The Peeling-Ballooning Model of ELMs and Pedestal Constraints*

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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 temperature. 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, localization to the outer midplane, and variation in pedestal height with discharge shape and density [2,3].

We present a systematic characterization of peeling-ballooning constraints on the pedestal as a function of pedestal width, density, plasma shape and other important parameters. Recent results will be presented in two areas: 1) Inclusion of compression and toroidal rotation shear effects in ELITE, and calculations of rotation shear effects on edge instabilities, 2) Nonlinear simulations of peeling-ballooning modes with the electromagnetic reduced-Braginskii BOUT code [4], 3) Progress on dynamical simulation of the ELM cycle.

References:

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