PHY492 Spring 2001 Nuclear and Elementary Particle Physics
Homework set 2 Due date: Friday, 02/16/2001

Please clearly state your assumptions, number the equations and indicate logical connections between different lines.

1. [5+5+5+5+5 pt] Nuclear electric form factor

The nuclear electric form factor is given by $F(q^2) = \frac{1}{Ze}\int r(\vec{r})\exp(i\vec{qr}/\hbar)dV$.

a. Show that this expression reduces for spherically symmetric charge densities to $F(q^2) = \frac{4p\hbar}{Ze}\int r(r)r\sin(\frac{qr}{\hbar})dr$.

b. Show that the form factor for the charge density $r(r) = \begin{cases} r_0 \text{ for } r < a \\ 0 \text{for } r > a \end{cases}$ is given by $F(q^2) = \frac{3\{\sin(qa/\hbar) - (qa/\hbar)\cos(qa/\hbar)\}}{(qa/\hbar)^3}$.

c. For a nucleus with a=4fm, plot the square of this form factor versus the momentum transfer over the range 0 MeV/c < q < 1 GeV/c.

d. Plot the differential cross section for the scattering of 500 MeV electron over the same range of momentum transfer.

e. Show that for a spherically symmetric charge density $\lim_{q^2\to 0}\frac{dF(q^2)}{dq^2} = -\frac{\langle r^2\rangle}{6\hbar^2}$, where $\langle r^2\rangle = \frac{4p}{Ze}\int r(r)r^4dr$ is the mean square of the electric charge distribution. For this proof, expand the answer from part a) in q^2 up to order $O(q^2)$.

2. [5+5+5+5+5 pt] Muonic atom

Before you work on this problem, please review the Bohr Hydrogen Atom (e.g. in Ohanian's Quantum Mechanics book)

a. Williams 3.6 (a)
b. Williams 3.6 (b)
c. Williams 3.7 (a)
d. Williams 3.7 (b)
(Model I refers to charge distribution I given in Figure 3.1 on page 41 of William's book.)
e. Williams 3.8