Sigma Pi Sigma Research Grant

Interim Report

Northern Virginia Community College

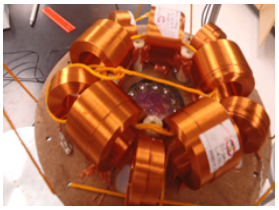
Advisor: Walerian Majewski

This past spring semester has been a very productive one, thanks to the Sigma Pi Sigma grant we received for our research. Though spring is more a time for seminars and community outreach, we were able to create one new experiment and improve two others from last semester. These experiments and the data obtained were presented at several conferences, all of which increased community awareness of SPS activities and also garnered professional interest in our society.

As the spring semester began, one of our first priorities was to construct an experiment that could approximate a linear form of inductive magnetic levitation. Using the Sigma Pi Sigma grant, we were able to purchase 30 Jantzeen 5.0mH 20AWG air core copper inductors at a cost of $455.15. As shown in Figure 1, an unbroken line of coils was placed circumferentially around a wooden disk. With this experiment we were able to further explore the inductive magnetic levitation effect. For the project involving the circular Halbach array, we were able to use some of the coils mentioned above to modify the original coil array (Shown in Figure 2). This allowed us to begin studying and separating what aspects of the experiment are a result of the arrangement of the coils and which are common to any circular inductive magnetic levitation system. We also purchased an aluminum base (not pictured) for another coil array at a cost of $38.25. The results from these experiments which were made possible by our grant were presented at three separate professional conferences during the spring.

(Figure 1)

(Figure 2)



The first of three conferences was the March 2013 meeting of the American Physical Society in Baltimore, Maryland. The conference was the largest gathering of physicists in history to date. Here, NOVA Annandale's SPS was able to present posters displaying our research alongside professional researchers from the world over (see Figure 3). This was a great opportunity for us to experience what cutting-edge technology is being developed in multiple fields of study but it also served for us to let these researchers (some of whom were also educators) know about SPS and what we're all about.

(Figure 3)

The second conference we attended was a meeting of the American Association of Physics Teachers, Chesapeake Section (CSAAPT) (see Figure 4). This was a unique seminar because many of the presentations focused on how to improve physics education. The main talk actually even centered on how to set up and encourage undergraduate research at educational facilities.

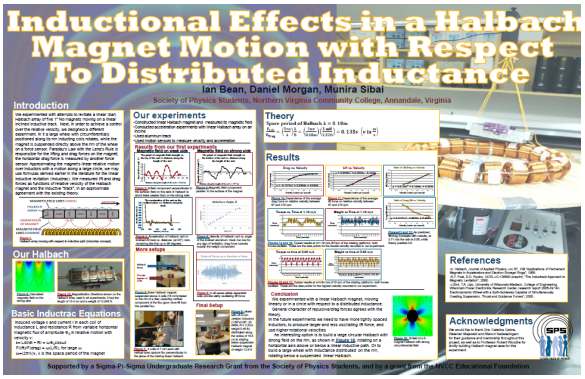
(Figure 4)

Being able to trade thoughts about the research we did but also the challenges and rewards of undergraduate research itself was truly an enriching experience. Through talking to these educators we were able to objectively view our position and opportunities at being exposed to research so early in our academic careers.

Finally, we were invited by the SPS branch of Towson University to present our research and also view their presentations. In addition to hosting the entire gathering, they graciously provided breakfast and lunch for all attendees. We were able to compare and contrast our methods of research with those of our contemporaries. It was also good to reach out and make acquaintance with others involved in SPS and over all this was a very nice experience for our group and a pleasant note to end our series of presentations on. In conclusion, the spring semester for NOVA Annandale's SPS was an extremely successful one. From construction of experimental materials, to research, analysis, and community outreach, we set multiple goals and achieved them all (although there's always more research to be done!). This was all made possible by the funds that were generously provided by the Sigma Pi Sigma society. As for the fall semester, we have plans to create at least one new experiment to further probe possible applications of inductive magnetic levitation, the funds for which will be pulled from the remaining grant funds. We're all very excited to see what surprises and opportunities our activities will provide us with next semester. Included below are copies and excerpts from the posters that were presented at the APS Baltimore conference and the Towson SPS zone meeting. All projects and posters were supported by our advisor Dr. Walerian Majewski, with support from Dr. Catalina Cetina. Construction of the experiments was helped by Dr. Robert Woodke and funds were generously supported by Sigma Pi Sigma, the physics honor society.

