

The Propagation of An Impulsive Coronal Mass Ejections (CMEs) due to the High Solar Flares and Moreton Waves

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ABSTRACT

This paper provides a short review of some of the basic concepts related to the origin of Coronal Mass Ejections (CMEs). The numerous ideas which have been put forward to elucidate the initiation of CMEs are categorized in terms of whether this event is a gradual CME or impulsive CME. In this case, an earth-directed Coronal Mass Ejection (CME) was observed on April 2, 2014 by the Large Angle Spectrometric Coronagraph (LASCO) C2. This recent observations obtained a large impulsive CMEs. The CME, originating from the active region AR2027. The speed of CMEs is 1600 km s^{-1} . A halo CME, a bright expanding ring at the North- West region is exploded beginning at about 14:36 UT, and the process of departing, expansion and propagation are highlighted. We discuss the correspondence of this event with the structure of the CME in the LASCO data. It is believed that the high solar flare and a Moreton waves initiate this kind of CMEs.

Keywords: Sun; solar eclipse; solar radio; burst, type III; e-CALLISTO

1. INTRODUCTION

The Coronal Mass Ejections (CMEs) phenomenon was discovered only in 1972 [1], but has become the most important form of solar activity because it is the most energetic phenomena on the Sun with a wide range influence throughout the heliosphere that affected the space weather. This phenomenon can generate major disturbances in the interplanetary medium and trigger severe magnetic storms when they collide with the Earth's magnetosphere. It is associated with a whole host of radio bursts caused by non-thermal electrons accelerated during the eruption process.

As the largest scale eruptive phenomenon in the solar atmosphere, it can be observed as enhanced brightness propagating out from coronal-loop-sized scale (10^4 km), expand to cover a significant part of the solar surface which is responsible for the most extreme space weather effects on Earth [2]. Moreover, CMEs may frequently interact with the Earth (and other planets), producing a series of impacts on the terrestrial environment and the human high-tech activities [3].

Further observations indicate that CMEs can also be observed in other wavelengths, such as soft X-rays [4,5], an extreme ultra-violet (EUV, [6,7], radio [8] and so on. CME also can be defined as a different plasma physical process and may even lead to the conditions for reconnection, causing a flares. We will highlight in the theoretical review of CMEs in the next section.

2. THEORY OF CORONAL MASS EJECTIONS (CMEs)

There are two classes of CMEs, namely flare-related CME events and CMEs associated with filament eruption are well reflected in the evolution of active regions, flare related CMEs mainly occur in young active regions containing sunspots and as the magnetic flux of the active region is getting dispersed, the filament eruption related CMEs will become dominant [9]. This is confirmed by statistical analyses. Based on previous two events that has been analysed critically, the Coronal Mass Ejection has the dominant component of the released energy, and covers an extensive fraction (30 %) of the existing magnetic energy [10]. It should be noted that a CME is not simply the explosive result of a flare, but has its own magnetic driver. Strong shock waves are expected to develop from fast CMEs [11].

Meanwhile, several CMEs appear as narrow jets, some arise from pre-existing coronal streamers while others appear as wide almost global eruptions. This phenomenon also can be divided into two categories [12] which are:

