SLIP-RUNNING RECONNECTION AND EVOLUTION OF SHEAR IN POST-FLARE LOOPS

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We analyze the physical mechanisms of an eruptive flare via 3D magnetohydrodynamic simulations of a flux rope. We focus on the relaxation process associated with the reconnection of magnetic field lines driven by the free expansion of the magnetic field.

First, the origin of the shearing of post-flare magnetic loops is investigated in relation to the pre-flare geometry of the magnetic field. Indeed, space-borne satellites can observe the temporal changes of post-flare structures that are important observational manifestations of the solar flare phenomenon. As such, understanding the evolution of post-flare loops can reveal the characteristics of the pre-flare magnetic field. Here, we introduce different proxies to quantify the shear angle. We show that strong geometrical similarities exist between the initial magnetic field and the post-flare loops. Analysis of the eruption dynamics shows that magnetic reconnection at the origin of the post-flare field lines forms less and less sheared magnetic loops on top of one another. We confirm this tendency by direct measurements of the shear angle seen in flare events such as that of May 9, 2011 recorded by STEREO-B/EUVI. Our results also highlight that vertical stretching of the magnetic field lines may play a role in the shear angle evolution of post-flare loops.

The analysis of the eruptive flare evolution is followed by a detailed investigation of the flux rope growth and of the post-flare loops formation due to coronal slip-running reconnection. For that, we study the dynamics of different regions around two ribbons of opposite current. We find that these ribbons correspond to quasi-separatrix layers (QSLs), associated with J-shaped pre-flare magnetic field lines, reconnected S-shaped flux rope lines and post-flare loops. Simulations with very small time steps are required so as to show the detailed time evolution of those QSLs as well as the time variations of the slip-running velocities. Our results provide
a fully 3D extension of the standard 2D flare model.