Davisson and Germer Experiment

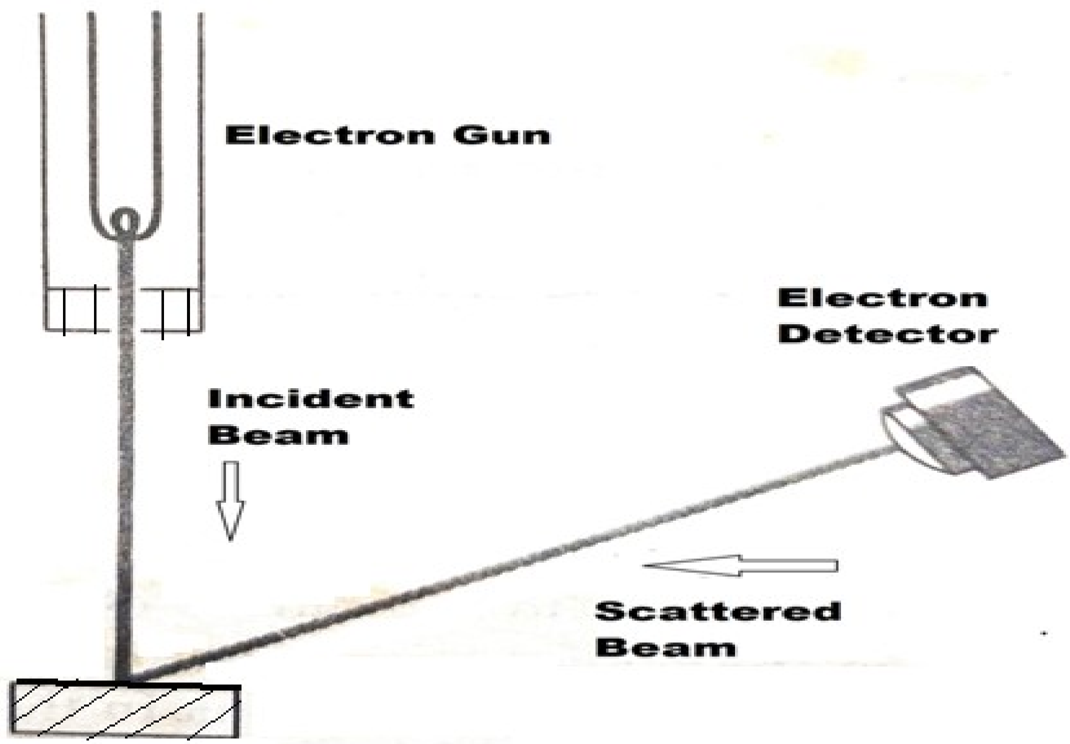
The Davisson and Germer experiment demonstrated the wave nature of the electrons, confirming the earlier hypothesis of de Broglie.

Davisson and Germer Experiment

Electrons exhibit diffraction when they are scattered from crystals whose atoms are spaced appropriately.

Davisson and Germer Apparatus

The apparatus had facility to vary the energy of the electrons in the primary beam, the angle at which they are incident upon the target and the position of the detector.



According to the classical physics the scattered electrons should emerge in all directions with only a moderate dependence of their intensity upon scattering angle and even less upon the energy of the primary electrons.

During the experiment an accident occurred that allowed air to enter the apparatus and oxidize the metal surface.

To reduce the oxide to pure nickel the target was baked in high temperature oven. After heating the target was returned to the apparatus and measurements resumed.

Surprisingly, instead of a continuous variation of scattered electron intensity with angle distinct maxima and minima were observed whose position depended on the electron energy.

