FOR IMMEDIATE RELEASE
November 2, 2009

High-Performance Plasmas May Make Reliable, Efficient Fusion Power a Reality

Progress in advanced operational scenarios for tokamak fusion devices provides hope for steady-state fusion power plants

ATLANTA—In the quest to produce nuclear fusion energy, researchers from the DIII-D National Fusion Facility have recently confirmed long-standing theoretical predictions that performance, efficiency and reliability are simultaneously obtained in tokamaks, the leading magnetic confinement fusion device, operating at their performance limits. Experiments designed to test these predictions have successfully demonstrated the interaction of these conditions.

These new findings will be presented at the American Physical Society – Division of Plasma Physics 51st annual meeting, November 2-6, at the Atlanta Hyatt Regency Hotel.

Nuclear fusion energy has kept the sun burning for billions of years. When nuclear fusion occurs in a laboratory, power performance is determined by the temperature and density achieved by plasma, an ionized gas formed when hydrogen isotopes are heated to temperatures of over 10 million degrees Celsius. Because of these extreme temperatures, the hot plasma is confined by magnetic fields in a "tokamak" (Fig. 1), a donut-shaped device surrounded by powerful electromagnets.

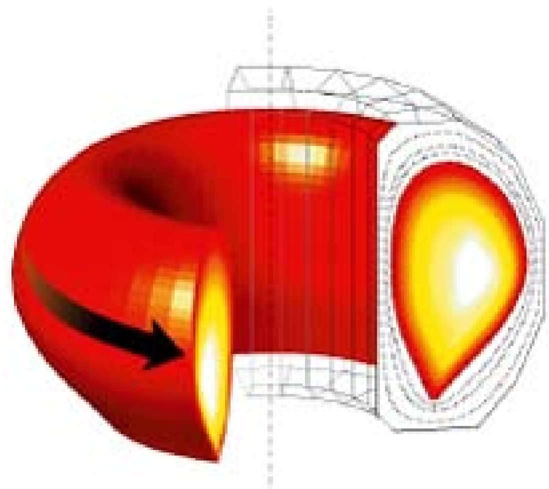

Figure 1: Artist's rendering of a tokamak plasma. The plasma is confined by the combination of strong magnetic field in the toroidal direction (around the hole in the "donut" as shown by the black arrow) generated by external coils (not shown) and the magnetic field from a large current flowing in the same toroidal direction. The plasma is held inside a sealed metal structure that is evacuated and lined with special material to keep the plasma pure and handle the heat exhaust.

Over the past decade, scientists have made tremendous progress toward realizing high pressures for increasingly long periods. A key element of recent experiments is the confirmation of theoretical predictions that one can rely on the walls of the tokamak chamber to improve plasma stability at high pressure.

Once plasma becomes sufficiently hot and dense, fusion occurs, producing large quantities of high-energy helium ions (known as alpha particles). For optimal efficiency, this self-generated heat must be well contained within the tokamak's "magnetic bottle." Models have predicted that the heat loss from the tokamak due to turbulence (Fig. 2) is quite sensitive to the exact details of the magnetic field configurations. Researchers recently found that turbulence is minimized in the same configuration necessary for achieving the highest pressures. Hence, performance and efficiency can be synergistic.

Interestingly, turbulent eddies in the plasma can also affect plasma heating by high-energy helium nuclei formed by the fusion of hydrogen atoms. Recent theoretical work suggests that these energetic particles not only feel turbulence differently, but can also stir up large eddies of their own (Fig. 3). While these fine-scale turbulent eddies are predicted to cause negligibly small transport of energetic alpha particles, the new large eddies can increase this transport substantially. As the alpha particles cool, their transport becomes similar to the background level.

