BSC physics ① 26.09.2020

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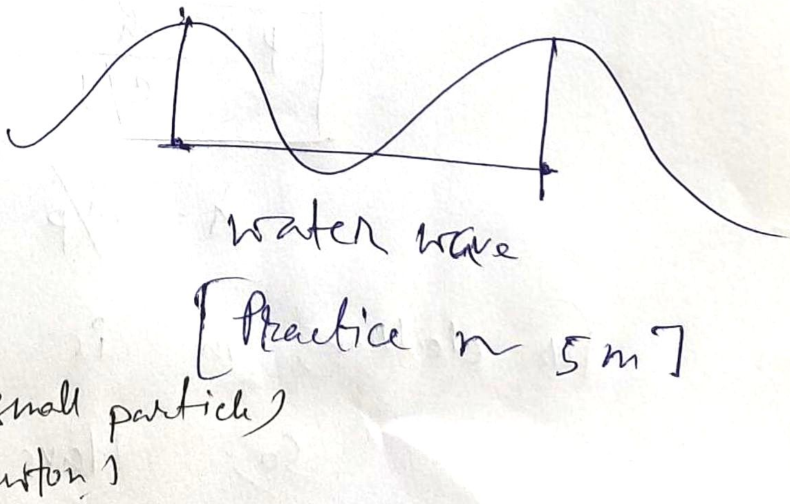
Topics [Quantum mechanics]

1. Before introducing Quantum mechanics ⟶ take a look on what is particle and what is wave ⟶

Particle	Wave
1) localized	1) Not localized
2) Definite momentum (p) and Energy (E)	2) ~~Defi~~ Wavelength (λ) frequency
3) Some extent	3) Infinite extent — theoretically

marble



water wave

[Practice in 5 m]

Photoelectric effect and compton scattering

→ evidence of corpuscular (small particle) nature of light [Newton]

On the other way interference, diffraction and polarisati.

→ evidence of wave nature of light [Huygens]

Wave – particle duality :– 1923

De–Broglie proposed that a moving particle of momentum P ~~or~~ associated with wavelength λ follow the relation

Linkage between particle and wave

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

$h = 6.625 \times 10^{-34}$ Joule sec
= planck's constant

The momentum of ~~particle~~ photon is

$$P = h\nu/c$$

We know

$$h\nu = mc^2$$

$$\Rightarrow h\nu/c = mc$$

$$\Rightarrow \boxed{P = h\nu/c}$$

$$\boxed{P = \frac{h}{c/\nu} = h/\lambda}$$ For Radiation

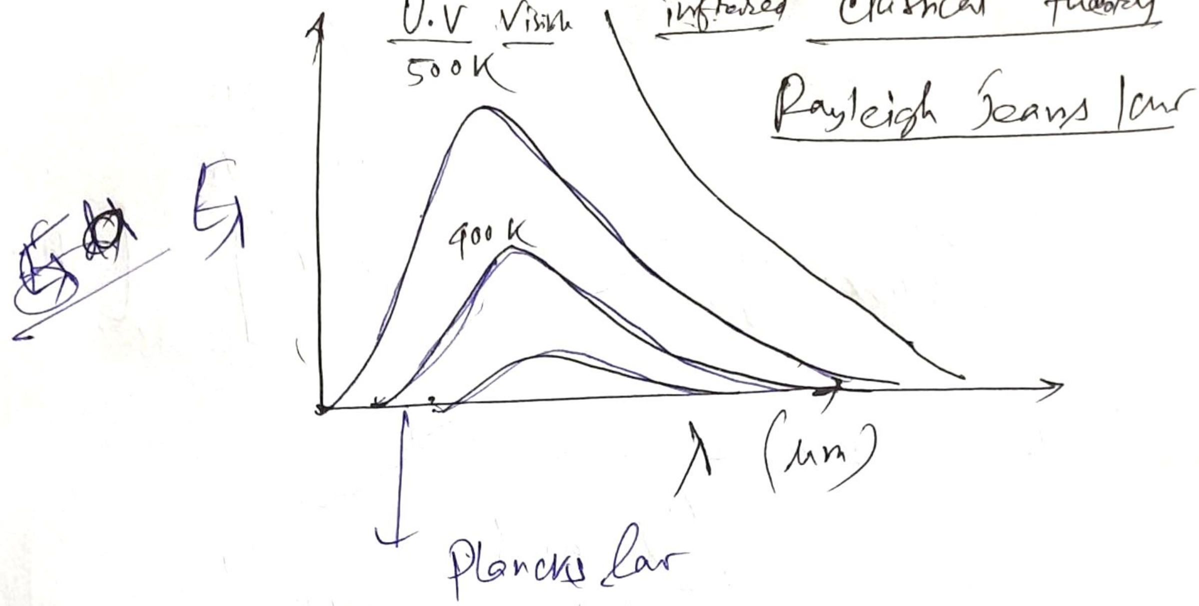
$$\lambda = h/p = \frac{h}{mv}$$

For electron, m is very less ~ 9.31×10^{-31} kg

So, Wave property dominate

Black body radiation

Ultraviolet catastrophe



Plancks describe it

1. Electromagnetic radiation can be emitted or absorbed only in discrete packets called quanta or photon →

$$E = h\nu = hc/\lambda$$

Maxplanck quantum theory of radiation :-

1. An accelerati electron does not emit ~~light~~ /radiate energy continuously as predicted in em theory, but the energy is emitted in tiny packet

