Wave Behaviour of Particles

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Particles exhibit wave behaviour with a wavelength determined by the 'de Broglie relation'.

$\lambda = \dfrac{h}{p}$ h is Planck's constant and p is the momentum of the particles

Experimental Evidence for Wave Behaviour of Particles

From the topic on the interference of light it was seen that the interference pattern are best observed when the diffraction effect is most pronounced, that is when the size of the slit openings is close to the wavelength.
The spacing of the atoms in crystals is similar to the wavelength of low-energy electrons, so interference effects are observed when electrons are given a small amount of momentum and passed through a crystal.
Two physicists, Davisson and Germer, designed and built a vacuum apparatus for the purpose of measuring the energy of electrons scattered from a metal surface. Electrons from a heated filament were accelerated by a voltage, and allowed to strike the surface of nickel metal.
The beam of electrons was directed at the nickel target, which could be rotated to observe the effect different striking angles would have on the electrons.

Their electron detector was mounted on an arc so that it could be rotated to observe electrons coming from the metal at different angles. It was a great surprise to them to find that at certain angles there was a peak in the intensity of the scattered electron beam. The peaks corresponded to those that interference would produce if waves were being diffracted by the surface layers of the nickel crystal lattice.

The nickel structure in the Davisson–Germer experiment above is effectively a diffraction grating, so the equation $d \sin \theta = m\lambda$ applies for constructive interference (which corresponds in the experiment to angular positions with lots of electrons being detected). This equation can be used for example to find the wavelength of the electrons, given the measured angle of any specific maximum, as long as the lattice spacing in the crystal is known.

Given the energy of the electrons, $p = mv$ and $E = \frac{1}{2}mv^2$ can be used to find the momentum of the electrons:

$$E = \tfrac{1}{2}mv^2$$
$$\therefore mE = \tfrac{1}{2}m^2v^2 \quad \{\text{multiplying both sides by } m\}$$
$$\therefore mE = \tfrac{1}{2}(mv)^2$$
$$\therefore mE = \tfrac{1}{2}p^2$$
$$\therefore p = \sqrt{2mE}$$

Knowing the momentum of the electrons, the 'de Broglie wavelength' can be calculated using the de Broglie relation, and compared to the value found using $d \sin \theta = m\lambda$, to verify the de Broglie relation.

Electron Microscopes

The resolution of an optical instrument is the amount of image distinguishable for any given area. The shorter the wavelength used in a standard microscope, the higher resolution and magnification is possible.

Compared to the wavelength of visible light (between about 4×10^{-7} and 7×10^{-7} m) the wavelength of electrons is very short (about 5×10^{-12} m). This means that any two points much closer together on a sample can be distinguished with an electron microscope.

An electron microscope does not pass electrons through lenses made of matter (since this would just scatter them), instead electric or magnetic fields are set up to deflect the electrons (since they are charged and moving particles).