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"Whle Lightning is one of the Most Energetic Natural Processes much Remains to be Learned about the Underlying Physics of Various Lightning Processes"

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Project Summary

While lightning is one of the most energetic natural processes, much remains to be learned about the underlying physics of various lightning processes. Most people are familiar with the return stroke - the brightest and most identifiable part of a lightning flash. However, the return stroke is preceded by a faint process known as a leader. Much of the interesting aspects of lightning involve the leader.

Since the leader is relatively faint, special instrumentation is required to analyze this process. A high speed camera is well suited for this purpose. This project will use a camera capable of capturing lightning at up to 100,000 frames per second and seeks to increase our understanding of this phenomena by capturing new data. The student, with support from the mentor and associated research group, will lead the acquisition of data. Examples of the type of imagery to be produced are in Figure 1.

In addition, there are other instrumentation systems that detect lightning. We will further explore the lightning processes that produce optical emission and how they manifest in other lightning data sets. The discharges that produce optical emission are known to be energetic; hence, characterization of these processes is important in the context of thunderstorm development.

Finally, the progression of lightning in a high speed video can be quite complicated. Different features emit light at different times. For reference, an example video can be found at the link `http://youtu.be/gCFUi-A2zSg`. This project will explore other methods of displaying video to highlight these features in both scientific analysis and for a broader audience.

The major goals of this project are:

1. Capture new high speed videos of lightning
2. Develop (with collaboration from the mentor) a new way to display high speed lightning video for both scientific and outreach purposes
3. Quantitatively assess various attributes of lightning processes, including leader speed, variations in luminosity, and the types of processes that produce significant optical emission in the context of other methods of lightning detection

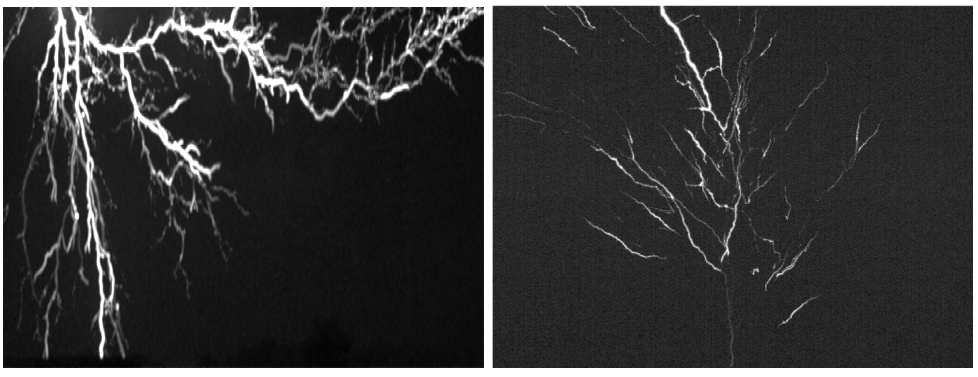

Figure 1: Two examples of the type of imagery the student will produce in this project. Each image is comprised of many superimposed video frames. The image on the left is from a typical cloud to ground lightning flash, in which the leader propagates from the cloud to the ground. The image on the right is from a novel type of leader - it propagates from the ground to the cloud. This leader initiated off the WAFF tower. The student will capture data similar to these.

Student Duties

In the first two weeks, the student will develop an understanding of basic lightning terminology. In addition, the student will begin to explore and analyze various high speed lightning video already captured. In doing so, the student will develop a base working knowledge of the various code algorithms used to analyze video. During this time, the student will craft a research plan and receive formal feedback on the plan. This will provide the student with the experience of developing a working knowledge of research area and identifying a plan of attack. This differs from the typical student experience in which the plan of attack is provided to the student.

The student will be trained how to operate the camera, a specialized piece of equipment, and will be taught photography basics to enable the best manner in which to capture lightning data. An major component of the experience will be to operate the camera during thunderstorms. Hence, the student will monitor the weather for active patterns. Depending on weather patterns, this may occur at any time during the project.

In addition to nominal operation, the student will also participate in field campaigns to capture high speed video in the summer of 2015. The mentor's research group has a mobile facility to remotely deploy the high speed camera. This would provide valuable in field experience for the student - identifying advantageous positions to capture new data, solving problems that arise in a field campaign, and working as part of a team to gather new information. The student will also interface with other research groups to coordinate data acquisition, particularly radar operators so that detailed studies of the meteorological conditions that exist at the time the high speed video of lightning are captured.

There is a significant code base currently available to explore and analyze videos captured. To accomplish the goals of the project, the student will develop new code and extend the capabilities of this program. This will provide the student experience in developing code to analyze data, a skill needed in scientific research.

Using this program, the student will characterize various attributes of the lightning, including leader speeds and overall optical emission of individual processes. To aid in this, he or she will compare the video data to the North Alabama Lightning Mapping Array and Huntsville Alabama Marx Meter array and other national based lightning detection networks.

Techniques to analyze when portions of the lightning channel are heating up will be explored. This will include a method to show with different parts of the lightning "light up" (produce optical emission). The goal is to aid in the scientific analysis as well as present the data as part of outreach, i.e., in a manner in which it is more suitable to a broader audience. This is a requirement of National Science Foundation proposals and not something a student would normally be introduced to.

Mentor Supervision and Interaction

The student will meet weekly with the mentor to receive feedback and foster a collaborative environment in which the project will develop. These weekly meetings will assess the student's current understanding and performance. In addition, the mentor will work with the student to develop suitable algorithms to accomplish the goals of the project.

In addition, the student will participate in weekly scientific group meetings of the mentor's research group. These meetings will give the student a chance to present on-going work and develop working relationships with peers. Further, the student will be exposed to other on-going work in lightning research, which will enhance the research experience. The research presented will be at various levels: from post-doctoral work to beginning graduate students. These researchers will also provide mentoring for the student, so that the student will be introduced to various levels of academic research. This will provide informal feedback on a regular basis.

By the end of the work period, the student will present to the lightning research group at UAH and NASA. The student may also be asked to present results at a scientific conference in Dec. 2015.