"RECENT ADVANCES IN ASTRONOMY AND ASTROPHYSICS"
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Type III events, flares and CMEs, in the extremely active period October-November 2003

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Abstract. The type III observations trace the propagation of energetic electron populations through the Solar Corona which, more often than not, precede or are associated with energy release on the Sun. A sample of Type III bursts in the range 20–650 MHz during the period of extraordinary solar activity (20 October to 4 November 2003) recorded by the ARTEMIS–IV[1] radio spectrograph is analysed; its parameters are compared with characteristics of associated flares (Ha and GOES SXR) and CMEs, observed in the same period and reported in the SGR and the LASCO archives respectively. In this report we attempt to establish a correlation between energetic particles and major manifestations of solar activity such as flares and CMEs.

Keywords: Solar activity; Corona; Radio; Radiation and spectra; Solar electromagnetic emission; Flares
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INTRODUCTION

The active period from 20 October to 5 November 2003 has attracted considerable attention ([3], [5], [6], [4], [7], [8]) because of its abundance in of powerful flares and large coronal mass ejections (CMEs) as well as by strong space weather disturbances. Although within the descending phase of the solar cycle the intensity of the solar activity has been dramatic, culminating with the X17.2 flare of October 28, 2003 and the X28/3B flare of the 4 November 2003, one of the more powerful flares ever detected. This activity was associated with the appearance of a global complex consisting of three large, remote but connected active regions (AR): AR 484 (Carrington coordinates, N04; L = 354), AR 486 (S15; L = 283) and AR 488 (N08; L = 291) (cf. [3]).

The large number of flares, CMEs and radio bursts during this period, has provided a data set adequate for an initial study on the association of CMEs and flares with type III radio bursts. The importance of the radio bursts of the type III family in the

[1] Appareil de Routine pour le Traitement et l' Enregistrement Magnetique de l' Information Spectral

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study of energy release processes is two fold: Firstly, the electron beams exciting the type III radio emission, stream along the coronal magnetic lines, thus tracing magnetic structures; secondly the study of these suprathermal electron populations is of interest because it is directly associated with particle acceleration mechanisms in the lower corona. In this paper we present a study with emphasis on the relationship between the

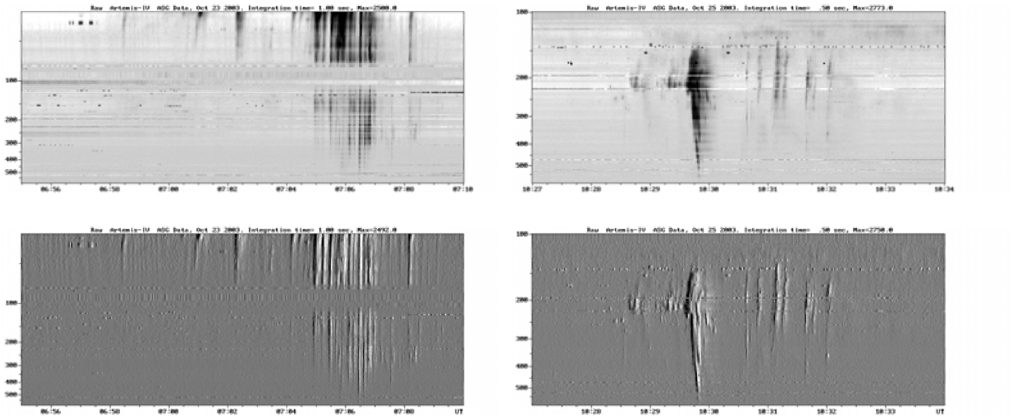

FIGURE 1. ARTEMIS–IV recordings of type III groups; The upper panels are intensity dynamic spectra, the lower are differential spectra. Left: A type III group 23 October 2003 06:55–07:10 UT; it was found associated with an M class SXR flare and a CME. Right: A type III group 25 October 2003 10:27–10:34 UT; it was found associated with an M class SXR flare without accompanying CME.

