Abstract Submitted
for the APR12 Meeting of
The American Physical Society

Spreading of Magnetic Reconnection X-lines in Three Dimensions

PAUL CASSAK, LUCAS SHEPHERD, West Virginia University — Naturally occurring magnetic reconnection often begins in a spatially localized region and spreads in the out-of-plane direction in time. A number of authors have studied this problem for magnetotail applications such as substorms and bursty bulk flows, for which the out-of-plane (guide) field is typically small. However, spreading also occurs in laboratory experiments and two-ribbon solar flares (such as the Bastille Day flare), and is inferred to occur at the dayside magnetopause. The reconnection site in each of these settings is known or thought to have a significant guide field. With no guide field, it was shown that the reconnection spreading is controlled by the species that carries the current. However, laboratory experiments with a large guide field (Katz et al., Phys. Rev. Lett., 104, 255004, 2010) revealed that spreading takes place in both directions at the Alfven speed based on the guide field. This implies a qualitative change of behavior as the guide field varies. We present a scaling argument for the condition on the guide field at which the nature of the spreading switches from being caused by current carriers to Alfven waves. Further, we show results of three-dimensional two-fluid simulations that agree with the theory. We discuss applications to observations.

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Date submitted: 06 Jan 2012 Electronic form version 1.4