2. the oscillator emit energy when it passes from higher state to lower state and absorb energy or vice versa

Linear momentum interms of wave vector

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

$$= \frac{h}{2\pi} \frac{2\pi}{\lambda}$$

$\hbar = \frac{h}{2\pi}$

$= 1.05 \times 10^{-34}$ J sec.

$$\boxed{p = \hbar K}$$

$[K = 2\pi/\lambda]$

Energy $E = \frac{hc}{\lambda} = h\nu$

$$= \frac{h}{2\pi} 2\pi\nu = \frac{h}{2\pi}\omega$$

$$\boxed{E = \hbar\omega}$$

(A) (a) Calculate the energy of the photon which have the wavelength 4000 A° in eV ?

(b) Calculate the energy of the scatter electron, the photon of wavelength $\lambda_1 = 1.4$ A°, collide with electron and its wavelength after collison is $\lambda_2 = 2.0$ A°

[Hint $\Delta E = hc/\lambda_1 - hc/\lambda_2$]

(b) limitations of old quantum theory

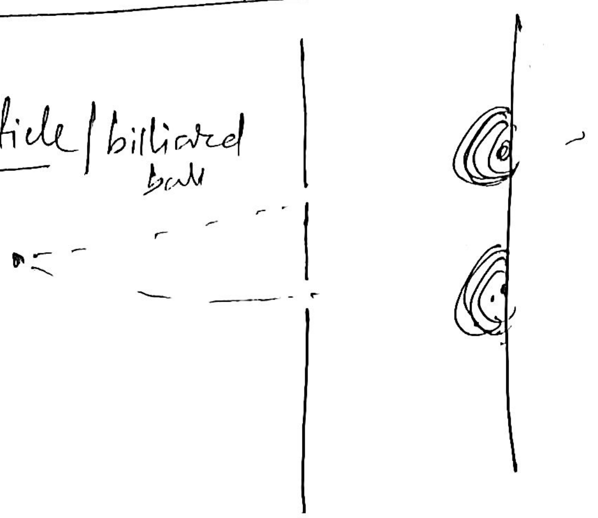
[Why we need ~~to~~ develope Quantum mechanics]

Though it explain phenomena like black body, photo-electric effect, comton effect but it has a number of drawbacks →

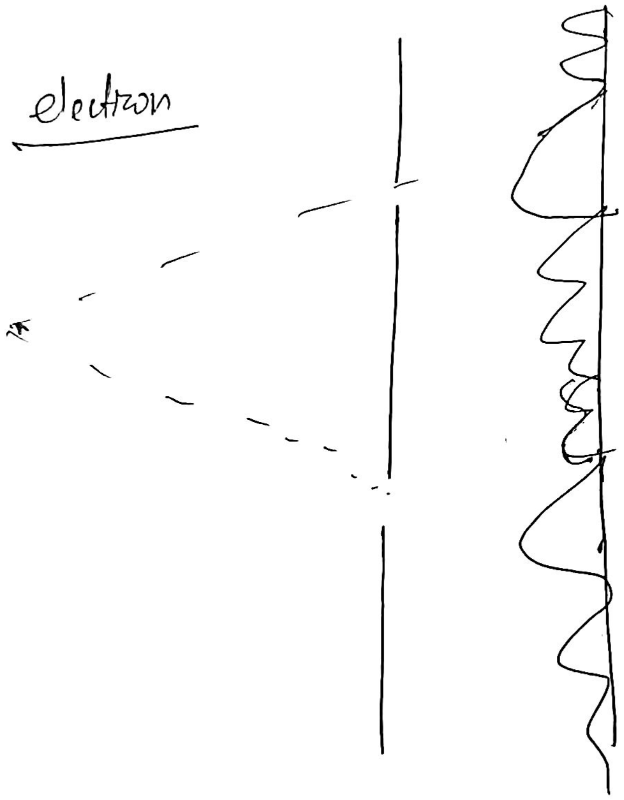
1. Bohr quantisation rules are arbitary → No physical explanation
2. Non radiating states — empirical (without any theoritic background)
3. Could not explain the spectra of Helium and more complex atoms.
4. It also not explain — fine structure of spectral lines [Why certain spectra consist of more than one line]

Double slit experiment

particle / billiard ball



electron

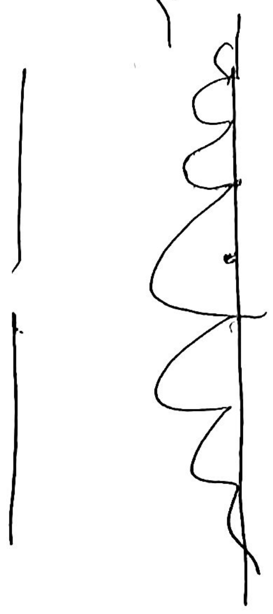


wave nature

Interference

Single slit

one electron



Also shows interference if we not looking it.

