

720.

Problem 49.54 (RHK)

The quantity h/mc is often called the Compton wavelength λ_c , of the scattering particle and that Compton scattering equation is written as

$$\Delta\lambda = \lambda_c (1 - \cos\phi).$$

We have to calculate the Compton wavelength of an electron; of a proton. (b) We have to find the energy of a photon whose wavelength is equal to the Compton wavelength of the electron; of the proton. (c) We have to show that in general the energy of a photon whose wavelength is equal to the Compton wavelength of a particle is just the rest energy of the particle.

Solution:

(a)

The mass of an electron, $m_e = 9.11 \times 10^{-31}$ kg.

The Compton wavelength of electron will be

$$\begin{aligned} (\lambda_c)_e &= \frac{h}{m_e c} = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 3 \times 10^8} \text{ m s}^{-1} \\ &= 2.43 \times 10^{-11} \text{ m s}^{-1}. \end{aligned}$$

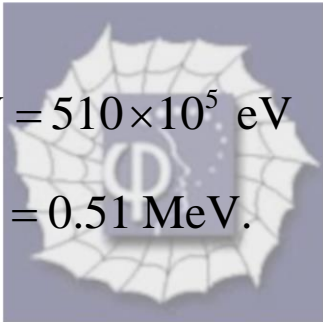
The mass of a proton, $m_p = 1.67 \times 10^{-27}$ kg.

The Compton wavelength of proton will be

$$\begin{aligned} (\lambda_c)_p &= \frac{h}{m_p c} = \frac{6.63 \times 10^{-34}}{1.67 \times 10^{-27} \times 3 \times 10^8} \text{ m s}^{-1} \\ &= 1.32 \times 10^{-15} \text{ m s}^{-1}. \end{aligned}$$

(b)

The energy of a photon which has a wavelength equal to Compton wavelength of electron will be

$$\begin{aligned} \varepsilon &= \frac{1240 \text{ eV} \cdot \text{nm}}{\lambda} \\ &= \frac{1240}{2.43 \times 10^{-2}} \text{ eV} = 510 \times 10^5 \text{ eV} \\ &= 0.51 \text{ MeV}. \end{aligned}$$


The energy of a photon which has a wavelength equal to Compton wavelength of proton will be

$$\begin{aligned} \varepsilon &= \frac{1240 \text{ eV} \cdot \text{nm}}{\lambda} \\ &= \frac{1240}{1.32 \times 10^{-6}} \text{ eV} = 939.4 \times 10^6 \text{ eV} \\ &= 939.4 \text{ MeV}. \end{aligned}$$

(c)

In general Compton wavelength of a particle of rest mass m is

$$\lambda_c = \frac{h}{mc}.$$

The energy of a photon of wavelength λ_c will therefore be

$$\varepsilon = \frac{hc}{\lambda_c} = \frac{hc}{h/mc} = mc^2,$$

which is the rest mass energy of particle of mass m .

