Extending the Peeling-Ballooning Model of ELMs: Toroidal Rotation and 3D Nonlinear Dynamics*

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The peeling-ballooning model proposes that intermediate wavelength magnetohydrodynamic (MHD) instabilities, driven by the sharp gradients and resulting bootstrap current in the edge barrier region, are responsible for ELMs and impose constraints on the pedestal. Recent studies of linear peeling-ballooning stability [e.g. 1] have found encouraging agreement with observations, both in the onset time and some characteristics of individual ELMs, and in constraints on the pedestal and their variation with a number of parameters.

To allow more detailed prediction of mode characteristics, including eventually predictions of the ELM energy loss and its deposition, we consider effects of sheared toroidal rotation, as well as 3D nonlinear dynamics. A formulation for toroidal rotation shear has been developed and incorporated into the framework of the efficient ELITE stability code [2]. Rotation shear is found to significantly impact the structure of peeling-ballooning modes [Fig. 1(a)], causing radial narrowing and shearing of the mode structure. Studies of the evolution of edge instabilities [Fig. 1(b)] with the 3D nonlinear BOUT code [3] reveal dynamical effects including poloidal narrowing, filamentary structure, and fast radial pulse propagation over a broad region. Use of the extended MHD code NIMROD for ELM simulations is also discussed.

[1]P.B. Snyder *et al.*, Phys. Plasmas **9**, 2037 (2002); Nucl. Fusion **44**, 320 (2004).
[2]H.R. Wilson, *et al.*, Phys. Plasmas **9**, 1277 (2002).
[3]X.Q. Xu, *et al.*, New J. Physics **4**, 53 (2002).

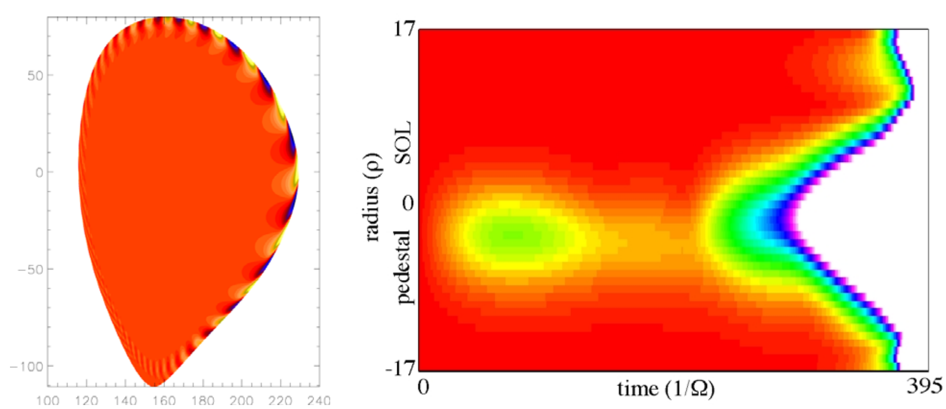

Fig. 1. (a) Calculated structure of an n=11 peeling-ballooning mode in a DIII-D plasma, including the effect of toroidal rotation shear. (b) Time evolution of the perturbed density from a 3D BOUT simulation of an ELM shows initial mode growth in the pedestal region, followed later by a fast pulse extending over a broad radial region.

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