- Davisson-Germer experiment

Photons:

$$E_{ph} = h\nu$$

$$p = \hbar k = h/\lambda$$

Wave → Particle

What about the opposite?

Particle → Wave ?

$$\lambda = h/p$$

Matter waves:

$$\lambda_B = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mK}}$$

Wavelength for a walking man?

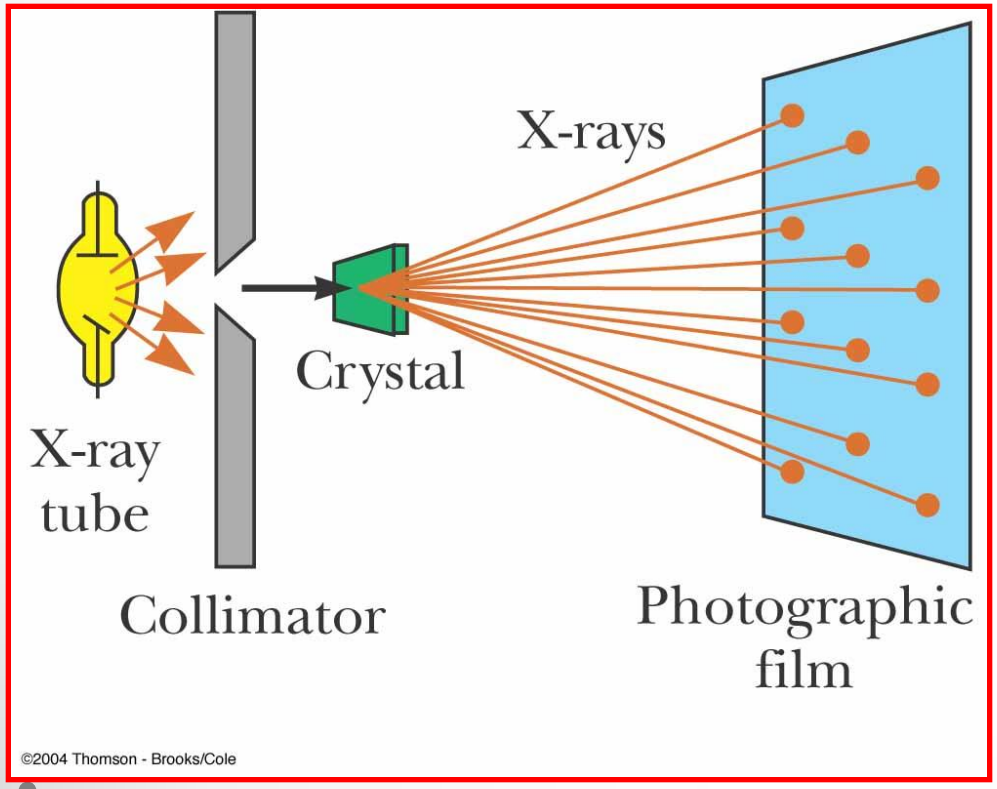
Wavelength for a moving electron?

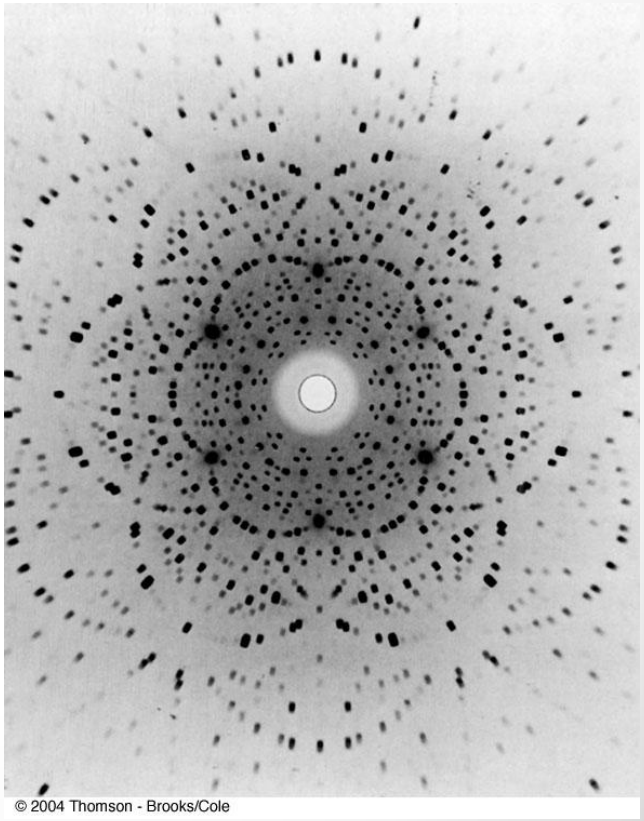
What is the wavelengths difference for 5 eV electron and 5 eV photon?

