AST 383 Nucleosynthesis – Assignment 3

Due Tuesday, February 16 in class. Attempt questions 1 and 2, and two from questions 3-7.

1. In nuclear astrophysics and almost everywhere in astronomy, one needs to move quickly between temperature and electron volts. Adopting E=kt determine the temperature equivalent for 1 eV.

2. In many circumstances, one encounters expressions such as Ø = exp(E/kt). Often, one knows E in eV and then it is convenient to recognize that Ø = $10^{-\Theta X}$ where $X = (\equiv E)$ is in eV and $\Theta = 5040/T$

Using the table E. 1 from Iliadis estimate a more precise value of the constant 5040.

The following problems came from Chapter 1 of Iliadis:

3. Determine the number of protons, *Z*, and the number of neutrons, *N*, for the nuclides ^{18}F, ^{56}Ni, ^{82}Rb, ^{120}In, ^{150}Gd, and ^{235}U.

4. How much energy is released in the following reactions: (i) ^{3}He(d,p)^{4}He;(ii)^{17}O(p, γ)^{18}F; (iii) ^{12}C(α,γ)^{16}O; and (iv) ^{13}C(α,n)^{16}O? Assume that the reactions involve nuclei only in their ground states. Use the results presented in Table 1.1.

5. With the aid of Figure 1.11, predict the spins and parities of ^{19}O, ^{31}P, and ^{37}Cl for both the ground state and the first excited state. Compare your answer with the observed values. These can be found in Endt (1991) and Tilley *et al.* (1995).

6. Suppose that an excited state with spin and parity of 2^+ in a nucleus of mass $A = 20$ decays via emission of a γ-ray with a branching ratio of 100% to a lower lying level with spin and parity of 0^+. Assume that the γ-ray energy amounts to $E_\gamma = E_i - E_f = 6$ MeV. Estimate the maximum expected γ-ray transition probability $\Gamma = \lambda\hbar$.

7. Consider a nucleus in a plasma at thermal equilibrium. Calculate the population probabilities of the ground state ($E_0 = 0$) and of the first three excited states ($E_1 = 0.1$ MeV, $E_2 = 0.5$ MeV, $E_3 = 1.0$ MeV). Perform the computations for two temperatures, $T = 1.0 \times 10^9$ K and 3.0×10^9 K, and assume for simplicity that all states have the same spin value.