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Three-Dimensional Simulations of Sheared Current Sheets: Transition to Non-linear Regimes

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Systems of multiple current sheets arise in various situations in natural plasmas, such as at the heliospheric current sheet in the solar wind and in the heliosheath. Three-dimensional simulations have shown that such systems can develop turbulent-like fluctuations resulting from forward and inverse energy cascade. We study the transition to turbulence of such multiple current sheet systems, including the effects of adding a magnetic guide field and velocity shears across the current sheets. Three-dimensional hybrid simulations are performed of systems with eight narrow current sheets in a periodic geometry. We carry out a number of different analyses of the evolution of the fluctuations as the initially highly ordered state relaxes to one which resembles turbulence. Despite the evidence of forward and inverse cascade in the fluctuation power spectra, we find that none of the simulated cases have evidence of intermittency after the initial period of fast reconnection associated with the ion tearing instability at the current sheets. Cancellation analysis confirms that the simulations have not evolved to a state which can be identified as fully developed turbulence. The addition of velocity shears across the current sheets slows the evolution in the properties of the fluctuations, but by the end of the simulation they are broadly similar. However, if the simulation is constrained to be two-dimensional, differences are found, indicating that fully three-dimensional simulations are important when studying the evolution of an ordered equilibrium towards a turbulent-like state.