Magnetohydrodynamic Simulation of an Erupting Magnetic Flux Rope on February 13 2009: Journey to Coronal Mass Ejection

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We performed a magnetohydrodynamic (MHD) simulation of a solar eruption launched from solar active region 11012 on February 13, 2009. We in particular concentrated on the evolution of the magnetic flux rope (MFR) leading a coronal mass ejection. We first extrapolated the pre-eruptive magnetic flux ropes using a flux insertion method, in which the MFRs can be extrapolated from the normal component of the magnetic field (Bz) observed by SOHO/MDI and Extreme-Ultra Violet (EUV) images observed by the STEREO satellite. The extrapolated magnetic field reproduced the sigmoidal magnetic structure observed in EUV image well. Next we performed the MHD simulation using the extrapolated magnetic field.

The resulting simulation showed the dramatic eruption of the magnetic flux rope under which the current sheet and the post-flare loops are formed. This is well explained by the standard CSHKP flare model. The evolution of the MFR did not show simple dynamics, rather it showed very complicated dynamics through a magnetic reconnection. We found, during the eruption, that the coherent MFR is created through the reconnection of multiple pre-existing MFRs. Magnetic reconnection plays a role in producing the coherent, erupting MFR and supplying further twist into it. Furthermore we found that the footpoints of the erupting MFR moves along or away from the polarity inversion line, as seen in two-ribbon flares. The locations of both the footpoints of the MFR correspond to those of dimming regions observed in EUV images. Since the location and shape of the post-flare loops obtained from the simulation is reproduced in the observations, we can confirm the reliability of our simulation.

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