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Experimental observations of the plasma shape effect on the RMP-ELM coupling for optimization of the KSTAR ELM-crash control

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Reliable and robust resonant magnetic perturbation (RMP) on the edge-localized-mode (ELM) crash control is crucial for the success of ITER and beyond. In recent KSTAR experiments, a critical dependence of RMP-ELM coupling on the plasma shape was found to be as important as much as q_{95}. In application of the low-n RMP fields, small variations in the lower triangularity by controlled $R_{X,lower}$ (radial position of lower X-point) made significant changes on RMP coupling, suggesting a narrow window for the ELM-crash suppression. For the shape effects found in 2016, such R_X window for the RMP induced ELM-crash suppression was surprisingly narrow ($\delta_{lower} = 0.74 \pm 0.04$ and $R_{X,lower} = 144 \pm 2cm$), while the other shape parameters, such as Z_X, seem to have weak effects. Also it was found that the same shape valid for the n=1 RMP was not effective for the n=2 RMP induced ELM-crash suppression. In 2017, further study revealed that such a strict condition of triangularity ($R_{X,lower}$) can be relaxed by allowing for an additional small up-down asymmetry on the plasma shape. Applying this new optimized plasma shape led us to make substantial improvements on reliability and robustness of the RMP induced ELM-crash control. As a result, the n=1 RMP induced ELM-crash suppression were successfully demonstrated in a wide range of q_{95} even with a fixed RMP spectra, achieving a record-long sustainment of ELM suppression more than ~30 sec. Similarly, the n=2 RMP-induced ELM-crash suppression was achieved with the same shape (universality) at ITER-relevant low q_{95}=3.3~3.5. Furthermore, we found a singular response to the shape change for the RMP-plasma coupling, with a support of ideal MHD modeling.

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