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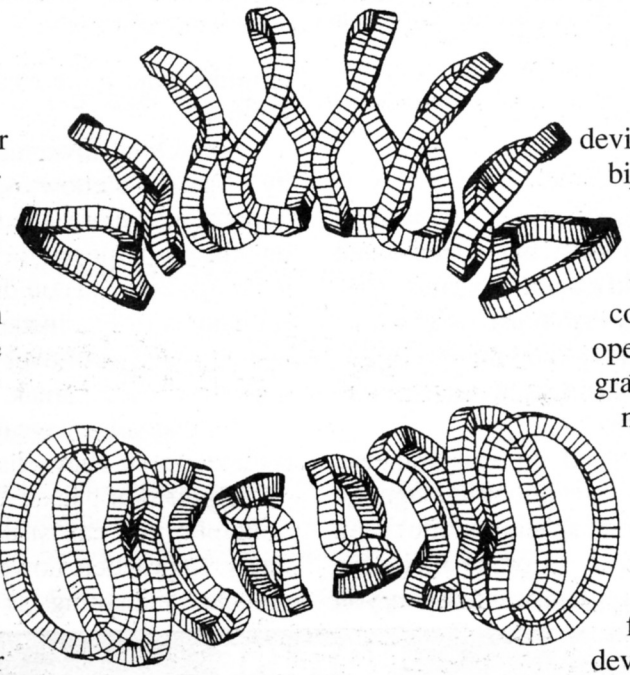
Hotline

The Princeton Plasma Physics Laboratory is a United States Department of Energy Facility

Team Develops Stellarator Concept

Early next year, a national stellarator experiment may be proposed for construction at PPPL. The project team, which is presently engaged in developing the conceptual design of a medium-sized, non-axisymmetric device, includes researchers from PPPL, Northrup-Grumman, Oak Ridge National Laboratory, the University of California at San Diego, the University of Texas at Austin, Columbia University, and New York University. The stellarator configuration is slated to be presented during an international workshop on stellarator concept improvement at PPPL in January, and the machine's first plasma is proposed for 2002 or 2003. Below, Stellarator Project Leader Allan Reiman talks about the rebirth of interest in stellarators and their potential for advances in the development of fusion power. The image is of modular coils.

By Patti Wieser



In a way, designing stellarator experiments during contemporary times is similar to navigating a ship in the late Middle Ages. Both — whether charting new territory in fusion research or crossing the ocean — pose difficulties without the proper navigational tools. And only with new inventions and technology are the hurdles overcome.

"Until the compass was invented, people pretty much sailed ships along the shoreline. They couldn't go very far from the shore without getting lost at sea. With the invention of the compass, they were able to cross the ocean," said PPPL Stellarator Project Leader Allan Reiman.

Just as the invention of the compass allowed sailors to venture across the ocean without getting lost, the recent development of sophisticated computer programs gives scientists the tools to design, investigate, and conduct research on a broader range of devices such as stellarators.

"Once researchers give up the guiding principle of axisymmetry and begin research with non-axisymmetric devices they find themselves a little bit at sea. So they need something to guide them — some compass or navigational tool. In recent years, larger computers have become available, and we've developed sophisticated computer programs that provide such a tool. And now we're beginning to see that there's no fundamental reason why axisymmetric devices are better than non-axisymmetric devices."

The term stellarator refers to a large class of toroidal devices that are non-axisymmetric. A non-axisymmetric device is one in which the magnetic field changes as one follows it around the torus (in contrast to an axisymmetric device, where the field does not change). A non-axisymmetric magnetic field can be produced from an axisymmetric one by giving it a twist. Some stellarators have modular magnetic coils that look like deformed toroidal field coils. Another example of a stellarator is the heliac model in the Lobby, which is similar to one being built in Spain and to a smaller one in Australia.

Continued on page 2

The PPPL stellarator team are (from left): Larry Grisham, Irving Zatz, Martha Redi, Mike Zarnstorff, Rob Goldston, George Sheffield, Hutch Neilson, Allan Reiman, John Schmidt, Harry Mynick, Don Monticello, Morrell Chance, Bob Simmons, Gerd Schilling, Guo-Yong Fu, Harold Furth, and Long-Poe Ku. Not pictured are Art Brooks, Neil Pomphrey, and Gregory Rewoldt.

