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Modelling of edge transport and screening of tungsten impurity for different divertor conditions in EAST

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The W transport and screening in the edge plasma of EAST are investigated under high dissipative divertor conditions. By combining the one-dimensional impurity fluid model (1DImpFM)[1] and the two-point model formatting (2PMF)[2], the impurity temperature gradient velocity pointing to the upstream can be expressed as $v_{\mathrm{TiG}} \propto C_{\mathrm{vTiG}} q_{\|u}{}^{5}/p_{\mathrm{totu}}{}^{6}$, where the C_{vTiG} is a coefficient related to parallel momentum and power losses. For the plasma density rump-up discharge, the increase of the upstream plasma density is found to result in a smaller value of C_{vTiG}, and thus a lower v_{TiG}. Therefore, a better W screening is expected with the divertor operation condition transforming from the high-recycling regime to the detached regime.

Then based on dedicated EAST density ramp-up experiments, two-dimensional simulations of W erosion and transport are carried out for different levels of dissipative divertor conditions by using the SOLPS-DIVIMP code package. According to the simulation results, the edge W screening process is divided into three parts: the prompt-redeposition, the divertor screening and the SOL screening, which are quantitively analyzed. For detached divertor conditions, the increase of the W ionization length reduces the prompt redeposition rate, but both the divertor screening and SOL screening are reinforced because of the lower impurity temperature gradient velocity in the divertor region and the longer cross-field transport distance in the main SOL.

The comparation of the W ionization front and the W velocity stagnation point is found to be a convenient method to evaluate the divertor W leakage ability. The ratio of the W^0 mean-free-path over the distance between the W velocity stagnation point and the targe $\lambda_{\mathrm{ion}}/L_{\mathrm{StagnPt}}$ shows an obvious lower value for Tet smaller than 15 eV. Therefore, from the aspect of the divertor W screening, keeping the electron temperature on the whole target below 15 eV is proposed if a fully detached condition cannot be achieved. Moreover, the 1DImpFM can well interpret the W leakage in the near separatrix region, but the 2D simulations suggest that the pressure gradient force which is neglected by the 1DImpFM plays an important role especially in the far-SOL region. Therefore, the impurity pressure gradient force cannot be neglected for edge W transport analysis.

References

[1] P. C. Stangeby *et al*, Nucl. Fusion 60, 106005 (2020)

[2] P. C. Stangeby *et al*, Nucl. Fusion 57, 56007 (2017)

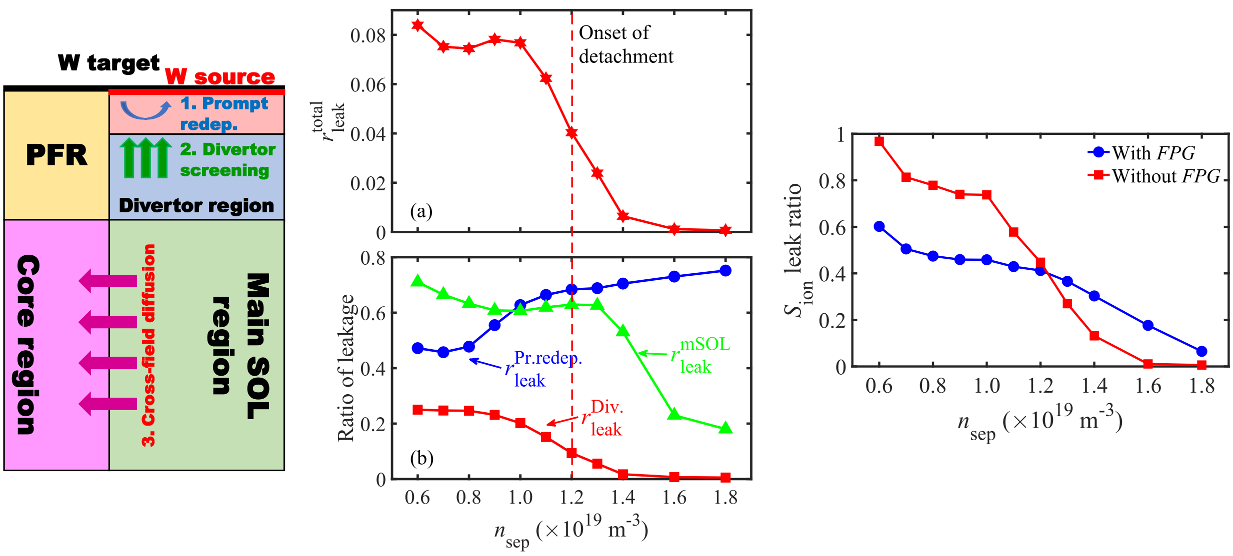

Figure 1. Scheme view of 3 parts of W impurity screening in the edge plasma: (1) screening by prompt redeposition near the target, (2) screening in divertor region and (3) main SOL screening by cross-field diffusion (left), as well as the corresponding W leakage rates during above process (middle). Value of the fraction of W ionized above the impurity velocity stagnation point (right).