Interplanetary Propagation of a CME on 05 May, 2015

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Abstract :-

We report the interplanetary effects of a fast coronal mass ejection (CME) associated with an intense flare, X2.7, occurred on 05 May, 2015.

(i) Near-Sun signatures of the CME at low-coronal heights <2 $R_\odot$ are obtained from the EUV images at 171 Å and metric radio observations,

(ii) LASCO coronagraphs provide the images of the CME at heights below 20 $R_\odot$, and

(iii) The interplanetary scintillation measurements on a large number of radio sources, along with the low-frequency radio spectrum, are useful in understanding the radial evolution of the speed and expansion of the CME in the inner heliosphere as well as its interaction with a preceding slow CME.

Near-Sun Observations

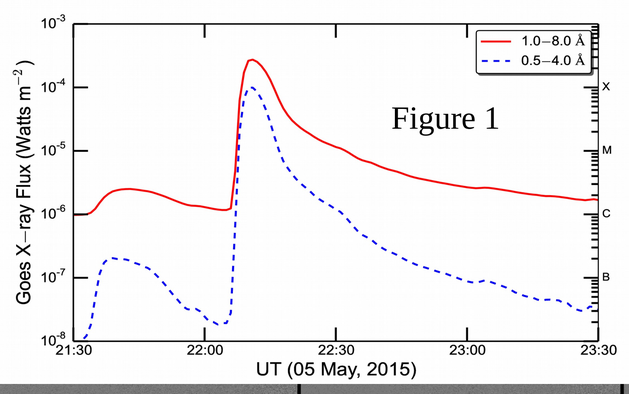


Figure 1

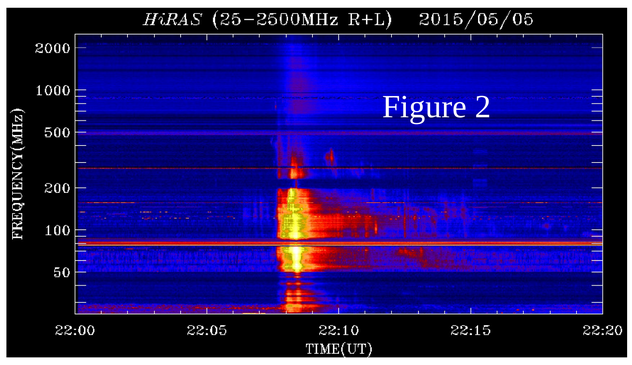
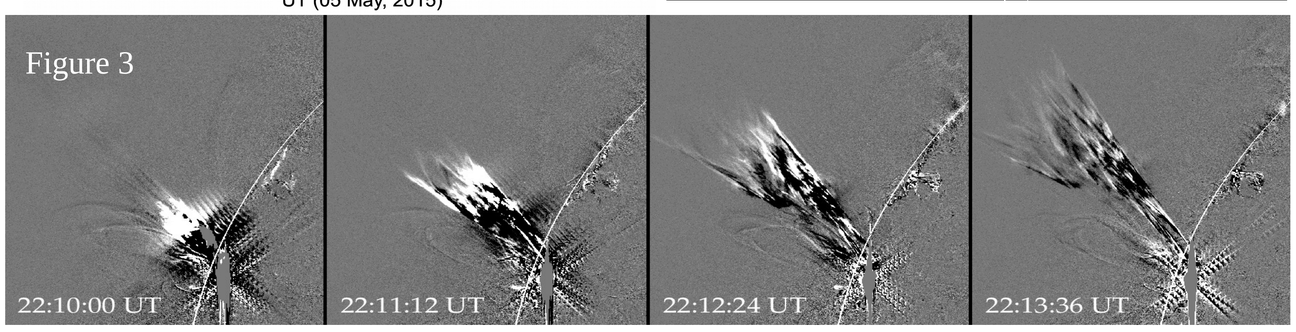


Figure 2



(i) The studied intense event of the year 2015 (X2.7), originated from the active region AR#2339 on 05 May, 2015 at 22:07 UT, when the active region was located close to the east limb of the Sun.

(ii) Soft X-ray profiles of the flare are shown in Figure 1.

(iii) In association with the flare, a fast eruption was seen in Solar Dynamic Observatory (SDO) EUV images (e.g., at 171 Å in Figure 3). The radial speed of eruption was ~1300 km/s at heights below 1.5 $R_\odot$. But, the eruption showed limited expansion in its lateral direction (~300 km/s only).

(iv) The fast eruption caused a coronal shock, which was observed in HiRAS and Culgoora radio spectra in the frequency range of ~50-80 MHz (2nd harmonic emission in Figure 2). The shock speed of ~1500 km/s is consistent with the eruption speed observed in the SDO images.

