31 - ELECTRON MOTION IN ELECTRIC AND MAGNETIC FIELDS – EVALUATING THE e/m VALUE

HELMHOLTZ COILS

Finding the e/m value with the application of Helmholtz coils

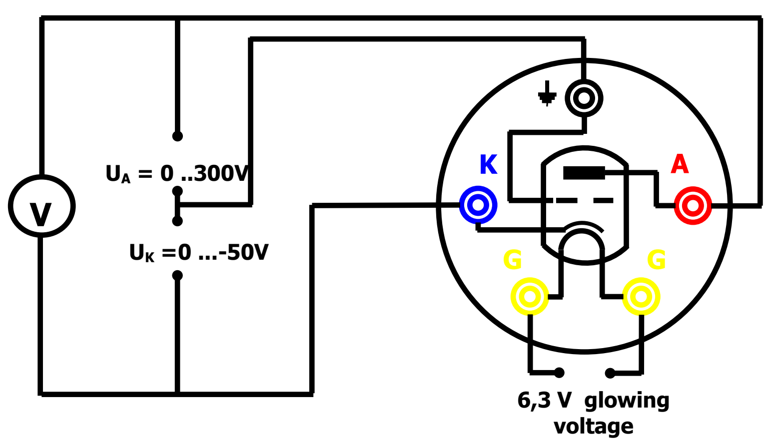
In this part of the experiment, a special lamp filled with low-pressure neon (about $4x10^{-4}$ Pa) is used. This gas plays a key role in the experiment as the electrons colliding with gas particles cause their ionization. The ion recombination leads to luminescence phenomenon and the electrons' trajectory can be observed. On the other hand, due to electrostatic interaction between ions and electrons, the electron beam is being collimated. The electrons are injected to the lamp bulb from an electron gun that accelerates them to the energy of E=eU. The lamp is located between two coaxial coils made of copper wire that are called **Helmholtz coils**. The current flowing through the coils induces a magnetic field inside the lamp of the B induction vector of the direction perpendicular to the lamp axis. **The Helmholtz coils are relatively large to assure a homogenous (approximately) field inside the lamp.** The lamp can be rotated around its own axis, which enables to change the direction of electron motion with respect to the direction of the magnetic field. At a certain position of the lamp, the electrons will move on the circle. Inside the lamp, there is also a metal ladder coated with a fluorescent paint which enables to determine the diameter of the electron trajectory.

1. Once the instrument has been heated, set the appropriate acceleration voltage (the full brightness of the electron beam is obtained in about 3 minutes after the instrument is on).
2. Turn on the power supply of the current flowing through the Helmholtz coils and observer the electron trajectory in gas. **(Caution: the maximum current flowing through the coil is 5 A.)**
3. Rotate the lamp to such a position that the direction of electrons is exactly perpendicular to the direction of magnetic field lines. If the lamp is correctly set, the electrons move on the circle trajectory.
4. By controlling the coil current, set such a diameter, that the trajectory goes through the horizontal steps of the ladder. The ladder is coated with a paint that lights when the electrons are falling on it so in case the appropriate diameter is set, the respective ladder stem emits the light. When the trajectory reaches a ladder step, only half of the circle can be seen. **The circle radiuses are 2, 3, 4 and 5 cm (when the trajectory reaches respective steps)**.
5. For a chosen accelerating voltage U measure the respective coil current I values for which respective ladder steps light.
6. Perform two next measurement series for various U values.

CAUTION:
If the measurement is going to be interrupted for a few minutes, please turn both control knobs of the power supply to the zero position. This will increase the lamp lifetime.

Use the formula given in the manual to calculate the e/m value for each measurement, treat the results as measurement series. Calculate the most probable value and its uncertainty.

Voltage value shown on the power supply display



The electric circuit consists of two power supplies:

305D power supply– power supply of the coils creating the magnetic field. On the front panel, there are two control knobs used to set the current. On the right display, the coil voltage is shown. The left display shows the coil current.

1502D power supply – power supply of the glowing unit and anode and cathode voltage. All the voltages necessary for the proper operation are connected to the multipin connector on the back panel of the power supply. The right control knob is used to change the anode voltage U_A, and the left one – for the U_K cathode voltage. The overall accelerating voltage is shown on the display.

For both power supplies: c_1=2% c_2=0,2%. Current measurement range 5 A, voltage measurement range 500 V.

DO NOT DISCONNECT ANY CORDS FROM THE POWER SUPPLIES!