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Increase of turbulent fluctuations and perpendicular flow bifurcation At the transition to RMP-driven ELM-crash suppression

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Dynamics influence of static resonant magnetic perturbation (RMP) on turbulent fluctuations and perpendicular flow ($v_\perp$) has been studied using electron cyclotron emission imaging (ECEI) system in the KSTAR [1]. To our surprise, we have identified ELM filaments that still maintained, even when the ELM crash has been completely suppressed on H_α signal by RMP. Correlation analysis among the ECEI channels showed that the RMP would keep enhancing turbulent fluctuations at plasma edge toward the ELM-crash suppression. A cross-phase analysis showed that such edge turbulence has a rather broad dispersion with wide range of wave number ($k_\theta < 1\ \mathrm{cm}^{-1}$) and frequency ($f < 70$ kHz). A detailed analysis suggests that an energy exchange between ELM and RMP-driven turbulent fluctuations would be responsible for the ELM-crash suppression [2].

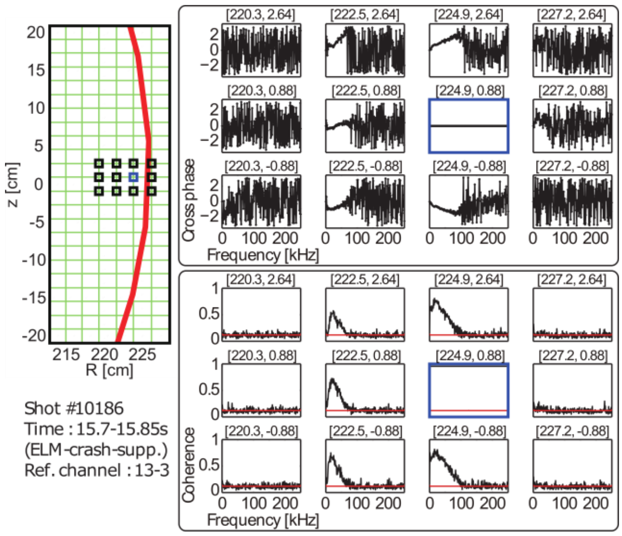

Figure 1. The cross-phase and coherence measurement using 4 (radial) × 3 (poloidal) ECEI channels. Each channel position is marked by coordinates [R,z].

In addition, the direct evidence of perpendicular electron flow ($v_\perp$) bifurcation has been measured at the onset of ELM-crash suppression by tracking the high-speed motion of turbulent eddies [3]. The phase-slope calculation between the ECEI channels revealed that ELM crashes have been suppressed along with a rapid reduction of $v_\perp$, which synchronizes with the transition into and out of ELM-crash suppression. The profile change of electron temperature T_e and density n_e before and during the ELM-crash suppression was too small to explain the significant change of $v_\perp$. These observations indicate that the change of $\mathrm{E} \times \mathrm{B}$ flow ($v_{\mathrm{E}\times\mathrm{B}}$) is the main contribution to the $v_\perp$ bifurcation whose magnitude is the smallest value at the pedestal top near the q_{95} rational flux surface during the ELM-crash suppression. The changes in normalized $v_\perp$ show that the effective rational flux surface for the ELM-crash suppression is $\psi_\mathrm{N}{\sim}0.95$, and the ELM crashes are suppressed when the $v_\perp$ response is strongly sustained at this location. Thus, keeping $v_\perp$ to a small value at the q_{95} rational flux surface could play an important role in suppressing ELM crashes, which could have benefited from a strong plasma response to the RMP.

Such direct measurement of the turbulent fluctuation and changes of $v_\perp$ will contribute significantly to reveal the underlying physics of ELM-crash suppression.

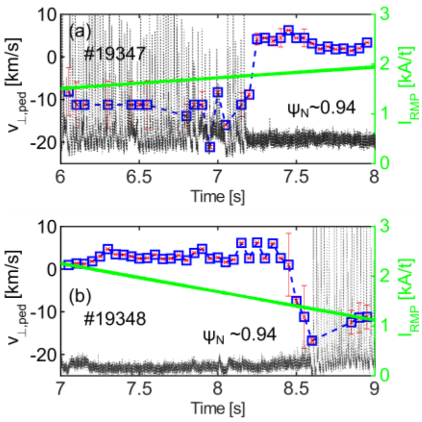

Figure 2. Time trace of perpendicular flow near the pedestal $v_{\perp,\mathrm{ped}}$ with slowly (a) increasing and (b) decreasing RMP field strength respectively.

References
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