Magnetic reconnection in solar flares and pulsar magnetospheres

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Abstract

In this lecture, I review early ideas on magnetic reconnection, and discuss the present-day status of the application of reconnection to astrophysical and space plasmas.
The need for magnetic reconnection at magnetic nulls was first recognized in connection with solar flares in the 1940s and 1950s. By the 1960s this had led to models involving X-type neutral points for flares, and also for the Earth's magnetosphere. The related concept of tearing modes was developed in connection with laboratory plasmas around the same time. These early models assumed two-dimensional magnetic nulls and it was not until the 1990s that the generalization to three-dimensional nulls and to reconnection in the absence of a null were explored.
I discuss the present-day status of the application of reconnection to solar flares, emphasizing the enormous mismatch between the scales relevant to existing reconnection models and the scales relevant to flares. Some form of turbulent reconnection, or related concept, is needed to bridge this gap. I also explain why three-dimensional models for reconnection that include pre-existing currents are essential. A global model for a flare requires both null-point and non-null-point reconnection in widely separated locations. Although non-null-point reconnection is usually ignored in flares, I explain why it has been an ingredient in models for pulsar electrodynamics since the 1970s.