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ELMs and the Role of Current-Driven Instabilities in the Pedestal

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Abstract

Edge localized modes (ELMs) can limit tokamak performance both directly, via large transient heat loads to divertor plates, and indirectly, through constraints placed on the edge pedestal height which impact global confinement. Understanding the physics of ELMs has proved challenging, in part because the sharp edge pressure gradients and consequent large bootstrap currents in the pedestal provide drive for a variety of magnetohydrodynamic (MHD) instabilities over a wide range of toroidal mode numbers (n). We present a brief review of recent developments in ELM theory, focusing on ELMs whose frequency increases with input power, and emphasizing theories which incorporate current-driven MHD instabilities such as external kink or "peeling" modes. We describe recent progress both in analytic theory of peeling-ballooning modes, and in the development of computational tools which can calculate edge MHD growth rates in shaped toroidal geometry over the full relevant spectrum of n. This progress has led to the development and refinement of ELM theories based on peeling-ballooning modes, including models for ELM characteristics and temperature pedestal limits. Comparisons of ELM theory with experiment, and recent experimental efforts to control ELMs will also be discussed.