ELM Suppression by Real-Time Boron Powder Injection


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Experiments provide the first observation of edge-localized-modes (ELMs) suppression without confinement degradation when boron powder is injected in the upper X-point of the EAST tokamak [1] (as shown in figure 1). While boron powder injection was previously aimed at conditioning walls, experiments reveal that interactions of the ablated boron with background plasmas have beneficial effects for confinement as well as impurity accumulations. In addition to these effects, ELM suppression was shown to occur when the ablated boron reaches a certain threshold in the discharge. Similarly, when boron injection is halted during the discharge, ELMs return promptly suggesting that the effects of boron on the wall can be ruled out. Furthermore, boron injection and subsequent ELM suppression are associated with the onset of an edge harmonics mode (see figure 2). The observed mode has multiple harmonics and was shown to produce particle transport. The ablated boron produces a local density perturbation akin to a density accumulation that in turn leads to GAM-like modes[2].

We hypothesize that boron injection can in principle trigger a GAM-like mode in the edge and enhance X-point orbit loss. Preliminary calculations show using two-fluid and XGC gyrokinetic that secondary GAM frequencies are consistent with the frequency observed in the experiments. Results presented could open new research opportunities in providing an actuator for triggering edge mode capable of making the pedestal marginally “leaky” in order to suppress ELMs without confinement degradation.


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Figure 1: Time history of the boron-induced ELM suppression (red) and the reference ELMy discharge (black). (a) A proxy for the boron injection indicated by the B-V line emission. (b) The total stored energy showing a slight increase during boron-induced ELM suppression. (c) The line-averaged density essentially showing stationary density evolution. (d) The upper Dα trace showing the ELMs in the reference case and the absence of ELMs when the IPD is injected. (e) Time history of carbon impurity, clearly indicating a drop. (f) No W accumulations observed during boron injection with slight drop in W after 5 s.

Figure 2: Edge coherent modes. (a) spectrogram of XUV chord. (b) cross-spectrogram of magnetic probe and XUV