Consequences of the Breakout Model for Particle Acceleration in CMEs and Flares

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The largest and most efficient particle accelerators in the solar system are the giant events consisting of a fast coronal mass ejection (CME) and an intense X-class solar flare. Both flares and CMEs can produce 10^{32} ergs or more in nonthermal particles. Two general processes are believed to be responsible: particle acceleration at the strong shock ahead of the CME, and reconnection-driven acceleration in the flare current sheet. Although shock acceleration is relatively well understood, the mechanism by which flare reconnection produces nonthermal particles is still an issue of great debate. We address the question of CME/flare particle acceleration in the context of the breakout model using 2.5D MHD simulations with adaptive mesh refinement (AMR). The AMR capability allows us to achieve ultra-high numerical resolution and, thereby, determine the detailed structure and dynamics of the flare reconnection region. Furthermore, we employ newly developed numerical analysis tools for identifying and characterizing magnetic nulls, so that we can quantify accurately the number and location of magnetic islands during reconnection. Our calculations show that flare reconnection is dominated by the formation of magnetic islands. In agreement with many other studies, we find that the number of islands scales with the effective Lundquist number. This result supports the recent work by Drake and co-workers that postulates particle acceleration by magnetic islands. On the other hand, our calculations also show that the flare reconnection region is populated by numerous shocks and other indicators of strong turbulence, which can also accelerate particles. We discuss the implications of our calculations for the flare particle acceleration mechanism and for observational tests of the models.

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