Effect of divertor materials on the power decay width in EAST

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In tokamak devices, the plasma heat flux across the separatrix and then enter scrape-off layer (SOL) by cross-field transport. Most of this heat flux transport along narrow channel in SOL and deposited onto plasma-facing components (PFCs). The outer midplane (OMP) SOL parallel heat flux profile can be express as $q(r) = q_{||}e^{\frac{-r}{\lambda_{q,sol}}}$, in which $\lambda_{q,sol}$ is the power decay length of SOL, $r = R - R_{sep}$, R_{sep} being the major radius of the separatrix at OMP. Assuming the $\lambda_{q,sol}$ is the competition result between parallel transport and perpendicular transport in SOL, the $\lambda_{q,sol}$ is dependent on the SOL parameters and the connection length along field lines to the outer target. For the parallel heat flux profile of the outer target, the power decay length $\lambda_{q,OT}$ could express as $q(\bar{s}) = \frac{q_0}{2}\exp\left[\left(\frac{S}{2\lambda_{q,OT}}\right)^2 - \frac{\bar{s}}{\lambda_q f_x}\right]\mathrm{erfc}\left(\frac{S}{2\lambda_{q,OT}} - \frac{\bar{s}}{S f_x}\right) + q_{BG}$, where q_0 is the peak parallel heat flux, f_x is flux expansion, $\bar{s}$ is perpendicular path length along the divertor, q_{BG} is the blackground heat flux, and a Gaussian width S representing the heat flux transport into the private flux region (PFR)[1]. The high heat flux density of PFCs is a crucial issue to measure plasma discharge performance, and the narrow power decay length is an importance parameter affecting the heat flux density. The multi-machine studies of the heat flux width λ_q show that λ_q is roughly inversely proportional to the poloidal magnetic field B_p at the OMP for H-mode discharges[2], so called Eich-scaling.

In fusion devices, the high erosion and tritium retention rates will limit the application of carbon (C) divertor in future operation. Tungsten (W) is the main PFMs due to its excellent physical properties. In our previous work[3], the effect of plasma-facing materials (PFMs) on the plasma in the EAST device, whose lower carbon (C) divertor has been replaced by tungsten (W) material, is obviously, due to the significant difference in particle and energy reflection coefficients between the C and W materials. Therefore, its change of λ_q by divertor material change should be investigated.

In this work, the SOLPS-ITER is applied to estimate the effect of different material divertor condition on the λ_q in EAST. The simulation result reveals that in the attached divertor with same magnetic and SOL condition, the divertor materials hardly affect the λ_q of SOL, but play an important role on the λ_q of target by radiation and impurity. It indicates a strongly positive correlation between SOL collisionality effective-Z, power radiation ratio $f_{rad,OD}$ in divertor region and power decay length of divertor $\lambda_{q,OT}$, due to the SOL collisionality and impurity would increase the perpendicular transport, also decrease the parallel transport. And the $f_{rad,OD}$ could decrease the peak value of $q_{||,ot}$. Moreover, similar relations have also been found in Gauss width S and integral power decay width λ_{int}. In addition, the effects of drifts (**E**×**B**) on λ_q are also studied by SOLPS-ITER. The result shows that the **E**×**B** drifts are benefit to both the SOL/divertor λ_q. These studies show that a large power radiation and reasonable drift would increase the heat flux decat length of divertor, which has meaningful for the future fusion devices.

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