Physics 457 Problem Set 7

Due in Class, March 23, 2005

Reading: Frauenfelder and Henley Chapter 16-18.

1. The deuteron is a nucleus in the sense that it is a bound system of neutron and proton. However in many ways it is very much unlike all heavier nuclei. Discuss the differences including evidence from electron scattering, binding, structure etc.

2. Use the deuteron magentic moment to estimate the D-state probability a_2^2. This requires completing the calculation described in class. You should work out the Clebsch-Gordon coeficients yourself and get the factors of 2 correct!

3. Assume the deuteron wave function

$$\psi(\vec{r},t) = R(r)(a_0 Y_{,00} + a_2 Y_{2,0})e^{-i\omega t}$$

a.) Show by explicit calculation that the electric quadrupole moment vanishes for a nucleus with a spherically symmetric charge distribution (i.e. the s-state).

b.) Find the electric quadrupole moment Q in terms of $< r^2 >$, a_0 and a_2.

The electric quadrupole moment operator is

$$\mathbf{Q} = r^2(3\cos^2\theta - 1)$$

4. Use the data attached to find the binding energies and binding energies per nucleon for the ground states of ^{56}Mn, ^{56}Fe, ^{56}Co, and the binding energies per nucleon for ^{206}Pb, ^{207}Pb, ^{208}Pb, and ^{209}Pb. Compare these measured binding energies to the liquid drop predictions. (Make a table and discuss any discrepancies.) Be sure to read the Explanation to Table Section of the Nuclear Wallet Cards.

5. Use the liquid drop model to find the most stable value of Z for $A = 238$.

6. Find the electro-magnetic (coulomb) binding energy of a nucleus with charge Ze and mass number A. Numerically evaluate this for ^{4}He, ^{56}Fe, and ^{208}Pb.