e/m

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The intention of this experiment was to accurately measure the ratio of an electron's charge to its mass. This is accomplished by observing how a beam of electrons interaces with perpendicular electric and magnetic fields.

1. INTRODUCTION

The kinetic energy of a moving object (an electron in this experiment) is

$$\frac{1}{2}mv^2 \tag{1}$$

where m is the mass of the electron and v is its velocity. If the electron has been accelerated from rest using an electric field, its energy will also be equal to the product of its charge (e) and the accelerating voltage (V). Combining these two and solving for v^2 gives

$$v^2 = \frac{2eV}{m} \tag{2}$$

An electron in a magnetic field will exhibit circular motion as a result of the magnetic and centripetal forces represented by the following equation

$$evB = \frac{mv^2}{r} \tag{3}$$

where B is the magnetic field and r is the radius of the circle the electron is traveling. Solving for v^2 results in

$$v^2 = \frac{e^2B^2r^2}{m^2} \tag{4}$$

Combining equations **??** and **??** and solving got the ratio e/m gives

$$\frac{e}{m} = \frac{2V}{B^2r^2} \tag{5}$$

This relation will be used through out this experiment.

FIG. 1: $\frac{e}{m}$ appatatus used in this experiment

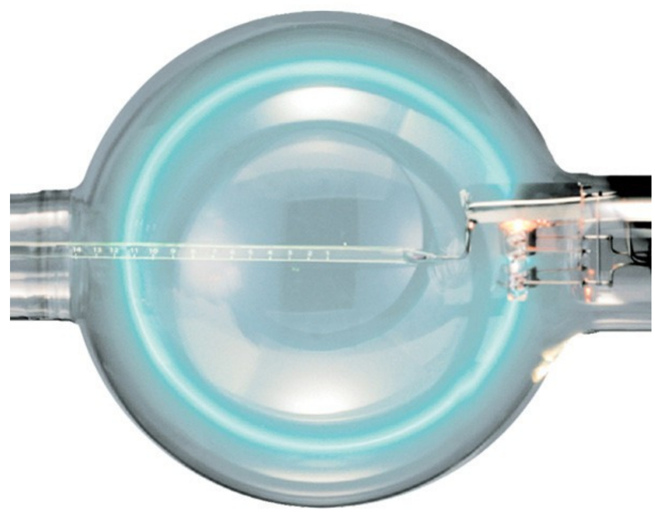

FIG. 2: Electron gun and ruler

2. EXPERIMENTAL SETUP AND PROCEDURES

The apparatus used in this lab consisted of an electron burning filament (that liberated free electrons when heated with a voltage), a variable electric potential (which accelerated the free electrons), a variable magnetic eld (generated by a set of Helmholtz coils), and a cathode tube containing a small amount of helium gas. The helium gas allows the path followed by the electrons to be observed by glowing.

The electron emitting ensemble was oriented vertically so that as the electrons left the accelerator they were bent over and down to form an upright circle which was bisected by a glass ruler inside the tube (see Fig. 2). This allowed the radius of the circle to easily be measured with a fair amount of accuracy. The voltages supplied to the electron emitter/accelerator and the current supplied to the Helmholtz coils were monitored by digital multimeters.

There are three independent variables r, V and B. A different variable was held at a constant value while the other two were varied and recorded. The data for each set was then plotted such that the slope of the resultant line was equal to the unknown charge to mass ratio.

For the first set of the measurements, the accelerating voltage was held at 142.6 V, the coil current was varied, and the radius was recorded (Fig. 3).

The second set of measurements was taken with the coil current kept at 1.6 Amp, the voltage modifed, and the radius again observed and recorded (Fig. 4).

The lasrt set of measurement was taken with the radius held at a constant $0.06 \pm 0.001m$ while we varield both the field current and the accelerating voltage(Fig. 5).

3. RESULTS AND DISCUSSION

TABLE I: Results

e/m	% Difference
$1.67 \times 10^1 1 \pm 2 \times 10^9$	5.0
$1.69 \times 10^1 1 \pm 1 \times 10^9$	3.8
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The data agrees quite well with the accepted value of 1.761011 (C/kg), only having percent differences of 5.0% and 3.8%.

4. CONCLUSION

This experiement was a great experience is working with electromagnetism to find the electron charge to mass ration.