PHY983 - Nuclear Astrophysics - Spring 2013
Homework set 1
Due: Friday, January 18 at beginning of class

1. 1 g of an electrically neutral astrophysical plasma contains 700 mg ^{1}H and 250 mg ^{4}He and 50mg ^{28}Si. The mass density is 100 g/cm^3 and remains constant throughout.

   Feel free to submit a printout of an excel spreadsheet. However, you need to explain clearly how all the calculations are done (equations). It is not sufficient to just give numbers.

   a. [3pts] Characterize the composition using the different abundance measures used in nuclear astrophysics (you only have to worry about nuclei). In a table that gives for each constituent isotope:
      i. mass fraction
      ii. abundance ("mole fraction")
      iii. number fraction
      iv. number density
      v. abundance using the notation and units used by Grevesse & Sauval Space Sci Rev 85 (1998) 161, Table1.
      vi. Abundance relative to 10^6 Si atoms
   b. [2pt] Calculate mean molecular weight, Ye and electron number density for the mix.

2. [4 pts] For the same astrophysical plasma described in problem 1 the following nuclear reactions occur. All helium is destroyed by the triple alpha reaction were three helium nuclei fuse into one 12C nucleus: 3 ^{4}He → ^{12}C. Subsequently all ^{12}C is destroyed by proton capture (each 12C nucleus captures a proton)

   Make a table that lists initial and final (after all reactions have occurred) mass fraction and abundance (mole fraction) of each nuclear species.

   Also calculate mean molecular weight and Ye of the final composition.

3. [4 pts] Now assume that for the composition obtained in problem 2, all ^{13}N beta decays into ^{13}C (a neutrino and an electron are emitted in the process). Add mass fraction and abundance of the new composition to the table created in problem 2.

   Calculate the Y_e of the new composition.

4. [4 pts] Compare the initial Ye in Problem 1 with the Ye obtained in Problem 2 and 3. Explain why Ye does or does not change in each case.
   In general, which reactions do change Ye and which don't?

5. [2 pts] Can you see the advantage of using abundance vs mass fraction?