ELMs and Constraints on the H-Mode Pedestal: A Model Based on Peeling-Ballooning Modes

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Abstract We propose a model for Edge Localized Modes (ELMs) and pedestal constraints based upon theoretical analysis of instabilities which can limit the pedestal height and drive ELMs. The sharp pressure gradients, and resulting bootstrap current, in the pedestal region provide free energy to drive peeling and ballooning modes. The interaction of peeling-ballooning coupling, ballooning mode second stability, and finite-Larmor-radius effects results in coupled peeling-ballooning modes of intermediate wavelength generally being the limiting instability. A highly efficient new MHD code, ELITE, is used to calculate quantitative stability constraints on the pedestal, including constraints on the pedestal height. Because of the impact of collisionality on the bootstrap current, these pedestal constraints are dependant on the density and temperature separately, rather than simply on the pressure. A model of various ELM types is developed, and quantitatively compared to data. A number of observations agree with predictions, including ELM onset times and variation in pedestal height with collisionality and discharge shape. Stability analysis of series of model equilibria are used both to predict and interpret pedestal trends in existing experiments and to project pedestal constraints for future burning plasma tokamak designs.