MF1-I38 AAPPS-DPP2020

4th Asia-Pacific Conference on Plasma Physics, 26-31Oct, 2020, Remote e-conference

The effect of edge plasma and impurity fueling on 3D divertor fluxes in the RMP ELM-suppression regime

Manni Jia[1], Youwen Sun[1], Alberto Loarte[2], Qun Ma[1], Bin Zhang[1], Liang Wang[1], Huihui Wang[1], Shuai Gu[3], Zhendong Yang[4], Jichan Xu[1], Guizhong Zuo[1], Jilei Hou[1], Fang Ding[1], Kedong Li[1], Ling Zhang[1], Tonghui Shi[1], Biao Shen[1] and the EAST team

[1] Department of physics, Postech, [2] Institute of Advanced Energy, Kyoto University (times, 12pt)

e-mail: jiamanni@ipp.ac.cn

The suppression of type-I ELMs using resonant magnetic perturbations (RMPs) with toroidal mode number n=4 and n=2 in low q95 of about 3.65 and low torque-input of about 0.3 Nm plasma discharges, which is close to ITER operational window, has been achieved in EAST [1]. The experiments under the similar ELM-suppression window in EAST using the edge plasma fueling to increase the pedestal density and using edge impurity fueling to increase the radiation in the divertor volume show their compatibility with the RMP ELM suppression operation. The heat flux to both the original and splitting strike lines are reduced during these fueling phases, showing a favorable trend for both transient and steady-state divertor power load control [2].

During the $n = 4$ ELM suppression phase, the strike point splitting induced by the RMP is observed on divertor heat and particle fluxes and the position is consistent with the numerical modeling prediction by TOP2D[3]. The gas puffing from the mid-plane increases both the line averaged and the pedestal densities while maintaining the suppression of ELMs until the line averaged density reaches $4.3 \times 10^{19}\,m^{-3}$, which is about 0.57 of the Greenwald density limit of 480kA plasmas in EAST. The divertor heat flux to the original strike line is reduced and that to the splitting strike line is almost removed.

During the ELM suppression with a step rotating n=2 RMP field, the impurity seeding with Neon gas injected from the vicinity of the original strike point on the upper outer divertor also induce a substantial divertor flux reduction on the original strike lines. The heat flux on the splitting strike lines is reduced less but has been spread to different regions with the RMP rotation, as shown in Fig 1, in which the divertor temperature profiles with and without impurity seeding of two different toroidal angles are compared. The increasing radiations in the divertor volume indicates a power dissipation near the strike points region. The observations of the reduction of the steady state divertor heat fluxes and the increasement of the divertor radiation is consistent with the prediction by the numerical modeling. The combination with the RMP rotation is also a promising method for an integrated divertor flux control scheme.

In addition, the modeling results in comparison with the experimental observations also show the importance of taking into account the plasma responses. Although at present only the linear plasma responses calculated by MARS-F code are used [4], the discussions of the role of plasma responses will benefit the understanding of the edge plasma transport in the 3D edge magnetic topology.

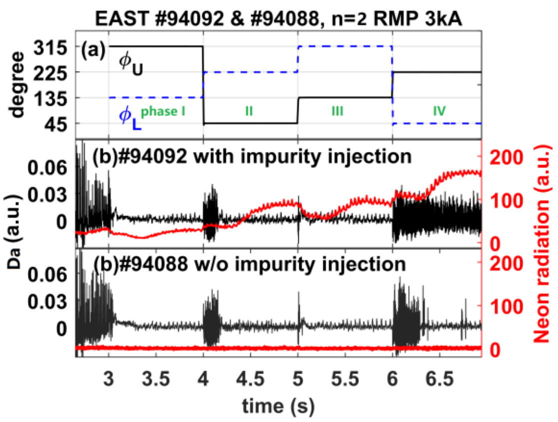

Fig 1. The upper and lower current phase of the n=2 RMPs show a step rotation RMP fields in (a). The D_α and Neon radiation signals of the shots with and without impurity injection are shown in (b) and (c) respectively.

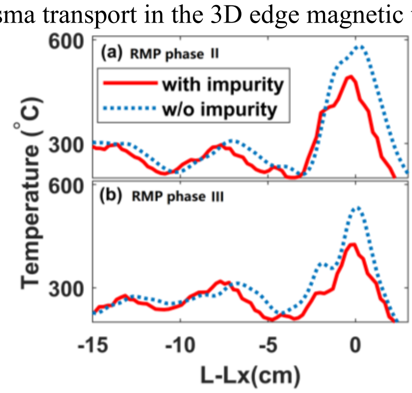

Fig 2. The temperature profile on upper outer divertor targets under RMP phases II and III as indicated in Fig 1(a). The profiles with and without impurity seeding are compared.

References

[1] Y. Sun et. al., 2019, First demonstration of full suppression of type-I ELMs using n=4 RMP in EAST, APS-DPP(2019)

[2] A. Loarte et. al., 2014, Nucl. Fusion 54, 033007

[3] M. Jia et. al., 2016, Plasma Phys. Control. Fusion 58 055010

[4] M. Jia et al., 2018, Nucl. Fusion 58, 046015