# Suppression of larger ELMs and triggering of small ELMs with gravitationally accelerated Li granules in EAST

Z. Sun
zsun@pppl.gov

*Princeton Plasma Physics Laboratory, 08543 Princeton NJ, USA*

Large edge-localized modes (ELMs) were mitigated by gravitational injection of lithium (Li) granules (0.7mm nominal diameter) into the upper X-point region of the EAST device, which has tungsten plasma-facing components (PFCs) [1]. The maximum ELM size was reduced by ~ 70% in Type-1 ELMy H-mode plasmas. Large ELMs were stabilized for up to ~ 40 energy confinement times. Constant core radiated power held constant, and there was no evidence of impurity accumulation, both high-Z and low-Z. The Li granule injection reduced the edge plasma pedestal electron density and temperature, and also their gradients, due to increased edge radiation and reduced recycling from the PFCs. ELITE code calculations indicate that the stabilization of large ELMs correlates with improved stability of intermediate-n peeling-ballooning modes, due to reduced edge current resulting from the relaxation of edge profile gradients. The pedestal pressure reduction was partially offset by a core density increase, with the net result of a modest ~ 7% drop in core stored energy and normalized energy confinement. This result is attractive, given that an impeller driven by a high speed motor is typically used to drive granules into EAST plasmas at speeds > 50 m/s for ELM triggering [2-4]; the use of the dropper eliminates the second impeller stage required for a high speed granule injector.

During the phase that large ELMs are dynamically suppressed on a 0.5s timescale, small ELMs are triggered soon after Li granule dropping, with ~ 20-30% amplitude of large ELMs. These remnant small ELMs appear to be triggered by the penetration of multiple, closely-packed Li granules just past the separatrix, similar to small ELMs triggered by deuterium pellets [5]. The clustering allows deeper penetration just past the separatrix where small ELMs can be destabilized. This study extends previous ELM elimination with Li and Boron powder injection [6, 7] in EAST because 1) use of small, dust-like powder and the related potential health hazards were eliminated, and 2) use of macroscopic granules should be more applicable to future devices, due to deeper penetration than dust particles, e.g. inside the separatrix with velocities ~ 10 m/s in EAST. *Supported in part by the U.S. DoE under Contract Number DE-AC02-09CH11466, and in part by the National Key Research and Development Program of China (2017YFA0402500, 2017YFE0301100), and National Nature Science Foundation of China (11625524, 11775261, 11905148 and 11905138).

[1] Z. Sun et al., 2021 *Nucl. Fusion* **61** at press
[2] D. K. Mansfield *et al.*, 2013 *Nucl. Fusion* **53** 113023
[3] Z. Sun *et al.*, 2018 *IEEE Trans. Plasma Sci.* **46** 1076
[4] R. Lunsford *et al.*, 2018 *Nucl. Fusion* **58** 036007
[5] S. Futatani et al., 2014 *Nucl. Fusion* **54** 073008
[6] R. Maingi *et al.*, 2018 *Nucl. Fusion* **58** 024003
[7] Z. Sun et al., 2021 *Nucl. Fusion* **61** 014002