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Active handling of heat flux and impurity accumulation in EAST long pulse operation with tungsten divertor

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The excessive heat load on divertor targets during long pulse operations is a critical issue for tokamaks, especially superconducting devices of long pulse operation [1]. EAST is now equipped with actively water-cooled,ITER-like tungsten divertor and near 30 MW RF dominant heating and current drive capability, which poses a great challenge for the target plates and thus plasma-wall interactions. This talk will show recent advances in active control of heat/particle flux and impurity accumulation, plasma-wall interaction on EAST.

The 3-dimensional (3D) edge magnetic topology has been applied for active control of heat and particle fluxes deposited on the divertor targets in steady-state operation on EAST. The change of edge magnetic topology can be achieved by the application of either LHWs [2] or RMPs [3]. Through comparing the particle fluxes deposited on the divertor target in the same poloidal location but different toroidal locations, we find the 3D divertor particle flux footprints [4], induced by LHW, closely fits the pitch of the edge magnetic field line in a wider range of q_{95}, which has been qualitatively modelled by a field line tracing mode. LHW-induced particle and heat flux striations are also present in the H-mode plasmas, reducing the peak heat flux and erosion at the main strike point, thus facilitating long-pulse operation with a new steady-state H-mode over 60 s being newly achieved in EAST. Both impurity seeding with argon and neon in the divertor region to reduce heat load have been performed on EAST. It is shown that neon is a good radiator for EAST with strong radiation in the divertor region, while argon seeding could cause significant core radiation and thus degrades the plasma confinement performance. It is also found that neon injection can broadly redistribute the 3D heat/particle flux profile on the divertor target plates [4], which shows a promising capability in 3D particle and heat flux control for long pulse operation.

In EAST, an alternative way to operate EAST in a quasi-snowflake (QSF) or X-divertor configuration, characterized by two first-order nulls with primary null inside and secondary null outside the vacuum vessel has been recently developed. Both modelling and experiment [5] showed this QSF can result in significant heat load reduction to divertor target in either L-mode or H-mode operation on EAST. The longest pulse QSF plasma has been reached up to 20 s. In the 2016 campaign, the QSF experiments with tungsten divertor have advanced significantly, e.g., high-performance QSF scenario, density limit operation and so on.

The evaluation of tungsten and graphite divertor performance comparison has been made, which suggests that tungsten divertor is a better one in both power exhaust and recycling/density control. The plasma detachment with tungsten divertor has also been observed, with the threshold density normalized to the Greenwald limit being $n_e/n_G \sim 0.6$. The direction of the toroidal field has been optimized for the control of divertor particle and impurity exhaust [6]. In the upper single-null with tungsten divertor, more particles reach the outboard divertor with $B \times \nabla B$ downwards, which facilitates the particle and impurity exhaust with the top cryo-pump. This in-out divertor particle flux asymmetry is in good agreement with Pfirsch–Schlüter (PS) flow in the scrape-off layer (SOL) and thus provides very important information on the particle and impurity exhaust in EAST long pulse operations.

In addition, the SOL width scaling and the broadening in LHW-heated H-mode with respect to NBI-heated regime will also be discussed [7], including the recent joint experimental study on DIII-D.

References

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