

Fast Astrophysical Reconnection with Anomalous Resistivity and Petschek Shocks

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In astrophysical situations, the normal magnetic reconnection rate, even with anomalous resistivity, is woefully slow often longer than the Hubble time. In order to develop a reconnection model that is fast enough to be interesting one needs the slow shocks proposed by Petschek to enhance the parallel flow of plasma out of the reconnection layer.

It has been shown that with constant resistivity these shocks cannot be sustained, but are themselves unstable to being swept out of the reconnection layer. With a mild resistive inhomogeneity, these shocks can be made stable, but only lead to a mild enhancement of the reconnection rate. However, the anomalous resistivity produced by microinstabilities is very sensitive to current density. Under certain conditions this extreme sensitivity can lead to a great enhancement in the inhomogeneity of the resistivity, and, thus, a large enhancement of the reconnection rate by means of the Petschek shocks. The reconnection rate is different from that first proposed by Petschek. It involves the inverse cube root of a very large effective anomalous resistivity rather than the logarithm of the Spitzer resistivity. It is fast enough to be of astrophysical interest.

This fast reconnection does not always occur. It depends on the parameter $\xi = \delta_{SP}/\delta_s$ where δ_{SP} is the ordinary Sweet Parker reconnection layer thickness and $\delta_s = c/\omega_{pi}$ is the ion skin depth. When $\xi > 1$ ordinary Sweet Parker reconnection occurs, while when ξ is less than about one third one gets very fast reconnection. The ideas behind this will be presented and astrophysical examples will be given. An example of a microinstability that is strong enough to produce the above results will also be presented.