SOURCE REGIONS IDENTIFICATION AND GEOPHYSICAL EFFECTS OF STEALTH CORONAL MASS EJECTIONS

Zagainova Iu.S.¹, Fainshtein V.G.², Gromova L.I.¹, Gromov S.V.¹

¹ - Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation Russian Academy of Sciences, Russian Federation
² - Institute of solar-terrestrial physics, Russian Federation
What is meant by a Stealth CMEs?

The vast majority of the coronal mass ejections (CMEs) recorded in coronagraph field-of-view (FOV) is associated with various manifestations of the solar activity in emission corona (low coronal signatures - LCSs): flares, filament eruptions, coronal jets, dimming, etc.

Contrary to this, there are such CMEs, observed by coronagraphs, those are not associated with LCSs. At present, CMEs without LCSs are called stealth CMEs (D’Huys et al., 2014).

And what is it really?
Stealth-CME kinematic properties

Coronal mass ejections (CMEs) are characterized by a wide range of maximum linear speed $V_{\text{lin\_max}}$ in the coronagraph field-of-view (FOV). $V_{\text{lin\_max}}$ vary greatly from N*10 to ~3000 km/sec ... \textit{(Gopalswamy et al, 2009)}.

An average linear speed $<V_{\text{lin}}>$ of a stealth-CMEs is equal about 300 km/s. It is more less than $<V_{\text{lin}}>$ of CMEs with LCSs of 435 km/s.

What is the type of stealth-CME velocity profile?
Data

SDO AIA and HMI http://jsoc.stanford.edu/ajax/exportdata.html

By Rudenko G. V., Anfinogentov S. A. Very Fast and Accurate Azimuth Disambiguation

Solar active monitor: https://solarmonitor.org/
OMNI database: https://omniweb.gsfc.nasa.gov/
IMAGE magnetometer network http://space.fmi.fi/image/
Catalogs of classification of solar wind types:
- "Near-Earth Interplanetary Coronal Mass Ejections (ICMEs)
  Since January 1996"
- "List of ICMEs“ http://space.ustc.edu.cn/dreams/wind_icmes.html
- catalog by Yu. I. Yermolaev’s team (Yermolaev, 2009)

For our study we selected 2 events:
Stealth-CME on 16.06.2010 and Stealth-CME on 07.07.2012.
New approach to detect the source location and initiation time of a stealth-CME formation

Zagainova et al., Sun and Geosphere, 2019, Volume 14, number 1.

New approach is based on a hypothesis that any forms of solar activity could be followed a stealth-CME initiation stage. It could be a short-time small-scale solar activity as EUV emission bursts in different spectral ranges (in several spectral AIA channels, i.e. on 93Å, 304 Å, 171 Å, 193Å, 211Å, and 131Å images).

Temperature response functions for the AIA channels were listed by Boerner et al. (2012), Lemen et al. (2012), and Downs et al. (2012).

It is necessary:
- To split solar disk into [200”×200”] segments;
- To plot the time dependence of the normalized maximum emission intensity \( I_n(t) \) in every channels within every segment;
- To find the low-intensity bursts of EUV emission within all segments.
IDENTIFICATION of the Stealth-CME source area

Stealth-CME

NE

NW

SE

AIA 193: 06/16 16:30
C2: 2010/06/16 16:30
**Observational characteristics of coronal mass ejections without low-coronal signatures**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2012/07/07 18:12:08</td>
<td>101</td>
<td>24</td>
<td>480</td>
<td>772</td>
<td>1714</td>
<td>120.0²</td>
<td>1.9e+14</td>
<td>2.2e+29</td>
<td>104</td>
<td>C2 C3 PHIX DST Java Movie</td>
<td>Poor Event, Only C2</td>
</tr>
<tr>
<td>2010/06/16 14:54:05</td>
<td>64</td>
<td>153</td>
<td>226</td>
<td>424</td>
<td>597</td>
<td>6.3²</td>
<td>6.8e+14</td>
<td>1.9e+29 ²</td>
<td>73</td>
<td>C2 C3 193 PHIX DST Java Movie</td>
<td>Poor Event, Partial Halo</td>
</tr>
</tbody>
</table>

**16.06.2010**

**EUV-micro-Burst-131Å**

**Stealth-CME**

**GOES X-Rays: 2010/06/16 14:06**

**Stealth-CME**

**EUV-micro-burst-93Å**

**07.07.2012**

**B. Heber et al., Forbush decreases associated to Stealth CMEs, 2014**
Identification of low coronal sources of "stealth" coronal mass ejections using new image processing techniques.

Two coronal Loop-like structures

Coronal jet

- 16.06.2010
- 07.07.2012
Stealth-CME on 16 June 2010

Stealth-CME on 7 July 2012

Coronal jet

Formation of frontal structure (FS) of the Stealth-CME

AIA 193Å

F_{LLS} is the footpoint brightening at the base of a loop-like structure

stealth-CME frontal structure

Loop-like structure
Stealth-CME on 16 June 2010

Stealth-CME on 7 July 2012

Graph showing the kinematic profile with different markers for coronal jet, frontal structure, LASCO C2 and C3, loop-like structure 1, and loop-like structure 2.
16.06.2010

B, arcsec

07.07.2012

|B_r|, G

07.07.2012 10:58:25 UT

NOAA 11520

07.07.2012 10:58:25 UT

6173. 2010/06/16 10:58:26.50

-550 -500 -750 -700 -650

L, arcsec

07.07.2012 10:58:25 UT

500 -500

16.06.2010
Stealth-CME on 7 July 2012

A lot of observed Stealth-CME sources are located on the limb, on Sun’s backside or on a visible solar disk next to the limb. Angular width of the Stealth-CMEs is about 25°.

It is possible that a Stealth-CME initiated from the area next to the solar disk center was occulted by coronagraph disk.
Conclusions

1. Formation stage of the stealth-CME observed by LASCO coronagraphs were associated with various manifestations of short-time small-scale solar activity, such as the EUV bursts, the activation and moving of the small-scale structures.
2. Formation of stealth-CME frontal structures was observed for the first time.
3. Stealth-CME velocity profiles were determined. It's shown that the profile neither gradual nor pulse.
4. The radial component of the magnetic field $B_r(t)$ is varied in initiation area before and after the Stealth-CME formation stage.
5. The stealth-CME arrival at the Earth did not lead to a noticeable geomagnetic field disturbance described by the Dst-index. The passage of the stealth-CME front close to the Earth was followed by a weak substorm. The stealth-CME structure on the Earth's orbit is similar to a magnetic cloud structure.

Thank you for your attention