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"Terrestrial Gamma-ray Flashes (TGFs) are very Brief (sub-ms) and Extremely Intense Pulses of Gamma-rays Emitted by Thunderstorms and Generally only Observed by Space Based Instruments"

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Project Summary

Terrestrial Gamma-ray Flashes (TGFs) are very brief (sub-ms) and extremely intense pulses of gamma-rays emitted by thunderstorms and generally only observed by space based instruments. There are many aspects of TGFs that are poorly understood and we have an active research program in this field. TGFs were first discovered here in Huntsville in the early 1990's with the Burst and Transient Source Experiment (BATSE) on NASA's Compton Gamma-ray Observatory and are currently being monitored with the Gamma-ray Burst Monitor (GBM) on board NASA's Fermi space craft. UAH played an important role in the development of BATSE and GBM and is a world leader in TGF science. We are currently investigating how the next generation of space base instruments will expose the mechanism behind TGF production.

We are developing instrumentation for a novel CubeSat concept that will enable unique measurements of TGFs. Our methods require multiple CubeSats to be flown in Earth orbit at controlled distances of a few 10s of kilometers. This will allow us to make simultaneous measurements of a TGF across the beam profile which has never been accomplished before. This is the most direct way to constrain models of TGF production. We have teamed up with Jean-Marie Wersinger of Auburn who is a veteran in the field of CubeSat development. Auburn will provide the spacecraft and flight controls while we will provide the instrumentation.

Currently we have computer simulation verifying our approach is sound but have yet to validate our results with actual hardware. In order to increase our technical readiness for the next proposal opportunity, we will prototype sections of our TGF detector using instrumentation and materials that will be used in an actual CubeSat. We believe that the initial steps of characterizing the detector material and instrument response is a perfect summer project for an undergraduate student under the RCEU program. A student, durning the summer, will be able to learn the necessary skills and perform the task of determining the energy threshold and response of the two scintillators that we wish to fly on a CubeSat. This is a critical step in our efforts in that these measurements will determine the efficiency of the TGF detectors and thus the ability of the measurements to constrain TGF models.

The student will learn valuable laboratory skills as well as gain experience with common tools used in the gamma-ray and X-ray community. The student will learn a great deal about the detection of gamma-rays and hard X-rays that has useful application in many fields including astrophysics, medical imagery and nuclear physics. At the end of the program, the student will gain confidence in the lab environment and

be able to design and execute his/her own experiments in X-ray and gamma-ray detection.

Student Duties

1) The student will first learn the fundamentals of gamma-ray scintillator detectors and scintillation light collection.
2) The student will be instructed in laboratory safety gear and the safe use of power supplies and laboratory tools.
3) The student will learn how to use Nuclear Instrumentation Modules (NIM) and be tutored in the proper use of digital oscilloscopes.
4) The student will learn about Pulse Height Analyzers (PHA) and their use and limitations.
5) The student will use a prepackaged NaI crystal scintillator and PMT to gain hands on experience with the detection of gamma-rays. The student will calibrate the NaI detector using the PHA.
6) The student will learn the basics of Si photomultiplier detectors and build a simple circuit to operate and test one.
7) The student will couple the Si photomultiplier to different scintillators and determine the differential efficiency of the devices as well as the threshold energy.
8) The final project will be building and testing a prototype gamma-ray detector that may be used in an actual CubeSat. The student will determine the energy threshold and calibration for one or two of the proposed scintillation materials depending on the available time.

Mentor Supervision and Interaction

The lab is down the hall from my office. For the first week of the program, I will devote most of my time tutoring the student and teaching him/her basic lab skills as well as specific skills associated with our application. After that, the student will be working on his/her own with my assistance being available at any time. Each morning we will review what the student has accomplished and what he/she hopes to accomplish during the day. I will guide the student in order to ensure the student understands his/her current tasks and the project proceeds at a reasonable pace. The student will present the results of each step for evaluation. Once suitable results are obtained, I will assist in setting up the next phase for the student. Dr. Michael Briggs has also volunteered his time to help the prospective student and will be available in my absence. He is a senior scientist who helped developed the Gamma ray Burst Monitor currently on board the Fermi gamma ray observatory.