OERSTED'S EXPERIMENT AND THE INTENSITY OF EARTH'S MAGNETIC FIELD

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1. Introduction

Force field theory, which interprets the interactions between different objects, states that there are three main types of force fields: Gravitational field, electric field, and magnetic field. This paper focuses on Earth's magnetic field in relation to its importance to the protection of all living creatures from deadly cosmic rays. In 1600, William Gilbert was the first to prove that Earth has a magnetic field of its own [1]. However, the intensity of this field was not measured until the end of the 18th century. The aim of this study is to use Oersted's electromagnetic theory to calculate the intensity of the horizontal component of Earth's magnetic field and compare it to its theoretical value [2].

2. Experimental Setup

In this experiment, the intensity of Earth's magnetic field can be calculated using a circular wooden base surrounded by insulated wires, a power supply, a switch, an ammeter, and a compass placed in the middle of the wooden base and oriented in the north-south direction. The electric current flowing in the wires produces a magnetic field whose intensity can be calculated using the following formula:

$$B_0 = k_m \frac{2\pi I}{R} N \qquad (1)$$

Where k_m is equal to $10^{-7} \frac{N}{A^2}$, I is the electric current flowing through the wires, R is the radius of the wooden base, and N is the number of coils around the wooden base.

The intensity of Earth's magnetic field can be related to B_0 as it is perpendicular to it and the angle of deflection of the magnetic needle due to B_0 is equal to φ:

$$B_{Earth} = \frac{B_0}{\tan\varphi} \qquad (2)$$

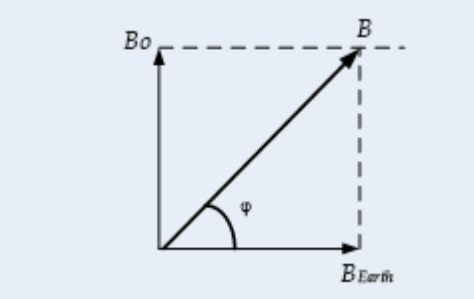

Figure 1 – The relation between the vectors B_0 and B_{Earth}

3. Results

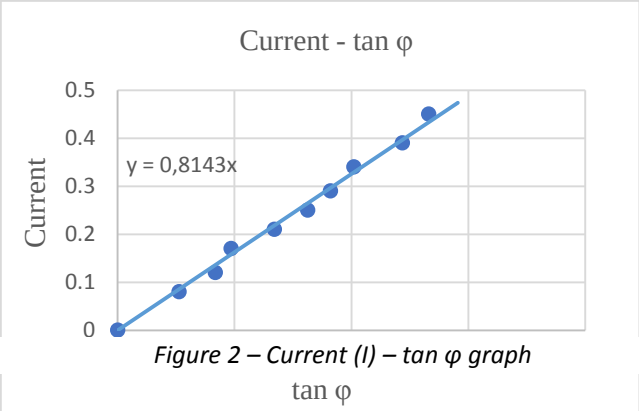

Figure 2 – Current (I) – tan φ graph

From the graph above, it can be correctly concluded that the intensity of the horizontal component of Earth's magnetic field is equal to 25.58μT, while according to the arithmetic mean of the observations made it is equal to 25.09μT. The theoretical value of the horizontal component of Earth's magnetic field is equal to 25μT and, therefore, the experimental error of both the observations and the graph is equal to 0.36% and 2.3% respectively. This error could be due to incorrect observation of the angle of deflection, inaccurate placement of the compass in the north-south direction, or experimental error due to the Ohmic resistance of the wires.

4. Conclusion

The experiment was successfully conducted and the conclusions are:

a. Oersted's experiment was verified as the electric current was observed to produce a magnetic field.

b. The existence of Earth's magnetic field was verified as the compass was oriented in the north-south direction.

c. The observations of this experiment were very close to the theoretical value of the intensity of the horizontal component of Earth's magnetic field.

5. References

[1] McElhinny, M. W., and Phillip L. McFadden. *The magnetic field of the earth: paleomagnetism, the core, and the deep mantle*. Vol. 63. Academic Press, 1998.

[2] Snelders, H. A. M. "Oersted's discovery of electromagnetism." *Romanticism and the Sciences* (1990): 228-40.