Wave- Particle Duality

B. Tech-I

Count Loius de Broglie

- Postulated that all objects have a wavelength given by
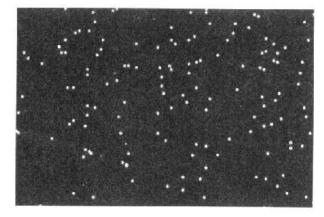
  $\lambda = h/p$

  - λ=wavelength
  - h=Planck's constant
  - p=momentum of object

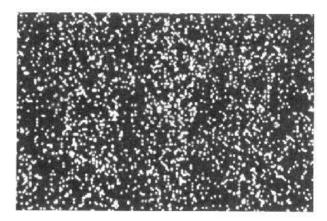- In practice, only really small objects have a sensible wavelength
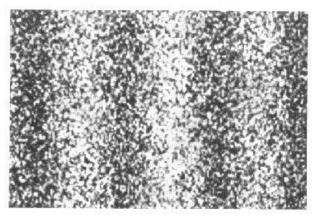
Wave-Particle duality

- A consequence of the deBroglie hypothesis is that all objects can be thought of as "wavicles": both particles and waves

- This has troubled many philosophically-minded scientists over the years.

- Inescapable if we want to build atomic-resolution sensors.

(b) After 100 electrons

(c) After 3000 electrons

(d) After 70 000 electrons

Heisenberg's "Uncertantity Principle"

- Cannot simultaneously measure an object's momentum and position to a better accuracy than ℏ/2

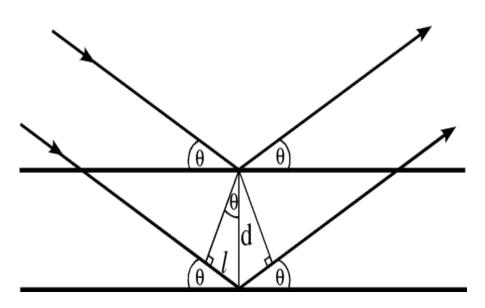 $\Delta p_x \, \Delta x \geq \hbar/2$

- Direct consequence of wave-particle duality

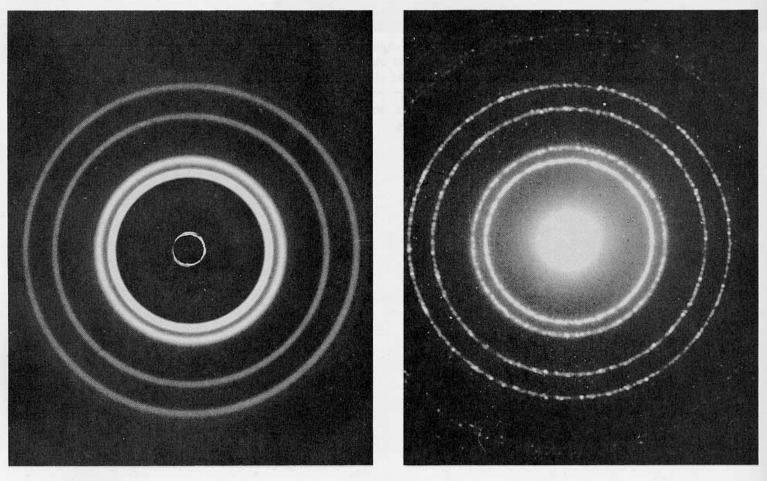- Places limitations on sensor accuracy

Electron Diffraction

- Accelerated electrons have wavelength of order 1 Angstrom=1×10^{-10} m

- Same order as atomic spacing

- Electrons undergo Bragg diffraction at atomic surfaces if the atoms are lined up in planes, (i.e. in a crystal)

Bragg reflection

- Constructive interference when the path length difference is a integer multiple of the wavelengths

- $n\lambda = 2d\ \sin\theta$

- Detailed description requires heavy (mathematical) Quantum Mechanics.

Diffraction Patterns

The diffraction pattern on the left was made by a beam of x rays passing through thin aluminum foil. The diffraction pattern on the right was made by a beam of electrons passing through the same foil.

- Only certain angles of reflection are allowed.
- The diffracted electrons form patterns.
- In polycrystalline material, these are rings

X-rays on left, electrons on right.