Progress in the peeling-ballooning model of ELMs: numerical studies of 3D nonlinear ELM dynamics

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Abstract. Nonlinear simulations with the 3D electromagnetic two-fluid BOUT code are employed to study the dynamics of edge localized modes (ELMs) driven by intermediate wavelength peeling-ballooning modes. It is found that the early behavior of the modes is similar to expectations from linear, ideal peeling-ballooning mode theory, with the modes growing linearly at a fraction of the Alfvén frequency. In the nonlinear phase, the modes grow explosively, forming a number of extended filaments which propagate rapidly from the outer closed flux region into the open flux region toward the outboard wall. Similarities to non-linear ballooning theory, as well as additional complexities are observed. Comparison to observations reveals a number of similarities. Implications of the simulations and proposals for the dynamics of the full ELM crash are discussed.