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STUDY OF HALO CME ON 22 SEPTEMBER 2011 WITH IN-SITU AND DBM PARAMETERS

ABSTRACT

Coronal mass ejections (CMEs) are the frequent expulsions of massive magnetized plasma from the solar corona into the heliosphere. These CMEs provide an opportunity to study their in-situ parameters from multiple vantage points. In this paper, we examine the in-situ magnetic and plasma parameters from different viewpoints using LASCO/SOHO and STEREO A/B spacecrafts. We also studied the estimation of arrival time of CMEs using Drag Based Model (DBM).

Keywords: *Coronal mass ejection, magnetic and plasma parameters, DBM*

INTRODUCTION

The sun drives the space weather which produces the strong geomagnetic storms. There are many disturbances take place in the IP medium due to solar explosion: Flare, Solar energetic particle and Coronal mass ejection.

Halo CMEs have 360^0 angular span and expand rapidly to surround occulting disk of the observing coronagraph (http://www.livingreviews.org/lrsp-2006-2) (Gopalswamy et al., 2007). The term 'Interplanetary Coronal Mass Ejection' (ICME) was originally used for near-Earth observations of CME by an in situ spacecraft, to distinguish from the coronagraphic observations near the Sun.

Based on an empirical relationship between measured projected speeds and arrival time characteristics of various events, various models have been developed to forecast the CME arrival time at 1 AU (Gopalswamy et al. 2001; Vrsnak & Gopalswamy 2002; Schwenn et al. 2005). We used the DBM developed by Vršnak et al. (2013) to estimate the arrival time of the 22 September, 2011 CME. In the DBM, it is assumed that after 20 $R_\odot$, the drag parameter and ambient solar wind speed do not change with heliocentric distance. However, the statistical analysis of sample event from Vršnak et al. (2013) shows the drag parameter lies in the range 0.2×10^{-7}–2.0×10^{-7} km^{-1}. In our study, we only used the extreme values of the range of the drag model for CME.

In this paper, we examine the interplanetary in-situ magnetic and plasma parameters from different viewpoints using LASCO/SOHO and STEREO A/B spacecrafts. We also studied the estimation of arrival time of CMES using Drag Based Model (DBM).

OBSERVATION TECHNIQUIES

For CME

- We have considered data from LASCO (Large Angle Spectroscopic Coronagraph) SOHO (SOlar and Heliospheric Observatory) CME catalog during 2011.

  https://cdaw.gsfc.nasa.gov/CME_list/

- Halo CMEs are 360^0 angular span, so they should also arrive at other spacecraft like STEREO.

In order to check the IP properties in details, we need more viewpoints – STEREO (Solar TErrestrial RElations Observatory).

https://stereo-ssc.nascom.nasa.gov/cgi-bin/images

For ICME

❖ In-situ measurements are made at L1 point by ACE/WIND (Advanced Composition Explorer) [OMNI (1 AU IP data) IMF and plasma data] and at STEREO-A and STEREO-B.

https://cdaweb.sci.gsfc.nasa.gov/index.html/

For DBM

❖ We use Vršnak et al. (2013) to estimate the arrival time of CME on 22 September 2011.

http://oh.geof.unizg.hr/DBM/dbm.php

RESULTS AND ANALYSIS

Halo CME observed on 22 September 2011 at 10:48 UT with linear speed 1905 km/s in LASCO C2 and STEREO spacecraft images (Fig 1).

