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Multiple Large-scale MHD Shocks Related Radio Emission at Decameter Wavelengths

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Abstract. We present here preliminary results on the shock characteristics of doublet type II radio bursts and their association with flares and /or CMEs.

1. Introduction

Type II radio bursts were first discovered by Wild & McReady (1956) from the dynamic spectra of solar radio bursts and the detailed description of the characteristics of type II bursts are given in Nelson & Melrose (1985) and Gopalswamy (2001). The slow drift rate ($\leq$ 0.5 MHz/s) of the type II bursts were sugggested due to MHD shock waves by Uchida (1960). Multiple type II bursts which occur in sequence were reported by Robinson & Sheridan (1982) and Klassen et al. (1999). The study of multiple type II bursts are important from the point of whether they are caused by multiple shocks generated by flares and (or) CMEs. We present here some preliminary results on the shock speed characteristics of the doublet type II radio bursts in which two type II bursts occur in sequence. We also look into their association with flares and CMEs.

2. Data Analysis and Results

The data for the present study were taken from the Solar Geophysical Data (SGD) for the period July 1994 - July 2004 and from the recently constructed high time and frequency resolution Gauribidanur radio spectrograph (Ebenezer et al. 2001). Figure 1 shows a typical example of a type II doublet observed with the Gauribidanur radio spectrograph, in which two type II bursts can be seen with a time difference of approximately 10 min. The first type II burst starts above 130 MHz where as the second burst starts at a lower frequency (100 MHz). Both the bursts show fundamental and harmonic structure. These bursts were also seen at still lower frequency of upto 25 MHz as reported by the Bruny Island spectrograph. Figure 2 shows the dynamic spectrum of the doublet type II burst observed by Bruny Island spectrograph in the frequency band 10-60 MHz. One can see type III groups before each of the type II bursts at 04:30UT and at 04:46UT in the Gauribidanur dynamic spectra which are the signature of flares.

The doublet type II burst analysed in this paper were reported by CULG (Culgoora), SVTO (San Vito), HOLL (Holloman), LEAR (Learmonth), PALE (Palehua) and SGMR (Sagamore) Solar Radio observatories. We have taken the data only for the type II doublets for which the Estimated Shock Speed (ESS)

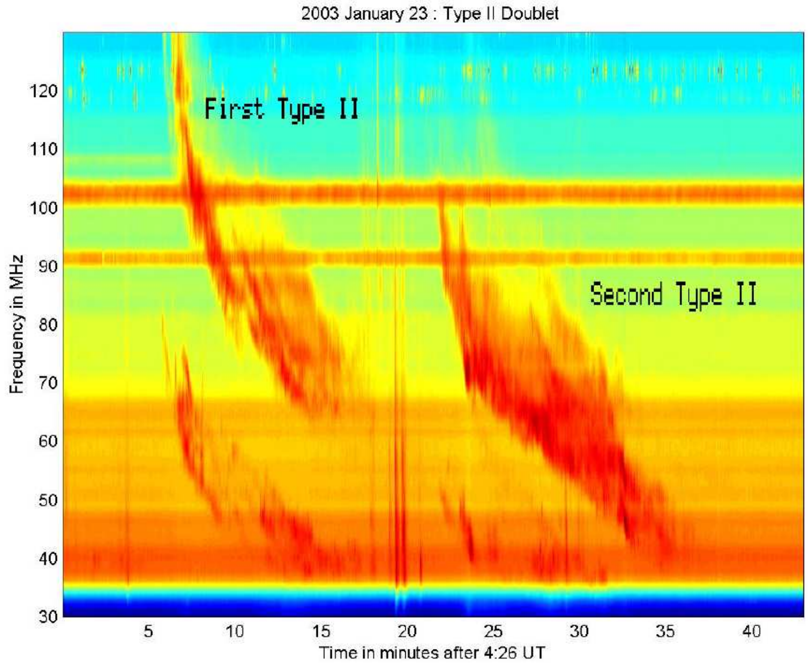

Figure 1. Dynamic spectrum of the type II doublet observed on January 23, 2003 showing fundamental and harmonic. The harmonic of the first type II starts at 04:33 UT and the harmonic of the second type II starts at 04:49 UT.

is given and the time difference between the onset of the first and the second type II burst is less than one hour. Among the 74 events we have studied, three events showed the time difference between the onset of the burst is above 30 min. In 63 cases, we found the time difference to be less than 15 min.

