PHY 4210-01 Senior Lab
Lab M-1: Magnetic Field Mapping

Sarah Arends
Jacquelyne Miksanek
Ryan Wojtyla

Instructor: Jerry Collins II

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Abstract

In this experiment the magnetic field inside a Helmholtz coil was measured and compared to theoretical calculations determined from the Smythe derivation of the Biot-Sarvat Law for a plane displaced from the central axis, with coordinates z, ρ, and ϕ.

Contents

1 Objective of the Experiment

During this lab, the number of turns of wire inside a Helmholtz coil was determined for use in theoretical calculations. Then a 3-dimensional and 2-dimensional mapping of the magnetic field inside the Helmholtz coil was created in order to investigate the presence of a uniform field, running along its axial direction.

2 Theory of the Experiment

Recall for a straight current-carrying wire, circular magnetic field lines are generated around the wire in accordance with the curling right-hand rule. The Helmholtz coil contains two regions of circularly wound wires. Due to the the circular symmetry, all components of each infinitesimal segment of the wire will cancel *except* for that in the axial direction. In summary, a circular current produces a linear magnetic field.

3 Equipment Utilized

A DC Gaussmeter (AlphaLab Model GM-1-HS) was connected to a Hall Effect Probe in order to measure the field strength inside the Helmholtz coil. The Hall Effect Probe contains a semiconductor junction that, when exposed to a magnetic field, produces a voltage proportional to the field strength.

The position of the Hall Effect Probe can be modified in the ρ direction by sliding the ruler bar through the acrylic cube shown in figure **??**. The position can be modified in the ϕ direction by rotation the ruler bar about the central pole. However, for the sake of this experiment, this did not have to be modified because measurements were taken in a single ρ, z plane. The z coordinate was modified by sliding the acrylic cube and ruler bar up and down the central pole.

4 Procedure

Note that, per suggestion of the laboratory manual, the procedural steps of this experiment have been omitted. The discussion section provides sufficient detail on what actions were taken.

4.1 Data Analysis

5 Results

5.1 Comparing the directions of the Magnetic Field

When measuring at a probe height of a/2 (16cm), where 'a' is the separation distance between the coils, the strength of the magnetic field in the 'z' direction was measured to be -3.13 Gauss. When measuring t he magnetic field in the 'z' direction at a probe height of 5cm, the magnetic field strength was measure d to be -3.28 Gauss. These results follow with the theory as it is expected that the magnetic field is p ropagated in the 'z' direction. The measured magnetic

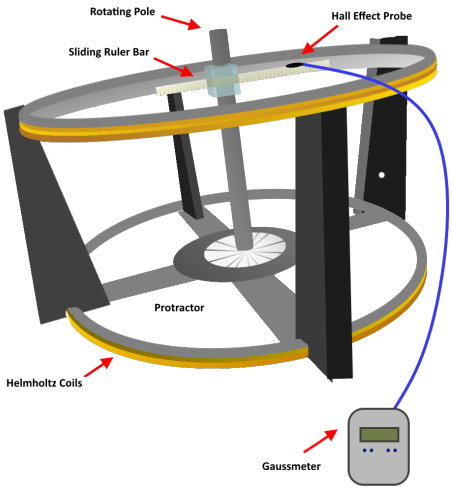

Figure 1: Two concentric Helmholtz coils seperated by a distance equal to their radius. Rotating pole and sliding ruler allow for modification of the probe's position.

field strength for the ρ direction was -0.46 and -0.05 Gauss for a probe height of 16cm and 5cm respectfully. The measured magnetic field strength fo r the ϕ direction was -0.51 and -0.31 Gauss for a probe height of 16cm and 5cm respectfully. For a probe height of 16cm the percentage for the magnitude of the magnetic field that is measured to be in th e ρ direction is 14% while the percentage for the magnitude of the magnetic field that is measur ed to be in the ϕ direction is 16%. For a probe height of 5cm the percentage for the magnitude o f the magnetic field that is measured to be in the ρ direction is 1% while the percentage for th e magnitude of the magnetic field that is measured to be in the ϕ direction is 9%.The magnetic f ield produced by the Helmholtz coils should be directed along the 'z' axis. These small measuredvalues f ollow the aforementioned theoryand we can determine that the magnetic field produced by the Helmholtz c oil is indeed axial. Furthermore, we can determine thatthe magnetic field is axial along the 'z' direct ion.

6 Conclusion