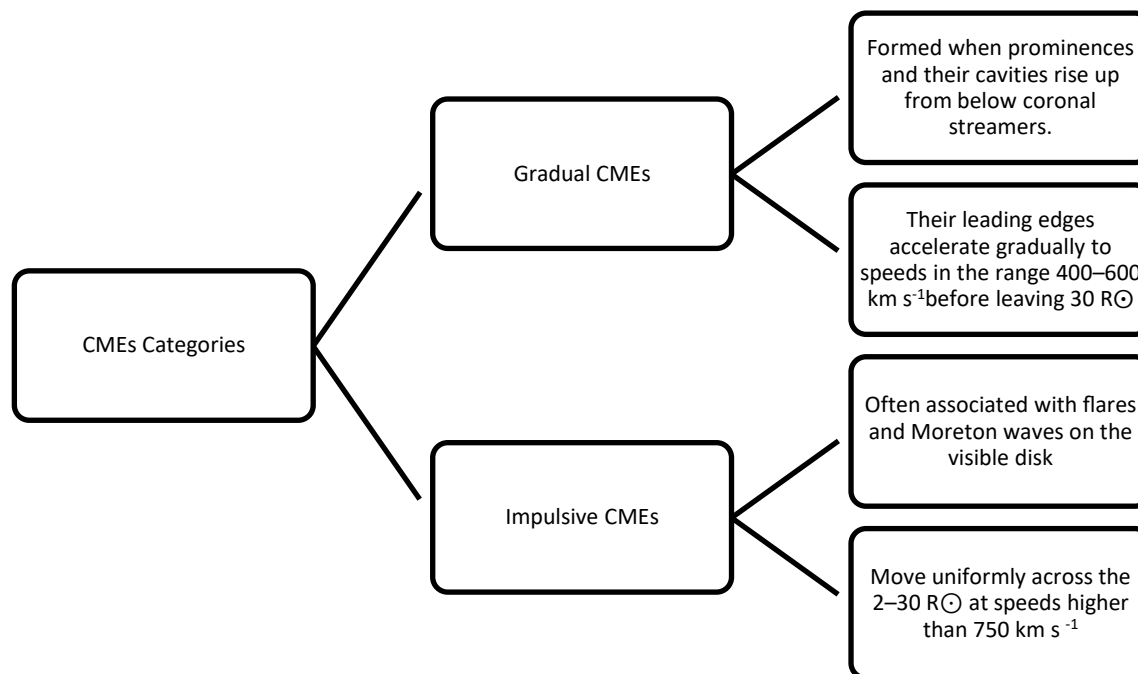


Figure 1. Categories of Coronal Mass Ejections (CMEs).

The CMEs are the most important transient constitute a form of intermittent massive expansion of mass from the solar corona. It is believed that the formation and eruption of prominences is one of the central issues of CME initiation [13]. It is responsible for non-recurrent disturbances in the interplanetary medium and their interactions with Earth's magnetosphere cause severe geo-effective storms. They may appear with a frequency of one event per every few days during solar minimum to several events per day during solar maximum. The CMEs carry typically 10^{12} kg of coronal material; originate from active and filament or prominence regions where the magnetic field is closed and result from the catastrophic disruption of large scale coronal magnetic structures, such as coronal streamers.

2. EXPERIMENTAL SETUP AND OBSERVATION

The data are taken from the Large Angle and Spectrometric Coronagraph (LASCO) is one of a number of instruments aboard the Solar and Heliospheric Observatory satellite (SOHO). This coronagraph captured an image from 2 to 6 solar radii. This spectrometer has been launched since 1990s observations has made major strides toward understanding the solar interior, the heating of the corona, and the acceleration and composition of the solar wind events. The observation of CMEs in the radio region in Malaysia has started since 2005 [14]. Compound Astronomical Low-frequency, Low-cost Instrument for Spectroscopy Transportable Observatories (CALLISTO) system is used in obtaining a dynamic spectrum of solar radio burst data. A construction of Log Periodic Dipole Antenna (LPDA). This system is mounted at the National Space Centre (ANGKASA) building at Sg. Lang, Banting, Selangor located at (N 02° 49.488' E 101° 36.168') covered from 45-870 MHz [15]. Several analysis of RFI have been done consistently [16]. In order to improve the quality of the system, the modification, calibration process and basic testing of the antenna has been made [17-21]. We focused the range of 150 MHz till 400 MHz with the very minimum of the RFI region [22,23]. Up to date, this region is the best region with minimum interference at our site [24]. The range of 150-400 MHz region seems is selected seems this is the finest range with lowest of Radio Frequency Interference (RFI) [25]. Routinely, an observation of 12 hours solar monitoring is done from 7:00 am - 7:00 pm [26-41].

3. RESULTS AND ANALYSIS

It is found that at a preliminary stage, it is expected that the CMEs is associated with M6.5 solar flare will graze the Earth at ~ 9:20 UT on 4th April 2014, however, it did not occur. As a consequence of the interaction, the core of the slow CME changed its trajectory significantly. Therefore, it is expected that a minor geomagnetic is possible to occur. The speed of CMEs is 1600 km s^{-1} . The dispersion of CMEs is around the North-West with wide angle. This feature seems to be the reconnection current sheet predicted by flux rope models of CMEs. In the case of high solar flare, the Moreton waves will be one of the main factors for the initiation of a solar Coronal Mass Ejection (CME). Moreton waves are the chromospheric signature of a large-scale solar coronal shock waves propagate at a speed of 500–1500 km/s. Also known as the Tsunami waves, this wave can be observed primarily in the H α band. Figure 1 shows the CMEs explosion during 2nd April 2014 and the chronology of Coronal Mass Ejections (CMEs) is illustrated in Figure 2.

