PHY983 - Nuclear Astrophysics - Spring 2009
Homework set 10
Due: Friday April 17 in class
Key words: r-process

1. [6pts] For typical r-process conditions of neutron density of 1e24 /cm^3 and a temperature of 1.3 GK, and assuming (n,g)-(g,n) equilibrium, calculate the relative abundance distribution (properly normalized) within the Zr isotopic chain as a function of neutron number. You can assume that the nuclear partition functions are equal to one. Do this calculation for 2 different mass models - the FRDM and the HFB-14. The masses can be downloaded from the class website.

Present the result in a graph, where one can read off clearly the relative abundance of at least the top 10 or so most abundant isotopes. You do not have to show ridiculously small fractions.

Which is the most abundant isotope?

Obviously this task is done numerically, but please list the equations used.

2. [6pts] Calculate the neutron separation energy that corresponds to the r-process path for the conditions in 1) using the equation discussed in class and used in the group exercise. In the group exercise you used a simple rule to guess the most abundant isotope in a mass chain by comparing this calculated neutron separation energy to the neutron separation energies along the chain. Check how well the rule you used would have predicted the correct maximum abundance in the Zr chain in problem 1. Find an improved rule that could be used by future groups.

The equation used in the group exercise is:
$S_n = (T_9/11.605) * [78.461 + 1.5*\ln(T_9) - \ln(n_n)]$

This gives S_n in MeV for n_n in 1/cm^3

3. [6pts] List the nuclear physics quantities that can enter r-process calculations and describe in 1-2 sentences how this quantities influence the reaction sequence and the final r-process abundances.