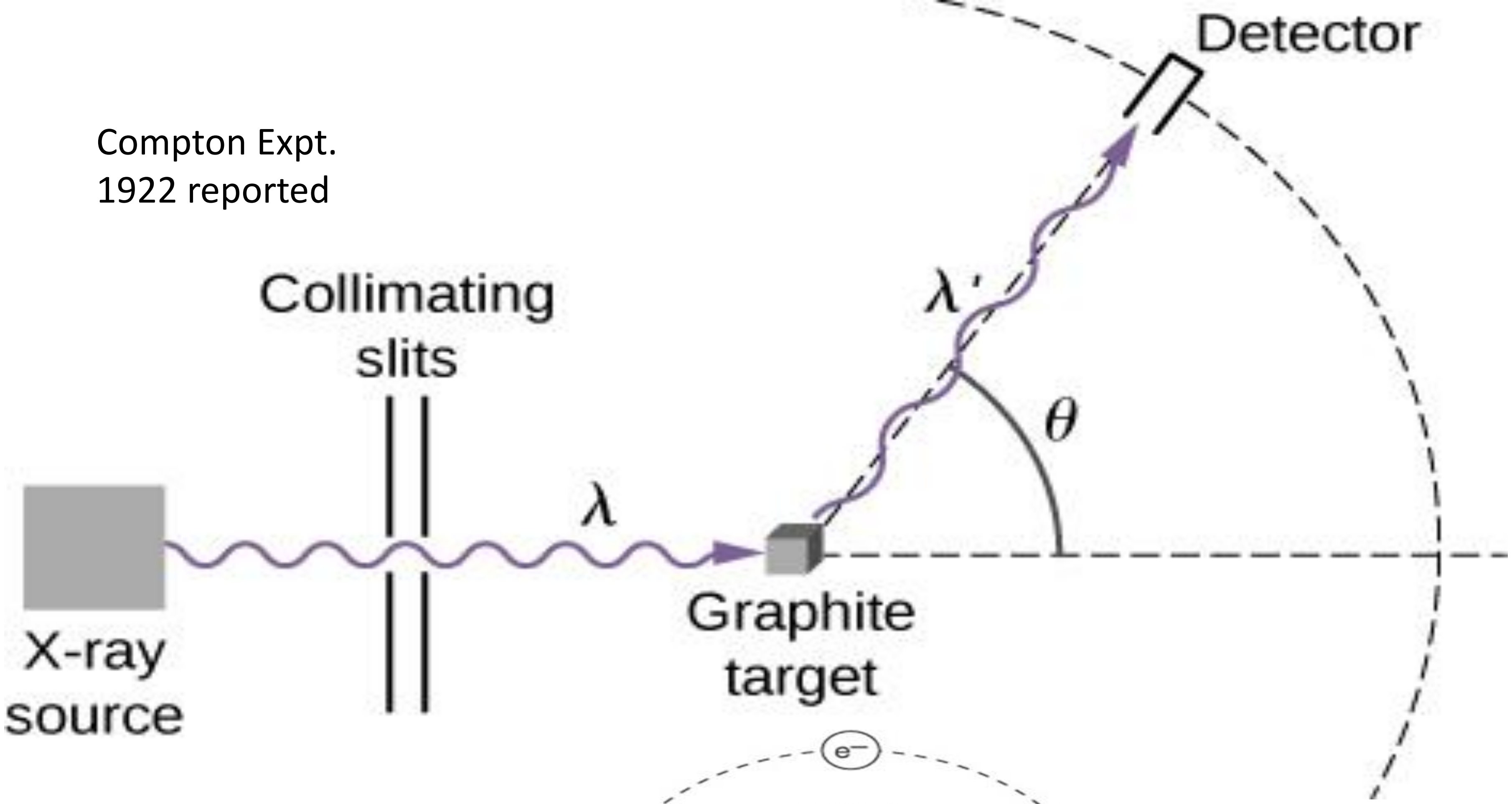
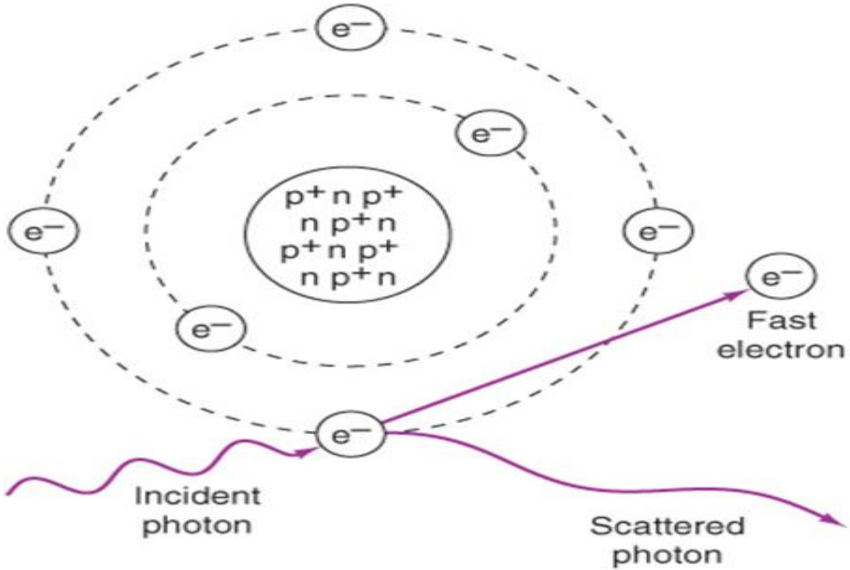
