From large-amplitude kinetic Alfvén fluctuations to kinetic turbulence at proton scales

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Turbulence in the solar wind has been extensively studied, both by detailed analyses of in situ measurements and from a theoretical point of view [1]. Beside the homogeneous turbulence, generation of small scale fluctuations can take place also in other realistic configurations. Recent numerical simulations of these kind of configurations have shown that phase mixing of large-scale parallel-propagating Alfvén waves is an efficient mechanism for the production of kinetic Alfvén waves (KAW) at wavelengths close to $d_p$ and at a large propagation angle with respect to the magnetic field [2]. Many observational and theoretical works have suggested that these fluctuations may play a determinant role in the development of the solar-wind turbulent cascade.

In this work, we study numerically large amplitude KAW fluctuations in inhomogeneous backgrounds and their effects on the protons by means of hybrid Vlasov-Maxwell simulations [3]. For this, the kinetic dynamics of protons has been investigated by varying both the magnetic configuration and the amplitude of the initial perturbations. Of interest here is the transition from quasi-linear to turbulent regimes, focusing, in particular, on the development of important non-Maxwellian features in the proton distribution function driven by KAW fluctuations. We employ several indicators to quantify the deviations of the protons from thermodynamic equilibrium. These numerical results might help to explain the complex dynamics of inhomogeneous and turbulent astrophysical plasmas, such as the heliospheric current sheet, the magnetospheric boundary layer and the solar corona.

References