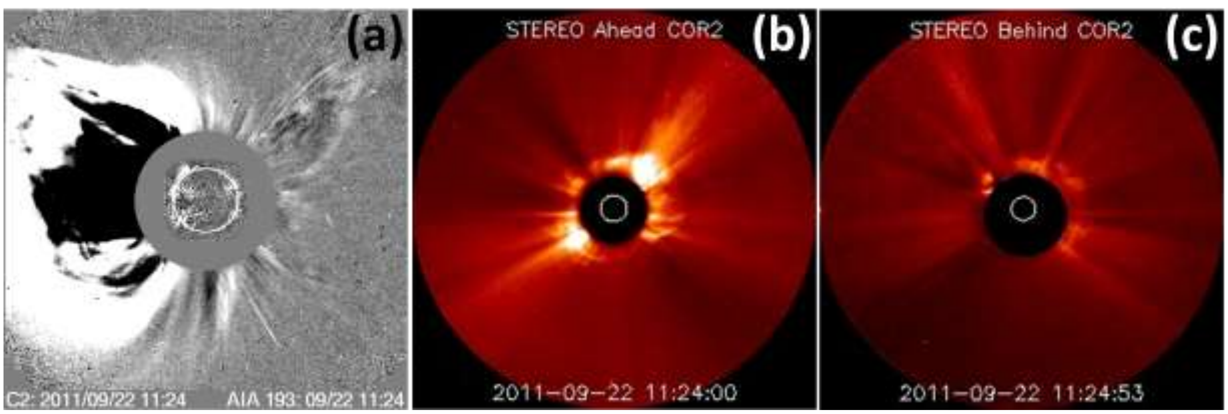

Figure 1- CME on 22 September 2011 observed on images (a) LASCO C2, (b) STEREO-A COR-2 and (c) STEREO-B COR-2

As the CME reached near the Earth, ICME in-situ parameters are not observed near L1 point (Fig 2). But ICME parameters observed at STEREO-A (Fig 3) and STEREO-B (Fig 4).

As seen in Fig 3, the first vertical line at STEREO-A indicates the shock arrival on 24 September with the speed of 449 km/s at 8:47 UT. ICME arrives on 24 -25 September with the average speed of 500 km/s. The second vertical line indicates the trailing edge of ICME on 25 September at 18:00 UT. During the ICME at STEREO-A, we observed the total magnetic field (B) ~ 10 nT, proton density (Np) ~ 20 n/cc and temperature ~ 5.0×10^5 K (Fig 3).

As seen in Fig 4, the first vertical line at STEREO-B indicates the shock arrival on 24 September with the speed of 810 km/s at 4:16 UT. ICME arrives on 24 -25 September with the speed of 800 km/s. The second vertical line indicates the trailing edge of ICME on 25 September at 02:50 UT. During the ICME at STEREO-B, we observed the total magnetic field (B) ~ 30 nT, proton density (Np) ~ 42 n/cc and temperature ~ 1.6×10^6 K (Fig 4).

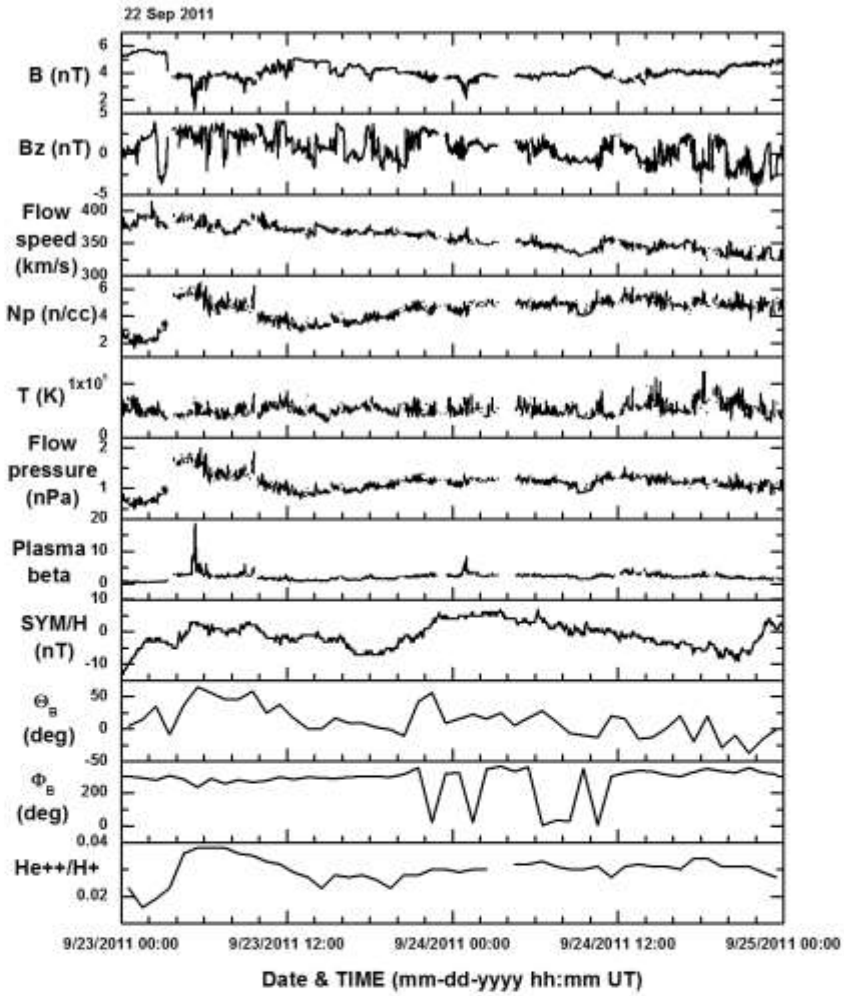

Figure 2- in-situ ICME parameters of CME on 22 September 2011 at L1 (https://cdaweb.sci.gsfc.nasa.gov/index.html/)

