PHYSICS 722/822 - Fall Semester 2018 - ODU

Nuclear Physics - Problem Set 4 – Due Tuesday, 10/2

Problem 1)

An electron of energy E_e scatters elastically off a nucleus *A* at rest in the lab. Show that the square of the four-momentum transferred to the nucleus is given by $Q^2 = -q^2 = -\left[(E_e - E_e')^2 - (\vec{p}_e - \vec{p}_e')^2\right] = 4E_e E_e' \sin^2\frac{\theta_e}{2}$ (neglecting the mass of the electron). Show that the relationship $Q^2 = 2m_A(E_e - E_e')$ holds. Calculate the energy of the scattered electron as a function of the scattering angle θ_e.
This is largely what we already did in lecture, but I want you to go through the math yourself to convince you everything is correct.

Problem 2)

A 1000 MeV electron scatters quasi-elastically from a proton bound in a Carbon-12 nucleus, creating a proton and a Boron-11 nucleus in its ground state. The reaction can be written as $^{12}C(e,e')p^{11}B$, meaning that we only detect the scattered electron e', not the proton p. The electron is detected at an angle of 30 degrees, and the proton was moving with an **initial** momentum of 200 MeV/c . The distribution of final electron energies ranges from E' = 740.385 MeV to E' = 933.895 MeV. Show that these two extremes are consistent with the proton moving initially either along the direction of the **q**-vector or exactly opposite to it. Which way does the **final** proton move in both csaes?
(Take the **fully relativistic** 4-momentum conservation into account. Make sure that you use the correct masses for the **nuclei** involved - don't include the electrons!)

Problem 3)

An electron beam of 2.5 GeV energy impinges on a proton target. Calculate the elastic differential cross section $\frac{d\sigma}{d\Omega}$ for a scattering angle $\theta = 90^o$. Use the dipole form factors given in Eq. (6.12) in the book by Povh et al..