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Observational Study on Current Sheet of Magnetic Reconnection in Two Solar Eruptions† ⋆

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Abstract The coronal magnetic configuration behind coronal mass ejections (CMEs) can commonly be stretched severely, thus to push the magnetic fields with opposite polarities to approach each other, and to form a current sheet of magnetic reconnection. The current sheet in solar eruptions is not only an important region to convert the magnetic free energy into thermal energy, plasma kinetic energy, and energetic particle beams, but also plays a role to connect CMEs and flares. In the CME events of 2003 January 3 and 2003 November 4, the development of current sheet has been observed in both cases. We have investigated the dynamic features and physical properties of current sheet in the two events, based on the data of LASCO (Large Angle and Spectrometric Coronagraph) and UVCS (Ultraviolet Coronagraph Spectrometer) on board of SOHO (Solar and Heliospheric Observatory), and the H_α data from BBSO (Big Bear Solar Observatory) and YNAO (Yunnan Astronomical Observatory). The existence of ions with a high degree of ionization, such as Fe^{+17} and Si^{+11}, indicates a high temperature up to 3×10^6 ~5×10^6 K in the region of current sheet. A direct measurement shows that the thickness of current sheet varies between 1.3×10^4 and 1.1×10^5 km, which increases first and then decreases with time. Using the CHIANTI code (v.7.1), we have further calculated the average values of electron temperature and corresponding emission measure (EM) respectively to be 3.86×10^6 K and 6.1×10^{24} cm^{-5} in the current sheet of the 2003 January 3 event. We also find that the current sheet twisted forth and back

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quasi-periodically during the eruption event on 2003 November 4 by analyzing the observational data from SOHO/UVCS.

Key words Sun: coronal mass ejections—Sun: current sheet—Sun: emission measure—Sun: UV radiation

1. INTRODUCTION

Coronal mass ejection (CME) is the most violent eruptive phenomenon in the solar atmosphere, which ejects a great amount of plasmas ($10^{14} \sim 10^{16}$ g) into the interplanetary space in a short duration[1]. Besides plasmas, it also carries a great amount of magnetic fluxes ($10^{20} \sim 10^{22}$ Mx) into the interplanetary space. These magnetic fluxes and plasmas are associated with the previous coronal magnetic structures before eruption, which are ejected from the Sun due to the disruption of a part of magnetic structures in the eruptive process. CMEs are commonly associated with the active regions related to prominence eruptions, flares, solar energetic particle (SEP) events and radio bursts[2], it is shown by Cheng et al.[3,4] that the fast CMEs are associated with the super-strong proton events.

It is necessary for triggering CMEs that the equilibrium of coronal magnetic structures is broken, and the magnetic reconnection is necessary for the propagation of CMEs[5−7]. Magnetic reconnection plays an important role in solar eruptive events, and it is a process of magnetic reconfiguration and magnetic energy release due to the local dissipation of magnetic field lines with opposite polarities. In the classical CSHKP flare model[8−11], the magnetic field lines are extremely stretched in the initial stage of eruptions, and forms a current sheet (CS) in the region where the magnetic field lines with opposite polarities approach to each other. By using the 2-D model of magnetic flux ropes, Lin and Forbes[12] studied how the magnetic reconnection driven by a catastrophic process helps the magnetic flux ropes to escape and to form CMEs, and how the motion of magnetic flux ropes reversely affect the magnetic reconnection. In the catastrophic model of Lin and Forbes[12], the most prominent feature is a long CS of magnetic reconnection to connect CMEs with flares. Ciaravella et al.[13] used the spectral data of UVCS (Ultraviolet Coronagraph Spectrometer) on board of SOHO (Solar and Heliospheric Observatory) to analyze the eruptive event on 1998 March 23, and first confirmed observationally the existence of CME/flare CS through the spectral data.

One of the most prominent features of CS followed after CMEs is the smaller thickness in comparison with the large-scale structures around CMEs, as well as the higher temperature of plasmas inside it (see the summary of Ciaravella et al.[14]). A typical observational feature of CS is the narrow region with a high temperature (several millions K), which often appears in the spectrogram or monochromatic image of the high-temperature spectral line of $[Fe_{XVIII}]\lambda 974$ formed at about 6×10^6 K (lg(T/K)=6.8). Generally, this high-temperature region is observed after CMEs swept over the slit of UVCS (Ciaravella and Raymond[15], Lee et al.[16], Schettino et al.[17]), and it can last for several hours even several days (such as