How to reveal the wave properties of electrons?

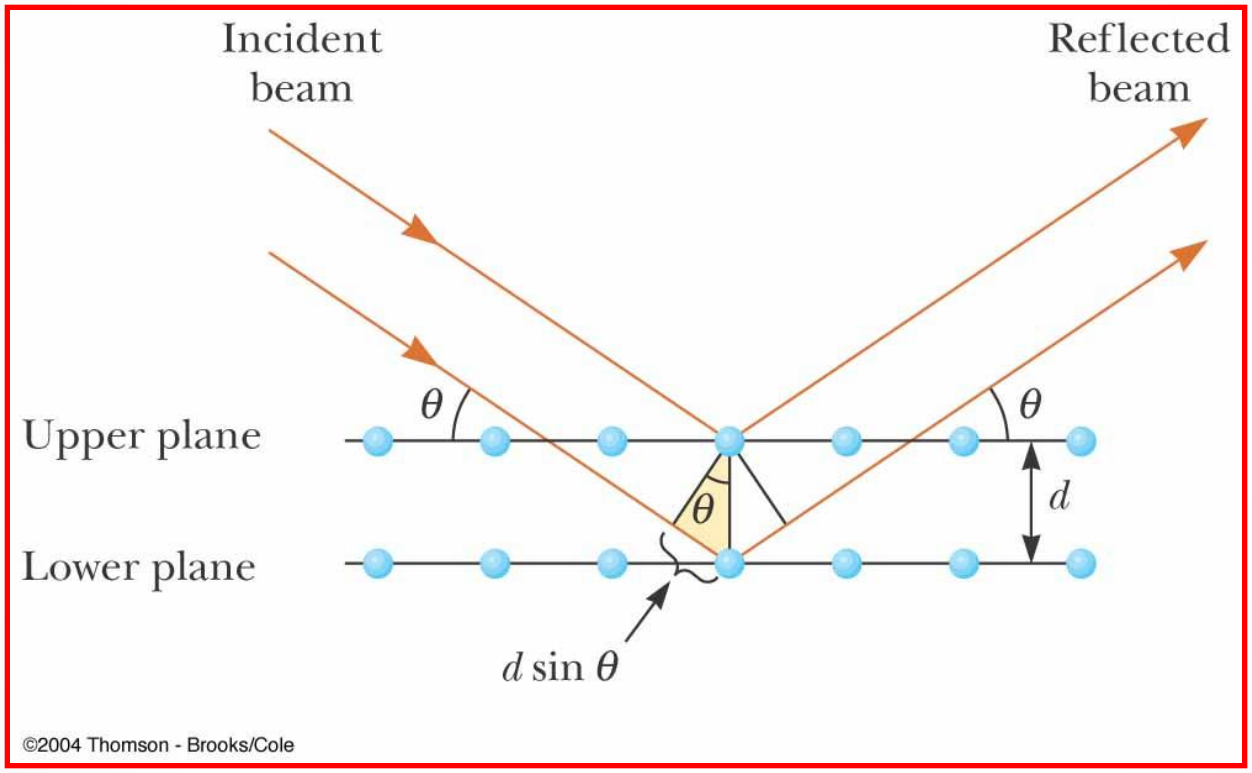
X-rays diffraction:

