Compton Effect: (Momentum and Photons)

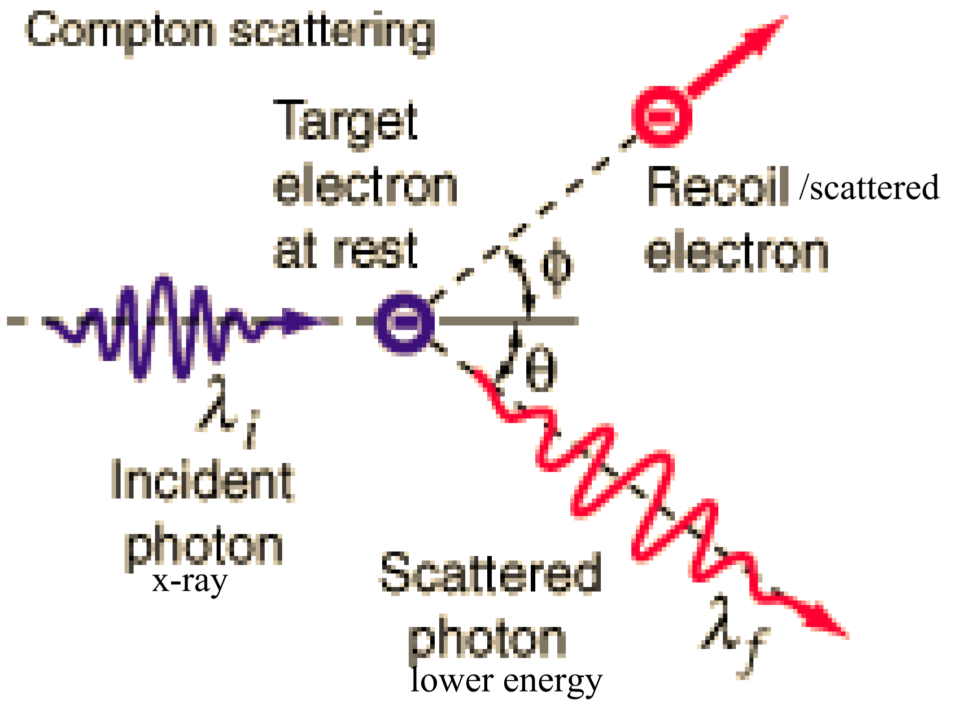
Light, as a wave, should not have momentum, since momentum requires

$$p = mv.$$

However, Compton's work showed that photons collide and exchange energy with particles according to the law of conservation of energy, that they possess momentum that this is conserved during a collision.

http://www.youtube.com/watch?v=Q_h4IoPJXZw&safety_mode=true&persist_safety_mode=1&safe=active

http://www.youtube.com/watch?v=_riIY-v2Ym8&safety_mode=true&persist_safety_mode=1&safe=active


Compton scattering
Target electron at rest
Recoil /scattered electron
ϕ
θ
λ i
Incident photon
x-ray
Scattered photon
lower energy
λ f

Compton used Einstein's ideas to explain.

Conservation of Energy

$E_{incident\ x\text{-}ray} = hf_{scattered\ photon} + 1/2\ mv^2_{electron}$

hf E_k

Conservation of Momentum

$\vec{p}_{x\text{-}ray} = \vec{p}_{scattered\ photon} + \vec{p}_{electron}$

How do we calculate the momentum of a photon?

Einstein used $E = mc^2$

$m = \frac{E}{c^2}$

so... $\vec{p} = m\vec{v}$

$\vec{p} = \frac{E}{c^2} \times c$

$\vec{p} = \frac{E}{c}$ for a photon

or $p = h/\lambda$

**low f photons small momentum act like waves
**high f photons larger momentum act like particles

$p = h / \lambda$

Where: $m = E / c^2$ is known as the **mass equivalence**

Ex.1 What is the frequency of photons that have a momentum of 2.80×10^{-27} kg x m/s?

Ex.2 An 85 eV photon collides with an electron. The resultant photon is deflected 60° from the original line of travel and has a wavelength of 214 nm.

(a) What is the momentum of the original photon?
(b) What is the momentum of the resultant photon?
(c) How much energy was given to the electron?
(d) How much has the electrons speed increased?