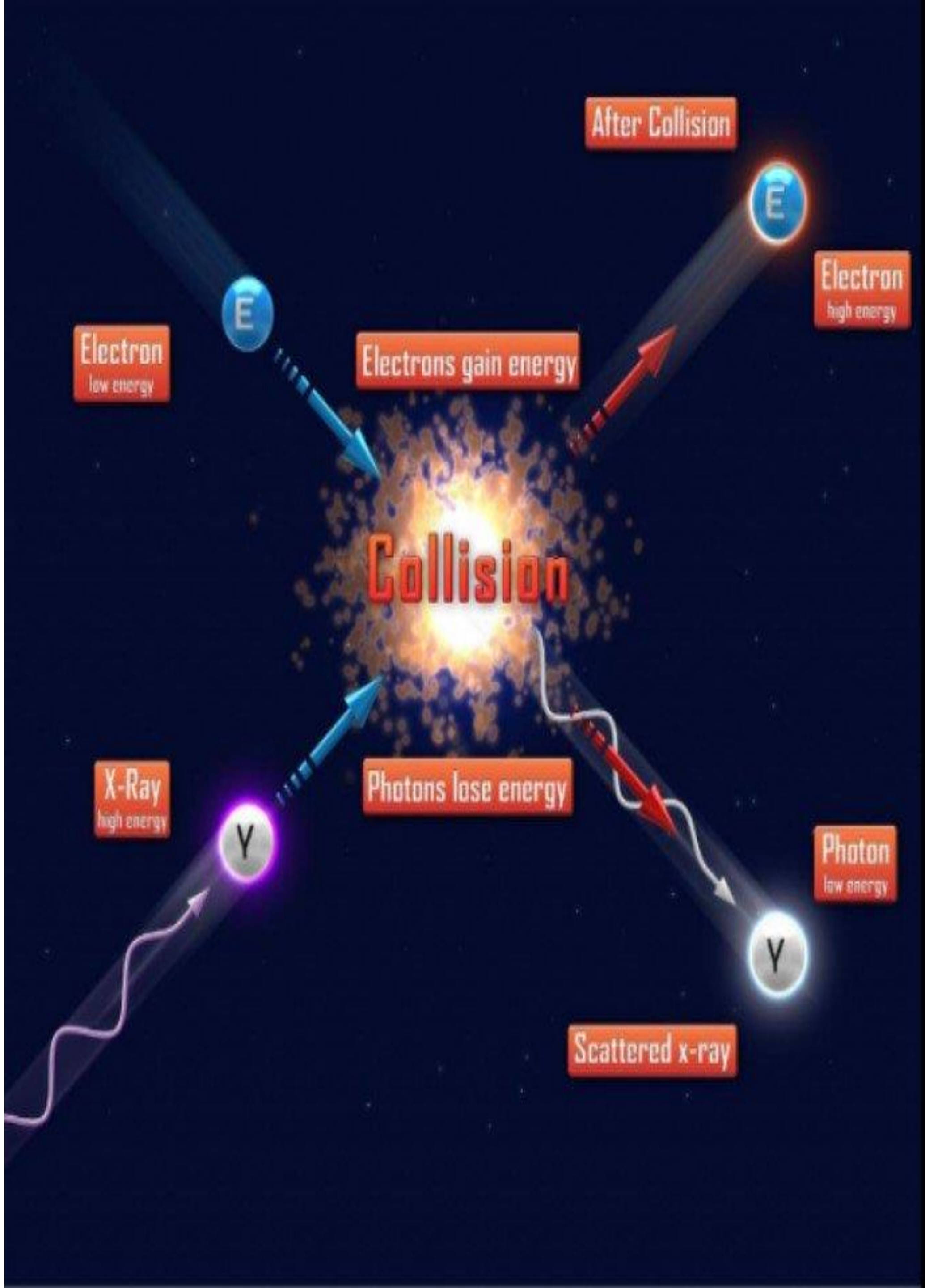
