Non-curvature driven modes in the edge pedestal

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Abstract

We explore the linear stability of simple slab plasma configurations without magnetic curvature using gyrokinetic simulations based on the GS2 code as well as analytic calculations. The configurations, intended to model some of the salient features of the H-mode edge pedestal, are characterized by sheared $E \times B$ flows, strong ion and electron diamagnetic flows that are driven by gradients in the plasma density and/or temperatures, weak collisionality, and finite magnetic shear. Strong parallel flows, though sometimes present in laboratory fusion experiments, are not addressed in this work. We find at least three linear modes of potential importance in such systems: the Kelvin-Helmholz instability, the so-called Tertiary mode, and a non-local driftwave instability. The well-known Kelvin-Helmholz instability is driven by the spatial variations in the $E \times B$ velocity. According to our rough estimates, it is near marginal stability under typical H-mode edge conditions due to the combined stabilizing influence of the magnetic shear and ion diamagnetic effects. The Tertiary mode is an adiabatic, electrostatic mode arising at higher-$k_{||}$ that is driven primarily by the ion temperature gradient. According to the GS2 simulations, this mode is also near marginal stability in the H-mode edge due to the stabilizing contribution of finite Larmor radius effects. Finally, the non-local driftwave mode is driven by the plasma gradients in conjunction with either electron inertia, electron-ion collisionality, or electron Landau damping. We find this mode is robustly unstable in the presence or absence of magnetic shear at typical H-mode edge discharge levels. Our analysis also suggests that an accurate description of this mode for typical H-mode parameters requires a model that includes electron Landau damping effects, as well as electromagnetic effects and nonlocal profile variations. This mode seems to be a good candidate for driving particle and heat transport in the H-mode edge, in which curvature-driven modes are known to become weak due to diamagnetic stabilization, or in the edge of linear devices.