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ScienceDirect

Advances in Space Research 55 (2015) 688–695

Advances in Space Research (a COSPAR publication)

www.elsevier.com/locate/asr

Filaments disappearance in relation to coronal mass ejections during the solar cycle 23

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Received 25 November 2013; received in revised form 4 October 2014; accepted 4 November 2014
Available online 22 November 2014

Abstract

We have studied the relationship between filament disappearances with CMEs during solar period 1996–2010. We used the observed disappearing filaments in Hα data from Meudon given in NOAA, and coronal mass ejections data (CMEs) from SOHO/LASCO. We obtained 278 CME events (14%) contemporary filament disappearances and CME ejections (from a total of 2018 filament disappearance events and 15,874 CME events during 1996–2010). We found that the number of associated CME–filament disappearance events increased with the increase of the solar activity and significantly decreased with quiet sun. The longer filament disappearances have activity and ability to contemporary association with CMEs more than shorter filament disappearances. The filament disappearance powers the associated CMEs. CMEs which are associated with filament disappearance are ejected with higher speeds, massive, more energetic, and smaller angular width compared to non-associated CME events. In addition, the associated filament disappearance CMEs have two types depending on their duration; short-lived (<9 h), and long-lived (>9 h).

Keywords: Filament; Filament disappearance; Coronal mass ejection; CME

1. Introduction

Filaments and prominences refer to the same physical structures on the Sun, either projected onto the disk or extended above the solar limb. The majority of the previous statistical studies regarded the connection between filament (or prominence) eruptions and CMEs have focused on prominences because they could easily be detected, observed, and measured against the dark sky background. Many studies show that the disappearances of prominences/filaments are often associated with coronal mass ejections (CMEs) (Webb and Hundhausen, 1987). The Catalogue of Solar Filament Disappearances 1964–1980 (Wright, 1991) offered the most useful data set to investigate whether quiescent filaments (disparition brusques, DBs), However, although the connection between DBs and CMEs is clearly demonstrated in individual cases (e.g. Schmieder et al., 2000), conflicting overall conclusions are obtained for the correspondence between these two phenomena: from a nearly one-to-one (Gilbert et al., 2000) to a poor correlation (Yang and Wang, 2001). During the lifetime of prominences/filaments, incidents may occur that lead to the sudden disappearance of the prominence, a phenomenon also called "disparition brusque" (DB). This sometimes violent event results from

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http://dx.doi.org/10.1016/j.asr.2014.11.002
0273-1177/

instability of the prominence structure, and takes place on a very short time-scale (from a few minutes to several hours). In some cases, it is followed by a reappearance of the prominence at the same location. Many studies show that the disappearances of prominences/filaments are often associated with coronal mass ejections (Pojoga and Huang, 2003). Yang and Wang (2001) compared the data of filament and prominence disappearances which are observed from Big Bear Solar Observatory Hα full disk images observed between January 1997 and June 1999 (431 filament and prominence disappearance events), and CME data from LASCO aboard Solar and Heliospheric Observatory (SOHO), they found that most of filament disappearances seem to have no corresponding CME events. Even for the limb events, only 10–30% (very low) filament disappearances are associated with CMEs.

Yang and Wang (2001) found that there are three possible reasons: (1) they did not make a distinct between the thermal filament disappearance and the filament eruptions. Even for filament eruptions, only the dynamic filament eruptions might cause CMEs (Mouradian et al., 1995). (2) It is possible that some filament disappearances on the disk might be associated with very weak halo CMEs which are difficult to be detected. (3) They recently noticed that some erupting filaments come back to the sun, if they have no continuous acceleration and their speeds are lower than the escaping speed of the gravity of the sun.

Different types of prominence activity that are often referred to as disappearances, and these types may have a different relationship with CMEs. Detailed studies of individual events (Pettit, 1943; Mouradian and Soru-Escaut, 1989; Tonooka et al., 2000) clearly indicate that there are different scenarios that lead to the same result: the disappearance of the prominence or filament. In many cases, the actual eruption of the prominence takes place, while in other situations the prominence vanishes with no portion of it appearing to escape from the Sun.

Few studies that investigate the DB–CME correspondence take into account the specific type of disappearance (often for a limited number of well-observed events), many other broader studies do not consider such differentiation (Yang and Wang, 2000; Pojoga et al., 2003).

Moreover, CMEs, associated with the prominences, are not difficult to detect. Many classifications of prominence have been proposed in the past. Gilbert et al. (2000) developed definitions of active prominences (APs) and eruptive prominences (EPs) and studied the relationship between APs, EPs, and CMEs for 54 events. They found that 94% of the EPs had an association with CMEs compared to only 46% for APs. Gopalswamy et al. (2003) defined a prominence as a radial or a transverse event. They showed that the radial events have a strong correlation to the CMEs, 83% of the radial events were associated with CMEs compared to 24% for transverse events (Jing et al., 2004). Filaments are thin condensed sheets of chromospheric material located in the low corona. They are suspended above neutral lines between two opposite magnetic polarities.

Their temperature and density are two orders of magnitudes smaller and greater than that of the ambient corona respectively. When observed in Hα, they appear as dark ribbons against the chromosphere. When they appear on the limb, they are bright features and are called prominence. Some filaments and prominences end their existence by eruption (Yang and Wang, 2001).

Pojoga and Huang (2003) classified the filament disappearances to three classes: eruptive, quasi-eruptive and vanishing filaments. They Studied the Sudden disappearances of prominences/filaments as identified from the Prairie View Solar Observatory Hα images and Meudon Observatory spectroheliograms for the period January 1, 2000–March 31, 2000. The Hα events were compared with CME data from LASCO C2 and C3 coronagraphs aboard SOHO. Their study shows that the eruptive events are strongly associated with CMEs while the other types are not. The disappearance of filament event of September 26, 1997 was detected by LASCO C2 and EIT. By the end of the next day, this filament disappearance resulted in a halo CME.

From northwest on 2003 February 18, with a LASCO and EIT combined image, a filament with more substantial thickness and length was seen in the northern hemisphere and slightly to the west on February 17 in the BBSO Hα image. The disappearance of this filament the next day accompanied the limb CME at 02:42 (Feynman and Ruzmaikin, 2006).

LASCO coronagraph images can only detect apparent speeds and widths of the CMEs since the images are two-dimensional projections of the white light emission on the plane of the sky (POS). The three dimensional structure and actual speed of CMEs remain unknown due to the projection ambiguity (Xie et al., 2004). some authors prefer to studying the ‘solar mass ejection’ (SME), rather than ‘coronal mass ejection’ (CME), because the origin and evolution of transient events in the solar atmosphere is not yet known from current white-light coronagraph observations and in situ solar wind measurements (Bothmer and Schwenn, 1996).

The Catalogue of Solar Filament Disappearances 1964–1980 (Wright, 1991) offered us the most useful data set to investigate whether quiescent filaments (disparition brusques, DBs) and MCs can be associated and related their magnetic structures (Bothmer, 1993; Rust, 1994). The solar latitude of the filaments was ∼30–60°. Nine of MCs cases identified in Helios and near Earth solar wind data to be uniquely associated with quiescent filament disappearances (DBs) at mid to high solar latitudes outside active regions. In eight of the nine cases was found agreement between the magnetic flux tube structure of the MC and that of the associated filament as inferred from the orientation of the filament axis and its magnetic polarity, on the assumption of left-handed (right-handed) magnetic helicity dominance