1.5.DAVISSON & GERMER EXPERIMENT

Introduction:

The practical evidence for the wave nature of matter was given by C.J. Davisson and L.H. Germer in 1927.

- In this experiment, the wave nature of matter is verified by calculating the wavelengths of an electron beam and then comparing it with De Broglie's wave equation.

Principle:

- Electrons emitted from the source strike the target and are diffracted. The resulting diffraction pattern provides evidence for the wave nature of matter.

Apparatus - Arrangement:

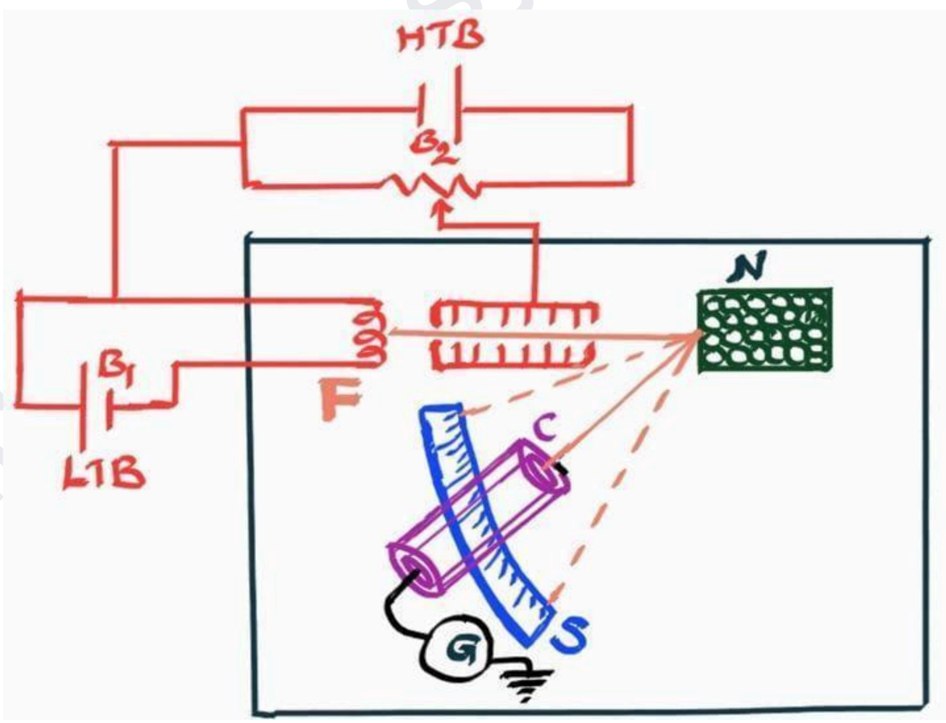
- The Davisson & Germer experiment is carried out in a vacuum, and this experimental arrangement consists of the following main parts as shown in the figure

  1.Electron gun(**F**)

  2.Target(**N**)

  3.Circular scale arrangement(**S**)

  4.Faraday's cylinder(**C**)



1.Electron gun (F):

Electron gun consists of Filament, LTB, HTB and diapghragms(D1,D2) with pin holes for accelerating electrons when the tungsten

- filament is heated by LTB & applying sufficient potential by HTB.

2.Target (N):

- It has a Nickel crystal that is capable of rotating about an axis parallel to the incident beam.
- Diffraction pattern was observed when the fast moving beam of electrons from the Electron gun is made to incident on it.

3.Circular scale arrangement (S):

It is used for collecting the scattered electrons in all directions by a collector called a Faraday cylinder or detector.

4.Faraday's cylinder(C):

- This Faraday cylinder(C) is connected to a sensitive galvanometer (G) and can be moved
- along a graduated circular scale (S), so that it is able to receive the electrons at all angles between 20 to 90 degrees.

