Islamic University / Najaf
College of Medical Technology
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Radiation Physics Labstage/second

Electron Diffrcion experiment

Lecture 3

By

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The aim of experiment:

1-Achieve the wave property of the electron by finding his wavelength.

2-Calculation of the interlayer distance between levels in a graphite crystal .

The device used in this experiment:

1-Electron diffraction tube .
2- Electron diffraction tube holder.
3-Power supply (0- 10 Kv) .

Theory:

* The particle-wave property of the electron is one of the most important properties of quantum physics.

* The particle property of the electron was verified through a series of experiments, the most important of which was that by the scientist Thompson in tracking the path of electrons as they passed between two fields: electric and magnetic.

* As for the wave property of the electron, the scientist De Broglie took the lead in crystallizing the idea that, the moving electrons may have both the particle and the wave properties at the same time. Based on this assumption, the wavelength of the particle will be inversely proportional to its linear momentum.

$$\lambda = \frac{h}{p} = {}^{h}/_{mv} \qquad \ldots\ldots\ldots\ldots (1)$$

Where h is Plank constant = 6.62 $*10^{-34}$ J. sec.

P= mv is (Liner momentum) .

In this experiment we will apply equation (1) to prove theparticle property of the electron by studying the diffraction of accelerated electrons that drop a sample of polycrystalline graphite (hexagonal crystal structure), and from there to a display screen.

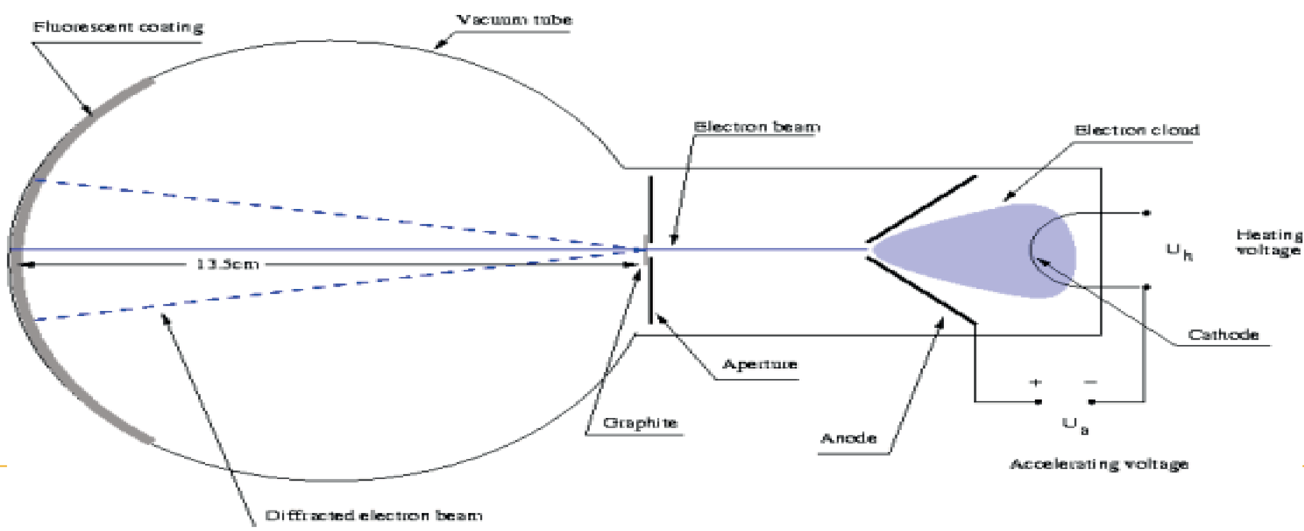


Fig. (1) shows the emission of electrons

By performing an acceleration by applying the voltage, theelectrons will acquire kinetic energy, which is given by the following relationship:

$$\lambda = \frac{h}{p} \quad ....(1)$$

then this eq(1) becomes:

$$p = \frac{h}{\lambda} \quad ....(2)$$

$$\frac{p^2}{2m} = eV \quad ....(3)$$

Sub. Eq.(2) in Eq.(3) then we get :

$$\frac{1}{2m}\left(\frac{h}{\lambda}\right)^2 = eV \quad ......(4)$$

$$\boldsymbol{\lambda^2 \times 2m \times eV = h^2} \Longrightarrow \lambda = \frac{h}{\sqrt{2m*ev}} \quad .....(5)$$

