Ph 441/541 Problem Set 7

Due: Friday, April 6, 2012

1. Solar Neutrinos:
The flux of energetic neutrinos from ^{8}B decays in branch III of the proton-proton chain is very dependent on the central temperature of the Sun. Confirm this by showing that the rate of the reaction producing ^{8}B,

$$p + {}^7Be \rightarrow {}^8B + \gamma,$$

is approximately proportional to T^{14}, when the temperature T is near to 1.5×10^7 K. In fact, the local production rate of neutrinos from ^{8}B decay is proportional to T^{24} when the temperature dependence of the reactions leading to ^{7}Be formation is taken into account; see Bahcall (1989, *Neutrino Astrophysics*, Cambridge University Press).

2. Helium Burning:
Calculate the power per kilogram produced by helium burning in pure helium when the density is 10^8 kg m^{-3} and the temperature is 10^8 K. By how much would this power change if the excitation energy of the 0^+ state of carbon-12 were 7.66 MeV instead of 7.65 MeV?

3. Origin of Helium (Ph 541 students only):
Estimate what fraction of our Galaxy's mass has been converted from H to He in stars since its formation (say 1.0×10^{10} years ago, the approximate age of the Galactic disk), assuming that the average star has a mass-to-luminosity ratio ($\mathcal{M}/\mathcal{L}$) ten times that of the Sun. How does this fraction compare to the observed mass fraction of helium in the Sun, which is about 0.25?