D' Broglie
Particle and wave nature of electron. de-l

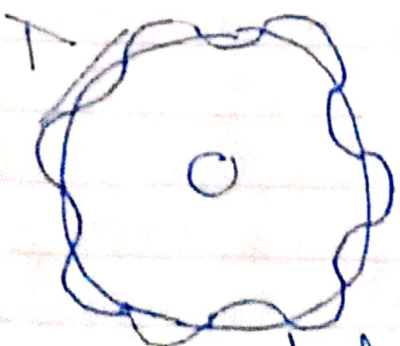
de-Broglie equation.

Inadequacy of the Bohr theory was revealed by finer details of multi-electron system and the theory was in contradiction of the Heisenberg uncertain principle. Soon de-Broglie and Heisenberg made dashing contribution in this area and Bohr's theory based on particle nature of the electron was replaced by a wave model.

Thomson studies have reviled the particle number of the electron namely it has mass energy, and momentum. de-Broglie point out that just as light has both particle and wave nature. so also is the case with electrons. He suggested that electrons travel in wave analogus to light wave.

de-Broglie equation.

de-Broglie derived an expression for calculating the wave length λ of the wave associated with an electron. Let an electron of mass m move with a velocity c around the nucleus and associated with a wave length λ as shown in the a figure.



An electron wave extending round the nucleus

With the help of the equation we,

$E = h\vartheta$

Plank equation.

$E = mc^2$

Einsteins mass energy relationship.

E = Energy of the electron.

h = Plank constant.

ϑ = frequency.

It can be shown that,

$mc^2 = h\vartheta$

No since,

wavelength × frequency = velocity.

$\frac{c}{\lambda} = \vartheta$.

Putting this value in equation.

$mc^2 = h\vartheta$

$= \frac{hc}{\lambda}$.

we get,

$mc = \frac{h}{\lambda}$.

$\therefore \lambda = \frac{h}{mc} = \frac{h}{p}$ ....(1).

where. p = momentum.

The above equation is called de-Broglie equation and the wave length λ is called de-Broglie wave length.

From this equation it is evident that the momentum p of the moving electron is inversely proportional to its wave length λ.

$\lambda \propto \frac{1}{p}$.

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Similarity between de Broglie's character of the electron and Bohr theory

Bohr's quantum condition which have been assumed by Bohr arbitrarily in this theory can be derived from de Broglie's equation in a more natural way by considering the wave like properties of the electron in an atom:-

According to de Broglie the electron is not a solid particle revolving round the nucleus in a circular orbit but it an standing wave extending round the nucleus in a circular orbit.

If r is the radius of the circular orbit now if λ = wave length and n = total number wave length associated with the electron wave extending round the nucleus the circumference = $n\lambda$.

Thus, $2\pi r = n\lambda$.

or, $2\pi r = \frac{nh}{mv}$. $\quad \therefore \lambda = \frac{h}{mv}$

or, $mvr = \frac{nh}{2\pi}$.

or, Angular momentum, $mvr = \frac{nh}{2\pi}$.

~~This equation which is based~~

This equation which is based on the wave nature of the electrons which shows that the electron can move only in those orbits for which the angular momentum mvr is an integral multiple of $\frac{h}{2\pi}$. In other words the angular momentum is quantised.

Thus we see that the wave mechanical nature of the atom presented by de Broglie lead naturally