Path to the ITER-relevant divertor thermal loading control under RMP-driven, ELM-crash-suppression

Yongkyoon In[1], Hyungho Lee[2], Kimin Kim[2], Alberto Loarte[3],
Jinyoung Heo[1], Y.S. Han[4], W.H. Choe[4], J. Hwang[4], and H. Shin[4]
[1] Ulsan National Institute of Science and Technology
[2] Korea Institute of Fusion Energy
[3] ITER Organization
[4] Korea Advanced Institute of Science and Technology
e-mail (speaker): inyongkyoon@unist.ac.kr

Significant progress in resonant magnetic perturbation (RMP)-driven, edge-localized-modes (ELM) control has enabled us to envision ELM-crash-suppressed ITER baseline scenario, rather than to rely on ELM-crash-mitigated H-modes, whose spatiotemporal influences are hardly generalized nor readily predicted [1]. In particular, considering almost all the major toroidal devices have demonstrated robust RMP-driven, ELM-crash-suppression in experiments, in addition to a variety of theoretical studies, no or little question arises about the access to ELM-crash-suppression via RMP in ITER [2]. Arguably, the next big challenge goes to the clarification of whether such RMP-driven, ELM control would be compatible with divertor thermal loading requirements (i.e. 10 MW/m^2 in steady state, and 20 MW/m^2 in transient state in ITER-like plasma conditions) [3].

However, based on an extensive database in KSTAR, the divertor heat flux peaks had been doubled or even tripled during RMP-driven, ELM-crash-suppressions, in comparison with those of inter-ELMs without RMPs [2,4,5]. Thus, it is critical to find a solution of how to lower the divertor thermal loading, while sustaining RMP-driven, ELM-crash-suppression.

In principle, the increase of radiative loss at edge and scrape-off-layer (SOL) region can be one of the straightforward remedies, in which substantial fraction of momentum and thermal loadings associated with particle and heat fluxes could be greatly attenuated prior to their arrival on the divertor target [3]. In that regard, higher density or impurity gas injection have been extensively explored in the vicinity of divertor area. In fact, both main fuel and impurity gas are routinely utilized to make a detached plasma that could further reduce the divertor thermal loading in comparison with attached plasmas [6]. On the other hand, such addition of either deuterium or impurity gas in the divertor area often leads to vastly different edge conditions, which had been barely successful to reach ELM-crash-suppression even at high level of RMPs that are more prone to mode-locking [2].

Now in KSTAR, taking advantage of the resilience of highly shaped plasma against mode-locking [7] and diffusive deuterium gas puffing, a promising path has been established to lower the divertor thermal loading during RMP-driven, ELM-crash-suppression, where the divertor heat flux peak gets lowered to a level comparable to that of pre-RMP inter-ELMs [8]. As reported earlier, intentionally misaligned RMP configuration (IMC) with 3-rows are seen to have broadened the divertor thermal loading up to 15-20%, whose feature has been missing in 2-row RMPs [2]. Also, ITER-like 3-row RMPs have been found to be better coupled with lower 2-rows, in lower-single-null (LSN) plasmas, rather than with upper 2-rows [9].

This paper will elaborate divertor thermal loading variations in ELM-crash-suppressed H-modes in KSTAR via ITER-like RMP configuration, suggesting a *modus operandi* of the ITER RMP control to simultaneously meet the divertor thermal loading requirements.

References

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