7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Demonstration of divertor stationary heat flux control during RMP ELM suppression in EAST

M. Jia[1], Y. Sun[1], A. Loarte[2], H. Yang[1], Q. Ma[1], P. Xie[1], G. Chen[1, 3], X. Wu[1], S. Gu[4], K. Li[1], Y. Liang[5], R. Liang[1], C. A. Paz-Soldan[6], J. Qian[1], B. Shen[1], H.H. Wang[1], B. Wan[1], S. Xu[5], Q. Zang[1], L. Zhang[1]
[1] Institute of Plasma Physics, Chinese Academy of Sciences, China, [2] ITER Organization, France, [3] Donghua University, China, [4] Oak Ridge Associated Universities, USA, [5] Forschungszentrum Jülich, Germany, [6] Columbia University, New York, United States of America
e-mail: jiamanni@ipp.ac.cn

Compatibility of divertor stationary heat flux control by impurity injection with the type-I edge localized modes (ELMs) suppression by resonant magnetic perturbations (RMPs) has been demonstrated in EAST. A clear reduction of divertor heat flux on the original strike lines can be observed after carbon impurity being injected during ELM suppression. While the change of heat fluxes onto the splitting strike line is not significant. At the same time, good confinements of both energy and particles are maintained. The advantages of using n=4 RMPs are further confirmed.

An example of the effective heat flux reduction by impurity injection during n = 4 RMP ELM suppression is shown in Fig. 1. Here n is the toroidal mode number of the RMP field. Another shot #115755 without impurity injection is shown as comparison. To address the ITER concerned issues on characterization and control of stationary divertor power fluxes with RMP fields [1], these experiments are operated in low input torque plasmas, which are close to the ITER equivalent torque 1.1 Nm in EAST [2] with the edge safety factor at 95% of normalized poloidal flux $q_{95} \sim 4$, the line averaged plasma density $n_e \sim 3\times10^{19}$ m^{-3} and the normalized plasma beta $\beta_N \sim 1.5$. Both of the two shots achieve ELM suppression by the n = 4 RMP field with even parity except for some occasionally appeared single ELMs. The RMP coil current are 3.5 kA in #115793, which is higher than that in #115755. As a result, the suppression is relatively stable in #115793 with less occasionally appeared ELM spikes. In #115793, CD_4 gas is injected from 4 s to 6 s from the valve on the low field side target of the newly upgraded tungsten lower divertor module. The heat flux splitting can be observed after RMP application, which is consistent with the numerical modelling. An effective reduction on heat flux to the original strike point at about L ~ 30 mm can be distinguished after 4s in #115793. Here L is the distance to the divertor corner in the poloidal direction. The change of heat fluxes onto the splitting strike line is not significant.

The plasma confinement is well maintained with CD_4 injection during ELM suppression. The carbon radiation is effectively increased but localized near the divertor target and the slight increase in plasma density is contributed to the fueling effect by injecting CD_4. It indicates that the carbon impurity can be well screened by the edge stochastic layer formed by the n = 4 RMP field. Although previous EAST experiments have shown the compatibility of divertor heat flux reduction by neon impurity injection with the n = 2 RMP field [3], there were about 30% drop in the energy confinement, which is not an attractive result for ITER. Such good energy confinement with edge localized impurity radiation during ELM suppression further increases the confidence in using high n RMPs in future ITER application. To expand the physics understanding for integrated divertor and heat flux control, modeling of plasma response to RMP as well as the three-dimensional plasma and neutral particle transport modelling using EMC3-EIRENE would address new understanding of 3D edge transport and divertor heat flux profiles. More detailed discussions of modelling and analysis will be addressed in this presentation. As a result, the advantages of using n=4 RMPs is further confirmed not only in ELM suppression but also in the compatibility with integrated divertor flux control, which is attractive for ITER and future devices.

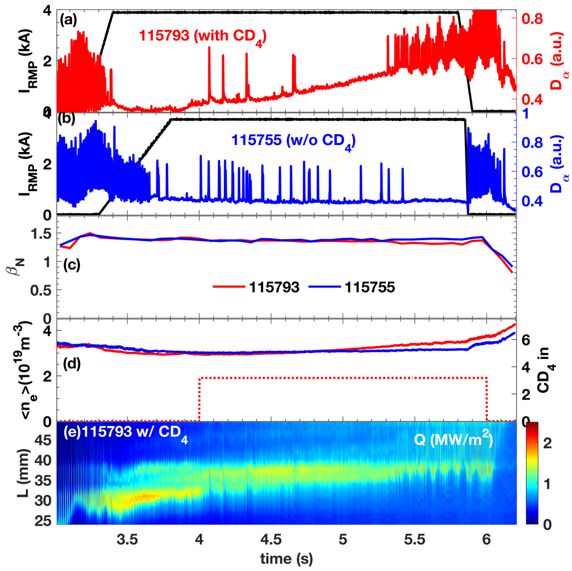

Figure 1. The effective heat flux reduction by CD4 injection in EAST #115793 discharge and the comparison with another discharge #115755 without any impurity injection. (a)(b)

References
[1] A.Loarte et. al. Nuclear Fusion 54, 033007 (2014)
[2] Sun Y et al, Nuclear Fusion 61, 106037 (2021)
[3] Jia M. et al, Nuclear Fusion 61,106023 (2021)