FOR IMMEDIATE RELEASE
October 29, 2012
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Measuring Tiny Waves with High Power Particle Beams

Experiments explore difficult-to-measure wave-particle interactions within plasma, with implications for future plasma performance.

PROVIDENCE—Experiments at the DIII-D National Fusion Facility in San Diego, California, have led to the discovery of a new method for investigating the naturally occurring magnetic waves in the center of high temperature fusion plasmas. Scientists from the University of California, Irvine (UCI), and General Atomics have discovered that their instruments are well placed and sensitive enough to see the effect these waves have on the path of very energetic particles launched into the plasma from megawatt-sized particle beams.

Physicist Xi Chen, from UCI, is excited about the possibilities of learning how the weak electromagnetic fields of these Alfvén waves (named after their discoverer, the Nobel winner Hannes Alfvén) are able to have such a large effect on the path of particles through the plasma.

"By combining our measurements of their trajectory with separate measurements of the wave structure, we can probe the mechanism by which the waves eject particles from the plasma with unprecedented detail," she said.

Such wave-particle interactions are of interest to fusion scientists because they can increase energy loss from the plasma, reducing fusion power. The impact of high energy particles ejected by these waves causes local heating of reactor walls. The present experiments are carried out in the DIII-D tokamak at General Atomics in San Diego. The DIII-D tokamak uses strong magnetic fields to hold hot plasma inside a toroidal or donut-shaped vacuum chamber for pulses lasting several seconds.

While it is comparatively easy to observe energetic particles once they hit the walls, it is incredibly difficult to observe the particles interacting with the waves while still inside the plasma. A unique particle beam geometry on DIII-D launches high energy deuterium nuclei in such a way that they pass through the magnetic fluctuations and precisely hit Dr. Chen's instrument when they are kicked out of the plasma (see Figure 1).

The beam particles are so fast that only Alfvén waves are able to eject them while they are in the plasma. Separate microwave measurements show the location and size of the waves in great detail. Using a powerful computer code developed at the Princeton Plasma Physics Laboratory in Princeton, New Jersey, Dr. Chen and her colleagues are able to calculate the trajectories of hundreds of thousands of particles to relate the signals they measure at the wall to the waves inside the plasma for the first time.

"We expect that the knowledge gained from these measurements will allow us to control Alfvén waves and improve fusion performance," Dr. Chen said.

This work supported in part by the U.S. Department of Energy under DE-FG03-94ER54271, SC-G903402, DE-FG03-97ER54415, DE-FC02-04ER54968, and DE-AC02-09CH11466.

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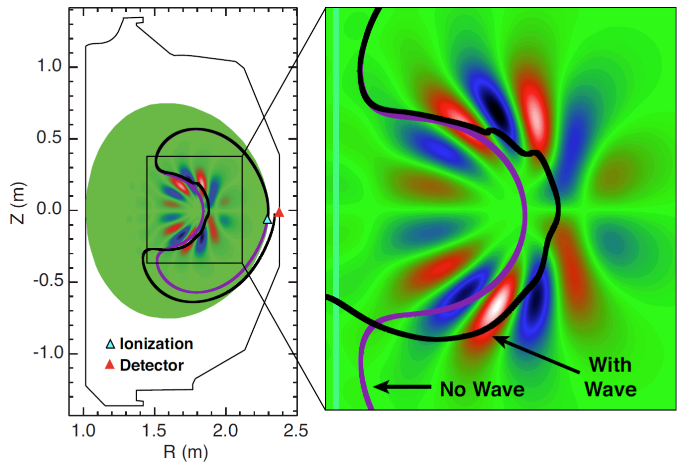

Figure 1. wiggle trajectory (black) of particles kicked out by the wave onto the detector compared to the smooth particle trajectory (purple) without wave

Abstracts:

NO4.00011 **Neutral Beam-ion Prompt Loss Induced by Alfvén Eigenmodes in DIII-D**

Session **NO4: DIII-D Tokamak,**

Room: 551AB, Wednesday, October 31, 2012, 9:30AM–12:30PM