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The 3D Dynamics of Solar Flare Magnetic Reconnection

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Solar eruptive events (SEE) consisting of a massive filament eruption, intense X-class flare, and a fast CME are the most powerful manifestations of explosive energy release in our solar system and the primary drivers of highly destructive space weather at Earth and in interplanetary space. These giant events, which have global scale of solar radii, allow us to study in great detail fundamental space plasma processes such as magnetic reconnection that are important to many cosmic phenomena. Both 2.5D and 3D numerical simulations have shown that the fast energy release is due to reconnection in a large-scale current sheet that forms in the corona, but the 3D dynamics of the reconnection are far from understood. The greatest challenge to understanding SEEs is their extreme rate of energy release, and for some events, the amazing efficiency at converting magnetic energy into high-energy particle energy. We present new ultra-high-resolution 3D simulations of flare reconnection using the adaptive-mesh-refinement code ARMS. We find that the reconnection dynamics are dominated by 3D magnetic islands, and show that the islands should have clear observational signatures, especially in the so-called flare ribbons that are commonly observed in the chromosphere. We discuss the central role of the islands for understanding the multiscale coupling at the heart of reconnection, the fast energy release rate, and the high efficiency of particle acceleration.

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