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Comprehensive understanding of critical conditions near the onset of RMP-driven ELM-crash suppression

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KSTAR has newly secured a comprehensive knowledge set to access the edge-localized-mode (ELM)-crash suppressed stages by resonant magnetic perturbation (RMP). Specifically, taking advantage of highly reproducible n=1 RMP-driven, ELM-crash suppression, several critical conditions near the onset of ELM suppression have been better understood in terms of *shape parameters*, *rotation-associated onset criteria and plasma response*. First of all, the importance of shape parameters cannot be overemphasized in ELM control. While fixing other key parameters, such as edge safety factor $q_{95,}$ and collisionality ν*, an optimal window of radial position of the lower X-point (R_x), equivalent to lower triangularity (δ_l), was found to delineate the onset of ELM suppression by n=1 RMP. Geometrically, the choice of R_x, which determines the outer striking point on divertor tiles, is thought to be responsible for a recycling pattern near divertor baffle area. Taking into account virtually no dependence of vertical position of lower X-point (Z_x), such strong R_x dependence can be utilized as a new ELM control knob, which could be as flexible as edge safety factor q_{95}. Also, we have explored one of the important onset criteria for ELM suppression related to edge rotation. While fixing n=1 RMP configurations near the onset of ELM suppression, a refined torque control alone was found to have suppressed the ELMs. This strongly supports the existence of rotation-related critical point (e.g. $\omega_{e,\perp}$ or $\omega_E \sim 0$) as required for ELM suppression, as had been proposed in theory. Preliminary two-fluid M3D-C1 modeling is also consistent with the experimental observations. Besides, we have confirmed that RMP configuration should be effectively coupled to edge without affecting core. A leading hypothesis postulates that an optimal n=1 RMP configuration would be required to minimize the resonant δB components in core to avoid mode-locking, while maximizing the counterparts at edge to suppress ELMs [1]. Assuming such *a-priori* guideline is valid, an ideal plasma response calculation predicted the onset conditions of ELM suppression and mode-locking respectively. Indeed, the experimentally observed RMP thresholds necessary for ELM-suppression, as well as for mode-locking, have been remarkably well-matched with theoretical predictions [2]. This suggests that global plasma response against applied RMP should be simultaneously factored, while tailoring edge resonant δB components for ELM suppression. Currently, since the KSTAR is the only major tokamak whose RMP coils can be configured similarly to what ITER has planned with 3 row RMP coils, strong collaboration efforts between KSTAR and ITER are being poured to address the urgent ITER RMP needs, focusing on the striation pattern studies of divertor heat flux during RMP ELM control.

References

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