Double Filament Eruption and Associated Ribbon Flare and Halo Coronal Mass Ejection

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Abstract.

We observe and study a double filament eruption and associated ribbon flare and halo coronal mass ejection. The filament eruption occurred 31 August 2012. The eruption was followed by a C8.4 two-ribbon flare and second filament eruption. We explore the kinematics of the events and found velocities in the range of 1–151 km/s and accelerations from 0.9 to 125 km/s^2. The kinematic parameters of the associated CME are also disscused.

Introduction

Prominence/filament eruptions are believed to be one aspect of a more general single eruption that can produce a solar flare and a coronal mass ejection (CME) (e.g. Forbes, 2000; Priest & Forbes, 2002). These three eruptive phenomena may be different manifestations of the same magnetic energy release process in the corona (e.g. Moore et al., 2001; Sterling et al., 2012). Many studies of the relationship between eruptive prominences (EPs), solar flares and CMEs (e.g.Chandra et al., 2010, Dechev et al., 2018) point out to strong relations between Eps, solar flares and CMEs.

In this work we report a rarely observed case of a dual prominence eruption, leading to the solar flare and CME. Our aim was to study time evolution and causal relationships between the observed events in order to analyse in deep the dynamical processes involved in CME initiation and evolution and its impact for space weather and geospace climate.

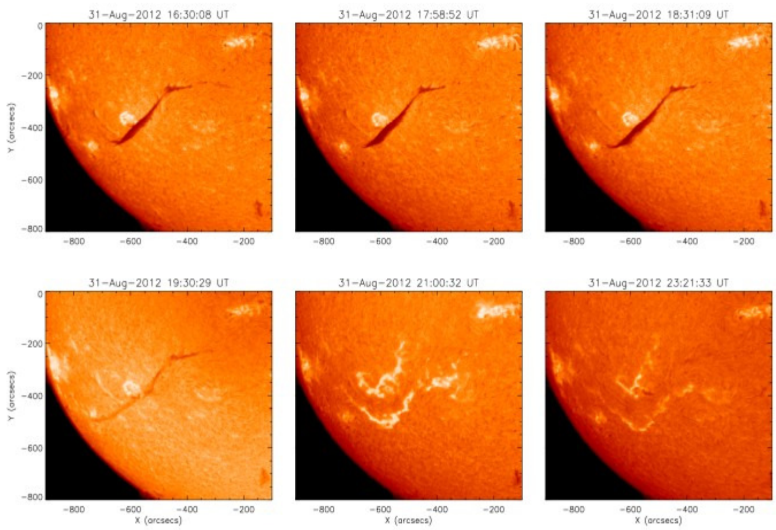


Fig. 1 Evolution of the two-ribbon flare occurred at the base of the erupted filament as seen in KSO Hα images

Observations

A major filament eruption (FE) occurred on 31 August 2012 and was observed in the southeast solar hemisphere close to the solar limb (Figs. 1, 2). During the activation, the filament slowly rose as compact body between 18:00 UT and 19:10 UT. During the eruptive phase, two main flux ropes (FRs) from the filament body erupted consecutively that was well

