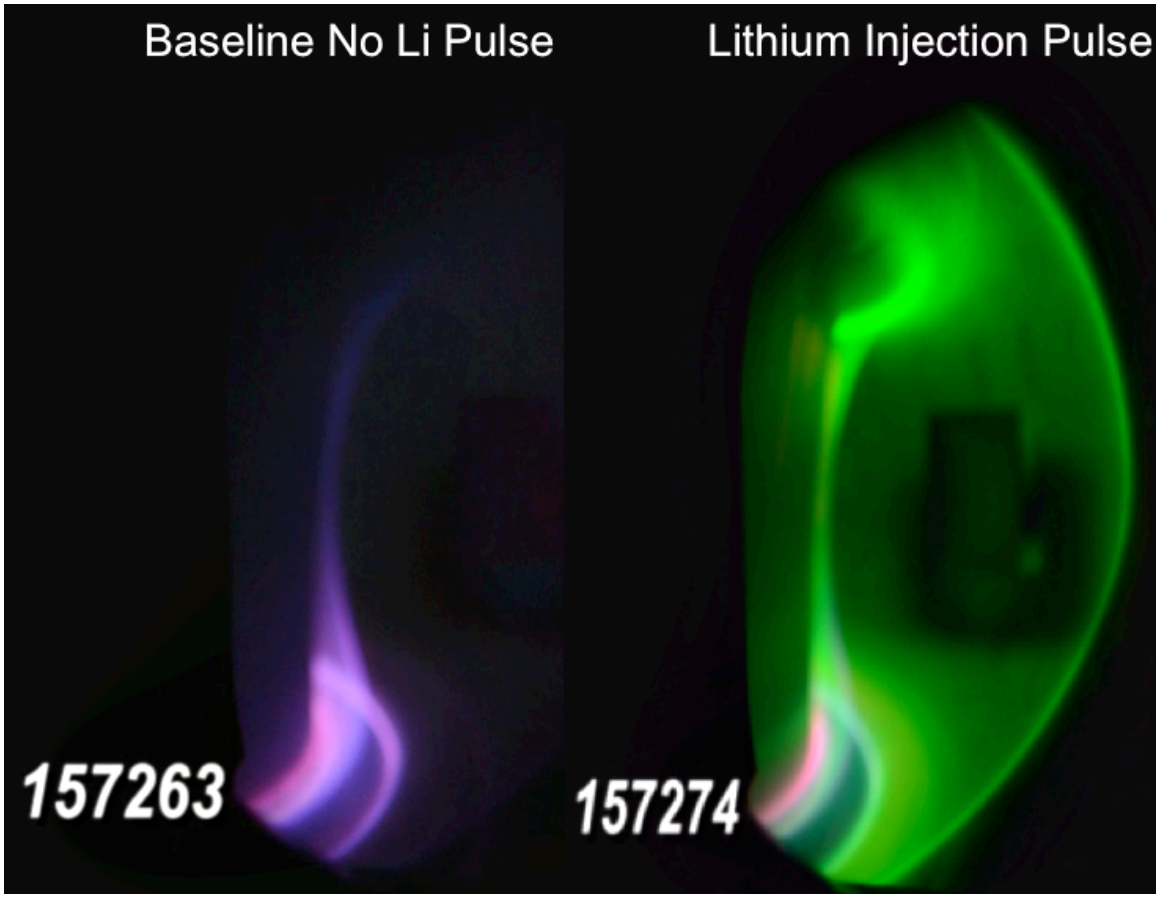
Calming the Plasma Edge: the Tail that Wags the Dog

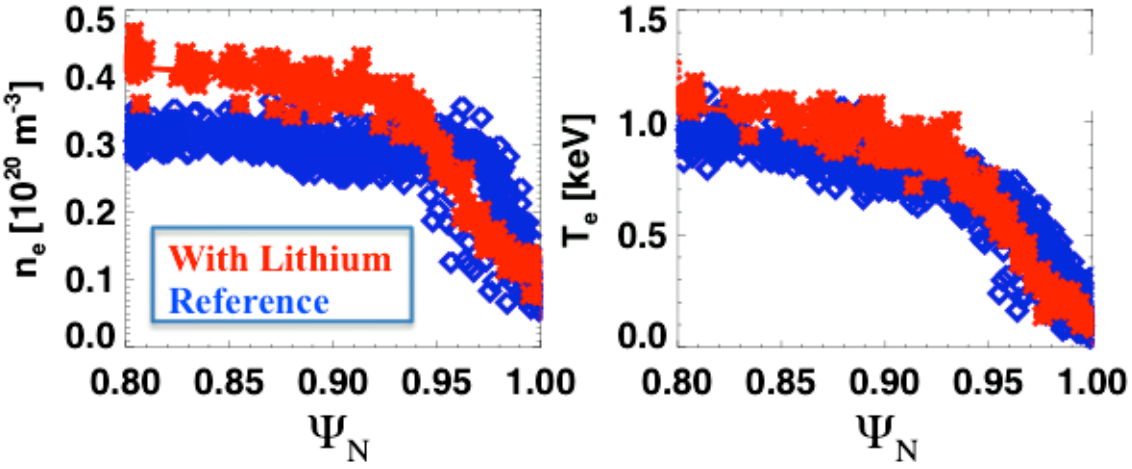
An experiment on DIII-D has demonstrated the ability to double the plasma edge pressure with lithium injection and delay the onset of transients, using a lithium injection device developed at Princeton Plasma Physics Laboratory (PPPL). This in turn allowed increased energy content in the entire plasma.

Lithium can have an important role in controlling both the pedestal and, hence, the entire plasma evolution. In particular, the need to avoid or minimize periodic heat pulses associated with transients such as edge localized modes (ELMs) is especially important for burning plasma devices. Hence, control of the pedestal is crucial in tailoring the plasma pulse for best performance. Lithium has been shown in devices such as NSTX and EAST to reduce recycling, i.e. particles that are reflected from the wall, and this has led to improvements in overall plasma performance [1,2].



Comparison of visible light from a baseline discharge and one with lithium injection (LI^{II} (visible emission is primarily green).

In the present work, lithium aerosol was injected at low velocity (44 μm granules at 6–7 m/s) from the top of DIII-D during plasma discharges, and then compared to no-lithium reference pulses. DIII-D is optimally suited for this work since no lithium was present before these experiments. Thus, using the DIII-D world-class diagnostics, a careful evaluation of the direct effect of lithium was studied.



Pedestal widths noticeably increase after a transition to ELM-free H-mode with lithium injection (red) compared to a baseline no-lithium ELMing H-mode.

When the amount of injected lithium was appropriately tailored, ELM-free periods of up to 0.4 s were obtained, while reference discharges without lithium continued ELMing. With lithium, the width of the edge transport barrier was dramatically increased by up to 100%, and the edge electron temperature, inferred from fits to Thomson scattering measurements, increased by up to 150%. These effects also led to a 60% increase of the total energy confinement time with lithium. The transition to ELM-free H-mode with lithium was itself very rapid, taking only 5–40 ms. However, no secular increase in impurities or radiated power was observed, possibly related to continuous instabilities that developed in the edge plasma. To date, the ELM-free periods with lithium are transient and further work will focus on extending these high performance ELM-free phases and uncovering the mechanisms behind the transport barrier expansion.

[1] R. Maingi, *et al.*, Phys. Rev. Lett. **107**, 145004 (2011)
[2] G.Z. Zuo, Plasma Phys. Control. Fusion **54**, 015014 (2012)

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