Locality of non-linear interactions in gyrokinetic turbulence

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Determining the strength of the nonlinear couplings between instability dominated large scales and collisional small scales is crucial for the fundamental understanding of plasma turbulence, for which, a large value would imply a non-universal characteristic. To account for this, the scale redistribution of free-energy is numerically investigated in toroidal axisymmetric flux tube geometry, for gyrokinetic (GK) turbulence, driven by an ion-temperature gradient instability. Previous works reported that the exchange of energy takes place between similar scale structures [1, 2]. However, although the energy exchanges are local, the fundamental question regarding the locality of the interactions was never addressed so far in GK turbulence.

In this work, we describe a quantitative way of asserting the degree of locality for GK turbulence, employing Kraichnan’s infrared (IR) and ultraviolet locality functions [3]. The idea of locality can be seen as the disparity between scales contributing to a nonlinear interaction. For a given energy flux through a scale, the degree to which each scale contributes to the mentioned flux represents an assertion of locality, [4]. For the interaction to be local, the contribution of highly separated scales should be small and decrease fast with the increase in separation. Due to the nontrivial dissipative nature of GK turbulence, an asymptotic level for the locality exponents, indicative of a universal dynamical regime for GK’s, is not recovered in spite of the local energy cascade observed. Moreover, the IR interactions tend to have an accentuated non-local behavior indicating a sensitivity of GK turbulence to the type of instability generating it.

References