Where: $e = 1.6 * \mathbf{10^{-19}} C$

$m = 9.1 * \mathbf{10^{-31}}$ kg

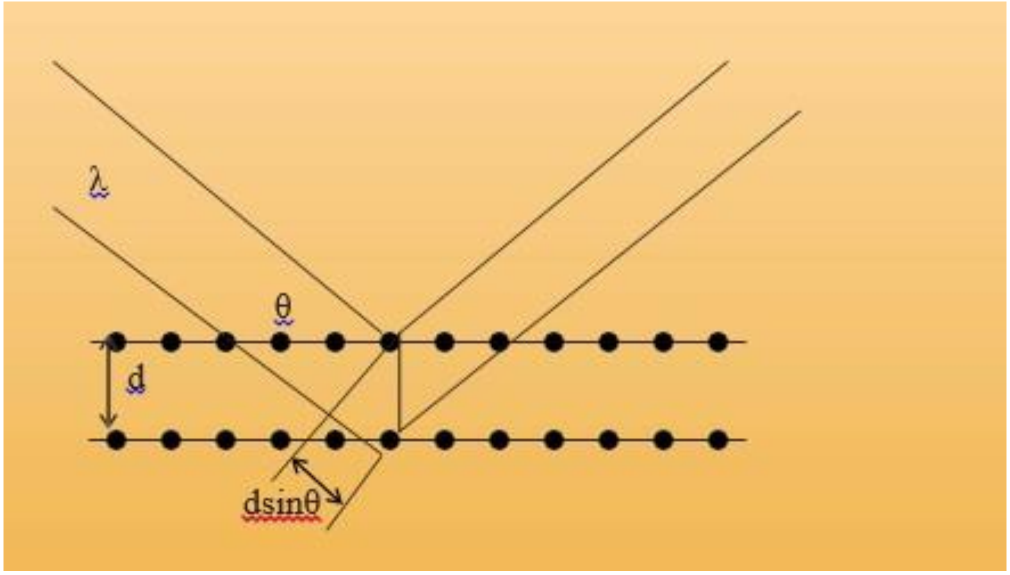
If the accelerated electrons possess the wave characteristics, the two phenomena of diffraction and interference will appear on the screen, which are among the most important characteristics of thewave.

Accordingly, the electron beam will collide with graphite crystals, which form a high-precision diffraction grating and then be reflected.

There are two conditions to obtain constructive interference of waves:

1-The angles of incidence and reflection are equal.

2-That the length of the path difference equals an integer numberof wavelengths.



Fig(2)

From Figure (2), according to Braque's law :

$$n\lambda = 2d \sin\theta \qquad \text{-----------------------------} \ \textbf{(6)}$$

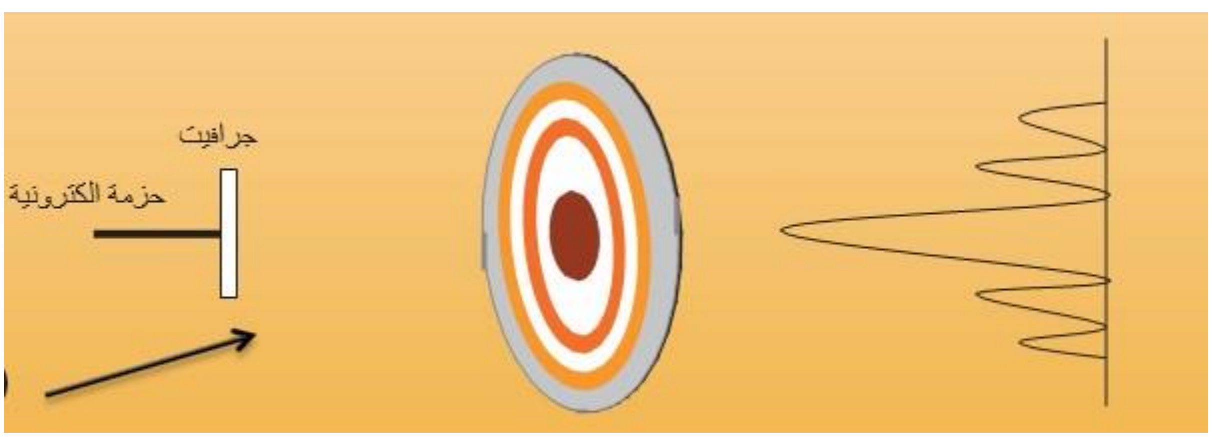
Where:

