CONTACT: **Valerie Izzo**
Phone: 858-455-4144

FOR IMMEDIATE RELEASE

Simulating a “soft landing” for an unstable fusion plasma

Computer simulations may help guide design of future tokamak fusion reactors.

Fusion experiments face a danger from the occasional rapid release of stored energy in the form of plasma bursts or intense beams of high-energy electrons, which can damage the experiment. Sophisticated computer simulations are helping scientists develop effective methods to deal with this challenge.

The fuel for nuclear fusion takes the form of an ionized gas, called plasma, reaching temperatures of over 100 million C. Devices known as tokamaks use a strong magnetic field to confine the plasma and hold it away from the walls of the device. Tokamak experiments push the limits of plasma pressure, density and temperature that can be confined by the magnetic field. This can sometimes lead to an unstable situation in which the energy stored in the plasma is suddenly released in an avalanche-like event. A tokamak avalanche, known as a disruption, can do damage to the experimental device itself, especially as larger tokamaks with more stored energy are designed and built. This includes ITER, an international experiment now beginning construction in France, whose roughly $10 billion price tag strongly motivates strategies to mitigate damaging events.

Experiments in tokamaks such as DIII-D (at General Atomics in San Diego) and Alcator C-Mod (at the Massachusetts Institute of Technology) have shown that filling the chamber with a dense cloud of gas (such as neon, argon or krypton) as the disruption begins can remove the plasma’s heat in a benign way and protect the device’s walls from the impact of the disruption. Questions remain as to exactly how this technique works, however, and whether it can also provide protection against the intense beams of high-energy electrons that are sometimes generated during disruptions.

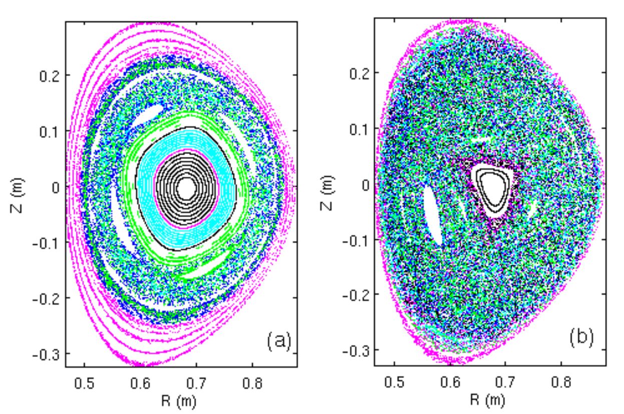

Figure 1. Computer simulation of the magnetic field structure (a) early and (b) later during neon injection, showing the progressive loss of magnetic confinement. Well-confined magnetic surfaces remain in the central and outer regions of the first case.

Recent computer simulations have begun to answer these questions. Simulations of Alcator C-Mod experiments show that injection of neon gas quickly reduces the temperature at the surface of the plasma. Although the neon does not penetrate deeply into the plasma, the cooling of the surface leads to instabilities that destroy good magnetic confinement in the plasma center (see Fig. 1). As a result, the plasma’s heat is conducted rapidly from the center to the surface, where it is absorbed and then radiated by the neon. This sequence of events explains the experimental observations well.

While simulations and experiments show that the plasma's heat energy can be removed effectively, they also indicate that the injected gas does not mix into the core of the plasma where high-energy electrons may be generated. Fortunately, the loss of confinement at the center that is seen in the simulations may also allow the high energy electrons to escape the plasma quickly, before they can build up into an intense beam. More detailed simulations will determine whether the gas injection technique can indeed prevent formation of electron beams. One-to-one comparisons of the simulations and experiments also increase confidence in the simulations, so that simulations of future tokamaks can provide guidance before they are built.

The complexity of modern fusion experiments requires the efforts of many scientists. The team for these simulations and experiments includes scientists from the University of California-San Diego, Massachusetts Institute of Technology, and General Atomics. Details of this work will be reported in a talk by Dr. V.A. Izzo of the University of California-San Diego, at the APS-DPP meeting in Orlando, Nov. 12-16, 2007.

Work supported by the U.S. Department of Energy under DE-FG02-05ER54809, DE-FG02-04ER54762, DE-FC02-04ER54698, and DE-FG02-95ER54309.

Contacts: V.A. Izzo, University of California-San Diego, 858-455-4144, izzo@fusion.gat.com
D.G. Whyte, MIT Plasma Science & Fusion Center, 617-253-1748, whyte@psfc.mit.edu
M.R. Wade, General Atomics, 858-455-4165, wade@fusion.gat.com
E.M. Hollmann, General Atomics, 858-455-3209, parks@fusion.gat.com
P.B. Parks, University of California-San Diego, 858-822-3775, ehollmann@ucsd.edu

Abstract: UI1.00005

MHD simulations of disruption mitigation on DIII-D and Alcator C-Mod

Invited Session UI1: MHD

4:00 PM–4:30 PM, Thursday, November 15, 2007
Rosen Centre Hotel - Junior Ballroom