GENERAL ATOMICS

News Release

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"SPINNING" FUSION ENERGY SOURCE IMPROVES PROSPECTS FOR POWER APPLICATIONS

The DIII–D National Fusion Facility Announces Major Advance For Fusion Energy Research

San Diego, CA – July 2, 2001 — Researchers at the U. S. Department of Energy funded DIII–D National Fusion Facility at General Atomics, the largest fusion energy experiment in the United States, have nearly doubled the usual limits on pressure in a fusion energy device by spinning the hot, fusion fuel very rapidly. A significant scientific advance in understanding the pressure limit in fusion energy devices made these higher limits possible. These results are an important step towards controlled fusion power production that is feasible, economical, and attractive.

Fusion, the combining of two small atomic nuclei to form a heavier nucleus, is the vast energy source that powers the sun and the stars. Scientists worldwide are striving to harness the fusion process. As stated in the recently released U. S. National Energy Policy: "Fusion — the energy source of the sun — has the long-range potential to serve as an abundant and clean source of energy. The basic fuels, deuterium (a heavy form of hydrogen) and lithium, are abundantly available to all nations for thousands of years." Fusion power will have no smog or greenhouse gas emissions to pollute air, ground, or water.

The fusion process requires extraordinarily high temperatures in the fusion fuel to produce useful amounts of energy. The DIII–D fusion energy device uses strong magnetic fields to contain the very hot (200 million degrees) fusion fuel (called a "plasma") inside a 15-foot diameter donut-shaped metal reaction chamber. This tokamak magnetic field configuration is presently the most successful fusion system being investigated by scientists worldwide. At these very high temperatures, all atoms are separated into their constituent nuclei and electrons forming an electrically conducting, high pressure plasma similar to the plasma inside a fluorescent light bulb or neon sign, but thousands of times hotter.

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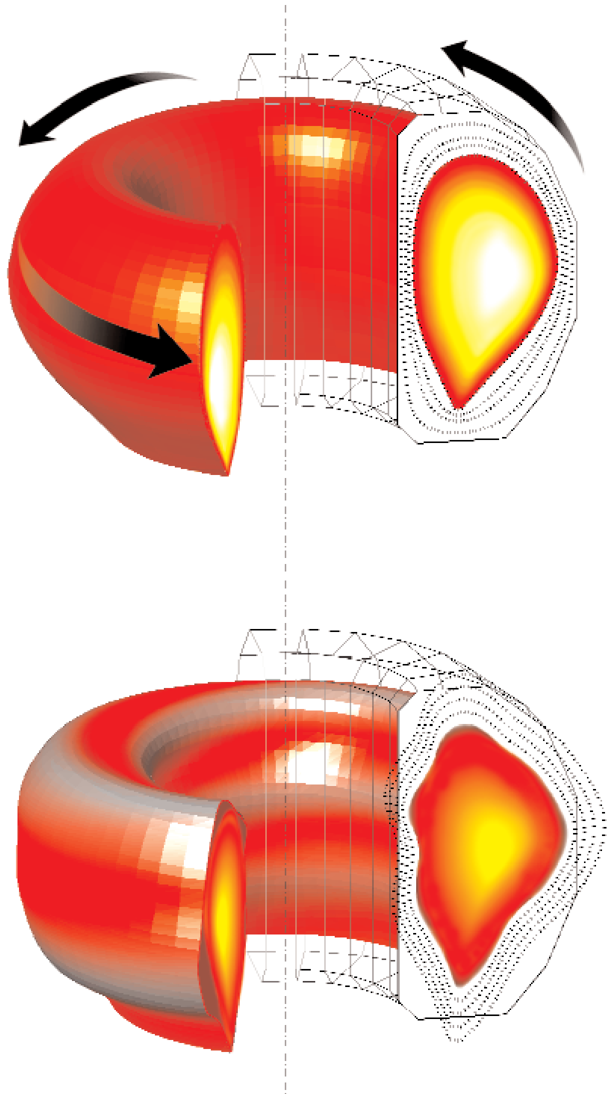

*SPINNING PLASMA **stabilizes the plasma surface allowing improved performance.** When stable, the plasma in the DIII–D tokamak is a tear-drop shaped donut inside a metal chamber as shown in the upper cutaway figure. When unstable, the plasma surface distorts as shown in the lower figure (exaggerated about 10 times). Control magnet coils (not shown) push back on these distortions, keeping the surface smooth, allowing the plasma to continue spinning rapidly (in the direction of the arrow) and to remain stable to higher pressure.*

"Spinning" Fusion Energy Source Improves Prospects for Power Applications (continued)

High pressure in the fusion fuel is critical because the power released from fusion reactions increases very rapidly with increasing pressure. However, previous experiments and theory have identified an upper limit to the allowable pressure, called the free-boundary pressure limit. Beyond this pressure limit the hot fusion fuel becomes unstable, bulges outward (see figure), contacts the metal chamber wall, and cools rapidly.

In the early 1990's, theoretical and experimental work had suggested that the plasma pressure might be increased beyond the usual free-boundary pressure limit by rapidly spinning the fusion fuel. Current experimental plasmas are easily spun at extremely high rates (10 to 100 miles/second!) like a spinning top. In the initial experiments on DIII–D that sought to raise the plasma pressure while spinning the fusion fuel, the spin rate would always slow down and the hot plasma would become unstable and be lost. "Scientists felt that the free-boundary pressure limit was unavoidable — we could not get beyond it. Sustaining the pressure beyond this limit is a significant scientific breakthrough," said Dr. Ronald D. Stambaugh, Program Director at the DIII–D National Fusion Facility at General Atomics.

"The observed slow-down of the spinning plasma was a big mystery to us initially, and we were concerned that more aggressive stabilization methods would be needed to raise the plasma pressure," said Prof. Gerald A. Navratil of Columbia University, one of the leaders of the multi-institutional team from Columbia University, Princeton Plasma Physics Laboratory, and General Atomics studying stabilization of high pressure plasmas on the DIII–D National Fusion Facility. However, the recent experiments on DIII–D clearly demonstrated that the slow-down of the spinning plasma was due to a tendency of the plasma to amplify very small imperfections in the magnetic field (at the level of the Earth's magnetic field). By applying new controls that automatically correct these small magnetic field imperfections the team was able to maintain the necessary high rate of spin needed for stability at high plasma pressure. These techniques have been used to sustain the pressure above the free-boundary limit in a variety of conditions, reaching levels nearly double the free-boundary limit in some cases.

Pioneering work on stabilizing plasmas using metal walls and control coils was done on a small tokamak at Columbia University. This research work on DIII–D is led by some of those same Columbia scientists, as well as scientists from Princeton Plasma Physics Laboratory (PPPL) and General Atomics (GA). Their work is supported by many collaborators from about 25 national laboratories and 25 universities worldwide that make up the DIII–D national research team. In addition, PPPL and GA provided major equipment for this research. Results of this research were briefly reported on behalf of the DIII–D team last week in a paper presented by Dr. Larry Johnson of PPPL at the European Physical Society meeting in Madeira, Portugal. A full report of these results will be made in an invited paper by Dr. Andrea Garofalo of Columbia University at the American Physical Society Division of Plasma Physics Meeting in Long Beach, California in October.

The capability to double the pressure limits in fusion devices by spinning the fuel will have broad application to a range of approaches to fusion energy. These results will increase the emphasis on developing methods to spin the fusion fuel in a fusion power source. The DIII–D research team expects this advance could ultimately allow the design of more economical fusion power sources and reduce the time required to develop and deploy reliable sources of fusion energy.

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