Groups of solar type III bursts associated with CME events at decameter wavelengths

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INTRODUCTION

We report on observations of solar type IV bursts and their precursors, namely groups of type III bursts, in the frequency range of 8 – 33 MHz. Type IV burst, which represents CME at radio frequencies, is a complex event. These phenomena are observed with a fine structure in the form of fiber bursts and with different accompanying events, such as solar type II bursts or type III bursts, or both of the former. At decameter wavelengths we consider accompanying events, which appear in about 30 minutes before type IV burst, as precursor events. We suppose, these events occur from a single active region as a result of a particular flare.

OBSERVATIONS

Solar type IV bursts and the related events discussed in the present work were observed in 2011 and 2012 within the frequency range of 8 – 33 MHz, which corresponds to heights in solar corona from 1.5 to 3 solar radii. For the observations three sections of the ground-based radio telescope UTR-2 (Kharkiv, Ukraine) with total effective area of 30000 m^2 were used. It provides the «pencil» beam of about 1^0 x 13^0. Registration of solar radio emission was carried out using digital spectral receiver DSP-Z with time resolution of 100 ms and frequency resolution of 12 kHz. For analysis of selected events additional data from SOHO, STEREO, Wind/WAVES and GOES were used.

RESULTS

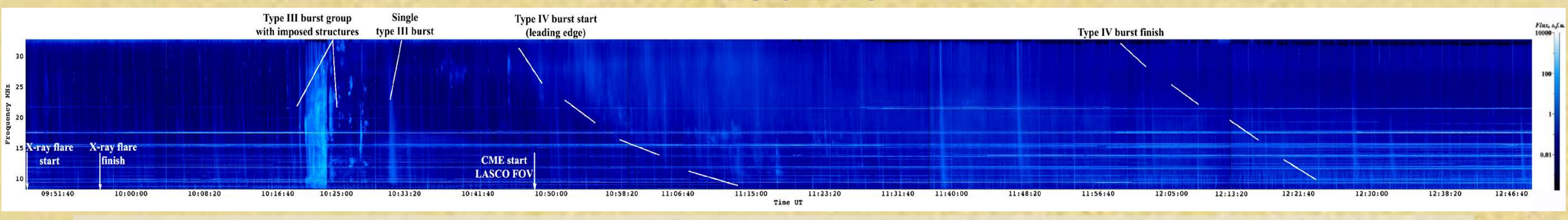

Fig.1. Dynamic spectrum of 8 July 2012 event observed with the radio telescope UTR-2 in the frequency range of 8 – 33 MHz

For this study we chose days when groups of solar type III bursts were observed before solar type IV bursts and a type IV burst was seen from the beginning to the end. Selected days are:
2 August and 9 August 2011, 6 July, 8 July and 31 July 2012. Dynamic spectra of solar events, i.e. the intensity as function on both time and frequency were analyzed. Example of a dynamic spectrum for 6 July 2012 is presented in Fig.1.
We tried to find functional dependencies between groups of type III bursts and type IV bursts comparing the same parameters of events. Table 1 gives information about duration and flux for type III bursts and type IV bursts, active regions where CME originates, and angular width and velocity of CMEs for selected days. Total flux for type III burst group is calculated as a sum of products of flux and duration for each burst in the group. All types of durations and fluxes are defined at frequency 22.5 MHz. At this particular frequency the statistics of events for all chosen days was the highest. For each CME its position and velocity are determined at heights close to 1.5 – 2.5 solar radii.

