Wave- particle duality

Count Loius de Broglie

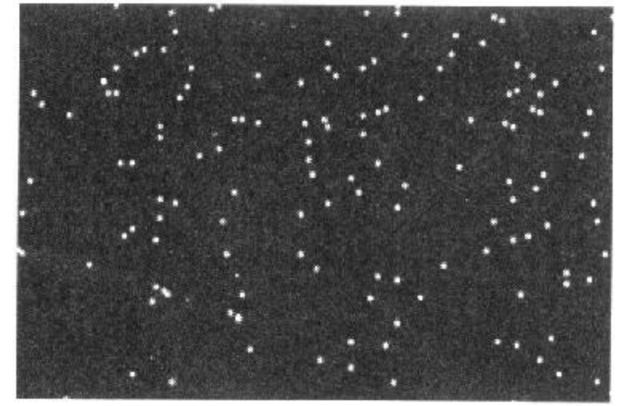
- Postulated that all objects have a wavelength given by

  $\lambda=h/p$

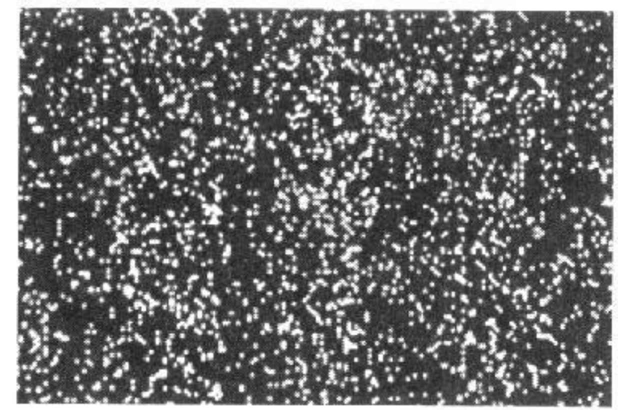
  - λ=wavelength
  - h=Planck's constant
  - p=momentum of object
- In practice, only really small objects have a sensible wavelength

Wave-Particle duality

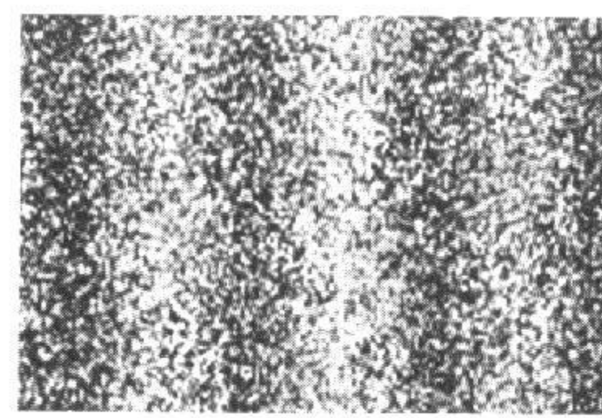
- A consequence of the deBroglie hypothesis is that all objects can be thought of as “wavicles”: both particles and waves
- This has troubled many philosophically-minded scientists over the years.
- Inescapable if we want to build atomic-resolution sensors.



(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

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

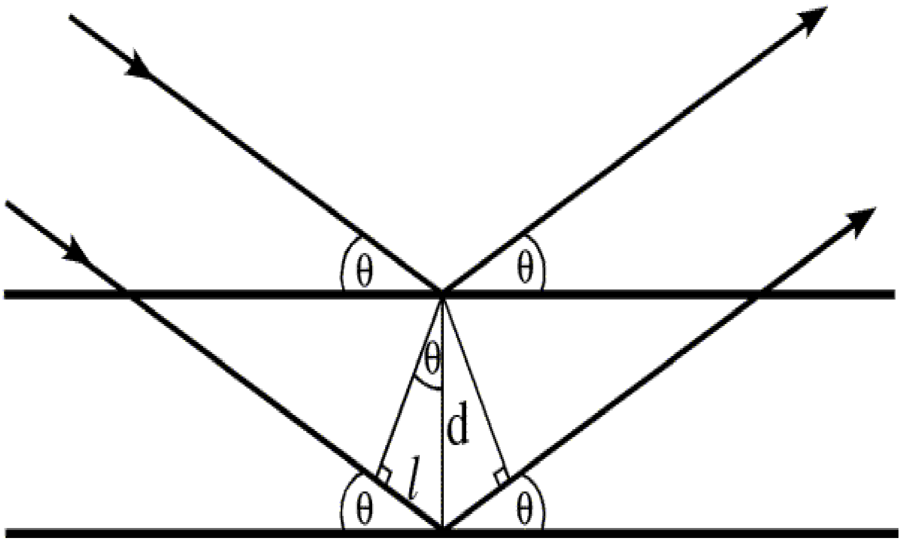
- Direct consequence of wave-particle duality
- Places limitations on sensor accuracy

