2D-3V Vlasov simulations of plasma turbulence

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A frontier problem in plasma physics and among the hot ones in space plasmas research, is the understanding of the kinetic processes at play in plasma turbulence controlling the energy ”re-organization” after crossing the ion microscopic lengths. The energy, typically injected at large fluid scales and constrained by the MHD invariants, cascades non-linearly towards smaller and smaller scales eventually leading to the onset of non-MHD regimes. Ions kinetic effects come first into play well before ”collisional processes” and contribute to open different channels of energy transfer depending on the main physical parameters, first of all the plasma beta.

Here we present high-resolution 2D-3V numerical simulations of forced e.m. turbulence using a hybrid Vlasov-Maxwell code. The initial ambient magnetic field is perpendicular to the (x,y) real space plane. The random compressible forcing injects the energy on the largest wavelengths giving rise to strong fluctuations in the perpendicular plane and making the plasma strongly inhomogeneous and turbulent. Intense current sheets are generated where magnetic reconnection eventually occurs. We observe interplay between turbulence and reconnection making them intimately entwined processes eventually reaching a quasi-stationary turbulent state.

Several regimes have been investigated varying the plasma β and resistivity. In particular, for low-β regimes, the turbulence is dominated by whistler-like fluctuations, while for high-β regimes it is mostly driven by Alfvènic ones even if both whistler and KAW turbulence are present in the two regimes, the difference being only in their relative importance. Furthermore, in the high-β plasma regime, strong signatures of the presence of coherent structures are found in the magnetic energy spectra, as well as a steepening of the spectra has been observed probably due to a higher level of collisionless damping and to the interplay of the magnetic structures with the turbulent cascade.