The mean duration for the first type II burst is approximately 8.8 min and the same for the second type II burst is 9.66 min. Among the 74 events we found 16 events (21%) for which both the bursts showed the same ESS. In 47 events (64%) the ESS of the first burst (ESS1) is found to be greater than that of the second burst (ESS2). In the remaining 11 cases (14%) ESS2 is greater than the ESS1.

From the analysed data, we found that in majority of the cases, the second type II burst starts at a lower frequency compared to the first one. The ESS1 varied from 343 kms^{-1} to 4187 kms^{-1} and for the ESS2 it varies from 200 kms^{-1} to 1800 kms^{-1}. The mean of ESS1 was 987.46 kms^{-1} and that for ESS2 was 674.97 kms^{-1}. Figure 3 shows the scatter plot of the estimated shock speeds of both the type IIs and a linear least-square fit. The weak correlation of 0.0297 between the ESS1 and ESS2 shows that they are not related to each other.

Table I shows the list of 11 events for which the ESS2 is greater than the ESS1. In such cases, the second burst may be due to a high energetic event compared to the first one.

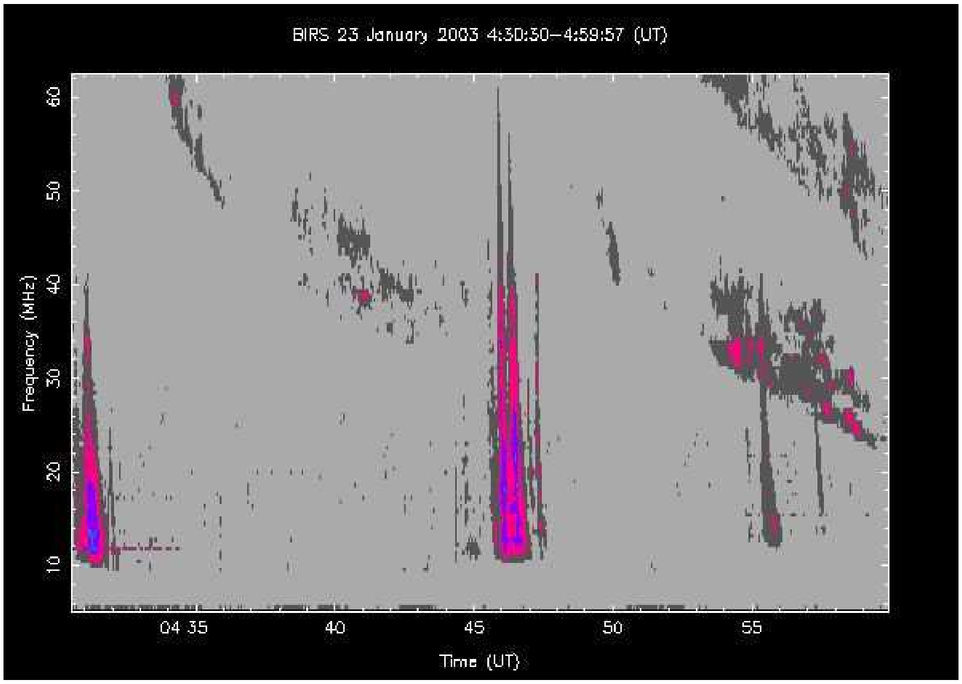

Figure 2. Dynamic spectrum of type II doulet burst obtained by Bruny Island Low frequency spectrograph showing the radio emission of these two type II bursts extending upto 25 MHz and type III bursts upto 10 MHz.

