WAVE PARTICLE DUALITY

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Wave Theory-Light is a wave which spreading out the energy continuously.(Wave nature of light)

The phenomenon such as Interference and Diffraction were successfully described using wave nature of light.

Quantum Theory-light consists of individual photons ,each of definite amount of energy and small enough to be absorbed by a single electron.(particle nature of light)

Photoelectric effect can be explained only on the basis of particle nature of light.

Thus Light possesses *dual character both wave and particle nature.*

The wave theory and quantum theory complement each other.Either theory can explain certain phenomenon of light

DE-BROGLIE HYPOTHESIS

Electromagnetic radiations have dual nature.

In 1924,Louis De Broglie made a bold suggestion that like radiations ,matter should possess dual nature.the suggestion is due to following obsevations:

1.The whole energy in the universe is in the form of electromagnetic radiation and matter

2.Nature loves symmetry.As the radiations possess dual nature ,matter should also possess the same.

According to De Broglie,a wave is associated with every moving particle and these waves are called De broglie waves or matter waves .

The wavelength of the wave associated with a particle having mass m and moving with a velocity v is given by

$$\lambda = h/mv = h/p$$

The above equation gives the relation connecting the linear momentum which is the characteristics of particle with its wavelength which is the characteristics of wave.

De broglie wavelength is independent of the electric charge or the nature of the particle,hence it is not electromagnetic in nature.

Another method to find out the expression of Debroglie wavelength:

Energy of Photon $E=h\upsilon =hc/\lambda$

Photon is a particle of zero rest mass hence its energy is given by $E=mc^2$

$$hc/\lambda=mc^2$$

or $$\lambda= h/mc =h/p$$

where p=mc ,linear momentum of photon

If the velocity of the particle is comparable to the velocity of light,then its mass

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} = \gamma m_0$$

Then De broglie wavelength is $\lambda = \frac{h}{mv} = \frac{h}{\gamma m_0 v}$

The existence of matter waves was experimentally demonstrated in 1927.This duality principle provided the starting point for Schrodinger ‘s successful development of quantum mechanics.

Debroglie wavelength of electron

When an electron is accelerated under a p.d V,the kinetic energy acquired by the electron is

K.E=eV

If p is the linear momentum of the electron of mass m then K.E is

K.E=$P^2/2m$

From the above two equations $P^2/2m=eV$ OR $p = \sqrt{2meV}$

The De broglie wavelength associated with moving electron under a p.d is therefore

$$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2meV}}$$

$Taking\ m = 9.1\times10^{-31}\,kg, e = 1.6\times10^{-19}\ and\ h = 6.62\times10^{-34}\,Js$

$We\ get$

$$\lambda = \frac{12.27}{\sqrt{V}}\times10^{-10}\,m\ or\ \frac{12.27}{\sqrt{V}}\,^{0}A$$