Magnetic reconnection at the leading edge of a solar erupting loop and an ICME

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Abstract

CMEs and coronal loops are related to twisted magnetic flux tubes, which can be either present before the solar filament eruption or is built up by reconnection of a sheared arcade. Flux emergence, dispersion of the external magnetic field, and/or reconnection of field lines above/below the flux rope are mechanisms that can trigger the eruption (Schmieder et al. ASR 51, 1967, 2013). In order to probe the mechanism of reconnection above the flux rope, we report the observation of magnetic reconnection at the leading edge of a coronal loop and an ICME, respectively, using remote and in situ data.
First, we report high spatially-resolved observation of a solar eruptive event on 3 November 2010, emanating from an active region behind the east solar limb.(Zimovets et al., A&A 547, A6, 2012). The relative dynamics of multi-thermal eruptive plasmas and of type-II radio bursts are observed in detail by the AIA instrument of SDO and the Nançay Radioheliograph, respectively. The leading edge (LE) of the eruptive plasmas (T ≈ 1–2 MK) moved upward from the flare region at a speed of v ≈ 900–1400 km s–1. It is found that the low-frequency component (LFC) source of the splitted type-II burst is situated above the high-frequency component (HFC) source ahead of the LE. Our interpretation of the type-II burst band-splitting is that the LFC component is emitted from the upstream region of the shock, whereas the HFC is emitted from the downstream sheath region. The energetic electrons associated with the production of type-II bursts are possibly related to magnetic reconnections and/or other plasma heating and particle acceleration processes at the leading edge of an erupting solar loop (Foullon et al. ApJ 767, 170, 2013).

Second, we report the in situ observation of current sheets, turbulence, and magnetic reconnections at the leading edge of an ICME detected by Cluster upstream of the Earth's bow shock on 21 January 2005 (Chian & Munoz ApJL 733, L34, 2011; EAS 55, 327, 2012). We present the observational evidence of two magnetically reconnected current sheets in the vicinity of a front magnetic cloud boundary layer with the following characteristics: (1) a Kolmogorov power spectrum in the inertial subrange of the magnetic turbulence, (2) the scaling exponent of structure functions of magnetic fluctuations exhibiting multi-fractal scaling predicted by the She–Leveque magnetohydrodynamic model, and (3) bifurcated current sheets with the current density computed by both single- and multi-spacecraft techniques.

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Finally, we discuss the impact of the ICME of 21 January 2005 on geomagnetic activities. A comparison of the time series of magnetic field fluctuations detected by ACE at the L1 point in the solar wind with the data measured by ground magnetometers in Brazil shows a close correlation of the geomagnetic field with the ICME, which is indicative of the solar wind turbulence being a driver of space weather (Miranda et al. IAU Symp. 264, 363, 2011).

Our two findings provide evidence of magnetic reconnections at the leading edge of an erupting coronal loop and an ICME.

Keywords: magnetic reconnection, erupting solar loop, ICME, turbulence, space weather