X-rays are electromagnetic waves with
$\lambda = 10^{-8}$ to 10^{-12} $m = 10 - 0.001$ *nm*





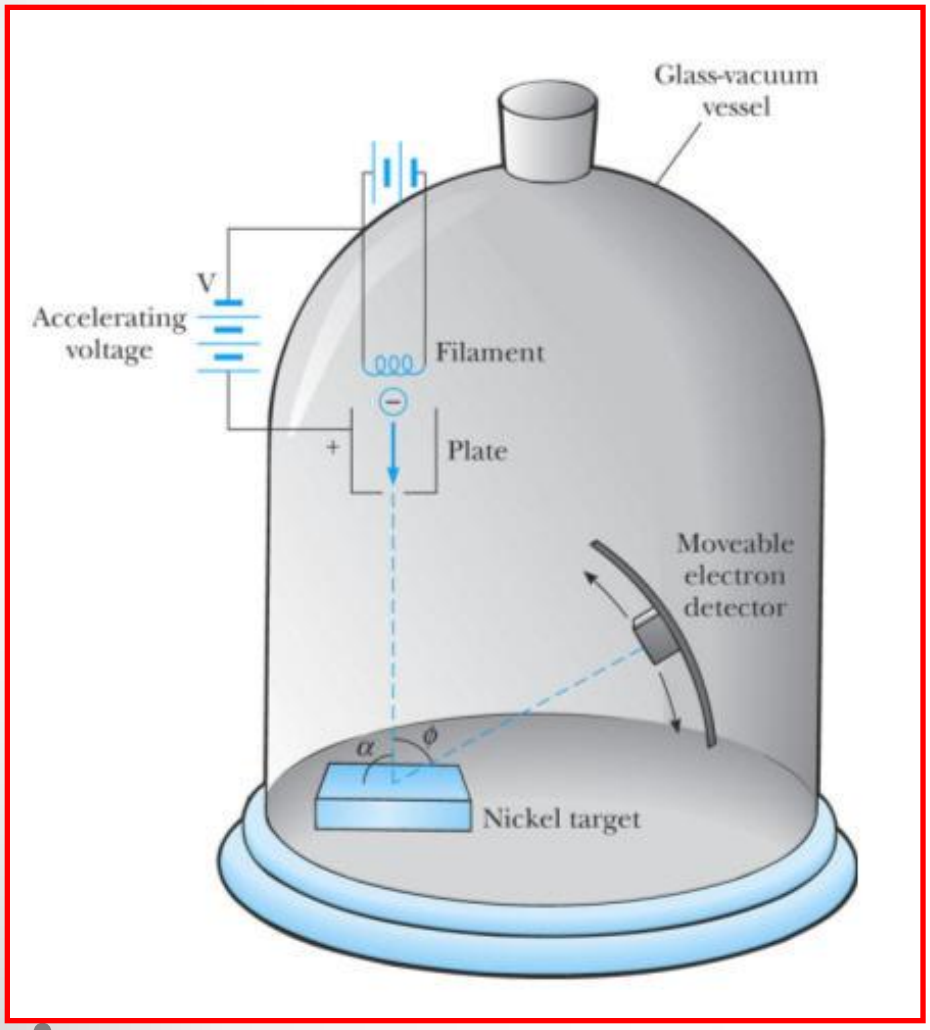
Bragg's law:



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

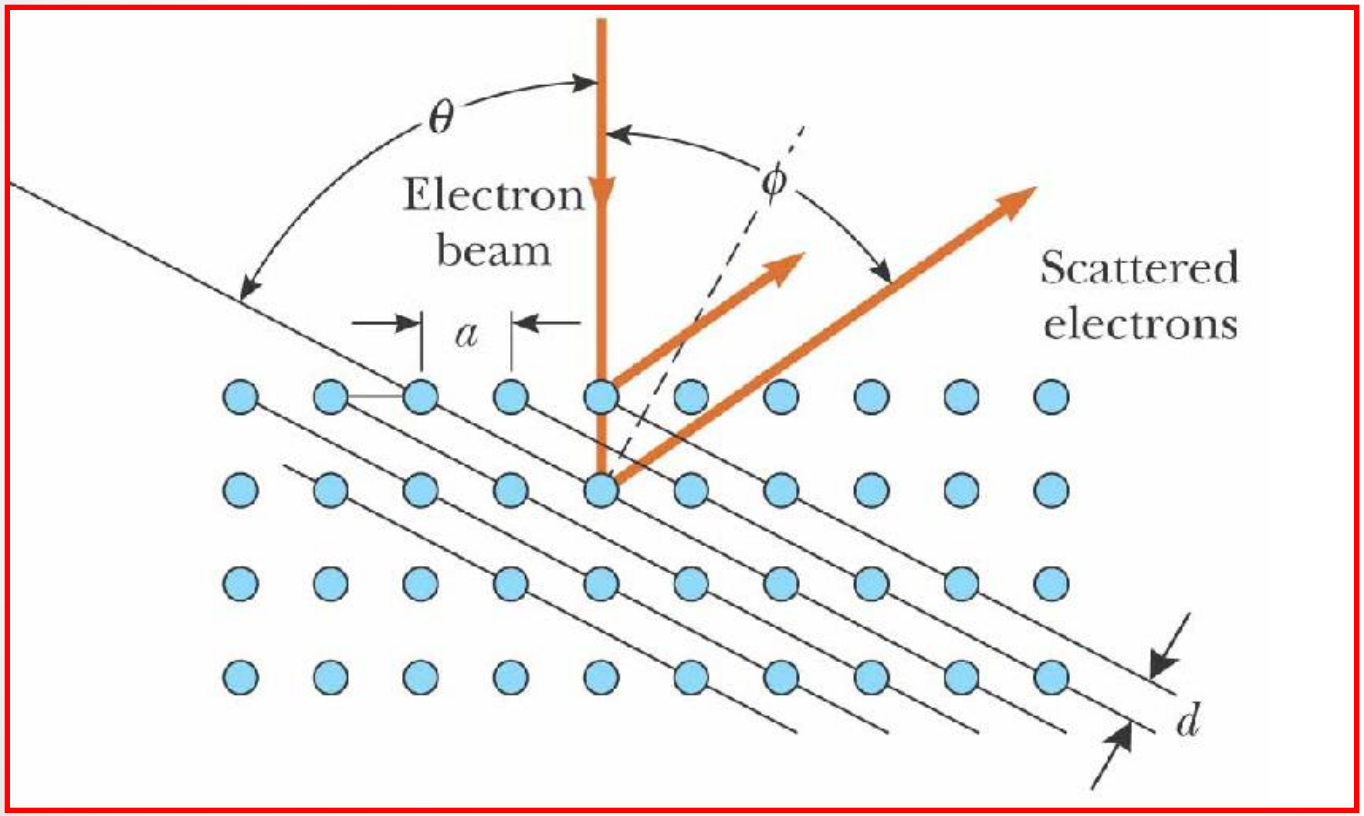
If θ and λ are known, d can be determined

Davisson-Germer experiment:



- **Electrons were directed onto nickel crystals**
- **Accelerating voltage is used to control electron energy: $E = |e|V$**
- **The scattering angle and intensity (electron current) are detected**
  - **φ is the scattering angle**