Stellarators

Continued from page 1

Lyman Spitzer founded the Laboratory with a stellarator experiment in the 1950s, but it presented problems which researchers could not solve because they lacked the necessary computational tools. And while some level of interest in stellarators continued at PPPL over the years, tokamaks became the favored fusion device during the last two decades.

"Until recently, people focused on axisymmetric machines such as tokamaks. An axisymmetric magnetic field has basically the same shape as an automobile tire in the sense that if you rotate it, it looks pretty much the same. This simplifies things conceptually and allows you to understand more easily what's going on," explained Reiman.

A potential advantage to a stellarator is more flexibility. "Once you allow the magnetic field to become three dimensional, there is more flexibility in terms of controlling the properties of the magnetic field and being able to do things that you couldn't do in axisymmetric devices," Reiman said. For instance, in a stellarator, researchers have more control over the shape and pitch of the field lines than in a tokamak.

Another advantage the stellarator has over a tokamak is that it doesn't have disruptions, said the project leader. Also, you don't need to drive a plasma current. "In principle, you can sustain a stellarator plasma indefinitely. In practice, however, you have limitations unless you have such things as superconducting coils," he said.

HOTLINE

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In addition, researchers can get a better test of their codes than before. "So you have these computer codes that tell you how to design your machine and in some sense they embody the present state of knowledge in plasma physics," said Reiman. "The codes tell you to go off in a certain direction and twist the coils in a certain way. You then can test the physics basis for following that direction. That leads to advances in plasma science that benefit the whole magnetic fusion program."

There are about ten medium-sized to large stellarators in the world. The stellarator that will be proposed for construction at PPPL would be medium-sized — about as large as the Princeton Beta Experiment-Modification (PBX-M). It would be the third — and largest — stellarator in the U.S. Larger stellarators — comparable in size to the Tokamak Fusion Test Reactor (TFTR) — include the soon to be completed LHD in Japan and the planned W7-X in Germany. Both are in the $500 million to billion dollar range.

The stellarator at PPPL would use many existing facilities such as power supplies, machine components, heating systems, and diagnostics. One possibility is to convert PBX-M to a stellarator. "That would have a lot of advantages including the ability to reuse the coils, vacuum vessel, and diagnostics. We are presently looking into the various options," noted Reiman. If PBX-M is reused, the project would need some additional coils inside the vacuum vessel to produce the non-axisymmetric field. "The main new component would be the coils. We're asking our computer programs to come up with an optimal shape," said the project leader.

In addition to equipment and experimental space, PPPL has another important stellarator resource — its staff. "We have a number of people with expertise in stellarators. In addition to current staff, John Johnson, who is retired, maintains an interest. He's now in Japan as a visiting professor at the stellarator lab there for three months. We are always happy to get his input," Reiman said.

Returning to his analogy, Reiman said, "It was only after they started using the compass in the late Middle Ages that they really learned how it worked. When Columbus sailed to America and got close to the Caribbean, he discovered that his compass no longer pointed toward the North Star. There was a major panic on the ship. And it was only with time that people discovered that the north magnetic pole was not the same thing as the north pole of the earth. With this knowledge, they improved the use of the compass for navigation. That's analogous to how we use our computer programs to help us design a stellarator. We know that we can rely on our computer programs only up to a point, and then we have to do an experiment and see what is really going to happen." ●

This year, the newly organized Diversity Working Group (DWG) developed a diversity charter to guide PPPL in its mission to promote an inclusive working environment. Below is the charter and the mission statement of the Lab's Diversity Program.

Diversity Working Group Mission Statement

To promote an inclusive work environment in which all employees are respected and valued by being supported, encouraged, and professionally developed.

Diversity Working Group Charter

The PPPL Diversity Working Group recognizes the value of diversity. Tapping into the richness of a diverse work force and utilizing each individual to his or her highest potential boosts morale, increases productivity, offers new ways of tackling problems, and furthers the Laboratory's mission.

