PHYSICS 722/822 - Fall Semester 2018 - ODU

Nuclear Physics - Problem Set 2

Problem 1)

The nucleus ^{238}U has 92 protons and 146 neutrons. Its proton radius is 6.8 fm, while its neutron radius is somewhat larger (perhaps 7.2 fm), see, e.g., http://web.mit.edu/pavi09/talks/Michaels_prex.pdf and http://hallaweb.jlab.org/parity/prex/prexII.pdf

a) Calculate the overall binding energy of this nucleus in the Fermi Gas model. Be careful to calculate the total Fermi energy of protons and neutrons separately, and to add the Coulomb repulsion energy to the former (use the same expression as in the first Problem Set, when we derived the Coulomb term for the Weizsäcker mass formula). Express your final result in terms of the unknown average nuclear potential energy, V_o, per nucleon. Show that the sum of Coulomb and Fermi kinetic energy is roughly similar for the protons and the neutrons in ^{238}U. Why would we expect this to be true? (Of course, the Fermi gas model is much too crude to expect an exact match).
b) Find the *actual* binding energy of ^{238}U (from a mass table etc.). Solve for the unknown V_o. Compare to the "average" V_o of about 28 MeV for typical "Fermi gas nuclei".
c) Calculate the sum of kinetic and potential energy E_F - V_o of the least bound neutron, using your results from above. Surprise! Compare with the *actual separation* energy (from a mass table etc.) which of course has the opposite sign. Explain the discrepancy in a sentence or two.

Problem 2)

For the following nuclei, calculate total spin J, parity π, and magnetic moment μ (assuming the extreme single-particle picture):
^{3}He, ^{5}He, ^{15}N, ^{15}O, ^{17}F, ^{41}Ca and ^{131}In.
Explain the assumptions and formulae that you use. Where possible, compare to the actual numbers.