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Nov. 16, 2015

Daring Move for First U.S.-China Fusion Team

Discoveries in Bootstrap Plasma Regime Could Lower Fusion Power Costs

SAVANNAH, GA (NOV. 16) – The way to lower costs and increase the power of magnetic fusion energy may be to risk running the plasma – hotter than 100-million-degrees C -- closer than ever to the edge, according to new experimental results achieved by the first U.S.-China fusion research team.

The team's most recent results will be discussed in an invited talk at the 57th American Physical Society conference this week by a team-member from one of China's leading scientific labs, the Institute of Plasma Physics in the Chinese Academy of Sciences (ASIPP).

Groundbreaking U.S.-China experiments *continued in September between DIII-D, led by GA's Dr. Andrea Garofalo (at center), and China's ASIPP at the EAST fusion program, whose scientists connect via videoconferencing (pictured at left screen). At right is Huiqian Wang, an ASIPP post-doctoral scientist Huiqian being trained at DIII-D. Photo courtesy Lisa Petrillo/General Atomics*

The multinational fusion research team is led by Dr. Xianzu Gong of ASIPP, and Dr. Andrea Garofalo of General Atomics (GA), where scientists have pursued advancing their work in "high-bootstrap current" scenario, which is the self-generated plasma current that could lead to lowering the cost of fusion energy production.

This joint experiment directly demonstrates for the first time the stabilizing effect of reducing the plasma-wall distance on a high beta plasma with achievement of good performance and high bootstrap current fraction, according to Dr. Gong, who said, "I think, in simple terms, these experiments may provide better physics and operation foundation for ITER (fusion energy) plasmas."

A challenging and critical issue for advanced plasmas is the integrated demonstration of high normalized fusion performance operation with a high bootstrap current fraction, he noted.

"This is unlike any other regime," said Dr. Garofalo. The team has been working in both China and at DIII-D National Fusion Facility, operated by GA for the U.S. Department of Energy and site of the most recent experiments.

Focus was on resolving "the kink mode instability" with a scientifically daring move of moving

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…the plasma closer to the vessel's edge, he explained. Operating closer to the wall suppresses the kink mode and enables higher pressure inside the tokamak, the toroidal or doughnut-shaped steel-lined fusion device.

Magnetic fusion energy research uses magnetic fields to confine fusion fuel in the form of a plasma (ionized gas) heated to temperatures hotter than the Sun's core, necessary to fuse the ions and release excess energy that can be turned into electricity -- harnessing the Sun's power on Earth. The most developed approach uses tokamaks, which is the basis for ITER, a 500-megawatt fusion plant currently being built in France by a consortium of 35 nations including China and the U.S.

Positive results from the experiments, Dr. Garofalo said, could have direct relevance for future production-level fusion devices including the ITER fusion-energy program.

The process involved creating a "transport barrier" inside the DIII-D plasma, Dr. Garofalo explained. "You gain by needing less power and you lower the cost, which helps reach the break-even point for fusion power."

The downside has been that a steep transport barrier produces stronger kink instability, until the DIII-D-ASIPP team found a way around that challenge. They tried a daring experiment, by moving the plasma closer to the steel walls of the tokamak, and discovered they were able to stabilize the kink mode and achieve the "pressure-driven" plasma flows that maintain the confinement quality even with lower external injection of velocity.

As Dr. Garofalo said, "It's very risky to move the plasma that close to the wall, the chief operator said, 'You can't do that anymore, you're going to damage the machine,' so it was a struggle to prove our theory was correct."

Their risk paid off. Moving the plasma closer to the wall removed the kink mode, a wobbling effect that reduces plasma performance, and enabled higher plasma pressure, which, in turn, makes the plasma less dependent on externally injected flow. This is important because in a tokamak reactor, such as ITER, it is very difficult and expensive to drive a rapid plasma flow with external means.

The DIII-D-China team performed the bootstrap exploration following-up work on the record-setting milestone in clean-energy science achieved at China's EAST tokamak, where GA scientists have also been collaborating. An ASIPP scientist Dr. Qilong Ren will deliver the invited talk on the topic of Magnetic Confinement-Experiments.

While fusion has been open source since the 1950s and its advances achieved by teams around the world, this U.S.-China team is setting new milestones in global cooperation.

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For realization of magnetic fusion energy, global cooperation is needed, said Dr. Gong of ASIPP, who cited the EAST/DIII-D partnership as "an efficient and effective new model" for international science collaborations that benefits both partners and the field of study.

"We have made a very good start of international collaboration in fusion research between China and the U.S., and we are very proud to be a pioneer in this field," said Dr. Gong.

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Session:
KI2.00004 "Progress Toward Steady State Tokamak Operation: Exploiting the high bootstrap current fraction regime." Chatham Ballroom C

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