Davisson-Germer experiment

An experiment to prove the wave nature of electron

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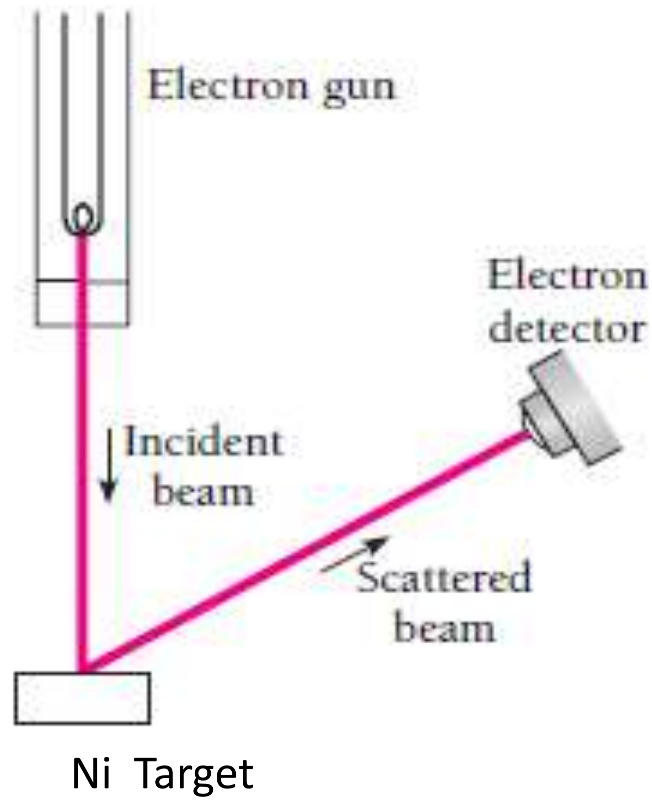
Experimental Setup

Davisson and Germer setup was for studying the scattering of electrons from a Ni crystal using an apparatus as shown in the figure. The angle of incidence of electron beam on the target and the position of detector could be varied. The complete setup was placed in vacuum.



Predictions of classical physics

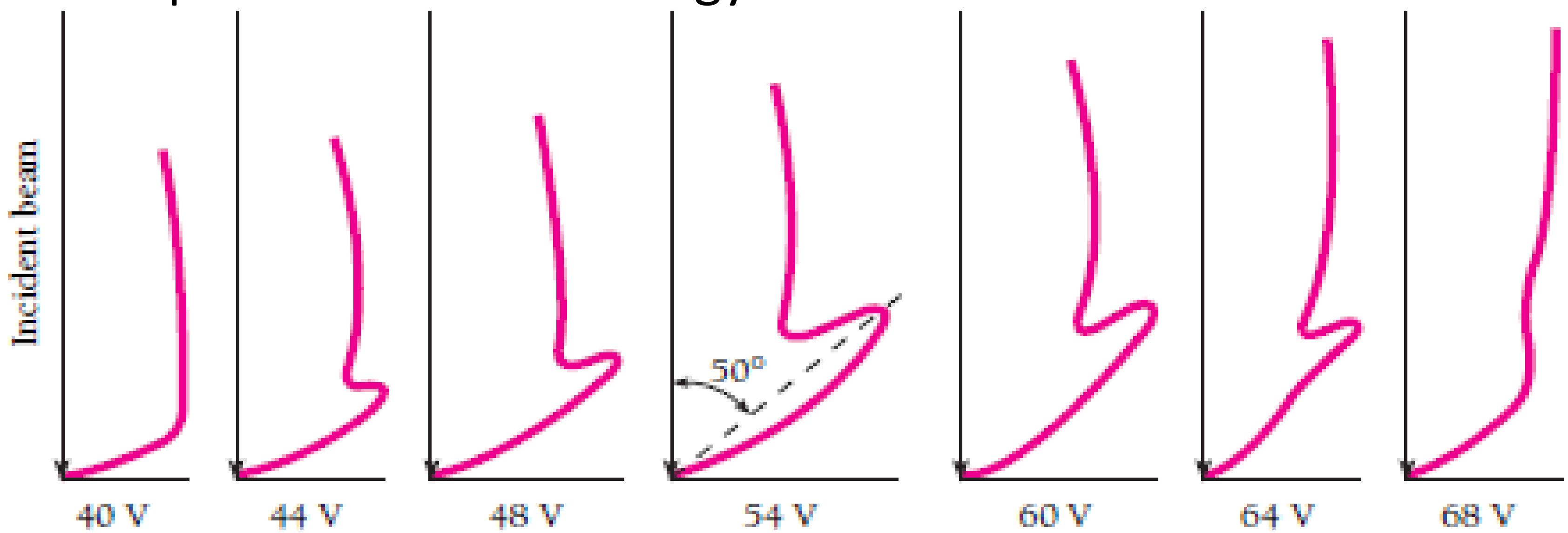
- No dependence of the intensity of scattered electrons on scattering angle
- Negligible dependence on the energy of the primary electrons.

