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Numerical modeling of observed fast streams in the solar wind – plasma instabilities and energy exchange between fields and particles

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Collisionless fast solar wind streams comprise of ubiquitous electromagnetic fluctuations and highly non-equilibrium electrons and ions, whose distributions exhibit various non-thermal features, such as faster field aligned beams, temperature anisotropies and relative drifts between the multiple ion populations. The nature of these kinetic features, their origin and the inter-relation with the ambient electromagnetic fields and fluctuations are still open problems which need to be better understood. In this work we perform series of 2.5D hybrid simulations with fluid electrons and kinetic ions to study the in situ heating and particle acceleration by local fluctuations, such as plasma waves. We also consider the particle heating and acceleration by small-scale spatial structures, such as locally generated current sheets. We initialize the system with a set of ion-cyclotron and kinetic Alfven waves. The latter fluctuations co-exist with self-generated small-scale turbulent current sheets in an anisotropic drifting proton-alpha particles plasma. We investigate the nonlinear evolution of the modeled observed fast stream parcels and follow the relaxation of the initial ion temperature anisotropies and relative drifts and their interaction with the plasma oscillations and the small-scale currents. We test the predicted linear evolution of the ion-cyclotron plasma micro-instability in the case of initially larger perpendicular temperature for the protons and determine the nonlinear time-scales. Further, we follow the dissipation of the imposed spectra of magnetic fluctuations and study the related field-particle correlations and the energy transfer between the multiple ion species. In all cases we observe preferential heating for the minor ions, while the protons cool off in perpendicular direction.