A Brief Analysis of Microwave FS Events Observed by BAO in 1991

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Abstract

In this paper, some results of a brief analysis of microwave fine structure (FS) events registered by BAO at 2840 MHz in 1991 are presented. It has been shown that the time scales of most of FS events are between tens of msec and hundreds of msec, and the amplitudes of them are less than 200 s.f.u.

I. Introduction:

The significance of microwave msec bursts, or microwave FS events, for the diagnosis of the physical processes in solar flares and the physical conditions in plasma source region of solar flares has been recognized by solar physicists for a long time [1] [2]. The valuable qualitative observations of microwave msec bursts at 2840 MHz with a simple fast sampling equipment were made by the group of BAO from 1981 to 1983 [3] [4]. In the June of 1989, this equipment was improved and renewed. Since the August of 1990, a patrolling msec- observation with high reliability started to work. A number of microwave bursts' data with high quatity and high time resolution have been registered.

Some results obtained by statistical analyses of the data mentioned above, are presented in this paper.

II. Observations:

During the patrolling observation period of 348 days (2592 hours) in 1991, 602 microwave bursts at 2840 MHz were recorded, FS were found in 45 out of 602 bursts, and the ratio was about 7.5%. But for the observations during the interval between April of 1981 and June of 1983, this ratio was 17.5 %. Table 1 lists the whole FS events observed by BAO in 1991.For some of them, FS only appeared in one section, but for others, in more than one section. For whole 45 events, there appeared 93 sections of FS. It provides us a more completed FS event cluster of this solar maximum period. Firstly, we made analyses from some statistical features of the FS event cluster.

III. Distribution features of FS events:

1. Distribution of time scales:

For each FS section, we take the least time duration of single pulses as the time scale of the FS section Δ T. The distribution of time scale of FS section is shown in Table 2.

Table 2. Distribution of time scale

Δ T	< 10 msec	10~100 msec	100~1000 msec	1~3 s
%	3.2	20.5	46.2	30.1

2. Intensity distribution of spikes:

For each FS section we take the largest intensity of single spike as the spike intensity of the FS section ΔF. The distribution of spike intensity of FS sections is shown in Table 3.

Table 3. intensity distribution of spikes

ΔF	< 50sfu	50~ 200 sfu	200~500 sfu	> 500 sfu
%	48.3	38.2	7-9	5.6

3. Intensity dibtribution of associated microwave bursts:
The results are shown in Table 4, here Δs is the peak flux density of burst.

Table 4. Intensity distribution of associated microwave bursts

ΔS (sfu)	< 100	100~ 500	500~ 1000	1000~ 2000	≥ 2000
1) number of FS events	3	22	8	5	7
2) Distribution of FS events (%)	6.7	48.9	17.8	11.1	15.5
3) Total number of microwave bursts	500	65	15	7	10
4) Appearance rate of FS event (%)	0.6	33.8	53.3	71.0	70

Line 3 indicates the total number of microwave bursts observed by BAO in 1991. Line 4 represents the ratio of 1) to 3). It is clearly shown that the appearence ratio of FS events increases with the peak flux density of microwave bursts.

4. The relationship between FS and the phase of microwave bursts (MB):

Table 5.

phase of MB	before peak time of MB	peak time ($\pm 5^s$)	post-peak
%	38.2	19.8	42

Table 5 shows the distribution of FS sections with the phase of associated MB. It seems to be that no obvious relation between them. But it is undoubted, that the FS appearing in the phase before peak time and of peak time are stronger and more crowded.

5. The relation between FS events and H alpha flares:

Table 6. FS events Vs.Imprortance of associated flares and Vs. type of associated flares

Imp. of flare	S	1	2	3	Type of flare	F	N	B
%	13.3	37.8	33.3	11.1	%	6.7	26.7	62.2

Table 6 shows the distribution of FS events with importance of associated flare. And the flares with type B are mostly associated with FS, and most significant for research on FS phenomena.

IV. Discussion.

From the analyses mentioned above, somethings should be pointed out:

1. The change of appearance rate of FS events in different solar active cycle:

From Table 7, it seems likely, not only for fixed frequency observations but also for spectral observations, that the appearance rate of FS events in the 22nd solar maximum period is quite lower than that in 21st period. Whether, it results from the different characteristics between the 21st and 22nd solar maximum period.

2. Time scale and characteristic intensity of FS:

From Table 2, in about half of FS events, the time scale Δ T are some hundreds of msec; some tens of msec in about one fifth; and some of msec in only a few percent. These results consist with those of G *ü*del and Benz (1990) [8]. Possibly, the FS with different time scale are the manifestations of distinct kinds of fast process, such as microwave type III bursts, microwave spike emission and so on. For further analysis radio spectral observations with higher time resolution should be made.

