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Calming the Plasma Edge: The Tail that Wags the Dog

Lithium injections show promise for optimizing the performance of fusion plasmas.

NEW ORLEANS—Experiments on the DIII-D tokamak fusion reactor that General Atomics operates for the U.S. Department of Energy have demonstrated the ability of lithium injections to transiently double the temperature and pressure at the edge of the plasma and delay the onset of instabilities and other transients. Researchers conducted the experiments using a lithium-injection device developed at the DOE's Princeton Plasma Physics Laboratory (PPPL).

Lithium can play an important role in controlling the edge region and hence the evolution of the entire plasma. For example, researchers have used lithium on the National Spherical Torus Experiment (NSTX) at PPPL and the EAST tokamak in China to improve the performance of the plasma. When lithium is injected, the boundary of the plasma emits green light, characteristic of lithium atomic processes (Figure 1).

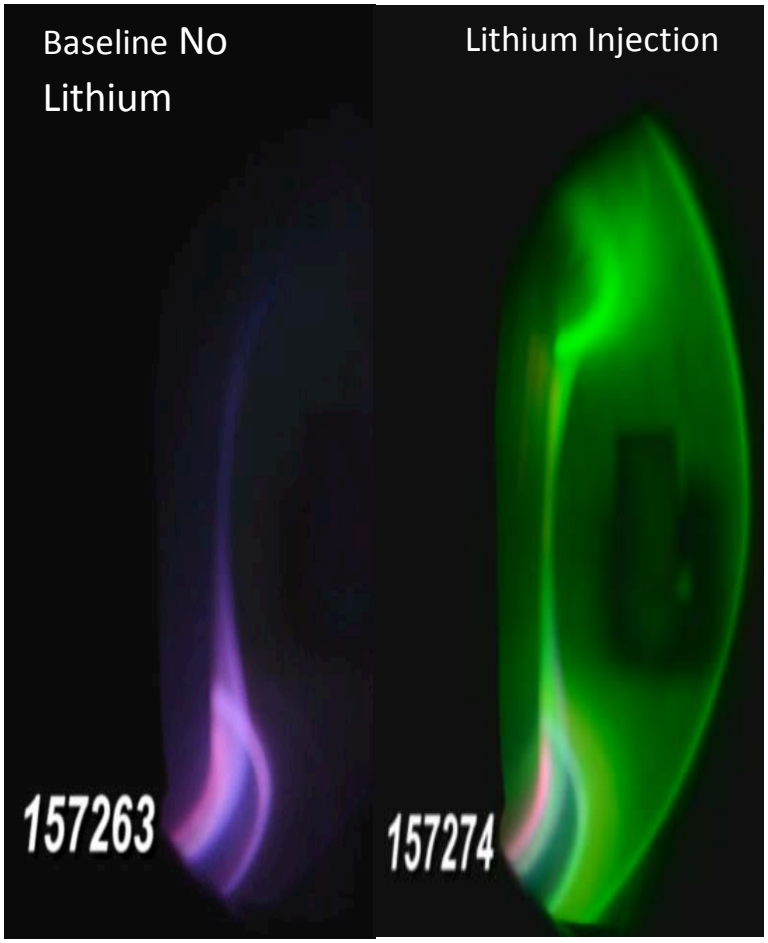

Figure 1: Figure 1: Comparison of visible light from a reference no-Li discharge and one with Li injection in DIII-D. Li-II visible emission is primarily green in this image from Lawrence Livermore National Laboratory.

In the present work reported in a number of papers at the 56th American Physical Society Division of Plasma Physics Conference, New Orleans, LA, Oct. 27-31, 2014, lithium diminished the frequency of instabilities known as "edge localized modes" (ELMs), which have associated heat pulses that can damage the section of the vessel wall used to exhaust heat in fusion devices. The experiments injected lithium powder at low velocity from the top of DIII-D during plasma discharges, and compared the results with previous discharges done without lithium. DIII-D is optimally suited for this work since no lithium was previously present

before these experiments, and world-class diagnostics on the device enabled careful evaluation of the direct effect of the lithium.

The tailored injections produced ELM-free periods of up to 0.35 seconds, while reference discharges without lithium showed no ELM-free periods above 0.03 sec. The lithium rapidly increased the width of the pedestal region—the edge of the plasma where temperature drops off sharply—by up to 100 percent and raised the electron pressure and total pressure in the edge by up to 100 percent and 60 percent respectively. These dramatic effects produced a 60 percent increase in total energy-confinement time. Further work will focus on extending these high-performance ELM-free phases and uncovering the mechanisms by which lithium calms the plasma.

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Abstracts:

CO5.00006 Plasma Imaging of the DIII-D Tokamak
3:00 PM–3:12 PM, Monday, October 27, 2014

CO5.00009 H-mode Pedestal Enhancement and Improved Confinement in DIII-D with Lithium Injection
3:36 PM–3:48 PM, Monday, October 27, 2014

Session CO5: DIII-D Tokamak
2:00 PM–5:00 PM, Monday, October 27, 2014
Room: Galerie 2/3

GP8.00036 Bifurcation to Expanded H-mode Pedestal Width and Height with Lithium Dust Injection in DIII-D

9:30 AM–9:30 AM, Tuesday, October 18, 2014

GP8.00037 Impact of Lithium Injection on the H-mode Pedestal in DIII-D

9:30 AM–9:30 AM, Tuesday, October 18, 2014

GP8.00038 Onset of a ``Broadband Bursty'' with Lithium Aerosol Injection in DIII-Dl

9:30 AM–9:30 AM, Tuesday, October 18, 2014

Session GP8: Poster Session III: DIII-D Tokamak; Computer Simulation Methods: Shocks, Waves, Dynamo and Dipole; Low Temperature Plasmas Science and Engineering

9:30 AM–9:30 AM, Tuesday, October 18, 2014

Room: Preservation Hall