16. Small Fields

Construct a device based on a compass needle to measure the Earth’s Magnetic Field.

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The importance

- Superficial
- Exterior Field (Van Allen Belt)

How to measure it

- Using the magnetic needle deviation
- Using the charge deviation
- Using a rotating coil
### Vectorial sum of two fields
- #1: Earth’s Magnetic Field
- #2: A field of known intensity and direction

### Biot-Savart Law
- Intensity and direction the magnetic field in a coil
- Linear relation between the current in a coil and the tangent of the deflection angle.

### Mathematical Model

### Practice
- Electric Circuit
- Data acquisition (current and deflection angle)
- Linear regression
- Final value of the Earth’s magnetic field
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The Method

1. Measure the current
2. $B_{coil}$
3. Biot-Savart Law
4. $\text{tg}(\theta)$
5. Measure the angle $\theta$

Process:
- Graphic
- Linear Regression
- Inclination
- $B_{Earth}^H$
- $B_{Earth}$
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Development - Theory

- Deviation
- Biot-Savart Law

\[
\alpha = \cos B
\]

\[
\hat{B}_{\text{Earth}} \hat{r} = \mu I \theta B_{\text{Earth}} t g \theta
\]

\[
\left(90. \frac{\mu_0}{2r}\right) I = \left| B_{\text{Earth}} \right| t g \theta
\]

\[
\left| B_{\text{Earth}} \right| = \frac{B_{\text{Earth}}}{\cos \alpha}
\]

\[
B_{\text{TOT}} = B_{\text{EV}} + B_{\text{EH}}
\]

\[
\alpha
\]
Materials

Set up

Collected Data
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Development - Experiment

- Photos
- Video
### Table of Data (increase of current)

<table>
<thead>
<tr>
<th>Current ($I$) [mA]</th>
<th>Angle ($\theta$) [$^\circ$]</th>
<th>$\text{tg } \theta$</th>
<th>Magnetic Field of the Coil ($B_{coil}$) [$\mu T$]</th>
<th>Horizontal component of the Earth's Magnetic Field ($B_{EarthH}$) [$\mu T$]</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1,732</td>
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</table>
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Experiment - Error Sources

- Other Magnetic Sources and interference in the Net Field
- The Geometry of the model
  - Magnetic needle is an extensive body
  - Geometric center of the coil
- Imprecisions in the measurement of the angle and current
- Friction in the magnetic needle
- Parallaxes
Comparison with a theoretical value

\[ \left| \mathbf{B}_{ET} \right| = 23.18 \, \mu T \]
\[ \left| \mathbf{B}_{ET} \right| = 23 \, \mu T \]
\[ \left| \mathbf{B}_{ET} \right| = 24.46 \, \mu T \]

Good theoretical model