Test-electron analysis of magnetic reconnection topology

D. Borgogno[1], A. Perona[1], and D. Grasso[1,2]

[1]*Politecnico di Torno, C.so Duca degli Abruzzi 24, 1024, Torino, Italy*
[2]*Istituto dei Sistemi Complessi - CNR, Via dei Taurini 19, 00185, Roma, Italy*

Three-dimensional (3D) investigations of the magnetic reconnection field topology in space and laboratory plasmas have identified the abidance of magnetic coherent structures in the stochastic region that develop during the nonlinear stage of the reconnection process [1-4]. Further analytical and numerical analyses highlighted the efficacy of some of these structures in limiting the magnetic transport [5-6]. The question then arises as to what is the possible role played by these patterns in the dynamics of the plasma particles populating the chaotic region. In order to explore this aspect, we provide a detailed description of the nonlinear 3D magnetic field topology in a collisionless magnetic reconnection event with a strong guide field [7]. In parallel, we study the evolution of a population of test electrons in the guiding-center approximation all along the reconnection process [8]. In particular, we focus on the nonlinear spatial redistribution of the initially thermal electrons and show how the electrons dynamics in the stochastic region depends on the sign and on the value of their velocities. While the particles with the highest positive speed populate the coherent current structures that survive in the chaotic sea, the presence of the manifolds calculated in the stochastic region define the confinement area for the electrons with the largest negative velocity. These results stress the link between the magnetic topology and the electron motion and contribute to the overall picture of a non-stationary fluid magnetic reconnection description in a realistic geometry.

References

[1] D. Borgogno, D. Grasso, F. Porcelli, F. Califano, F. Pegoraro and D. Farina, Phys. Plasmas 12, 032309 (2005)
[2] D. Borgogno, D. Grasso, F. Pegoraro, T. J. Schep, Phys. Plasmas 18, 102307 (2011)
[3] D. Borgogno, D. Grasso, F. Pegoraro, T. J. Schep, Phys.Plasmas 18, 102308 (2011)
[4] D. Borgogno, F. Califano, M. Faganello, F.Pegoraro, Phys. Plasmas, 22, 032301 (2015)
[5] G. Rubino, D. Borgogno, M.Veranda, D.Bonfiglio, S. Cappello, D. Grasso, Plasma Physics and Controlled Fusion 57, 085004 (2015)
[6] M. Veranda et al., Nuclear Fusion 57, 116029 (2017)
[7] T. J. Schep, F. Pegoraro, B. N. Kuvshinov, Phys. Plasmas 1, 2843 (1994)
[8] A. Perona, D. Borgogno, L.-G. Eriksson, Comput. Phys. Commun. 185, 86 (2014)