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DE-BROGLIE HYPOTHESIS FOR MATTER WAVES

According to quantum theory, radiation of frequency ν consist of quanta or photons each of energy $E = h\nu$ where h is Plank's constant the value of which is $= 6.62 \times 10^{-34}$ joule sec.

The equivalent mass of the photon $m = \frac{E}{c^2} = \frac{h\nu}{c^2}$

Since the speed of the photon in free space is c, the equivalent momentum of the photon.

$p = mc = \frac{E}{c^2} c = \frac{h\nu}{c} = \frac{h}{\lambda}$ where λ is the wavelength of the radiation of frequency ν.

By analogy with this, de-Broglie suggested that a moving particle is associated with a wave. The frequency of the wave is taken to be

$\nu = \frac{E}{h} = \frac{mc^2}{h}$ where "m" is the mass of the particle. The wavelength of the wave

$\lambda = \frac{h}{p} = \frac{h}{mv}$ where v is the velocity of the particle.

Thus a particle of mass 'm' moving with a velocity v has an associated wavelength.

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

This is known as de-broglie wave equation and λ is called de-Broglie wavelength. The associated wave is termed matter, guide, pilot or de-Broglie wave.

de-Broglie wave velocity or phase velocity of the wave is given by

$$v_p = v\lambda = \frac{mc^2}{h} \cdot \frac{h}{mv} = \frac{c^2}{v}$$

Since, the particle velocity v, must be less than the velocity of light c, de-Broglie waves travel faster than velocity of light.

Like other waves, de-Broglie wave can also be ~~~~ represented by a function $\Psi(\vec{r}, t)$ ie a function of position $\vec{r}$ and time t. It is known as wave function representing matter wave guiding the particle. The wave function can be positive, negative or a complex quantity. It has an amplitude or modulus and a phase like other complex functions. The wave vector $\vec{k}$ for de-Broglie wave is given by

$$|\vec{k}| = k = \frac{2\pi}{\lambda} = \frac{2\pi}{h/p} = \frac{p}{h/2\pi} = \frac{p}{\hbar}$$

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