Controlling Edge Localized Modes with the Lithium Granules on DIII-D

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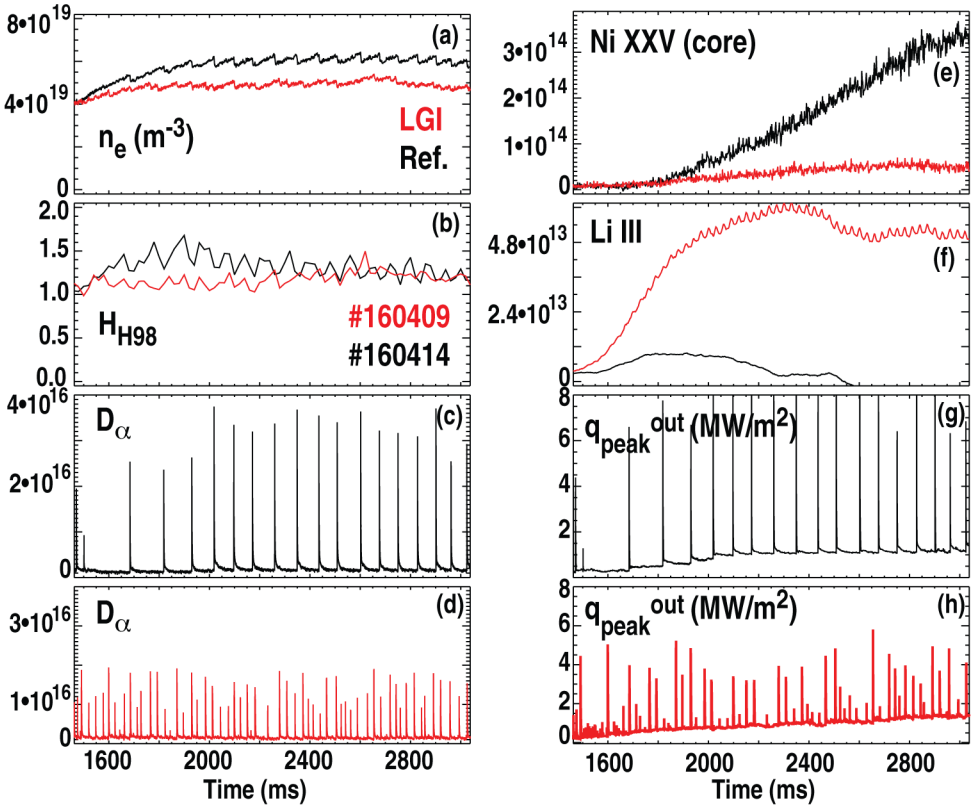
Lithium granules injected into DIII-D increased the edge localized mode (ELM) frequency by 2-5x and decreased the ELM peak heat flux, while maintaining good H-mode energy confinement. Control of transient events in fusion devices represents an area of significant challenge for H-mode operation in tokamaks. Periodic, unmitigated edge localized modes (ELMs) are projected to result in unacceptable damage to plasma facing components in ITER, which requires a 20-50x reduction in peak ELM heat flux, or complete ELM elimination with acceptable density control [Loarte, NF 2014]. While deuterium pellets are the leading method to destabilize and pace ELMs [Baylor, PRL 2013], use of non-fuel particles for ELM destabilization should reduce core fueling and gas load to the pumping system, albeit at the cost of managing in-vessel inventory of the injected material.

A simple device to inject non-fuel granules (lithium) was shown to trigger ELMs in EAST [Mansfield, NF 2013]. An upgraded version of this device with four reservoirs for different granule sizes (0.3 mm, 0.5 mm, 0.7 mm, 0.9 mm +/- 0.1 mm) was tested in DIII-D in a number of different ELMy discharge scenarios. The figure compares measurements made in discharges with (red) and without(black) Lithium granule injection. The increase in ELM frequency can be seen in panels (c), (d), while the decrease in ELM peak heat flux is shown in panels (g), (h). A reduction in core metallic impurities can be seen in panels (e), (f). Additionally the ELM triggering efficiency increased with granule size, reaching ~ 92% for the largest granules.



The overall energy confinement tended to decrease with increasing ELM frequency; in some cases, however, the energy confinement could be maintained, e.g. panel (b) using 0.5 mm Li granules.

Direct comparisons of ELM triggering between Li granules and Deuterium pellets were made in the same discharges; the planned profile and stability analysis will lead to more insight on the ELM trigger physics. Finally the ability to modify the natural ELM frequency in low torque, ITER baseline discharges was demonstrated.

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