Electric signatures of magnetic reconnection

Karl Schindler

Abstract

This talk addresses kinematic concepts of the role of electric fields in magnetic reconnection, as they have developed since the early days of this field.
In the two-dimensional foundation models of reconnection, such as Petschek's model, the characteristic electric field property is an electric field along the magnetic neutral line, supported by a localized deviation from ideal MHD. In cases with a superimposed magnetic field component in the invariant direction (guide field) the *separator*, the intersection line of the magnetic separatrix surfaces, has taken the role of the neutral line. Since for a nonvanishing guide field the separator is a magnetic field line, the electric signature then is an electric field component ($E_{||}$) in the direction of the magnetic field. A similar concept applies to configurations with magnetic nulls.
In the late 1980s it was realized that in some three-dimensional cases involving the formation of flux ropes, such as magnetotail reconnection with nonvanishing magnetic field strength B, a global separator is not necessarily available as a structurally stable object. This called for a more general concept and led to the choice of breakdown of magnetic line conservation as the appropriate characteristic property. In a corresponding approach the electric signature, again, is based on $E_{||}$. The central quantity is the generalized potential U obtained by integrating $-E_{||}$ along magnetic field lines. The system is not required to be in a steady state. The reconnection rate can be expressed by the extreme values of U.
Several examples indicate that these kinematic considerations can provide a useful background for building quantitative reconnection models and for interpreting observations and numerical simulations. Particularly, this applies to investigations focused on the role of the electric field.