Davisson and Germer verified these predictions using a block of nickel as the target.

Observations

Figure below shows the polar graph of the observations. The method of plotting is such that the distance of the curve at any angle from the point of scattering is proportional to the intensity at that angle. If the intensity were the same at all scattering angles, the curves would be circles centred on the point of scattering

However distinct maxima and minima were observed whose positions depended upon the electron energy.



Polar Graphs of electron intensities with different incident electron energies

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Wave Nature of Electrons

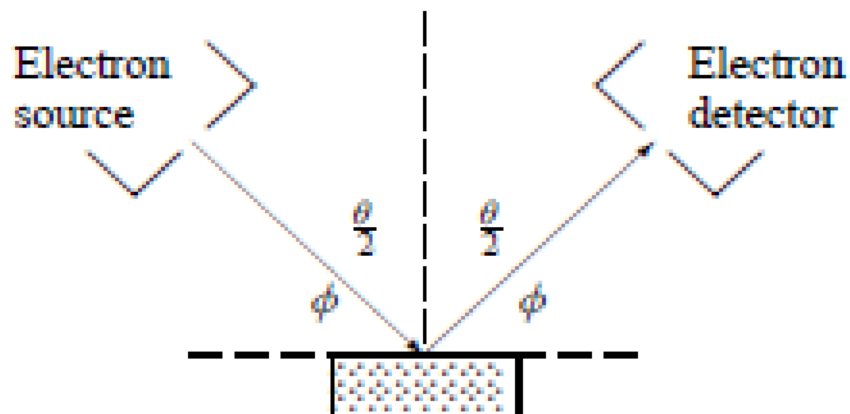
If the electrons were to behave like waves we could expect diffraction maxima and minima as observed in diffraction of X-rays by regularly spaced planes of atoms in a crystal.

In 54 eV electron beam, the polar graph showed a maxima at 50°.
De Broglie wavelength of electron accelerated through 54 eV is given by

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

$$= \frac{6.63\times10^{-34}\,Js}{\sqrt{2\times(9.1\times10^{-31}kg)(1.6\times10^{-19}J)(54V)}}$$

$$\boxed{\lambda = 1.66\times10^{-10}\,m}$$



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The electron beam's wavelength can also be calculated usin Bragg's formula for X-ray diffraction. It was observed that electron beam was diffracted by (111) plane of Ni. The inter planar spacing for (111) plane is 0.91×10^{-10} m which can be measured by X-ray diffraction.

The maxima occurred at 50°. This implies that glancing angle of incidence as well as scattering with respect to the Bragg planes were

(180° −50°)/2= 65° each

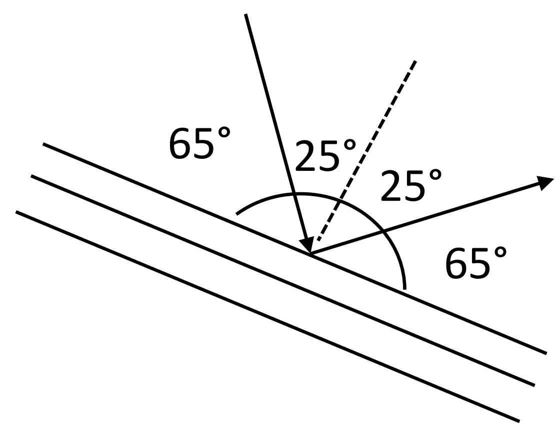
$$2d \sin\theta = n\lambda$$

For n=1

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

$$\lambda = 2 \times 0.91 \times 10^{-10} \sin 65^{o}$$

$$\lambda = 1.65 \times 10^{-10} m$$



So, we have an excellent agreement of de-Broglie wavelength with the experimentally measured wavelength. This provides the evidence of wave nature of electrons and quantitative conformation of de-Broglie wavelength.

Thank You

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