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Global Gyrokinetic Simulations of the Dominant High-n and Intermediate-n Instabilities in the H-Mode Tokamak Edge Pedestal[1]

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Global electromagnetic gyrokinetic simulations show the existence of near threshold conditions, for both a high-n Kinetic Ballooning Mode (KBM) and an intermediate-n kinetic version of Peeling-Ballooning Mode (PBM). The KBM and the PBM have been used to constrain the EPED model [1]. Global gyrokinetic simulations show that the H-mode pedestal, just prior to the onset of the Edge Localized Mode (ELM), is very near the KBM threshold. Two DIII-D experimental discharges are studied, one reporting KBM features in fluctuation measurements [2]. Simulations find that in addition to the high-n KBM, an intermediate-n electromagnetic mode is unstable. This kinetic version of the PBM has phase velocity in the electron diamagnetic direction, but otherwise has features similar to the MHD PBM. When the magnetic shear is reduced in a narrow region near the steep pressure gradient, the intermediate-n "kinetic PBM" is stabilized, while the high-n KBM becomes the most unstable mode. Global simulation results of the KBM compare favorably with flux tube simulations. The KBM transitions to an unstable electrostatic ion mode as the plasma beta is reduced. The intermediate-n "kinetic peeling ballooning mode" is sensitive to the q-profile and only seen in global electromagnetic simulations. Collisions increase the KBM critical beta and growth rate. These results indicate that an improved pedestal model should include, in detail, any corrections to the bootstrap current, and any other equilibrium effects that might reduce the local magnetic shear. It is known that the bootstrap current may flatten the q-profile in the steep gradient region [3]. Simulations are carried out using the global electromagnetic GEM code, including kinetic electrons, electron-ion collisions and the effects of realistic magnetic geometry. In addition to global linear analysis, nonlinear simulations will be reported showing that, while the equilibrium radial electric field has a weak effect on the linear growth rate, it has a larger stabilizing effect nonlinearly.

[1] P. Snyder, et al., Phys. Plasmas 16 056118 (2009).
[2] Z. Yan, et al., Phys. Plasmas 18 056117 (2011).
[3] J. Callen, et al. Nucl. Fusion 50 064004 (2010).

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