Date	Type III bursts parameters		Type IV bursts parameters		CMEs parameters*	
02.08.2011	Burst number	4			Active region number (NOAA) and position	1261 N17 W12
	Average flux multiplied by burst number, s.f.u.	897	Average flux, s.f.u.	104	Class of X-ray flare, corresponds to CME	M 1.4
	Total flux, s.f.u.	8815	Total flux, s.f.u.	588103	CME position	N15 W12
			Velocity, km/s	890	Velocity, km/s	850
	Group duration, s	510	Duration, s	6784	Angular width, deg	268
09.08.2011	Burst number	6			Active region number (NOAA) and position	1263 N14 W69
	Average flux multiplied by burst number, s.f.u.	2587	Average flux, s.f.u.	115	Class of X-ray flare, corresponds to CME	X 6.9
	Total flux, s.f.u.	34421	Total flux, s.f.u.	1001487	CME position	N9 W69
			Velocity, km/s	1400	Velocity, km/s	1800
	Group duration, s	94	Duration, s	8421	Angular width, deg	360
06.07.2012	Burst number	14			Active region number (NOAA) and position	1515 S18 W41
	Average flux multiplied by burst number, s.f.u.	5036	Average flux, s.f.u.	12	Class of X-ray flare, corresponds to CME	C 3.8
	Total flux, s.f.u.	101076	Total flux, s.f.u.	1780228	CME position	S41.3 W41
			Velocity, km/s	850	Velocity, km/s	825
	Group duration, s	2229	Duration, s	9093	Angular width, deg	63
08.07.2012	Burst number	7			Active region number (NOAA) and position	1515 S16 W70
	Average flux multiplied by burst number, s.f.u.	1172	Average flux, s.f.u.	16	Class of X-ray flare, corresponds to CME	M 1.1
	Total flux, s.f.u.	2638	Total flux, s.f.u.	116128	CME position	S8 W70
			Velocity, km/s	630	Velocity, km/s	620
	Group duration, s	806	Duration, s	7258	Angular width, deg	61
31.07.2012	Burst number	6			Active region number (NOAA) and position	1535 N16 E64
	Average flux multiplied by burst number, s.f.u.	7134	Average flux, s.f.u.	42	Class of X-ray flare, corresponds to CME	C 5.7
	Total flux, s.f.u.	56616	Total flux, s.f.u.	93786	CME position	N29.6 E64
			Velocity, km/s	590	Velocity, km/s	690
	Group duration, s	996	Duration, s	2603	Angular width, deg	360

* http://cdaw.gsfc.nasa.gov/CME_list/; http://www.lmsal.com/solarsoft/latest_events_archive.html

Table 1. Parameters of type III bursts, type IV bursts and corresponding CMEs for chosen days.

