CPS Plasma Page

Published by the Coalition for Plasma Science, Vol.5, No. 1, February 2002

UCLA Receives 4.8 Million Grant for Plasma Physics Research Facility

UCLA's Basic Plasma Science Facility has been awarded a $4.8 million grant by the U.S. Department of Energy and the National Science Foundation to become the country's first national research facility for scientists worldwide to study the mysterious properties of plasma – the ionized, gas-like matter that may help us destroy toxic waste and chemical and biological weapons, and perhaps help generate unlimited energy through fusion.

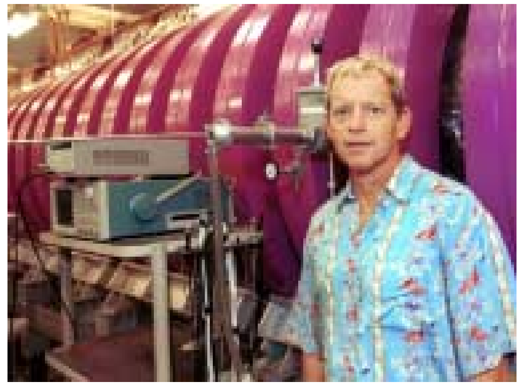
Plasma is believed to make up more than 99 percent of the visible universe, including the sun, the stars, galaxies and the vast majority of the solar system. The centerpiece of the facility is an enormous machine called the Large Plasma Device (LAPD), which weighs more than 80 tons.

Walter Gekelman, UCLA professor of physics and director of the facility, and five of his colleagues, built the machine - from the sophisticated electronics and the plasma source to the plumbing and welding - over three-and-a-half years. The machine is unique in the world, and allows physicists to create and analyze plasma and plasma waves of superheated, energized gas.

"Studying plasma waves in space is like finding one tooth of a dinosaur and trying to determine what the whole dinosaur looked like," Gekelman said. "In our machine, we can see the whole dinosaur.

"Much about plasmas and how they behave is very poorly understood," he said. "Our machine will help us understand plasmas. We can make measurements in tens of thousands of locations, using technology we have developed over 30 years."

Plasmas in space support thousands of waves that may be 100,000 miles long, exist nowhere else in nature and dictate how the plasma behaves. "We can study these waves in tremendous detail, and are able to scale them so they fit in our device," Gekelman said. Gekelman and his research team will use the facility half the time for research, and other physicists worldwide will propose experiments to use the LAPD for the other half.



Prof. Walter GekelmaN of UCLA helped build the Large Plasma Device. Photo by Todd Cheney (UCLA)

Plasmas could have many practical uses, including plasma torches that cut through steel like butter (which Gekelman used in making LAPD), weigh no more than a pencil and may eventually be used to destroy toxic waste; devices that instantly destroy chemical and biological weapons such as anthrax; improved computer chips; and devices into which garbage can be thrown and recycled. They may also be used to generate a clean and unlimited supply of energy in the future through fusion – the energy source of the sun.

"We are doing pure research on fundamental issues such as understanding how heat and energy are transported through a plasma, and learning the structure of plasmas, but the payoff could be tremendous," Gekelman said. "Understanding these fundamental issues could help enormously with designing and building better devices, including, perhaps, a better fusion reactor. Until we understand the fundamental science of plasma physics, it is like trying to cure a brain disease without knowing what part of the brain is involved. Transport, for example, is one of the factors preventing fusion from being a reality. If scientists understood transport, we could design more efficient fusion devices."

Plasmas are very odd. Remarkably, the temperature in a plasma within a magnetic field can differ tremendously in different directions. "Looking one way from one particular spot, it could be a million degrees, while looking another way it could be only a thousand," Gekelman said. "An analogy would be your face is at a million degrees and your shoulder is freezing."

As they move through oscillating plasma, superheated and energized plasma waves can transform themselves and can change the properties of the plasma.

The Earth is too cold for plasmas to exist here naturally. "Plasmas start above the Earth's atmosphere; a few hundred miles up, it's all plasma," Gekelman said. "From then on out, the whole solar system is filled with plasma."

The Department of Energy and the National Science Foundation have initially funded the facility for five years. The predecessor to this machine was funded by the U.S. Navy.

In addition to conducting research and teaching, Gekelman has built the country's only plasma physics laboratory for high school students, with funding from another DOE grant. Students and their teachers from some two dozen Los Angeles-area high schools conduct plasma physics experiments in this laboratory.

