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Effects of Density and Impurity on Edge Localized Modes in Tokamaks[1]

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Plasma density and impurity concentration are believed to be two of the key elements governing the edge tokamak plasma conditions. Optimal levels of plasma density and impurity concentration in the edge region have been searched for in order to achieve the desired fusion gain and divertor heat/particle load mitigation. However, how plasma density or impurity would affect the edge pedestal stability may have not been well known. Our recent MHD theory modeling and simulations using the NIMROD code have found novel effects of density and impurity on the dynamics of edge-localized modes (ELMs) in tokamaks. First, previous MHD analyses often predict merely a weak stabilizing effect of toroidal flow on ELMs in experimentally relevant regimes. We find that the stabilizing effects on the high-n ELMs from toroidal flow can be significantly enhanced with the increased edge plasma density [1]. Here n denotes the toroidal mode number. Second, the stabilizing effects of the enhanced edge resistivity due to lithium-conditioning on the low-n ELMs in the high confinement (H-mode) discharges 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 not be sufficient for a complete suppression of the low-n ELMs. The enhanced resistivity due to the increased effective electric charge number Z_{eff} after lithium-conditioning provides additional stabilization of the low-n ELMs [2]. These new effects revealed in our theory analyses may help further understand recent ELM experiments and suggest new control schemes for ELM suppression and mitigation in future experiments. They may also pose additional constraints on the optimal levels of plasma density and impurity concentration in the edge region for H-mode tokamak operation. [1] S.-K. Cheng, P. Zhu, and D. Banerjee, Enhanced toroidal flow stabilization of edge localized modes with increased plasma density, submitted to Phys. Plasmas (2017). [2] D. Banerjee, P. Zhu, and R. Maingi, Stabilizing effects of resistivity on low-n edge localized modes in NSTX, Phys. Plasmas 24, 054501 (2017).

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