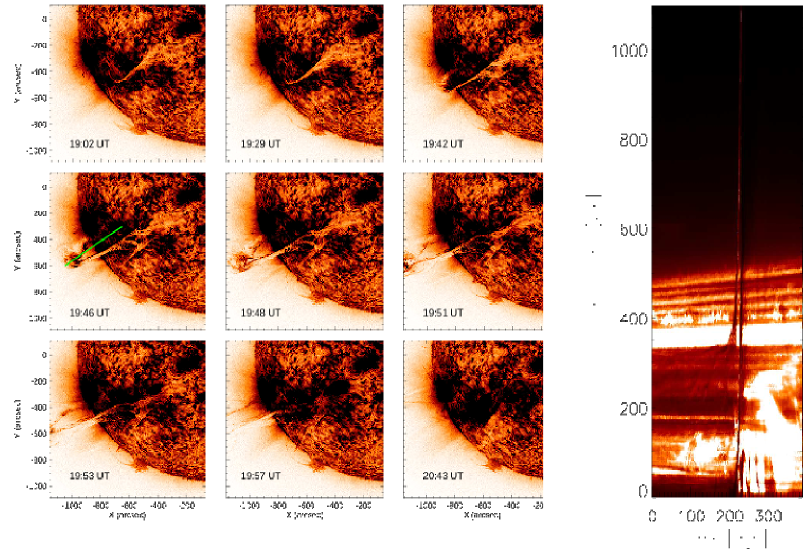
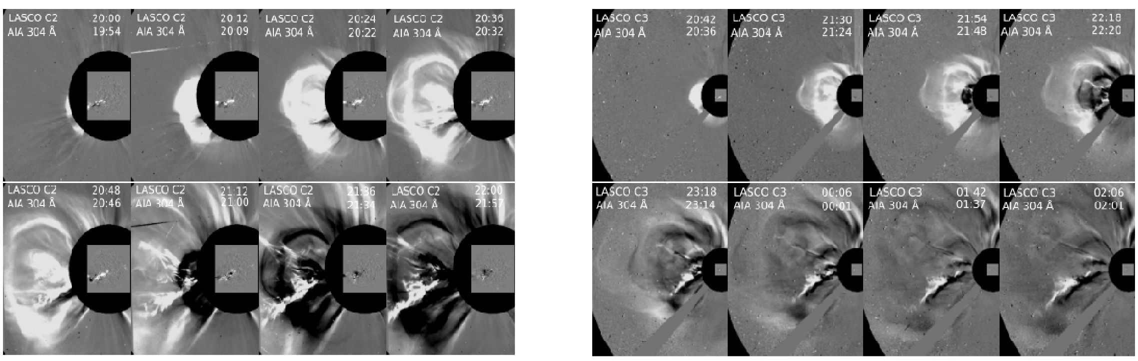


Fig. 2 Evolution of the filament eruption on 2012 Aug 31 in the AIA/SDO 304Å inverted color images (left). The green line shows the slice position. AIA/ 304Å time-distance diagram (right).

observed in the AIA/SDO instrument. First FR eruption started at19:10 UT and after 19:50 UT, when the upper part of FR was out of AIA field-of view, two ribbon flare began to form at the filament feet.

Later, at 20:20 UT, when two ribbons evolved as C8.4 flare, the eruption of second FR started. Double filament eruption was associated with coronal wave, fast halo CME and solar energetic particles (SEP). The kinematic parameters of two FRs were established. We found causal relationships between all events in the following order: first filament FRs eruption - C8.4 ribbon flare - second filament FRs eruption - coronal wave - fast halo CME - SEP event.

The observations of the FE analyzed here are obtained from the Atmospheric Imaging Assembly (AIA) instrument onboard SDO (Lemen, et al. 2012), that provides high cadence (12") and high spatial resolution (0.6 arcsec/pixel) data, allowing to see more details of the filament eruption. The AIA images were processed through a aia_prep routine in IDL SolarSoft data analysis package for SDO AIA. We use data from AIA/SDO 304Å channel to analyze the filament evolution and its kinematics. In order to study the kinematics of the filament eruption, we create a time-slice diagram, showing the eruption evolution in He II 304Å channel.



a b

Fig. 3 Composite image of the white-light SOHO/LASCO-C2 running difference images on 2012 August 31 between 20:00 UT and 22:00 UT and the SDO/AIA 304Å images during the same time interval (a) and composite image of the white-light SOHO/LASCO-C3 running difference images from 2012 August 31 between 20:30 UT and 2012 September 1 02:30 UT and the corresponding AIA/SDO 304Å images (b).

We also use LASCO/SOHO (Brueckner, et al. 1995) C2/C3 data to study the kinematics of associated CME and the FE as a CME bright core. Synoptic Hα observations by the Kanzelhöhe Solar Observatory (KSO) are also included in the study.

Kinematics

The plot the time evolution of the filament height (Fig. 5) reveals two distinct phases of the FE: acceleration phase followed by constant velocity filament raising.

