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Topic :- Elementary Quantum mechanics

The schrodinger's wave equation:-

Erwin schrodinger gave a wave equation to describe the behaviour of electron waves in atoms and molecules. In schrodinger's wave model of an atom the discrete energy levels or orbits proposed by Bohr are replaced by mathematical function ψ which are related to the Probability of finding electron at various places around the nucleus.

Let us consider a simple wave motion as that of the vibration of a stretched string. Let y be the amplitude of this vibration at any point whose coordinate is x at time t.

The equation for such a wave motion may be expressed as

$$\frac{\partial^2 \psi}{\partial x^2} = \frac{1}{v^2} \times \frac{\partial^2 y}{\partial t^2} \quad \text{——— (1)}$$

Where v is the velocity with which the wave is propagating. There are two variables x and t in the above differential equation i.e the amplitude y depends upon two variables x and t.

In order to solve the above differential equation, it is necessary to separate the two variables. Thus y may be expressed as

$$y = f(x)\, g(t) \quad \text{———} \quad (2)$$

where $f(x)$ is a function of the co-ordinate x only and $g(t)$ is a function of the co-ordinate x only and $g(t)$ is a function of time t only.

For stationary waves such as occur in a stretched string, the function $g(t)$ be represented by the expression

$$g(t) = A \cdot \sin(2\pi \nu t) \text{—} (3)$$

where ν is vibrational frequency and A is a constant known as the maximum amplitude.

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Hence, for stationary waves the equation for w may be written as

$$y = f(x) \cdot A \cdot \sin(2\pi \nu t) \quad \text{—— (4)}$$

Hence $\dfrac{\partial^2 y}{\partial x^2 . dt2} = -f(x)\, 4\pi^2 \nu^2 A \sin(2\pi \nu t)$ —(5)

$$= -4\pi^2 \nu^2 f(x)\, g(t) \quad \text{— (6)}$$

similarly it follows from equation(4) that $\dfrac{\partial^2 y}{\partial x^2} = \dfrac{\partial^2 f(x)}{\partial x^2} \cdot g(t)$ —— (7)

Combining equation (1), (6) and (7) we have

$$\frac{\partial^2 f(x)}{\partial x^2} = -\frac{4\pi^2 \nu^2 f(x)}{V^2} \quad \text{— (8)}$$

As is well known the frequency of vibration ν is related to the velocity by the expression.

$V = \nu . \lambda$ where λ is the corresponding wave length.

$$\frac{\partial^2 f(x)}{\partial x^2} = -\frac{4\pi^2}{\lambda^2} f(x) \quad \text{—(9)}$$

Equation (9) is for the wave motion in one dimension only.