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MHD Modeling of Edge Localized Modes in Tokamaks

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Novel effects of impurity, sheared flow, and resonant magnetic perturbation (RMP) on the dynamics of edge-localized modes (ELMs) in tokamaks have been discovered for the first time in our recent MHD modeling and simulations. First, the stabilizing effects of enhanced edge resistivity on edge-localized instabilities in high confinement discharges due to lithium−conditioning in NSTX have been identified. Linear stability analysis of the experimentally constrained equilibrium suggests that the change in the equilibrium plasma density and pressure profiles alone due to lithium-conditioning may be insufficient for a complete suppression of ELMs with low toroidal mode numbers. The enhanced resistivity due to the increased effective electric charge number Zeff after lithium-conditioning provides additional stabilization of ELMs [1,2]. Second, traditional MHD analysis often predicts merely a weak stabilizing effect of toroidal flow on ELMs in experimental parameter regimes. We find that the stabilizing effects of ELM by toroidal shear flow can be significantly enhanced with the increase in plasma density, even for the flow with low Mach number in the experimentally relevant regimes [3]. Third, we have evaluated the characteristic profile and magnitude for the neoclassical toroidal viscosity (NTV) torque induced by plasma response to the RMP in a tokamak edge pedestal. Based on the evaluation, we have identified the tokamak operation regimes where the significance of NTV torque in edge pedestal induced by RMP can approach those from other more conventional momentum sources such as the neutral beam injections [4]. All these novel effects revealed in our MHD modeling provide new understanding on recent ELM experiments and suggest new control schemes for ELM suppression and mitigation in future tokamak experiments.

References

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