Gyrokinetic study of slab entropy modes and the (specious) Gradient Drift Coupling (GDC) instability

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We present a gyrokinetic linear stability analysis of a collisionless, shearless slab geometry in the local approximation. We focus on $k_\parallel = 0$, electromagnetic universal (or, entropy) modes driven by plasma gradients at small and large plasma β. These modes are small scale non-MHD instabilities with growth rates that typically peak near $k_\perp \rho_i \sim 1$ and vanish in the long wavelength $k_\perp \to 0$ limit. Analytical analysis shows that in the long wavelength limit a necessary condition for this instability is that at least one of η_e and η_i be negative where $\eta_\alpha = L_n/L_{T_\alpha}$ is the ratio of the density to the (electron, ion) temperature gradient scale lengths. In other words, the density gradient must point in the opposite direction of either the electron or the ion temperature gradient in order to excite the slab instability [1]. This instability condition is explored with linear and nonlinear gyrokinetic simulations [2]. We also show a mode known as the Gradient Drift Coupling (GDC) instability previously reported in the gyrokinetic literature, [3, 4] which has a finite growth rate $\gamma \simeq \sqrt{\beta/[2(1+\beta)]} C_s/|L_p|$ with $C_s^2 = p_0/\rho_0$ for $k_\perp \to 0$, is a spurious, unphysical artifact that erroneously arises due to the failure to respect the total pressure balance $p_0 + B_0^2/(8\pi)$ = constant of the equilibrium, which renders the assumption $B_0' = 0$ inconsistent if $p_0' \neq 0$.

[1] B. Rogers, B. Zhu and M. Francisquez, in press, *Physics of Plasmas*

[2] B. Zhu et. al., in preparation

[3] M. Pueschel, P. Terry, D. Told, and F. Jenko, *Physics of Plasmas* **22**, 062105 (2015)

[4] M. Pueschel et. al., *Plasma Physics and Controlled Fusion* **59**, 024006 (2017)