density at the center of the Sun as $u_{\mathrm{plasma,c}} = \frac{3}{2} n_c k T_c$, with $n_c \sim 10^{32}\,\mathrm{cm}^{-3}$ and $T_c = 1.5 \times 10^7\,\mathrm{K}$. How does the plasma energy density compare with the radiation energy density ($u_{\mathrm{rad},c} = aT_c^4$) at the center of Sun? If we assume the same ratio of plasma energy to radiation energy throughout the Sun's interior, and use our estimate of the leakage time from the first supplemental problem, about how long would it take for the Sun to "turn off" if all the nuclear reactions in the Sun's core stopped?
- Q9.12
- Q9.13
- Q9.15
- Q9.16