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The simulations on the nonlinear interactions between edge turbulence and ELMs

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This presentation focuses on the simulations of the nonlinear interactions between the edge turbulence and the edge localized modes (ELMs) in the RF heating and driving scenarios on EAST with BOUT++ framework. A general phenomenon that ELMs can be effectively mitigated/suppressed by the edge turbulence has been observed on EAST [1,2]. For this phenomenon, the experimental statistical analysis and the electromagnetic (EM) simulations have been performed. In the simulations, we found that both the electromagnetic and electrostatic components of the edge turbulence are able to mitigate the amplitude of ELMs. In the previous, the magnetic fluctuations are found effective to mitigate the ELM[3]. For study of the effects of the electrostatic perturbations of the edge turbulence, the EAST ELMy-free H-mode equilibrium #77741 is reconstructed by k-EFIT code. At the time of this equilibrium, ELM is mitigated and a coherent mode (CM) are found. Using the ELITE and BOUT++ analysis, we found that the pedestal of this equilibrium is located outside the P-B boundary. It is inconsistent with the experiment. Therefore, the effects of the CM are considered to explain the mitigation/suppression of ELM. Modifying the three-field reduced MHD model, an imposed electrostatic perturbation is added as the CM effect in the simulation. The simulation results reveal that the ELM size belongs to the large ELM region if without CM effects. After considering the CM, the ELM size is reduced by about 44.5%. Analysis shows that the CM can enhance the three-wave nonlinear interactions in the pedestal and reduce the phase coherence time (PCT) [4] between the pressure and potential, which lead the perturbation to tend to be ‘multiple-mode’ coupling. The competition of free energy between the multiple modes leads to the lack of obvious filament structures and the decreased energy loss. The above reveals that there is a competitive relationship between turbulence and ELMs, and the CM can effectively regulate the ELM energy loss. This conclusion is also valid for the electromagnetic fluctuations on the ELM mitigation. In addition, through the parameter scanning, we found that there is a threshold of the amplitude A, which is consistent with the statistical results in the experiments.

References

[1] Xiao G L, et al. 2019 Nuclear Fusion 59 126033.
[2] Zhang T, et al. 2017 Plasma Physics and Controlled Fusion 59 065012.
[3] Xia T Y, et al. 2019 Nuclear Fusion 59 076043.
[4] Xi P W, et al. 2014 Physical Review Letters 112.

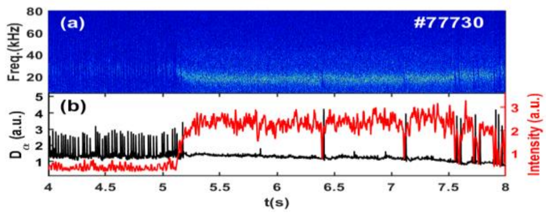

Figure 1. Temporal evolution of the EAST H-mode discharges: (a) the density fluctuation spectrograms measured by the DBS in shot #77730; (b) the Dα signal and the CM intensity in shot #77730.