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Stabilizing Plasma through Microwave Emission

Themistoklis Chronis

RCEU 2020: Stabilizing plasma through microwave emission

1. Research Mentor

Dr. Themis Chronis is a Clinical Assistant Professor in UAH Physics department and a senior research scientist at the UAH Earth Center System Science (ESSC). Dr. Chronis is currently teaching PH112-H3 and PH112-01 that cover the physics of electromagnetism as well as the laboratory curriculum for the all undergraduate students. Dr. Chronis has 15+ years of research experience and published more than 40 journal papers in atmospheric electricity and related fields. He is currently advising 1 PhD student. Dr. Chronis has mentored several Capstone and RCEU projects.

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2. Proposal description

In the field of Plasma Physics understanding the oscillations at work within a plasma is crucial for effectively manipulating it to receive the desired effects of one's work. Whether this is in large scale fusion reactors where the stability of a plasma is directly related to one's ability to keep ions in compact, closed path states and away from the walls of the reactor, or in wake-field accelerators where proton bunches are accelerated by waves of oscillating ions throughout a plasma medium, our knowledge of the forces at work in these oscillations provide opportunity to exploit them in our pursuit of ever increasing technological advancement. In order to understand these oscillations and compare them to the theoretical models already designed for this application, we will be attempting to create as stable and uniform plasma as possible, using this as a ground state through which we can measure our own input oscillatory modes and better model a range of these effects on the plasma itself.

We plan to do this by using a vacuum chamber and high voltage supply to create our uniform plasma, being further stabilized by a DC magnetic field placed around the plasma using multiple small electromagnets, and using a Langmuir probe within the plasma to record our baseline stability . Then we will disturb the plasma using a magnetron as the source for our oscillations, recording these effects in comparison to our baseline to form an accurate model of the waves being produced.

The proposed RCEU project is a unique synergy between theoretical, hands-on practice and experimentation. The advantage of this proposal is twofold. On the one hand, the student, under the proposer's guidance, will gain significant experience in theoretical conceptualization, laboratory experimentation and design, aptitudes necessary for the student's future career. On the other hand, the completion of this project will directly enhance UAH's curriculum outreach in introductory physics experimentation and research as it will be employed as a demonstration to effectively combine teaching material in electricity, magnetism and Newtonian mechanics. To this end, this project will also be used as grounds for further research initiatives by future graduate or undergraduate students. The proposed RCEU project is also a synergy between UAH's Physics and Mechanical Engineering Departments since the majority of the experimentation will take place in the Johnson Research Center with the kind contribution from Dr. Gabriel Xu

3. Student Pre-requisites

The student will be required to have 1) Analytical skills with physics background, extensive knowledge of physics of electricity and magnetism 2) Familiarity with spreadsheet and word-processing software for the final report. Some computer programing may be required during the conceptualization and theoretical modeling of the final results. Note: All safety precautions will strictly follow laboratory protocols.

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 ~10^{th} 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 UAH-student oriented 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 (Curiosity lab), 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 students develop their critical thinking, design and reporting skills.

6. Statement of Support for the Student

Dr. Chronis will provide the student with the lab space and instrumentation that is necessary to successfully carry out the project. I will meet with the student on a weekly basis. The student will be required to have 1) Analytical skills with physics background, extensive knowledge of circuit design, electricity, magnetism and material properties 2) Familiarity with spreadsheet and word-processing software for the final report. Some computer programing may be required during the conceptualization and theoretical modeling of the results. Note: All safety precautions will strictly follow laboratory protocols (see section 3).

7. Adjunct Mentorship

Dr. Chronis will be the main supervisor and mentor for this RCEU project. The student will be working both in the OPB laboratory space (Curiosity lab), as well as Johnson Research Center (lab space kindly contributed by Dr. Gabe Xu). As a result the student will have interaction with other colleagues and students from different majors. This interaction is expected to be highly beneficial to the student's

professional skills and experience.