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

Homework Set 6 Instructor: Ralf W. Gothe **4/3/25**

6.1) **Diffractive Scattering**
Fraunhofer diffraction by a circular disk of a diameter D produces pattern of concentric diffraction rings. The first minimum appears at $\vartheta = 1.22\,\frac{\lambda}{D}$.

6.1.1) [5] Determine the angular separation of the diffraction minima in α scattering off a ^{56}Fe nucleus for a given kinetic energy of the α particles in the lab frame $E_\alpha = 100\,MeV$. Both nuclei should be considered as impenetrable disks. Calculate first the CMS momentum p^*_α of the α particle, then the corresponding de-Broglie wave length $\lambda^* = \frac{h}{p^*_\alpha}$ and then the scattering angle ϑ^*.

6.1.2) [5] Determine the scattering angle ϑ in the lab frame. Calculate first the CMS momentum p'^*_α, then the velocity of the CMS with respect to the lab frame $\beta = \frac{p_\Sigma}{E_\Sigma}$, then the momentum p'_α in the lab frame and finally the scattering angle ϑ in the lab frame!

6.2) **Electron Radius**

6.2.1) [5] Suppose one wants to obtain an upper bound for the electron radius by looking for a deviation from the Mott cross section in electron electron scattering and that this cross section can be measured with an uncertainty of $1\,\%$. What center of mass energy is necessary to set the upper limit for the electron radius to $10^{-18}\,m$?

6.2.2) [3] Calculate the needed primary electron energy *(ies)* for a fixed target *(collider)* experiment!

6.2.3) [2] What would be the necessary center of mass energy, if the cross section is measured to a precision of $0.01\,\%$?