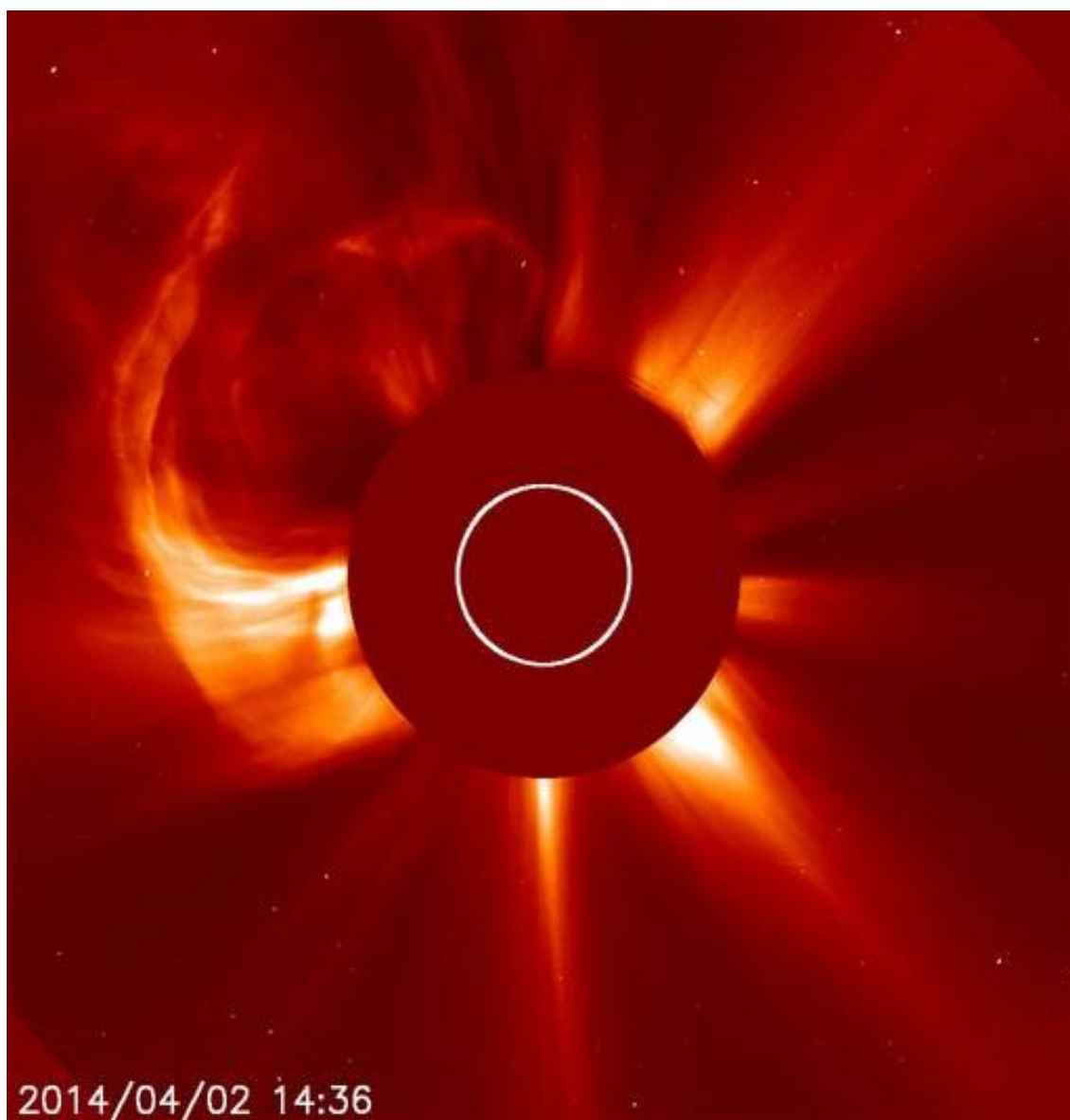


Figure 1. Coronal Mass Ejections (CMEs) on 2nd April 2014 (Credit to: LASCO 2).

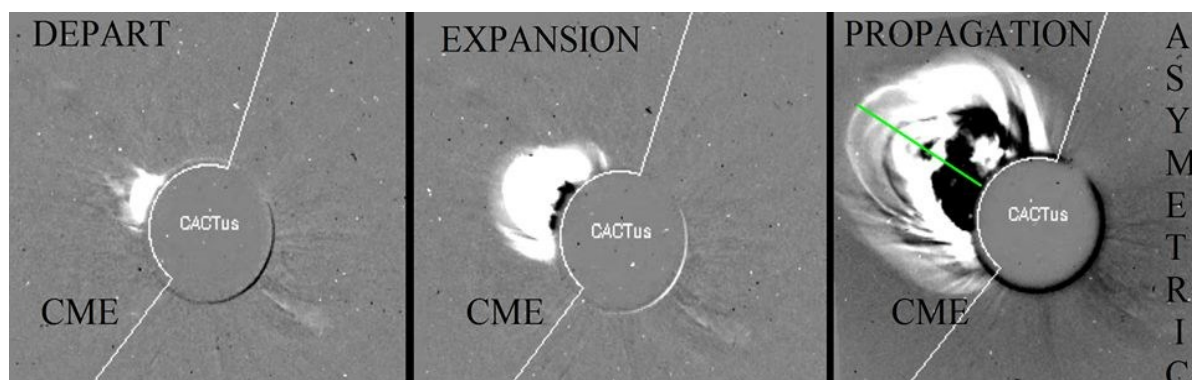


Figure 2. The chronology of Coronal Mass Ejections (CMEs) (Credit to: CACTUS).

