# Hollow Current Improves Fusion Performance

Recent experiments in the DIII-D National Fusion Facility have shown that the performance of tokamak fusion devices is improved by the use of an unusual, hollow distribution of electric current.

At the temperatures of greater than 10 million degrees that are required for controlled nuclear fusion, the fuel takes the form of an ionized gas called a plasma. A tokamak confines a donut-shaped ring of plasma by means of strong magnetic fields; these magnetic fields are generated in part by external coils and in part by electric current flowing in the plasma itself. In general, once it is formed the electric current tends to "pinch" together and become concentrated at the center of the plasma (Fig. 1a).

However, DIII-D researchers have shown that plasmas with high temperature and high pressure can also be made where the current is concentrated midway between the center and the edge of the plasma, with very little central current (Fig. 1b). Several techniques were combined to create this unusual current distribution, including the direct generation of off-center current using high-power beams of microwaves. This configuration, although more difficult to produce, has several advantages in the stable, sustained confinement of a high-temperature fusion plasma.

A hollow current distribution improves the confinement of the plasma's heat by helping to reduce turbulence in the plasma, in accordance with theoretical predictions. A distribution of current that is farther from the center and closer to the edge also enables the plasma to take advantage of electromagnetic stabilization by the metal wall that surrounds the plasma, thus allowing the plasma to reach higher pressure without the occurrence of instabilities. Finally, at very high temperature and pressure the plasma is known to spontaneously generate its own current with a similar hollow distribution, suggesting that this favorable configuration could become self-sustaining.

Previous experiments at other laboratories have shown the existence of plasmas with hollow current distributions: most notably the tokamaks JET (United Kingdom) and JT-60U (Japan). The recent DIII-D experiments have extended the use of this configuration to support much higher plasma pressure relative to the pressure of the confining magnetic field, pointing the way to more compact and efficient fusion power plants.

The complexity of modern fusion experiments requires the efforts of many scientists to run them and analyze the results, and experiments at the DIII-D National Fusion Facility are typically performed by broad, multi-institutional collaborations. The team for the hollow-current experiment included scientists from Columbia University, General Atomics, Lawrence Livermore National Laboratory, Oak Ridge National Laboratory, Princeton Plasma Physics Laboratory, and the University of California-Los Angeles. Details of this experiment will be reported in a talk by Dr. A.M. Garofalo of Columbia University, at the APS-DPP meeting in Denver, October 24-28, 2005.

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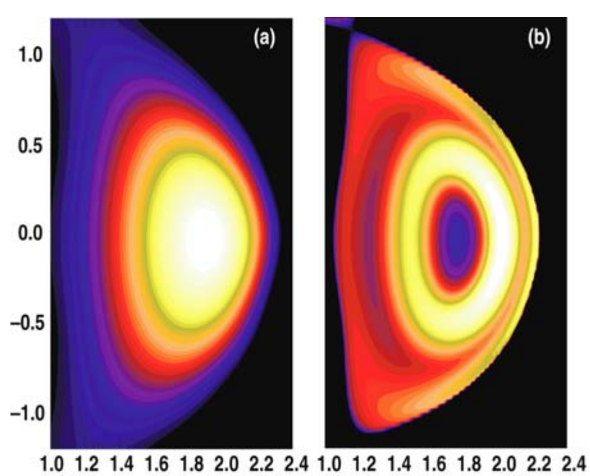


Fig. 1. These figures show the distribution of electric current in a vertical cross-section through the donut-shaped plasma. Brighter color indicates a greater intensity of current. (a) shows a conventional current distribution concentrated near the center of the plasma. (b) shows the hollow current distribution as measured in a high-performance DIII-D plasma.