Stellar Astrophysics
ASTR 404 Fall 2014
Homework 3
Due 10/10

1. The probability for two particles to occupy the same position is given by

$$P(0) = \exp(-(E_G/E)^{1/2}),$$

where E_G is the Gamov energy and E is the energy of the particles.

What is the probability for the p–p interaction when the temperature doubles relative to the nominal case?

2. Building on the previous example, what is the temperature of a ^{4}He–^{4}He interaction relative to that of a p–p interaction when their probabilities are equal? Provide a number for the factor (not just symbols).

3. The central temperature of the Sun is approximately 1.5×10^7 K. It is thought that about 1.6% of the solar luminosity comes from the CNO cycle. Estimate how much this would change if the temperature of the Sun increases by 1%. You can ignore how this would change the p–p luminosity.

4. Using MESA, examine how the structure of a star depends on the details of its energy generation. Evolve two models of a solar mass model, where one has only p–p fusion and the other only through the CNO cycle to the end of the main sequence. Compare the models in the ways explained below. In each case use physical arguments to explain the differences between the two models. Don't worry about getting all the small differences correct (e.g., wiggles in the HR diagram); focus on the large-scale differences between the models.

(a) Plot the evolutionary tracks on an HR diagram. Mark the zero-age main sequence.

(b) At the zero-age main sequence, plot the interior structure of the star. Specifically, plot ρ, T and $\epsilon_{\rm nuc}$ as a function of M_r (mass coordinates). Mark any convective regions.

(c) Plot the evolution of ρ_c and T_c from the zero-age main sequence to hydrogen exhaustion.