The acceleration phase is well fitted by an exponential function, while for the second phase the best fit is linear function. The regression error for exponential fit is 230±30 Mm and those for linear fit is 376±14 Mm.

We found that during the acceleration phase the velocity increases in the range of 1–151 km/s and the acceleration increases from 0.9 to 125 km/s^{-2}. During the second phase, the filament rise up with constant velocity of 163 km/s.

The filament eruption is associated with a fast halo CME. According to the LASCO CME catalog (https://cdaw.gsfc.nasa.gov/CME_list/), the CME first appearance in the LASCO/C2 field of view was around 20:00 UT. The linear speed of the CME was 1442 km/s. Second order velocity and the acceleration of the CME were 1454 km s−1 and 2 m s−2, respectively.

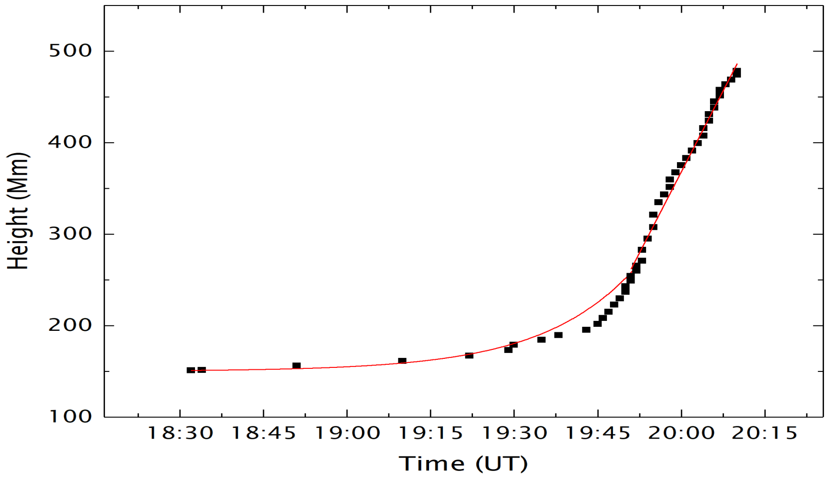


Fig. 4 Height–time plot of the filament leading edge, measured using the SDO/AIA 304Å slice diagram (Fig. 2 right).

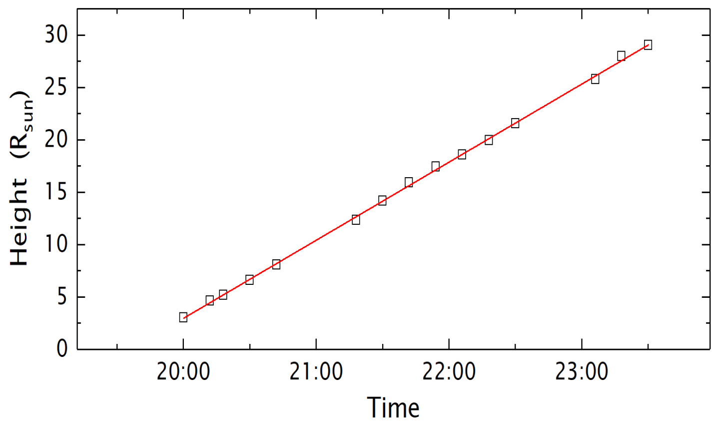


Fig. 5 Height–time plot of the CME, measured in the LASCO C2 and C3 field-of-view (Fig. 3).

Results

The FE showed two distinct eruptive phases: phase with acceleration and constant velocity phase.

- The eruption of the first filament FR triggered two ribbon flare, which acted as a possible trigger for the second filament FR eruption.
- The FE was associated with fast halo CME and it could be traced as a bright CME core up to 20 solar radii in the LASCO C3 field of view.
- The time evolution of all associated events on 31 August 2012 reveals causal relationships between events in the following order: first filament FRs eruption - C8.4 ribbon flare - second filament FRs eruption - coronal wave - fast halo CME - SEP events.

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