Table 7.

Authors	Frequency (GHz)	Time period	.appearance rate of FS events (%)	references
Fu. et al.	2.84	1981-1983	17.5	[3]
Stä hli and Magun	3.2	1980-1982	13.4	[5]
Allaart, et al.	4-8.0	1982-1983	30	[6]
Brugymann	6.0-8.0	1988-1989	17.4	[7]
Fu, Zhao and Liu	2.84	1991	7.5	in this paper

From Table 3, Characteristic intensity of 86 % of FS events is less than 200 s.f.u. The largest pulse is about 2000 s.f.u. This result is quite different from that of Jin, et al (1986) [4], and Slottje (1978) [9]. Does it result from the feature of the 22 nd solar active maximum period ?

3. Intensity of associated microwave bursts:

From the first line of Table 4, almost half of FS events are in the range of 100 $\sim$ 500 s.f.u. But from the last line, it is obvious that the appearance of FS increases quickly with intensity of associated bursts. It is only 0.6 % in the range of less than 100 s.f.u., but the rates inclease quickly up to 70 % in the range of more than 1000s.f.u.

4. Table 5 shows that the appearance of FS has no obvious relation with the phase of bursts.

But, it is undoubted, that the FS appearing around impulsive phase should be more intense. Certainly, there are some processes which can product fast FS phenomena in the declining phase of bursts. For example, tremendous change of magnetic field topology happens when small loops with rapid rising speed interact with preexisting post-flare loop system, as found by Fu, et al. (1993) [10].

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Reference

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Table 1. List of Radio Millisecond Spike Bursts (BAO 2840MHz)

NO.	Date	msec–Burst			sec–Burst			
		HHMMSS	Int	time scale	Start	Max.	End	Int
	1991.		SFU /%		(UT)	(UT)	(UT)	SFU / %
1	Jan.8	0429:57.07			0357.0	0429.7	0451.0	712/299
		-04:29:57:45	114/48	10-60ms				
		04:29:21						
		–04:30:14	30/13	2-3 s				
		04:32:32.7						
		-04:32:32.9	64/34	200ms				
2	Jan.25	06:50			0629.0	0639E		
		–07:22	160/56	1-5 s		0722D	0755.0	1123/393
		06:53:02						
		–06:53:42	80/28	50-600ms				
3	Jan.31	01:55:13.0			0153.0	0204.3	0453.0	821/202
		–01:55:35.2	30/8	1.5-3 s				
		01:58:56.6		400				
		–01:59:18	110/28	-800ms				
		02:00:29						
		–02:04:39.7	73/19	0.4-1 s				
4	Feb.6	06:46:15			0644.0	0646.5	0704.0	355/153
		–06:46:34	53/22.8	1-4 s				
5	Feb.8	02:48:11			0236.0	0248.1	0258.0	184/85.8
		–02:48:32	19/8.7	3-5 s				
6	Mar.5	02:22:50			0218.0	0222.9	0232.0	73/29.6
		–02:22:57	57/23	2-3 s				
7	Mar.5	06:18:37			0606.0	0618.9	0631.0	88/35.4
		–06:18:52	33/13.3	1.8 s				
8	Mar.6	07:41:00			0737.0	0742.6	0800.0	983/401
		–07:41:00.5	34/13.8	30 ms				
9	Mar.11	07:32:34			0726.0	0733.3	0742.0	196/76.6
		–07:33:29	22/8.5	0.5-1 s				
10	Mar.13	02:59:05			0249.0	0302.1	0400.0	198/74
		–03:04:20	130/48.6	0.5-1 s				
		03:00:10						
		–03:00:20	40/15	270 ms				
11	Mar.13	07:31:58			0728.0	0732.8	0742.0	136/50.9
		–07:32:48	62/23	0.5-1 s				
		07:35:58						
		–07:37:51	59/22.1	1.5 s				
12	Mar.19	01:57:15			0156.6	0158.0	0202.0	1255/417
		–01:57:53	38/12.6	0.1 s				
13	Mar.21	08:15:52.8			0809.0	0815.5	0836.0	209/75
		–08:15:55	42/15	0.5 s				
14	Mar.24	02:52:48			0236.0	0244.2	0258.0	221/73
		–02:53:06	47/15.6	50-100ms				
		02:44:05						
		–02:44:12	140/46	100ms-1s				
15	May.10	01:47:09			0126.0	0147.2	0200.0	575/193
		–01:47:27	270/91	50-100ms				
		01:54:00						
		–01:55:26		40 ms				
16	May.16	06:41:00		50,380ms	0631.0	0646.9	0907.0	3041
		–06:49:00	900/400	3ms 1.5s				/1352
17	May.17	04:18:00			0415.0	0419.7	0428.0	237/112
		–04:21:15	84/39	2 s				
18	May.31	04:03:15			0353.0	0406.1	0423.0	201/81.7
		–04:04:17	7/3	1.5 s				
19	Jun.4	06:14:41			0604.0	0614.8	0634.8	160/53.1
		–06:14:48	153/50.8	30-40ms				

