WAVE-PARTICLE DUALITY

Concept:
- neither the wave nor the particle model are sufficient to describe light / particle behaviour.

1924 - de Broglie

↳ starting from Einstein's proposition that light had linear momentum $\left(p = \frac{E}{c}\right)$

Proved by observing the Compton Effect

↳ combined with $E = \frac{hc}{\lambda}$ results in the equation:

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

momentum (of photon) → p; wavelength (of photon) → λ

↳ de Broglie hypothesised that if light can have momentum, why can't particles have wave like properties?

(✱) Proposed that all matter can have wave AND particle properties

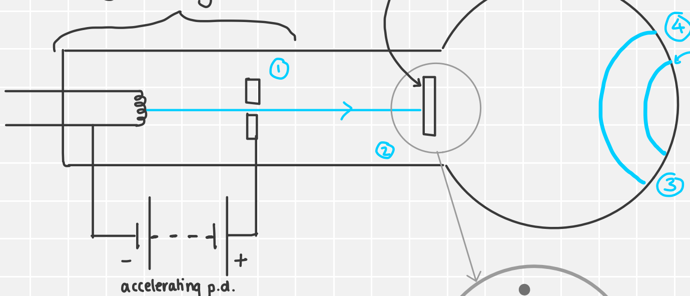
↳ suggested that particles (electrons) have a λ and can exhibit wave behaviour like diffraction (called matter waves)

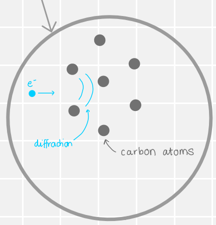
$$\lambda = \frac{h}{mv}$$

wavelength of matter wave → λ (aka. "de Broglie wavelength"); particle speed → v; particle mass → m

Electron Diffraction

↳ 1927, de Broglie's hypothesis proved through electron diffraction (Davisson and Germer)





as the electrons pass between the carbon atoms in the graphite they diffract and overlap, creating an interference pattern.

(1) electron gun used to accelerate electrons:

$$eV = \frac{1}{2}mv^2$$

momentum of electrons:

$$2eV = mv^2$$

$$2meV = m^2v^2 \quad (\times m)$$

$$2meV = p^2$$

$$p = \sqrt{2meV}$$

(2) λ of electrons:

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

$$\lambda = \frac{h}{\sqrt{2meV}}$$

(3) λ is dependent on V in above investigation (m, e, h constant)

as $V\uparrow$, $\lambda\downarrow$

(4) diffraction pattern of concentric circles

↳ as $\lambda\uparrow$, angle of diffraction $\uparrow$

↳ circles more spaced out

As $V\uparrow$, $\lambda\downarrow$ ∴ more tightly spaced concentric circles.

crystallography: smaller λ means more detailed images can be obtained

$\sim d = \lambda$