WAVE PROPERTIES OF PARTICLES

1. De Broglie waves.
2. Waves of what?
3. Describing a wave.
4. Phase and group velocities.
5. Particle diffraction.
6. Particle in a box.
7. Uncertainty principle I.
8. Uncertainty principle II.
9. Applying the uncertainty principle.

INTRODUCTION

In 1924, de Broglie proposed that **moving objects** have **wave** as well as particle characteristics.

DE BROGLIE WAVES

A photon of light of frequency ν has the momentum:

$$p = \frac{h\nu}{c} = \frac{h}{\lambda}$$

Therefore, the wavelength of a photon is specified by its momentum by:

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

De Broglie suggested that this a general equation that applies to material particles as well as photons.

The momentum of a particle of mass m and velocity υ is:

$$p = \gamma m \upsilon$$

Its de Broglie wavelength is:

$$\lambda = \frac{h}{\gamma m \upsilon}$$

DE BROGLIE WAVES

The wave and particle duality of a moving body can never be observed at the same time. ← just like in EM waves.

In certain situations a moving body resembles a wave and in others it resembles a particle.

Which set of properties is most conspicuous?

This depends on how its de Broglie wavelength dimension compares with the dimension whatever it interact with.

These waves were called **matter waves**. ← **is there an experiment that verifies this?**

DE BROGLIE WAVES

Example 3.1:

Find the de Broglie wavelengths of:

(a) A 46-g golf ball with a velocity of 30m/s.

$$\lambda = \frac{h}{\gamma m \upsilon} = \frac{6.6\times10^{-34}\ J.s}{(1)(0.046\ kg)(30\ m/s)} = 4.8\times10^{-34}\ m$$

(b) An electron with a velocity of 10^7 m/s.

$$\lambda = \frac{h}{\gamma m \upsilon} = \frac{6.6\times10^{-34}\ J.s}{(1)(9.1\times10^{-31}\ kg)(10^{7}\ m/s)} = 7.3\times10^{-11}\ m$$

DE BROGLIE WAVES

Remember…

A moving body behaves in certain ways as though it has a wave nature.

WAVES OF WHAT?

Water waves ← height of the water surface varies periodically.

Sound waves ← pressure varies periodically.

Light waves ← electric and magnetic fields vary periodically.

What varies in the case of matter waves?

The quantity whose variation make up matter wave is called **wave function Ψ.**

The value of the wave function associated with a moving body at a particular point x, y, z in space and the time t is related to the ***likelihood of finding the body there at the time***.

WAVES OF WHAT?

Ψ has no direct physical significant ← because it cannot be interpreted in terms of an experiment (not observable)

$|\Psi|^2$ is know as the **probability density**:

The probability of finding the body described by the wave function Ψ at the point x, y, z at the time t is proportional to the value of there at $|\Psi|^2$ t.

$|\Psi|^2$ has values between 0 and 1.

WAVES OF WHAT?

Remember...

Matter waves are waves of probability.