Interplay between density profile and zonal flows in drift-kinetic simulations of slab ITG turbulence

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Understanding turbulent transport in magnetically confined fusion plasmas remains a key issue for present and future devices. The instabilities driven by ion temperature gradients (ITG) are mainly responsible for ion anomalous transport. This work addresses non-linear global drift-kinetic simulations of slab ITG turbulence in an inhomogeneous collisionless plasma confined by a strong uniform magnetic field [1]. One considers the limit $k_\perp \rho_i \ll 1$, so that finite Larmor radius effects are only taken into account in the quasi-neutrality equation. In such a limit the ion distribution function is 3D in space and 1D in the velocity, namely $v_\parallel$. The $\mathbf{E} \times \mathbf{B}$ drift governs the transverse dynamics, while the parallel motion is governed by $\mathbf{E}_\parallel$. The electron response is assumed adiabatic hence impeding particle transport. The Vlasov-Poisson like system is solved on a fixed grid with a Semi-Lagrangian scheme [2] for the entire distribution function. The energy conservation, which is recognized as a key test of validity, is achieved with an accuracy better than 2.5%. The profiles of density, electron and ion temperatures are initialized as hyperbolic tangents. In the non-linear regime, the system is found to relax preferentially either via heat transport or via mean sheared flows, depending on the density profile. A strong density gradient appears to be stabilizing both linearly, by increasing the instability threshold, and non-linearly, by activating sheared flows. A quasi-linear analysis in the fluid limit suggests that the latter mechanism is due to the dependence of the Reynolds stress on the gradients of the density profile.

[1] V. Grandgirard et al, submitted to Journal of Comput. Physics.

[2] E. Sonnendrücker et al, Journal of Comput. Physics, 149, 201-220, 1999.