(MP3-1) Charge of Electron, Thomson's experiment

Aim of experiment

Determination of the specific charge (e/m_o) of electrons.

Apparatus

Electron Beam Deflection tube - Helmholtz Coils Set Up. - Stand for Electron Tube - High Voltage Power Supply; *250V*.

Theory of experiment

If an electron of mass m_o and charge e is accelerated by a potential difference U it attains kinetic energy eU is given by:

$$eU = \frac{1}{2} m_0 v^2 \qquad (1)$$

where v is the velocity of the electron.
The Lorentz force acting on an electron with velocity moving in a magnetic field of strength B is:

$$\vec{F} = e\vec{v} \times \vec{B} \qquad (2)$$

If the magnetic field is uniform, as it is in the Helmholtz arrangement, the electron therefore follows a spiral path along the magnetic lines of force, which becomes a circle of radius r if $\vec{v}$ is perpendicular to $\vec{B}$.
Since the centrifugal force $m_o v^2/r$ thus produced is equal to the Lorentz force we obtain

$$v = \frac{e}{m_0} Br \qquad (3)$$

where B is the absolute magnitude of $\vec{B}$.
From Equation 1, it follows that:

$$\frac{e}{m_o} = \frac{2U}{(Br)^2} \qquad (4)$$

For the Helmholtz arrangement of two coils (separation distance = coil radius R) with number of turns, n, in the center between the coils, one obtains for the operating device in the laboratory *(n=154 turns, R=0.2 m)*

$$B(T) = \left(\frac{4}{5}\right)^{3/2} \mu_0 n \frac{I}{R} = 692x10^{-6}\ x\, I(A)\ T$$

with $\mu_0 = 4\pi x10^{-7}$ *Vs/Am*

So, $$\frac{e}{m_0} = \frac{U}{2D^2 (692x10^{-6})^2 I^2} \quad (C/kg)$$

where, $D=2r$

$$D^2 = 5.938x10^{-6}.\frac{U}{I^2}.$$

Procedure

1. Set on the filament heater at about 5 V.
2. Set on the accelerator voltage and adjust knob clockwise to increase the voltage, you may see a rectilinear orbit of the moving electrons, which means that moving electrons are not acted upon by external electric or magnetic field.
3. Revolving the Lorentz force tube so that pointer point out angle is 90°. The magnetizing current direction switch is set to clockwise.
4. Turn magnetizing current adjust knob clockwise to increase the current, you may see an orbit of the moving electrons is inclined to up.
5. Increase the current to increase the inclination of the moving electrons orbit, as shown in *Figure 1*.

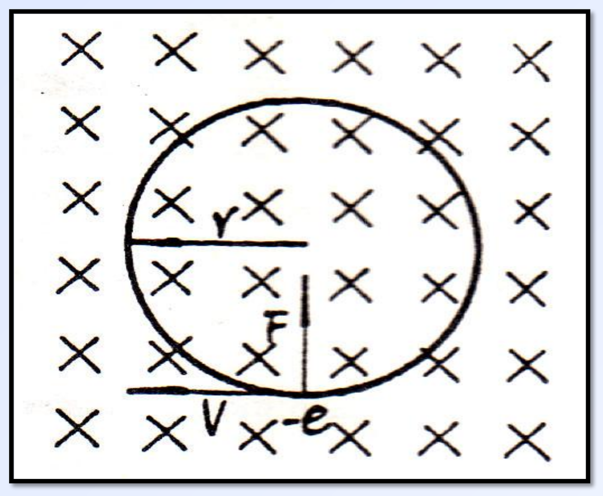

Figure 1

6. Measure the diameter D of the orbit, at constant current, I, at applied accelerating voltage, U =100 V.
7. Increase the applied voltage U in steps of 20 V up to 200 V, and determine D in each case.
8. Repeat steps 5 and 6 three times at least, and tabulate your results.
9. Plot the relation between U and D^2_{av} and find the slope.
10. Determine e/m_o from the relation:

$$\therefore \frac{e}{m_0} = \frac{1}{slope} \frac{1.044x10^6}{I^2} \qquad \text{(C/kg)}$$

Edusoft
Innovate to educate

(MP3-1) Charge of Electron, Thomson's experiment

Results

$I = \dots\dots\dots\dots A$

U (V)	D (10^{-2} m)			$D_{av.} \pm \Delta D$	$D^2_{av} \pm \Delta D^2_{av}$
	1	2	3	(10^{-2} m)	(10^{-4} m^2)

Slope = …........... m^2/V

$$\frac{e}{m_0} = \frac{261034}{I^2.Slope} = \text{.......... .....} \quad (C/kg)$$

Edusoft
Innovate to educate