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Secondary reconnection, energisation and turbulence in dipolarisation fronts: results of a 3D kinetic simulation campaign

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Dipolarization fronts (DF) are formed by reconnection outflows interacting with the pre-existing environment. These regions are host of important energy exchanges [1], particle acceleration [2] and a complex structure and evolution [3]. Our recent work has investigated these regions via fully kinetic 3D simulations [4].
As reported recently on Nature Physics [3], based on 3D fully kinetic simulations started with a well defined x-line, we observe that in the DF reconnection transitions towards a more chaotic regime. In the fronts an instability develops caused by the local gradients of the density and by the unfavourable acceleration and field line curvature. The consequence is the break up of the fronts in a fashion similar to the classical fluid Rayleigh-Taylor instability with the formation of “fingers” of plasma and embedded magnetic fields. These fingers interact and produce secondary reconnection sites.
We present several different diagnostics that prove the existence of these secondary reconnection sites. Each site is surrounded by its own electron diffusion region.
At the fronts the ions are generally not magnetized and considerable ion slippage is present. The discovery we present is that electrons are also slipping, forming localized diffusion regions near secondary reconnection sites [1].
The consequence of this discovery is twofold. First, the instability in the fronts has strong energetic implications. We observe that the energy transfer locally is very strong, an order of magnitude stronger than in the “X” line. However, this energy transfer is of both signs as it is natural for a wavy rippling with regions of magnetic to kinetic and regions of kinetic to magnetic energy conversion.
Second, and most important for this session, is that MMS should not limit the search for electron diffusion regions to the location marked with X in all reconnection cartoons. Our simulations predict more numerous and perhaps more easily measurable electron diffusion regions in the fronts.
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[4] Lapenta, Giovanni, et al. "Secondary reconnection sites in reconnection-generated flux ropes and reconnection fronts." Nature Physics 11.8 (2015): 690-695.