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Kinetic profiles and impurity transport response to 3D-field triggered ELMs in NSTX

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The response of kinetic plasma profiles to 3D-field triggered edge localized modes (ELMs) and the inter-ELM carbon impurity transport were analyzed in lithium-conditioned H-mode discharges in NSTX. ELM-free lithium-conditioned H-mode discharges were characterized by core accumulation of impurities as a result of near-neoclassical impurity transport, an edge inward pinch and the absence of impurity flushing mechanisms. Non-axisymmetric magnetic perturbations (n=3) were applied to trigger ELMs (triggering frequency f_ELM=10-62.5 Hz), and mitigate core impurity buildup maintaining the positive effects of lithium on energy confinement.

Edge impurity flushing increased with f_ELM, with a progressive reduction in the carbon density n_C at the pedestal top. For ELMs triggered at 10Hz, up to a 30% drop in n_C was observed, with comparable effects in the n_e, T_i, and toroidal velocity v_phi profiles. The increase in f_ELM led to a reduction in the core carbon inventory and progressively modified edge profiles. Inside the pedestal top, n_C and n_e were reduced by up to 60% and 40%, respectively, while being unaffected in the steep gradient region. T_i and v_phi normalized edge gradients increased by up to a factor of three. The ELM effect on the n_C profiles was reproduced in simulations with the impurity transport code MIST with an inward convective perturbation and an outward diffusive/convective perturbation to the steady state carbon transport coefficients (inside and outside normalized volumetric radii R_VOL of 0.6, respectively).

The agreement of inter-ELM carbon transport with neoclassical estimates improved with the increase in f_ELM. The changes in T_i and n_D profiles due to triggered ELMs led to changes in carbon neoclassical transport coefficients comparable and opposite to those observed with the transition from ELMy boronized discharges to ELM-free lithium-conditioned discharges. In particular, the carbon neoclassical convective velocity (evaluated via NCLASS) at the top of the pedestal changed direction (from inward to outward). Concomitantly, better agreement between the neoclassical transport predictions and experimental inter-ELM n_C profile shapes was observed in lithium-conditioned discharges with triggered ELMs in a similar way to naturally ELMy discharges.

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