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Fluctuation Characteristics of Non-ELM Crash Plasmas on KSTAR

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The characteristics of two different non edge localized mode (ELM) crash plasmas have been investigated through the correlation analysis of 2-D fluctuation diagnostics: (1) Resonant Magnetic Perturbation (RMP)-driven ELM crash suppressed H-mode plasma, (2) natural ELM-less H-mode plasma. A reliable non-ELM crash plasma is essential for steady-state tokamak operation, so it is important to understand the underlying physics for future burning plasmas.

The ELM crash suppression under $n = 1$ RMP is characterized by the coexistence of the filamentary mode and small scale turbulent eddies at the pedestal region [1]. It is found that the filamentary mode structure is maintained with substantial fluctuations in amplitude without large scale collapse, which is distinguished from the ordinary ELMs with a quasiperiodic collapse of the pedestal. The cross-correlation technique on the 2-D electron cyclotron emission imaging (ECEI) [2] signals revealed that the RMP induces the turbulent fluctuations in the edge, which have a wide range of poloidal wave numbers $k_\theta < 1\ \mathrm{cm}^{-1}$ and rotates in the electron diamagnetic direction. Bicoherence analysis of these fluctuations demonstrates that the coexisting filamentary mode and turbulent eddies nonlinearly interact with each other. Such nonlinear interaction suggests that the turbulent fluctuations induced by the RMP dissipate the free energy of the ELM growth by exchanging the energy between them.

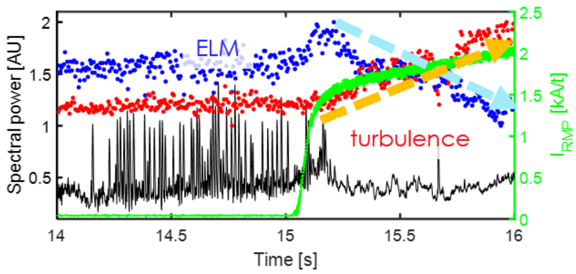

Figure 1. Time history of integrated spectral powers of ELM and turbulence along with the RMP coil current.

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 had been suppressed along with a rapid reduction of $v_\perp$ and its shear, which synchronizes with the transition into and out of ELM-crash suppression. Such reduction of the $v_\perp$ and its local shear could lead to an increase of the turbulent fluctuations at the edge in the ELM crash suppression.

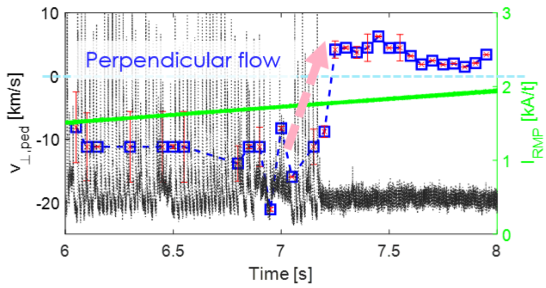

Figure 2. Time trace of perpendicular plasma flow near the pedestal with slowly varying RMP field strength.

In contrast, the natural ELM-less H-mode plasma is accompanied by benign edge harmonic oscillations (EHOs). The EHOs have low toroidal mode number ($n \leq 4$) and remained stable, ELM crashes hardly occurred during the presence of EHOs. Bicoherence analysis shows that there is a strong nonlinear interaction between EHOs, and such interaction has a significant effect on the ELM structure and dynamics. The ELM-less phase is closely related to the $v_\perp$ shear, especially the ELM crashes disappeared when the $v_\perp$ shear is large compared to typical ELMing H-mode plasmas. Finally, the EHOs are correlated with edge transport and RF spikes that affect ELM stability and expects it to play an important role in understanding the mechanism of the ELM-less plasmas.

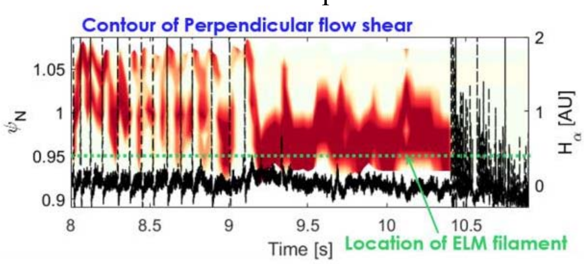

Figure 3. Contour of perpendicular flow shear overlaid with H_α signal.

References
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