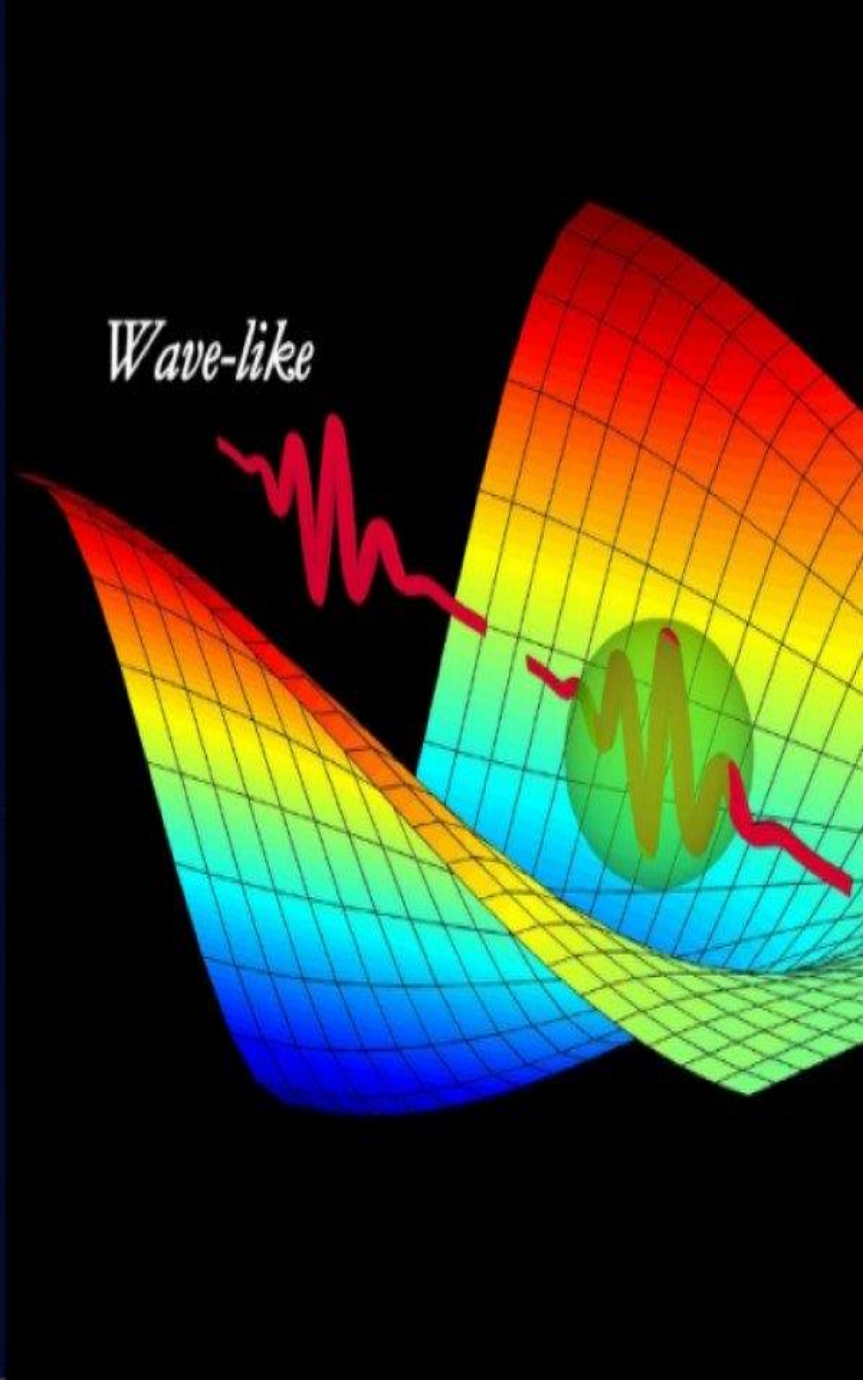
Compton Expt.
1922 reported





