RESEARCH OPPORTUNITY PROGRAM FOR STUDENTS FROM HBCUs, WOMEN'S COLLEGES AND HISPANIC-SERVING INSTITUTIONS

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ABSTRACT

Sponsored by the Office of Fusion Energy of the U. S. Department of Energy, the research opportunity program for students attending Historically Black Colleges and Universities, Women's Colleges and Hispanic Serving Institutions was established at Princeton Plasma Physics Laboratory in 1995. The purpose of the program is to provide outstanding undergraduates from underrepresented groups with an opportunity to spend a summer participating in projects at the forefront of research and development in plasma physics and controlled fusion. The goals of the 10 - week program are to stimulate the interest of members of underrepresented groups in science and engineering, especially those fields relevant to plasma physics and fusion research; to expose those students to state-of-the-art research equipment and facilities, in an environment that is both challenging and supportive; and to enhance the education offered at their schools. Participants are also able to establish close relationships with mentoring scientists. These mentors provide close academic support and offer enhanced preparation for the professional challenges which exist in a scientific work environment.

BACKGROUND

Our Nation's capacity to produce scientists and engineers is supported by a network of colleges and universities that provide educational opportunities for a broad cross-section of citizens. There are in the United States more than 3,300 institutions of higher learning, and science and engineering degrees are offered in 2,700 of these institutions. A significant subset of the Nation's network of colleges and universities is the Historically Black College and University (HBCU), of which about 80 offer undergraduate degrees in science, engineering and mathematics. Approximately 17 percent of the African American students enrolled in higher education are enrolled in HBCUs. Of the African American citizens who earned doctorates between 1985-1991, 40 percent had their baccalaureate origins in HBCUs. Further, HBCUs play an important role in the production of Black scientists by providing the undergraduate origins in Computer Science, 67%, Physical Sciences, 29%

and Mathematics, 23%.[1] A recent study of science and math majors graduating from a leading women's college differentiated between those who stayed in science, those who changed to a non-scientific pathway in graduate school, and those who left science within a few months of graduation. Compared to those who left or changed out of science, a woman who persisted in a scientific career was, among other factors, likely to have participated in undergraduate research experiences outside the classroom.[2] Additionally, low levels of science education achievement among Hispanics results in few U.S.Hispanic scientists and engineers. According to the National Academy of Sciences, in 1990, of 2,303 doctoral degrees awarded in engineering, only 53 were awarded to Hispanics. Figures are similarly low in Mathematics (10 Hispanics/416), Computer Science (5 Hispanics/396) and the Physical Sciences (70 Hispanics/2,244).[3] These data are impressive and provide a compelling case for the support of scientific research experiences for students attending HBCUs and women's colleges, and those institutions that reach members of the Hispanic community.

PROGRAM OVERVIEW

Twenty-five years ago, Professor John G. King (Physics Department, MIT), pioneered a teaching method he called concentrated study. About one dozen students, meeting with a single professor for 4 hours per day and in smaller working laboratory groups for 3 hours, completed a single undergraduate course in three weeks, proving a significant amount of course work could be covered in a short period of time. This concept was modified for the HBCU program by intensifying the laboratory component and improving faculty interaction by decreasing the student-to-faculty ratio to less than 2:1.The course consists of a daily one-hour lecture followed by six hours of lab work, including experiments in: plasma formation and Langmuir probes, microwave cavities, microwave interferometry, sputtering magnetron and spectroscopy. After the two-week lab course, students participated in hands-on research for 8-weeks with PPPL senior scientists and engineers. During the first program year, students attended specially designed seminars which explored ethics and responsible conduct in research. The lectures were given by leading professors from various departments at Princeton University. During the second year, an additional dimension was added to the program. After completing the 2-week concentrated study laboratory component, program participants had the opportunity to teach a portion of the course to high school students. There were additional activities to facilitate interaction among students in this program, other research programs, and PPPL staff. Students were required to complete a paper on their research findings and to present their paper at the conclusion of the program. Several students presented the results of their research at the annual meeting of the American Physical Society.

