Experiment # 02

object:

To determine the $\frac{e}{m}$ ratio of an electron by fine beam tube.

Apparatus:

Helmhaltz coil apparatus

Helmholtz coil:

The radius of the coil is equal to their seperation This geometry produces a highly uniform magnetic field near the centre of the coil. The helmholtz coil of the e/m apparatus have a radius and seperation of 15cm. Each coil is proportional to the current through the coil. Helmholtz coil is specially arranged. set of two conical coils which produce uniform magnetic field. The coil of radius d/2 are placed at a distance equal to the radius of either coils. Both coils are parallel to each other.

Fine Beam Tube

This tube is basically a special purpose C.R.T (Cathode ray tube). The tube is used to study the gas focussed electron tracks. This tube is filled with helium at pressure of 10^{-2} mm of Hg.

Fine tube consist of

Glass tube:

The C.R.T consist of glass Tube of 17.5cm in diameter.

Electron Gun

Electron gun consist of cathode and anode grid. Electron gun is especially designed to get a fine beam of electrons of energy. Cathode electron gun is supplied -2V to -3V w.r.t the positive potential grid. Shape of The cathode is concave so that the no of turns of electrons are focussed to a certain region. A variable +ve anode voltage is applied to anode.

Electron Beam:

The electron beam leaves a visible light in the Tube because some of the electrons collide with the Helium atoms. The atoms get excited and radiate visible light.

Heater

The heater heats the cathode which emits electrons. The electrons are accelerated by a P.D between cathode and anode.

Grid

The grid is held +ve w.r.t to cathode and negtive w.r.t anode. It helps to focus the electron beam

Magnetic field due to current:

The magnetic field around a moving charge was first formed by Danish Scientist **"Hans Christian Oersted"**. He showed that an electric current in a wire deflects a merely compass needle. It means that an electric current in a wire produces a magnetic field along it. The magnetic field is represented by the magnetic lines of forces concentric circles around the current carrying wire. The magnetic field is denoted by B. and it is a vector quantity

The conclusion drawn from experiment are:

The field exists as long as the current continues to flow.

The lines of forces are circular.

The Strength of magnetic field is greater near the wire and decreases as the distance increases

from current carrying wire.
The direction of magnetic field is formed by right hand rule.

Force on a moving Charge in the magnetic field.

When a charge q moves with velocity v in the magnetic field of Strength B.
Then the force on this charge will be

$$F_m = qvB\sin\theta$$

In vector form

$$F_m = qvB\sin\theta\,\hat{n}$$

$\hat{n}$ is a unit vector prependicular to the plane containing the vector $\vec{v}$ and $\vec{B}$. Also

$$F_m = q(\vec{v}\times\vec{B})$$

Determination of e/m of an electron:

When beam of electrons enters a magnetic field it moves in a circular path due to presence of magnetic field.

$$F_m = eVB$$

The magnetic field provides necessary centripetal force to electron so

$$F_m = F_c$$

$$e\times B = mv^2/r$$

So

$$\frac{e}{m} = \frac{v}{Br}$$

and we have K.E as

$$K.E = \frac{1}{2}mv^2 = \frac{1}{2}eV_A$$

$$K.E = eV_A$$

$$v^2 = \frac{2eV_A}{m}$$

The quantity $\frac{e}{m}$ can be calculated as function of accelerating voltage (V_A). The radius of the circle 'r' and flux density 'B' of magnetic field is

$$Br = \frac{mv}{e}$$

$$Br = \frac{m}{e}\sqrt{\frac{2eV_A}{m}}$$

$$\frac{e}{m} = \frac{2V_A}{B^2 r^2}$$

Although some 10^4 electron present which are derived from an electron beam. These eq's which are derived from an electron have the same property and can not be distinguished one from another. Hence, the property of electron can be infered from the behaviour of a great no of electrons for the measurement of $\frac{e}{m}$, we must measure:

Path radius 'R' for known value of V_A.

The flux density of magnetic field.

Result:

The actual $\frac{e}{m}$ ratio is but experimental $\frac{e}{m}$ ratio formed by beam is 1.8×10^{11} c/kg and % age error is 30%.

Procedure

The apparatus was set and the circuit is switched on. Cathode starts producing electron beam. When no magnetic field was applied electrons moves in a straight line but when current on in a coil a magnetic field was observed. The electron beam moves in a circular path. We can take two sets of reading:

→ firstly keeping voltage of anode constant (100-200) V and changing current in a coil.

After that we measure the diameter of the path from one side of the circle shown to the other side from this diameter we can find radius $r = d/2$

→ Secondly keeping current constant

and varying anode voltage. Again find the diameter and radius. After finding B and r we find e/m by $\frac{e}{m} = 2V_A / B^2 r^2$. The actual ratio of e/m is 1.76×10^{11} C/kg. In order to find the nature of any particle we should have to find the e/m ratio.