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Preparing a Gamma Ray Instrument for Space Flight

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RCEU 2022 Project Proposal

Project Title

Preparing a Gamma Ray Instrument for Space Flight

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I. Project Description

Terrestrial Gamma-ray Flashes (TGFs) are very brief (sub-ms) and extremely intense pulses of gamma-rays associated with thunderstorms and generally observed by space-based instruments in low Earth orbit. Electrons in the atmosphere are accelerated to high energies by electric fields within thunderstorms. When these electrons encounter the electric fields of atomic nuclei, their paths are bent, and they emit gamma rays in the process known as bremmstrahlung.

The Terrestrial RaYs Analysis and Detection (TRYAD) Cubesat project is designed to distinguish between the two leading theories for the origin of Terrestrial Gamma-ray Flashes (TGFs). One theory for TGFs is that the electron acceleration takes place in large-scale fields in thunderstorms. Another idea is that the acceleration takes place in the intense fields at the tips of lightning leaders. For the large-scale theory, the acceleration would tend to be parallel so that the TGF beams would typically be narrow. On the other hand, the electric field of a lightning tip diverges from a point and rapidly changes direction as the lightning propagates. This would naturally produce a broad beam.

TRYAD consists of a pair of 12U CubeSats and is a collaboration between UAH, Auburn University and NASA/GSFC, with UAH and Auburn funded by the National Science Foundation. UAH is responsible for the gamma-ray detectors, GSFC is contributing electronics designs and Auburn is responsible for the spacecrafts.

We are developing TRYAD for a novel NSF funded CubeSat mission that will enable unique measurements of TGFs. Our methods require multiple CubeSats to be flown in low Earth orbit at controlled distances of a few tens of kilometers. This will allow us to make simultaneous measurements of a TGF across the beam profile which has never been accomplished in a controlled manner. This is the most direct way to constrain models of TGF production.

TRYAD development has been underway for several years. In Summer 2018 a student team successfully tested all components of the detector. During the 2018-2019 academic year, we made several changes to the design to mitigate issues that came up in the practical assembly and operation of the detector. In the 2020-2021 academic year we assembled an engineering unit using flight ready hardware. Initial testing uncovered a few issues that should be resolved before the summer of 2022.

The goal for the summer of 2022 is to assemble and test the two gamma ray instruments that will fly to low Earth orbit.

II. Student Duties, Contributions, and Outcomes

a. Specific Student Duties

The student will learn how the gamma ray instruments are assembled and learn how to test a gamma ray detector using weak radioactive sources. The student will be responsible for recording data from the instrument and determining the instrument's performance. We are planning to travel to Auburn for instrument integration and testing at the end of the summer.

b. Tangible Contributions by the Student to the Project *(10% of Review)*

Understanding how a gamma ray instrument responds to radiation is essential for interpreting the data that is obtained during operation in space. With the instrument response, we can use the counts detected in the instrument to predict the gamma rays produced in the TGF. It will be the student's responsibility to help develop this instrument response. The student will also assist in integrating the detectors with the spacecraft.

c. Specific Outcomes Provided by the Project to the Student *(30% of Review)*

The student will learn how a gamma ray instrument works and how the data from a gamma ray instrument informs the investigator about the physical processes under investigation. The student will learn about radiation sources used to calibrate gamma ray detectors and learn the data analysis techniques involved with calibrating and testing a gamma ray instrument. This knowledge is essential for developing gamma ray instruments and very useful for performing data analysis with data from a gamma ray instrument. In addition, the student will learn the basic elements required to support an instrument in low Earth orbit such as communication, attitude control and power.

III. Student Selection Criteria

The student is required to be studying Physics, Mechanical, Aerospace or Electrical Engineering. The student is required to have sophomore rank. Due to export control regulations on space hardware, the student is required to be a US Citizen or Permanent Resident. The student will also be required to have basic programming knowledge in at least one programming language.

IV. Project Mentorship *(30% of Review)*

The mentor will have a weekly meeting with the student team to review progress and plan the following weeks activities. Additional group or individual meetings will be held with the mentor prior to tests, or to discuss test results. For the first three weeks, two additional meetings per week will be held to present a presentation on TRYAD, laboratory and radiation safety, TGF science, development practices for space projects, gamma-ray detectors, etc. The mentor will often work side by side with the students to guide them in their progress, help interpret results, and ensure that the work environment and techniques remain safe. Our group is dedicated and expects a safe, inclusive, and productive work environment. The mentor is available at any time if the student feels that his or her experience does not live up to this expectation. In the rare case that the primary mentor is unavailable, the project has a second mentor.