Extended magnetohydrodynamic insights into edge-localized mode suppression/mitigation by three-dimensional magnetic perturbations

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The extended magnetohydrodynamics (MHD) code M3D-C^1 [1] is used to study the linear response of tokamak equilibria to applied three-dimensional magnetic perturbations. In doing so, we seek to develop a more complete understanding of what MHD phenomena are responsible for the mitigation and suppression of edge-localized modes (ELMs) and to explain why the success of ELM suppression experiments differs both within a single tokamak and across different tokamaks. An overview of experimental observations of ELM suppression/mitigation on various tokamaks will be presented. The results of M3D-C^1 simulations are shown to be quantitatively consistent with many of these experimental observations, including the timescale of and magnetic response due to ELM suppression bifurcations. Both resonant (tearing/screening) and non-resonant (kink) plasma responses are considered and correlated to observations of ELM suppression/mitigation. Particular attention is paid to cross-code verification studies between M3D-C^1 , IPEC [2], and MARS-F [3], along with validation studies comparing the code results to experimental magnetics measurements. Fourier decompositions of the magnetic fields are used to examine the detailed structure of the plasma response calculated by each code in order to explain the mixed success of these studies. The importance of non-ideal physics (e.g., two-fluid effects and viscosity), a variety of plasma equilibrium parameters (particularly, the rotation profile), and various numerical parameters are investigated. Results from various experiments will be considered, particularly DIII-D, ASDEX Upgrade, and KSTAR.

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