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Database analysis for RMP-driven ELM-crash-suppression experiments in KSTAR carbon wall

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Applying external resonant magnetic perturbation (RMP) is one of the promising methods for a steady-state long-pulse operation by regulating heat and particle flux driven by edge-localized mode (ELM) crash if an H-mode is adopted as an operation scenario in a fusion reactor. During the KSTAR carbon-wall era to an end after the 2022 campaign, a number of RMP-driven ELM-crash-control experiments have been conducted since the ELM crash suppression was realized in 2011 first [1]. A database for the RMP experiments is constructed for systematic and statistical analysis related to ELM-crash-suppression conditions.

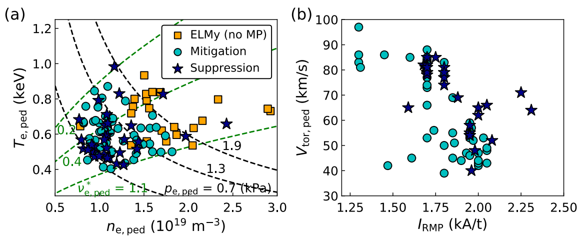

Figure 1. Pedestal profile analysis results: (a) Electron temperature (T_e) versus electron density (n_e), and (b) toroidal plasma rotation speed (V_{tor}) versus RMP current (I_{RMP}) [2]. T_e, n_e, and V_{tor} are from T_e pedestal top.

This presentation provides an updated dataset based on the previous analysis in Ref. [2]. The pedestal profiles are analyzed for discharges in a static n = 1, 90° phasing RMP configuration. The profile analysis provides pedestal parameter ranges where the accessibility to the ELM crash suppression is confirmed in the KSTAR RMP experiments: n_e (electron density) < 1.5 x 10^{19} m^{-3}, V_{tor} (toroidal rotation speed of carbon impurity) > 40 km/s, and 0.2 < ν^*_e (normalized electron collisionality) < 1.1 at the pedestal top.

The database presents the plasma performance (represented by the normalized beta) during the suppression phase related to plasma and engineering parameters. β_N highly depends on total auxiliary heating power (P_{heat}) and RMP strength (I_{RMP}) rather than other factors, such as plasma shape, line-averaged electron density, and plasma current; β_N has a positive (negative) correlation to P_{heat} (I_{RMP}). Based on β_N database analysis, it is investigated whether the ELM crash suppression is maintained in high β_N (> 2.4) conditions. The RMP onset right after the L-H transition using the machine learning (ML) based real-time classifier helps enhance β_N in the RMP phase due to relative high core T_i compared to conventional RMP application case [3]. The duration of β_N > 2.4 ELM crash suppression is ~1.1 s (maximum β_N ~ 2.46). Additionally, the edge-localized RMP (ERMP) [4] and adaptive I_{RMP} control algorithm [5] are applied to enhance β_N in the suppression phase further. Transiently, β_N reaches up to ~2.55 with the ELM crash suppression.

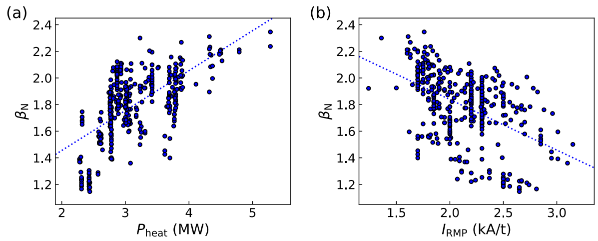

Figure 2. Normalized beta (β_N) in the ELM crash suppression phase versus total auxiliary heating power (a) and RMP current (b) in static n = 1 RMP configuration.

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References

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