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Developments in the peeling-ballooning model of ELMs and pedestal constraints*

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Maximizing the pedestal height while maintaining acceptable edge localized modes (ELMs) is a key issue for optimizing tokamak performance. We present a model for ELMs and pedestal constraints based upon theoretical analysis of edge MHD instabilities which can limit the pedestal height and drive ELMs. Sharp pedestal pressure gradients drive large bootstrap currents which play a complex dual role in the stability physics, on the one hand driving peeling modes, while on the other hand opening second stability access to high n ballooning modes. Low n modes are stabilized by line bending and coupling to the conducting wall, while high n modes are stabilized by second stability access and FLR effects; consequently the dominant modes are often intermediate-n coupled "peeling-ballooning" modes, driven both by current and the pressure gradient. A highly efficient MHD code, ELITE,[1,2] is used to study these modes, and calculate quantitative stability constraints on the pedestal, including direct constraints on the pedestal height. A model of various ELM types is presented, and quantitatively compared to data from multiple tokamaks. A number of observations agree with predictions, including ELM onset times, ELM depth, localization to the outer midplane, and variation in pedestal height with discharge shape and density.[2,3]

Recent progress will be presented in three areas: 1) systematic characterization of peeling-ballooning constraints on the pedestal and comparison with observed trends, 2) inclusion of compression and toroidal rotation shear effects, 3) nonlinear simulations of peeling-ballooning modes with the electromagnetic reduced-Braginskii BOUT code.[4]

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