DEPARTMENT OF PHYSICS, COLORADO SCHOOL OF MINES

PHGN 422: Nuclear Physics – Assignment 2

Due: October 17, 5:00pm

Download the supplemental material from the course website:
inside.mines.edu/~kleach/PHGN422

1 THE LIQUID DROP MODEL

We have shown over the last two weeks how much information we have been able to obtain about nuclear binding and collective nuclear behaviour from our simple approximation of an incompressible liquid drop. From this model, we were able to define the nuclear binding energy as:

$$B(A,Z) = a_V A - a_S A^{2/3} - a_C \frac{Z(Z-1)}{A^{1/3}} - a_A \frac{(A-2Z)^2}{A} + a_P \frac{\delta}{A^{1/2}},$$

where,

$$\delta = \begin{cases} +1 & \text{for even-even nuclei} \\ 0 & \text{for odd-}A \\ -1 & \text{for odd-odd nuclei} \end{cases}$$

and $a_V = 15.85$ MeV, $a_S = 18.34$ MeV, $a_C = 0.71$ MeV, $a_A = 23.21$ MeV, and $a_P = 12$ MeV. The following questions will attempt to test our model and see where and how it fails.

1.1 Experimental Binding Energy per Nucleon

Start by downloading the supplemental material from the course website. The file includes experimental binding energies (again, no uncertainties) for several nuclei, and is formatted in the following way:

A	Z	Binding Energy (keV)

1. Write a program to extract the experimental binding energies. Include the code you have written with the assignment (or just the first two pages if it is longer).

2. Using the code you have just written, generate a plot of B_{exp}/A as a function of A (in MeV) as we showed in class (use points instead of lines to generate the plot).

1.2 Binding Energies from the Liquid Drop Model

Using the same code (or writing another small one) execute the following:

1. Compute the binding energies per nucleon using the liquid drop model (B_{LDM}/A) of the same nuclei included in the file, and generate a plot as a function of A (use points instead of lines to generate the plot).

2. Overlay the two sets of points B_{exp}/A and B_{LDM}/A on the same plot using two different colours.

3. Discuss the agreement between the two sets of points.

1.3 Revealing the Magic Numbers

As we mentioned in class, we are particularly interested in finding where our model fails so we can improve on our description of the atomic nucleus. Using the information you have obtained in the first two parts:

1. Plot $A \cdot [B_{exp}/A - B_{LDM}/A]$ as a function of the proton number Z (again, use points to generate the plot). Identify on the plot where you think the magic numbers are (ie. where our model breaks down).

2. Plot $A \cdot [B_{exp}/A - B_{LDM}/A]$ as a function of the neutron number N. Identify on the plot where you think the magic numbers are.