MAGNETIC FIELD OF THE EARTH

EXPERIMENT PROCEDURE

- **Measure the angle of rotation of a compass needle initially aligned parallel with the horizontal component of earth's magnetic field when a second horizontal magnetic field is superimposed with the help of a pair of Helmholtz coils.**
- **Determine the horizontal component of the earth's magnetic field.**
- **Measure the inclination and vertical component and calculate the overall magnitude of the earth's magnetic field.**

OBJECTIVE

Determine the horizontal and vertical components of the earth's magnetic field.

SUMMARY

This experiment involves determining the inclination and magnitude of the earth's magnetic field as well as its horizontal and vertical components at the point where the measurement is made. The horizontal component of the earth's field can be found from the turning of a compass needle when an additional magnetic field is applied by means of a pair of Helmholtz coils. By measuring the angle of inclination, it is also possible to work out the vertical component and calculate the overall magnitude of the earth's magnetic field.

REQUIRED APPARATUS

Quantity	Description	Number
1	Helmholtz Coils 300 mm	1000906
1	DC Power Supply 0 – 20 V, 0 – 5 A (230 V, 50/60 Hz)	1003312 or
	DC Power Supply 0 – 20 V, 0 – 5 A (115 V, 50/60 Hz)	1003311
1	Digital Multimeter P1035	1002781
1	Inclination and Declination Instrument	1006799
1	Rheostat 100 Ω	1003066
1	Set of 15 Safety Experiment Leads, 75 cm	1002843

UE3030700

GENERAL PRINCIPLES

The earth is surrounded by a magnetic field generated by a so-called geo-dynamo effect. Close to the surface of the earth, this field resembles that of a magnetic dipole with field lines emerging from the South Pole of the planet and circling back towards the North Pole. The angle between the actual magnetic field of the earth and the horizontal at a given point on the surface is called the inclination. The horizontal component of the Earth's field roughly follows a line running between geographical north and south. Because the earth's crust exhibits magnetism itself, there are localised differences which are characterised by the term declination.

This experiment involves measuring the inclination and the absolute magnitude of the Earth's magnetic field along with the horizontal and vertical components of it at the point where the measurement is made.

The following relationships apply:

(1)
$$B_v = B_h \cdot \tan\alpha$$
α: inclination
B_h: horizontal component
B_v: vertical component

and

(2)
$$B = \sqrt{B_h^2 + B_v^2}.$$

It is therefore sufficient to determine the values B_h and α, since the other values can simply be calculated.

The inclination α is determined with the aid of an dip needle. In order to obtain the horizontal component B_h, the dip needle is aligned in horizontal plane in such a way that its needle points to 0° when parallel to the horizontal component 0°. An additional horizontal magnetic field B_{HH}, which is perpendicular to B_h, is generated by a pair of Helmholtz coils and this field causes the compass needle to turn by an angle β. According to Fig. 1 the following is then true:

(3)
$$\frac{B_{HH}}{B_h} = \tan\beta.$$

Diese Messung wird zur Verbesserung der Genauigkeit für verschiedene Winkel β durchgeführt.

EVALUATION

From equation (3) the following can be deduced:

$$B_{HH} = B_h \cdot \tan\beta.$$

The horizontal component Bh is therefore equivalent to the gradient of a line through points plotted on a graph of B_{HH} against tanα.

The magnetic field of the Helmholtz coils B_{HH} can be determined easily. Inside the pair of coils it is highly uniform and is proportional to the current *I* through either of the coils:

$$B_{HH} = k \cdot I \text{ with}$$

$$k = \left(\frac{4}{5}\right)^{\frac{3}{2}} \cdot 4\pi \cdot 10^{-7}\,\frac{\text{Vs}}{\text{Am}} \cdot \frac{N}{R}$$

N = 124: number of windings, *R* = 147,5 mm: radius

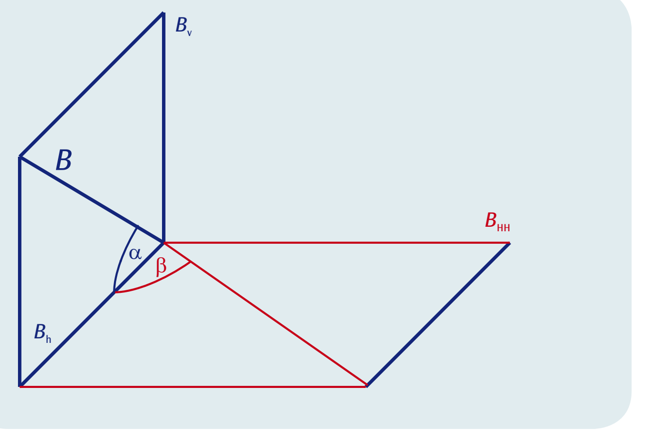

Fig. 1: Diagram of components of the magnetic fields observed in the experiment and definition of the corresponding angles

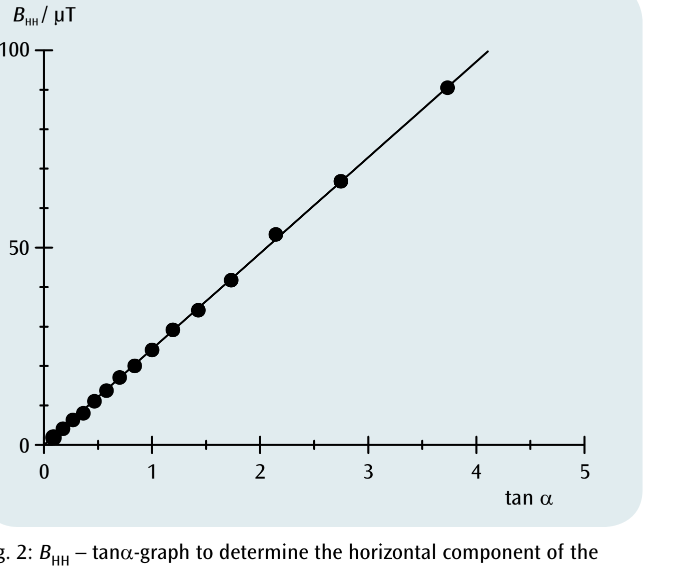

Fig. 2: B_{HH} – tanα-graph to determine the horizontal component of the earth's magnetic field