The polar graph of electrons intensity

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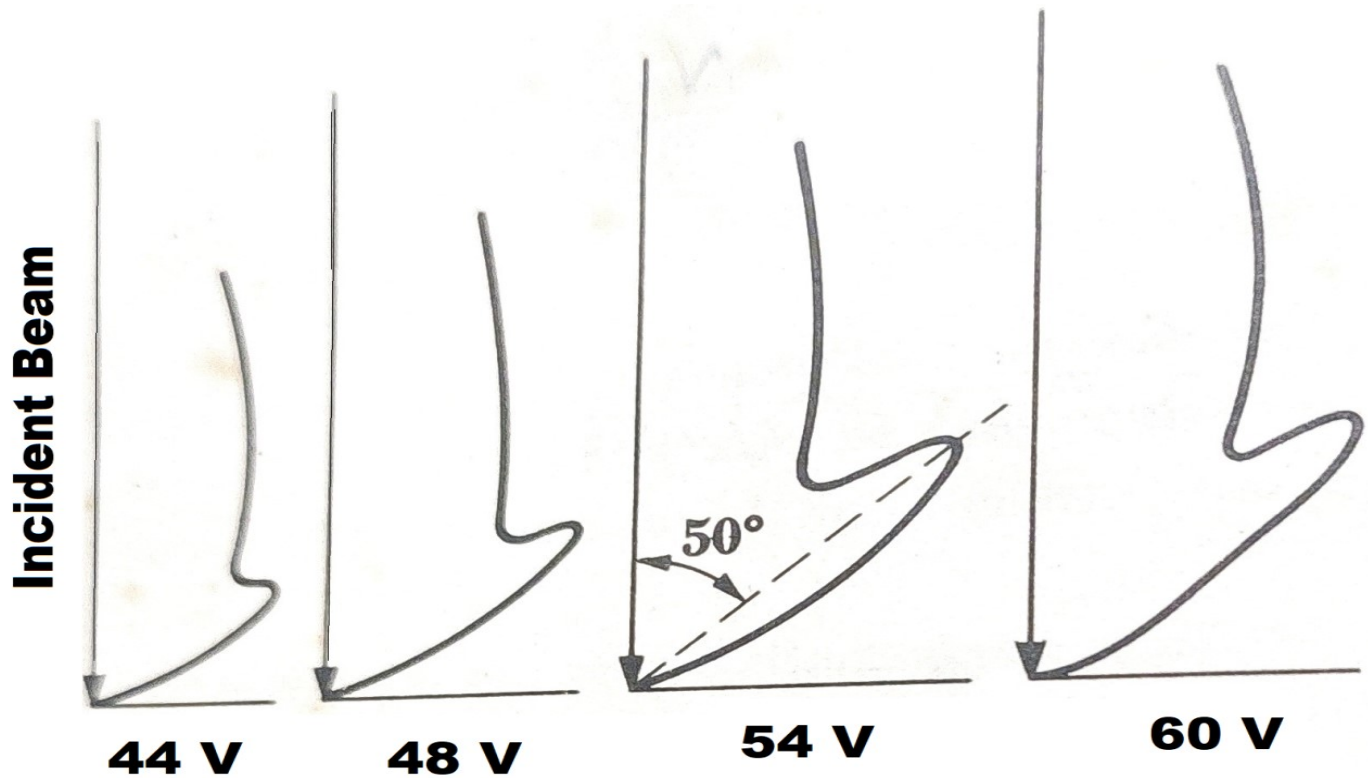
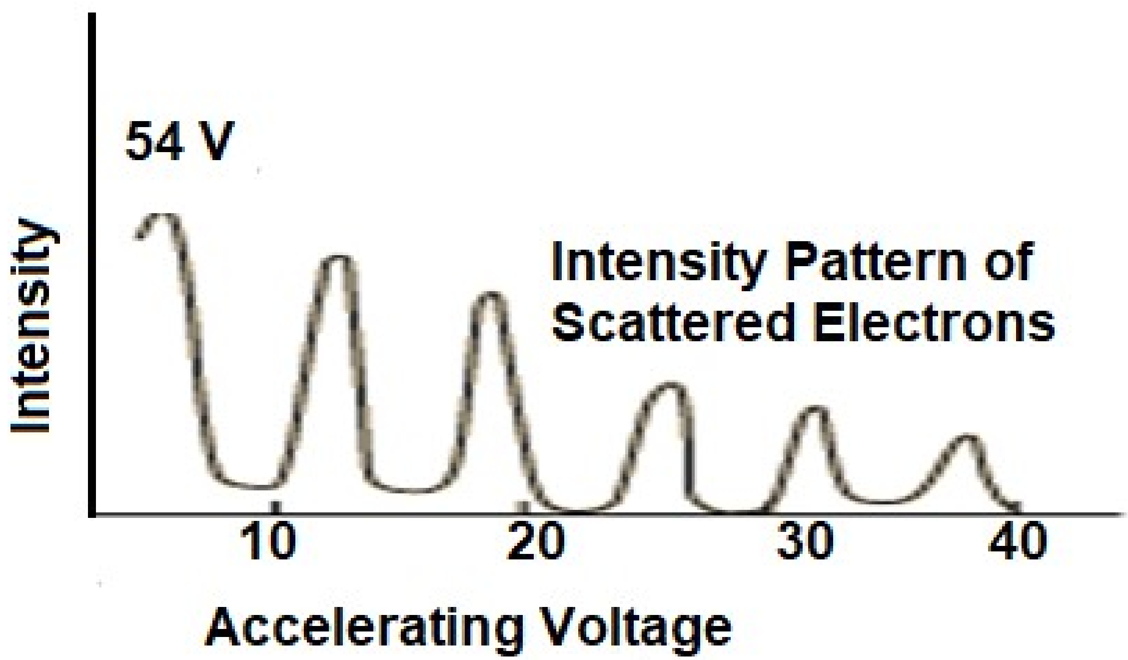