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1. NSF. Undergraduate Origins of Recent Science and Engineering Doctorate Recipients, Special Report. December, 1992.
2. *Journal of Higher Education*, July/August 1995. As reported in Women in Higher Education. October 1995.
3. The U. S. Department of Energy. The Hispanic Outreach Initiative, Partnering for the Future. July 1996

PARTICIPANTS

Students were recruited from Historically Black Colleges and Universities, Women's Colleges and Hispanic Serving Institutions, throughout the United States including Puerto Rico. The selection committee was made up of members of the PPPL research and science education staff. Students were selected based on their academic abilities, potential to do research work, and interest in graduate study. Seven students from 5 different colleges and universities, including one college for women, participated in the 1996 program. Four of the participants are majoring in physics and one each in computer science, chemical engineering and mechanical engineering.

PROGRAM DESIGN

Two-week concentrated study laboratory in plasma physics

The course consists of a single one - hour lecture each morning followed by six hours of lab work. Written lab reports were required after completion of each two day long experiment. Lectures are given by PPPL researchers, staff and Princeton University graduate students. Lectures topic included:

- What is a Plasma?, Dr. Sam Cohen, PPPL
- How to write a lab report, Dr. Matthew Goeckner, PPPL
- The Diffusion Equation, Dr. Sam Cohen, PPPL
- Important Plasma Parameters, Dr. Rush Holt, PPPL
- Error Bars, John Menard, Princeton University Graduate Student
- The Fluorescent Light, Dr. Sam Cohen, PPPL
- How to Make a Plasma, Jaeyong Park, Princeton University Graduate Student
- Magnetic Fusion Research, Dr. Martha Redi, PPPL
- Publishing Scientific Articles, S.L. Schmidt, *The Physics of Plasmas*

In the labs student are able to see how plasmas appear; they control how plasmas behave; and they interpret the plasma data using the equations learned in the lectures. Through written reports they summarize what they have learned in their own words. The labs offer challenging and up-to-date subject matter applicable to both applied and basic research areas. Experiments performed included:

- DC Breakdown of gases: Paschen curves
- Langmuir probes: Single probe I-V characteristics
- Microwave cavities: Measuring plasma density and collisionality
- Microwave generation, propagation, polarization, and transmission

- Application to plasma density and transport measurements via interferometry
- Spectroscopy, operating principles, and I-V characteristics of the magnetron plasma device

A total of eight scientists offered their services in various aspects of the concentrated study course. Graduate students lectured, conducted homework sessions, and provided moral support to program participants by offering advice on graduate schools and selection of academic coursework.

For all students, the two-week course was their first exposure to plasma physics. All found the two-week course to be a challenging introduction that increased their knowledge of plasma physics. In addition to the benefit of an increase in science content knowledge, many students cited the opportunity to works as a team and draw on the strengths of their colleagues to be a positive feature. Participants also found the laboratory instructors helpful and willing to provide additional support in absorbing difficult and challenging material. The majority of students suggested that more time should be allowed between experiments to write up the lab reports and suggested that the course be longer. Students offered additional comments in the laboratory course evaluation summary completed at the end of the two-week intensive study course. Evaluations were completed by six out of 7 participants. When asked if the course provided an overview of plasma physics and increased knowledge of plasma physics students said:

> *"Yes, before the program I knew very little about plasma, its uses or its formation."*
>
> *"The two-week lab was enjoyable and it indeed enhanced my knowledge not only in plasma physics but also in technology."*
>
> *"The lab course was my first course in plasma physics. I was a good, comprehensive introduction. It was intensive and challenging, I enjoyed it."*

Students found expressed their satisfaction with the laboratory course in the following ways:

> *"I enjoyed being able to participate in the operation of the lab equipment and actually seeing the results. I also enjoyed working with my peers in the labs."*
>
> *"I like the fact that I learned a lot about something completely new to me. It also brought together concepts from the physics classes I'd taken at school. It was good to think about all the concepts together in contrast to taking course where you concentrate on a few at a time."*
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> *"The laboratory and its equipment were a great learning experience. It feels good to know that you're able to operate equipment that is used to do such important experiments."*
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> *"I enjoyed the course, the hard work was satisfying in spite of the stress. It felt good to be able to do a lot of work and learn a lot in a short time. I liked working in groups, the group members' strengths come through. The teachers were excellent, they answered allour questions no matter how silly and were very supportive."*

RESEARCH PROJECTS

Students participated in a variety of research projects led by senior researchers at Princeton Plasma Physics Laboratory.