Working process:

- When the tungsten filament 'F' is heated by a low-tension battery (LTB) which maintains a constant Potential difference then electrons are emitted by thermionic emission.
- These emitted electrons are accelerated to a required velocity by applying sufficient potential by a high-tension battery (HTB).
- They are then collimated into a fine pencil beam by passing through a system of pinholes in the diaphragms (D1 & D2).
- This beam of electrons is allowed to incident on a Ni crystal, which acts as the target. The electrons are then scattered in all directions.
- A Faraday cylinder (C) acts as a detector, which detects only the beam of moving electrons entering the inner cylinder.
- This Faraday cylinder is connected to a circular scale arrangement and a galvanometer (G) to measure the intensity of the scattered electron beam entering the collector at different angles.

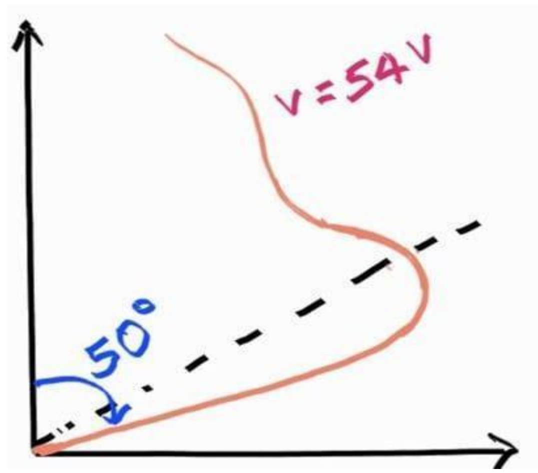
Calculation of wavelength:

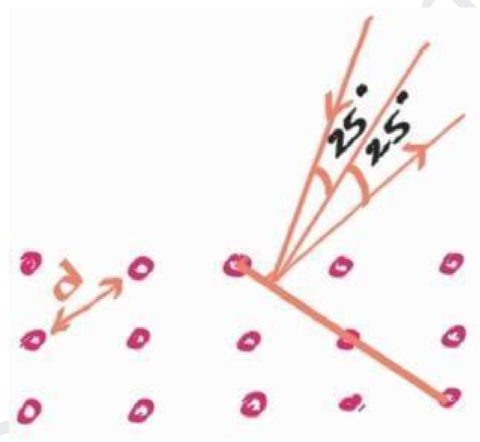
(i)Experimental value of wavelengths from Bragg's Equation:

- The below graph shows the first-order diffraction maxima is obtained between the incident and reflected electron rays at an angle of 50° when a 54V potential is supplied by a high tension battery (HTB).
    - **From graph**: V = 54V and $\theta_1 = 50°$ => $\theta_1/2 = 25°$

- The side figure shows the atomic planes and the incident scattered beams for the first order maxima.
  - **Here:** n = 1(since first order maxima),
    d = 0.909 (for nickel),

    θ = 90 - θ/2 = 90 - 25 = 65°





- **From Bragg's formula**:

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

$$1 \times \lambda = 2 \times 0.909 \times \sin 65°$$

$$\lambda = 1.818 \times 0.906 \text{ (since } \sin 65° = 0.906)$$

$$\lambda = 1.647$$

$$\lambda = 1.65 \text{ Å} \text{ --------------(1)}$$

<u>(ii)Wavelengths from de-Broglie wave equation:</u>

- The theoretical value of de-Broglie wavelength that is accelerated by a potential difference of 54 V is given by
- **The wavelength,** $\lambda = 12.27 / \sqrt{V}$

$$= 12.27 / \sqrt{54}$$

$$= 12.27 / 7.35$$

$$\lambda = 1.67 \text{ Å} \text{ ---------------(2)}$$

<u>Conclusion</u>:

- From (1) and (2), it is seen that the values obtained experimentally using Braggs' equation and de Broglie equation agree well. Therefore, the Davisson-Germer experiment gave conclusive evidence that electrons exhibit diffraction properties. Hence, the wave nature of matter is experimentally verified.