Observation and modeling of inner divertor re-attachment in discharges with lithium coatings in NSTX*

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Conditioning of wall and divertor graphite tiles with evaporative coatings in the National Spherical Torus Experiment (NSTX) has led to modifications in core performance [1,2], edge plasma profiles and MHD stability [3], and scrape-off layer (SOL) and divertor conditions. In particular, the lithium coatings reduced recycling in the divertor, thereby modifying the behavior of the divertor plasma. The outer divertor changed from a conduction limited (high recycling) regime to a sheath limited (low recycling) regime while the generally detached inner divertor was observed to re-attach.

In this work we focus on the modifications to the inner divertor plasma regimes. In high triangularity H-mode discharges, electron densities in the inner divertor were inferred from Stark broadening of high-*n* Deuterium Balmer line radiation *n*=2-6...12. In Li-assisted discharges, the measurement indicated as much as 50-75% reduction in density from the pre-Li discharges values of $n_e \sim 1\text{-}5 \cdot 10^{20}$ m^{-3}. The disappearing/weakening of high-*n* Balmer transitions suggested a drop in the recombination rate and thus a re-attachment of the inner divertor leg. Another observation in lithium conditioned discharges was the disappearance of X-point multifaceted asymmetric radiation from the edge (MARFE), which is thought to have a degrading effect on NSTX performance. This suggested that the hydrogen pumping by Li coatings kept plasma and neutral densities below the thresholds for MARFE onset.

To understand the divertor reduced recycling regimes and the inner divertor re-attachment, the NSTX divertor spectra are being simulated using the non-local thermodynamic equilibrium radiation transport code CRETIN [4]. CRETIN is coupled with TOTAL, a line shape calculation code, and PIP [5], a 1D partially ionized plasma transport model which includes charge exchange coupling in the transport coefficients and the effects of plasma properties on local atomic processes rates. The transition from detached to attached divertor plasmas is modeled by varying the recycling coefficient. The simulation results are compared to experimental data in order to understand how the reduced recycling affects the divertor transport regimes in NSTX discharges with Li coatings.

[1] H.W. Kugel *et al.*, Phys. Plasmas **15**, 056118 (2008).

[2] M.G. Bell *et al.*, Plasma Phys. Control. Fus. **51**, 124054 (2009).

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

[4] H.A. Scott, J. Quant. Spectr. Radiat. Transfer. **71**, 689 (2001).

[5] M.L. Adams and H.A. Scott, Contrib. Plasma Phys. **44**, 262 (2004).

* Supported by the U.S. DOE under Contracts DE-AC52-07NA27344 and DE-AC02-09CH11466.