The PPPL Diversity Working Group will act as the catalyst to foster the implementation of the PPPL Diversity Program by:

- Increasing communication of diversity issues throughout the Laboratory.
- Seeking and recommending opportunities and methods to foster a highly qualified, diverse applicant pool in all job groups.
- Recommending Laboratory policies to attract and retain a diverse work force.
- Fostering the development of a work place where all individuals are respected, outstanding achievements are recognized, and inclusion is promoted.
- Leveraging our scientific capabilities through partnerships and strategic alliances with other institutions, including traditionally minority and women's institutions, to further diversify the PPPL talent pool.

PPPL Collaborates with Agriculture Department in Development of Pasteurization Process

Researchers Investigating Use of Radio Frequency and Microwave Heating for Pasteurization

By Patti Wieser

A small group of researchers at PPPL — including physicist Randy Wilson, engineer Elmer Fredd, and technician Dave Ciotti — is focusing its attention on an innovative pasteurization process through a collaboration with the Agriculture Department.

Earlier this fall, PPPL and the U.S. Department of Agriculture (USDA) signed an interagency agreement to jointly develop new pasteurization methods that use radio frequency (RF) waves and microwave heating. These heating techniques — also used to warm plasma in a fusion device — are being tested for pasteurizing raw liquid foods such as eggs, fruit juices, and milk.

"This is another example of applying our fusion and plasma science capabilities to an area that benefits the U.S. public," said PPPL Technology Transfer Head Lewis Meixler.

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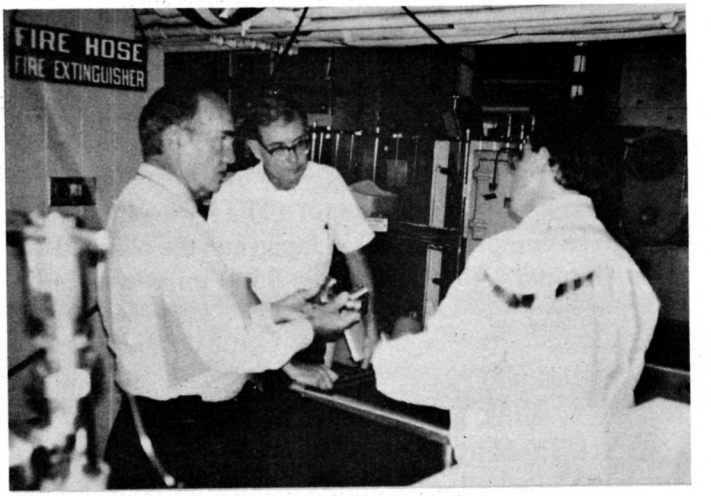
— Lewis Meixler

The $120,000 agreement between the two federally funded agencies came about after researchers at the USDA's Eastern Regional Research Center (ERRC) in Philadelphia evaluated RF radiation while exploring improved methods for pasteurization. Initial results and subsequent evaluation of micro-organisms introduced into liquid foods indicate that RF radiation is a potentially effective means for pasteurization.

RF waves offer advantages over the traditional pasteurization method of directly heating raw liquid foods. The direct method often heats foods unevenly, possibly resulting in incomplete pasteurization in lower temperature regions and in denaturing foods in overheated regions. Using radio frequency waves in the appropriate wavelength may allow pasteurization without heating liquid foods to temperatures that cause food deterioration.



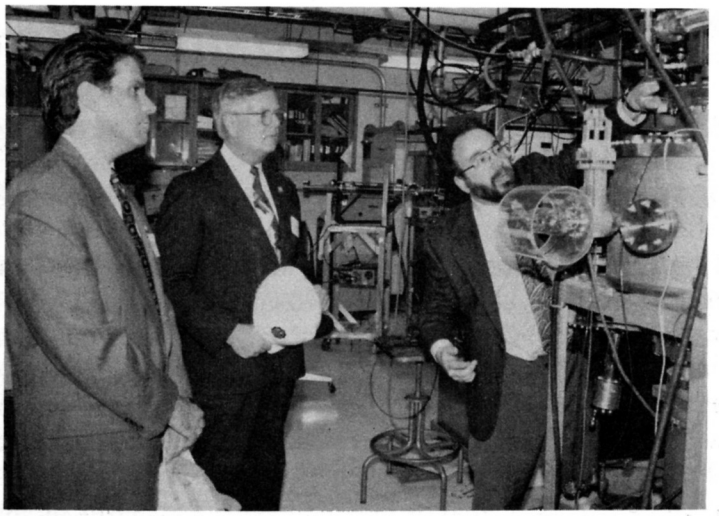
Members of the collaborative team for developing a new pasteurization method discuss the project at the USDA's Eastern Regional Research Center (ERRC) in Philadelphia. From left are PPPL's Elmer Fredd and the ERRC's Mike Kozempel and Neil Goldberg.

