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Title: Current fragmentation and particle acceleration in strongly turbulent plasmas

Abstract

Numerous recent studies demonstrate that a relatively large number of current sheets may be formed during the evolution of strong (δB/B) turbulence. A large fraction of the current sheets present in strongly turbulent environment will be forced to reconnect and will further be fragmented or will interact with their close neighbours. The subset of the current sheets that are forced to reconnect will be associated with a statistical distribution in space and time of relatively strong electric fields. Fragmented electric fields (associated with reconnecting current sheets) may be spread over large volumes and are associated with coronal heating, or they may be compressed into relatively smaller volumes due to the emergence of new magnetic flux, and in this case they may be associated with intense explosive acceleration and heating correlated with the magnetic topology. Based on the above scenario, two main lines of research are currently in progress and will be outlined in my tutorial: (1) we may start on data-driven 3D magnetic field which is perturbed by a turbulent driver. A relativistic test-particle simulation traces each particle's guiding center within these configurations. Using the simulated particle-energy distributions, we test our results against experimental data. (2) We may consider 3D nonlinear MHD simulations of a turbulent system. We first analyze the statistical nature and spatial structure of the electric field, calculating histograms and making use of isocontour visualizations. Then test-particle simulations are performed for electrons, in order to study heating and acceleration phenomena, as well as to determine the high energy emission. This study is done by comparatively exploring quiet, turbulent explosive, and mildly explosive phases of the MHD simulations. Also, the importance of collisional and relativistic effects is assessed, and the role of the integration time is investigated. Particular aim of this project is to verify the quasi- linear assumptions made in standard transport models, and to identify possible transport effects that cannot be captured with the latter. In order to determine the relation of our results to Fermi acceleration and Fokker-Planck modeling, we determine the standard transport coefficients. In different MHD time-instances we find heating to take place, and acceleration that depends on the level of MHD turbulence. Also, acceleration appears to be a transient phenomenon, there is a kind of saturation effect, and the parallel dynamics clearly dominate the energetics.