SG-I4 AAPPS-DPP2020

4th Asia-Pacific Conference on Plasma Physics, 26-31Oct, 2020, Remote e-conference

Kinetic Physics of Compressed Boundary Layers: Theory, Simulation, and *in situ* Observations

Chris Crabtree[1], Guru Ganguli[1], Alex Fletcher[1], David Malaspina[2]
[1] Plasma Physics Division, Naval Research Laboratory, Washington, DC, 20375,
[2] Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder CO 80303
e-mail (speaker): chris.crabtree@nrl.navy.mil

Dipolarization fronts (DFs) are fast Earthward propagating plasma structures with spatial gradients (in the frame moving with the front) of the order of the ion gyroradius or smaller. Broadband, mostly electrostatic, wave power is observed at the front and complex nonlinear electromagnetic waves behind the front. DFs are thought to be formed in the magnetotail due to magnetic reconnection, which is often observed to be the result of thin current sheets with plasma gradients on scales smaller than the ion gyroradius. In this paper, we describe new semi-analytic equilibrium solutions to the Vlasov-Maxwell set of equations with a finite number of undetermined parameters that includes a self-consistent electric field perpendicular to the front [1-2]. The scale size of this electric field can be shorter than (or of the order of) the ion gyroradius so that the ions do not experience the full $\vec{E} \times \vec{B}$ drift while the electrons do. This strongly sheared flow can drive many different kinds of instabilities, in particular the electron ion-hybrid instability (EIH) [3]. We use multi-satellite data from the Magnetospheric Multiscale Spacecraft (MMS) to determine the most-likely parameters for the kinetic equilibrium solutions and use this as a basis for further theory, simulation, and observations. In particular, these kinetic equilibria are used to study the generation of waves through linear theory, and nonlinear particle-in-cell simulation. In the linear theory, we find the possibility of driving waves near the lower-hybrid frequency over a large bandwidth where the free energy comes from the inhomogeneous electric field and not the density gradient as in the lower-hybrid drift instability. These predicted linear waves agree with the frequency of waves seen in satellite observations. In the particle-in-cell simulations, we see the generation of the waves predicted by linear theory, the production of long-lived vortices in the nonlinear state, and the tendency for the density profile to be maintained even in the presence of this turbulence. Finally, we point out that in certain regimes the new equilibrium is a generalization of the Harris equilibrium with perpendicular sheared flows and we study the unstable eigenmodes of the equilibrium related to thin current sheets with sharp gradients. We discuss the implications of these new sources of free energy on magnetic reconnection and the formation of dipolarization fronts.

References

[1] Ganguli, G., Crabtree, C., Fletcher, A.C. *et al*. Kinetic Equilibrium of Dipolarization Fronts. *Sci Rep* **8,** 17186 (2018). https://doi.org/10.1038/s41598-018-35349-9

[2] Fletcher, A. C., Crabtree, C., Ganguli, G., Malaspina, D., Tejero, E., & Chu, X. (2019). Kinetic equilibrium and stability analysis of dipolarization fronts. *Journal of Geophysical Research: Space Physics*, 124, 2010– 2028. https://doi.org/10.1029/2018JA026433

[3] Ganguli, G., Lee, Y. C., & Palmadesso, P. J. (1988a). Electron–ion hybrid mode due to transverse velocity shear. *Physics of Fluids*, **31**(10), 2753–2756.