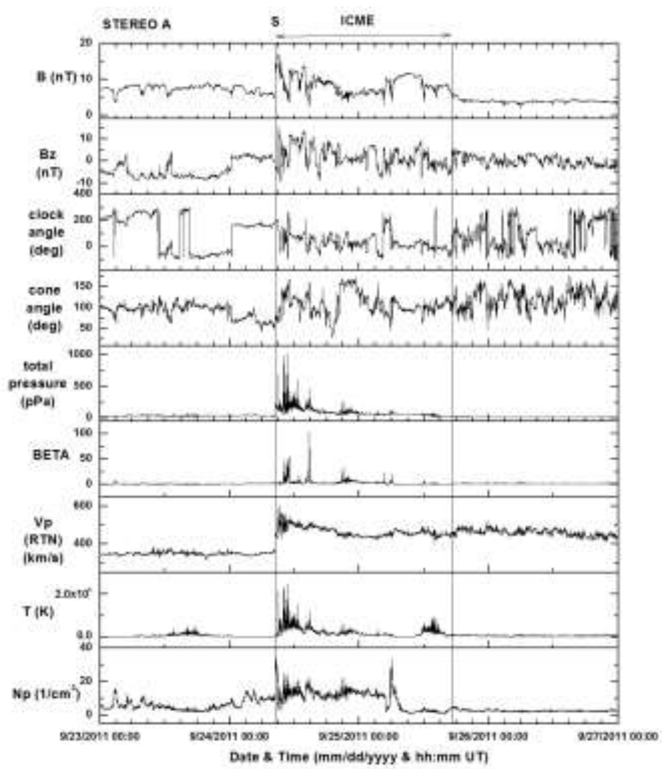

Figure 3- in-situ ICME parameters of CME on 22 September 2011 at STEREO-A (https://cdaweb.sci.gsfc.nasa.gov/index.html/)

