An extended-MHD model for peeling-ballooning stability thresholds in spherical tokamaks*

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We show that non-ideal physics can significantly alter peeling-ballooning (PB) stability thresholds in spherical torus (ST) configurations, such as NSTX and MAST. Novel resistive kink-peeling modes are found to limit macroscopic edge-stability in ELMing NSTX discharges [1], and can possibly be a limiting factor in other ST devices. Edge-localized modes (ELMs) are associated with ideal peeling-ballooning (PB) modes occurring in the edge pedestal due to strong pressure and current density gradients. A long-standing problem has been the reliable modeling of such stability boundaries in spherical tokamaks (STs), where ideal-MHD models often predict stability for ELMing discharges [2]. Some MAST discharges were found to be located on the ballooning stability boundary [3]. Employing the extended-MHD initial value code M3D-C1 [4], we investigate macroscopic edge-stability in ELMing and ELM-free discharges in NSTX and MAST. In ELMing discharges robust resistive peeling-ballooning modes [5] are found well before the ideal stability threshold is met. In contrast, ELM-free wide-pedestal and enhanced-pedestal H-mode discharges in NSTX are limited by ideal ballooning modes. Plasma resistivity is seen to destabilize the kink-peeling components, but not the ballooning components. Finite Larmor radius effects affect the stability limits moderately and can explain experimental access to some ELMing regimes. Based on these extended-MHD calculations ELMing discharges are correctly predicted to be unstable, whereas ELM-free plasmas remain inside the stable domain.

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