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Study of Magnetic Reconnection in Plasma: how it works and energizes plasma particles

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Magnetic reconnection is a phenomenon of nature in which magnetic field lines change their topology in plasma and convert magnetic energy to plasma particles by acceleration and heating. It is a fundamental process at work in laboratory, space and astrophysical plasmas. Magnetic reconnection occurs throughout the Universe: in star forming galaxies; around supernovae; in solar flares; in the earth's magnetosphere; and in fusion plasmas. One of the great challenges in reconnection research has been to understand why reconnection occurs so much faster than predicted by MHD theory. This talk begins with a review of recent discoveries and findings in the research of fast magnetic reconnection in laboratory plasmas and space astrophysical plasmas [1]. I compare the experimental results and space observations with theory and numerical simulations. The collaboration between space and laboratory scientists in reconnection research has reached a point where we can directly compare measurements of the reconnection layer using recently-advanced numerical simulations. In spite of the huge difference in physical scales, we find remarkable commonality between the characteristics of the magnetic reconnection in laboratory and space-astrophysical plasmas. In this talk, I will focus especially on the energy flow, a key feature of reconnection process. We have recently reported our results on the energy conversion and partitioning in a laboratory reconnection layer [2]. In Magnetic Reconnection Experiment (MRX) the mechanisms of ion acceleration and heating are identified [1] and a systematic study of the quantitative inventory of converted energy within a reconnection layer has been made with a well-defined but variable boundary. The measured energy partition in a reconnection region of similar effective size ($L \sim 3$ ion skin depth) of the Earth's magneto-tail [3] is remarkably consistent with the laboratory results. A more comprehensive study is proposed using MMS satellites very recently put into the magnetosphere orbits [4]. Finally I discuss our future plans to investigate reconnection dynamics beyond the proto-typical reconnection geometry explored so far, focusing on the just discovered, highly dynamic reconnection regimes of large systems [5], such as those found in most space and astrophysical environments.

[1] M. Yamada, R. Kulsrud, and H. Ji, Rev. Mod. Phy. 82, 603 (2010).
[2] M. Yamada et al., Nature Communications. 5, 4474 (2014)
[3] J. Eastwood et al., Phys. Rev. Lett. 110, 225001 (2013)
[4] J. Burch et al, This conference
[5] H. Ji et al, This conference