The LAPTAG Plasma Physics Experiment

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Abstract

We propose to augment an existing DOE research grant (Award number DE-FG03-98ER54494) for the sole purpose of initiating a high school project in plasma physics. We plan to construct a small device in space in our laboratory for the use of high school students in research projects. These projects will accrue extra credit for the students, but much more importantly introduce them to the topic of plasma physics and enable them to do their experiments in a university setting. The high school Physics teachers, who will help construct the machine and write the laboratory manual, will directly supervise the students during their laboratory time. Faculty and research staff at UCLA will give additional lectures and help devise new experiments as time goes on. These high school teachers are a subset of the LAPTAG (**L**os **A**ngeles **P**hysics **T**eachers **A**lliance **G**roup http://plasma.physics.ucla.edu/laptag). Most of the machine will be constructed from spare parts, many of which were recently donated by TRW after it disbanded one of its laboratories.

This proposal is organized in three parts. In a brief introduction we will give a brief description of LAPTAG and underscore the LAPD plasma laboratory's support of it. We will then describe the machine we will build, the associated personnel and personnel involved. We will then describe the rudiments of the course of study we will create.

LAPTAG:

Nearly six years ago the **L**os **A**ngeles **P**hysics **T**eachers **A**lliance **G**roup was formed. **LAPTAG** was created so that universities and colleges could interact strongly with High Schools to strengthen the high school science educational process. The organization now has about sixty members in 32 institutions. Many in the group have been in education for decades, and have developed innovative curricula and effective demonstration materials. What they have in common is a dedication to science and a desire to broaden the educational experience that their schools offer. The LAPTAG group is strongly supported by the UCLA administrations and by the participating high schools and colleges[i].

During the first LAPTAG year we arranged tours for high school teachers and their students to half a dozen laboratories, seminars were conducted, high school classes visited universities, and members engaged in numerous discussions about the educational process. Since then we have instituted a seismology study program involving eleven high schools. Each of the participating schools received a seismometer, which was interfaced to a PC. They record seismic events and then place their data on the Web. The University of California Office of the President has supported this research at a level of about 5K per year. Presently we are experimenting with GPS clocks, which will be installed on the seismic stations so that meaning temporal comparisons can be made with the data. LAPTAG presented these results last year, in six posters, at the March APS

condensed matter meeting, and early this year in the APS-AAPT Winter meeting in Anaheim.

The high school teachers in this alliance have had a great deal of experience in innovative projects, science fairs, curriculum development and the like. Their experience has led to the following observations:

1. Students of all backgrounds, particularly minority students, are "turned on" by project oriented tasks. They seem to come alive when asked to work with high-tech equipment, particularly when they understand how it works.
2. The need for relevance in high school science education is tremendous. The average student is bored and sees no reason to pursue the study of science. Parents do not relate the importance of the study of science to their children and teachers do little to steer them in that direction. A relevant topic, such as the study of plasmas and energy science, would be a strong motivator. In addition it would bring them into contact with a branch of science they have not yet seen in class.
3. Many of the jobs emerging in today's society are technology driven. Few students have seen any of the modern tools used in such endeavors. Working on a plasma physics device in a modern laboratory would be a thrill for the students in our secondary schools and would certainly help bridge the technology gap.

The machine:

Presently we have a meter long vacuum chamber with a roughing pump as well as vacuum plumbing an ionization gauge controller and thermocouple. We have also inherited a turbo-pump, which needs reconditioning, but would be ideal for the project. We also have some vacuum glassware, which we will attach to one end of the chamber. We plan to build a helicon plasma source around the glass extension and allow the plasma to stream into the main vacuum vessel in with the experiments will be performed. We decided to use a helicon source since these types of sources are rugged and operate at low voltages and modest power levels. Since relatively inexperience high school students will use the machine, safety is a prime consideration. The LAPD laboratory has also acquired several Textronix analog scopes, signal generators and power supplies, which can be dedicated to this project. All that is required to build the device is some modification to the existing machine, construction of the helicon source, and building diagnostic probes and a probe drive. We wish to involve the high school teachers interested in the project from the very beginning. Thus far the teachers that committed to the project are: (Keith Barker: Royal High School, John Altounji: Sylmar High School, Richard Buck: Louisville High School, Bill Layton:, Palisades High School, UCLA Bob Coutts: Van Nuys High School, Michael Buck : Chiminad School) We have several other interested teachers and will have to choose among them later on.

