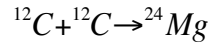


ASTR 3730: Astrophysics 1 – Problem Set #5
Due in class Friday 16th November

1) A star of mass $10 M_{\text{sun}}$ is composed entirely of fully ionized ^{12}C .

- (a) What is the mean molecular weight μ ?
- (b) Suppose that the star generates energy via the reaction:



The atomic weight of carbon 12 is 12, and that of magnesium 24 is 23.985 (the atomic weight is defined as the ratio of the mass of the nucleus to $1/12$ of the mass of a carbon 12 nucleus). What fraction of the star's mass can be converted into energy via this fusion process?

2) The nuclear reaction rate in a star can be written as:

$$f(E) = e^{-E/kT} e^{-\sqrt{E_G/E}}$$

where E is the energy, T is the temperature, k is Boltzmann's constant, and E_G is a constant called the Gamow energy.

- (a) Show that $f(E)$ has a maximum at an energy:

$$E_0 = \left(\frac{kT}{2}\right)^{2/3} E_G^{1/3}$$

- (b) Perform a Taylor expansion of $f(E)$ about the maximum to second order (take the logarithm first, then exponentiate once you've made the expansion). Show that $f(E)$ can be approximated as a Gaussian near the peak,

$$f(E) \propto \exp\left[-(E - E_0)^2 / 2\sigma^2\right]$$

and find an expression for the width σ .