Laboratory Studies of Magnetic Reconnection

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Abstract

Magnetic reconnection, the efficient release of magnetic energy by topological rearrangement of field lines, is one of the most important and fundamental plasma processes in space, solar and more distant astrophysical plasmas. It plays key roles in a wide range of phenomena including solar flares, coronal mass ejections, solar wind propagation and dissipation, interaction of interplanetary plasma with Earth and other planets magnetosphere, star formation, and explosive phenomena from strongly magnetized neutron stars. Despite the long history of magnetic reconnection research, the most important progress has been achieved only recently. Much of this progress was accomplished with valuable contributions from dedicated laboratory experiments, which have become increasingly well-controlled and well-diagnosed. This talk highlights a few examples such as quantitative tests of the classical Sweet-Parker model, two-fluid effects for fast reconnection, first detections of the electron diffusion region, and impulsive reconnection via local 3D flux rope dynamics. Looking into the future, a new theme of magnetic reconnection with multiple X-lines is emerging to possibly provide solutions for fast reconnection in large systems and for efficient particle acceleration as suggested by recent numerical and theoretical studies. Scientific opportunities for a next generation laboratory experiment to study magnetic reconnection in such regimes directly relevant to space and astrophysical plasmas will be described.