They will help construct the device and plan the experiments. If we are awarded this supplement we will build the machine in the summer of 1999. The LAPTAG plasma machine will be located in the Science and Technology Research building at UCLA. It will be housed next to the LAPD upgrade in part of a space dedicated to the development of high frequency diagnostics. Dr. Tony Peebles who has generously offered it and will donate some of his time to the project presently uses this space. Prof. Walter Gekelman

and Dr. Patrick Pribyl will do most the work on the UCLA side, both from the LAPD team. They will work with the high school teachers to build and debug the helicon source and probes as well as get the vacuum system up and running.

The high school lab/course.

This summer four high school teachers have enthusiastically agreed to participate not only in the device construction but also in the design of a plasma physics laboratory course. We will carefully plan the plasma lab so that it may be integrated into the existing science curriculum. We will also design modules that could supplement what is taught in AP (Advanced Placement) Physics. The course will have both general subject material of great use to any budding scientist, as well as plasma physics. Some of the subjects we are thinking of including are:

- Vacuum system technology. How is most of the air in a chamber removed? What are all the components in a vacuum system? How is low pressure measured? In this area we have been encouraged by the American Vacuum society which may donate equipment as well as send one high school teacher to a specialized course, all expenses paid.
- Use of measurement equipment. How do oscilloscopes and signal generators work? How are they set up and used in a laboratory ?
- How does the plasma source (in this case the helicon system) work? Note a subject such as this, as well as the proceeding ones can be taught on many levels. In fact the exact way in which helicon sources make plasma is still a subject of debate. However we feel confident that the key elements in these topics can be put into a form that is understandable to high school science students.
- What electric potential means and how is it measured in a plasma.
- The use of probes to measure density (and possibly electron temperature) in a plasma. These will be Langmuir probes.
- The propagation of a sound wave in plasma. Ion acoustic waves will be contrasted to regular sound waves in air. We will set up an experiment using ultrasound pulses in air and a grid in the plasma to launch both these waves and compare the difference between them.

When the device is complete the high school teachers who are interested will participate in plasma physics workshops, held at UCLA. These will provide them with the tools they need to supervise their students in the laboratory. The staff of the LAPD device will be available to answer any questions that crop up during the course and deal with any experimental problems they cannot solve. The goal of the course is to acquaint the students with both the rudiments of plasma physics as well as some of skills necessary to make measurements in a modern laboratory setting. They will work in a space adjacent to an ongoing University research project, which, we hope, will convey some the excitement, which goes along with leading edge research. The students will perform the experiments under the watchful eye of their high school teacher and then write laboratory reports. We will also prepare posters to be

presented at the American Physical Society DPP division meeting in the fall of each year.

Budget and Justification:

Summer Stipends for high school teachers. This will support four teachers for a month and is necessary since high school teachers are (under)paid for nine months of service. Most of the LAPTAG teachers seek additional employment in the Summer to make ends meet. They must be compensated for the month of work they will do.	$ 5000.00
Supplies and expenses This includes printing fees for the laboratory manual, software for data Acquisition associated with the experiment, parking fees etc.	$ 3,000.00
Fabrication and equipment for device This is funding for construction of the helicon source, convectron gauge, gas regulator, ultrasound source and detector for sound waves in air, glass ports O-rings, X-Y plotter, probe drive and other incidentals that cannot be supplied from the existing LAPD laboratory.	$ 7,000.00
Total without Overhead on Supplies and Expenses	$ 15,000

We wish to augment an existing DOE/NSF grant (Award number DE-FG03-98ER54494) with the above funds to carry out this project.

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[i] Some of the most active schools in LAPTAG are: Santa Monica College, UCLA, USC, Camarillo High School, Royal High School , Birmingham High, Louisville, Sylmar High School, Monroe High School, Van Nuys High School, Grant High, Westridge School, Crossroads School, Crenshaw High School, Westchester High, San Marino High School, Narbonne High School, Mayfair High School