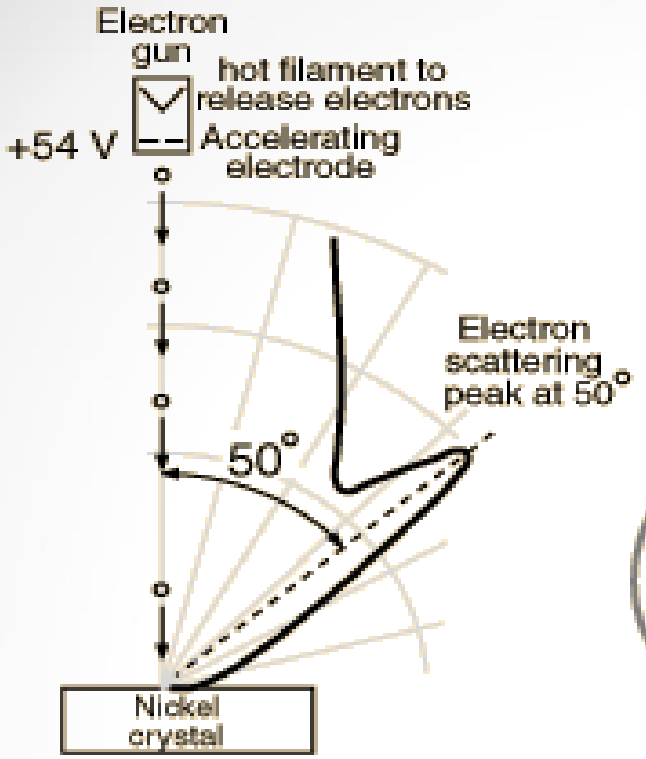
Electron scattering:



From X-ray experiments:
***d* = 0.091 nm**

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

For φ = 50° (θ = 65°):
λ = 0.165 nm



Theory

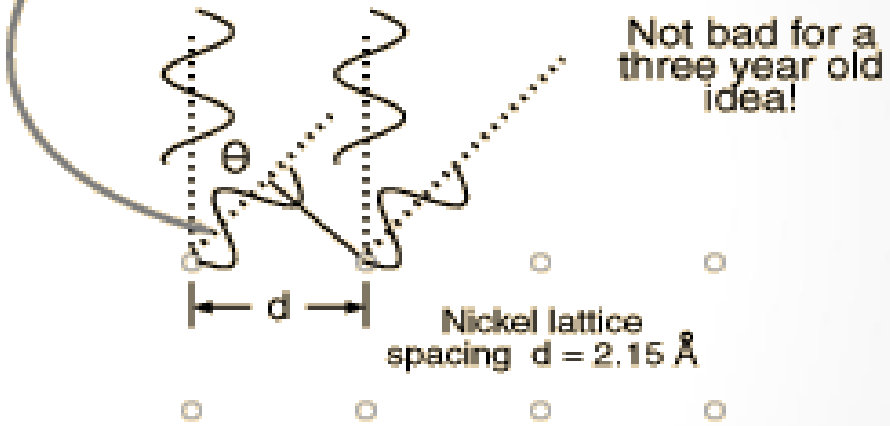
$$\lambda = \frac{h}{mv} = 1.67 \text{ Å for } 54 \text{ V}$$

Experiment

Pathlength difference

$d \sin\theta = 2.15 \sin 50^\circ = \lambda = 1.65$ Å

for constructive interference



Not bad for a three year old idea!

1924 de Broglie's hypothesis

1927 Davisson-Germer experiment

1929 Nobel Prize for de Broglie

- Application of diffraction to measure atomic spacing
- Single crystal Ni target
- Proved deBroglie hypothesis that $\lambda=h/p$

Davisson-Germer experiment

Proof that λ=h/p

Accelerated electrons have energy eV:

$$eV = \tfrac{1}{2} mv^2 \Rightarrow v = (2Ve/m)^{1/2}$$

de Broglie said:

$$\lambda = h/p = h/(mv) = h/(2mVe)^{1/2} = 1.67 \text{ Å}$$

Davisson-Germer found lattice spacing:

$$\lambda = d\sin\theta = 1.65 \text{ Å}$$

Excellent agreement between theory and experiment!

Application: Pressure sensing

- Atomic spacing changes with pressure:

  Pressure=E(ΔL/L)

  Where E=Young's modulus (N/m^2)
- As d (spacing between atomic planes) changes, the angle of diffraction changes
- Diffraction rings move apart or closer together