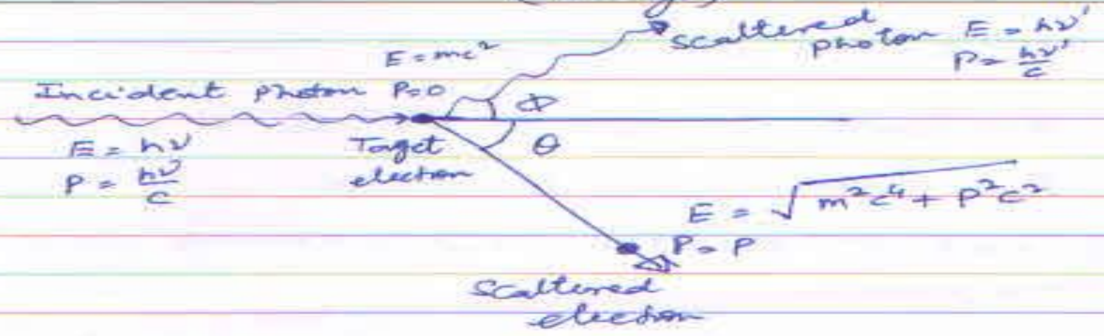

After Collision
Electron
high energy
Electron
low energy
Electrons gain energy
Collision
X-Ray
high energy
Photons lose energy
Photon
low energy
Scattered x-ray


Wave-like

Compton Effect :

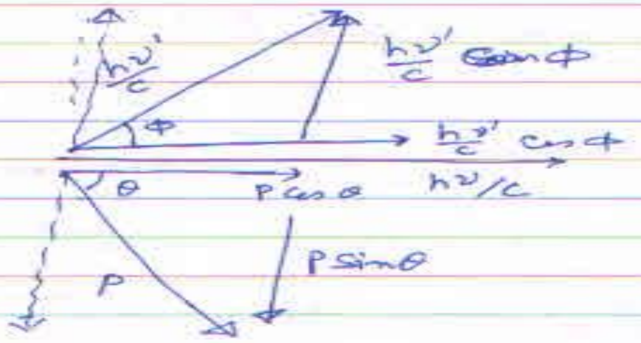
(i) X-rays were emitted by electrons. ①

(ii) Photon – electron collision
(x-rays)



$E = PC$

Vector diagram



$$\nu' < \nu$$

loss in photon energy = gain in electron energy

$$h\nu - h\nu' = K.E. \quad — ①$$

Energy – Momentum relation of photon

$$E = PC \quad — ②$$

Photon momentum $P = E/c = \frac{h\nu}{c}$ — ③

Law of momentum conservation at the time of collision.

in the direction $\frac{h\nu}{c} + 0 = \frac{h\nu'}{c}\cos\phi + P\cos\theta$ — ④

Perpendicular to the direction.

