MAGNETOHYDRODYNAMIC SIMULATION OF THE X9.3 FLARE ON 2017 SEPTEMBER 6: EVOLVING MAGNETIC TOPOLOGY

Chaowei Jiang\(^{1,2}\), Peng Zou\(^1\), Xueshang Feng\(^2\)

\(^1\)Institute of Space Science and Applied Technology, Harbin Institute of Technology, Shenzhen 518055, China
\(^2\)SIGMA Weather Group, State Key Laboratory for Space Weather, National Space Science Center, Chinese Academy of Sciences, Beijing 100190, China

Three-dimensional magnetic topology is crucial to understanding the explosive release of magnetic energy in the corona during solar flares. Much attention has been given to the pre-flare magnetic topology to identify candidate sites of magnetic reconnection, yet it is unclear how the magnetic reconnection and its attendant topological changes shape the eruptive structure and how the topology evolves during the eruption. Here we employed a realistic, data-constrained magnetohydrodynamic simulation to study the evolving magnetic topology for an X9.3 eruptive flare that occurred on 2017 September 6. The simulation successfully reproduces the eruptive features and processes in unprecedented detail. The numerical results reveal that the pre-flare corona contains multiple twisted flux systems with different connections, and during the eruption these twisted fluxes form a coherent flux rope through tether-cutting-like magnetic reconnection below the rope. Topological analysis shows that the rising flux rope is wrapped by a quasi-separatrix layer, which intersects itself below the rope, forming a topological structure known as a hyperbolic flux tube, where a current sheet develops, triggering the reconnection. By mapping footpoints of the newly reconnected field lines, we are able to reproduce both the spatial location and, for the first time, the temporal separation of the observed flare ribbons, as well as the dynamic boundary of the flux rope’s feet. Furthermore, the temporal profile of the total reconnection flux is comparable to the soft X-ray light curve. Such a sophisticated characterization of the evolving magnetic topology provides important insight into the eventual understanding and forecasting of solar eruptions.