PHYSICS 415/515 - Fall Semester 2025 - ODU

Nuclear and Particle Physics - Problem Set 9

Problem 1)

Revisit the liquid drop mass formula from the beginning of the semester. Which of the 8 terms in that formula can be explained from the Fermi gas model of nuclei? (Only qualitatively – you don't have to show that numerically they come out correctly).

Problem 2)

The nucleus ^{238}U has 92 protons and 146 neutrons. Its radius is 6.8 fm.

a) Calculate the Fermi momentum for this nucleus, separately for the protons and for the neutrons.
b) Given that the average kinetic energy per nucleon is $E_{kin} = \frac{3}{10m} p_f^2$, what is that average kinetic energy for a neutron *vs.* a proton in ^{238}U?
c) Why does the excess kinetic energy for neutrons not immediately lead to a chain of beta-decays to "even out" the energy between the two species?
d) Calculate the quantitative value for the extra energy of an average proton and compare to the difference in kinetic energy for the protons and the neutrons. (You may use the energy of a charged sphere, divided by the total number of protons).

Problem 3) (XC)

In your own words (1-2 paragraphs), explain the difference between the nuclear shell model and the "microscopic ab-initio" models of light nuclei. Which is more accurate? What are the limitations of each model?