Study of W impurity transport in the boundary plasma of EAST with different divertor conditions

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Tungsten (W) impurity contamination is a key issue for long-pulse high-performance plasma operation in tokamaks with W plasma-facing materials. Dedicated gas puffing experiments were carried out on EAST tokamak with full W divertor to achieve divertor detachment and evaluate the W impurity transport under different divertor conditions [1]. Ne and D_2 injection from the divertor target were observed to have different impacts on the edge W screening. Before the onset of divertor detachment, Ne seeding increases both the W source and the W leakage rate, while D_2 puffing helps to reinforce the W screening in the edge plasma. Based on the EAST experiments, W impurity transport processes from the divertor target to the core plasma are quantitatively analyzed by sequential SOLPS-ITER and DIVIMP simulations [2] with drift velocities included. Simulation results reveal that, for the D_2 puffing cases, the increase of the friction and the decrease of the ion temperature gradient force near the divertor target are the main reason for the enhancement of edge W screening during the transition from the high recycling regime to detachment. However, when increasing the Ne injection rate, the friction and the ion temperature gradient force vary little, and a higher Ne concentration can lead to more W erosion which finally makes more W leakage to the core plasma. The $\mathbf{E}\times\mathbf{B}$ drift can dramatically enhance the W leakage ability for both B_t directions, but the enhancement effect becomes weaker when the divertor is detached. With the help of drifts, W leakage from the PFR to the upstream or core plasma by diffusion near the X point is proved to be significant, especially for the divertor condition with good SOL screening. Modeling results also reveal that there exists an impurity flow reversal in the near-SOL region due to the $\mathbf{E}\times\mathbf{B}$ drift under the pronounced detached condition. This kind of flow reversal plays an important role in impurity distribution and will be discussed in the presentation.

[1] R. Ding et al., Nuclear Materials and Energy 33 (2022) 101250

[2] H. Wang Nuclear Fusion 62 (2022) 126018