Magnetic Reconnection and Instability in Solar Eruption

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Abstract

Coronal Mass Ejections (CMEs) are the most energetic eruptions in the solar system and can cause strong geomagnetic storms and other space-weather catastrophic effects when they interact with the geo-space at high speeds ranging from several hundred to even more than three thousand kilometres per second. Therefore, it is important to investigate their acceleration mechanisms in space/solar physics and space-weather studies. It is generally believed that the accumulated magnetic free energy serves as the main energy source for CME accelerations (Forbes 2000), but it remains open regarding how the magnetic energy is released.

Two mechanisms have been proposed (Song et al. 2015 and references therein): one is the resistive magnetic reconnection process and the other is the ideal global magnetohydrodynamic (MHD) magnetic flux rope (MFR) instability. Both mechanisms are supported by observations. For example, good correlations exist between the CME speed (acceleration) and the associated soft X-ray (hard X-ray and microwave) profiles (Zhang et al. 2001; Qiu et al. 2004; Maričić et al. 2007). In addition, studies showed that the extrapolated magnetic flux in the flaring region was comparable with the magnetic flux of the MFR reconstructed from in-situ data (Qiu et al. 2007). These CME-flare association studies, among others, support that the reconnection plays an important role in accelerating CMEs. On the other hand, statistical studies showed that the projected speed in the sky plane and kinetic energy of CMEs only had weak correlations with the peak X-ray fluxes of their associated flares (Yashiro et al. 2002; Vršnak et al. 2005). There also exist some fast front side CMEs without accompanying flares (Song et al. 2013). These observations support that the ideal MHD instability also plays an important role in the CME dynamics. Simulations demonstrate that both mechanisms can make comparable contributions to the CME acceleration (Chen et al. 2007), which is supported by latest observation with a case study (Song et al. 2015).

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