The method of plotting is such that the intensity at an angle is proportional to the distance of the curve at that angle from the point of scattering two questions



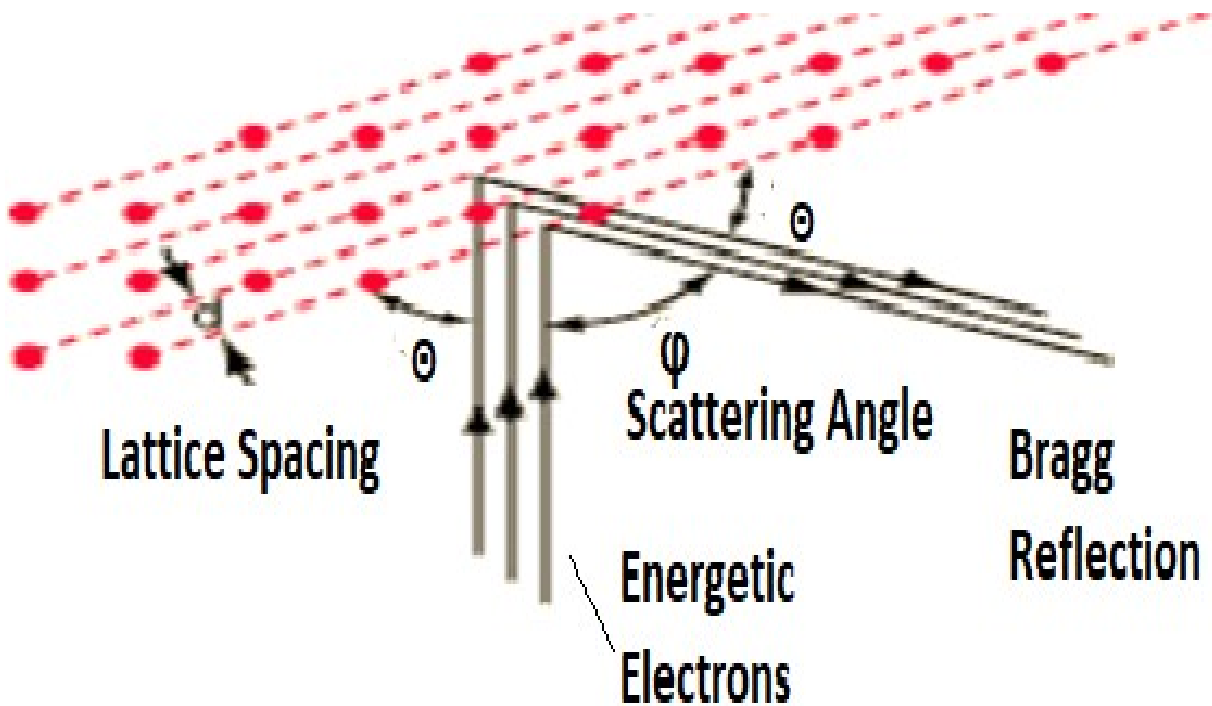
54 V
Intensity
Intensity Pattern of
Scattered Electrons
10
20
30
40
Accelerating Voltage

What is the reason for this new effect?

