HIGH MODE NUMBER MHD STABILITY AT THE EDGE OF A TOKAMAK*

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Understanding and controlling the edge stability of a tokamak is important for optimizing tokamak performance. Stability determines the maximum sustainable pressure gradient at the edge and is believed to be responsible, at least in part, for ELM behavior. The sensitivity of "stiff" transport models to the magnitude of the edge pressure pedestal has increased the interest in the maximum sustainable pressure gradient near the plasma boundary. High mode number ballooning stability appears to be insufficient to explain experimental observations: the local pressure gradient near the boundary in DIII–D ELMing H–mode discharges exceeds the first regime ballooning limit by as much as a factor of two.[1] Recently Connor, Hastie, and Wilson[2] [CHW] developed a high-mode-number peeling/ballooning mode model at the tokamak edge in which a critical role is played by the edge current density. The origin of the edge current is the bootstrap current density, with its dependence upon pressure gradient and collisionality. When bootstrap current effects are included, the CHW model suggests a power threshold for L–H transitions and provides a plausible explanation for an ELM cycle.

The CHW model is cast in a large aspect ratio circular geometry. Here we extend the ballooning/peeling analysis to finite aspect ratio, non-circular geometry including effects of a separatrix boundary. The effect of a plasma separatrix is studied using the local equilibrium model of Bishop[3] and numerical equilibria for direct comparison with experiment. In limited plasmas, the most restrictive mode is one with the resonant surface just outside the plasma boundary. A separatrix introduces two new effects: every resonant surface occurs inside the plasma boundary and even at high toroidal mode number, n, the variation of q across the mode width cannot be neglected. A 2D eigenvalue code determines the marginal edge current density for high mode numbers. The radial coordinate is discretized with extensive packing of mesh points about rational surfaces while the poloidal variable is decomposed into Fourier modes with special treatment near the separatrix. The code is constructed in such a way that additional physics effects such as rotation may be added and additional terms can be added to accurately treat intermediate mode numbers. Results will be presented for the pressure gradient and edge current density stability boundaries for a range of shapes and pedestal widths and including the effects of a separatrix boundary, finite-n corrections, and a self-consistent bootstrap current. Comparisons will be made with DIII–D equilibria and edge pressure and current density measurements.

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[1] T.H. Osborne et al., "Scaling of ELM and H–mode pedestal characteristics in ITER shape discharges in the DIII–D tokamak," to be published in Controlled Fusion and Plasma Physics (Proc. 24th EPS Conference, Berchtesgaden, Germany 1997).

[2] J.W. Connor et al., UKAEA FUS 383 November 1997, submitted to Physics of Plasmas.

[3] C.M. Bishop et al., Nucl. Fusion **24** 1579 (1984).