A study of the role of particle sources in secular density rises in NBI-heated H-mode plasmas in NSTX*

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Plasma density control in divertor tokamaks is accomplished either by active divertor cryo-pumping, or through passive pumping by the wall conditioned by pre-pulse glow discharge cleaning (GDC). In NSTX, a secular density rise is observed in unpumped NBI-heated H-mode plasmas despite helium GDC wall conditioning between discharges and an apparent pumping state of graphite tile walls (inferred from a 0D particle balance analysis). The corresponding particle inventory increase is in the range dN_e/dt = 0.2-3 x 10^{21} s^{-1} for plasmas with $N_e < 10^{21}$, where N_e is a total particle (electron) inventory. The density rise is observed regardless of 1) gas fueling sources (ranging from a pseudo-continuous high field side fueling to a pulsed low field side supersonic gas jet fueling); 2) much reduced main chamber and outer divertor recycling, e.g. in initial lithium experiments [1]; 3) discharge duration in respect to τ_p*, the particle containment time. We use the window-frame plasma-wall interaction analysis technique [2,3] and available ion and impurity flux, density, recycling, neutral atomic and molecular measurements to estimate poloidal ion and neutral flux profiles, including the inner and outer divertor and main chamber boundaries of the divertor scrape-off layer (SOL). The analysis suggests that 1) the inner and outer divertor recycling is a dominant ionization source, exceeding the main chamber inner and outer SOL sources by up to an order of magnitude 2) the outer divertor and the main chamber SOL fluxes increase monotonically with input power and density 3) the ionization-recombination state, and fluxes, in the detached inner divertor region are weakly affected by variations in n_e, P_{NBI}, and divertor surface conditioning 4) in HHFW-heated H-mode plasmas with similar gas fueling, the inner divertor is attached, and plasma density rises are not observed. We further discuss a possible strong contribution of the inner divertor leg region in fueling of NBI-heated H-mode discharges. The extended neutral-dominated region shows a complex structure. Strong volume recombination is measured in the inner strike point region, where $T_e < 1.5$ eV, n_e = 1-4 x 10^{20} m^{-3} and $p_0 \sim 1$ mTorr. However, T_e is higher further upstream in the radial vicinity of the X-point, where an ionizing layer (front) may directly contribute to the confined plasma fueling.

[1] H. W. Kugel et. al, Phys. Plasmas, submitted
[2] P. C. Stangeby, Phys. Plasmas 9, 3489 (2002)
[3] D. G. Whyte et. al, Plasma Phys. Control. Fusion **47** (2005) 1579–1607

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