Regarding the association of the doublet type II bursts with flares and (or) CMEs, we found that atleast two flare peak occur in 55% of the cases and the peak time of the flares coincide with the begining of the type II bursts. It is found that 45 cases out of 74 (65%) of the type II doublets are also associted with the onset of CMEs and in that 25 out of 74 are associated with Halo-CMEs.

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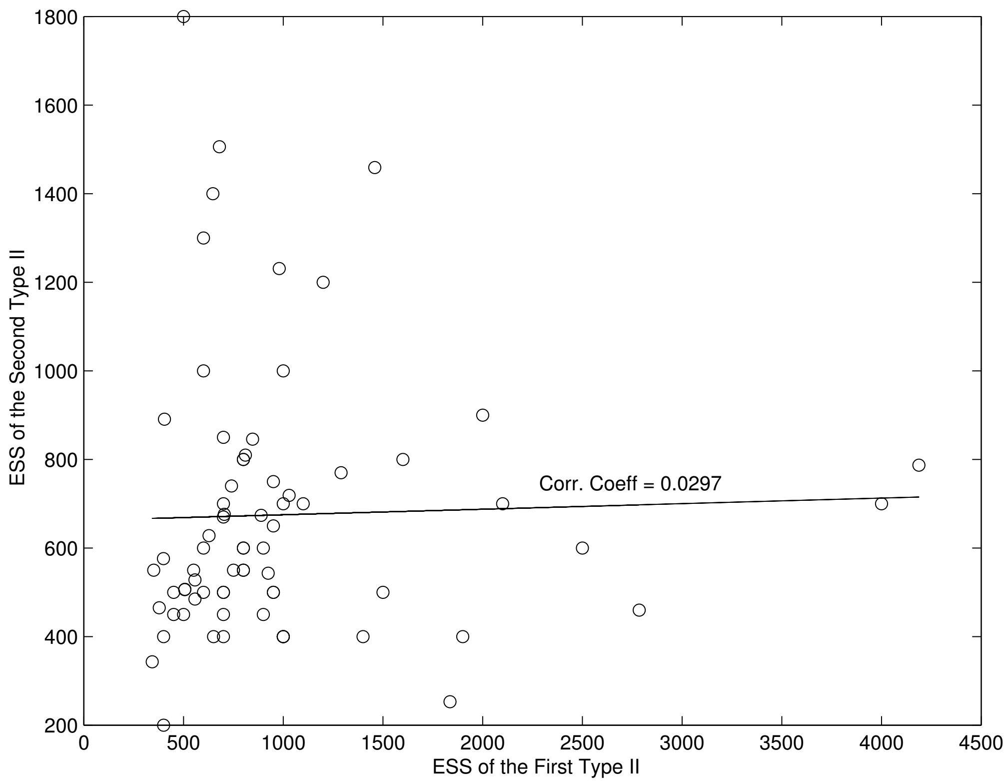

Figure 3. Scatter plot of the estimated shock speeds of the first and second type II bursts of the doublet typeII showing the linear fit with a correlation coefficient of 0.03.

Table 1. This table shows that the estimated shock speed (ESS) of the second type II is greater than the first type II.

Date	Observatory	Time1(UT)	Time2(UT)	ESS1	ESS2
95 Sep 03	CULG FN,SH	00:01	00:08	600	1000
98 Jan 25	CULG SH,H	21:35	21:55	350	550
98 May 08	CULG SH	02:00	02:10	600	1300
98 Sep 23	CULG SH	06:57	07:05	700	850
98 Nov 27	CULG SH	07:33	07:45	500	1800
00 Jun 10	HOLL	16:56	17:16	680	1506
00 Sep 01	HOLL	18:21	18:42	378	465
00 Sep 19	LEAR	08:18	08:19	399	576
01 Apr 11	SVTO	13:03	13:11	980	1231
02 Apr 09	CULG SH	00:44	00:51	450	500
02 Jun 01	LEAR	23:48	00:01	647	1400