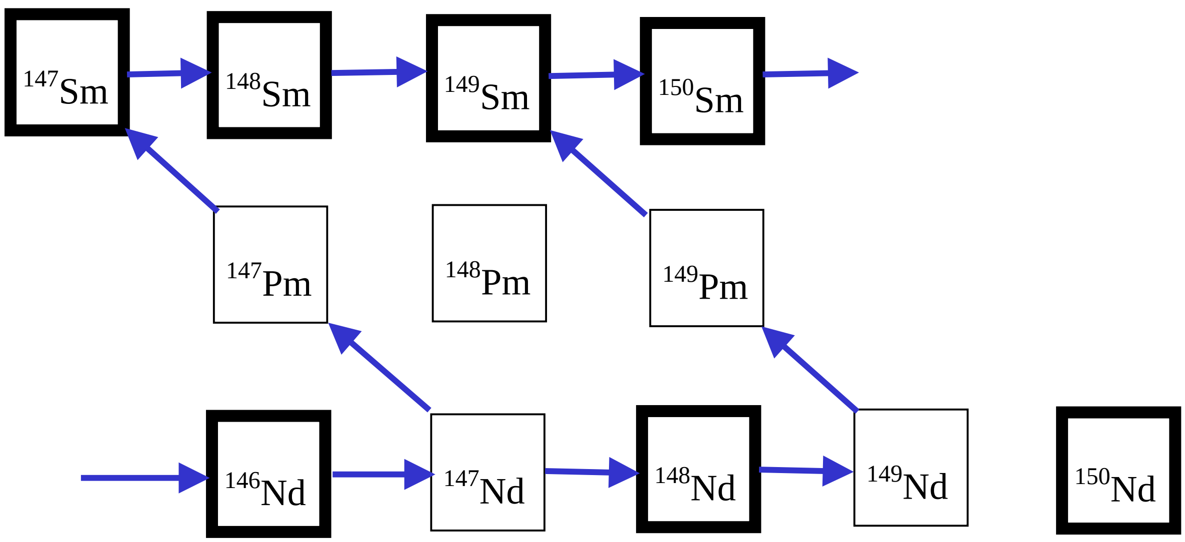
PHY983 - Nuclear Astrophysics - Spring 2007
Homework set 11
Due: Thursday April 20
Key words: steady flow and s-process

1. The s-process branches at 147Nd because this isotope has a beta decay half life of 5.3 days (under stellar conditions, this is slightly modified compared to what you would find in a table of terrestrial rates), which is not too many orders of magnitude away from the neutron capture timescale. Below is a simplified scheme of the reaction flows in the Nd/Sm region during the s-process (stable isotopes are marked with thick lines)



As you can see 148Sm and 150Sm are s-only isotopes. The neutron capture rates for a stellar neutron spectrum corresponding to a temperature of kT=30 keV (typical for s-process) have been measured in the laboratory. The ratio of the 148Sm neutron capture rate to the 150Sm neutron capture rate could be determined particularly accurately and was found to be 0.596. This laboratory result can be used directly to determine the neutron density during the s-process (see Winters et al. ApJ300(1986)41 to see how this is really done – here we simplify the problem considerably).

   a. [5 pts] Determine the fraction of the reaction flow that branched into the beta decay at 147Nd during the s-process that produced the solar system abundance distribution. You can use the steady flow approximation (which is locally a very good approximation) that tells you that the reaction flow is proportional to Yλ, where Y is the observed s-process abundance of the nuclide and λ is the rate of destruction per target nucleus. This means you can measure the (relative) flow that occurred during the s-process at any isotope provided you know Y and λ. Pick the suitable isotopes and work with ratios only.

   b. [5 pts] Using the measured neutron capture rate for 147Nd at a temperature of kT=30 keV of 2e7 cm3/s/mole determine the neutron density during the s-process.