Physics 556 Nuclear Physics
Homework 2

[1] Calculate the average binding energy of a nucleon in $^{58}_{28}Ni_{30}$. Start with the value in the Appendix C of Krane. Read pages 59-65 in Krane. Are there corrections to be made to the value found in Appendix C of Krane?

[2] Go the National Nuclear Data Center. Lookup, S_n , the 1st neutron and S_p, the 1st proton separation energy. That is the energy required to take 1 neutron or 1 proton from the nucleus.

[3] Given the knowledge gained in Q1 and Q2 give an argument why the study of Nuclear Structure can be considered non-relativistic. What sets the energy scale?

[4] In class we found the classical radius of the electron, $r_{classical}$ by assuming that all the mass of the electron, 511 keV, is due to its electric field energy. In a similar way estimate the amount of the proton mass that can be attributed to the electric field energy of the proton. The charge distribution of the neutron and proton is found to have a radius of 0.8 fm.

Some useful numbers:

$$\frac{e^2}{4\pi\varepsilon_0} = 1.44 \text{ MeV fm}$$

$$\hbar c = 197 \text{ MeV fm}$$

$$1\text{u} = 931 \frac{\text{MeV}}{c^2}$$

[5] The proton and neutron can be considered to be a nucleon. In other words they are same particle, just as the electron can be considered to have two states spin up and spin down. A nucleon has two states isospin up (proton) and isospin down (neutron). Using the results of question [4] at what level would you expect this concept of isospin to break down.

[6] Solve the infinite well potential.

[a] List the step required to solve a quantum mechanical potential for the quantum energy spectrum and the normalized wave functions.

[b] Solve for $\psi(x)$ and E_n for the following potential.

$$V(x) = \infty \quad x < -\frac{a}{2}, \quad x > \frac{a}{2}$$

$$V(x) = 0 \quad -\frac{a}{2} \le x \le \frac{a}{2}$$

[c] Draw the wave function and probability function for the first four energy states within the well.

[d] Is the potential invariant to parity?

[e] Are the wave functions Eigen states of parity?

[f] Assign even and odd parity to each state. What is the pattern?

[g] Fill this potential with 3 protons. What is the parity of the resulting nucleus?

[h] Fill this nucleus with 2 protons and 1 neutron. What is the parity of the resulting nucleus?

[7] Fill out the following table.

Particle	Symbol	Class /spin	Lepton #	Baryon #	Charge	Mass	Color	Isospin	Lifetime
up quark									
down quark									
Gluon									
Electron									
Muon									
Neutrino									
Photon									
W-boson									
Z boson									
Proton									
Neutron									
Pion									