

Name: _____

PHYS 7501, FS 2017

Homework 7

Due: Start of class, December 5th

1. The length of time the Sun will spend burning hydrogen in its core (i.e. on the “main sequence”) is determined by the lifetime of that hydrogen. The lifetime for a nuclear species τ is directly related to destruction rate for that species in a given environment: $\frac{dN}{dt} = -\lambda n = \frac{-n}{\tau} = -r$. Given the core conditions $\rho = 80\text{g/cm}^3$, $T = 13.5\text{ MK}$, $X_H = 0.73$, and the fact that the reduced reaction rate at this temperature for the $p + p \rightarrow d$ rate is

$$N_A \langle \sigma v \rangle_{pp} = 5 \times 10^{-20} \frac{\text{cm}^3}{\text{mol s}}, \text{ how long will the Sun spend on the main sequence?}$$

2. In the Atlas of Neutron Resonances (S.F. Mughabghab, 2006), the thermal neutron capture cross section for $^{197}\text{Au}(n, \gamma)$ is listed as 98.65b. Assuming the $1/v$ law holds for this cross section near thermal energies, calculate the reduced reaction rate $N_A \langle \sigma v \rangle$ at a temperature of 0.3GK. Compare to the REACLIB value $8.3 \times 10^7 \frac{\text{cm}^3}{\text{mol s}}$.

3. Plot the Gamow windows for ${}^3\text{He}(\alpha,\gamma)$ at 1GK, at 0.1GK, and ${}^{59}\text{Cu}(p,\gamma)$ at 1GK.

4. In the Hot CNO cycle 1, the CNO cycle is modified by the fact that high temperatures allow ${}^{13}\text{N}$ to undergo proton capture, resulting in the sequence:

${}^{12}\text{C}(p,\gamma){}^{13}\text{N}(p,\gamma){}^{14}\text{O}(\beta){}^{14}\text{N}(p,\gamma){}^{15}\text{O}(\beta){}^{15}\text{N}(p,\alpha){}^{12}\text{C}$. For this case, all strong interactions are much faster than any weak interactions. As such, what are the most abundant nuclei in an environment where the Hot CNO-1 cycle has reached equilibrium (and why)?

5. Briefly describe the origins of the features labeled in this plot of the solar system abundances as a function of mass number A .

