Name: _____ Partner: _____

PH4: Nuclear properties and the astrophysical r process

Summer 2017

Computational Exercises

The full set of computational exercises for the three PH4 demo periods (11:00-13:00 on 16-18 Aug) appear below. **Upon completing each task, please check your results with the instructor before moving on to the next.**

1. Use the nuclear Saha equation to find the relative equilibrium abundances of ^{132}Sn, ^{133}Sn, and ^{134}Sn in an astrophysical plasma with temperature $T = 1.5$ GK and neutron number density 1.0×10^{24} cm^{-3}. Write out the full calculation by hand, with the numerical values used for all quantities clearly specified, and the final answers circled.

2. Write a computer code that will extend the calculations above to the entire tin isotopic chain. Calculate the relative equilibrium abundances of the tin isotopes for two sets of r-process conditions:

Set 1: $T = 1.5$ GK, $n_n = 1.0 \times 10^{24}$ cm^{-3}

Set 2: $T = 1.5$ GK, $n_n = 1.0 \times 10^{28}$ cm^{-3}

and compare the results on a single plot of relative abundance versus mass number. For which set of conditions is the r-process path farther from stability? Is this as expected?

3. Extend your computer code from task 2 above to calculate the relative equilibrium abundances for every isotopic chain. Run your code for the two sets of r-process conditions listed above, and make comparison plots of the following:

(a) the r-process path, Z versus N_{path}, where N_{path} is the neutron number of the isotope of maximum equilibrium abundance for each Z, and

(b) the predicted isotopic abundance pattern, $Y(A)$ versus A.

Is your plot of the two r-process paths consistent with your findings in task 2 above? Explain. Also, how does the resulting abundance pattern compare to the solar r-process pattern? Comment on the specific similarities and differences.

4. Extend your computer code from task 3 to introduce the steady β flow condition: $Y(Z, N_{path})\lambda_\beta(Z, N_{path}) \sim$ constant. Repeat the calculations of task 3 and plot the new predicted isotopic abundance pattern, $Y(A)$ versus A. How does the resulting abundance pattern compare to the solar r-process pattern? Comment on the specific similarities and differences.

5. Repeat task 4 for different choices of masses and/or β decay rates.