Most students felt they made a meaningful contribution to their respective research teams. One student said, *"I feel that I was a significant part of the team."* Another student felt he did make a meaningful contribution because he was unable to complete the experimental portion of the project. Another felt he didn't make a much of a contribution as he would have liked. He said, *" I feel I haven't made such a contribution as I would have liked to, but if can get my computer program up and running, then I will have made a good contribution."*

All students felt they were given interesting and rewarding tasks which were appropriate for someone with their background. Three of this year's program participants presented their research at a special session of the 1996 meeting of the American Physical Society.

IMPACT OF PROGRAM ON PARTICIPANTS

Research has shown that exposing undergraduate students to ongoing research develops their confidence, emotional maturity, perseverance and independence, in addition to enhancing their content knowledge and laboratory skills.

The 1996 program participants felt that participation in the program increased their research skills, and made them more determined to pursue a career in science. A few comments follow:

> *"(I) am more aware of the hard work involved....I am still interested in science."*
>
> *"This is my first research (experience) and I am really likely to participate in another."*
>
> *"I now know I will pursue scientific research."*

MENTORS AND THE RESEARCH ENVIRONMENT

The goal of the Program is to exposure students to state-of-the-art equipment and facilities in a research environment that is both challenging and supportive. The relationship between the student and his or her mentor can have a profound effect on the students' overall research experience.

This year both research mentors and students provided comments on the mutual benefit gained by participation in the program. Overall, mentors felt the student assigned to them made a meaningful contribution to the research group. Two mentors felt that in spite of impressive credentials the students achieved less than they expected. However, they commented that the students were able to make a few minor contributions. Research mentors cited "exposure to a research environment" and an improvement in certain skills, such as programming and others, to be primary benefits derived by the students. Additional benefits were cited such as "contribution of their skills and knowledge to a fundamental research project; a chance to interview people in several careers at PPPL; and exposure to a 'real world' research enterprise."

CONCLUSION

The Research Opportunity Program for Students attending Historically Black Colleges and Universities, Women's Colleges and Hispanic Serving Institutions at Princeton Plasma Physics Laboratory has proven to be a rewarding experience for its participants. The program is meeting its goal of stimulating the interest of members of underrepresented groups in science and engineering, especially those fields relevant to plasma physics and fusion research, and exposing those students to state-of-the-art research equipment and facilities in an environment that is both challenging and supportive. Last year's program participants had this to say.

> *"My institution does not have the type of experimental equipment, or access to the data available in ground-breaking physics as PPPL."* KS, Prairie View A&M University
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> *"...the research experience was fulfilling, in that it exposed me to a relatively new area of physics. I am no considering plasma physics and other related branches of physics."* AS, Mt. Holyoke
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> *"The experience at PPPL makes scientific research more interesting and challenging."* XY, Prairie View A&M University
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> *"This program gives students exposure to other disciplines of science which may not have been available to them at their universities."* CR, Elizabeth City State University

Students were able to establish close relationships with mentoring scientists.These mentors provided close academic support and enhanced preparation for the professional challenges which exist in a scientific work environment. Students worked closely with graduate students as well as other undergraduates. PPPL scientists, technicians and administrative staff are actively involved in the students overall research experience. As illustrated by the students' comments, the entire laboratory not just the research mentors, played a major role in the success of the program. Summer research programs leverage an institution's resources in the effort to attract and train future researchers. As one researcher stated "the students benefit, the host institution benefits, the research field benefits, and the country as a whole benefits by providing a very good start to promising young scientists."