Why did it not appear until after the Ni target was baked?

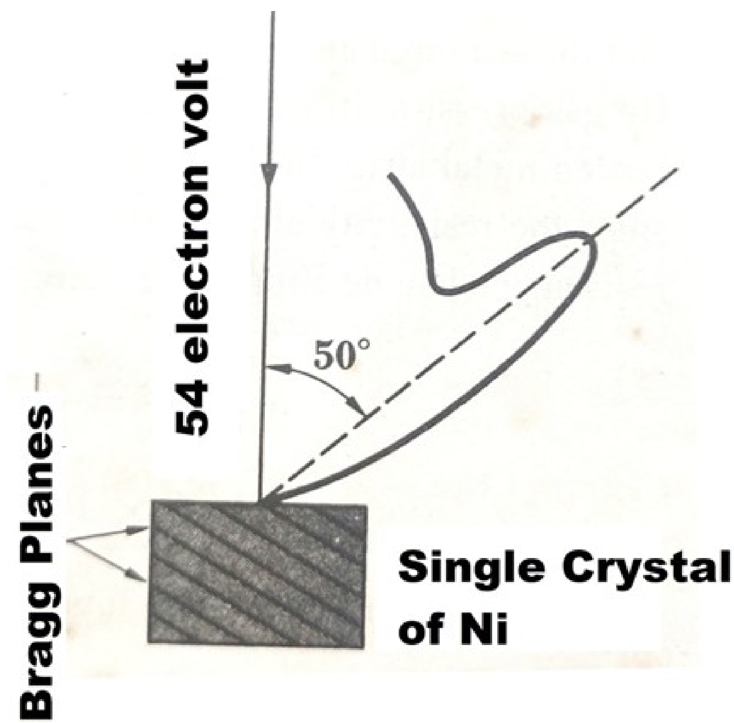
De Broglie hypothesis suggested that the electrons waves were being diffracted by the target much as X rays are diffracted by Bragg reflection from crystal planes.

It was realized that the effect of heating a block of nickel at high temperature caused many small individual crystals of which it was composed to form into a single large crystal, all of these atoms got arranged in a regular lattice.



Can we verify that the De Broglie waves were responsible for the findings of Davisson and Germer?

Consider the beam of 54 eV electrons directed perpendicular to the Ni target. The sharp maximum for this energy in the electron distribution occurred at an angle of 50˚ with the original beam.



The angle of incidence and scattering relative to the family of Bragg planes will both be 65˚. The spacing of the planes is 0. 91 Å, the Bragg equation for Maxima in diffraction pattern is

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

a=0.91 and θ=65°; assuming that n=1, the Broglie wavelength λ of the diffraction electron is

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

λ = 2 x 0.91 Å x sin65° = 1.66 Å

Now we use De Broglie formula

$$\lambda = \frac{h}{mv}$$

To calculate the expected wavelength of the electrons

$$T = \frac{1}{2}mv^2$$

The electron kinetic energy of 54 eV is a small compared to its rest energy of 5.1×10^5 eV and so we can ignore relativistic consideration.

$$mv = \sqrt{2mT}$$

The electron momentum is

$$mv = \sqrt{2\ X\ 9.1\ X\ 10^{-31}\ kg\ X\ 54\ ev\ X\ 1.6x10^{-19}\ joule/ev}$$

mv = 4.0×10^{-24} kg-m/sec

The electron wavelength is therefore

$$\lambda = \frac{h}{mv} = 1.66\ \breve{A}$$

The electron wavelength is therefore is in excellent agreement with the observed wavelength.

Davisson and Germer experiment does provides direct verification of De Broglie hypothesis of the wave nature of moving bodies.