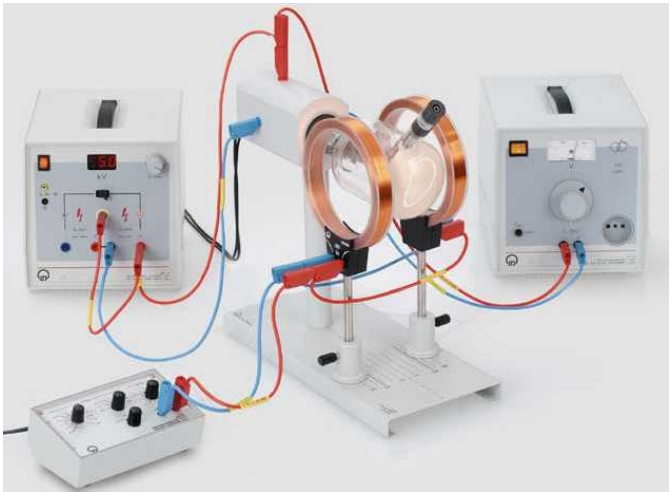
Electron beams in parallel alternating electric and magnetic fields
Perrin tube

Object of the experiment

1. Investigating the behaviour of an electron beam in parallel alternating electric and magnetic fields

Setup



Safety notes:

As a hazardous contact voltage is applied to the deflection plates of the Perrin tube, use safety connecting leads!

The Perrin tube can be destroyed by incorrect connection and by voltages and currents that are too high.

Regarding the connection and technical data heed the instruction sheet 555 622.

Apparatus

1 Perrin tube	555 622
1 tube stand	555 600
1 pair of Helmholtz coils	555 604
1 high-voltage power supply 10 kV	521 70
1 variable low-voltage transformer, 0 to 250 V	521 40
1 function generator S 12	522 621
2 safety connecting leads, 100 cm, red	500 641
2 safety connecting leads, 100 cm, blue	500 642
2 safety connecting leads, 100 cm, black	500 644
1 safety connecting lead, 50 cm, red	500 621
1 safety connecting lead, 50 cm, blue	500 622
2 safety connecting leads, 25 cm, red	500 611
1 safety connecting lead, 25 cm, blue	500 612

Carrying out the experiment

Remarks:

For better visibility of the Lissajous figures on the screen of the Perrin tube, carry out the experiment in a slightly darkened room.

The results form the experiments D 3.9.4.4.b (Deflection of electron beams in a magnetic field) and D 3.9.4.5 (Deflection of electron beams in an electric field) should be known.

- Switch the high-voltage power supply on, and enhance the voltage until the luminous spot of the electron beam is visible on the screen of the Perrin tube.
- For generating a horizontal alternating magnetic field, switch the function generator on, and adjust an output voltage of approx. 2.5 V with a frequency f_M of approx. 1 Hz.
- Observe the luminous spot on the screen.
- Increase the frequency f_M to approx. 50 Hz, and observe the luminous spot again. Then turn the voltage at the function generator down to 0 V.
- For generating a horizontal alternating electric field (f_E = 50 Hz), switch the adjustable transformer on, and enhance the voltage slowly.
- Observe the luminous spot on the screen.
- The frequency f_M being unchanged, turn the voltage of the function generator up to approx. 2.5 V. Then set other frequencies.
- Observe the picture on the screen.

Observation

If an alternating voltage with a frequency f_M of 1 Hz is applied to the Helmholtz coils, the luminous spot on the screen moves back and forth vertically.

If the voltage is slowly enhanced, the up and down deflection of the luminous spot increases.

When the frequency is increased to 50 Hz, a vertical line is observed.

If an alternating voltage with a frequency f_E of 50 Hz is applied to the deflection plates, a horizontal line is seen on the screen.

If the voltage is enhanced, the horizontal line becomes longer uniformly to the left and to the right.

If an alternating voltage with a frequency of 50 Hz is applied to both the deflection plates and the Helmholtz coils, a rotating ellipse appears on the screen.

If the frequency f_M is varied at the function generator, other figures are seen.

Evaluation

If an electron beam moves between an electric and a magnetic field, whose field lines are parallel to each other, rotating figures are seen on the screen. These figures are called Lissajous figures.

If the frequency f_E and the frequency f_M of the magnetic field are equal, the Lissajous figure is a circle or an ellipse. If the ratio of the frequencies is changed, other figures appear. The horizontal and vertical dimensions of the Lissajous figures on the screen depend on the magnitudes of the voltages applied to the deflection plates and the Helmholtz coils, respectively.

Remark:

The Lissajous figures can be used to analyse the magnitude and the frequency of the alternating voltage applied to the Helmholtz coils if a scale is applied to the screen and if an alternating voltage of known magnitude and frequency is applied to the deflection plates.

Thus the setup of this experiment is suited as a model of an oscilloscope.

LEYBOLD DIDACTIC GMBH · Leyboldstrasse 1 · D-50354 Hürth · Phone (02233) 604-0 · Fax (02233) 604-222 · e-mail: info@leybold-didactic.de