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A Generalized Flux Function for Three-dimensional Magnetic Reconnection

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The definition and measurement of magnetic reconnection in three-dimensional magnetic fields with multiple reconnection sites is a challenging problem, particularly in fields lacking null points. We propose a generalization of the familiar two-dimensional concept of a magnetic flux function to the case of a three-dimensional field connecting two planar boundaries. Using hyperbolic fixed points of the field line mapping, and their global stable and unstable manifolds, we define a unique flux partition of the magnetic field. This partition is more complicated than the corresponding (well-known) construction in a two-dimensional field, owing to the possibility of heteroclinic points and chaotic magnetic regions. Nevertheless, we show how the partition reconnection rate is readily measured with the generalized flux function. We relate our partition reconnection rate to the common definition of three-dimensional reconnection in terms of integrated parallel electric field. An analytical example demonstrates the theory, and shows how the flux partition responds to an isolated reconnection event.

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