PHYS4702 Atomic, Nuclear, & Particle Physics Fall 2015 HW #9

Due at the start of class on Thursday 22 Oct 2015

(1) The spin-orbit interaction energy of a level in an alkali atom might be written as

$$\overline{\Delta E} = \frac{\hbar^2}{4m^2c^2}\left[j(j+1) - l(l+1) - s(s+1)\right]\overline{\frac{1}{r}\frac{dV(r)}{dr}}$$

Come up with an estimate for the average value of $(1/r)dV/dr$, and compare to the value of the splitting listed in Table 10-1 of the text. Also find as recent a reference as you can, for a measurement of the "D-line" splitting in sodium, and compare to the tabulated value.

(2) Use classical, circular orbits of an electron around a nucleus, to derive an expression for the energy splitting caused by an applied magnetic field $\mathbf{B}$. Assume that $\mathbf{B}$ is perpendicular to the plane of the orbit. Compare your expression to the quantum mechanical Zeeman effect, Equation (10-22) in your text.

(3) Use the Born approximation to calculate the differential scattering cross section for the *screened Coulomb potential*

$$V(r) = \frac{1}{4\pi\epsilon_0}\frac{zZe^2}{r}e^{-r/d}$$

Take the limit $d \to \infty$ for the cross section, and compare the result to the classical Coulomb scattering (aka "Rutherford Scattering") of a low mass particle with charge ze from a high mass nucleus with charge Ze. Do you find the answer surprising?