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Role of SMBI deposition in ELM mitigation and the underlying turbulence characteristics

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In the next generation of large fusion device ITER, it has been accepted that the divertor could not endure the heat exhaust due to the edge localized modes (ELM), without any action to mitigate. The physical mechanism and controlling methods of ELM have become the important tasks in physics of boundary plasmas. The supersonic molecular beam injection (SMBI), one of numerous approaches to mitigate ELMs, has been observed effective for some conditions. But the mechanism of mitigation even the key parameters of injection are not clear exactly. In this work, the relationship of ELM mitigation effect with SMBI deposition is researched experimentally, and simulated with the minimal self-organized criticality model. The underlying turbulence characteristics are observed highly correlated with ELM mitigation for the first time.

The deposition position is obtained from the radial position of the greatest growth of density due to SMBI pulses. The mitigation effect is identified by increase of ELM frequency and decrease of the energy loss caused by one ELM. We found when deposit to the bottom, even outside of pedestal, mitigation is hardly realized. When inject deeper, deposit ~20% into the pedestal, significant mitigation is achieved. But when inject further to the middle or deeper region, the mitigation effect decayed rapidly, till frequency and amplitude of ELM did not change obviously, just similar with condition of bottom deposition. The cellular-automata sand-pile model is used to simulate the ELM burst and explain the mitigation effect at different SMBI deposition. It is deemed that there is a threshold to trigger ELMs. The slightly shallower depositions trigger the crash in advance, and thus make the crash smaller and more frequently.

The relevant theoretical works point out that occurrence of ELM crashes does not only depend on the linear threshold, but also relies on nonlinear processes. The inward turbulence is found to be an important factor. The perturbation of electron density measured by multichannel Doppler reflectometer is used to analyze the feature of turbulence spreading during ELM mitigation with SMBI. The inward spreading is observed during the unmitigated phase. The relation between the turbulence behaviors and ELM mitigation will also be presented.

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