

The e/m Experiment

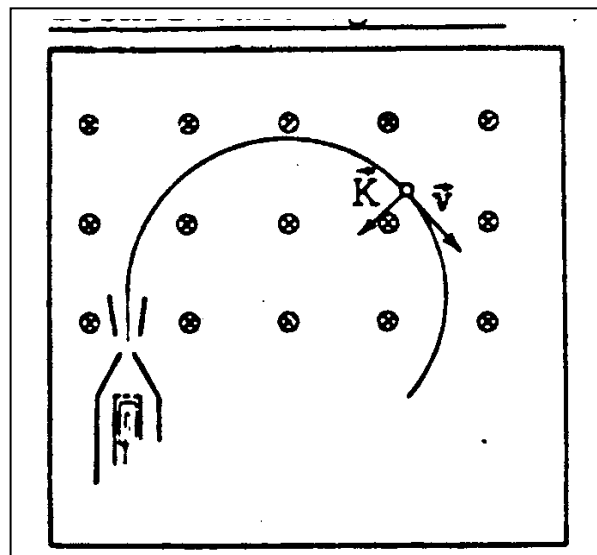
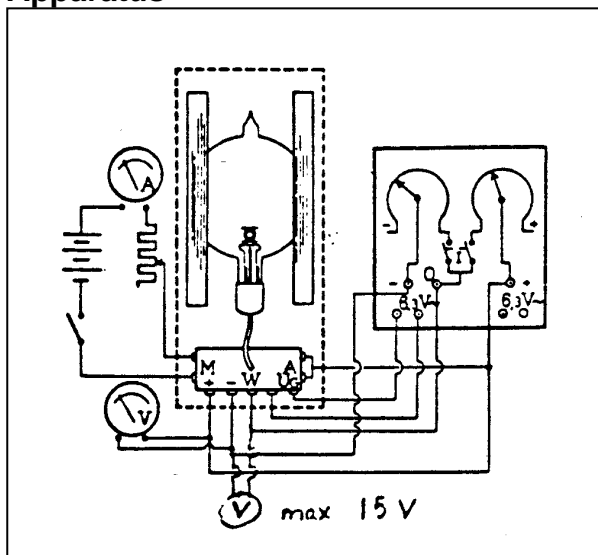
Criteria

No report.

Aim

To determine the ratio e/m between charge and mass of the electron using a cathode-ray tube with an electron gun (thermionic emission) with rarefied hydrogen placed between two Helmholtz-coils.

Apparatus



In this experiment we use a special power supply with 6.3 V AC to heat the cathode and with two adjustable DC supplies (-25 V to 0 V and 0 V to 300 V). The connections are done as described:

- The central switch must be put in upper position.
- Connect the left 6.3 V AC outputs to the “Heizung” on connection box.
- Connect the common 0 V on the DC supply to the grid (“Wehneltsp.”) on the box.
- Connect the -25 V on the DC supply to the cathode (“Anodespannung -”) on the box.
- Connect the 300 V on the DC supply to the anode (“Anodespannung +”) on the box.
- Short-circuit the two inputs “Ablenkung” on the box.
- Connect the 300 V on the DC supply to the short-circuited inputs “Ablenkung” on the box.
- The potential difference between the cathode (the -25 V) and the anode (the 300 V) is measured with a Voltmeter. Using the power supply +knob it is possible to alter this potential difference U , the acceleration potential of the electrons.
- The potential difference between the cathode (the -25 V) and the grid (the 0 V) is measured with another voltmeter. Using the power supply -knob it is possible to alter this potential difference. *It must not exceed 15 V!* The purpose of this is only to focus the electron beam.
- Using the power supply +knob it is now possible to change the potential of the anode creating different acceleration potentials U of the electrons.
- Using the power supply -knob it is possible to change the potential of the grid.
- The Helmholtz-coils are connected via “Magnetfeld” on the box to a separate power supply in series with an Ammeter showing the current I through the coils.

The e/m Experiment

The experiment

We measure the potential difference U between the cathode and the anode, current I in the coils and the diameter $2r$ of the circular electron beam (using a ruler with two pointers and the mirror behind the tube).

Start with U being approximately 100 V and adjust I until the electrons form a clearly visible circular beam in the middle of the tube with a diameter r approximately 10 cm. If the beam is deflected to the wrong side, the direction of the current in the coils must be changed. Now the potential difference between the cathode and the grid is adjusted (max 15 V) so the electron beam becomes focused.

Then perform two series of measurements:

- With I constant increase U in steps of 50 V up to 250 V, measuring $2r$.
- With $U = 200$ V constant change I to five different values, measuring $2r$.

Process the data in a reasonable way to get values of e/m .

Theory

- The electrons leave the electron gun with speed v given by (law of conservation of energy): $U e = \frac{1}{2} m v^2$.
- Since the velocity is perpendicular to the magnetic field between the coils, the orbit becomes a circle and the required centripetal force is exerted by the magnetic field: $e v B = (m v^2)/r$.
- Use the two former equations to express e/m U , B and r .
- The magnetic field between the coils can (using the laws of electromagnetism) be expressed as: $B = \frac{8N\mu_0 I}{5\sqrt{5}R}$ with $N =$ number of coils = 130, $R =$ radius of coils = distance between coils = 0.15 m.
- Express e/m by a number, U , I and r (SI-units).

Relativistic treatment?

Calculate the maximum speed v of the electrons you have obtained from your measurements. From this find the relativistic γ - factor. Judge if it was reasonable to disregard relativistic effects in the calculations.