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Davisson-Germer Experiment

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Abstract:

This article is about the experiment which provided the first evidence of matter waves.

In 1927 Davidson and Germer provided the first experimental evidence of matter waves through diffraction of slow electrons, the associated de Broglie wavelength of which is of the order of atomic spacings of most of the crystalline solids. Thus the atoms of a crystal can serve as a three dimensional array of diffracting centers for the de Broglie matter waves.

Experimental Setup:

Electrons moving with a known velocity are sent out from the electron gun G—a device that creates a strongly focused beam of electrons obtained from a heated filament F and accelerated by an anode A with a small hole in it.

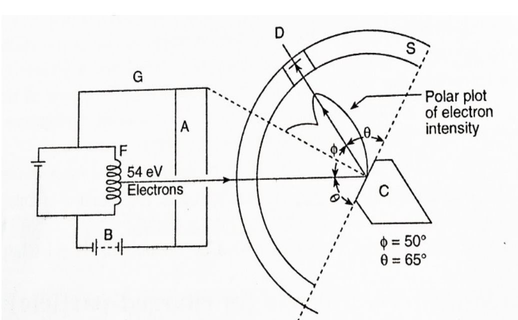

Fig. 1 Experimental set up of Davisson and Germer

The electrons are directed on to the surface of a large single crystal C of nickel in a high vacuum at an angle and are scattered in different directions. The detector D can be moved on a divided circle S to any angle Φ relative to the incident beam. Davisson and Germer measured the intensity of scattered electrons as a function of the angle Φ. The variation of intensity if plotted as a function of Φ , the resulting graph is called the polar graph or the polar plot.

Observation and interpretation—

Fig. 2 shows the results when the accelerating voltage is 54 V.

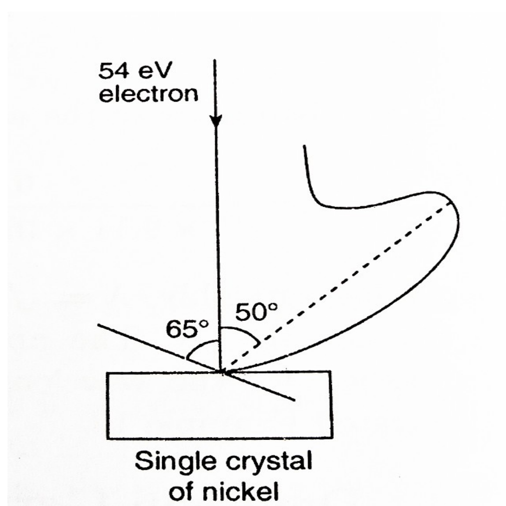

Fig. 2 Diffraction of de Broglie wave by Ni-crystal gives the results of Davisson and Germer experiment.

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There is an intense reflection of the beam at $\Phi=50°$, implying selective reflections from the crystal, analogous to those of X-rays.

If electrons are considered particles, there is no reason for any higher specific reflectivity to be associated with given velocities. But is they have associated waves of length $\lambda=h/mv$, the state of affairs that exists when an X-ray beam of progressively varying λ impinges on a crystal is reproduced, with consequent selective reflection– Bragg reflection– from certain families of atomic planes. Fig. 3 shows reflection satisfying Bragg's law, $2d\sin\theta=n\lambda$, where n=1,2,3,... . The effective wavelength found by this law and that from de Broglie's equation fully agree.

For instance, take the 54eV electron beam showing a sharp maximum at 50° with the original beam. The angles of incidence and scattering relative to the family of Bragg planes will be both $\theta=65°$. The d-value of the planes is 0.91A.

From Bragg's law,
for n=1, $\lambda=2\times0.91\times \sin65° =1.65$A
From de Broglie,
$\lambda=h/\sqrt{2meV}$
$=12.26\times10^{-10}/\sqrt{54}$ m= 1.66 A.

The observed wavelength is thus in excellent agreement with the calculated de Broglie's equation confirming the wave nature of electrons.

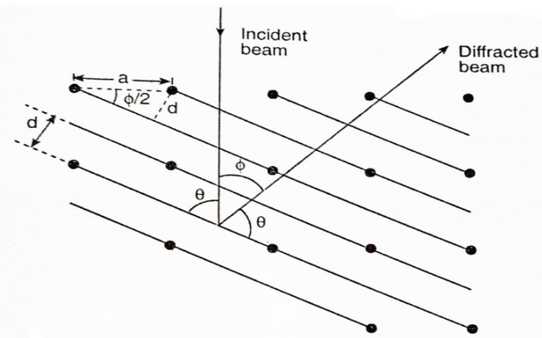

Fig. .3 Strong diffracted beam at φ=50°. Bragg angle θ=65° and the refraction at the surface neglected

Reference:
Modern atomic and nuclear physics: AB Gupta.