Al- Mustaqbal University

College of Science

Medical Physics Department

Second Stage

Atomic physics

Lecture one: electron diffraction

Dr. Sarah Mahdi

B.Sc. Mohammed Jamal

B.Sc. Zahraa Bassim

2024 – 2025

Objective of the experiment

1. To verify the wave property of the electron by finding its wavelength.

2. To calculate the distance between the levels in a graphite crystal.

Devices Used:

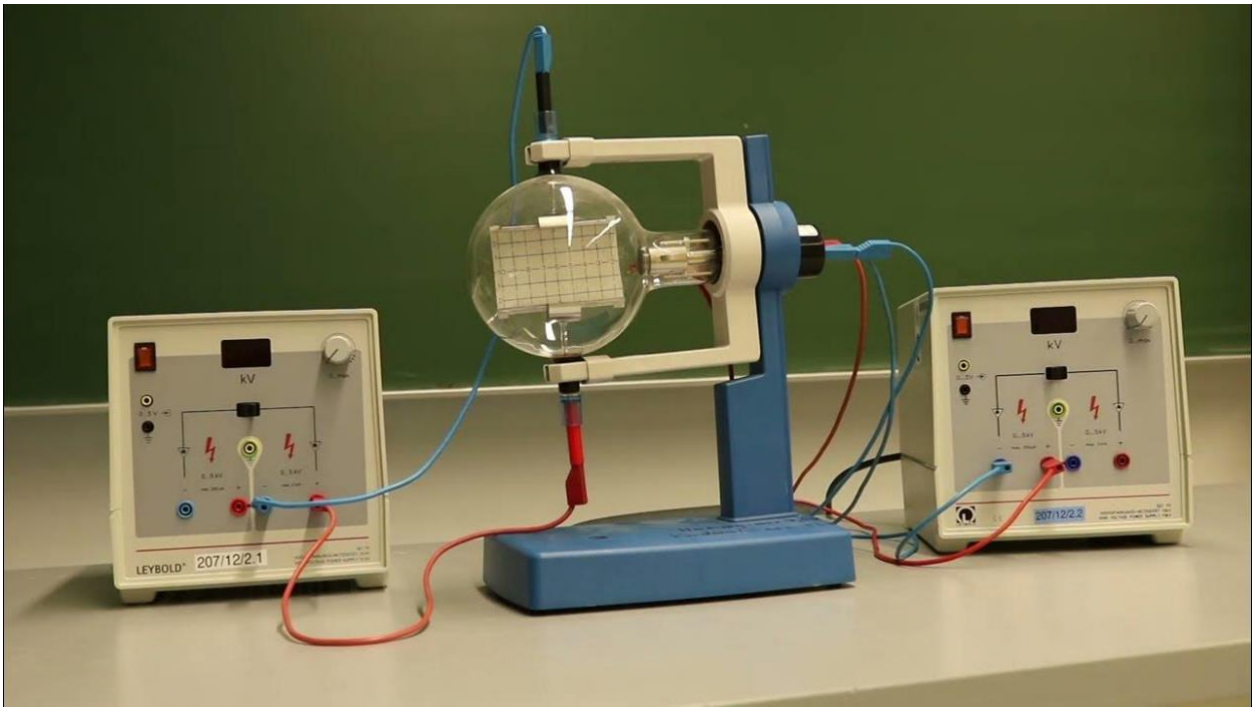
1. Electron Diffraction Tube.

2. High Voltage supply unit.

3. Power Supply (0-10).

4. High-value resistance.

5. Connecting Cords .



Theory:

The particle-wave property of the electron is one of the most important pillars upon which quantum physics is based.

