Impact of Divertor Configuration on H-Mode Access and Confinement on EAST


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

* Email: fding@ipp.ac.cn

Introduction

• It is vital to understand the impact of divertor conditions on H-mode plasma in order to make engineering designs and operational scenarios more favorable to high fusion gain.
• The upper graphite divertor in EAST was upgraded into full tungsten (W) one with ITER-like actively water-cooled monoblock structure in target plate in 2014.
• Both statistic analysis and dedicated comparison experiments have been executed to study the impact of divertor configuration on H-mode access and confinement on EAST.

EAST plasma-facing materials and relevant diagnostics

Experimental comparison between a pair of discharge shots with different outer strike point location

Comparison of edge density profile in two shots

Figure 3. (a) Edge density profile comparison between shots #65060 and #65066 at 3 s (before the L-H transition) and 5 s (during H-mode phase), respectively. The same line-averaged density ramping is set in the two shots. (b) Edge density gradient profile comparison of the two shots at 3 s and 5 s.

Figure 4. Time evolution of electron density profiles before transition into L-mode. The profiles are divided into four successive time intervals of 450 ms in #65060 (a) and #65066 (b). The curves in different colors are the averaged density profiles in the corresponding intervals.

Effect of plasma shaping on H-mode power threshold

Figure 5. Normalized experimental power threshold $P_w/S^{0.5}$ versus the ratio between two triangularities, $\delta_{l}/\delta_{s}$ for USN and DN, while $\delta_{l}/\delta_{s}$ for LSN. Similar effects were also observed in JET-ILW [Maggi C.F. et al 2014 Nucl. Fusion].

Summary

• High D$^+$ plasma with OSP closer to divertor pumping slot can enhance particle exhaust, reduce neutral recycling, hence, stiffen the edge density profile and improve core confinement.
• Plasma shaping may play an independent role, and need further investigation.

Effect of divertor configuration

The divertor configuration in #65066 provides more beneficial conditions for H-mode access and facilitates a higher plasma confinement compared to those in #65060.

• The subdivertor neutral pressure in #65066 is higher than in #65060 before L-H transition, indicating a higher divertor particle exhaust efficiency.
• The integrated $D^+_s$ intensity in upper divertor is weaker in #65066, pointing to a lower D recycling than in #65060.
• There is no obvious difference between the two shots in the plasma density in upper outer divertor according to the same line intensity ratios of $D^0/D$.
• C impurity contents in both edge and core plasmas are lower in #65066.
• The total radiations both in main plasma and divertor are also slightly lower in shot #65066 before the L-H transition.

The statistical analysis in EAST shows that the H-mode power threshold has a negative dependence on the $\delta$ ratio, implying the effects of plasma shaping.

The experimental results in JET-ILW also indicate that increasing $\delta$ can decrease H-mode power threshold despite the simultaneous decay of divertor particle exhaust due to strike point moving away from the pump slot, possibly indicating an independent role of plasma shaping.

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