For high reliability, a tokamak needs to sustain the hot and dense plasma for as long as possible. Recent work has shown that tokamak plasmas can be induced to exhibit the following

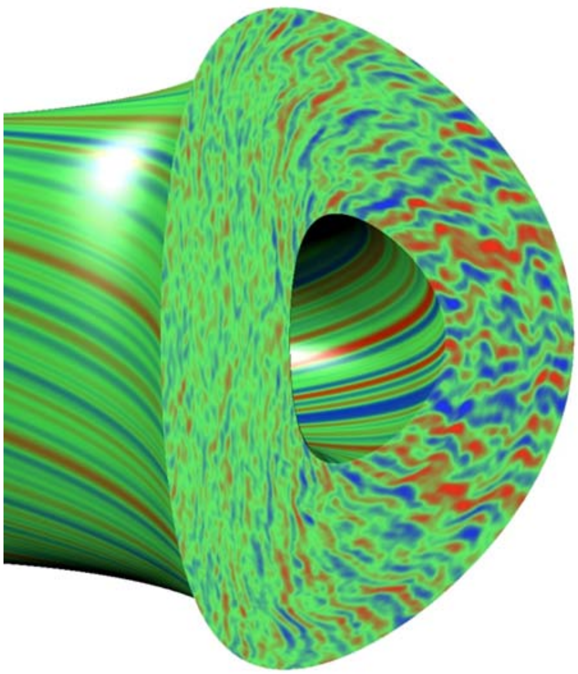

Figure 2: Direct numerical simulation of turbulent density fluctuations by the General Atomics GYRO code. Hundreds of such simulations are necessary to determine the self-consistent plasma profiles.

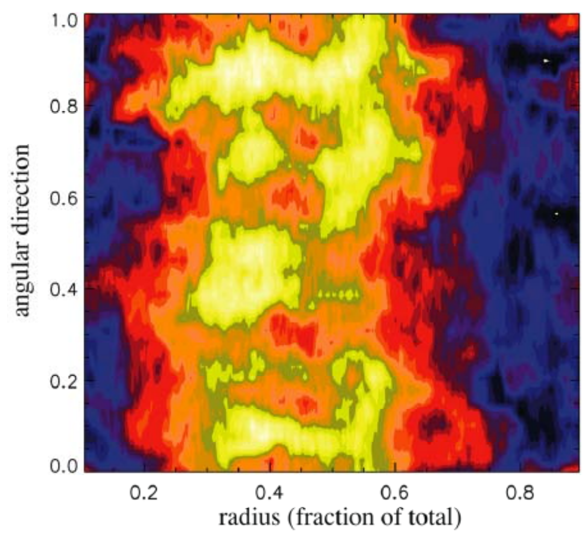

Figure 3: Simulated large plasma eddies excited by energetic fusion products.

relationships: higher pressure => more self-generated electrical currents that help control the plasma => less reliance on external controls => longer pulse (including potentially steady-state) operation => higher reliability.

After decades of effort to improve the behavior and output of fusion plasmas, scientists are discovering that nature may actually be so kind as to simultaneously allow high performance (lots of electricity!), optimal efficiency (affordable!), and high reliability (the electrical outlet will always work!) in the design of future power plants.

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Abstract: AR1.00001

Realizing Steady State Tokamak Operation for Fusion Energy
Invited Speaker: T.C. Luce (General Atomics)
8:00 AM–9:00 AM, Monday, November 2, 2009
Centennial I-II

Abstract: XI3.00002

Gyrokinetic Simulations of Enhanced Alpha Transport by De-stabilized Alfven Turbulence
Invited Speaker: E.M. Bass (General Atomics)
9:30 AM–12:30 AM, Friday, November 6, 2009
Centennial II

Abstract: DI3.00002

Predictive Gyrokinetic Transport Simulations and Application of Synthetic Diagnostics
Invited Speaker: J. Candy (General Atomics)
3:30 PM–4:00 PM, Monday, November 2, 2009
Centennial II

Abstract: KI3.00003

Probing Plasma Turbulence by Modulating the Electron Temperature Gradient
Invited Speaker: J.C. DeBoo (General Atomics)
4:00 PM–4:30 PM, Tuesday, November 3, 2009
Centennial II

Abstract: KI3.00001

Marshall N. Rosenbluth Outstanding Doctoral Thesis Award Talk: "Simultaneous Measurement of Electron Temperature and Density Fluctuations in the Core of DIII-D Plasmas"
Invited Speaker: A.E. White (ORISE)
3:00 PM–3:30 PM, Tuesday, November 3, 2009
Centennial II

Abstract: XI3.00003

Energetic Particle Transport by Microturbulence
Invited Speaker: W.L. Zhang (UC Irvine)
10:00 AM–10:30 AM, Friday, November 6, 2009
Centennial II