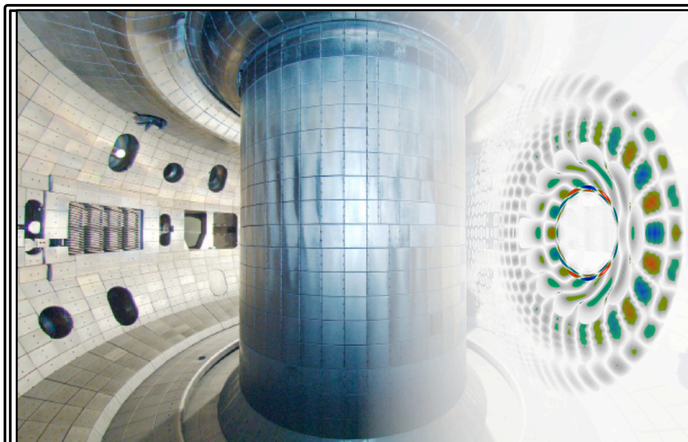
News advisory -- for immediate release
Nov. 16, 2015

Want Fusion Performance? Alfvén Eigenmodes Say Not So Fast…

Award-winning researcher finds important shortcut to calculate particle pathways

SAVANNAH, GA (Nov. 16) -- What goes in must come out…at least that's what happens to highly energetic plasma particles, or "fast-ions," in a fusion-energy producing tokamak device when instabilities called Alfvén Eigenmodes (AEs) are present.

Recent experiments at the DIII-D National Fusion Facility are helping scientists to better understand the basic physics of how AEs cause fast-ions to escape from a fusion plasma. At the DIII-D fusion energy program, which is operated by General Atomics for the Department of Energy, scientists discovered that when the fast-ion transport turns on, it increases in a predictable way, which allows them to use simplified computer models to map operating parameters that will optimize fusion performance in future fusion power plants.



***New route to fusion energy**: Cutaway view with simulated AE structures in DIII-D tokamak at GA. AE instabilities cause fast-ions to move away from plasma core; controlling them could increase fusion performance in future reactors.*

The experiments blazed a pathway to discovering how to calculate particle movement, particularly particle loss, that previously had to rely on expensive and time-consuming computer simulations that took weeks and even months to run, explained Dr. Cami Collins, who led the research team at DIII-D, the nation's largest magnetic fusion facility, as a post-doctoral researcher from University of California-Irvine.

Dr. Collins will present her findings at the 57th American Physical Society Division of Plasma Physics annual meeting.

Her latest research focused on AE instabilities that cause problems because they steal energy from the fast ions and kick them out of the energy-producing plasma flow. "They actually hit the wall," she said, "We want them to heat the plasma, not the wall."

Fast-ions play a critical role in achieving "burning plasma conditions," where the energy produced by the fusion reaction is enough to maintain the temperature of the plasma. In order to reach a burning plasma state, tokamaks must confine a large enough number of fast-ions for long enough times to allow for the transfer of energy through collisions to the colder, background plasma.

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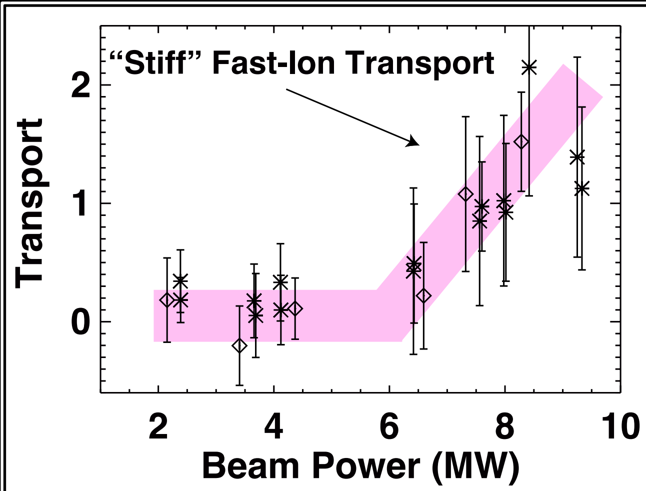

A shortcut to a predictable pathway in plasma transport: *Recent measurements using advanced diagnostics on DIII-D National Fusion Facility show Alfvén eigenmode-induced fast-ion transport increases in a much-needed predictable manner*

In tokamaks, fast-ions are generated by neutral beam injection, ion cyclotron resonance heating, or fusion reactions. However, large gradients in the fast-ion pressure profiles can provide free energy to excite AEs through wave-particle interactions. The AEs cause fast-ions to move away from the core of the plasma, flattening the profile and leading to reduced fusion performance and losses that could seriously damage reactor walls. Control of these losses is essential: As the next collective advance in magnetic fusion with the international partnership building the ITER project in France, the ITER tokamak must achieve less than 5% loss of fusion alpha particles to reach performance goals.

At DIII-D in San Diego, whose design is similar to ITER on a smaller scale, scientists have found that even though AE instabilities are relatively weak, when there are enough of them, they act together and cause large scale fast-ion transport. In the experiment, as more fast-ions were added to the plasma and the fast-ion pressure profile became more peaked, the total number of instabilities grew. Above a critical threshold the fast-ion transport suddenly switched on, exhibiting behavior known as "stiff" transport—increasing the power did not increase the temperature, but similarly caused faster loss.

Measurements of both the fast-ion critical gradient threshold and the scaling law for stiff transport are important for numerical model validation studies, giving greater confidence in predicting the relaxed fusion alpha density profiles and losses in future devices. These studies will ultimately allow scientists to modify the plasma conditions to control the growth of certain types of AEs so tokamaks can be operated in a regime that minimizes AE-induced fast-ion transport.

"People have been thinking about this issue for a long time, more than 20 years, but we've never been able to prove it before," Collins said, noting it was the advanced diagnostics systems on

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DIII-D and its complex beam system that made it possible. "It makes it possible to predict what fast ions will do, it helps us control instabilities—to predict and control."

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Abstracts:

JP12.00077**:** "Characterizing Critical Gradient Threshold for Alfvén Eigenmode Induced Fast-Ion Transport"

Session JP12: Poster Session IV (Education and Outreach; Undergraduate/High School Research; DIII-D I, Diagnostics and Simulation Methods; Low Temperature Plasmas, Breakdown, Thrusters, and Sheaths)

2:00 PM, Tuesday, Nov. 17, 2015 | Room: Exhibit Hall A