d : The distance between the graphite lattice plane .

θ: the angle between the incident electron beam and the layer ofatoms.

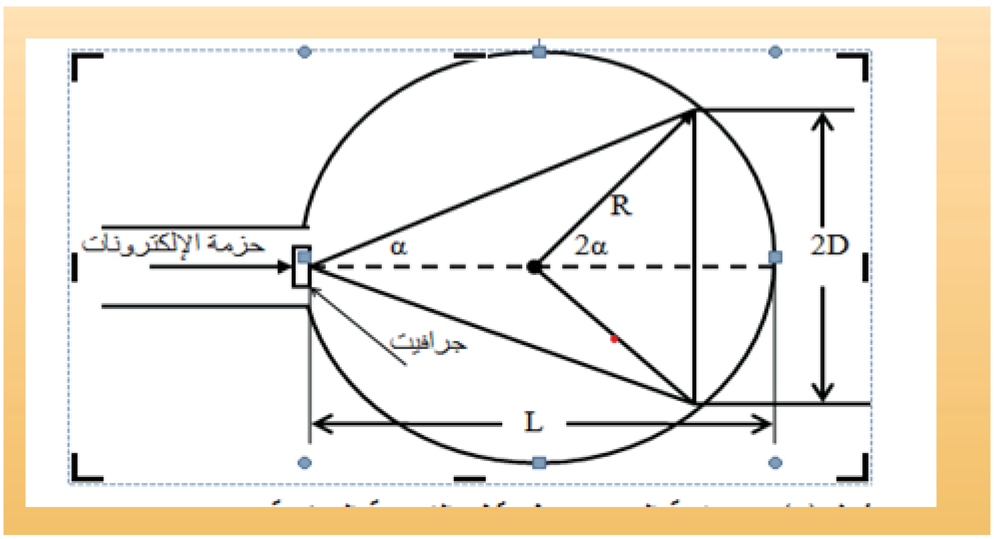
n: rank of diffraction.

If the electrons possess the wave characteristics, then we canuse equation (4) to describe the diffraction of the electrons.When they fall on the graphite crystal, they will be reflectedand received on a phosphorescent screen, which will ionize as a result of the fall of the electrons on it, which gives us the opportunity to see them as rings with a bright point center, Figure (3).



Fig(3)

Where the Fig.(3) is represented an image of the diffraction ofelectrons as a ring with a bright spot center As for the graphite crystals, the reflected electrons are spreadout in the form of a cone with its base on the screen Figure (4).



Fig(4)

$$tan2\alpha = \frac{D}{2L} \quad .... \textbf{(7)}$$

Where:

(α) : the diffraction angle and twice the angle of incidence (θ) .

(L):The length of the glass tube,which is a fixedquantity(13.5cm) .

(D): Radius of the diffraction ring .

