EPSC Abstracts
Vol. 10, EPSC2015-894, 2015
European Planetary Science Congress 2015

Low-coronal Sources of Stealth CMEs

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Abstract

Coronal mass ejections (CMEs) usually exhibit lower-corona dynamics such as flares, magnetic reconfiguration, EUV waves, jets or filaments. Recent studies have observed CMEs without a low-coronal signatures (LCS) which have been referred to as stealth CMEs. Through new image processing applied to EUV images we find clear evidence of LCS leading to stealth CMEs. The LCS of stealth CMEs are fairly sizeable yet faint eruptions with structure consistent with a rising flux tube, possibly formed higher in the corona in regions of weaker magnetic field. We believe these flux tubes are formed mostly in polar regions due to the large shear resulting from the slowly-rotating lower atmosphere below the more rapidly rotating corona. This would allow the formation of large flux tubes in weaker field regions, leading to low-energy and low-density flux tube eruptions.

1. Introduction

Coronal mass ejections (CMEs) are eruptions in the solar atmosphere which expand and propagate from the low corona to the interplanetary space [e.g. 1]. They are generally associated with eruptive phenomena in the lower corona such as solar flares, filament eruptions, EUV waves or jets, known as LCS.

[2] describe an event where there was no clear indication of a filament eruption or flare prior to a CME observed by white light coronagraphs. The lower coronal event leading to this stealth CME originated in a streamer at relatively large height. They interpreted this event as a very slow-rising flux tube leading to a streamer blowout CME. More recent work assembled a catalogue of ~40 stealth CMEs over a period of one year (2012), showing them to be relatively frequent events and revealing their unexplained preponderance over the North polar region [3]. The observational and kinematic properties of the 40 stealth CMEs were analyzed and compared to those of regular CMEs. To classify the events in the study, they searched for flares, filaments, EUV waves, jets, coronal dimmings, reconfiguration of the magnetic field in the higher corona, and flows in CACTus LASCO data coupled with the GOES/XRS data and the SoFAST catalog. Through visual inspection of SWAP, SDO and STEREO data, they narrowed down their data set to ~40 stealth CMEs.

As research suggests, the interaction between solar eruptions and the solar wind can create phenomena in the solar corona which are observed daily by space-based instruments. New image processing techniques can be applied to EUV [4] and white light coronagraph data [5] to reveal new detail. In this work, the new processing methods are applied to some of the data identified to contain stealth CMEs by [3] to investigate the possible existence of observable LCS.

2. Observations and methods

The instruments used in this study are the Large Angle and Spectrometric Coronagraph (LASCO) C2 which makes white light coronagraph observations, the Solar Dynamics Observatory (SDO)/Atmospheric Imaging Assembly (AIA) which images the solar atmosphere in seven extreme ultraviolet channels and three ultraviolet visible channels, and the Extreme Ultra-Violet Imager (EUVI) aboard the Solar Terrestrial Relations Observatory (STEREO).

LASCO C2 images were processed using the dynamic separation technique [4] and SDO/AIA and STEREO/EUVI images were processed with the new Multiscale Gaussian Normalization technique [5]. The method reveals fine details in the corona and can also reveal structure in off-limb regions.

3. Results

[3] identified 40 CMEs without low-coronal signatures occurring in 2012. One of these events took place on 23 February. Using our image processing techniques, we processed EUV data for this and similar events and compared results. Figure 1 is a composite image of this event in LASCO C2

and SDO/AIA 171. In the SDO image, we see activity in the lower corona we believe is evidence of LCS leading to the stealth CME identified in LASCO C2. Like this, we find other signatures in the lower corona, closer to the sun's surface, that may have caused the CME initiation process. This is shown in Figure 2. The same approach will be taken to study other cases listed in [3].

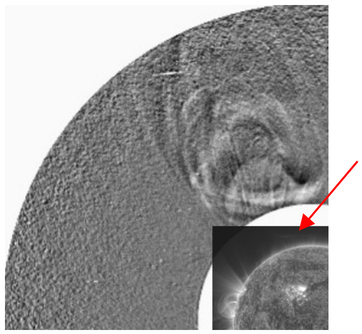

Figure 1: Outer: A CME seen in LASCO C2 data. Inner: Same event seen in SDO/AIA after our processing in which a low-coronal signature is visible (indicated by arrow).

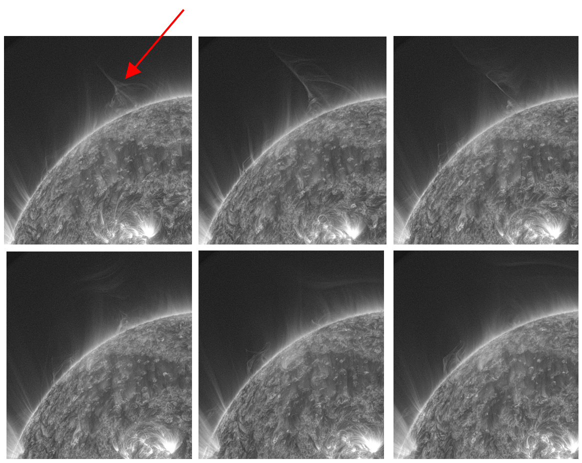

Figure 2: Coronal signatures (marked by arrow in first frame) associated with a stealth CME.

4. Discussion

- We are in agreement with conclusions of [2] and [3] that LCS of stealth CMEs are very faint events which form higher in the corona or in low-density regions of magnetic field weaker than usual CME-forming regions (i.e. filament eruptions or active regions).

- The 23 February 2012 event has the appearance of a large flux tube which through reconnection erupts slowly. It has low energy and very low initial velocity and acceleration.

- The differential rotation of the photosphere and the fact that the corona is a rigid rotator compared to the underlying photosphere [6] causes the formation at high latitudes. We believe this can lead to formation of large flux tubes following mechanisms similar to those described in [7], but in regions of weaker field and low density.

- We cannot explain the preference for formation of stealth CMEs in the North, but this is possibly due to the size and shape of the polar coronal hole.

5. Summary

Through careful processing of EUV images, we are able to show low-coronal signatures which lead to ejections previously referred to as stealth CMEs. With height-time profiles, we are able to show low-coronal events that appear to line up with stealth events. Proper fitting of these curves and further analysis will be able to confirm this.

References

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