"The high school students use the same techniques we do, the same software and much of the same equipment (but not the new LAPD)," said Gekelman, who has worked with high school students in his lab for several years.

Contact: Karen McBride, UCLA, mcbride@physics.ucla.edu

Fusion Energy May be Here by 2050, MIT Physicist Predicts at AAAS

Fusion energy, the plasma process that powers the sun, could become part of the nation's energy portfolio in the second half of the 21st century, an MIT professor reported February 17 at the national meeting of the American Association for the Advancement of Science. His prediction is based on increased federal interest in the field and recent progress in fusion energy research. "With adequate federal funding, a prototype nuclear fusion reactor could be tested within 30–40 years, and a commercial reactor could be deployed by the middle of the century," said Miklos Porkolab, director of MIT's Plasma Science and Fusion Center and a professor in the Department of Physics.

Miklos Porkolab, Director of MIT's Plasma Science and Fusion Center, stands next to the Center's Levitated Dipole Experiment, a new approach to fusion.

Photo by Donna Coveney/MIT.

Recently the White House and Congress have showed increased interest in fusion and other "next-generation" energy technologies. For example, the President's National Energy Policy Development Group recommended that the President direct the Secretary of Energy to develop such technologies, and on February 4, 2001 Congress (the House Energy Bill) authorized a 34 % increase in the FY 2003 budget for the Office of Fusion Energy Sciences. A similar authorization bill is still pending in the Senate. It remains to be seen whether such large increases would be appropriated given the present budget shortfalls in Washington. In the President's budget for 2003, a modest increase was provided to more fully operate the major national fusion research facilities, including MIT's Alcator C-Mod tokamak.

In nuclear fusion, light elements are fused together to make heavier elements. In the process, large amounts of energy are released. For some 50 years scientists have been studying how to reproduce this process on Earth, because among other advantages the resulting energy would be clean, with no carbon dioxide emissions. In addition, there is an inexhaustible supply of the fuel itself (heavy forms of hydrogen from water).

Porkolab notes that the deployment of a fusion reactor around 2050 "is consistent with the time scale when the domestic supply of crude oil in the U.S. is expected to be depleted, shortages in oil and natural gas could develop in the world markets, and when carbon dioxide reduction in the atmosphere becomes a critical issue." At his AAAS talk Porkolab gave examples of recent results in the science behind nuclear fusion. "Progress in fusion research over the last decade has been enormous," he said, "even with declining US budgets in recent years." One of the key factors involved in maintaining the high temperatures necessary for nuclear fusion is the control of plasma turbulence. Much like a stick that is driven to the shore in a turbulent roaring "white-water" river, heat tends to escape too rapidly from the roiling mass of turbulent charged gas, or plasma, in a fusion reactor. Porkolab says that optimistic predictions in the 50s and 60s about near-term commercial fusion proved unfounded because the heat loss from turbulence turned out to be much greater than expected. As a result, "much of fusion research over the last several decades has focused on learning about turbulence and devising techniques to control it."

"We have shown that, in principle, it's possible to eliminate (plasma) turbulence. This is just a mind-boggling achievement."

Over the last few years scientists around the world, including at MIT, have made significant strides toward doing just that. Among other things, they have demonstrated ways to break up the "tidal waves" of plasma into smaller eddies that don't carry away heat as rapidly as larger ones. "We have shown that, in principle, it's possible to eliminate turbulence," Porkolab said. "To me, this is just a mind-boggling achievement."

Powerful computers have also proved key to learning more about hot plasmas and the turbulent transport processes. For example, Porkolab said, at the APS, Division of Plasma Physics Meeting in November, 2001 researchers from Princeton showed by means of computer simulations that the "deleterious effects of heat loss resulting from turbulence seem to be reduced as one scales up from present-day experiments to future reactor-size machines." He stressed, however, that "it's dangerous to jump to conclusions based only on simulations. Computer results must be verified with experiments. So that's why it's important to expand our present research activity on ongoing experiments and at the same time, move ahead with construction of a next major scale experiment studying the physics of burning plasmas (the Burning Plasma Experiment.)"

MIT's Alcator C-Mod is one of only three major research fusion experiments in the United States, the others being DIII-D run by General Atomics in San Diego, and the National Spherical Torus Experiment at Princeton University. The MIT fusion work is supported by the US DOE.

Contact: Elizabeth Thomson, thomson@mit.edu