Dissipation measures in weakly-collisional plasmas

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The physical foundations of the dissipation of energy and the associated heating in weakly collisional plasmas are poorly understood. Here, we compare and contrast several measures that have been used to characterize energy dissipation and kinetic-scale conversion in plasmas by means of a suite of kinetic numerical simulations describing both magnetic reconnection and decaying plasma turbulence. We adopt three different numerical codes that can also include inter-particle collisions: the fully-kinetic particle-in-cell vpic, the fully-kinetic continuum Gkeyll, and the Eulerian Hybrid Vlasov-Maxwell (HVM) code. We differentiate between i) four energy-based parameters, whose definition is related to energy transfer in a fluid description of a plasma, and ii) four distribution function-based parameters, requiring knowledge of the particle velocity distribution function. There is overall agreement between the dissipation measures obtained in the PIC and continuum reconnection simulations, with slight differences due to the presence/absence of secondary islands in the two simulations. There are also many qualitative similarities between the signatures in the reconnection simulations and the self-consistent current sheets that form in turbulence, although the latter exhibits significant variations compared to the reconnection results. All the parameters confirm that dissipation occurs close to regions of intense magnetic stresses, thus exhibiting local correlation. The distribution function-based measures show a broader width compared to energy-based proxies, suggesting that energy transfer is co-localized at coherent structures, but can affect the particle distribution function in wider regions. The effect of inter-particle collisions on these parameters is finally discussed.