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Spontaneous Development of Current Sheets in Two and Three Dimensional MHD

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Enhanced rates of plasma heating and magnetic reconnection in the solar corona can be explained in terms of the spontaneous development of current sheets. One example of how such structures could spontaneously occur is offered by the coalescence instability in two dimensions. We review the basic physics of this ideal MHD instability whereby magnetic islands (flux tubes) containing currents of the same sign are attracted to one another. Using an initial magnetic equilibrium geometry different from that of the conventional coalescence model, we are able to show, by numerical simulation, that the nonlinear evolution of this system is toward a neighboring force-free equilibrium with lower magnetic energy.

In a purely ideal case this neighboring equilibrium has a genuine current sheet in the sense that the tangential component of the magnetic field is discontinuous. Such an equilibrium can be exhibited semi-analytically. The current sheet extends between two Y-points to replace what had been a single X-point in the initial, continuous equilibrium.

In a three dimensional coronal geometry line-tying of the flux tube at its ends has a stabilizing effect. This effect diminishes in longer flux tubes and beyond some critical length the equilibrium is unstable to a three dimensional analog of coalescence. Time dependent numerical simulations show the form of this instability and its nonlinear evolution in both ideal and resistive cases. As in two dimensions the nonlinear phase is characterized by the development of narrow regions of intense current at which resistive reconnection occurs. These are indicative of current sheets and their form is significantly affected by the line tying constraint. This demonstrates a scenario for localized magnetic reconnection in three dimensions in the absence of a magnetic null.

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Coronal Current Sheet Formation: 3D Simulations

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The magnetic field configurations present in an active region are often complex, having several polarity reversals and even areas of opposite polarity embedded within the opposite polarity. MHD modeling of the coronal often ignores this complexity, treating the corona as a uniform field or an idealized magnetic loop. We present the first results from our 3D MHD code, in which we model more realistic magnetic

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