The ERRC is collaborating with PPPL because of the Lab's extensive experience in the application of RF and microwave radiation to the study of plasmas. The Laboratory has particular expertise in optimizing the absorption of RF and microwave energy into a receiving medium. Experience includes the measuring of RF parameters, instrumentation, the design and fabrication of antennas, and the safe handling of these components.

The three-person PPPL team are working with Mike Kozempel, who is the USDA's Principal Investigator on the project. The work began at ERRC this fall and is expected to conclude in about six months. The PPPL team will assist the ERRC researchers in equipping their facility with the necessary RF power source, as well as providing the expertise to enable the measurement of power deposited, power launched, and launch efficiency. In addition, the PPPL group will concentrate on optimizing the RF launch configuration, and help monitor the effect of deposited power on the pasteurization process.

The agreement between ERRC and PPPL supports a memorandum of understanding between Secretary of Agriculture Dan Glickman and former Energy Secretary Hazel O'Leary to use one federal agency's technologies to benefit research at other federal agencies. ●

What's Happening at PPPL



PPPL Director Rob Goldston gave U.S. Representatives Michael Pappas and Curt Weldon a tour of PPPL in November. The Congressmen, who also went to main campus, visited the Tokamak Fusion Test Reactor and the L-wing experiments, including the Magnetic Reconnection Experiment and the high-intensity hyperthermal atomic beam apparatus (pictured). Goldston (right) describes the apparatus to Pappas (left) and Weldon (middle).

PPPL's Anthony Contino is the winner — again — of the Lab's United Way Campaign slogan contest. Contino received a gift certificate to The Forrestal from 1997 PPPL United Way Campaign Chairperson Mary Ann Brown for his winning entry, "So many to help; so much to do; United Way; it's up to you." The two-time winner also received the top prize for the slogan contest last year. Congratulations, Anthony!

Science Bowl Volunteers Needed

Volunteers for the New Jersey Regional Competition of the National Science Bowl®, which will be held at PPPL on Saturday, February 28, are needed. If you are interested in serving as a judge, timekeeper, moderator, scorekeeper, or could assist with logistics, please call James Morgan at ext. 2116.

On Halloween, everyone at the Lab was welcome to come in costume and three or four actually did. Among the specially costumed was PPPL Director Rob Goldston, who wore a pirate outfit, complete with an orange-and-black penguin peeking over his shield. He said he chose to carry a penguin rather than the typical pirate's parrot because "the penguin is a heartier bird than the parrot."

Once Again, PPPL Offers Science on Saturday

Want to beat the winter doldrums? Soon Saturdays will offer just such a chance. Beginning on January 17, you can learn about tree cloning, find out about a new high-density TV system, and even see how many transistors can fit on the head of a pin and still work. These topics and others will be featured during the annual Science on Saturday series at PPPL.

Science on Saturday is a series of eight free lectures geared toward high school students, but open to everyone. The lectures are given by scientists, mathematicians, and other professionals in the central New Jersey area who are leaders in their fields. Started as a grass-roots effort 14 years ago at PPPL, it now attracts more than 300 people each Saturday. This year's series is organized by PPPL physicists Norton Bretz and Janardhan Manickam, Science Education Program Administrator Chris Ritter, and other staffers from the Lab's Science Education Program.

"This is an opportunity for high school students to see real scientists talking about their current research and to share their excitement of discovery. The topics of many of these lectures have been in the news this past year and are interesting in their own right, but I hope they provide a window into the world of scientific thought and culture. This is a good way for young people to see how scientists think and work, and should offset the stereotypes available in the movies and television," said Bretz.