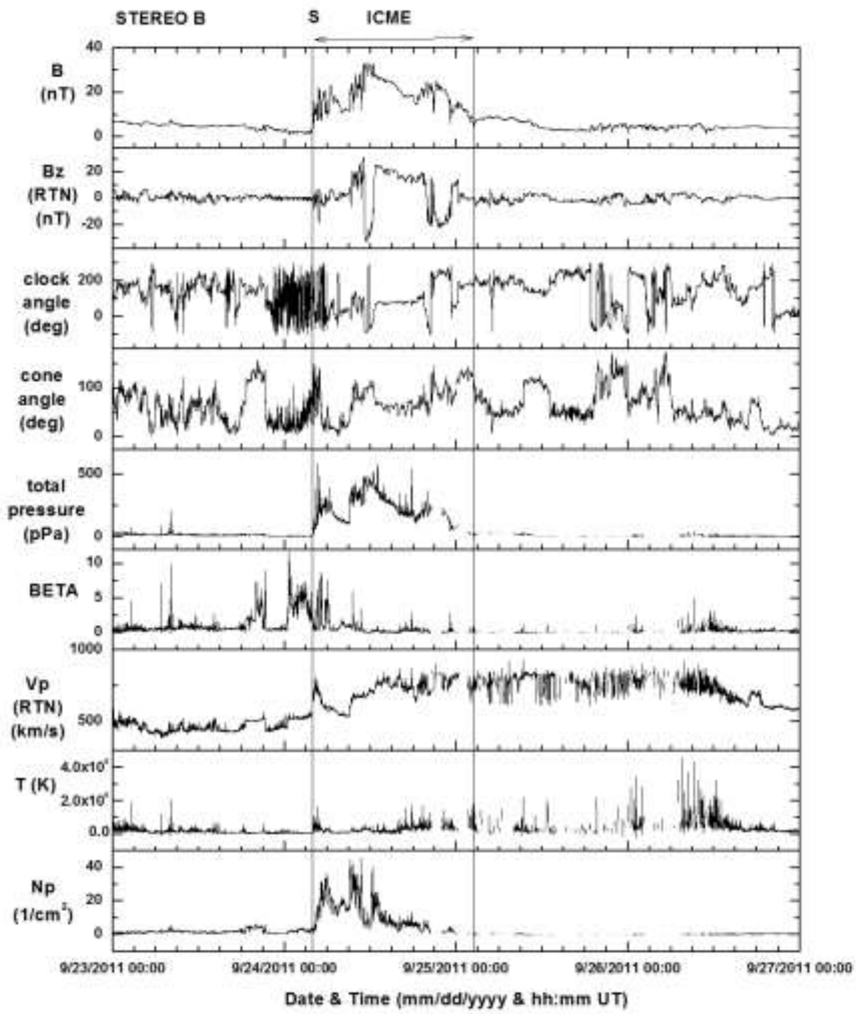

Figure 4- in-situ ICME parameters of CME on 22 September, 2011 at STEREO-B (https://cdaweb.sci.gsfc.nasa.gov/index.html/)

The arrival time of CMEs at L1 and STEREO-A was estimated using DBM model. The propagation speeds of CMEs listed in LASCO and SEEDs catalog were used as input. For the arrival time estimation of 22 September CME at L1, we take its speed at 20 Rs as 1800 km/s and the lower extreme of drag parameter (Γ) as 0.2×10^{-7} km^{-1} and ambient solar wind speed as 370 km/s. Using these inputs, the arrival time of the 22 September CME is estimated at 04:44 UT on 24 September (Table 1). With the same inputs while taking the upper extreme value of a drag parameter as 2.0×10^{-7} km^{-1}, the arrival of 22 September CME at L1, is found to be at 01:25 UT on 26 September (Table 1).

For the arrival of 22 September CME at STEREO-A, assuming its speed at 10 Rs as 1190 km/s, Γ as 0.2×10^{-7} km^{-1} and ambient solar wind speed as 350 km/s, the arrival times of the CME is estimated at 12:14 UT on 24 September (Table 1). Taking an upper extreme of drag parameter in the DBM, keeping the rest of the input parameters as same, the arrival time of 22 September CME at STEREO-A is noted to be at 02:14 UT on 26 September (Table 1).

For estimating the arrival time of 22 September CME at STEREO-B, we take its speed at 10 Rs as 1340 km/s and ambient solar wind speed as 500 km/s. Using these inputs with a lower and upper range of the drag parameter in the DBM, the CME of 22 September is found to arrive at STEREO-A at 07:58 UT and 09:19 UT on 24 September and 25 September, respectively (Table 1).

Table 1: CME arrival time using DBM of halo CMEs on 22 Sep, 2011

	Input Parameters						Output Parameters				
	CME take-off date & time UT	R_0 (R_S)	V_0 (km/s)	Γ 0.2 x 10^{-7} – 2 x 10^{-7} (km^{-1})	w (km/s)	R_t (AU)	CME arrival at target (date & time UT)	Transit time (hr)	Diff from actual time (hr)	Impact speed at target (at 1 AU) (km/s)	Diff from actual speed (km/s)
L1	22 Sep 12:28	20	1800	0.2×10^{-7}	370	1	24 Sep 04:44	40.3	---	648	---
				2×10^{-7}			26 Sep 01:25	84.9	---	386	---
STA	22 Sep 12:43	10	1190	0.2×10^{-7}	350	0.9	24 Sep 12:14	47.5	+3.5	567	67
				2×10^{-7}			26 Sep 02:14	85.5	+41.5	366	134
STB	22 Sep 12:34	10	1340	0.2×10^{-7}	500	1	24 Sep 07:58	43.4	+3.7	732	68
				2×10^{-7}			25 Sep 09:19	68.8	+29.1	520	280

CONCLUTION

- ❖ CME was directed towards STEREO-B.
- ❖ For STEREO – A/B, it is clear that higher value of drag parameter has decelerated the CME and caused its arrival at later time than that with lower extreme of drag parameter.
- ❖ According to DBM at L1, estimated arrival time of CME on 22 September is at 07:58 UT and 09:19 UT on 24 September and 25 September, respectively. But ICME signatures were not found in in-situ parameters. So, we conclude that ICME was decelerated towards L1.

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