The particle property of the electron was verified through a series of experiments, the most important of which was that conducted by the scientist Thomson in tracking the path of electrons as they passed between electric and magnetic fields. As for the wave property of the electron, the scientist De Broglie was the first to formulate the idea that moving electrons might possess both particle and wave properties simultaneously. Based on this assumption, the wavelength of the particle will be inversely proportional to its linear momentum, i.e.

$$\lambda = \frac{\mathrm{h}}{\mathrm{p}} = \frac{h}{mv} \qquad \ldots\ldots(1)$$

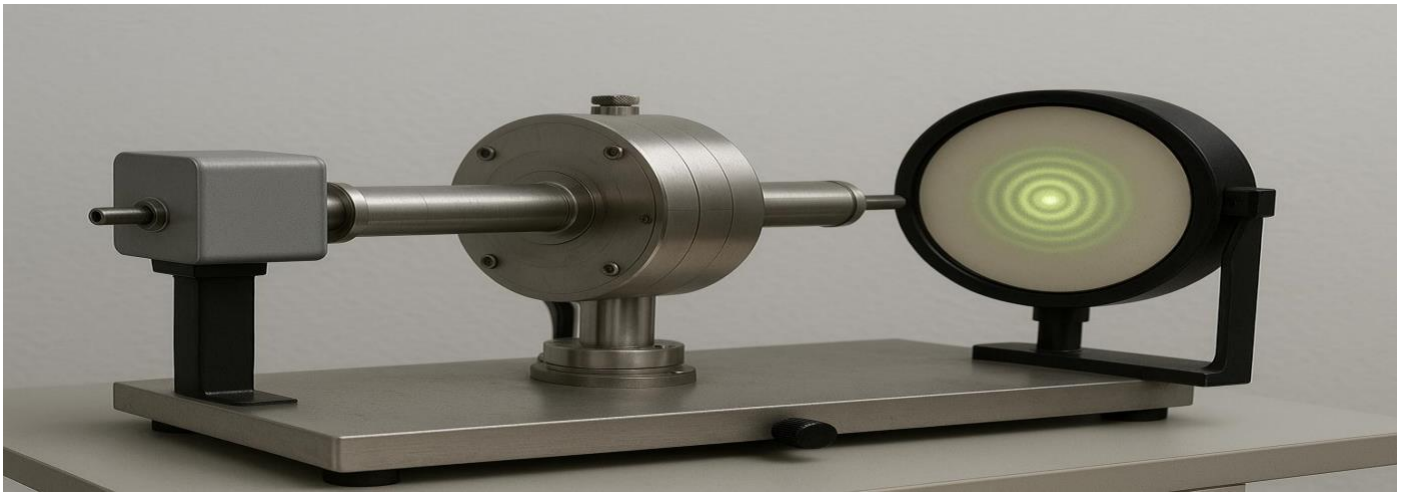
Where:

λ =wavelength.

h =is Planck's constant

(p = mv) = The linear momentum of the particle.

Planck's constant (h) = 6.63×10−34 J.S



🔷What is an electron?

An electron is an elementary particle with a negative charge.

•It is found inside an atom and orbits the nucleus.

•It has a very small mass and is one of the fundamental components of matter.

•According to quantum physics, an electron has a dual nature: sometimes it behaves as a particle and sometimes as a wave.

🔷 What is diffraction?

Diffraction is the bending or deflecting of waves (such as light waves, water waves, or even electrons) when

they pass through a narrow opening or around a small obstacle.

◆ What is electron diffraction?

It is a physical phenomenon that demonstrates that electrons not only behave as particles, but also have wavelike behavior.

When we shine a beam of electrons on a crystal or small opening, they are deflected and form a diffraction pattern similar to the diffraction of light.

◆ How does electron diffraction occur?

1. We fire a beam of electrons with a specific energy.

2. These electrons pass through a narrow slit or collide with a crystalline surface (where the atoms are arranged like a regular lattice).

3. Due to the wavelike nature of electrons (de Broglie's principle:($\lambda = h/p$), they don't just travel in a straight line, but propagate like waves.