Electron Diffraction

- Accelerated electrons have wavelength of order 1 Angstrom=$1 x 10^{-10}$ 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)

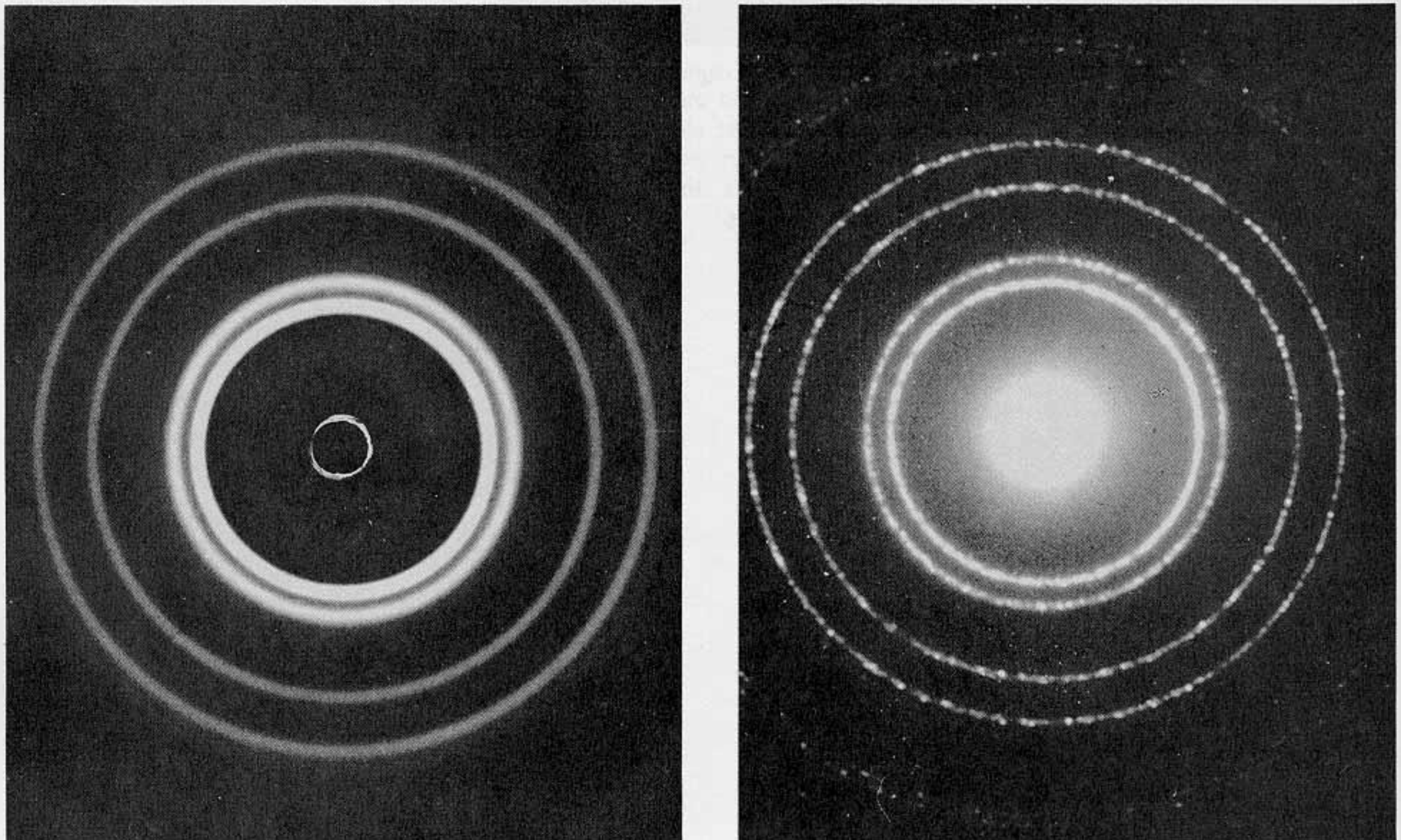
Bragg reflection

- 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.