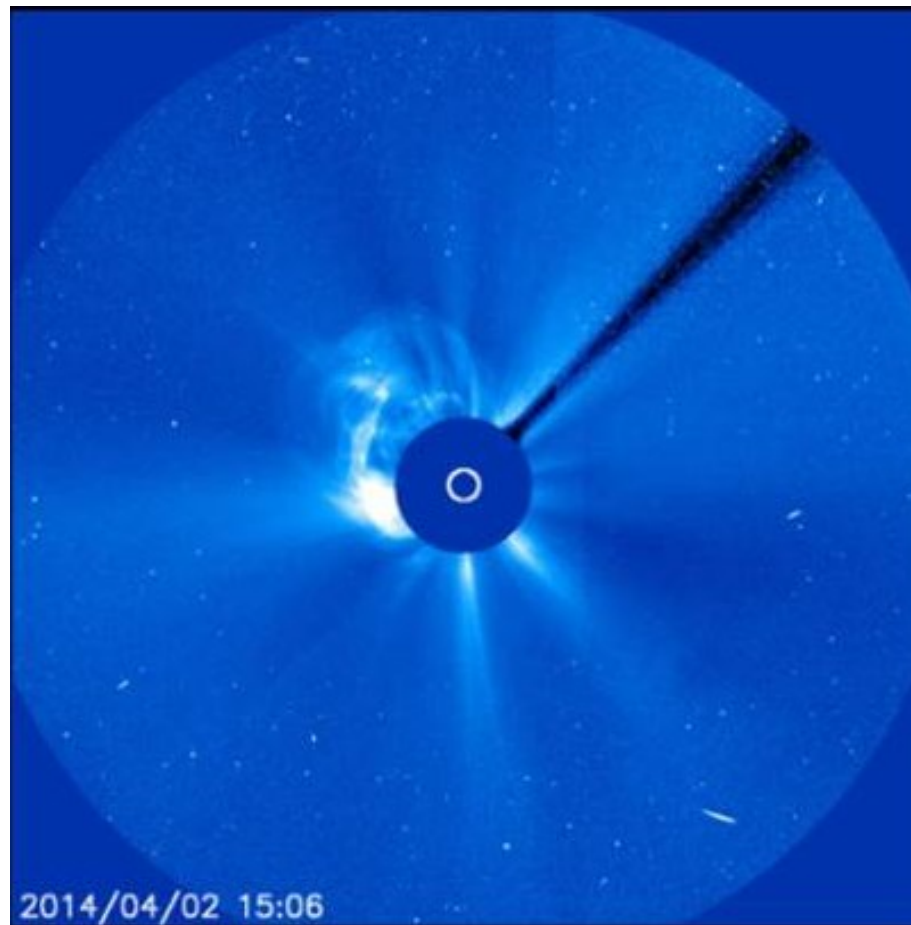


Figure 3. Coronal Mass Ejections (CMEs) detected by SOHO LASCO2.

This event occurs in multipolar topologies in which reconnection between a sheared arcade and neighboring flux systems triggers the eruption. In this case, the magnetic breakout, reconnection removes the unshaped field above the low-lying, sheared core flux near the neutral line, thereby allowing this core flux to burst open. From the observational evidence, that eruptions of quiescent filaments and associated coronal mass ejections (CMEs) occur as a consequence of the destabilization of large-scale coronal arcades due to interactions between these structures and new and growing active regions as shown in Figure 3.

4. CONCLUDING REMARKS

It is believed that the high solar flare and a Moreton waves initiate this kind of CMEs. This will lead a very fast and huge CMEs event. Our next study will focus on the interaction and the role of Moreton waves to this event. It should noted that the CME interaction has important implications for space weather prediction based on halo CMEs: some of the false alarms could be accounted for by CME interactions.

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Biography

Dr Zety Sharizat Hamidi is currently a senior lecturer and focused in Solar Astrophysics research specifically in radio astrophysics at the School of Physics and Material Sciences, Faculty of Sciences, MARA University of Technology, 40450, Shah Alam, Selangor, Malaysia. Involve a project under the International Space Weather Initiative (ISWI) and also a lecturer in School of Physics and Material Science, at MARA University of Technology, Shah Alam Selangor.

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