Phase Locking, Phase Slips, and Turbulence: A new Approach to Mechanisms for Quiescent H-mode

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Summary

Relaxation of the edge plasmas plays an essential role in the confinement of Tokamak. Generally, the relaxation falls into two classes: violent release of the stored thermal energy and the soft one. For violent relaxation, typical examples are disruption and type-I edge-localized-mode(ELM) crash, which are major threatens for continuous operation of future burning plasma, such as ITER. The soft relaxations, such as small ELM induced by resonance magnetic perturbation(RMP), are thus favored operating scenarios. Understanding the underlying physics mechanism of different relaxation scenarios is important both from experimental and theoretical viewpoints.

We demonstrate ExB shear and turbulence interaction govern the dynamics of the cross phase of the MHD-driven heat flux, and so determines the evolution from the ELMy H mode to the quiescent H mode. The major results of this paper are: (1) A physics-based scaling of the ExB shearing rate for accessing the QH mode is predicted (Fig. 1). The ELMy H mode to the QH-mode evolution is shown to follow from the conversion from a phase locked state to a phase slip state. In the phase locked state, MHD perturbations are pumped continuously, so bursts occur. In the slip state, the MHD activity is a coherent oscillation. Strong ExB shearing implies a higher phase slip frequency. (2) Turbulence interaction can degrade slip coherency and induce a turbulence QH mode state (Fig. 2). This model predicts a new state of cross phase dynamics and gives a new understanding of the mechanism for QH-mode formation.

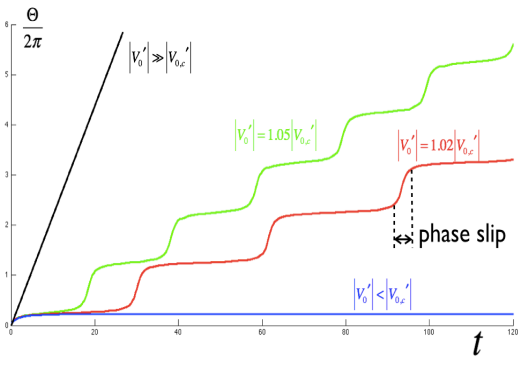

Fig. 1 QH mode with EHO

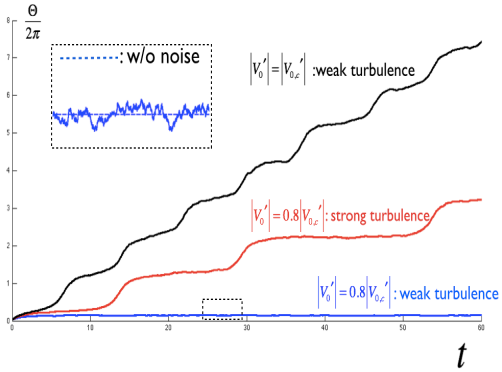

Fig. 2 turbulence QH mode

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