COLLEGE OF ENGINEERING
THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

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Pulsed Power Diagnostics for Fusion Propulsion Experiments

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Introduction

A major obstacle of interplanetary exploration is the extensive travel time. In order to make these missions routine, advanced propulsion methods must be developed. UAH is establishing a fusion propulsion laboratory within the Propulsion Research Center and the Aerophysics Research Center. Currently, a 3kJ pulsed power machine called the 'Can Crusher' is operational and a 60kJ, 1MA pulser is under development. As the magnitude of pulsed power experiments in our laboratory increases, simple methods for measuring voltage, magnetic field, and current begin to fail. Therefore, a more reliable approach is necessary. Magnetic field probes ($\dot{B}$) were constructed and calibrated to resolve this issue.

Method

The $\dot{B}$ probes consist of copper wire coiled around a nylon bolt. In our experiments, the probes are used measure the induced voltage of a time-varying magnetic field directly related to the current of the circuit. The voltage is observed on an oscilloscope and digitized for calculations.

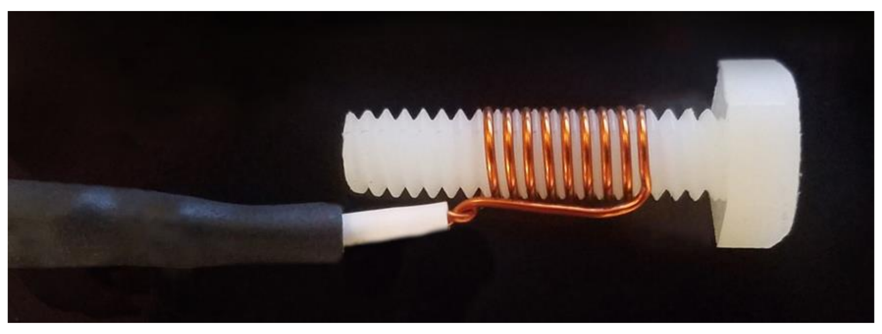
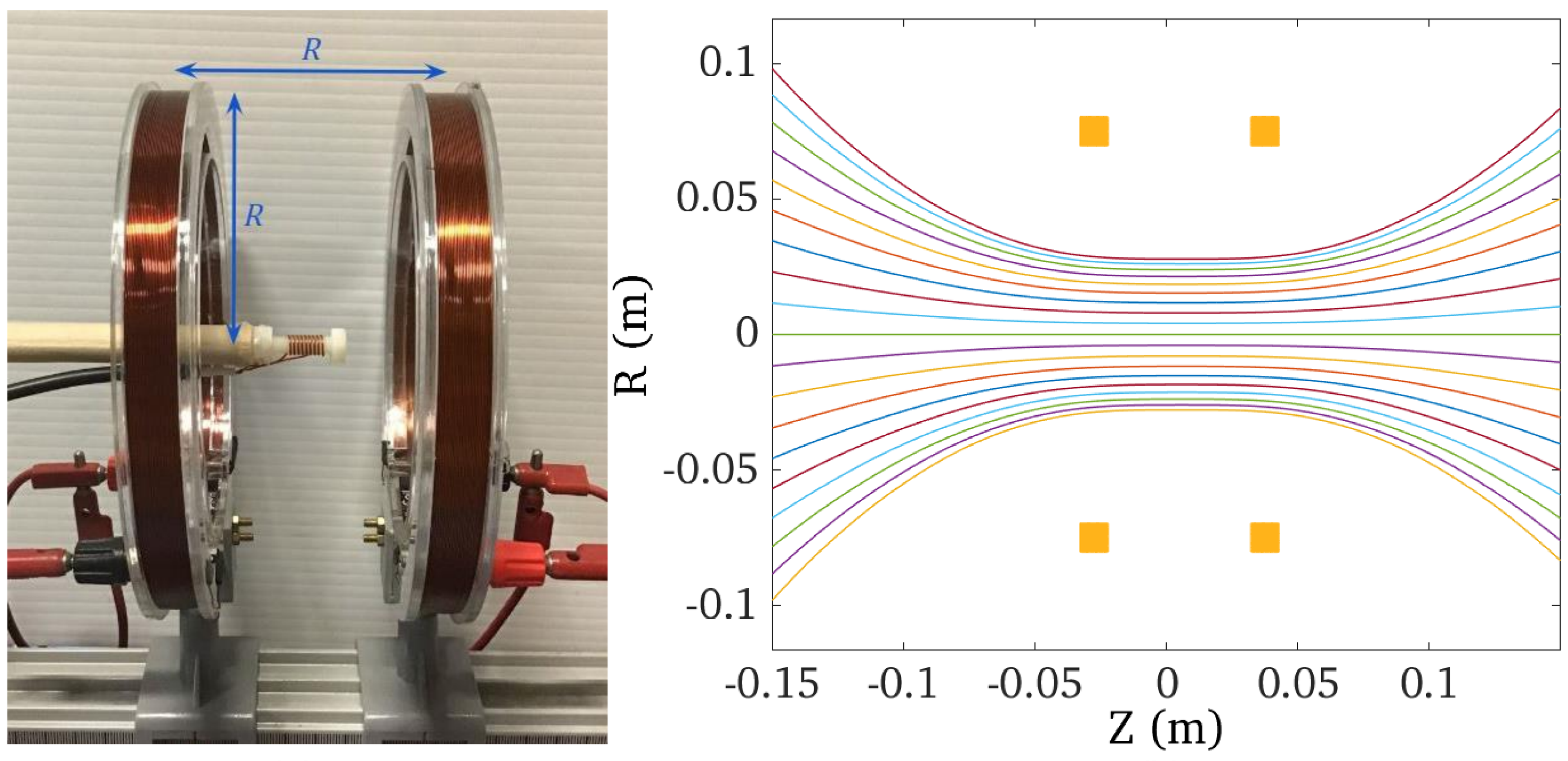


