

Perrin tube – sign of electron charge

Demonstration

This experiment, conducted by Perrin in 1895, was crucial in the very early studies of electron beams.

Apparatus and materials

- Perrin tube and stand
 - Coils for deflecting beam, 1 pair
 - Power supply, 0-5 kV (Extra High Tension, EHT)
 - Low voltage supply (6 volt) for heating filament (this is often included on the EHT supply)
 - Gold-leaf electroscope
 - Proof plane (an Insulated metal plate to transfer charge)
 - Power supply, low voltage, variable, 0 - 12 V
- OR
- Battery pack, 6V, 2

- Rheostat
- Switch, 1
- Helmholtz coils

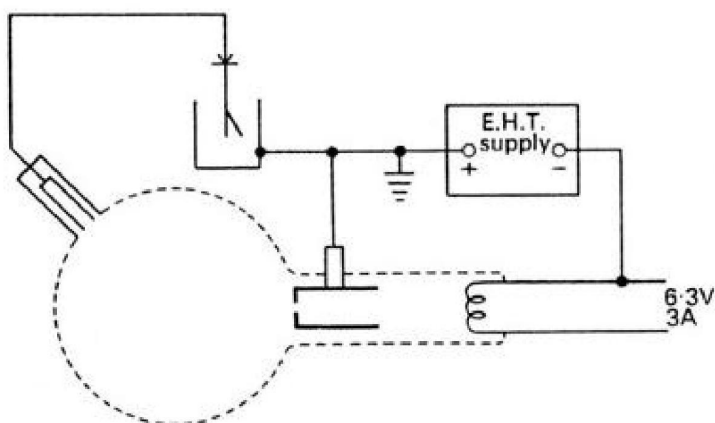
Technical notes

Follow the manufacturer's instructions for setting up the tube.

Ensure that you can identify the following:

- The 6.3 V supply to the cathode heater (if you connect the wrong voltage to the heater you can easily damage the tube beyond repair).
- The EHT supply to the electrode. Set this to zero.
- The collection plate and its connection terminal in the Perrin tube

Use a proof plane (a small insulated metal plate) to test the sign of the charge on the electroscope. Use the plane to transfer charge from the power supply to the electroscope. To transfer negative charge, earth the positive terminal and touch the plate with a lead from the negative terminal. To transfer positive charge, earth the negative terminal and touch the plate with a lead from the positive terminal.



Make sure the glass envelope is clean and dry. You can wash it in methylated spirits and dry it in warm air.

A Faraday cylinder is contained within the tube at about 45 degrees to the axis of the undeflected beam. The magnetic field is adjusted so that the beam enters the cylinder. If the cylinder is connected to a gold-leaf electroscope, there will be an immediate rise in potential.

Safety

Use an EHT supply of no more than 5 kV, which is current limited to less than 5 mA.

The power supply for the heater **MUST** have adequate insulation.

Leads used **MUST** have shrouded connectors and insulation capable of withstanding 5 kV.

Make all connections with the power supply turned off. Do not adjust connections while the EHT is switched on.

Electron beam tubes are fragile. Because they are evacuated, they will implode if they break. The tubes are also expensive, so handle them with great care. Use the purpose-designed holders during practical work.

Note that when switching the EHT supply off, it can take a little while for the voltage output from the EHT to fall to zero. Allow sufficient time before disconnecting.

[Read our standard health & safety guidance](#)

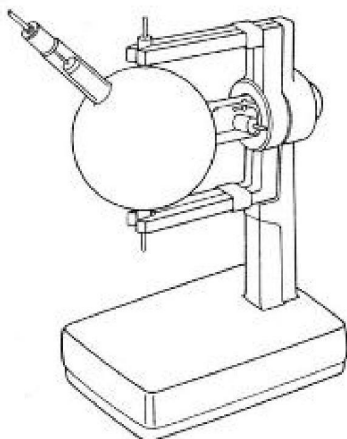
Procedure

Setting up

- a** Set up the Perrin tube in its special stand.
- b** Set up the coils – one on each side of the tube. Connect them in series with each other and with the 12-volt power supply (or battery, rheostat and the switch). Set the current in the coils as low as it will go and leave the coils switched off for now.
- c** Connect the gold leaf terminal of the electroscope to the terminal on the Faraday cylinder.
- d** Connect the 6.3 V supply to the filament. (Some EHT supplies available for school use incorporate this output.)
- e** Connect the negative terminal of the EHT supply to the filament and the positive terminal to the anode.

Carrying out

- f** Set the EHT voltage to zero and switch on the 6.3 V supply to the heater filament.
- g** Increase the voltage of the EHT supply. At about 3 kV, the electron gun produces a narrow circular beam of electrons which passes through the hole in the anode. You should be able to see a spot about 4 mm in diameter on the screen at the end of the tube.



h Switch on the coils circuit. Use the rheostat to steadily increase the current. The spot on the screen should be deflected more and more as the current in the coils increases.

i Increase the current until the beam is deflected into the Faraday cylinder. The charge is collected and it will produce an immediate deflection of the gold leaf in the electroscope.

j To test the nature of the charge deposited, the best arrangement is to use an insulated proof plane. Stand the proof plane on a sheet of paper, which itself lies on the bench. Momentarily touch the plane with a negatively charged rod e.g. by friction charging a piece of polythene. This will provide the plate with a considerable negative charge. Then use the plane to test the sign of the charge on the electroscope. (The gold leaf will fall.)

Teaching notes

1 The stream of electrons is deflected into a Faraday cage, which is connected to an electroscope, to show that electrons have a negative charge.

It is important that the whole beam should enter the cylinder to avoid the production of secondary electrons by the beam striking the sides. For this reason it is more reliable to use the coils to deflect the beam than to do the experiment with a bar magnet deflecting the beam.

2 You may find that the charge leaks away as soon as you remove the magnetic field that is causing the deflection. To prevent this happening, keep the lead from the Perrin tube to the electroscope as short as possible and avoid any sharp projections.