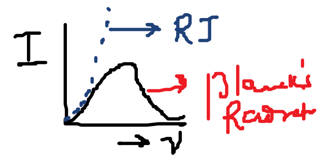
Lecture 21: Section 2

Thursday, February 24, 2022 8:54 AM

Quantum Mechanics



* Blackbody Radiation : $\lambda_{max} T = b$

Rayleigh-Jeans : $\frac{8\pi\nu^2}{c^3} \boxed{k_B T} d\nu$

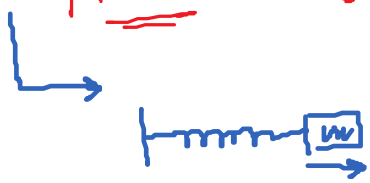
$\boxed{E = h\nu}$ $E_n = \left(n + \frac{1}{2}\right) h\nu$ $n = 0$

Planck's

BE statistics $\frac{h\nu}{e^{h\nu/kT} - 1}$

* Photoelectric Effect :

Expt.



$E = 0$

$\rightarrow E = \frac{1}{2} h\nu$

Particle behavior of wave

* Compton Effect :

$p = \frac{h\nu}{c}$

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

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

- $E = K.E + mc^2 \rightarrow (1.20)$
- $E^2 = p^2c^2 + m^2c^4 \rightarrow (1.24)$

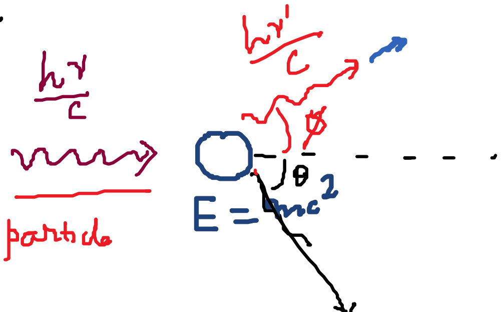
$K.E = pc$

$\rightarrow$ Rest mass 4 K.E energy

$W = \int F\,ds = \int \frac{dp}{dt} ds$

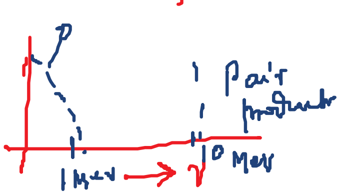
$\rightarrow p \quad p = \gamma mv$

$p_i = p_f$

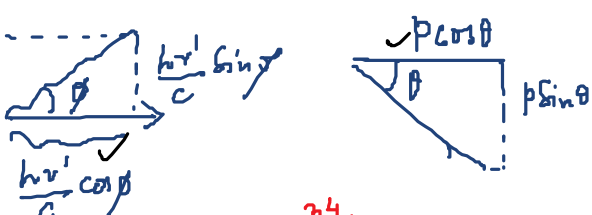


Loss of energy of photon =

$E^2 = m^2c^4 + p^2c^2$



$p_1 = p_f$



Horizontal : $\frac{h\nu}{c} + 0 = \frac{h\nu'}{c}\cos\phi + p\cos\theta \quad \hookrightarrow (1)$

vertical : $0 = \frac{h\nu'}{c}\sin\phi - p\sin\theta \quad \hookrightarrow (2)$

$F_g = mg$, $m_e \approx 10^{-34}$ kg

$c \times (1), (2)$

$F_g = mg$, $m_e \approx 10^{-34}$ kg

$c \times (1), (2)$ ↳(2)

$$h\nu = h\nu' \cos\phi + pc\cos\theta \quad -(3)$$

$$0 = h\nu' \sin\phi - pc\sin\theta \quad -(4)$$

$(3)^2 + (4)^2$

$$\boxed{p^2c^2 = (h\nu)^2 + (h\nu')^2 - 2(h\nu)(h\nu')\cos\phi}$$ ↳(5)

From Relativity → $\theta = 0,\ \phi = 0$

$$E = K.E + mc^2 = \sqrt{p^2c^2 + m^2c^4}$$

$$\Rightarrow (K.E + mc^2)^2 = p^2c^2 + m^2c^4$$

$$K.E^2 + \cancel{m^2c^4} + 2(K.E)mc^2 = p^2c^2 + \cancel{m^2c^4}$$

$$\Rightarrow p^2c^2 = K.E^2 + 2(K.E)mc^2$$

$K.E = h\nu - h\nu'$

$$\Rightarrow \boxed{p^2c^2 = \cancel{(h\nu)^2} + \cancel{(h\nu')^2} - 2(h\nu)(h\nu') + 2(h\nu - h\nu')mc^2}$$

$$= \cancel{(h\nu)^2} + \cancel{(h\nu')^2} - 2(h\nu)(h\nu')\cos\phi$$ → (5) from

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

$2h^2c^2$

$$\Rightarrow \frac{m}{h}\left(\frac{c}{\lambda} - \frac{c}{\lambda'}\right) = \frac{1}{\cancel{c^2}}\cdot\left(\frac{\cancel{c}}{\lambda}\right)\cdot\left(\frac{\cancel{c}}{\lambda'}\right)(1 - \cos\phi)$$

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

Photon

photon

↓

particle

1 – 10 MeV

$$\Delta\lambda = \lambda' - \lambda = \frac{h}{mc}(1-\cos\theta)$$

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

• 10 – 100 MeV

$e^+ \quad e^-$

Particle of wave

light I_2 I_1

Interference

Intensity dist^n

De Broglie wave ⇒ Particles also behave as wave

$e^- \quad e^-$
$e^- \quad e^-$
e^-

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

change ? $\psi = \psi_0 e^{i\theta(x,y,z,t)}$

$\psi(x, y, z, t)$

Double slit

$|\psi|^2 = \psi^* \psi$ = probability density

$-a \quad +a$

$\int_{-a}^{+a} |\psi|^2 dx =$

Phase / Group velocity

$$E^2 = p^2c^2 + m^2c^4$$

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