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Hall-MHD simulations of plasma turbulence

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In the framework of Hall magnetohydrodynamics, we investigate the properties of plasma turbulence, by means of both Hall magnetohydrodynamic (HMHD) and hybrid-kinetic particle-in-cell (HPIC) numerical simulations. We find that HMHD simulations are able to reproduce the magnetic spectral properties of the HPIC simulations at sub-ion scales and in agreement with solar wind observations. In particular the energy spectrum of magnetic fluctuations reproduces the Kolmogorov cascade of spectral index \$5/3\$ at MHD scales and a cascade with a spectral index of \$\sim -3\$ at kinetic scales. The location of the break observed in the spectrum between the MHD and the kinetic scales is also recovered. Concerning the magnetic fields, HMHD simulations are in remarkable agreement with HPIC simulations, not only at the final stage, when turbulence is fully developed, but also during the evolution and the onset of the turbulent cascade. In particular, at the time when reconnection is triggered, we retrieve the appearance at kinetic scales of a power-law cascade with the same slope in both simulations. The agreements extends to the other statistical properties, such us the kurtosis of the magnetic field. At kinetic scales, the same agreement between HMHD and HPIC simulations does not hold for other quantities, namely in the energy spectrum of the velocity. We conclude that Hall-MHD fluid description contains most of the main ingredients to characterize plasma turbulence around sub-ion scales.