Speed Profile of the CME

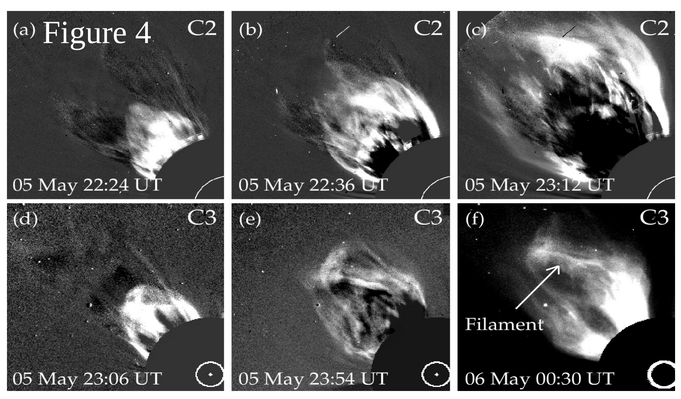


Figure 4

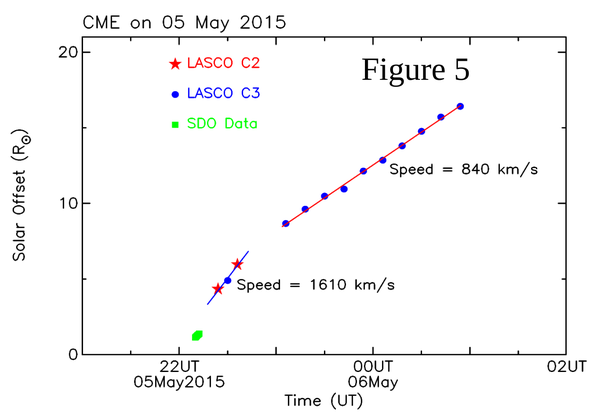


Figure 5

(i) The onset of the fast moving CME was observed on 05 May, 2015 at 22:24 UT in the LASCO/C2 field of view; the lateral expansion was rather large (compared to a confined eruption in the lateral direction recorded by the SDO, refer to Figure 3).

(ii) It indicated that the CME went through a fast expansion at height above 2 $R_\odot$. Figure 4 shows C2 and C3 LASCO images.

(iii) Within the LASCO field of view, the speed of the CME evolved from 1610 to 840 km/s, respectively, at heights below and above 8 $R_\odot$ (speed profile in Figure 5).

(iv) The intensity and duration of the CME-driven radio bursts in the near-Sun and interplanetary medium indicated the CME event to be an energetic event.

(v) The fast propagating CME interacted with a slow moving CME, which also originated from the same active region and on the same day, about 8 hours earlier. The expected height of interaction was ~50-75 $R_\odot$ at about 8-10 UT on 06 May, 2015.

CME in the Inner Heliosphere

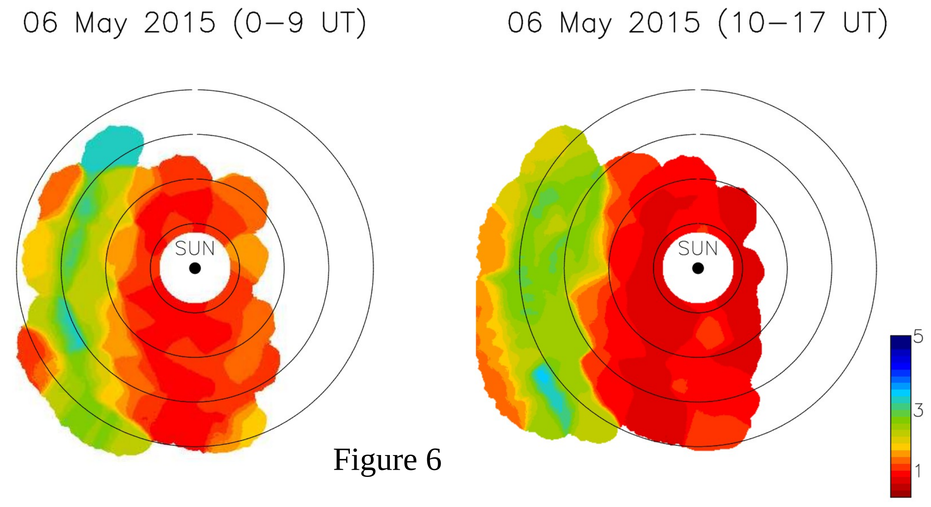


Figure 6

(i) The Interplanetary Scintillation (IPS) images from the Ooty Radio Telescope provide the distribution of CME-generated transients as well as the background solar wind in the heliocentric distance range of ~50-250 $R_\odot$.

(ii) The IPS images (i.e., normalized scintillation index, g-value, images) are displayed in Figure 6. These images are equivalent to LASCO white-light images, i.e., sky-plane "position angle-heliocentric distance" images.

(iii) The enhanced level of scintillation indicates the presence of interplanetary CME.

(iv) On 06 May, 2015, the CME onset in the IPS field of view is seen in the distance range of 50-100 $R_\odot$ (refer to image corresponding to 0-9 UT).

(v) These IPS images show that the CME has expanded considerably in the inner heliosphere. IPS measurements show that the ambient solar wind speed was ~300 km/s. The time series analysis of speed and normalized scintillation index (i.e., g-value) on 06 May, 2015 reveals that the CME propagated at a speed about 800 km/s in the 50 $R_\odot$ to 1 AU distance range.

(vi) The IPS image during 10-17 UT on 06 May, 2015 indicates the situation just after the CME-CME interaction. The turbulence levels associated with the CME and CME-generated disturbance increased significantly after the interaction.

(vii) It is to be noted that the CME has propagated at a speed about 800 km/s in the Sun to 1 AU distance and the drag experienced by the CME in the slow-speed dominated heliosphere seems to be less effective.

Summary

In this study, we report an energetic CME event, associated with an intense X2.7 flare on 05 May, 2015.

(i) The CME has gone through a rapid acceleration as well as expansion up to a height of ≈6 $R_\odot$,

(ii) the CME continued to propagate at speed ≥800 km/s in the mid way between Sun and 1 AU. These results show that the CME has likely overcome the drag exerted by the ambient/background solar wind with the support of its internal magnetic energy, and

(iii) when the CME interacted with a slow preceding CME, the turbulence level associated with the CME-driven disturbance increased significantly.

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