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H-mode detachment with ITER-like tungsten divertor operation in EAST

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For ITER and future tokamak reactors, the extremely high peak heat flux and erosion rate will limit the divertor target lifetime severely. The detached divertor operation, especially partial detachment, characterized by a drastic reduction of both heat/particle fluxes and electron temperature on the target exhibits to be the most plausible solution for these issues [1]. This talk will show recent advances in H-mode detachment on EAST, with ITER-like W divertor.

In the EAST 2017 campaign, the H-mode detachment was firstly achieved with ITER-like tungsten (W) divertor in upper single null (USN) discharges, without confinement degradation when plasma enters detachment. A clear rollover of particle flux to the target occurs during the ramp-up of the plasma density with reversed Bt (ion Bx▽B towards the upper divertor). In the same time, the high plasma flux on the target significantly reduce the divertor plasma temperature (below 5eV close to the target). Both particle flux and electron temperature at inner and outer divertor targets are significantly decreased near the strike point during the detachment phase, and thus the peak heat flux is greatly lower. It is shown that the detachment near the strike point occurs at a much lower density at inner target. The H-mode detachment initiates from the strike point, propagating radially outwards at both inner and outer targets. With plasma density ramping up, the increased edge density and outward particle transport were also observed. It is shown that the onset of detachment is marked differently during the H-mode detachment. Compared with previous L-mode detachment in EAST, H-mode appears to have a higher density threshold ($n_e/n_G \sim 0.65$) for detachment in reversed Bt. For plasma with higher heating power, the density need to be further increased to achieve H-mode detachment.

In addition, the in-out divertor asymmetry is significantly influenced by the direction of the toroidal magnetic field (Bt) direction in H-mode phase [2,3], especially in low density regime. The peak particle flux measured by the divertor triple Langmuir probe arrays favors the outer divertor in USN discharges for the ion B×▽B direction away from the upper X-point, while the asymmetry merely exhibits more symmetric, or slightly reversed for reversed B×▽B drift direction, presumably due to the effect of the E×B drift [4]. Compared with L-mode detachment in USN discharges, the peak particle flux is higher at outer targets with L-mode with reversed Bt. In contrast, particle flux is higher at inner targets, more symmetric with H-mode. It is also interesting to note that the total particle flux at the lower outer divertor is significantly enhanced with the increase of plasma density in USN discharges. Future experiments with power scan, different divertor geometry, impurity seeding are planned. New advances that may arise in the coming EAST campaign will also be presented.

References

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