De Broglie Wavelength

The de Broglie wavelength

The momentum of a photon is given by: $p = \frac{h}{\lambda}$

In 1923, Louis de Broglie predicted that objects we generally think of as particles (such as electrons and neutrons) should also exhibit a wave-like nature, with a wavelength of:

De Broglie wavelength: $\lambda = \frac{h}{p} = \frac{h}{mv}$

Examples of particles showing wave properties

The wave properties of matter are only observable for very small objects. de Broglie wavelength of …

- Double-slit interference pattern has been produced by using electrons as the source.

- 10 eV electrons (which is the typical energy of an electron in an electron microscope): $\lambda_{de\ Broglie} = 3.9 \times 10^{-10}$ m. This is comparable to the spacing between atoms. Therefore, a crystal acts as a diffraction grating for electrons. The diffraction pattern in turn allows the crystal structure to be determined.

Examples of particles showing wave properties

- In a microscope, the size of the smallest features we can see is limited by the wavelength used. With visible light, the smallest wavelength is 400 nm = 4×10^{-7} m. Typical electron microscopes use wavelengths 1000 times smaller, and can be used to study very fine details.

- Electrons orbiting in an atom. We will discuss how the concept of de Broglie wavelength is applied in deriving the shell model of hydrogen-like atoms.

Heisenberg uncertainty principle

It is not possible to measure both the position and the momentum of a particle with infinite precision.

The more accurately you measure a particle's position, the less accurately you're able to measure its momentum, and vice versa.

$$\Delta x\, \Delta p \geq \frac{h}{4\pi}$$

Heisenberg uncertainty principle

We can use the uncertainty principle to explain the diffraction of electrons by a single slit.

The narrower the slit, the more accurately we know the position of an electron as it passes through the slit. This decreases the accuracy we can know the electron's momentum, however, which is consistent with an increased spread of the electron beam as the slit width decreases.

$$\Delta x\, \Delta p \geq \frac{h}{4\pi}$$