The series kicks off with a lecture by Princeton University Astrophysics Professor Gillian Knapp, who will be discussing "Mapping the Universe." In addition to astrophysics, a variety of topics, many of which emphasize environmental issues and feature local research industries, will be offered. These range from global warming and maintaining biodiversity while protecting crops to the architectronics of living molecules.

A special demonstration and talk on digital, high-density television by its technical developers is scheduled at Sarnoff Research Center as part of the series. "Sarnoff has been at the forefront of TV technology since World War II, making major leaps in TV technology over the decades — from the commercialization of color TV more than twenty-five years ago to the more recent innovations in digital high-density television," said Bretz. He said students and community members alike are encouraged to attend any or all of the series. In the past, attendees have ranged in age from 8 to 80.

All lectures except for the February 14 talk will be at the Laboratory. The lectures begin at 9:30 A.M. and last about two hours. Registration is on-site prior to each session and seating is first come, first-served. For more information, call the Science on Saturday Hotline at (609) 243-2121. ●

Science on Saturday

Princeton University Plasma Physics Laboratory Lecture Series

January 17	**MAPPING THE UNIVERSE** Prof. Gillian Knapp, Department of Astrophysical Sciences, Princeton University
January 24	**SAT—NO PROGRAM**
January 31	**GLOBAL WARMING** Dr. Isaac Held, Geophysical Fluid Dynamics Laboratory, Princeton University
February 7	**MAINTAINING BIODIVERSITY WHILE PROTECTING CROPS** Dr. Laura Whatley, American Cyanamid Company, Clarksville, NJ
February 14*	**TV SYSTEMS OLD AND NEW: INTRODUCING DIGITAL, HIGH DENSITY TELEVISION** Mr. Norman Hurst and Dr. Michael Isnardi Sarnoff Research Center, Princeton, NJ **** Lecture is at Sarnoff Research Center, 201 Washington Rd., Princeton, NJ***
February 21	**HOW MANY TRANSISTORS CAN FIT ON THE HEAD OF A PIN (AND ALL WORK)?** Dr. Don Monroe, Bell Laboratories, Lucent Technologies, Murray Hill, NJ
February 28	**SCIENCE BOWL—NO PROGRAM**
March 7	**THE ARCHITECTRONICS OF LIVING MOLECULES** Prof. Clarence Schutt, Department of Chemistry, Princeton University
March 14	**CANNIBALS AND CONSERVATION** Dr. William Thomas, Governor's School of the Environment, Stockton State College, Stockton, NJ
March 21	**TREE CLONING AND FOREST BIOTECHNOLOGY** Dr. Steve Wann, Union Camp Corp., Lawrenceville, NJ

Future Physician Gets Start from Lab's Science Ed

Thanks, in part, to the Summer Research Program at PPPL, Shaefona Duette is on her way to medical school. Duette, who credits much of her success to her experiences at the Lab, was in the middle of her junior year at Trenton High School in 1993 when she heard about the program run by the Lab's Science Education staff. While she had completed high school chemistry and biology courses, Duette says she wanted to do "something different." Learning about fusion energy at PPPL seemed to fit the bill. Working with Andrew Post-Zwicker, then a post-doctoral researcher on the Princeton Beta Experiment-Modification (PBX-M) project, she became involved in developing a computer code to track impurity levels after a boronization in PBX-M.

Says Duette, "It was a big transition for me — from Trenton High to PPPL — but I felt capable of completing my assignment. One thing I noticed right away was that all I saw were men! As one of the only female minority students to complete the program, I was very proud."

Post-Zwicker, now a member of the Science Education staff, remembers that Duette had a "gleam in her eye and a hunger to learn." "She started off behind the other students who had stronger science programs in their high schools, but worked hard all summer. It was obvious this was a determined and mature student," he recalls.

That determination triggered a series of events profoundly affecting her life. The physics teacher at the Peddie School in Hightstown heard about Duette while at PPPL for his own research program. He came up with the idea of getting her into Peddie. Duette jumped at the opportunity. With recommendations and her transcripts in hand, she applied for admission. The school responded with an intriguing offer — acceptance with a full scholarship on the condition that she repeat her junior year.

