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Characteristics of Asymmetric (low-field-side and high-field side) Divertor Detachment in KSTAR L-mode Plasmas

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A divertor detachment experiment in low confinement mode and $B \times \nabla B$ into the divertor was performed in KSTAR to investigate various divertor operation regimes. The low field side (LFS) target parallel particle flux $\Gamma_{\|}$ started roll-over first ($n_e = 2.0 - 2.5 \times 10^{19} m^{-3}$), and then the high field side (HFS) target $\Gamma_{\|}$ began roll-over at the higher upstream electron density ($n_e = 2.5 - 3.0 \times 10^{19} m^{-3}$). The observed detachment pattern is similar to the one in TCV [1] and opposite to JET and ASDEX-U [2].
Numerical simulations using the SOLPS-ITER code [3] with different electron density values were performed to identify the physics behind the detachment behaviour observed in the experiment. The simulation result is qualitatively consistent with the experiment in terms of the roll-over pattern of the total particle fluxes on the targets. Pressure and power losses were decomposed into source terms including the kinetic neutral reactions. The dominant pressure and power loss mechanisms were identified in each SOL rings. In the high recycling condition (electron density at the separatrix, outer mid-plane $(n_e)_{sep}^{OMP}$ $1.49 \times 10^{19} m^{-3}$), volumetric reactions govern power and pressure losses along the flux tube, however the dominant reaction type depends on the radial position of the SOL ring. According to the recycled neutral deuterium particle trajectory observed in the code, D_2 molecules accumulate behind the divertor structure through a gap near the LFS target. The gap acts as a strong neutral particle source near the LFS target, resulting in a 2–10 times larger D_2 density at the LFS than at the HFS target. The simulations predict that this asymmetric neutral particle distribution causes divertor asymmetry. The accumulated D_2 enhances detachment, which is related to the strong correlation between the target D_2 density n_{D2t} and the target electron temperature [4]. This correlation results from additional power and pressure losses by the molecular related reactions, such as dissociation and charge exchange.
[1] R. A. Pitts et al, J. Nucl. Mater. 290, 940 (2001)
[2] A. Loarte et al, Nucl. Fusion 38, 331 (1998)
[3] S. Wiesen et al, J. Nucl. Mater. 463 480 (2001)
[4] P. C. Stangeby and C. Sang, Nucl. Fusion 57, 056007 (2017)

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