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

"Stalking" Multiple Tearing Modes with Microwave Beams to Safeguard ITER Fusion Plasmas

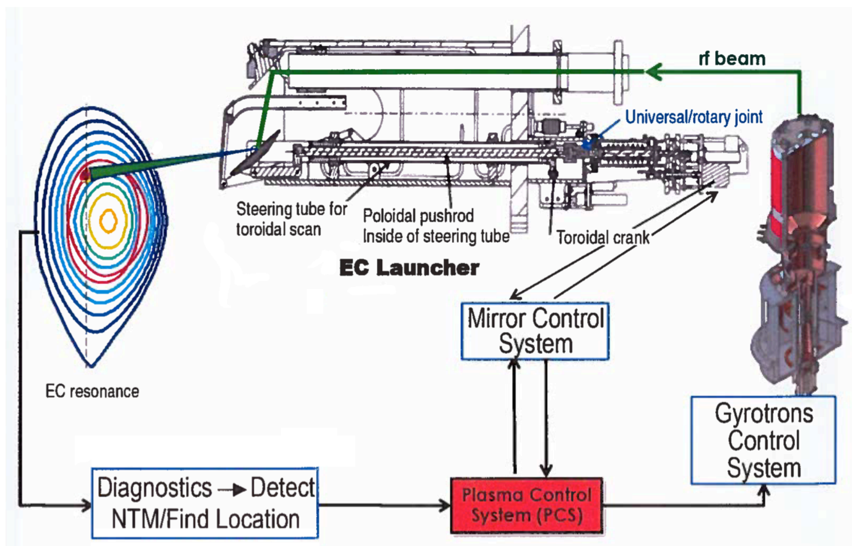
Advanced plasma control system at DIII-D National Fusion Facility successfully "stalks" rational surfaces with microwave beams to avert tearing mode "magnetic islands"

SAVANNAH, GA (Nov. 16) —Like Navy fighters positioning forward-looking radar to track the enemy, DIII-D physicists are strategically positioning mirrors and shooting high-frequency microwave beams to keep superhot fusion plasma at peak energy-producing levels.

Their recent results achieved in DIII-D National Fusion Facility experiments could have important implications for future fusion-energy production in the much-anticipated ITER fusion device now being built by a consortium of 35 nations, to prove the commercial viability of clean fusion energy.

"This is the first demonstration of tracking and controlling multiple instabilities, achieved using state of the art measurement systems and the flexible control tools we have in DIII-D," said Dr. Richard Buttery, Director of Experimental Science for DIII-D, operated by GA for the Department of Energy.

Buttery finds an analogy with flight, noting "there are many critical systems in an airplane, yet by developing robust control schemes we have ensured thousands of flights a day are safe. That's what we're doing with DIII-D - developing robust control for the tokamak to make fusion an everyday reality".



DIII-D scientists find success stalking fusion instabilities by using a unique targeted mirror control system with precise fast alignment of microwave RF beams inside the tokamak plasma. A beam is directed to be absorbed at the center of a 3/2 magnetic island. Illustration by General Atomics.

The enemies being stalked by these scientists at DIII-D are tearing modes that produce undesirable magnetic islands in otherwise toroidally symmetric tokamaks, which are complex steel-coated magnetic containers capable of containing plasma hotter than the Sun.

The islands that "leak" energy from the plasma can occur on flux surfaces where the safety factor, q, of the confining twisted magnetic field is a rational number m/n. An island that goes around three times the short way for every two times the long way, is q=3/2, as shown in cross-section in red in the image.

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GENERAL ATOMICS

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The DIII-D results demonstrate three major ITER-relevant innovations to the real-time plasma control system that give it the ability to:

- Track the positions of multiple rational surfaces as they move about during the plasma discharge in the tokamak
- Monitor where the microwave beams are being absorbed
- Move the distributed mirrors inside the chamber full of supercharged plasma to keep the driven radio frequency currents on the assigned targets

Key among the technology advances that enable this potentially breakthrough plasma control are DIII-D's gyrotrons Chewbacca, Leia, Luke (named from Star Wars), Scarecrow, Lion, Tinman (named from The Wizard of Oz), and NASA. DIII-D's gyrotrons are high-power linear beam tubes that generate powerful electromagnetic waves in a strong magnetic field.

The DIII-D plasma control system works with the gyrotron control system to adjust the motorized mirrors inside the vessel and direct the beams to keep the plasma tearing stable (see FIG. 1).

The current that is driven by the gyrotrons generates a magnetic field that opposes the field from the island and makes it go away, explained GA physicist Anders Welander, "Once the island is gone you can turn off the gyrotrons; but you can turn them back on quickly when a new island is observed."

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Abstract: JP12.00103 ITER Baseline Scenario with ECCD Applied to Neoclassical Tearing Modes in DIII-D
Session: Poster session DIII-D I

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