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Simulation Model Heads EAST

Research team takes high-efficiency computational approach to simulate short, intense plasma bursts on next-generation tokamak reactors.

PROVIDENCE—Scientists have developed simulation models to identify very short and intense plasma bursts, known as ELMs, on next-generation superconducting experimental tokamaks: the Experimental Advanced Superconducting Tokamak (EAST) in China, and Korea Superconducting Tokamak Advanced Research (KSTAR) in South Korea.

The results generated by these devices are needed to provide critical data for steady-state operation of the upcoming ITER facility, under construction in Cadarache, France. Once completed, ITER will be used to demonstrate magnetic fusion energy.

"By working together, this project will combine U.S. expertise in edge physics and numerical simulation with the large investments that China and Korea have made in new experimental facilities and new scientific staff," said Xueqiao Xu, a Lawrence Livermore National Laboratory physicist.

Xu led an international research team studying the plasma's thin surface layer and ripples near its edge, where heat can leak out in short and intense bursts (ELMs). In a fusion reactor like ITER, fusion takes place in the extremely hot (above 100 million °C) center plasma. ELMs generate periodic bursts of high heat and particle flux on very short time scales which, if left unchecked, could cause damage to the tokamak's plasma-facing components.

Xu and his team focused on the origin of the ELMs, developing predictive models for simulations, and also methods to control or mitigate ELMs. It's important to understand these modes and their potential effect on ITER before the final construction of the facility exhaust system is under way.

Edge plasma, where temperatures can climb tens of millions of degrees over mere inches, plays a key role in setting conditions for maximum fusion gain in the core of a reactor. This is a transition region where the stellar world of hot plasmas meets the earthly world of cold solids. Xu's team has been developing highly efficient models that can bridge these hot kinetic and cold fluid regimes, using an approach that reduces the phase-space dimensionality from five to three dimensions. Computationally, these models are as much as 100 times more efficient.

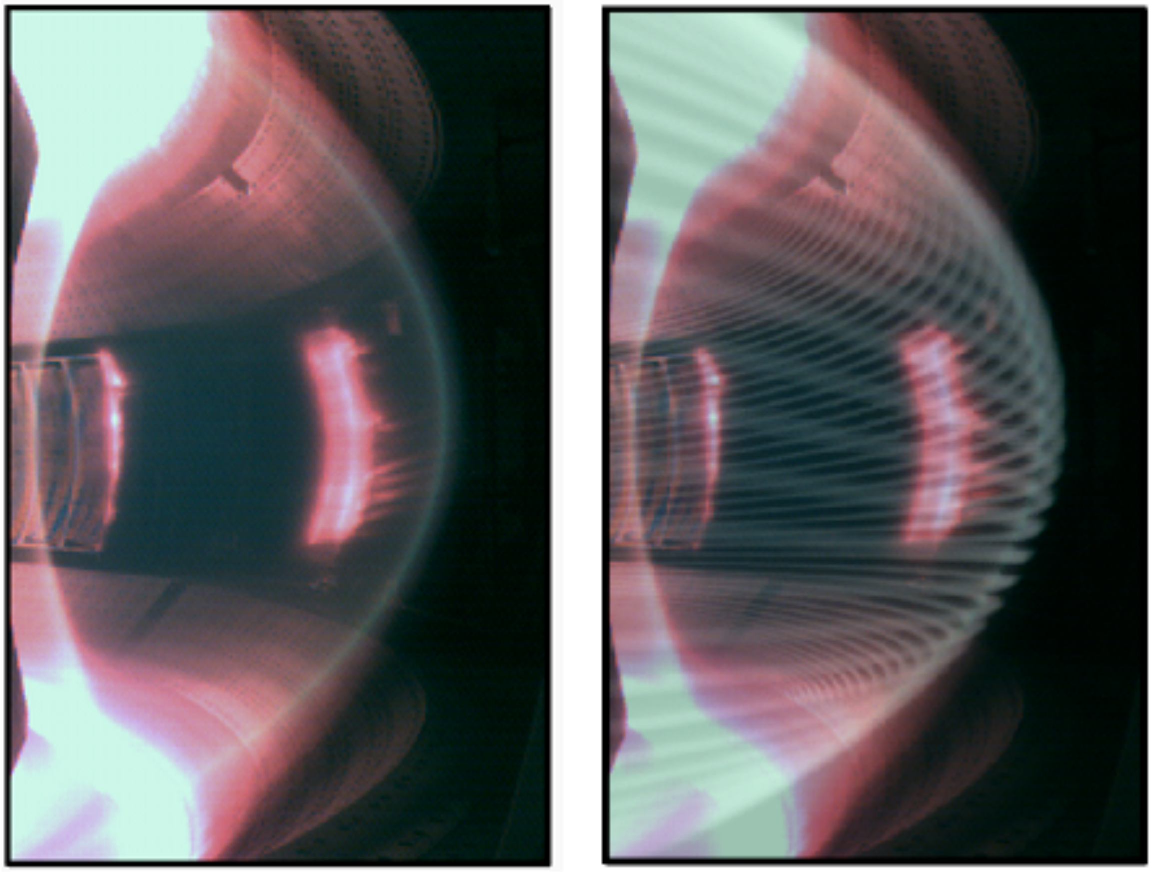

Figure 1 - At left a high speed camera captures ripples of cool plasma on the surface of the hot, but invisible, confined plasma in the EAST tokamak in China. The right image shows a new supercomputer simulation that produces the same surface ripples as the experiment where both the filament orientation and spacing match.

To test the computer models (as illustrated in Figure 1), the team is collaborating with two emerging Asian fusion programs: the two largest operating superconducting experimental tokamak research facilities in Asia, EAST in China and KSTAR in South Korea. These new superconducting tokamaks will be the first devices to operate plasma-exhaust divertors over long, reactor-relevant discharge times, making the edge boundary particularly challenging to experimentally understand and control, and even harder to simulate.

“Our goal will be to generate theoretical and simulation capability far beyond the present state-of-the-art and to validate the model using next-generation tokamak data,” Xu said.

This work was performed for the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DEAC52-07NA27344. LLNL-MI-593012. Further background information on LLNL’s BOUT++ project and its international collaboration is at https://bout.llnl.gov.

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Abstracts:

TI3.00002	**Gyro-Landau-Fluid Theory and Simulations of Edge-Localized-Modes**
Session	**TI3: Pedestal ELMs and ELM mitigation,** Ballroom BC, Thursday, November 1, 2012, 9:30AM–12:30AM