Inductional Effects in a Halbach Magnet Motion with Respect to Distributed Inductance

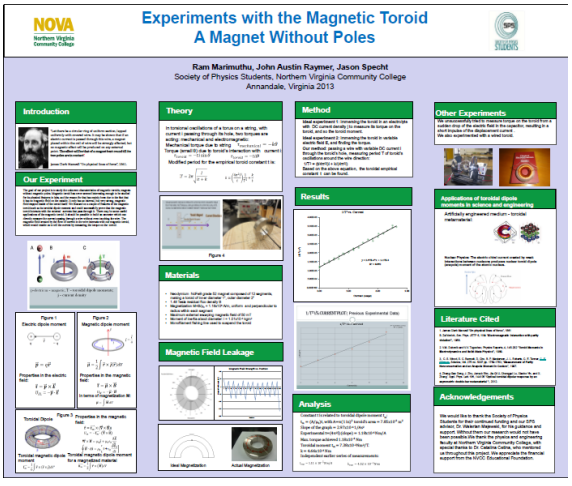
By: Daniel Morgan, Munira Sibai, and Ian Bean.



We experimented with attempts to levitate a linear (bar) Halbach array of five 1" Nd magnets moving on a linear inclined inductive track. Next, in order to achieve a control over the relative velocity, we designed a different experiment. In it a large wheel with circumferentially positioned along its rim inducting coils rotates, while the magnet is suspended directly above the rim of the wheel on a force sensor. Faraday's Law with the Lenz's Rule is responsible for the lifting and drag forces on the magnet; the horizontal drag force is measured by another force sensor. Approximating the magnet's linear relative motion over inductors with a motion along a large circle, we may use formulas derived earlier in the literature for the linear inductive levitation (Inductrac). We measured lift and drag forces as functions of relative velocity of the Halbach magnet and the inductive "track," in an approximate agreement with the existing theory.

Experiments with the Magnetic Toroid A Magnet Without Poles

By: Ram Marimuthu, John Austin Raymer, and Jason Specht

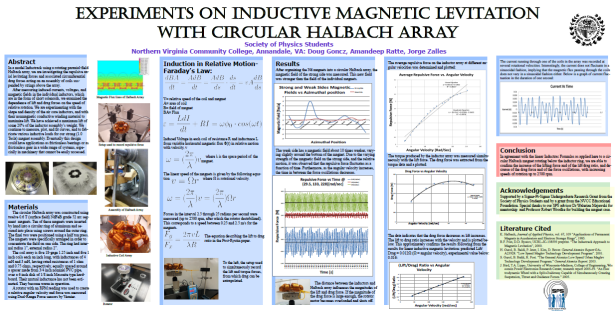


The goal of our project is to study the unknown characteristics of magnetic toroids, magnets without magnetic poles. Magnetic toroid has never seemed interesting enough to be studied for its physical features in labs, and the reason for that has mainly been due to the fact that it has no magnetic field on the outside. It only has an internal, but very strong, magnetic field trapped inside of the toroid itself. We focused on a couple of features of the magnetic toroid such as its toroidal dipole moment and could successfully prove that the magnetic toroid interacts with the external currents that pass through it. There may be some useful applications of the magnetic toroid. It should be possible to build an ammeter which can directly measure the current passing through a wire without even touching the wire. The magnetic field created by the flow of current in the wire interacts with our magnetic toroid, which would enable us to tell the current by measuring the torque on the toroid.

Experiments on Inductive Magnetic Levitation

With Circular Halbach Array

By: Doug Goncz, Amandeep Ratte, and Jorge Zalles



In a model Inductrack using a rotating paraxial-field Halbach array, we are investigating the repulsive axial levitating forces and associated circumferential drag forces acting on an assembly of coils suspended by strings above the array. After measuring induced currents, voltages, and magnetic fields in the individual inductors, which are in the form of short solenoids, we examined the dependence of lift and drag forces on the speed of relative rotation. We are experimenting with the shape and density of the air core inductors, and with their nonmagnetic conductive winding material to maximize lift. We have achieved a maximum lift of some 20% of the inductor assembly's weight. We continue to measure, plot, and fit curves, and to fabricate various inductive loads for our strong (1.0 Tesla) magnet assembly. Eventually this design could have applications as frictionless bearings or as frictionless gear in a wide range of systems, especially in machinery that cannot be easily accessed.