Computational Mathematics Applications in Klein-Nishina Cross Section

This project is broken up into 4 steps. Each step builds on the previous one so do them sequentially.

1. The Klein-Nishina differential cross section for an x-ray scattered by an angle $φ$, per unit solid angle, is defined as $\frac{d\_{e}σ}{dΩ\_{φ}}=\frac{r\_{0}^{2}}{2}\left(\frac{hν^{'}}{hν}\right)^{2}\left(\frac{hν}{hν^{'}}+\frac{hν^{'}}{hν}-sin^{2}φ\right)$ and has units of cm2 per steradian.

Write a Matlab script to determine the differential cross section for each unit value of $φ$, in 1 degree (1$°$) increments from 0$°$ to 180$°$ degrees, for incoming x-ray energies ($hν$) of 0.01, 0.1, 1, 10, and 100 MeV (see Figure 7.5). **Make a plot of the differential cross section on the y-axis, x-ray scattering angle on the x-axis for each of the energies; display all of the cross sections on the same plot.** It should match Figure 7.5 in the text.

Hint 1: you will need to first write a Matlab script to calculate the scattered x-ray energy ($hν'$) with respect to each possible scattering angle and for each set of incoming x-ray energies using Compton interaction kinematics equations. You could tabulate all possible values with respect to ($hν$) and ($φ$) in a 2D array.

Hint2: you will need two nested loops to calculate the differential cross section, one loop will iteratively calculate for each scattering angle ($φ$) and associated scattered x-ray energy ($hν'$) and another for each incoming x-ray energy ($hν$).

1. Similarly calculate the differential Klein-Nishina energy transfer cross section,$\frac{d\_{e}σ\_{tr}}{dΩ\_{φ}}$, for an x-ray scattered by angle $φ$, per unit solid angle and display the energy transfer cross sections for each incoming x-ray energy on the same plot. **Compare the meaning of the differential energy transfer cross section distribution to the differential cross section** (i.e. if the differential cross section vs. x-ray scattering angle plot tells us the probability of the x-ray interacting with respect to the angle the x-ray will be scattered; the energy transfer cross section tells us …). **Can you think of a way to spot check the output for** $\frac{d\_{e}σ\_{tr}}{dΩ\_{φ}}$ **with respect to** $φ$**?**
2. **For 100 MeV incoming x-ray, plot the** $\frac{d\_{e}σ}{dΩ\_{φ}}$ **and** $\frac{d\_{e}σ\_{tr}}{dΩ\_{φ}}$**, what does the space between the two cross sections represent? Why do they converge as** $φ\rightarrow 180°$**?**
3. Take the previous plot and change the x-axis so that instead of being in scattering angle ($φ$), it is in the scattered electron kinetic energy; again you need to use a Matlab script and Compton interaction kinematics equations. **What does this plot tell mean? Why does it look so much different than the plot in step 3? .**

Later we will review a method to determine the average value of the scattered electron energy using these plots and or tabulated data in step 4.