LAB 6 Report (The charge to mass ratio of the electron)

Abstract

The purpose of this experiment is to determine the charge to mass ratio of the electron in the magnetic field. The experiment consists of shooting electrons through a vacuum tube in a uniform magnetic field. Through analyzing the relationship between the magnetic field strength, the current and voltage and the diameter of the beam the charge to mass ratio could be calculated. To conclude the experiment I got 2.08E+11 +- 1.02E+11 C/kg as the charge to mass ratio which is very accurate to the true accepted value 1.75*10^11 C/kg which is within one sigma from the value. Calculating the true value came as electron charge = 1.6*10^-19 C m mass = 9.1*10^-31 kg and dividing the two values.

Procedure

The setup of the procedure requires a voltage supply up to 500 volts, a heater circuit that has a vacuum tube that can heat up, and the electromagnetic circuit. First connect the high voltage supply to the low voltage power supply connected to the heater circuit with 6 volts. Next connect the other Thornton power supply, in series with an ammeter, to the terminals marked coil. Next leave the high power supply unplugged until the instructor checks the circuit and lastly plug in the power supply and set it to 300 volts. Under the dark, the electron beam should light up. Next make the observations to find the q/m, adjust the current and voltage so that the electron beam touches the 10 cm glass rod and repeat with different values.

Raw Data

Trials	d(m)	V(V)	I(A)	B	q/m	Percentage
1	0.1	260.6	1.285	0.000999083	2.09E+11	18.81%
2	0.1	258.5	1.276	0.000992085	2.10E+11	19.52%
3	0.1	259.9	1.289	0.001002193	2.07E+11	17.75%
4	0.1	260.2	1.290	0.00100297	2.07E+11	17.71%
average	0.1	259.8	1.285	0.000999083	2.08E+11	18.44%
standard dev	0.03	0.790569415	0.005522681			
ave +dev	0.13	260.5905694	1.290522681			

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Diameter of EM	0.315m
Air	0.013m
z-offset avg	0.145m
loop thickness L	0.015m
loop thickness R	0.016m

	error	**original**	**value with error**
σ b	-4.49E+10	2.08E+11	2.53095E+11
σ h	3.26E+10	2.08E+11	1.75668E+11
σ I	1.78E+09	2.08E+11	2.06443E+11
σ V	-6.34E+08	2.08E+11	2.08855E+11
σ r	8.50E+10	2.08E+11	1.23208E+11
total sigma	1.02E+11		
original value	2.08E+11		
value with error	2.08E+11 +- 1.02E+11		

Calculation and reasoning(Calculating e/m)

In order to find the charge over mass I have to use the equation $\frac{q}{m} = \frac{2V}{B^2 * r^2}$ Where V is volts and m is the magnetic field and r is the radius. The magnetic field from this equation has to be solved for with this equation $B = \frac{2\pi K I b^2}{c^2(b^2+z^2)}$ where k is Coulomb's constant I is the current b is the diameter of EM c is the speed of light and z is the z-offset. This equation only accounts for one loop so it needs to be multiplied twice for the two sets of wires and by the number of wires it goes around so the equation would look like $B = 2 * N\frac{2\pi K I b^2}{c^2(b^2+z^2)}$. Now solving for the magnetic field would get N = 130 I = 1.29 Amps b is equal to .315/2 and z is equal to .145/2. Which would get me 0.001 T for the magnetic field. Now solving for q/m would get V = 260 volt and r = .½ which would get 2.08E+11 C/kg for the q/m.

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Calculation and reasoning (error Analysis)

For the error analysis I took the standard deviation of all of the different recorded values of the diameter of EM the z-offset, diameter of the curls the voltage and lastly the current and added them to the average values. Next I used those values into the equation to find q/m one by one and subtracted them by the original values and lastly I took the errors and squared them and added them and square rooted the sum. And finally got the value with the error which is 2.08E+11 +- 1.02E+11 C/kg.