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ELM Mitigation Enabled by Control of Neutral Recycling with New EAST Divertor

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Divertor recycling control is enabled by a new tungsten lower divertor on EAST, featured by a right-angled closed corner joining the vertical and horizontal target plates. ELM mitigation is observed as the outer strike point moves from the vertical target to the horizontal target with a significant reduction of the pedestal density gradient. Furthermore, the new closed corner divertor exhibits significantly better recycling control, power handling, lower detachment threshold and core confinement compatibility than the conventional vertical-target divertor.

FIG. 1. SOLPS-ITER simulation results for the 3 different divertor strike point locations with full drift effects. The two-dimensional distributions of particle ionization source SD+ for the strike point located on (a) the left side (further away from the corner) and (b) the middle of the horizontal target, and (c) the vertical target.

As shown in Fig. 1, SOLPS-ITER simulation indicate that when the strike point is located on the horizontal target most particles from the upstream SOL flow into the outer divertor slot and hit the horizontal target plate and the ionization source appears to concentrate in the vicinity of the horizontal target, due to the trapping of the recycled particles in the closed corner area, leading to a reduced pedestal fueling from the lower divertor, thus reducing the pedestal density gradient and elevating the SOL density. In contrast, when the strike point is located on the vertical target, a much stronger ionization source appears in the vicinity of the X-point, especially inside the separatrix [Fig. 1(c)]. The vertical target plate reflects recycled neutral particles towards the private region where the electron density and temperature are much lower than the SOL. Therefore, the neutrals cannot be fully re-ionized in the vicinity of the X-point and tend to diffuse into the pedestal. Furthermore, as the baffle area is closer to the divertor strike point for the vertical target case, much more particles from the upstream SOL hit the baffle, which also enhance the pedestal fueling. This results in a much steeper density gradient and a lower density in the SOL for the strike point on the vertical target.
This paves a new path in ELM mitigation through tailoring pedestal structure with divertor condition control. These new results may have strong implications for future fusion reactors where a low pedestal density gradient is anticipated due to much higher neutral opacity and lower pedestal fueling.

Speaker's Affiliation

Institute of Plasma Physics, Chinese Academy of Sciences, Hefei 230031, China

Member State or IGO

China, People's Republic of

Primary author: Mr XU, Guosheng (Institute of Plasma Physics, Chinese Academy of Sciences)

Co-author: Mr LIN, Xin

Presenters: Mr XU, Guosheng (Institute of Plasma Physics, Chinese Academy of Sciences); Mr LIN, Xin

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