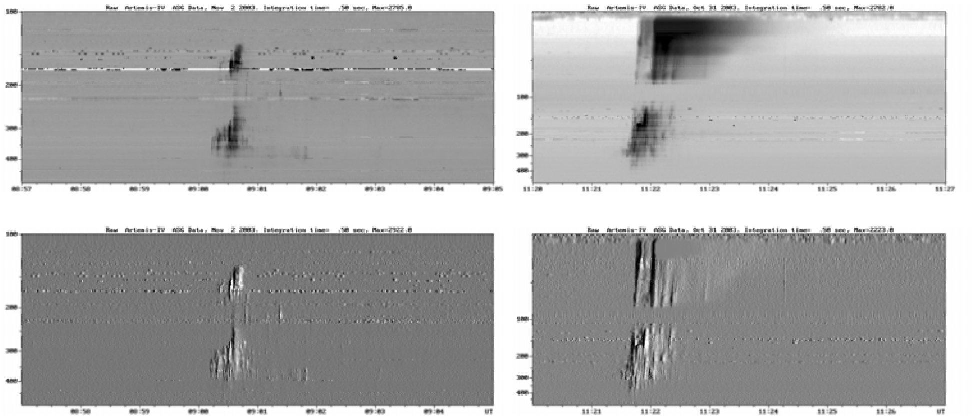

FIGURE 2. Same as 1 but for the Type III Groups: Left: Event 2 November 2003 08:55–09:05 UT with pronounced fundamental–harmonic structure; it was asociated with a halo CME without SXR flare. Right: 31 October 2003 11:20–11:30 UT; it was neither CME nor SXR flare associated.

metric solar type III radio bursts and coronal mass ejections (CMEs), and SXR flares.

DATA ANALYSIS & RESULTS

Our data set, covers the the period of intense solar activity from 20 October to 5 November 2003 and includes:

- Observations of the III metric radio bursts tabulated recorded by ARTEMIS–IV radiospectrograph ([1], [2]); it provides dynamic spectra in the frequency range

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20–650 MHz, ie. from the base of the corona to two Solar Radii, at 10 samples per second. This is our primary data list and comprises 206 type III bursts and groups. Although from the dynamic spectra we cannot deduce the position of the bursts on the disk, we have assumed that the emission orginated near the position of the associated flare.

- SXR (GOES) and Ha flare observations, from SGD[2]. In our study, we establish their temporal association with type III activity, using a time window of one minute.
- CMEs selected from the LASCO lists on line[3] ([9]). The CMEs were characterised as type III associated when recorded half an hour before and after the burst. They were, furthermore, examined for spatial assocition with the type III burst; this association was established if both were on the same quadrant of the disk.

The recorded type III bursts were separated into four categories, as follows:

1. *Type III with flare and CME*: Five only events were found temporally associated with an SXR flare and a CME; of these only two are spatially correlated.
2. *Type III with flare and without CME*: Twenty two events were closely associated with a flare, but not with a CME
3. *Type III without flare but with CME*: Five only, type III radio events were closely associated with a CME, but not with a flare
4. *Type III without flare and without CME*: For most of the type III radio events (173) neither a flare, nor a CME was recorded in the time window introduced for the association in our study. We note, however, that,in 111 of these bursts, considerable SXR enhancements have been observed, in the GOES recordings, which were not included as flares in the NGDC archives.

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DISCUSSION & CONCLUSIONS

Our analysis is affected by the two time windows for Type III–flare & Type III–CME association respectively; it is tacitly affected, further more, by the threshold for the inclusion of an SXR enhancement in the NGDC archive or not. We are, hence, to expect, some uncertainty due to the compromise between rejection of significant correlations and inclusion of spurious ones, as it is the case with threshold based processes.

The results of this study point out that the number of type III events exceeds significantly the number of CMEs and flares recorded. This implies that even minor energy releases, and small flares may result in *runaway* suprathermal electron populations which excite type III bursts. Therefore the statistics of this report are deemed inconclusive. The importance, however, of the analysis of the energetic electron populations streaming within magnetic structures during the *liftoff* of CMEs or the onset of flares remains since they may provide indication about the magnetic structure, and the commencement

[2] http//www.sel.noaa.gov/ftpmenu/indices
[3] http://cdaw.gsfc.nasa.gov/CME list

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of the magnetic reconnection. In the latter case, the examination of type III activity may complement the study of the type IV fine structure.

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