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Recent progress in understanding the outer divertor heat flux dynamics during the ELM-crash-suppression by RMPs on KSTAR

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For the reactor-scale fusion devices such as ITER or DEMO, control of the divertor target power loading, both in steady state and during ELMs, is particularly challenging with regard to tungsten target lifetime. It should be preferably reduced below a certain value so that the divertor target cooling capability ensures a planned long-term replacement period of the targets. It is widely accepted that resonant magnetic perturbations (RMPs) can be an effective method to achieve this since the peak heat flux is expected to be substantially reduced due to the profile broadening while ELM-crash being suppressed or significantly mitigated.
Since the installation of a new, high spatial resolution outer target IR thermography system [1], the characterization and control of the outer divertor heat flux during the application of RMPs has been one of leading research subjects on KSTAR. In KSTAR, 3-row and 4 column In-Vessel Control Coils (IVCCs) are used to apply the magnetic perturbation of the toroidal mode number is 1 or 2 with various phasing and phase configurations. Especially, recently improved controllability of the RMPs configuration has made it possible to investigate the divertor heat flux dynamics according to various RMPs configuration during a single plasma discharge while keeping the ELM-crash suppression region. In KSTAR, it has been found that the divertor heat flux profile is clearly split showing the pattern likely what is expected by the field line tracing calculation according to the RMPs phases although it has been found that some details can be slightly different regarding plasma response models [2]. On the one hand, it has been observed that the outer target peak heat flux usually becomes much higher during the ELM-crash-suppression regime than that without RMPs. Since the observation seemingly contradicts the expectation from the EMC3-EIRENE calculation, the underlying physics in the phenomenon is under investigation on KSTAR.
In addition, it has been demonstrated that intentionally misaligned ITER-like 3-row RMPs can not only suppress the ELM-crashes, but also disperse divertor heat fluxes in a wider area reducing the peak heat flux, while minimizing EM loads on RMP coils [3]. Along with the study on the RMPs configuration optimization, the methodology to obtain high density plasma ensuring RMP-ELM-suppressed regime compatible with detached divertor is ardently searched and some promising result has been achieved in KSTAR. In this paper, these recent findings, which has enhanced our understanding in the outer divertor heat flux dynamics during the ELM-crash-suppression by RMPs on KSTAR, are discussed compared to the simulation results by field line tracing or EMC3-EIRENE.

[1] H. H. Lee et al., Nuclear Materials and Energy 12 (2017) 541.
[2] H. H. Lee et al., 2nd IAEA Technical Meeting on Divertor concepts (Suzhou, China, 2017).
[3] Y. In et al., Nuclear Fusion, submitted.

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