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SOLAR TRANSIENT ACTIVITY: MAGNETIC ENERGY RELEASE AND TOPOLOGY

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We will discuss how the computation and analysis of the coronal magnetic field topology can be used to identify the energy release locations and their physical characteristics.

The energy released during transient atmospheric events in the Sun is contained in current-carrying magnetic fields that have emerged after traversing the solar convective zone. Magnetic field reconnection is thought to be the mechanism through which the stored magnetic energy is transformed into the kinetic energy of accelerated particles and mass flows, and radiative energy along the whole electromagnetic spectrum. Though this mechanism is efficient only at very small spatial scales, it may imply a large-scale restructuring of the magnetic field, which is inferred from the combined analysis of observations, models of the coronal magnetic field, and computation of its topology. From a theoretical point of view, magnetic configurations with a complex topology, i.e. having separatrices, are the ones where current sheets can form. In 3 dimensions (3D) a complete topological description is given by the skeleton formed by null points, spines, fans and separators, and associated separatrices (Longcope 2006, and examples therein discussed). Separatrices of a different origin are linked to the field lines curved up at the photospheric inversion line, defining bald-patch locations (Titov et al. 1993). For some observed configurations, those topological structures are enough to understand where flare brightenings appear as a result of reconnection. Coronal null points have been found associated with numerous flares (see e.g. Mandrini et al. 2014, and references therein), while bald patches have appeared in connection with lower energy release events (see Pariat et al. 2004, and references therein). However, flares can occur in a much larger variety of configurations (see e.g. Mandrini et al. 1997). Quasi-separatrix layers (QSLs) (Démoulin et al. 1996; Titov et al. 2002), which are regions where the field-line linkage changes drastically, generalize the concept of separatrices to magnetic configurations without null points and/or bald patches. Using coronal magnetic field models, QSLs have been computed in the largest variety of observed configurations (see e.g. Démoulin et al. 1997; Mandrini et al. 2014, and references therein). QSLs have been found located in coincidence with chromospheric and coronal loop brightenings of varied intensity; these could be connected by field lines in the way expected by magnetic reconnection theory. In order to find the relation between QSLs, the formation of strong current concentrations, and study the characteristics of the reconnection process, 3D MHD simulations using typical field distributions and photospheric motions have been developed by Aulanier et al. (2005, 2006). The results from these simulations show that intense electric currents develop at QSLs and that the reconnection process implies the continuous slippage of field lines along each other as they pass through QSLs. Furthermore, it was recently suggested by the results of Mandrini et al. (2014) that, because QSLs are determined by the photospheric field distribution, if the topology is known it can be used to predict the places where flare brightenings will be located.

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