Statistics on the occurence of CME related radio bursts observed by ARTEMIS IV radio spectrograph during the maximum of the solar cycle 23.

Bouratzis C. [1], Desyllas C. [1], Hillaris A. [1], Preka-Papadema P. [1], Moussas X. [1], Caroubalos C. [2], Alissandrakis C. [3], Maroulis D. [2], Patavalis N. [2], Polygiannakis J. [1], Bougeret J-L. [4], Dumas G. [4], Perche C. [4], Kontogeorgos A. [5], Tsitsipis P. [5].

[1] *Section of Astrophysics,Astronomy and Mechanics, Department of Physics, University of Athens, Panepistimiopolis Zografos, GR-15784, Athens, Greece.*

[2] *Department of Informatics, University of Athens, Panepistimiopolis Zografos, GR-15783, Athens, Greece.*

[3] *Department of Astro-Geophysics, University of Ioannina, GR-45110, Ioannina, Greece.*

[4] *Observatoire de Paris, Department de Recherche Spatial, CNRS UA 264, F92195 Meudon Cedex, France.*

[5] *Department of Electrical Engineering Technological Education Institute of Lamia, Lamia, Greece.*

Abstract

Type II radio bursts are attributed to emission from electrons accelerated in MHD shocks; they are frequently followed by moving and/or stationary type IV bursts and, at times, concurrent CMEs. However there is no clear and unambiguous picture about the CME-type II relationship. In this report we present a preliminary comparison of type II solar radio bursts, occasionally followed by type IV bursts and the associated CMEs during the time interval 1998-2000. The bursts were recorded by the ARTEMIS IV radio spectrograph at Thermopylae, Greece. Observations cover the frequency range from 110 to 688 MHz for the period 05:25-15:05 UT daily. The CME movies used in our analysis were recorded by LASCO. We expect that the study of CME-metric radio burst association may shed new light in the dynamics of magnetic flux restructing as well as the large scale energisation and material ejection from the Sun.

1 Introduction

Coronal Mass ejections are often assosiated with flares, radiobursts and various solar transients. They are commonly associated with type II radiobursts, or type IV continuum, or even complex II/IV (Type II followed by type IV) events. We present a preliminary analysis based on the ARTEMIS IV radio spectrograph (Caroubalos et al, 2001) catalogue of type II and /or type IV radio bursts observed during the 23rd solar maximum (1998 - 2000). We investigate in particular the relationship between the radiobursts, LASCO CMEs and flares (Ha & SXR) from the SGD catalogue.

2 Data Analysis and Results

Samples of used data sets are presented in figures 1 and 3. The association of type II bursts with CMEs was found to be 70 % in agreement with Sheeley et al (1984). The probability of association, however, increases from 70% to 100% in the case of complex II/IV events (cf figure 2a). The significance of this increase was found to be 97% for our data set. 60% of isolated type IV (without type II preceding them) were found associated with CMEs. We also examined the parameters of associated Hα (area and brightness) and SXR (intensity, duration and total flux)