1) What is the uncertainity principle

Hisenberg

~~The~~ We cannot determine the position and momentum of a particle simuntenously and accurately.

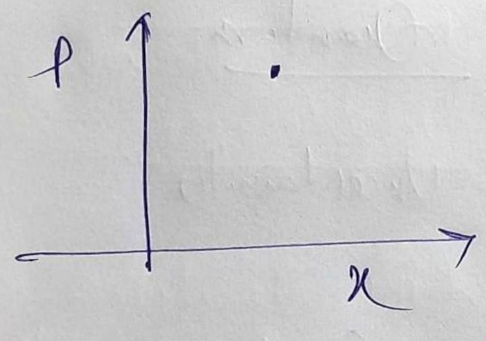
$$\boxed{\Delta x \cdot \Delta p \geq \hbar/2}$$

Simultonously → At the same instant of time

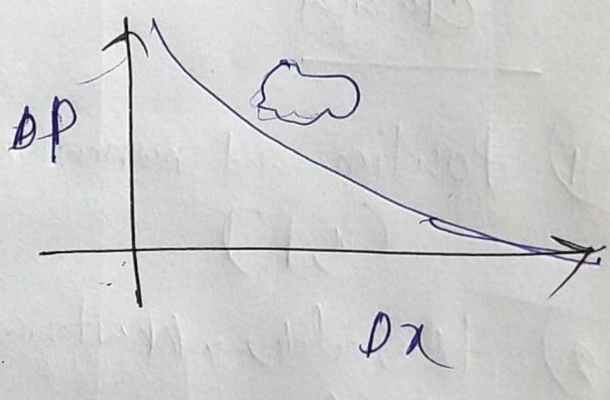
accuratly → Not specified in ~~pt~~ some

Position and momentum of a point particle cannot be measured simultanously and accuretely

classical



Quantum



2) Is this an experimental error →

No, not at all →

So basically Quantum mechanicals tells us the probablity of findings the particle

~~What~~ When system behave classical or quantum?

1) If the system size (d) is

$d \simeq \lambda$ then it obeys

quantum mechanics $\underline{d \sim A^0}$

<u>If</u> $\underline{d >>> \lambda}$

<u>Classical mechanics</u>

<u>Or</u> by temperature $\xrightarrow{\text{lowering}}$ Quantum mechanics

<u>Classical</u>	> <u>Quantum</u>
1) Position and momentum (x, p)	1) Uncertainty
2) trajectory → Newtonian mechanics Newtons law	2) <u>Scrodinger eqn</u> $\underline{\psi, E_n}$

$$\boxed{\Delta x \, \Delta p \geq \hbar/2}$$

$\Delta x \Rightarrow$ Uncertainity in determing the particle

$\Delta p \Rightarrow$ Uncertainity in determine the momentum.

Its true for any ~~conjg~~ Conjugate momentum like,

$$\Delta E \, \Delta t \geq \hbar/2$$

$$\Delta J \, \Delta \theta \geq \hbar/2$$

$\Delta J \rightarrow$ Angular momentum

1) Now if we specify the position of the particles at some point $\rightarrow$

so, x finite, $\Delta x = 0$

$$\Delta p \geq \hbar/0 \simeq \infty$$

<u>Momentum uncertain</u>

(*) Electron having mass m and velocity v

$E_K = \frac{1}{2} m v^2$

$$\Delta E_K = m v \Delta v = v\, m \Delta v$$
$$= v \Delta P$$
$$= \frac{\Delta x}{\Delta t} \Delta P$$

$$\Delta E \Delta t \geq \hbar/2$$

$$\Rightarrow \frac{\Delta x}{\Delta t} \Delta P \Delta t \geq \hbar/2$$

$$\Rightarrow \boxed{\Delta x \Delta P \geq \hbar/2}$$

(2) Consider a particle moving in a radius R with velocity v

$$\Delta S \Delta P_S \geq \hbar/2$$

as, $\theta = S/R$

$$\boxed{\Delta S = R \Delta \theta}$$

$$\cancel{R} \Delta \theta \frac{\Delta L}{\cancel{R}} \geq \hbar/2$$

$$\Rightarrow \boxed{\Delta L \Delta \theta \geq \hbar/2}$$

$$L = m v R$$
$$= P_S R$$

$$\boxed{\Delta P_S = \frac{\Delta L}{R}}$$