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Sparks: The Power of Electrostatics

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PROPOSAL TITLE: **SPARKS: THE POWER OF ELECTROSTATICS**

1. Research Mentor: Dr. Themis Chronis is a senior research scientist at the UAH Earth Center System Science (ESSC). Dr. Chronis has 15+ years of research experience and published more than 30 journal papers in atmospheric electricity, lightning and severe weather satellite remote sensing. He is currently advising 4 Masters students.

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2**. Proposal Description:** The Van de Graaff (VDG) generator was first discovered in 1929 by Dr. Robert J. Van de Graaff, born in Tuscaloosa, AL. Although it is an almost 100 year-old technology the VDG is still a valuable tool to perform novel and mind-blowing science experiments. The goal od this proposal is to introduce students to the secrets of electrostatics based on extensive hands-on experiments but also the comparison with the electrostatic theory. The project is comprised of the following experimental tasks:

Experimental Task 1: Silent and Loud Sparks! When the small discharge dome is moved further away from the VDG, sparks become less frequent but noisier and brighter. Can you prove this based on theoretical computations? How close are the computations and the experimental results? The student will need to "invent" a methodology to account for "noisier" or "brighter" sparks. What are the implications in nature (e.g., lightning)?

Experimental Task 2: Electron Boxing match The Coulomb force is an intricate part of electrostatics. However, visualizing it is not something that we do everyday. The VDG apparatus is a unique way to witness electrons "boxing" their way out. It is up to the student's ingenuity to find ways to calculate this "boxing" force acted upon the discharge wand, which is in fact nothing else but the Coulomb force. *Experimental Task 3: Can you make a lightning rod?* This task calls for some bravery! Can you be the one to support Benjamin Franklin's big discovery? The student will design a "made-up" lightning rod and examine how it works and how this is supported by the electrostatic equations. *Experimental Task 4: The dancing Water Droplet* In the presence of an electric field, water droplets have shown to distort. Can you capture this phenomenon in slow motion? The student may have the opportunity to work with professional slow-motion camera that is used in actual movies. Does the droplet get out of shape? How does it look like when it is closer or farther form the VDG? The student will compute the size and shape of the droplet from slow motion photos taken during the droplet's fly-by.

Experimental Task 5: The Cloud Maker This is fascinating experiment. The student will realize that the Earth is continuously bombarded with charged particles at any given second, called cosmic rays. This experiment will result in the visualization of collision of cosmic ray particles inside a box which will be next to the VDG. Does the collision rate depend on the presence of an electric field?

3**. Student Pre-requisites**: The student will be required to have 1) Analytical skills with physics background or knowledge of basic electrostatics 2) Familiarity with spreadsheet and word-processing software. More extended computer knowledge is not required although most of the experiments become more interesting with the addition of some basic image/video processing techniques (e.g., making an animation form still photos). If not, the mentor will contribute. The most important pre-requisite is self-motivation, curiosity and passion for science and research. **Note: All experiments are very safe, except for individuals with pacemakers.**

4. **Student Duties and Deliverables:** The project will require an extensive laboratory effort but also the drafting of results in a formal and high quality presentation. During these experiments the student will be require to use his/her analytical and observational skills. The experimental results must be routinely logged (e.g., on a spreadsheet or a log-book) and quality controlled. Repetition of experiments is required to assure consistency but also determine the inaccuracies of observations. The student will present and discuss the results on a weekly (or as frequently as needed) basis with the mentor. A final report will be submitted during the ~_10th-11th week and evaluated by the mentor. Illustrations will be made on a spread-sheet or any other software that the student is familiar with. The student can also have the opportunity to present the findings in routinely scheduled ESSC seminars. This will provide the student with additional experience in formal presentations. The laboratory time for each of the experiments highlighted above may vary based on the difficulty of each task. It is estimated that on average each task will require ~1.5 weeks while the remaining time will be used for drafting the final report and presentation of the results.

5. **Mentor Supervision:** The student will meet with the mentor (Dr. Chronis) on a weekly basis or as often as is deemed necessary. The mentor will help with the initial laboratory setup but it is the student who will be required to “devise” scientific techniques to carry out the experimental tasks. Dr. Chronis will provide all the laboratory space (UAH-ESSC), apparatus, although the student’s improvisation in effectively designing the experiment will be necessary. Dr. Chronis is a strong supporter of “hands-on” teaching and these experiments are designed in such a way so that student develops his/her critical thinking, design and reporting abilities.