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Plasmoid dynamics in 3D resistive MHD simulations of magnetic reconnection

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Magnetic reconnection is a well known plasma process believed to lie at the heart of a variety of phenomena such as sub-storms in the Earth's magnetosphere, solar/stellar and accretion-disk flares, sawteeth activity in fusion devices, etc. During reconnection, the global magnetic field topology changes rapidly, leading to the violent release of magnetic energy. Over the past few years, the basic understanding of this fundamental process has undergone profound changes. The validity of the most basic, and widely accepted, reconnection paradigm – the famous Sweet-Parker (SP) model, which predicts that, in MHD, reconnection is extremely slow, its rate scaling as $S^{-1/2}$, where S is the Lundquist number of the system – has been called into question as it was analytically demonstrated that, for $S \gg 1$, SP-like current sheets are violently unstable to the formation of a large number of secondary islands, or plasmoids. Subsequent numerical simulations in 2D have confirmed the validity of the linear theory, and shown that plasmoids quickly grow to become wider than the thickness of the original SP current sheet, thus effectively changing the underlying reconnection geometry. Ensuing numerical work has revealed that the process of plasmoid formation, coalescence and ejection from the sheet drastically modifies the steady state picture assumed by Sweet and Parker, and leads to the unexpected result that MHD reconnection is independent of S. In this talk, we review these recent developments and present results from three-dimensional simulations of high-Lundquist number reconnection in the presence of a guide field. A parametric study varying the strength of the guide field is presented. Plasmoid flux and width distribution functions are quantified and compared with corresponding two dimensional simulations.