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Hall-Effect

Abstract

The Hall-effect is a phenomenon that occurs in metallic conductors when there is an electric current perpendicular to a magnetic field. A voltage perpendicular to current and field is observed. The voltage is inversely proportional to the charge carrier density in the material and is extremely small in metals. In 1879 Edwin Herbert Hall discovered and measured this voltage for the first time and it was named after him.

Introduction

A charge moving in a magnetic field experiences the Lorentz-force. This causes the charges of a current which would normally follow the electric field lines to drift also in the direction of that force until the redistribution of the charges in the conductor creates an electrostatic force of the same magnitude, but of opposite direction. In balance of the two forces the charges stop to drift and continue to follow the external electric field lines undisturbed. For a conductor of width d, charge carrier density n and current I with a perpendicular magnetic field B this results in a Hall-voltage

$$V_H = \frac{IB}{ned}.$$

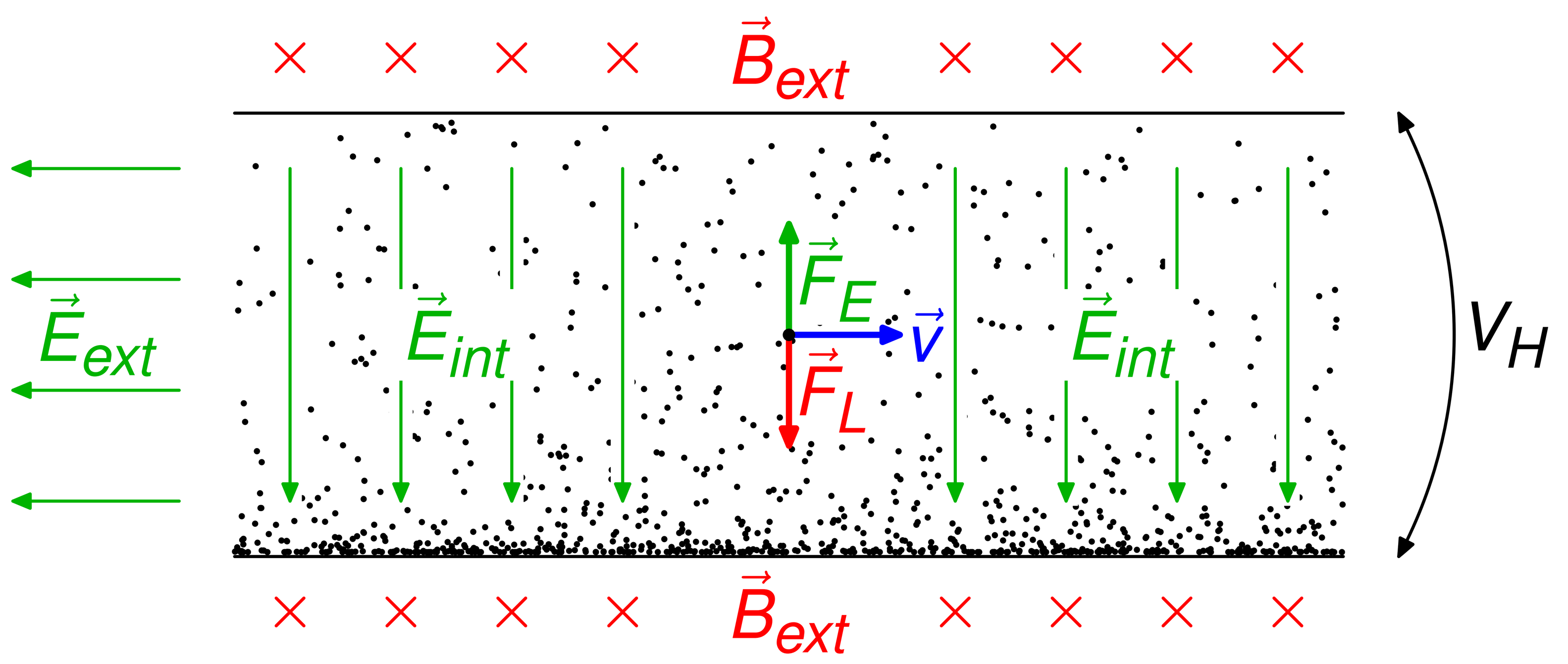

Figure 1: Force equilibrium in a conductor with magnetic field.

