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Filaments disappearances in relation to solar flares during the solar cycle 23

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Abstract

We studied the association between the filament disappearances and solar flares during 1996–2010; we listed 639 associated filament disappearances with solar flares under temporal and spatial condition, those particular 639 filament disappearance were associated with 1676 solar flares during the period 1996–2010. The best angular distance between filament disappearances and associated solar flares ranged between 30° and 60°. The number of the associated events increased with increasing solar activity and decreased with quiet sun. The location of filament disappearances ranges between latitude ±50° and longitude ±70°. We found that longer filament disappearances have activity and ability of contemporary association with flares more than shorter filament disappearance, filament disappearance powers the associated flares more than non-associated flares events. The associated flares have higher solar flux, longer duration, and higher importance compared to non-associated flares with filament disappearance. In addition the associated filament disappearance with flares have two types depending on their duration, short-lived (<9 h), and long-lived (>9 h).

Keywords: Filament; Filament disappearance; Solar flare

1. Introduction

A review of filament disappearance relationship which is given by Smith and Ramsey (1964) extracts from this review is given below:

Newton (1934) recognized 2 types of flare associated filament disappearances: (1) filament disappearances associated with sunspot groups, (2) filament disappearances not associated with sunspot groups. Newton (1935) also reported cases of filaments exhibiting high radial velocities and complete or partial disappearances after flare start. In a study of flares observed during the period from March to December 1988, Giovanelli (1940) found that approximately one fifth of the flares gave rise to eruptive prominences (filaments), and that there is a statistical increase in the velocity of the ejected prominence with an increase in the intensity of the flare. A more complete description of flare-associated filament motions was published by Newton (1942). Bruzek (1951, 1958) noted events in which strengthening of a filament, combined with ascending motion, occurred before the start of a flare and prior to the dissolution of the filament. Martres (1956) pointed out that for disparitions brusques (sudden filament

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disappearances) associated with flares, the flare assumes almost the exact position where the filament previously existed. Observers at the Royal Observatory in Greenwich (1930) described a filament which showed a negative radial velocity of 450 km/s before it disappeared during the occurrence of a flare. Smith and Ramsey (1964) considered that the term "disappearance of a filament" could be appropriately applied to 4 different kinds of filament changes. These 4 types may be distinguished by their relationship to the occurrence of flares as: (1) Flare effected, (2) Flare associated, (3) Associated with flare-like brightenings, (4) Not flare-associated.

Smith et al. (1964) surveyed all of the Lockheed flares of importance 2 or greater for association with sudden filament disappearances. This survey included 71 flares recorded during the period January 1959 to January 1963. With respect to the occurrence of disappearing filaments, the flares were divided into four groups: (1) *Definitely associated*: A filament disappearance clearly occurred above or adjacent to the flare and before flare maximum. (2) *Indeterminate*: Absence of adequate observations before flare start. (3) *Ambiguous*: Except for the absence of a clearly defined, pre-existing filament. This type of event has been referred to as "flare filament" by Bruzek (1951). (4) *Not associated*: No filament disappearance adjacent to or above the flare.

Smith et al. (1964) found that the filaments which disappear before or during a solar flare frequently display a consistent pattern of changes beginning many minutes before flare start. This pattern of filament changes may be summarized in seven overlapping phases: (1) Widening and darkening; (2) Arch-like expansion; (3) Break-up; (4) Transition to emission; (5) Ejection of matter; (6) Complete disappearance; (7) Appearance of absorption during flare.

The visibility of the phases is a function of the part of the Hα line profile being observed, and appears to be a function of the observed position on the solar disk. Dodson et al. (1971) studied the 'disparitions brusques' in solar cycles 19 and 20 (to 1969) indicate that such events occur frequently. Approximately 30% of all large filaments in these cycles disintegrated in the course of their transit across the solar disk. Major flares occurred with above average frequency on the last day on which 141 large disappearing filaments were observed (1958–1960; 1966–1969). Relationships between a disintegrating filament on July 10–11, 1959, a prior major flare, a newly formed spot, and concomitant growth of Hα plage are presented. Observation of prior descending prominence material apparently directed towards the location of the flare of 1959 July 15^{d} 19^{h} 23^{m} is reported. The development of the filament-associated flare of February 13, 1967 is described.

Dodson et al. (1971) Studies of prominence in the course of their transit as filaments across the solar disk can add significantly to information relating to the life histories of prominences and to their possible connection with other solar phenomena. The relatively sudden disintegrations of filaments, the 'disparitions brusques', are the disk counterparts of at least some of the phenomena called eruptive or ascending prominences when such events occur at the limb of the sun.

Statistics for 'disparitions brusques' appear in the tables of the *Cortes Synoptiques* published at Meudon Observatory. From these statistics, and from daily observations at the McMath–Hulbert Observatory, it is clear that the disintegration of a filament, even a great one, is a common event. In solar cycles I9 and 20 (to 1969) at least 252 large filaments 'disappeared' during the course of transit across the solar disk. These filaments represented approximately 30% of all filaments evaluated as importance 5 or greater on the Meudon scale. 'Disparitions brusques' were frequent during the years of high solar activity and few in the years near solar minimum. These findings are in general accord with the results of study of 'disparitions brusques' in earlier years by d'Azambuja (1948). In cycle l9, the greatest number of large filaments and major 'disparitions brusques' occurred in 1959, two years after sunspot maximum.

Kahler (1980) studied a flare event involved with the disappearance of a filament near central meridian on 29 August 1973. The event was well observed in X-rays with the AS & E telescope on Skylab and in Hα at BBSO. It was a four-ribbon flare involving both new and old magnetic inversion lines which were roughly parallel. The Hα, X-ray, and magnetic field data are used to deduce the magnetic polarities of the Hα brightenings at the footpoints of the brightest X-ray loops. These magnetic structures and the preflare history of the region are then used to argue that the event involved a reconnection of magnetic field lines rather than a brightening in place of pre-existing loops. The simultaneity of the Hα brightening onsets in the four ribbons and the apparent lack of an eruption of the filament are consistent with this interpretation. These observations are compared to other studies of filament disappearances. The preflare structures and the alignment of the early X-ray flare loops with the Hα filament are consistent with the schematic picture of a filament presented first by Canfield and Athay (1974).

Haimin et al. (2002) found that the thermal type of sudden filament disappearances in the filament disappeared during a time interval between 17:59 UT and 19:47 UT on 22 October 2001 immediately after the onset of a major flare, which occurred in the active region NOAA 9672. At about 23:23 UT of the same day, the filament began to reappear in Hα and, after about 15 h, the filament recovered to its steady state with its size being slightly smaller than that before its disappearance. This filament disappearance event belongs to the thermal type of sudden filament disappearances, which is caused by an input of additional heat.

In general, the heating mechanism that leads to sudden thermal disappearances of quiescent filaments is still not well understood.