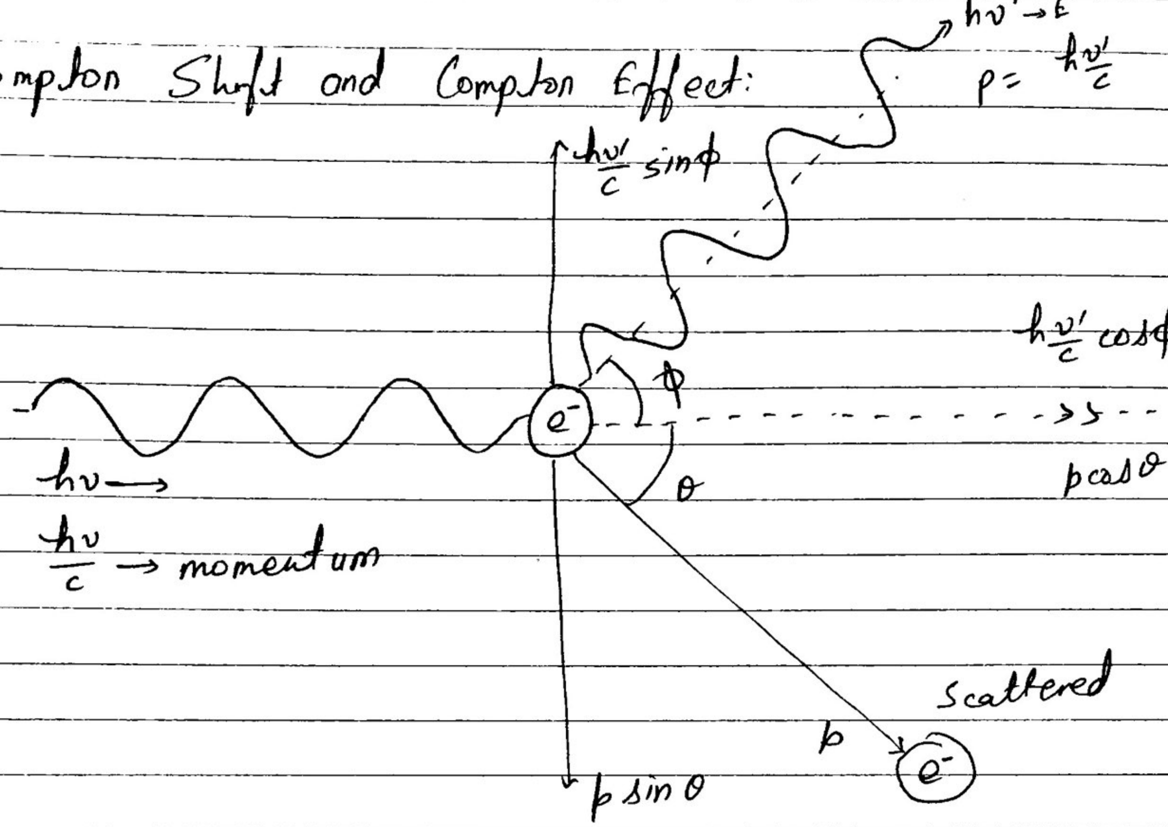
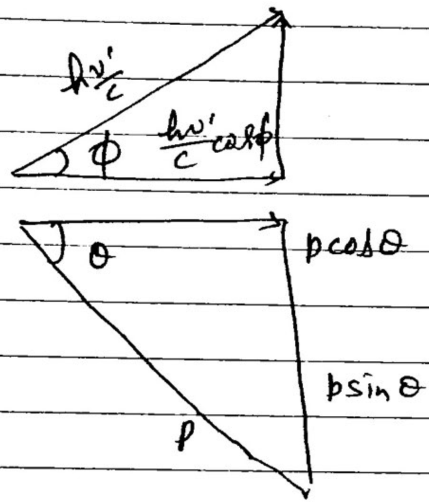
Unit -IV

Compton Shift and Compton Effect:



(a) Scattering of photon by an e^- :- The compton effect (or compton scattering) is the result of high energy photon colliding with the target, which releases loosely bond electrons from the outer shell of the atom or molecule. The scattered. The scattered experiances a wavelength shift that can not be explained in terms of classical wave theory, thus leading support to Einstein's photon theory. Probably the most important implication of the effect that it showed light could not be fully explained according to the wave phenomenon.

During the collision, momentum must be conserved in each of two mutually perpendicular directions



The initial photon momentum is $\frac{h\nu}{c}$, the scattered photon momentum is $\frac{h\nu'}{c}$ and the initial and final electron momentum are respectively 0 and p.

According to law of conservation of momentum

Initial momentum = final momentum

Hence, we have

Along X- axis

$$\frac{h\nu}{c} + 0 = \frac{h\nu'}{c}\cos\phi + p\cos\theta$$

$$pc\cos\theta = h\nu - h\nu'\cos\phi \quad \text{——— (1)}$$

Along Y axis.

$$0 = \frac{h\nu'}{c}\sin\phi - p\sin\theta$$

$$pc\sin\theta = h\nu'\sin\phi \quad \text{——— (2)}$$

Squaring and adding equation (1) & (2), we get

$$(\sin^2\phi + \cos^2\phi)\, p^2c^2 = (h\nu)^2 + (h\nu'\cos\phi)^2 - 2h^2\nu\nu'\cos\phi + (h\nu')^2\sin^2\phi$$

$\sin^2\phi + \cos^2\phi = 1$

$$p^2c^2 = (h\nu)^2 + (h\nu')^2 - 2(h\nu)(h\nu')\cos\theta \quad \text{--- (3)}$$

The total energy of the particle may be written as

$$E = KE + m_0 c^2 \quad \text{--- (4)}$$

and also

$$E = \sqrt{p^2c^2 + m_0^2 c^4} \quad \text{--- (5)}$$

equating equation (4) & (5), we get, and also squaring

$$p^2c^2 + m_0^2 c^4 = (KE + m_0c^2)^2$$

on solving;

$$p^2c^2 = KE^2 + 2m_0c^2 KE \quad \text{--- (6)}$$

Also $\quad KE = h\nu - h\nu'$

Thus equation (6) becomes;

$$p^2c^2 = (h\nu - h\nu')^2 + 2m_0c^2(h\nu - h\nu')$$

$$= (h\nu)^2 + (h\nu')^2 - 2(h\nu)(h\nu') + 2m_0c^2(h\nu - h\nu') \quad \text{--- (7)}$$

Substituting this value in equation (3), we get

$$2m_0c^2(h\nu - h\nu') = 2(h\nu)(h\nu')(1-\cos\phi) \qquad \nu = \frac{c}{\lambda} \,\&\, \nu' = \frac{c}{\lambda'}$$

$$\frac{hc}{\lambda} - \frac{hc}{\lambda'} = \frac{2}{2m_0c^2}\frac{hc}{\lambda}\frac{hc}{\lambda'}(1-\cos\phi)$$

$$hc\left(\frac{\lambda' - \lambda}{\lambda\lambda'}\right) = \frac{1}{\lambda\lambda'}\frac{(hc)^2}{m_0c^2}(1-\cos\phi)$$

$$\boxed{\lambda' - \lambda = \frac{h}{m_0c}(1-\cos\phi)}$$ This is known as Compton effect.

The quantity $\frac{h}{m_0c} = \lambda_c$ known as compton wavelength

$$\boxed{\Delta\lambda = \lambda' - \lambda = \lambda_c(1-\cos\phi)}$$