Measurement

In order to measure the Hall voltage in a metal (which has an extremely high charge carrier density: $n \approx 10^{28}\ \mathrm{m}^{-3}$) the magnitude of current I and magnetic field B have to be relatively large and the conductor should have a very small thickness d. Using practical values in a setup the Hall voltage will not exceed 1 mV. For this reason an elaborate measurement effort has to be made in order to measure the effect precisely.

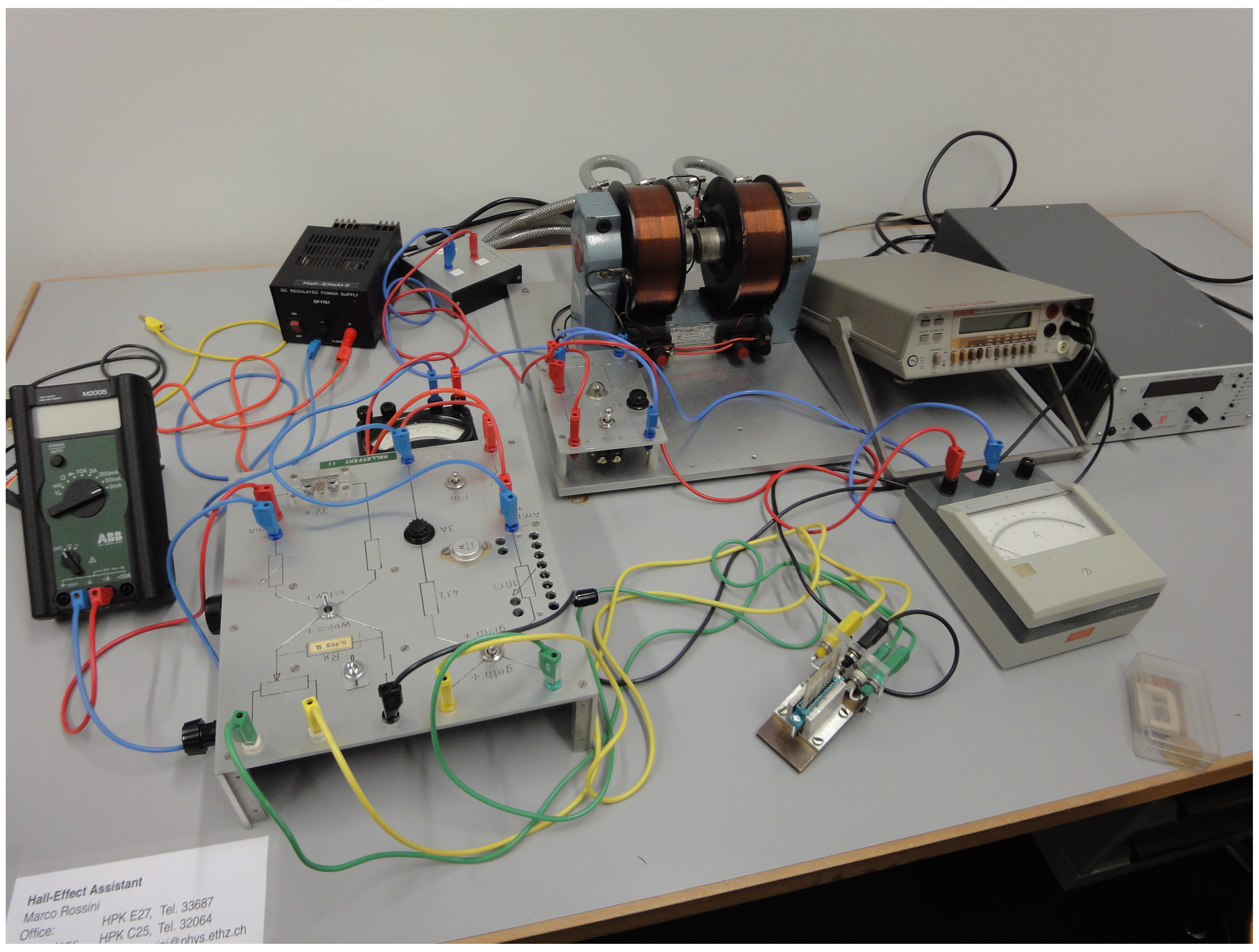

Figure 2: An elaborate setup is required to measure the Hall effect.

