ELM Topology and Dynamics*

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A conceptual model of the 3D topology and nonlinear evolution of an edge localized mode (ELM) following the initial linear peeling-ballooning growth phase is proposed in this paper. The model is based on the existence of a pre-existing topological structure, referred to as homoclinic tangle [1], that channels heat flux to the divertor targets during the linear growth phase. This creates an imbalance in T_e at the ends of the open field lines that drives a helical current through the lobes of the tangle. The helical current then amplifies size and toroidal phase (rotates the structure) of the lobes as they grow. In the final stage, the tangle becomes multiply connected to the walls and divertors which reduces the thermo-electric drive and the tangle relaxes to its initial pre-ELM state.

This model is motivated by the fact that ELMs present a unique challenge for sustaining full power H-mode operations in future tokamaks such as ITER. In ITER, unmitigated ELMs are expected to periodically deposit energy bursts in excess of 10 MJ on the divertor target surfaces over a period of 500 μs or less. Assuming the ELM energy is spread uniformly over the ITER target plate area (4.7 m^2), they will cause a rapid erosion of the material surfaces and could limit the number of full power discharges to less than a few dozen. Although ELMs are a common feature of stationary H-mode discharges in the current generation of tokmaks, there are many uncertainties concerning how these instabilities will scale to the ITER geometry and operating conditions. Thus, a model is needed that can predict the intensity, structure (3D topology) and temporal evolution of ELMs during their nonlinear growth phase when they are most likely to strongly interact with both the divertor and blanket module plasma-facing surfaces. The development of such a model requires urgent attention in the plasma-surface interaction community since it must be fully validated with experimental data from existing tokamaks before beginning high power H-mode operations in ITER.

The model proposed in this paper has been compared to fast midplane and divertor camera data during and between ELMs in DIII-D. This comparison will be discussed in detail. In particular, persistent filament-like structures are observed with the midplane camera during L-modes and between ELMs that appear to be consistent with the pre-existing 3D structures required by the model. In addition, the evolution of these structures appears to match the dynamics expected in the model.

[1] T.E. Evans, R.K.W. Roeder, J.A. Carter, et al., J. Phys.: Conf. Ser. **7** (2005) 174.

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