Initial momentum = Final momentum

$$0 = \frac{h\nu'}{c}\sin\phi - P\sin\theta \quad — (5)$$

multiply by 'c' in equ. (4) & (5), hence

$$Pc\cos\theta = h\nu - h\nu'\cos\phi$$

$$Pc\sin\theta = h\nu'\sin\phi$$

By squaring each of equation and adding them to eliminate "θ",

$$P^2c^2 = (h\nu)^2 - 2(h\nu)(h\nu')\cos\phi + (h\nu')^2 \quad — (6)$$

we know total energy of particle

$$E = K.E + mc^2$$

$$E = \sqrt{m^2c^4 + P^2c^2}$$

$$E^2 = (m^2c^4 + P^2c^2)$$

$$(K.E + mc^2)^2 = m^2c^4 + P^2c^2$$

$$P^2c^2 = (KE)^2 + 2mc^2(KE) + \cancel{m^2c^4} - \cancel{m^2c^4}$$

$$P^2c^2 = (KE)^2 + 2mc^2(KE) \quad — (8)$$

we know from equ. (1) $K.E = h\nu - h\nu'$

hence

$$P^2c^2 = (h\nu - h\nu')^2 + 2mc^2(h\nu - h\nu')$$

$$= (h\nu)^2 - 2(h\nu)(h\nu') + (h\nu')^2 + 2mc^2(h\nu - h\nu') \quad — (7)$$

Substituting p^2c^2 from equ. 6

$$\cancel{(h\nu)^2} - 2(h\nu)(h\nu')\cos\phi + \cancel{(h\nu')^2}$$

$$= \cancel{(h\nu)^2} - 2(h\nu)(h\nu') + \cancel{(h\nu')^2}$$

$$+ 2mc^2(h\nu - h\nu')$$

$$2mc^2(h\nu - h\nu') = 2(h\nu)(h\nu')$$

$$- 2(h\nu)(h\nu')\cos\phi$$

$$2mc^2(h\nu - h\nu') = 2(h\nu)(h\nu')(1-\cos\phi) \quad -8$$

$$\cancel{2}mc^2h(\nu - \nu') = \cancel{2}h^2\,\nu\,\nu'(1-\cos\phi)$$

$$\frac{mc}{h}\left(\frac{\nu}{c} - \frac{\nu'}{c}\right) = \frac{\nu}{c}\cdot\frac{\nu'}{c}(1-\cos\phi)$$

$$\frac{mc}{h}\left(\frac{1}{\lambda} - \frac{1}{\lambda'}\right) = \frac{1-\cos\phi}{\lambda\lambda'}$$

$$\boxed{\lambda' - \lambda = \frac{h}{mc}(1-\cos\phi)} \quad - 9$$

Equ. 9 Derived by A. H. Compton in early 1920 and effect $\lambda' > \lambda$ or $\nu' < \nu$ is called Compton effect

change in wavelength, called Compton wavelength

$$\lambda_c = \frac{h}{mc} \qquad \text{at } \cos\phi = 0,\ \phi = 90^\circ$$

λ_c is independent on λ of incident wave hence $\boxed{\lambda' - \lambda = \lambda_c (1 - \cos\phi)}$ — (10)

$\phi = 180°$ then $\lambda' - \lambda$ = Maximum.
or twice

$2\lambda_c$

$\lambda_c = 2.426 \times 10^{-12}$ meter

$= 2.426$ pm

$\lambda' - \lambda = 2\lambda_c = 2 \times 2.426 = 4.852$ pm

~~for visible light = 0.01 preset~~
~~x-rays $\star$ = ·1~~

Meaning:
x-rays loses energy when pass through matter

De-broglie wave : Matter wave

$$P = \frac{h\nu}{c} = \frac{h}{\lambda}$$

$E = h\nu$

$Pc = h\nu$

$$\lambda = \frac{h}{P}$$

The momentum of particle $p = \gamma m v$

$$\lambda = \frac{h}{\gamma m v}$$

$$\gamma = 1 \Big/ \sqrt{1 - \frac{v^2}{c^2}}$$ relativistic factor

wave & matter properties can not measure at the same time.

If $v << c$, $\gamma \approx 1$

$$\boxed{\lambda = \frac{h}{mv}}$$

$$P = \sqrt{2mE_K}$$

$$\lambda = \frac{h}{\sqrt{2mE_K}} \quad \text{or} \quad \frac{h}{\sqrt{2mqV}}$$

Q. Find the de Broglie's wavelength of a
(a) 46 g mass with a velocity 30 m/sec
(b) an electron of $v \sim 10^7$ m/sec.

(a) $\lambda = \cancel{4.8\times} \frac{6.63\times10^{-34}\ J.s}{(0.046\ kg)(30\ m/s)}$

$\lambda = 4.8\times10^{-34}$ meter

$\Rightarrow$

Size of particle $>>>$ wavelength.

No wave phenomena will be obser

(b) $\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}\ J.s}{(9.1\times10^{-31}\ kg)(10^7\ m/s)} = 7.3\times10^{-11}$

Radius of hydrogen atom is 5.3×10^{-11} met

equ to 7.3×10^{-11} met

It will show wave na

Q. Find the De. broglie wavelength of (a) an electr whose speed is 1.0×10^8 m/s and (b) $v = 2.0\times10^8$ m

Q. The equivalent wavelength of a moving electron is 0.24×10^{-10} meter. what Voltage applied betw two grids will bring it to rest.