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Alfvénic wave packets collisions in a kinetic plasma

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The problem of two colliding and counter-propagating Alfvénic wave packets has been analyzed in detail since the late Seventies. In particular Moffatt and Parker [1] showed that, in the framework of the incompressible magneto-hydrodynamics (MHD), nonlinear interactions can develop only during the overlapping of the two packets. Here we describe a similar problem in the framework of the kinetic physics.

The collision of two quasi-Alfvénic packets is here investigated by means of MHD, Hall-MHD and kinetic simulations performed with two different hybrid codes: a PIC code and an Eulerian Vlasov-Maxwell code. Due to the huge computational cost, only a 2D-3V phase space is allowed (two dimensions in the physical space, three dimensions in the velocity space). As in the pure MHD case, the most relevant nonlinear effects occur during the overlapping of the two packets. However, the extension to include compressive, dispersive and kinetic effects, while maintaining the gross characteristics of the simpler classic formulation, also reveals intriguing features that go beyond the pure MHD treatment [2].

By focusing on the Eulerian Vlasov-Maxwell simulation, we describe in detail the production of non-Maxwellian features in the proton distribution function [3] and the characteristics of the turbulence generated by the collision [4]. During the collision, regions characterized by temperature anisotropies and agyrotropies are recovered. Similarly to some recent observations of the solar wind [5], a clear beam along the direction of the magnetic field is also detected. Finally, it is shown that the approach based on the presence of linear modes features is still helpful in characterizing some low-energy fluctuations. However, other signatures, which go beyond the pure linear modes analysis, are recovered, such as the significant weakening of clear dispersion relations and the production of zero frequency fluctuations.

References

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