ENPHYS253

Lab 6: e/m Ratio

Viraj Bangari

10186046

# Results and Analysis

Using Eq. 1, the K­­r for the 4cm and 5cm electron radius was determined to be (771 +/- 4)\*10^(-6) T/A. The BE was experimentally calculated to be (-564 +/- 2)\*10^(-7) T using Eq. 2, which agrees with the accepted range of 54106.7 +/- 152 nT for the latitude and longitude of Ottawa, Ontario [1]. Using Eq. 3, the B­T for the 4cm beam radius was calculated as (1140 +/- 2)\*10^(-6) T and (901 +/- 2)\*10^(-6) T for the 5cm radius. Using these B­T values with Eq. 4, the average e/m value was calculated as (180 +/- 2)\*10^(9) C/kg, which is close to the accepted value of 175.8 \* 10^9 C/kg [2], but it does not overlap. The

# Conclusion

Lorem ipsum

# Appendix

## Equation List

Eq.

Note: For r/R = 0.3, B/Bo = 0.99621 where r is the electron radius and R is the Helmholtz coil radius.

Eq.

Eq.

Eq.

Eq.

## Raw Data

For the following tables, R = 15.4 ± 0.5 cm, 2b = 15.04 ± 0.5 cm, n = 130 turns, and K = (7.73 ± 0.04) \* 10^-4 T/A. Note that the anode voltages had 1% subtracted in the actual calculation to correct for the voltage drop due to the specific experimental setup.

Table : Voltage and Current for r = 4.0 +/- 0.2 cm (CCW Beam)

|  |  |
| --- | --- |
| Anode Voltage [V] +/- 0.1 [V] | Filament Current [A] +/- 0.001[A] |
| 149.5 | 1.226 |
| 169.9 | 1.332 |
| 190.3 | 1.36 |
| 210 | 1.451 |
| 229.9 | 1.517 |
| 250 | 1.597 |

Table : Voltage and Current for r = 4.0 +/- 0.2 cm with reversed current polarization (CW Beam)

|  |  |
| --- | --- |
| Anode Voltage [V] +/- 0.1 [V] | Filament Current [A] +/- 0.001[A] |
| 150.3 | 1.408 |
| 169.7 | 1.472 |
| 189.7 | 1.551 |
| 209.8 | 1.683 |
| 230.2 | 1.645 |
| 250.3 | 1.72 |

Table - Voltage and Current for r = 5.0 +/- 0.2 cm (CCW Beam)

|  |  |
| --- | --- |
| Anode Voltage [V] +/- 0.1 [V] | Filament Current [A] +/- 0.001[A] |
| 150 | 0.984 |
| 169.9 | 1.018 |
| 190 | 1.092 |
| 210.5 | 1.146 |
| 230.5 | 1.2 |
| 249.6 | 1.279 |

Table - Voltage and Current for r = 5.0 +/- 0.2 cm with reversed current polarization (CW Beam)

|  |  |
| --- | --- |
| Anode Voltage [V] +/- 0.1 [V] | Filament Current [A] +/- 0.001[A] |
| 150.1 | 1.093 |
| 170 | 1.16 |
| 190 | 1.227 |
| 209.9 | 1.298 |
| 230.1 | 1.338 |
| 249.8 | 1.394 |

## Sample Calculations

# Location of original data

data\_8cm\_normal = \

pd.read\_excel('./data/Data.xlsx', 0).as\_matrix()

data\_8cm\_reverse = \

pd.read\_excel('./data/Data.xlsx', 1).as\_matrix()

data\_10cm\_normal = \

pd.read\_excel('./data/Data.xlsx', 2).as\_matrix()

data\_10cm\_reverse = \

pd.read\_excel('./data/Data.xlsx', 3).as\_matrix()

all\_data = [data\_8cm\_normal, data\_8cm\_reverse, data\_10cm\_normal, data\_10cm\_reverse]

# Normalize Voltage

voltages = []

currents = []

**for** dataset **in** all\_data:

voltage = dataset[:, 0]

voltage -= 0.01 \* voltage

voltages.append(q.MeasurementArray(voltage, 0.1\*np.ones(len(voltage))))

current = dataset[:, 1]

currents.append(q.MeasurementArray(current, 0.001\*np.ones(len(current))))

# Calculating Kr

K = q.Measurement(7.74, 0.04)\*1e-4 # T/A

R = q.Measurement(15.4, 0.5)

r4cm = q.Measurement(8, 0.2)/2

r5cm = q.Measurement(10, 0.2)/2

print("K", K)

print("R", R)

print("r4cm/R", r4cm/R)

B\_Bo4cm = 0.99621

print("r5cm/R", r5cm/R)

B\_Bo5cm = 0.99621

Kr4cm = B\_Bo4cm \* K

Kr5cm = B\_Bo5cm \* K

print("Kr 4cm", Kr4cm)

print("Kr 5cm", Kr5cm)

*K (774 \pm 4)\*10^{-6}*

*R (154 \pm 5)\*10^{-1}*

*r4cm/R (26 \pm 1)\*10^{-2}*

*r5cm/R (32 \pm 1)\*10^{-2}*

*Kr 4cm (771 \pm 4)\*10^{-6}*

*Kr 5cm (771 \pm 4)\*10^{-6}*

# Calculating Bt and Be

Be4cm = Kr4cm/2 \* (currents[0] - currents[1])

print("Be4cm", Be4cm.get\_error\_weighted\_mean())

Be5cm = Kr5cm/2 \* (currents[-2] - currents[-1])

print("Be5cm", Be5cm.get\_error\_weighted\_mean())

Bt4cm = Kr4cm/2 \* (currents[0] + currents[1])

print("Bt4cm", Bt4cm.get\_error\_weighted\_mean())

Bt5cm = Kr5cm/2 \* (currents[-2] + currents[-1])

print("Bt5cm", Bt5cm.get\_error\_weighted\_mean())

Be = (Be4cm.get\_error\_weighted\_mean() + Be5cm.get\_error\_weighted\_mean())/2

print("Be", Be)

*Be4cm (-621 \pm 3)\*10^{-7}*

*Be5cm (-506 \pm 2)\*10^{-7}*

*Bt4cm (1140 \pm 2)\*10^{-6}*

*Bt5cm (901 \pm 2)\*10^{-6}*

*Be (-564 \pm 2)\*10^{-7}*

# em for 4cm

V4cm = (voltages[0] + voltage[1])/2

e\_m4cm = 2\*V4cm / (Bt4cm \* r4cm/100)\*\*2

print(e\_m4cm.get\_error\_weighted\_mean())

*(171 \pm 4)\*10^{9}*

# em for 8cm

V5cm = (voltages[-1] + voltages[-2])/2

e\_m5cm = 2\*V5cm / (Bt5cm \* r5cm/100)\*\*2

print(e\_m5cm.get\_error\_weighted\_mean())

*(188 \pm 3)\*10^{9}*

e\_m = (e\_m4cm.get\_error\_weighted\_mean() + e\_m5cm.get\_error\_weighted\_mean())/2

print(e\_m)

*(180 \pm 2)\*10^{9}*