TU Dresden
Fakultät Physik
Physikalisches Grundpraktikum

Platzanleitung **MF**

Earth's Magnetic Field

1 Tasks

1. Determine the strength of the earth's magnetic field H_E in Dresden.
2. Determine the magnetic moment m^* and the magnetic polarization J^* of a permanent magnet.

2 General Remarks

- Handle modern rare-earth magnets with care – they are brittle and easily broken!
- Interference from neighboring workstations should be minimized (approx. 2 m separation). (Store magnets in an iron yoke when not in use).
- Note: Apart from natural fluctuations, the local field is strongly distorted by iron structures in the building (beams, radiators, etc.).

3 Notes on Experimental Procedure and Evaluation

Calculate H_h from the auxiliary quantities a and b with

$$a = m^* \cdot H_\mathrm{h} = \frac{4\pi^2 J_\mathrm{T}}{\mu_0 T_0^2}$$

and

$$b = \frac{m^*}{H_\mathrm{h}} = 2\pi\tilde{x}^3 \tan\delta^{(1)} = 4\pi\tilde{y}^3 \tan\delta^{(2)}$$

using

$$H_\mathrm{h} = \sqrt{\frac{a}{b}}$$

To obtain a

- Determine m (with a balance) as well as R and L (using a caliper gauge).
- Suspend the magnet horizontally on a long thread (verify north-south alignment); initiate torsional oscillations ($\hat{\alpha} \approx 6°$); measure 3 values for 30 oscillation periods T_0. Note: Older mechanical stopwatches contain iron. Therefore, keep a 1 m distance from the magnet during time measurements.

To obtain b

- With the magnet initially about 2 m away, align the adjustment bar with the compass: first in the east-west direction for the axial GP; later in the north-south direction for the equatorial GP. Then place the magnet **always in the east-west direction** at distance r ($\tilde{x}$ or $\tilde{y}$) measured from the center of the compass needle to the center of the magnet. Note: The distance markings on the adjustment bar are only rough reference values; measure the distances precisely!

- Determine the angles $\delta_1^{(1)}, \delta_2^{(1)}$ for the axial, and $\delta_1^{(2)}, \delta_2^{(2)}$ for the equatorial GAUSSian positions at distances $r_1 = 0.45\,\mathrm{m}$ and $r_2 = 0.60\,\mathrm{m}$.

$$\tan\delta_j^{(1)} = \frac{H_\mathrm{D}}{H_\mathrm{h}} = \frac{1}{2\pi}\frac{m^*}{r_j^3 H_\mathrm{h}}$$

$$\tan\delta_j^{(2)} = \frac{H_\mathrm{D}}{H_\mathrm{h}} = \frac{1}{4\pi}\frac{m^*}{r_j^3} H_\mathrm{h}$$

  Here H_D is the magnetic field of the bar magnet at the measurement location.

  Determine each value $\delta_j^{(i)}$ as the mean of the absolute values of the deflection angles for two identical measurements with the bar magnet rotated by 180° in each case. Remember, for a well-aligned compass the magnitudes of both angles should be equal.

- Calculate the auxiliary quantities $b_1^{(1)}$ and $b_2^{(1)}$ for the axial position:

$$b_1^{(1)} = \frac{m^*}{H_\mathrm{h}} = 2\pi r_1^3 \tan\delta_1^{(1)}$$

$$b_2^{(1)} = \frac{m^*}{H_\mathrm{h}} = 2\pi r_2^3 \tan\delta_2^{(1)}$$

  and $b_1^{(2)}$, $b_2^{(2)}$ for the equatorial position:

$$b_1^{(2)} = \frac{m^*}{H_\mathrm{h}} = 4\pi r_1^3 \tan\delta_1^{(2)}$$

$$b_2^{(2)} = \frac{m^*}{H_\mathrm{h}} = 4\pi r_2^3 \tan\delta_2^{(2)}$$

- For carefully performed measurements, the values for $b_1^{(1)}$, $b_2^{(1)}$, $b_1^{(2)}$ and $b_2^{(2)}$ deviate only slightly from one another. For larger deviations, repeat the measurements. Then calculate the mean value b and estimate its measurement uncertainty.

To determine the vertical component, set the compass needle of the "declinometer" first to a declination angle of zero (north-south), then rotate the needle axis from the vertical by 90° into the horizontal plane, after which the inclination angle β (can also be read after reversing sides) is observed.