511 Nuclear Physics University of South Carolina **Spring 25**

Homework Set 5 Instructor: Ralf W. Gothe **3/27/25**

5.1) **Electron, Compton, and Proton Scattering**
Consider the two cases where an electron beam with $K_{10} = 3.0\,GeV$ is elastically scattered off either a proton $m_p = 938\,MeV$ or a lead nucleus $m_{Pb} = 192799\,MeV$. Both nuclei are initially at rest.

5.1.1) [5] Calculate the maximum four momentum transfer Q^2 or $-K_\mu^2$ to the nuclei with $K_\mu^2 = (K_{1\mu} - K_{2\mu})^2$!

5.1.2) [3] Calculate the corresponding kinetic energy, energy, and momentum of the scattered nuclei!

5.1.3) [2] Calculate the same quantities for elastic Compton scattering off both nuclei! Use for the initial photon energy $K_{10} = 3.0\,GeV$.

5.1.4) **[GS]** [2+4] Calculate the same quantities for elastic proton scattering off both nuclei! Use the same initial energy $K_{10} = 3.0\,GeV$ for the proton.

5.2) **Rutherford Scattering**

5.2.1) [5] α particles with $E_{kin} = 6\,MeV$ from a radioactive source are scattered off $^{197}_{79}Au$ nuclei. At which scattering angle is the distance of the α particle to the $^{197}_{79}Au$ nucleus smallest? Calculate this distance! Why do you expect no deviations from the classical Rutherford cross section?

5.2.2) [4] Which kinetic energy is needed so that the α particle, based on the classical radii of both particles, just reaches the $^{197}_{79}Au$ nucleus? Why do you expect now deviations from the classical Rutherford cross section?

5.2.3) **[GS]** [5] Calculate the smallest distance of the α particle to the $^{197}_{79}Au$ nucleus in dependence of the scattering angle ϑ!