1-1-2020

Electric Field Proximity Measurements for Pulsed Power Safety in Fusion Propulsion Experiments

Jason Cassibry
University of Alabama in Huntsville

1. Electric Field Proximity Measurements for Pulsed Power Safety in Fusion Propulsion Experiments

2. Faculty or Research Mentor

Jason Cassibry
Associate Professor
Mechanical and Aerospace Engineering
Propulsion Research Center
Jason.Cassibry@uah.edu
(256) 824-5107
OKT S231
University of Alabama in Huntsville

3. Proposal Identifier: RCEU20-MAE-JTC-01

4. Project Description

Our research program endeavors to develop the technologies required for fusion propulsion, enabling rapid, human piloted trips to Mars. Journeys to Mars will be possible with existing chemical propulsion technologies, but the journey takes 2 years to complete. The long duration in deep space exposes astronauts to debilitating microgravity effects on skeletal and muscle tissue and increases the risk of cancer from prolonged radiation exposure naturally occurring in space. Fusion can enable this trip with a roundtrip time of 4 months, making the trip to Mars both safe and routine.

A fusion propulsion laboratory is currently being developed at UAH within the Propulsion Research Center (PRC) and the Aerophysics Research Center (ARC). We now have operational a 5 kJ pulsed power machine and are refurbishing a 60 kJ machine we call Sparky. One of our graduate students, Jacob Kinsey, is studying radiation shielding for his Master's thesis. His research supports ongoing collaborative research with NASA MSFC on a pulsed fission/fusion hybrid propulsion concept, as well as a couple of other pulsed fusion efforts. One of the important aspects of safe operation is confirmation that the machine is at 0 V once the experiment has been conducted, and we desire non-contact meters as a double check against our volt meters monitoring the voltage. The undergraduate student will Mr. Kinsey, the PI, and the staff in conducting the experiments. The student will work with Mr. Kinsey in the construction of AC and DC electric field meters. These meters will be used in proximity to Sparky and will be designed to sound an alarm if the machine still has a nonzero voltage. The student will work with the PI, Dr. Cassibry, and our staff in the construction and testing of these probes. Both types (AC and DC) are inexpensive and fairly simple to build. The funding to purchase hardware will come from other sources. This student will be in the critical research path, and we will work closely with him/her to ensure success.

5. Student Prerequisites

Applicants need to have completed their first year of school by Summer 2019 and be a declared

major in aerospace engineering. The applicant is expected to have a 3.2 GPA. A U.S. citizenship is required in order to access the lab, located on the Redstone Arsenal. Required coursework includes Physics I and Calculus B. Some experiments with circuits (coursework and/or labwork) are prefereable. The rest of the work will be taught on site, and the PI and the graduate student will work the the RCEU student to learn what is necessary in order to be successful. Preference will be given to a student with demonstrated (coursework or other) good interpersonal communication and writing skills. The reasons are two-fold. We emphasize scholarly activity through the dissemination of our research work through presentations, conference papers, and journal articles, and we expect the student to participate in this process with us. Second, clear communication and interpersonal skills are paramount for safe operation in a high voltage laboratory environment. The latter skill goes beyond verbal communication to include tone, facial expressions, etc, which are important to help perceive if someone is not focused on the tasks and ultimately being unsafe.

6. Student Duties, Contributions, and Outcomes

The student will be taught how to solder, and construct a probes. These are simple devices which measure electric field without contacting the machine. He/she will learn how to calibrate the probe output. Next, the student will build two types of probes, one for measuring static electric fields and one for measuring A/C fields. He/she will be taught how to design these probes and test for frequency response and field strength. Calibrations will be performed using an ESR meter which has a calibrated measurement for low frequency fields. The PI and graduate student will work closely with the RCEU student to complete these tasks successfully. Specific duties include the documentation of the probes he/she constructs, collection of data, and and determination of calibration factors and sensitivity against known voltage sources we test. The student will also assist in providing inputs for presentations and conference papers using these data, and will lead on his/her poster for the von Braun symposium in the Fall of 2020. We have had success in this approach, as this summer one of our students, Shelby Westrich, won a best paper award in engineering. The student will be collaborating with her this coming year as well, leveraging her previous experience and success supported by the RCEU program.

There will be numerous contributions made by the student in this project. Construction of and use of these diagnostics is straightforward, but serves a critical role in providing a redundant safety feature of warning users about potential voltage hazards. At no point will we be putting anyone at risk, as the tests will be conducted at safe levels. Tests involving our electric field probes with the machine at dangerous levels can be performed remotely with all users at a safe distance. The students work will benefit the faculty by providing data for a publication in the Journal of Propulsion and Power coupled with the data from Mr. Kinsey, which we anticipate submitting in Fall of 2020 after performing the work. We will use the data from the student's independent work in follow on proposals with our NASA colleagues.

Specific outcomes for the RCEU student are related to the development and use of diagnostics, calibration, and dissemination of the work through scholarly activities. Specifically, these diagnostics are common to virtually any advanced propulsion concept appropriate for rapid interplanetary space travel. More generally, the student will learn the value of calibration to have confidence in the output of measurements. In addition to the hands on laboratory experience, the student will be lead author on a paper presented at the Fall 2020 von Braun Symposium and will be a coauthor on the conference paper based on Mr. Kinsey's research.