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Optical Isolation in Fusion Propulsion Experiments

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1. Optical Isolation in Fusion Propulsion Experiments

2. Faculty or Research Mentor

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3. Proposal Identifier: RCEU20-MAE-JTC-02

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. In safe operation of a pulsed power machine which is charged to 40,000 Volts, the controls are best implemented in a way that completely eliminates an electrical path from the machine to the people. An economic way to do this is to modify some older sfp+ transceivers. These devices are available at low cost, and used to be used for data transfer in servers and can handle large amounts of data throughput. These modules send and receive signals over long distances. The student will be responsible identifying the appropriate hardware with help from the PI, assembling the transceivers and fiber optical cable, and successfully transmitting and receiving square wave trigger signals and synthetic data. These tests will then inform how to trigger the pulsed power bank remotely, which we plan to implement also with the help of the RCEU student. 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 use signal generators and oscilloscopes, and how to assemble fiber optic lines and transceivers to optically isolate diagnostic and control cables. He/she will learn how to calibrate the probe output by measuring known signals before and after being transmitted across the fiber optic line. Next, a signal generator will be used for simulating magnetic field and voltage probe output on a storage scope which will then be transmitted down the fiber optic lines to a computer. Before and after transmission comparisons will inform our team how the transceiver method of optical isolation may affect the data. Finally, the student will send square wave pulses along fiber optic lines to trigger the discharge of low voltage capacitors. The technique will be adapted by the team to fire high voltage capactors. The PI and graduate student will work closely with the RCEU student to complete these tasks successfully. 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. First, the student will be helping to electrically isolate the experiments from the operators, which is important for safe operation of our pulsed power equipment. Next, the student will provide qualitative comparisons of data before and after transmission to assure the quality of the transmitted signals are not degraded. 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. The data will be from instruments developed by other students and transmitted from the machine to data acquisition tools safely located away from the experiments. 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. He/she will learn the value of calibration to have confidence in the measurements. 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.