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Current and vorticity sheets disruption in collisionless plasma turbulence

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Magnetic reconnection is a fundamental process in magnetized plasmas, associated with significant magnetic energy release, and is ubiquitous in several astrophysical environments characterized by high Reynolds numbers and turbulence[1]. In the presence of strong turbulence in the medium, magnetic field line reconnection is continuously met along the flow. This makes magnetic reconnection an intrinsic element of the turbulent cascade and vice versa[2].

Magnetic reconnection typically occurs where intense current sheets form, giving rise to plasmoid formation, while the turbulent cascade explains how the energy provided at large scales is dissipated at small scales. Significant efforts have been devoted to understanding how the reconnection process, via plasmoid instability, influences the turbulent cascade in resistive magnetohydrodynamics (MHD) [3-6]. However, space and astrophysical plasmas where reconnection and turbulence have mutual influence are most of the time collisionless suggesting that the electron inertia may play a crucial role as a driving mechanism for reconnection. In the framework of collisionless magnetic reconnection described by two-fluid equations, several studies [7,8] have also been devoted to the evolution of current and vorticity sheets that undergo secondary instabilities of the fluid type, especially the Kelvin–Helmholtz (KH) instability.

The evolution of current and vorticity sheets is studied here in the framework of collissionless turbulent plasmas, where magnetic and fluid instabilities coexist and play a role in determining their evolution.

A detailed linear analysis of the stability of a magnetized Bickley jet [9], that effectively model the sheared magnetic and velocity layers observed in ideal plasmas, will guide us in the interpretation of the numerical simulations. Thin current sheets may be prone to plasmoid or KH instabilities depending on the local values of the magnetic and velocity fields [10]. We find that the coexistence of these two instabilities prevent the colllisionelss plasma to achieve the fully mediated plasmoid turbulent regime. This behavior not only influence how the current and vorticity sheets break, but also affect the energy cascade, explaining the discrepancy between the magnetic energy spectrum evaluated from the numerical simulations and the one we derived analytically under the assumption that the fully plasmoid-mediated turbulent regime has been achieved. We will also see that, unlike the resistive magnetohydrodynamic context, in collisionless plasmas the magnetic and kinetic spectra decouple.

Preliminary results on the effect of electron temperature on the described scenario will also be shown. As an example fig. 1 shows a comparison of the current density distribution and magnetic surfaces for two simulations run with and without electron temperature effects. Starting from the effect on the linear growth rate of the reconnecting and KH modes we interpret the new results.

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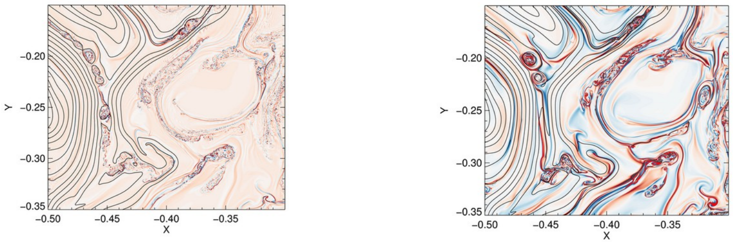

Figure 1: Current density distribution with superimposed magnetic field lines for a case with electron temperature effects (right panel) and without (left panel)