ELM Pacing with 3D Magnetic Perturbations in NSTX

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The application of 3D magnetic perturbations has been shown to robustly trigger edge-localized modes (ELMs) in the National Spherical Torus Experiment (NSTX) [1]. ELM destabilization has been observed over a wide range of parameters, including both with boronized carbon plasma facing components (PFCs), and with lithium coatings applied. The destabilization of ELMs with 3D fields is being developed as a pacing technique to control impurity content during lithium-enhanced H-modes, which typically show improved energy confinement and the suppression of ELMs [2], but also strong impurity accumulation The re-introduction of ELMs into these plasmas mitigates the impurity buildup, contributing to the development of steady-state discharges with lithium-coated PFCs.

The applied perturbation has a broad poloidal spectrum at the plasma edge, with strong resonant and non-resonant components. With boronized carbon PFCs, the pedestal density is unchanged following the 3D field application, whereas the electron temperature was measured to increase by ~30%; stability calculations using the PEST code showed the increased pressure gradient was sufficient to destabilize edge modes [1]. With lithium conditioning, the pedestal density and temperature are modestly reduced after 3D field application. Both with and without lithium, the 3D field reduced toroidal rotation. For the purpose of ELM pacing, the waveform and frequency of the triggering perturbation have been optimized for the impact on ELM size and plasma performance. While the ELM size is reduced at high triggering frequency, lower frequency is optimum for controlling impurity content while minimizing the impact on energy confinement. When combined with improved particle fuelling, the ELM-pacing technique has been successful in achieving stationary conditions in the line-averaged electron density and total radiated power, although the profiles continue to evolve.

[1] J.M. Canik *et al*, Phys. Rev. Lett. **104** (2010) 045001.

[2] R. Maingi *et al*, Phys. Rev. Lett. **103** (2009) 075001.

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