http://www.ornl.gov/info/ornlreview/rev25-2/net1425.html

ATF EXPERIMENT UNDER REPAIR

ORNL's Advanced Toroidal Facility (ATF), the world's largest fusion experiment of its type, ceased experiments on November 15, 1991, after nearly four years of operation (and over 20,000 "plasma shots"). The $20-million ATF is a stellarator, which, along with the better-known tokamak, belongs to the family of toroidal (doughnut-shaped) confinement devices that dominate modern controlled fusion research.

Fusion energy is produced by fusing high-energy nuclei of hydrogen isotopes. Magnetic fields can be used to confine these nuclei in a hot ionized gas, or plasma. In this way, loss of plasma energy to the vessel wall is substantially reduced. It is predicted that an improved toroidal device that effectively confines a fusion plasma could lead to a practical source of electricity by the middle of the next century.

The ATF stellarator (shown in the figure) uses helical windings to create the magnetic field that contains and stabilizes the plasma used in experiments; the circular coils position and shape the plasma. By contrast, for plasma confinement the tokamak requires a plasma current that must be driven for steady-state operation.

Other comparably sized stellarators operate in Germany, Japan, and Ukraine. (For background information on the ATF and magnetic fusion research at ORNL, see the Number Four, 1987, issue of the Review.)

Since it started operation in January 1988, the ATF has had a distinguished history. The ATF's unique design allowed creation of a wide range of plasma configurations for study of fundamental physics issues relevant to both tokamaks and stellarators.

During the first year, ATF researchers studied a regime of plasma operation that has the potential for confining plasma having more energy content for a longer time at a given magnetic field strength. An unexpected magnetic field perturbation had allowed access to this "second-stability" regime at much lower power than had been otherwise needed.

After compensating for this field perturbation, ATF researchers studied other basic confinement physics issues including the "bootstrap current," an internal self-generated current in toroidal plasmas that must be maximized in tokamaks and minimized in stellarators for optimum performance. The ATF group found that its experimental measurements of this current agreed with theoretically predicted values, giving confidence that the bootstrap current can be used for optimizing future tokamak and stellarator designs.

The ATF researchers have also made significant contributions to understanding confinement in toroidal plasmas. Comparison of measured fluctuations in the edge-plasma parameters in the ATF and in a comparably sized tokamak allowed researchers to gain a better understanding of the role of these fluctuations in causing deterioration in plasma confinement. These studies have been extended to the plasma core in the ATF in a collaborative experiment between ORNL scientists and researchers from the Institute of General Physics in Moscow. Results of preliminary analyses show evidence of a particular plasma instability that was sought in this experiment.

Throughout its history, the ATF program has featured collaborations of this type with U.S. universities and fusion laboratories in Japan, Spain, Russia, Ukraine, and Germany.

Although the ATF was developed as an experiment to test optimization principles and steady-state operation, budget restrictions have prevented the ORNL stellarator from reaching its full potential. A DOE decision in late 1990 to focus on tokamaks altered the ATF research program and resulted in operation of the ATF at a reduced level in fiscal year 1991 and a plan to mothball it in fiscal year 1992.

At the end of May 1991, an electrical short caused extensive damage to part of one of the large helical windings shown in the schematic above. A limited repair was implemented, and the ATF resumed operation on September 25, making it possible for the ATF group to accomplish most of the goals planned for the summer of 1991.

The ATF is currently being repaired to preserve the option of restarting the ATF program. In addition, the ATF group hopes to double the plasma heating on the ATF and to extend operation to the long-pulse, steady-state regime for which the device was designed.

Whether this restart occurs depends on a review of the U.S. fusion program strategy now under way. **Encouraging support from the U.S. fusion community and from DOE gives reason for optimism that the ATF program will restart in 1993.**

--James F. Lyon, ORNL's Fusion Energy Division