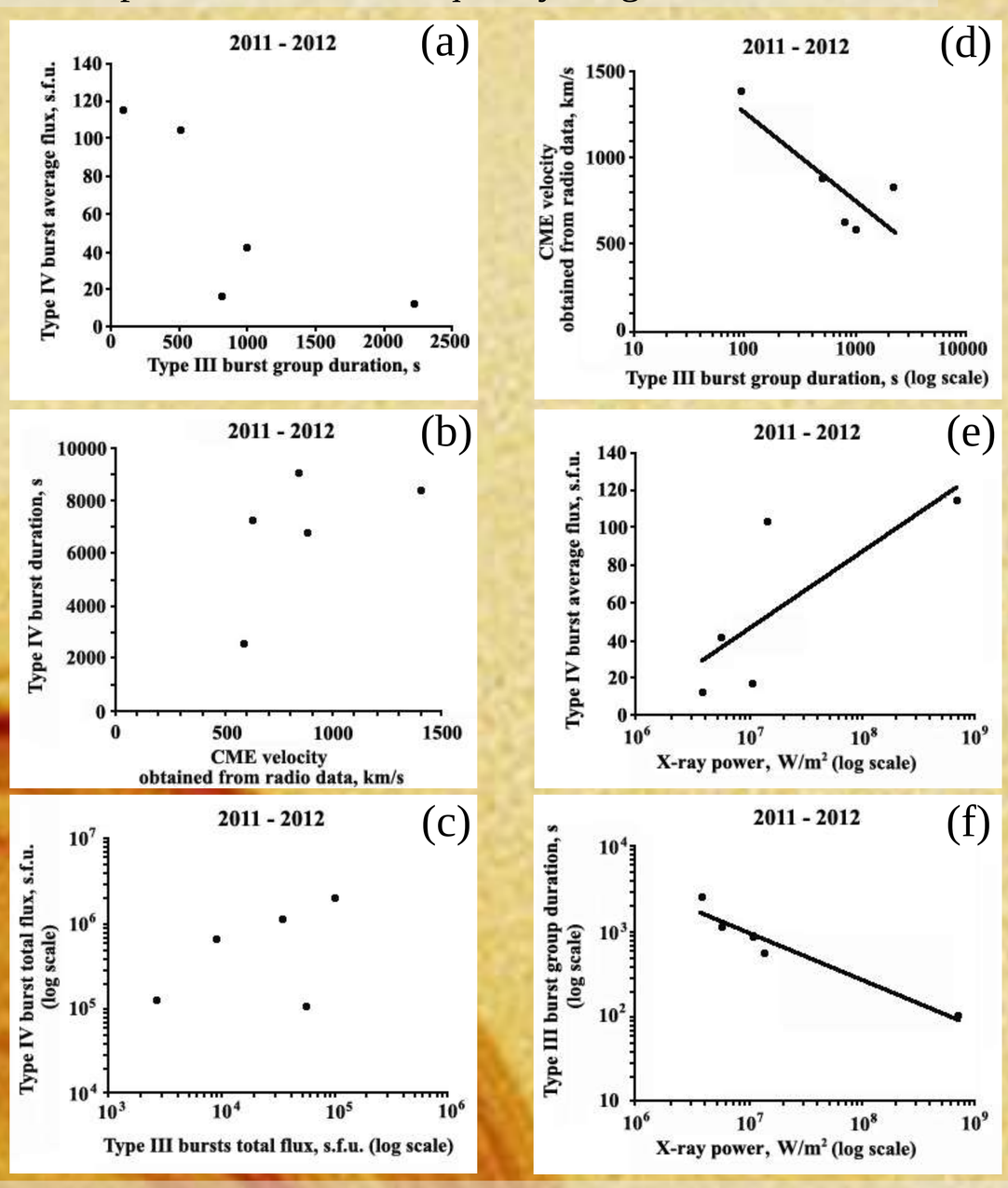

Fig.2. Dependencies of (a) type IV burst average flux on type III burst group duration, (b) type IV burst duration on CME velocity obtained from radio data, (c) type IV burst total flux on type III bursts total flux, (d) CME velocity defined from radio data on type III burst group duration, (e) type IV average flux on power of X-ray flare, (f) duration of type III burst group on power of X-ray flare for 5 chosen events. Lines for (d), (e) and (f) represent possible function approximation.

For five chosen events we looked for possible connection in parameters between groups of type III bursts, type IV bursts, CMEs corresponding to these events and X-ray flares. In Figure 2 the most significant results are presented. As it is seen, durations of type III bursts groups connect both to average flux of type IV (Fig.2a) and CME velocity (Fig.2d) obtained from radio data. The longer a type III bursts group lasts, the weeker and slower a type IV burst is observed. Another interesting result is the dependence of both type IV burst average flux (Fig.2e) and duration of type III bursts group (Fig.2f) versus power of X-ray flare. The more powerful is an X-ray flare, the stronger a type IV burst appears, and the shorter a type III bursts group precedes a type IV burst. In all these dependencies durations of type III bursts groups and average fluxes of type IV bursts appeared. We assume, these particular parameters should be primarily analyzed for possible forecast of type IV burst appearance at decameter wavelengths.

CONCLUSIONS

In the present study solar observations with high frequency and time resolution carried out with UTR-2 radio telescope were used to search for possible precursors of CMEs at decameter wavelengths. We considered as a possible precursor a solar type III burst group observed within about 30 minutes before the type IV solar radio burst. Functional dependencies for different parameters of type III bursts, type IV bursts, CMEs and X-ray flares were found.

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