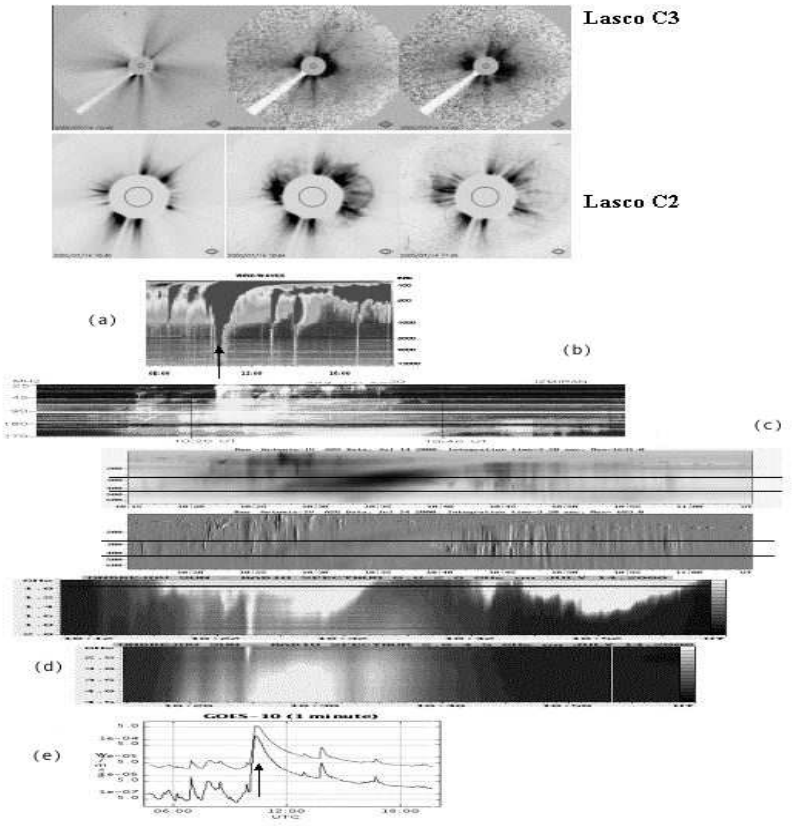

Figure 1: Dynamic spectra of the July 14, 2000 event from 4.5 GHz to 20kHz together with colonal and X-ray data. From top to bottom: The ejected CME (SOHO/LASCO) is presented in the upper panel. (a) WIND/WAVES data, (b) Izmiran Radiospectrograph, (c) ARTEMIS IV data, - a moving type IV (10:22- 10:38 UT) followed by a stationary type IV burst (10:25-10:42 UT) with fine structure (pulsations, fibers) are shown - (d) Odrejov Radiospectrograph, (e) Time profile of the soft X-rays emission (GOES).

flares. Our results are given in figures 2(c)-(f). The CME association rate for both type II and type IV bursts accompanied by an Hα flare increases with brightness, area, and duration of this flare. For SXR flares this rate increases too with peak intensity, total flux and duration. The velocities of type II bursts (figure 2(b)) were calculated assuming the Newkirk (1961) model for coronal density versus height and radial propagation; they were found to vary in 200-1000 km/sec range. The mean projected velocity of the CMEs of our data set was estimated from the LASCO/SOHO images to 650 km/sec. This value is consistent with previous results (Gosling et al (1976) etc). In figure 2(g) we present a superposed epoch diagram with respect to the Ha maximum. On this we have plotted the estimated time of CMEs onset (line bar) and the onset, maximum and end of the associated SXR flare (dotted bar). More often than not the CME onset precedes the Ha maximum by 10-20 minutes (occasionally 30 minutes).

3 Conclusions

1. The rate of CME-Complex type II/ IV radio burst assotiation was 100% in our data set

2. The probability for a type II burst to be associated with a CME was found 70%, rising to 100% in the presence of a large (2 or 3) and/or Bright (B) Ha flare (Significance of results was 88% and 94% respectively) or a strong (class M, X) SXR flare.