In this experiment the students learn not only about the Hall-effect but also what measurement device or circuit it takes to measure such small effects. They learn that the regular methods do not work and how to find a better method which takes into account the difficulties of measurement.

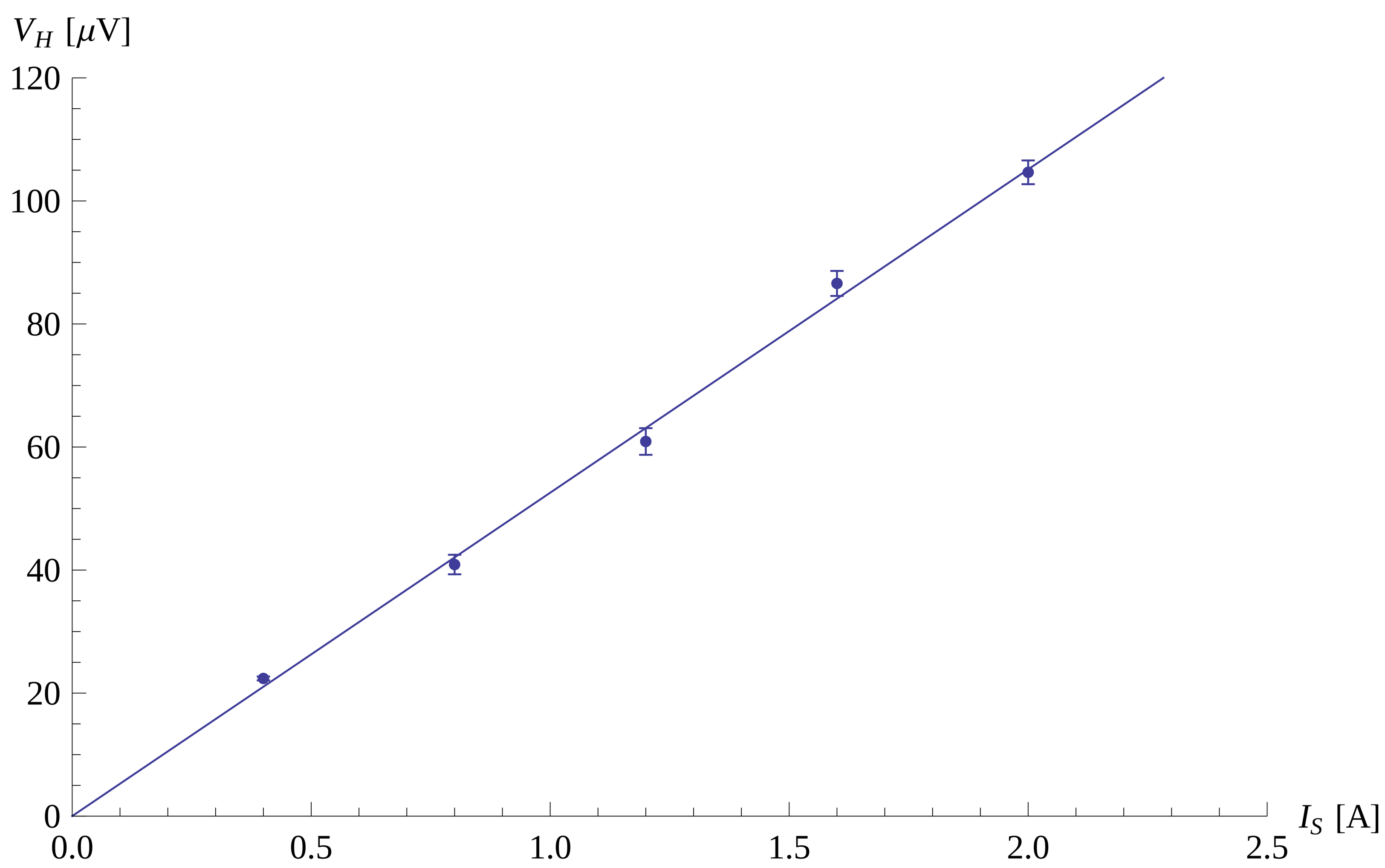

Figure 3: Example of a measurement showing the Hall voltage as a function of current.

The goal of the experiment is to determine the charge carrier density of a given metal such as silver using the formula and by measuring the Hall voltage at multiple current and magnetic field strengths.