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Divertor target heat and particle flux dynamics during long term RMP-ELM suppressed regimes in KSTAR

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Since the installation of the divertor infrared (IR) thermography system on KSTAR in 2014, it has allowed researchers to investigate the outer divertor target heat load in the KSTAR tokamak more comprehensively [1]. Recently, the divertor IR thermography system has been actively used to study the effects of resonant magnetic perturbations (RMPs) on the outer divertor target heat flux profile. Thanks to the controllability of RMPs phase and phasing during a single discharge and the high spatial resolution (~ 0.4 mm/pixel) of the divertor IR thermography system, it is now available in KSTAR to examine how the outer divertor heat flux profile changes by RMPs very accurately.

In KSTAR, we recently succeeded to measure the striation pattern of the outer target heat load in the full period of the RMPs phase sustaining the RMP-ELM suppressed regime using the divertor IR thermography system. The data has been obtained mainly in attached divertor heat load conditions in KSTAR discharges with I_p = 500 ~ 600 kA, q_{95} = 4.5 ~ 5.5, B_T = 1.8 ~ 2.0 T and P_{NBI} = 2.8 ~ 3.5 MW and a full carbon wall. For the ELM suppression, n=1 and 2 (n is the toroidal mode number) RMPs are applied. Experiments in which the RMPs phase is rotated during a single discharge have enabled us to argue that the non-axisymmetric outer divertor target heat flux pattern is mainly determined by the configuration of RMPs such as toroidal mode number and phase. It has been clearly observed that the striation pattern of the heat flux profile changes according to the phase of RMPs. We also observed that the change in the striation pattern is consistent with the modification of the magnetic field topology by RMPs, which can be estimated by field line tracing calculation [2]. Several issues remain unresolved, however, such as the plasma response to the external magnetic perturbations which results in the fine detail of the heat flux striation pattern, in particular the spacing between peaks and sharpness of each peak. KSTAR experiments have also demonstrated that the plasma response can be very different according to plasma conditions such as pedestal collisionality.

In addition, it has been found that the peak heat flux of the outer divertor target significantly increases due to RMPs in a specific condition. Especially, it has been realized that peak heat flux in ELM-suppressed regime becomes higher than those in the w/o RMPs and ELM-mitigated regimes regardless of the toroidal phase of RMPs. We also found that the integrated heat flux with RMPs is much higher than that w/o RMPs. Since the pedestal pressure is reduced and cross-field transport is usually expected to be enhanced when RMPs are applied to suppress ELMs, this phenomenon cannot be simply understood by the core plasma changes. Then, we need to study this phenomenon comprehensively while considering the SOL power balance and the divertor plasma dynamics. So, in this paper, to investigate the underlying physics in the effect of RMPs on the divertor heat flux in KSTAR, we discuss the dynamics of the divertor heat and particle flux during the application of RMPs in comparison with the EMC3-EIRENE that can evaluate the non-axisymmetric divertor heat and particle flux profiles by considering 3-dimensional plasma edge transport under the application of RMPs

References

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