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Some characteristics of Coronal Mass Ejections associated with Prominence Eruptions

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ABSTRACT

In this paper we have made a comprehensive statistical study on the Coronal Mass Ejections (CMEs) associated with Prominence Eruptions (PEs). A total number of 576 Prominence Eruptions observed by Nobeyama Radioheliograph during the period January, 1996 to December, 2013. We have studied the distribution of Coronal Mass Ejections speed, angular width and acceleration for Prominence Eruptions associated Coronal Mass Ejections. The median (average) linear speed is 492 (521) km/s. The mean angular width is 77°. The speed of Prominence Eruptions varies from few km/s to 400 km/s with the average value 89 km/s. Majority of Prominence Eruptions associate Coronal Mass Ejections are accelerating. On studying the speed-acceleration correlation for these events, we found that there is no correlation between them. The number variation during solar cycle of prominence activities is similar to that of sunspots. The fraction of Prominence Eruptions associated Coronal Mass Ejections during the solar minimum is less than that during solar maximum. We have also studied the mass, energy and latitudinal distribution of Prominence Eruptions associated Coronal Mass Ejections.

1. Introduction

Gosling et al. [1] show that the prominences eruptions (PEs), flares, and coronal mass ejections (CMEs) are the most important solar events as far as space weather effects are concerned; these solar events are linked with solar eruptions, major interplanetary disturbances, and geomagnetic storms [2]. Coronal Mass Ejections are often seen as spectacular eruptions of matter from the Sun, which propagate outward through the heliosphere and often interact with the Earth's magnetosphere [3,4] and references therein. It is well known that these interactions can have substantial consequences on the geomagnetic environment of the Earth, sometimes resulting in damage to satellites [5]. A bright core in the three part classical structure of CME is the remnant of an eruptive prominence [4,6,7].

Prominence Eruptions is one of the earliest known forms of mass ejections from the Sun since the late 1800s [8]. Two primary types of mass motions have been recognized in prominences, one with material streaming from one part of the solar surface to another (active Prominence Eruptions) and the other with prominence material leaving the Sun partially or completely (eruptive Prominence Eruptions). It is well established that quite often prominence eruptions are associated with coronal mass ejections. Several researcher have already done extensive studies about prominence eruptions and coronal mass ejections [2,8–14,15]. In view of above it seems worthwhile to make a detailed study of Coronal Mass Ejections associated with prominence eruption of SOHO

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era. In this paper we have studied different properties of Coronal Mass Ejections those associated with Prominence Eruptions (variation of speed, angular width, their acceleration, latitudinal position, mass and energy and also study their annual variation with sun spots) in brief.

2. Data and results

Over the past 18-years the SOHO/LASCO instrument has been detecting Coronal Mass Ejections. From Jan. 1996 to Dec. 2013, more than 23,000 Coronal Mass Ejections have been observed by SOHO/LASCO. During the above mentioned period total 576 Prominence Eruption events have been taken from Nobeyama Radioheliograph (NORH) which observes the Sun in two frequencies, 17 GHz and 34 GHz. from 22:30 to 6:30 UT. It provides high-quality data up to 8 h per day with little interruption due to weather conditions. In this study we use the 17 GHz images which are archived at the Nobeyama Radioheliograph observatory and further details can be found in Gopalswamy et al., [10]. The LASCO instrument [16] consists of three coronagraphs C1, C2 and C3 which images the corona in successively C1: 1-1.3R_S, C2: 2-6R_S; C3: 3.8-32R_S. The combined field of view of LASCO enables one to investigate the full kinematical evolution of Coronal Mass Ejections. The height-time data of Coronal Mass Ejections used in this study is taken from the online SOHO/LASCO CME catalog (http://cdaw.gsfc.nasa.gov/CME_list), in which CME kinematics are estimated from LASCO C2 and C3 images. Out of 576 PEs, 373 PEs are associated with Coronal Mass Ejections.

In our analysis we use the following selection criteria. (i) The given Prominence Eruption information should be clear (location and speed should be reported). (ii) The data gaps and Backside events are excluded from the analysis. The temporal time window between Prominence Eruptions and Coronal Mass Ejections is $\pm$30 min form Prominence Eruption onset but in some cases the time difference is longer since the Prominence Eruptions start at very low position at limb.