Figure 1. $\dot{B}$ probe soldered to a coaxial cable incased in heat shrink tubing.

A Helmholtz coil is commonly used to calibrate probes due to its ability to generate a predictable and uniform magnetic field. The $\dot{B}$ probe was placed as shown in figure 2a, and an experimentally determined calibration factor of the probe was derived.



(a) (b)

Figure 2. (a) Helmholtz coil of radius R, separated by a distance of R, and $\dot{B}$ probe alignment (b) simulation of the magnetic field produced by Helmholtz coil.

Results

The calibration factor of the probe was found to be 0.523 *turn*-m^2. To determine the probe's accuracy, a Pearson probe was also used to measure the current through the Helmholtz Coil. There was a 10% discrepancy in the calculated magnetic field as shown in figure 3.

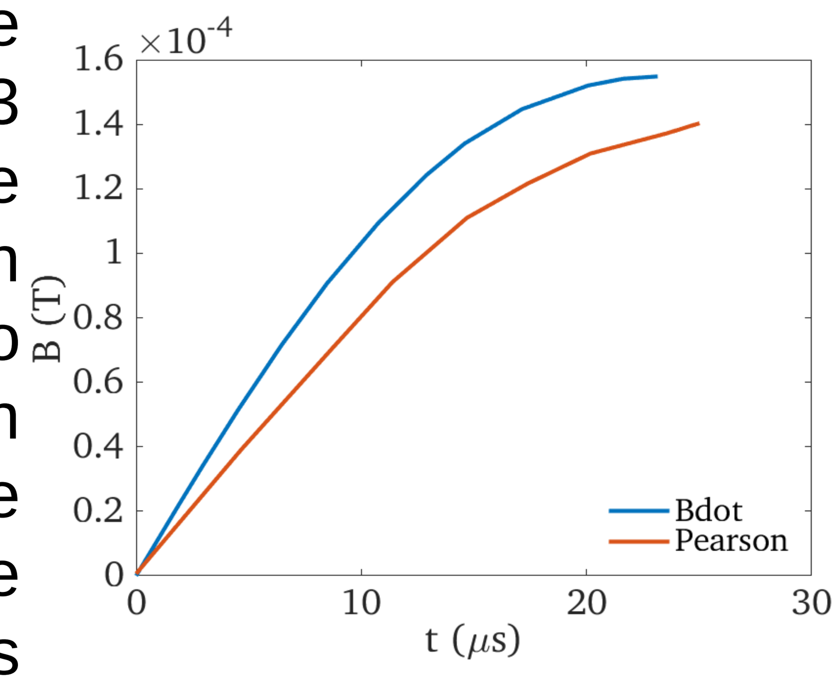
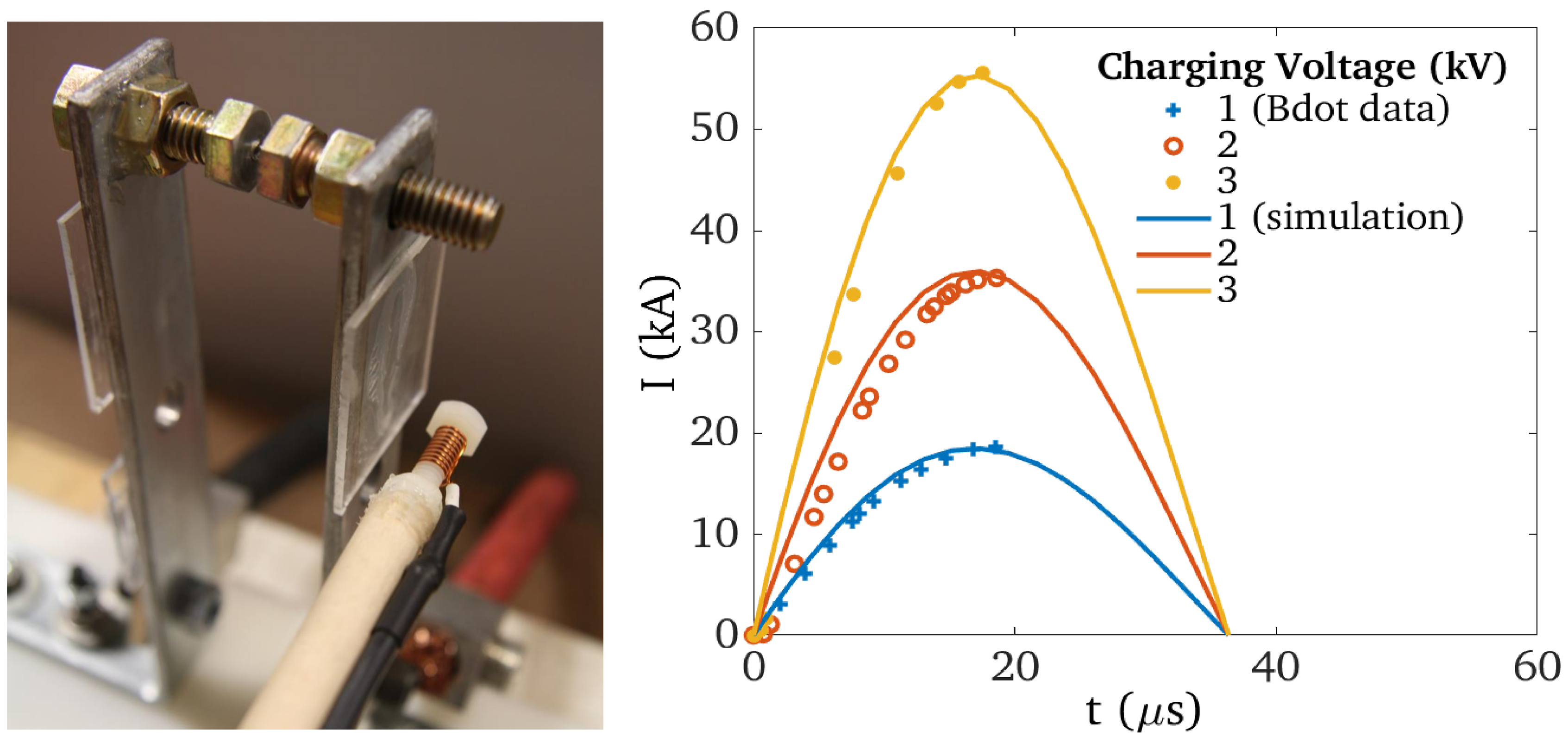


Figure 3. Magnetic field comparison of the Pearson and $\dot{B}$ probes.

The Can Crusher was operated at initial charging voltages of 1, 2, and 3kV. Figure 4a shows the $\dot{B}$ probe placement on the outside of the transmission line. Calculations were performed and the probe data was scaled in order to closely match simulated values. The peak currents were found to be 18, 36, and 55kA respectively.



(a) (b)

Figure 4. (a) Transmission line with $\dot{B}$ probe placement and (b) comparison of scaled $\dot{B}$ probe data and RLC simulated data.

Conclusion & Future Research

This project consisted of constructing and calibrating magnetic field probes to measure the voltage, current, and magnetic field of pulsed power experiments. The $\dot{B}$ probes will be scaled and paired with a Rogowski coil to provide diagnostics of larger experiments, including the 60kJ pulsed power machine. With these adjustments, we hope to generate more accurate measurements so that simulations are not relied upon in our upcoming experiments.

Acknowledgements

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