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Exponential Growth and Filamentary Structure of Nonlinear Ballooning Instability[1] P. ZHU, C.C. HEGNA, C.R. SOVINEC, University of Wisconsin-Madison — Ballooning instability is widely believed to be the underlying process for the type-I large edge-localized-modes (ELMs). The evolution equations for ballooning instability in the intermediate nonlinear regime are derived in an ideal MHD description. This nonlinear regime is operative when the MHD displacement of the plasma filament across the magnetic surface becomes the order of the linear mode width in that same direction. For application to ELM dynamics, this displacement amplitude is comparable to the pedestal width for intermediate-n instabilities. A remarkable feature of this nonlinear regime is that a perturbation that evolves from a linear ballooning instability will continue to grow exponentially at the same growth rate, and maintain the filamentary mode structure of the corresponding linear phase as described in the Lagrangian reference frame. The analytic prediction of the nonlinear exponential growth phase is in excellent agreement with the first-principle full MHD simulations. This may explain why in experiments and simulations, the nonlinear ELM filament strongly resembles the structure of a linear ballooning filament, and linear analyses have often been able to match certain observed features of ELMs in the precursor and collapse onset phases.

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