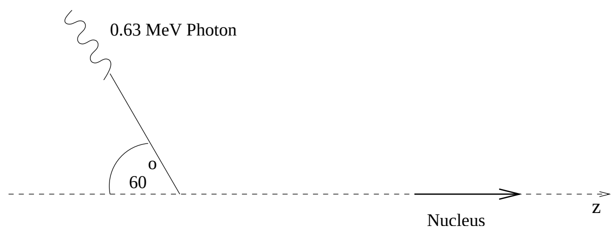
Solutions for problem set 1

1. With $E = 10,000\,\mathrm{V/m}$, $B = 0.5\,\mathrm{mT}$ and $l = 0.1\,\mathrm{m}$, I get $\tan\theta \approx 0.5$, so for a 20 cm long electron drift region after the field region, this would be a 10 cm shift in the electron beam.

Alpha particles would be deflected by $\tan\theta \approx 0.0005$, a shift of 0.1 mm after a 20 cm drift. This would be very difficult to measure accurately.

2.



Calculate the wave length of the detected photon (λ') from,

$$E = \frac{hc}{\lambda'} \tag{1}$$

A useful number to remember is $hc = 1240$ eV.nm;

$$\lambda' = \frac{hc}{E} = 1240\,\mathrm{eV.nm}/(0.63 \times 10^6\,\mathrm{eV}) \approx 2 \times 10^{-12}\,\mathrm{m} \tag{2}$$

We can use the Compton shift equation to calculate the wavelength of the photon before scattering off the electron:

$$\lambda' - \lambda_0 = \frac{h}{m_e c}(1 - \cos\theta) \tag{3}$$

for $\theta = 60^\circ$, we get $\lambda_0 \approx 0.8 \times 10^{-12}$ m.

By conservation of momentum, the momentum of the recoiling nucleus is equal to the momentum of the photon (before Compton scattering). Therefore,

$$\frac{h}{\lambda_0} = \frac{h}{\lambda} \tag{4}$$

and the wavelength of the recoiling nucleus $= \lambda \approx 0.8 \times 10^{-12}$ m.

3. Griffiths 1.1

(a)

$$\langle j\rangle = (14 + 15 + 3\cdot 16 + 2\cdot 22 + 2\cdot 245\cdot 25)/14 = 294/14 = 21.0$$

$$\langle j\rangle^2 = 441.$$

$$\langle j^2\rangle = (14^2 + 15^2 + 3\cdot 16^2 + 2\cdot 22^2 + 2\cdot 24^2 + 5\cdot 25^2)/14 = 5666/14 = 459.6$$

(b)

$$\Delta j_i = (-7,\ \ -6,\ \ -5,\ 1,\ 3,\ 4)$$

$$\sigma^2 = (7^2+6^2+3\cdot 5^2+2\cdot 1^2+2\cdot 3^2+5\cdot 4^2)/14 = (49+36+75+2+18+80)/14 = 260/14 = 18.6$$

(c)

$$\langle j^2\rangle - \langle j\rangle^2 = 18.6$$

so that equation 1.12 is verified.

4. Griffiths 1.3. This is same as the Gaussian wave function example we did in class, see the notes.