PHY983 - Nuclear Astrophysics - Spring 2013
Homework Set 4
Due: Feb 8, 2013 at beginning of class
Key words: reaction rates, half-life, branching

1. [6pts] Assuming the conditions in the center of the sun remain unchanged, calculate the time it would take to reduce the hydrogen abundance in the center of the sun by a factor of 2, starting with the proto-solar hydrogen abundance. Make a graph showing the hydrogen abundance as a function of time

Instructions:

- Find the current composition and conditions in the sun using the standard solar model BS2005-AGS,OP which can be found on John Bahcall's home page at http://www.sns.ias.edu/~jnb/ (go to "Solar Neutrinos" and "Solar Models").
- Use the conditions in the center of the sun (r=0)
- Assume temperature and density have stayed constant
- Use reaction rates from the JINA reaclib database
- Use the pre-solar hydrogen abundance from Lodders
- Hint: take into account the different hydrogen consumption rates of the different pp-chain branches by deriving an effective rate.

2. a. [6pts] The deuterium abundance in the sun reaches very quickly an equilibrium abundance where dY/dt=0 (equilibrium condition). Write down the equation describing the rate of change of the deuterium abundance and calculate the deuterium to hydrogen abundance ratio in equilibrium in the center of the sun using the same sources of information as in problem 1 on solar model and reaction rates.

2.b [2 pts] Give a rough time for how long it takes for deuterium to be in equilibrium (you can use the graphs provided in the text book "Nuclear Physics of Stars") - no calculation needed.

3. [6pts] Write down in algebraic form (no numbers) the Jacobian for the ppI chain considering 1H, 2H, 3He, and 4He as the only abundances to keep track of.