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EX/P3-34: Study of Carbon and Lithium Neoclassical Impurity Transport in ELM-Free H-Mode Discharges in NSTX

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Intrinsic impurity (carbon and lithium) neoclassical transport is analyzed for H-mode discharges in the National Spherical Torus eXperiment (NSTX). The application of lithium coatings on boronized graphite plasma facing components led to high performance H-mode discharges with edge localized modes (ELMs) suppression but affected by core carbon accumulation (core inventory increased by up to 3-4x). Lithium ions instead, did not accumulate and had densities (n_Li) only up to 1% of carbon densities (n_C)[1]. Carbon influxes from main wall and divertor did not increase, indicating an increase in core impurity confinement. Core transport codes TRANSP, NCLASS and MIST are used to assess the impact of lithium conditioning on impurity transport. In NSTX H-mode discharges, ion particle transport is close to neoclassical due to the suppression of anomalous ion transport[2]. Changes in neoclassical transport due to modifications in main ion temperature (T_D) and density (n_D) profiles, together with the disappearance of ELMs, can explain the core carbon accumulation. The reduction in edge carbon collisionality leads to reduced carbon diffusivities (D_C<1m^2/s) for ρ > 0.8. The increase in grad(n_D) results in an increase in both edge and core inward convective velocity (v_C~-10m/s at ρ~0.8) while the reduction in edge grad(T_D) reduces the v_C temperature screening component. These changes are consistent with the observed early formation of a hollow n_C profile and slower core accumulation. The enhancement in lithium particle diffusivities (D_Li~5m^2/s at ρ~0.8) due to the presence of a strong impurity (carbon) can account for the low lithium core contamination. MIST code modeling shows that the high D_Li results in n_Li of the order of 1-10% of n_C (assuming the same source for the two impurities).
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[1] M.G. Bell et al., Plasma Phys. Control. Fusion 51(12), 2009.
[2] L. Delgado-Aparicio, et al., Nucl. Fusion, 49(8):085028, 2009.

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