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Gradually Increased Turbulent Fluctuations and Rapidly Changing $E \times B$ Flow at the Onset of RMP-Driven ELM-Crash Suppression[1]

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Dynamic influence of static resonant magnetic perturbation (RMP) on turbulent fluctuations and $E \times B$ flow ($v_{E\times B}$) has been extensively studied using the electron cyclotron emission imaging (ECEI) system in the KSTAR. In this study, we have directly measured the turbulent fluctuations and $v_{E\times B}$ near the pedestal at the transition of the RMP-driven ELM-crash suppression. Detailed analysis is in remarkable agreement with the previous studies that the RMP gradually enhanced small-scale turbulent fluctuations near the pedestal, while preventing a large collapse of pedestal due to a nonlinear interaction with coexisting ELM filaments [1]. Recently, direct evidence of rapidly changing $v_{E\times B}$ bifurcation has been measured at the onset of RMP-driven ELM-crash suppression by tracking the high-speed motion of turbulent eddies [2]. Specifically, we have identified a rapid change of perpendicular electron flow, attributable to $v_{E\times B}$ close to zero, nearly synchronous to the sudden disappearance of ELM bursts. Since the local poloidal shear flow was also reduced, this might have increased turbulent fluctuations. Interestingly, the $v_{E\times B}$ remains the smallest near edge pedestal at $\psi_N \sim 0.95$ during the ELM-crash suppression, possibly suggesting a strong plasma response associated with fully penetrated resonant field necessary for ELM-crash suppression. It is worthwhile to note that the RMP field strengths at the entrance and exit of the ELM-crash suppression are vastly different, showing a hysteresis of RMP influence on ELM-crash-suppression. Such turbulent fluctuations and $v_{E\times B}$ changes are expected to help us clarify the underlying physics mechanisms of RMP-driven ELM-crash suppression and elaborate the onset conditions of critical transition, in particular, in an ITER-like low torque plasma. [1] J. Lee et al, Phys. Rev. Lett. 117, 075001 (2016). [2] J. Lee et al, Nucl. Fusion 59, 066033 (2019).

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