Evolution of current sheets under external influences and the role of electrostatic fields in self-organization

G. Lapenta (INFM, Italy and LANL), W. Wan (LANL)

Current sheet formation and intensification can be studied by compressing an initially uniform or weakly stratified plasma. Recently a collaborative effort has led to the so-called Newton challenge [1], a study of the effects of a small and localized perturbation applied at the boundary of a 2D simulation box. The perturbation is first slowly turned on and eventually slowly turned off. Current sheet intensification is produced by this gentle push, eventually leading to reconnection in the sheet.

We revisit the gentle push approach, trying also stronger and more sudden pushes leading to shock compression. We investigate the relationship between the properties and evolution of the intensified current sheet with the type of boundary perturbation and particularly its temporal variation. The importance of the study is that of course, in reality, the perturbation is self-consistently created by the overall Sun-Earth system itself, often with temporally and spatially localized events (e.g. FTE).

We report a number of simulations conducted with kinetic and fluid codes documenting the evolution of different properties of the forming current sheet. While the same final thickness can be obtained in different ways, the path followed to reach a certain thickness and the key properties of the sheet formed depend strongly on the push.

An unsuspected agent is emerging as a key player in a number of processes relevant to space, solar and astrophysical systems: electrostatic fields. We focus here on two processes that are present both in space and laboratory plasmas.

First, we consider the formation and properties of current sheets. Current sheets are key enablers for large scale system evolution: often large scale processes lead to the formation of thin sheets where small scale processes couple with larger scales. Our recent work proposes that small scales instabilities can produce electrostatic fields on large scales with profound effects on the evolution of the system where the sheet is present. In particular, their effect can lead to the onset of reconnection.

Second, a recent discovery suggests that electrostatic fields can affect the evolution of confined plasmas in laboratory experiments [2] suggesting that electrostatic fields can be a major player in magnetic dynamo processes. Our work suggests that similar processes can be also at play in space and astrophysical plasmas. We report a number of simulations that put forward a new possibility: that electrostatic fields can be a major player in processes where magnetic field energy is created (dynamo) or destroyed (reconnection).

[1] J. Birn et al., Geophys. Res. Lett., 32, L06105, 2005.
[2] W. Daughton, G. Lapenta, P. Ricci, *Phys. Rev. Lett.*, **93**, 105004, 2004
[3] D. Bonfiglio, S. Cappello, D. F. Escande, *Phys. Rev. Lett.*, **94**, 145001, 2005.