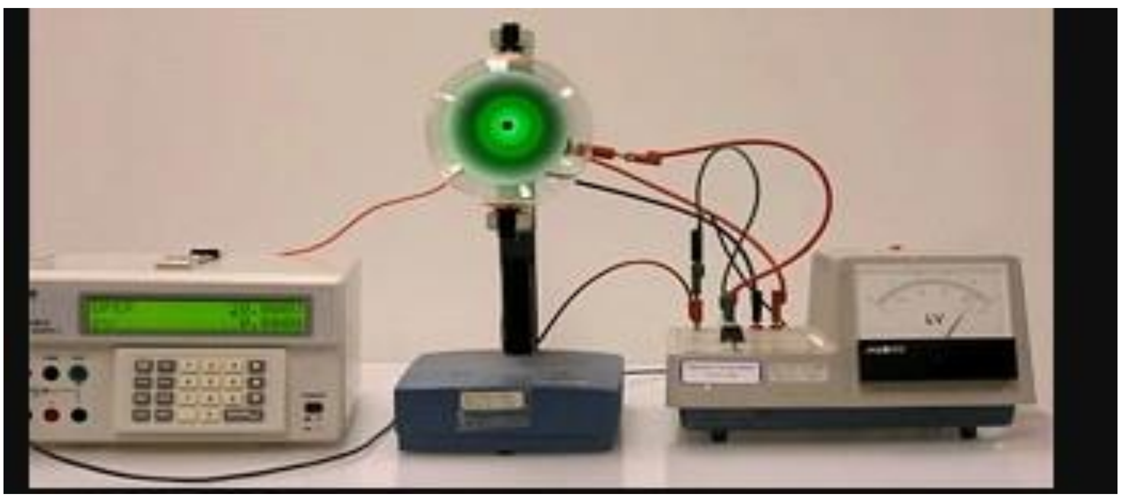
$$\tan 2a = 2 \sin \theta \text{ ------------------- } (8)$$

Sub. Eq.(8) in Eq. (7) then:

$$2 \sin \theta = \frac{D}{2L} \quad \text{.........................} (9)$$

Then we get:

$$d = \frac{2 Ln \lambda}{D} \quad \text{.........................} (10)$$



Fig(6) Diagram of the electron diffraction device

Working method:

1-Apply an acceleration voltage of (5KV).

2-Change the acceleration voltage between (2-5 KV by (0.5Kv)) and every time measure both D1 and D2 from the diffraction tubescreen, as shown in Figure (7), and then record the results in Table (1).

3-We take the distance between the graphite crystal and the screen ($L = 13.5cm$).

4-Plot the relationship between D1 and D2 on the y-axis and λ on the x-axis as in Figure (8).

5-Use equation (10) to calculate d1 and d2.

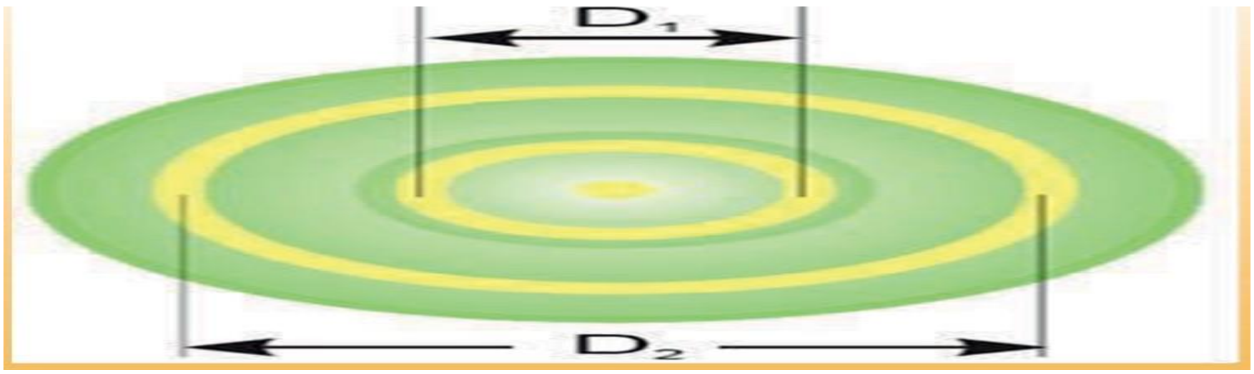


Fig. (8) : Shows the diameters of the two diffraction rings

Table (1).

V (kV)	D_1 (cm)	D_2 (cm)	λ_{th} (nm)
2.0	4	8	
2.5	3	7	
3.0	2.8	6	
3.5	2.6	5.6	
4.0	2.2	4.4	
4.5	2.4	4.2	
5.0	2.8	4.0	

The graph of experiment is the plot between the D(m) on Y-axis and the wavelength (λ m) on X –axis, then the figure is line straight as shown in the diagram :