"No way!" was Duette's first reaction. "I really wanted to go to Peddie, but I was going to be a senior at Trenton High. I wanted the solid background that I could get at Peddie before beginning college, but I didn't want to repeat a grade. Choosing to attend Peddie was the toughest decision I've ever made."

Shaefona Duette

While at Peddie, she decided she wanted to become a doctor. By her senior year, she was on the honor roll. "I doubted whether I was smart enough at first," she recalls. "But I realized I was doing better than many of the other students. It was a huge boost to my confidence and self esteem."

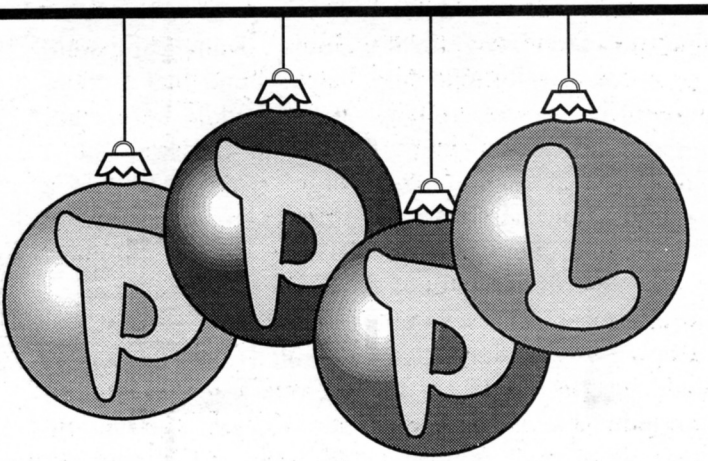
Duette began her pre-med studies in the fall of 1995 at George Washington University. She did research in the pharmacology department and was a volunteer at both George Washington Hospital and the Columbia Hospital for Women. "I want to be an obstetrician/gynecologist and give back to the community," she says.

Duette recently applied to the early admission program of the university's medical school. "I was one of 12 accepted into medical school out of more than 70 who applied." Without the worry of the Medical College Admissions Test and medical school applications, Duette is off to Lancaster University in England for her junior year before returning in 1998 for her last year of college. "If I hadn't been so determined, I would not have made it to PPPL. And I wouldn't have made it to Peddie or George Washington or been accepted early into medical school," she says.

"Perhaps," responds Post-Zwicker. "But some people have that extra ability and succeed at whatever they put their mind to. Shaefona is one of those special people." ●

Shaefona Duette spent the summer of 1993 at PPPL as part of the Summer Science Awards (SSA) program. Started in 1984, SSA accepted high achieving high school students from neighboring schools for eight-week summer internships at the Laboratory. "I began the program as part of a Lab-wide effort to improve PPPL's relationship with the surrounding communities," says Diane Carroll, Head of Science Education. "It's been gratifying to see how much students have benefited from the program and how well our research and engineering staff have mentored their students." Over 150 students have been through the high school level program and many have returned as undergraduate research assistants. "Our first cohort of students turned 30 this year. Think about that!" said Carroll. The SSA program continues as "PREP," Princeton Research Experience Program, under the guidance of Pamela Lucas, Program Leader in Science Education. "We've changed the nature of the program somewhat over the years, although our mission to provide quality summer research experiences to high school students remains the same," says Lucas. "PREP is a residential summer enrichment program that began as part of our outreach efforts to northern New Jersey communities. We also accept high school students for internships where they receive credit in lieu of stipends through cooperative arrangements with local schools."

Come One. Come All.



Holiday Party

Tuesday, December 23

12 noon - L.O.B. Lobby

Great Food!

PASTA STATION *TWO VARIETIES OF PASTA AND SAUCES.*

CARVING STATION *CARVED ROAST TURKEY.*

HORS D'OEUVRE STATION *MOZZARELLA, RAVIOLI, ZUCCHINI.*

DELI STATION *MINI WRAP SANDWICHES, SALADS, RELISH.*

All PPPL Employees are Invited!