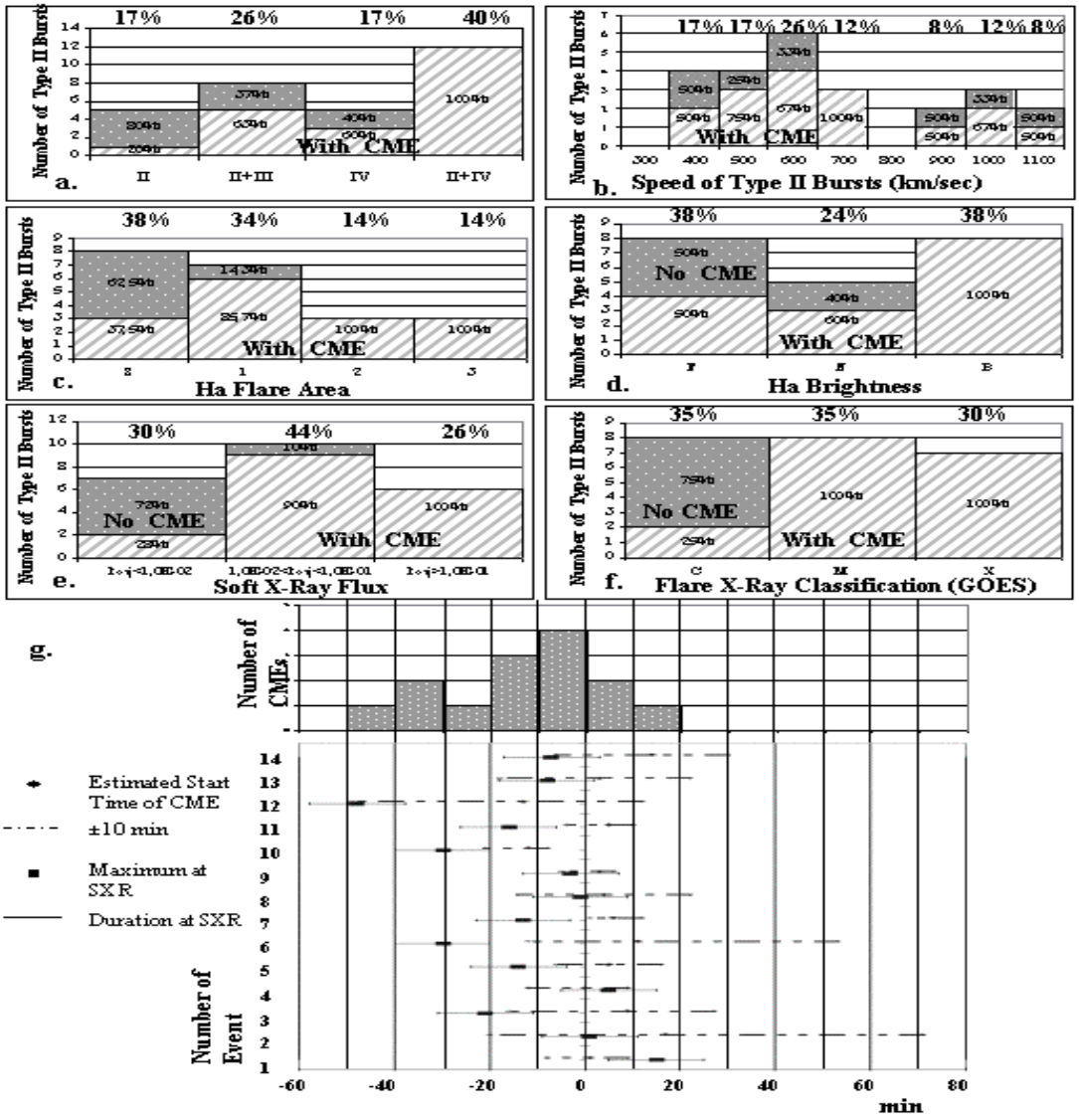

Figure 2: (a) The distribution of type II and/or type IV bursts associated with CME plotted in light grey. The remaining events are plotted in dark grey. The type II subcategory preceded by a type III precursor is shown separately. (b) The distribution of type II velocities. Events associated with CMEs are plotted in light grey, the remaining are in dark grey. (c)-(f) Dependence of type II bursts association with CMEs, on Ha (area and brightness) and SXR (total flux and intencity) flare characteristics. Associated events are plotted in light grey, the remaining in dark grey. Similar results apply for type IV bursts. (g) Time evolution of events: Superposed epoch analysis of estimated CMEs onset, time of onset, maximum and end of associated soft X-ray emission. The zero is set at the Hα flare maximum. The distribution of CME onset is shown at the top.

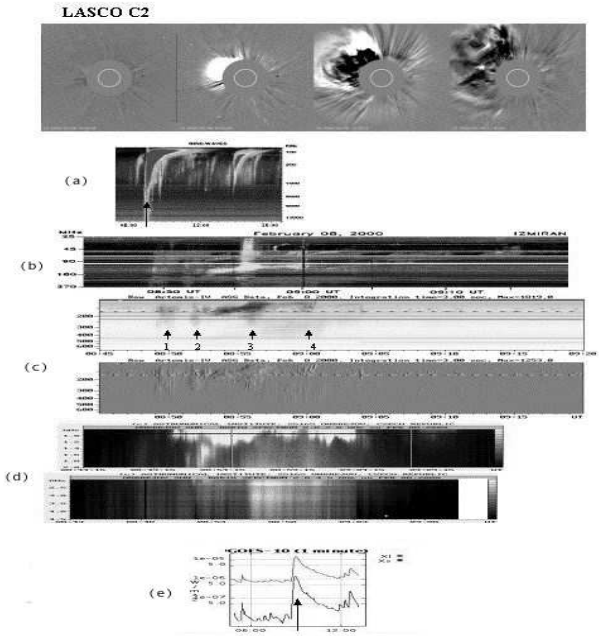

Figure 3: Dynamic spectrum of the February 8, 2000 event from 4.5 GHz to 20kHz. From top to bottom: The associated CME (SOHO/LASCO) is shown in the upper panel. (a) WIND/WAVES data, (b) Izmiran Radiospectrograph, (c) ARTEMIS IV data -a type II burst, 8:53-9:00 UT, and type III, 8:49:30-8:53 UT precursor are shown - (d) Odrejov Radiospectrograph, (e) Time profile of the soft X-rays emission (GOES).

3. The mean projected CMEs velocity was found approximately 650 km/sec.

4. The estimated CMEs onset was found to precede the maximum of Ha flare as well as the SXR flare by 10-20 minutes.

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