Fig. 1 shows the distribution of duration (the difference between the starting and ending time of the PE) for those events which are associated with Coronal Mass Ejections. The duration of the Prominence Eruption varies from few min to 360 min. 81% Prominence Eruption events (304/373) have duration within 90 min and the remaining 19% (69/373) have duration greater than 90 min. The mean duration of the events is 64 min. The longer Prominence Eruption duration time is because of enhanced action of Lorentz force which indicates high speed and acceleration of the associated Coronal Mass Ejection [17].

With the help of Coronal Mass Ejection speed the basic characteristic of Coronal Mass Ejection i.e. mass motion can be easily quantified. The speed distribution of Coronal Mass Ejections those associated with Prominence Eruptions has been shown in Fig. 2. The Coronal Mass Ejection speed listed in the LASCO Coronal Mass Ejection catalog is measured from the height time measurements projected in the sky plane. No attempt had been made to correct the projection effects, since all the measured parameters suffer from projection effects.

Upper part of Fig. 2 shows linear speed distribution of events. It shows that the peak of the histogram occurs at 550 km/s but the tail of the histogram, which contains high speeds, is very short. The overall median (average) speed is 492 (521) km/s. Middle part of Fig. 2 shows speed

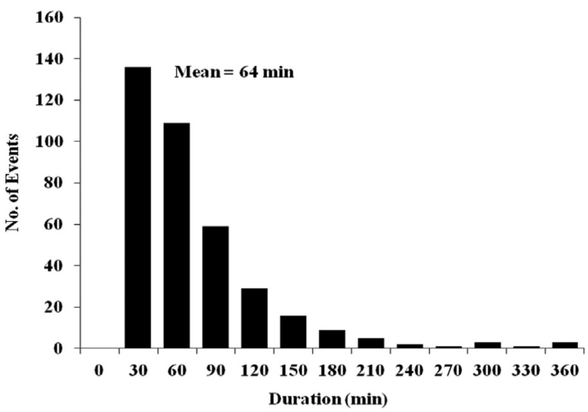

Fig. 1. Distribution of duration of PEs associated with CMEs.

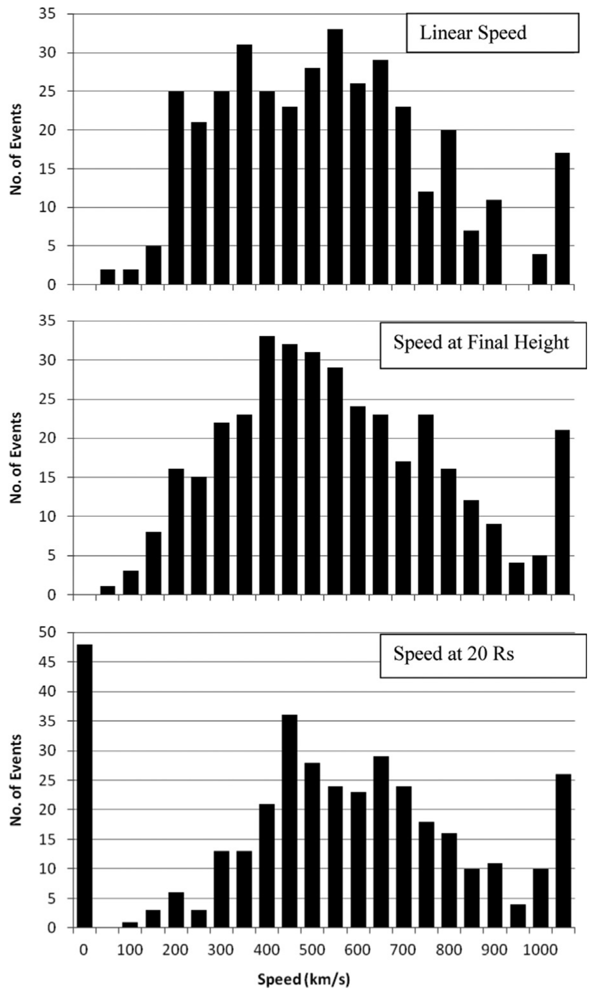

Fig. 2. Histogram shows the linear speed, speed at final height and speed at 20R_s distribution of CMEs those associated with PEs during 1996–2013.