Nonlinear Ballooning Filament Structure and Growth

P. Zhu, C.C. Hegna, and C.R. Sovinec
University of Wisconsin-Madison

Experiments and simulations indicate the persistent presence of ballooning filamentary structures well into the nonlinear stage of ELMs. Recent analytic theory developed for the description of ballooning instability in the intermediate nonlinear regime for general toroidal magnetic configurations suggests that the solutions of the associated local linear ballooning mode equations continue to be valid solutions of the equations governing the intermediate nonlinear regime. This implies that a perturbation that evolves from a linear ballooning instability will continue to grow exponentially at the same growth rate, and maintain its filament mode structure of the corresponding linear phase in the intermediate nonlinear stage. This may explain why in experiments and in simulations, particularly in the precursor and pre-collapse phases, the ELM filament, which is a nonlinear structure, strongly resembles the structure of a linear ballooning filament. This observation is also consistent with previous numerical analysis and simulations of the line-tied g mode which had reached similar conclusions. Quantitative comparisons between the numerical solutions of the analytic model and direct ideal MHD simulations will be discussed.