Small-ELM-regime access facilitated by a new tungsten divertor on EAST

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A new actively cooled tungsten lower divertor has been installed on EAST in 2021 [1]. The outer divertor is featured by a right-angled closed corner, allowing for the outer strike point being positioned on either vertical or horizontal target plate, see Fig.1.

When the strike point moves from vertical to horizontal target plate, large type-I ELMs change into small grassy ELMs with significant reduction of pedestal n_e gradient, increase of SOL n_e and n_e pedestal width, while T_e pedestal profile changes little. This phenomenon has been observed in a q_{95} range of 5.3-6.4 with both B_t direction and different heating power levels. Linear and nonlinear analyses of pedestal stability with ELITE and 6-field BOUT++ codes confirm that the ELM behaviour change is mainly induced by the edge n_e profile change rather than the triangularity change.

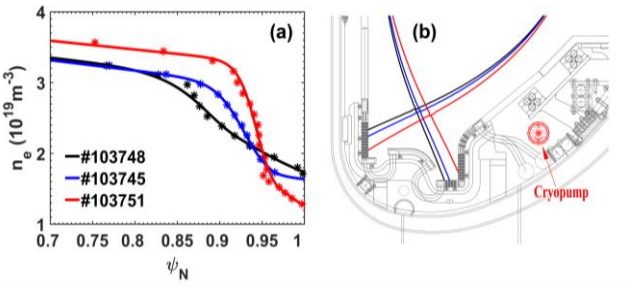

Fig. 1. (a) Electron density profiles corresponding to different strike point locations as shown in (b).

To uncover the mechanism of the edge n_e profile change with different divertor strike point locations, SOLPS-ITER simulations with full drifts have been used, indicating that when the strike point is located on the vertical target the recycling from the divertor baffle area causes much higher ionization source in the vicinity of X point, which leads to much stronger pedestal fuelling, thus much steeper n_e gradient in the pedestal. In contrast, when the strike point is located on the horizontal target, especially away from the corner, the horizontal target plate reflects recycling neutral particles into the SOL, where they are mostly re-ionized, thus trapped in the closed corner area, which dramatically reduces the number of recycling particles that can penetrate into the pedestal from the lower divertor. At the same time, the upstream ionization source is significantly higher in the SOL to maintain the particle balance, which explains the higher SOL n_e as observed with the strike point on the horizontal target.

This experiment demonstrates, for the first time, that a flat pedestal density profile is the key for access to the small-ELM regime and such density profile can be produced by using a closed divertor structure. These results may have strong implication for future fusion reactors where a low pedestal fuelling and a flat pedestal density profile with a closed divertor are anticipated.

[1] G.S. Xu, et al., Physics design of new lower tungsten divertor for long-pulse high-power operation in EAST, Nuclear Fusion 61 (2021) 126070