Magnetohydrodynamic Modeling of a Solar Eruptive Flux Tube

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Solar eruptions, which often accompany solar flares, are powerful phenomena observed in the solar corona and key drivers of the coronal mass ejections (CMEs). As CMEs transport coronal magnetic fields and vast quantities of plasma, causing great disturbances in the electromagnetic environment of the Geospace, the understanding of their initiation and dynamics is essential to further improve space weather forecasting. Although flux tubes, which are composed of helical magnetic twisted lines, are widely considered to drive the eruption and form the core structure of CMEs, their formation and dynamics, i.e., the flare –CME connection is not yet clear.

In this study, we performed Magnetohydrodynamic (MHD) simulations of a solar eruption based on the observed photospheric magnetic field from which the nonlinear force-free field is extrapolated as the initial state to reconstruct the realistic magnetic environment. Our results show that once the flux tube loses stability or equilibrium, it then exhibits a dramatic eruption even though the eruptive flux tube passes through an area where the flux tube is stable to torus instability. This result suggests that nonlinear processes, which are not suggested from theoretical models, are essential to drive the eruption. In particular, we revealed that a positive feedback process of flux tube evolution and reconnection plays an important role in the formation of the eruptive tube and its extra acceleration. We will present our recent achievements in studying the nonlinear dynamics of solar eruptive flux tubes and discuss futher prospective work.

Keywords: Solar Flares, Coronal Mass Ejections, Magnetohydrodynamics