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Temporal Evolution of the Guide Field in Eruptive Flares

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Solar flares are explosive space weather events that rapidly convert stored magnetic energy into bulk motion, plasma heating, and particle acceleration via magnetic reconnection. For eruptive flares, the free energy source is ultimately the highly sheared magnetic field of a filament channel above a polarity inversion line. During the flare, the shear field becomes the reconnection guide field, the strength of which has recently been demonstrated via kglobal hybrid-MHD modeling to control the efficiency of reconnection-driven particle acceleration. We present new high-resolution 3D MHD simulations that demonstrate the critical role of the magnetic shear/guide field throughout an eruptive flare. The magnetic shear evolves in three distinct phases: shear first builds up in a narrow region about the PIL, expands outward to drive the formation of a thin current sheet, and is finally transferred by the flare reconnection into sheared post-flare loops and erupting flux rope. We show that the guide field weakens more than an order of magnitude over the course of the flare, and instantaneously varies over a similar range along the three-dimensional current sheet. We demonstrate how the guide field may be inferred from observations of sheared post-flare loops. Interestingly, we find that the number of plasmoids increases with weakening guide field, underscoring the important role of the guide field in particle acceleration. We discuss implications for observations by IRIS, SDO/AIA, and DKIST. This work was supported in part by the SolFER DRIVE center.

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