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Effect of Shear Flow Oscillation and Turbulence on ELM Mitigation with SMBI in the EAST and HL-2A Tokamaks

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In tokamaks large ELMs can eject quasi-periodically a large quantity of particles and energy from the core plasma, causing significant erosion on the divertor target. Control of large edge localized modes (ELMs) is of crucial importance for the magnetic fusion [1]. Intensive efforts have been made to develop ELM control techniques in tokamaks, such as pellet pacing, resonant magnetic perturbation and other external perturbation fields. Recently, supersonic molecular beam injection (SMBI) has been demonstrated in HL-2A tokamak as a novel effective technique for ELM mitigation [2]. However, the ELM mitigation mechanism still remains unclear.

As shown in Fig.1, two new shear flow oscillations (SFOs) with high (≈200kHz) and low (≈50kHz) frequency have been observed in H-mode plasmas during ELM mitigation by SMBI. Bispectrum analysis shows strong nonlinear interaction between SFOs and background turbulence, indicating SFOs are turbulence driven. It has been found that intermittent high frequency turbulence bursts (400-1200 kHz), generated and nonlinearly regulated by the low frequency SFO, govern the edge pedestal transport. ELMs are mitigated or suppressed by LF-SFO with three possible ways, including as shown theoretically direct effect on the amplitude of ELMs, the extension of the Peeling Ballooning instability limit and the enhancement of the pedestal particle transport due to HFTBs.

ELM mitigation with multi-pulses of SMBI has been demonstrated in the EAST tokamak for quasi-steady state. Both experiments in EAST and HL-2A have revealed the underlying physics mechanism for ELM mitigation, showing how shear flow oscillations regulate the pedestal turbulence and control ELMs.

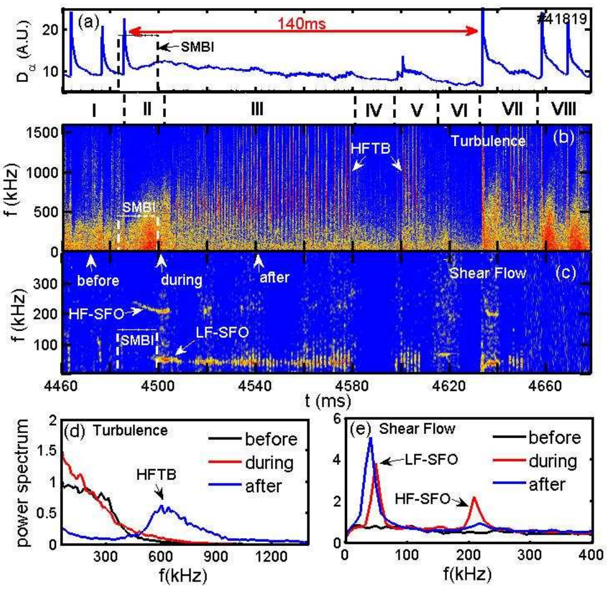

FIG. 1. (a) Time trace of the divertor D_α signal and the SMBI pulse. Frequency spectrogram of the turbulence (b) and shear flow $V_{E\times B}$ (c). Power spectra of the turbulence (d) and shear flow $V_{E\times B}$ (e) before, during and after SMBI.

References

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[2] W.W. Xiao, *et al*., Nucl. Fusion **52**, 114027 (2012)