**Charge to Mass Ratio of the Electron (E6)**

**ABSTRACT:** This experiment measured the ratio of the charge of the electron to its mass by examining the interaction of a moving charge with the magnetic field. The term is derived and it is found that the average experimental e/m is equal to 2.17e^11 ± 0.02e^11 C/kg which is slightly off the real ratio.

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**INTRODUCTION**:

The ratio e/m is simply the charge of the electron to its own mass. In 1897, J.J. Thomson first found this ratio using a similar experimental setup as described here. If one accelerates electron beams through a potential, the velocity of electrons can be calculated from:

where V is the accelerating potential that we impose on electrons. The electrons then enter a magnetic field produced by the Helmholtz coils in a glass tube filled with helium at a pressure of 10^-2mm of Hg and get deflected. With the help of helium atoms, the radius of the circular path of the beam can be calculated. The charge to mass ratio of the electron is given by:

where V is potential, r is the radius of electrons, a is the radius of the Helmholtz coils, N is the number of turns on each coil and I is the current in the coils.

The goal of this experiment was to confirm the aforementioned equations by altering the variables in the experiment.

**PROCEDURE**:

It is important not to turn on the power supplies before the circuits are correctly connected. One of the fluke meters should be used as an ammeter and configured to measure 0-2 amperes dc. The voltmeter, however, needs to measure 0-300 volts dc. There are three circuits in this setup. First circuit is for the current in the Helmholtz coils, second is for the potential that accelerates electrons. The third one is for the cathode heater in the electron gun. There is one low voltage and one high voltage supply. The third device is the experimental apparatus and has the glass tube on it.

The Low voltage supply’s AC VOLTAGE ADJUST knob should be set to 6 volts. This voltage must not exceed 6 volts. This heats up the cathode, from which the electrons are boiled off. At this point they are just released not accelerated. The toggle switch on the e/m apparatus must be switched up to the MEASURE position. The knob, however, must be turned fully clockwise to off position. The DC CURRENT ADJUST and VOLTAGE ADJUST knob on the low voltage supply also must be turned fully counterclockwise. 500 VOLT ADJUST knob on the high voltage supply must finally be turned fully counterclockwise.

When everything is correctly adjusted and checked with the instructor, the power supplies must be turned on. Now, that they have power the DC VOLTAGE ADJUST knob on the low voltage power supply must be turned until the front panel on the supply shows a value between 6V and 9V. After that, the current must be slowly increased using the DC current adjust knob and the Helmholtz coils current adjust on the apparatus. This should be measured by looking at the ammeter. The current should not exceed 2A. Finally, the accelerating potential should be increased to potential between 150 and 300 volts using the respective knob on the high voltage supply.

The cathode will take several minutes to heat up. From there the electrons will be released and accelerated through the potential. An electron beam will be emerged from the electron gun and will follow a circular path due to the magnetic field. If the beam is not sharp, focus knob might be used to sharpen. If the electron beam is not parallel to the plane of the coils, the tube must be turned until it is. With different accelerating potentials and currents in the Helmholtz coils, the radius of the electron beam must be measured and recorded. There is a mirrored scale to be used through the tube. To be more sure, one must align themselves with the reflection of the beam and measure the radii on both sides of the scale and average them.

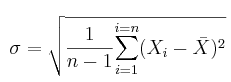
As a last step, the current in the coils must be turned off. Without touching the tube, a bar magnet should be used to deflect the beam. The concept of right-hand-rule will apply to this situation.

**RESULTS AND ANALYSIS:**

If you use a bar magnet close to the tube, but without touching the tubes, you get the following deflections visualized in the vector diagrams:

For the uncertainty in our measurements, we first calculated the uncertainty in the slope of the graph.

After this, we found the standard deviation of our set of numbers gathered in the experiment using the following formula:



= 4.63\*10^9

But the actual plus or minus value comes from the standard deviation of the mean:



= 2.07\*10^9

**CONCLUSION**:

Our measurements resulted in the following value:

e/m = 2.19\*10^11 C/kg ± 2.07\*10^9 C/kg

This obtained value is off the real value (1.758820088±39)×1011 C/kg. This has to do with several experimental setup issues. Firstly, the electron beam could have not been perfectly parallel with the plane of the coils. Secondly, the most of the experimental error might be due to parallax. It happened to be a great challenge for us to measure the diameter of the electron beam going around inside the tube.