4. They produce interference patterns (rings or lines) that can be seen on a background screen.

How to Use:

1. **Apply an accelerating voltage of (5KV).**
2. **Change the accelerating voltage between (2-5KV) by (0.5KV) and each time measure both D1 and D2 from the diffraction tube screen.**
3. **Take the distance between the graphite crystal and the screen (L=12 cm).**

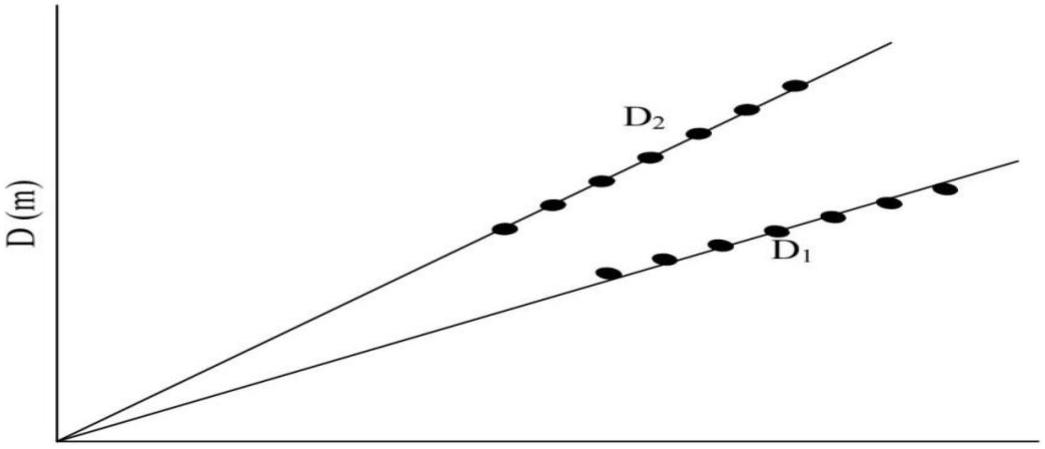


Figure shows the relationship between D and the wavelength

4- Practically find the wavelength from the following equations:

$$\lambda_1 = \frac{r_1 * d}{L} \quad \lambda_2 = \frac{r_2 * d}{L} \quad \ldots\ldots\ldots \quad \lambda_{av} = \frac{\lambda_1 + \lambda_2}{2}$$

Where:

d = distance between levels.(d= 4x10-10 m)

r = radius of the electron's circular path

V (v)	D1	D2	λ tot
5000	30 mm	52 mm	
6000	26 mm	46 mm	

Questions

Q1. Which device produces electron beam?
A) Electron diffraction experimental tube
B) Diffraction screen display panel
C) Power supply control box
D) Magnetic deflection coil system

Q2. Which device holds diffraction tube?
A) Simple wooden tube holder
B) Electron diffraction tube holder
C) Power supply electric board
D) Crystal lattice measuring device

Q3. Why do we use power supply?

A) Measure distance between rings

B) Provide accelerating electron voltage

C) Produce visible diffraction pattern

D) Record results into table

Q4. What does De Broglie principle state?

A) Energy equals mass times velocity
B) Wavelength inversely proportional momentum
C) Electrons always travel straight
D) Mass increases with acceleration

Q5. What forms on diffraction screen?

A) Bright and dark interference rings
B) Random scattered electron spots
C) Single sharp glowing dot
D) Straight continuous bright line

Q6. What should be measured in experiment?

A) Ring diameters D1 and D2
B) Voltage current and resistance
C) Distance crystal to cathode
D) Temperature of electron tube

Q7. What is fixed in experiment?

A) Tube accelerating applied voltage
B) Distance crystal to screen (L)
C) Diameter of diffraction rings
D) Planck constant universal value

Q8. What relation is drawn finally?

A) Voltage versus wavelength curve
B) D1, D2 versus $1/\sqrt{V}$
C) Mass versus energy relation
D) Brightness versus screen distance