Stabilizing Plasma for Fusion Energy

GERALD NAVRATIL

Thomas Alva Edison Professor
of Applied Physics and
Applied Mathematics

Gerald Navratil is among the world's leading researchers in the field of fusion energy. His findings have been incorporated in the design of ITER, the $12 billion international experimental fusion reactor project now under construction in France, which is expected to generate up to 500 MW of fusion power after completion of construction by 2018.

"It's a carbon-free way to provide energy, where the fuel sources are unlimited, and there's minimal long-term radioactive waste," said Navratil. "It could be an important part of our energy profile by the turn of the next century."

He conducts his experiments at three tokamaks—a donut-shaped machine that confines the super-hot plasma with magnetic fields. Ideas for experiments on his major projects are generated out of small-scale HBT-EP experiment in Columbia's Plasma Physics Laboratory. He then collaborates with teams of fusion researchers at larger tokamaks, like the DIII-D National Tokamak Facility in San Diego, Calif. and the National Spherical Torus Experiment in Princeton, N.J.

In 2010, his Columbia team on DIII-D was awarded $1.1 million and his team on HBT-EP was awarded $3.3 million to continue their work on these projects for three more years. Both projects are supported by grants from the United States Department of Energy.

A crucial issue in fusion energy research involves creating magnetic fields to contain the plasma at high pressure and at temperatures hotter than the interior of the sun. If the confined plasma become unstable, it comes in contact with the cold tokamak walls, loses its energy, and the fusion plasma is extinguished.

Navratil's experiments have focused on understanding the pressure limits of fusion systems. His team has created ways to increase the pressure—and the production of energy in future fusion power plant designs—while keeping the plasma stably contained. His team on DIII-D has been able to double the pressure in fusion systems, which quadruples the fusion-energy output. That's done by rapidly rotating the magnetically confined plasma. This important result was recognized in 2007 with the award to Navratil and his colleagues of the John Dawson Award for Excellence in Plasma Physics Research by the American Physical Society.

Another strategy for extending plasma pressure limits involves developing advanced forms of active feedback-control of the instabilities. That technique was pioneered on the HBT-EP experiment at Columbia, and is now being used in demonstration projects at the DIII-D tokamak in San Diego. Ultimately it will be employed in the operation of ITER in the next decade.

B.S., California Institute of Technology, 1973; M.S., University of Wisconsin, 1974; Ph.D., University of Wisconsin, 1976