20	Jun.4	03:44:00 –03:46:00 03:47:52 –03:49:40		Oscil.4s Oscil.4s	0337.0	0348.2	0618D	7719 /2490
21	Jun.6	01:09:41 –01:09:41.8 02:11:58 –02:12:01 02:12:29 –02:07:09	1880/690 90/33	50 ms 50 ms –8.7 s	0051.0	0105D	0634.0	14000D /5140D
22	Jun.9	01:36:49 –01:36:54 02:11:16 –02:11:26 02:28:26 –02:28:28 02:31:56 –02:34:22 02:36:00 –02:41:20	602/206 139/47.6 55/19 213/73 290/27	50 ms 40 ms 150 ms 32 ms 60 ms	0135.0	0139.6 0239.0	0406.0	8545 /2916 4522 /1543
23	Jun.10	02:28:40.2 –02:28:42.4 02:29:00 –02:29:06 02:29:16.25 -02:29:23.65	1195/385 217/70 93/30	400 ms 40 ms 400 ms	0226.0	0228.8	0232.0	492/293
24	Jun.12	07:06:09 –07:07:06	340/104	3-6 s	0704.0	0706.3	0708.0	358/110
25	Jul.7	02:01:42 –02:04:36	142/45.2	530ms-2s	0141.0	0154.2	0230.0	1176/376
26	Jul.17	06:42:41 –06:43:03	102/52	1.7 s	0619.6	0627.6	0657.0	1000/505
27	Jul.30	07:07:07 –07:07:13 07:07:18 –07:07:20.5	20/7.8 164/64	100 ms 100 ms	0704.0	0707.5	0714.0	468/184
28	Jul.31	00:50:53 –00:51:08 00:51:22 –00:51:42	124/46 75/28	0.1-1 s 1 s	0045.0	0049.8	0141.0	743/277
29	Jul.31	03:15:37 –03:16:37	42.8/16	10-100ms	0310.0	0316.9	0320.0	32.5/12
30	Aug.2	03:12:32 –03:12:49 03:13:11 -03:13:15.49 03:15:38 –03:16:02 03:19:35.8 -03:19:49.98	79/35 30/13.3 80/38 39/17	600 ms 150 ms 150 ms 50-100ms	0301.0	0312.7	0419.0	428/187
31	Aug.3	01:22:03 –01:22:20	22/9.2	Three peaks	0120.0	0122.3	0135.0	523/216
32	Aug.5	05:28:08 –05:28:21 05:28:21 –05:29:00	40/18.9 110/50	130 ms 1 s	0528.0	0528.4	0636.0	368/174
33	Aug.25	00:52:05.7 –00:56:34	669/211	5-300 ms	0033.0	0053.1	0240.0	3440 /1085
34	Oct.27	02:08:37.4 — 02:08:59.2 –02:09:00	33/11 25/8.2	0.1 s 60 ms	0204.0	0209.3	0212.0	233/76.4

35	Oct.27	05:41:30 –05:42:20	387/127	2-3 s	0505.0	0542.2	0616.0	4454 /1460
		05:42:40 –05:43:10	184/60	1 s				
		05:45:44 –05:45:50	59/19	sub-sec				
		05:51:34 –05:55:34	94/31	ten-sec				
		05:56:34 –05:58:00	146/47.9	ten-sec				
36	Oct.30	06:15:33.94 +10s	16/5	1-3 s	0600.0	0619.8	0730.0	3677 /1171
		06:17:54.80 +0.5s	46/14.5	0.1-0.5s				
		06:18:54 –06:22:08	21/6.7	0.1-1 s				
		06:35:42 –06:35:50	22/7	0.5-0.8s				
		06:36:38 –06:36:41.5	52/16.6	0.1-0.3s				
		06:39:30 –06:39:51.5	23/7.3	0.1-0.3s				
37	Nov.6	04:44:38 –04:47:48	36/18	1-2 s	0440.0	0449.2	0520D	1014/515
38	Nov.10	01:26:39 –01:26:40.5	9/4	0.5 s	0118.0	0128.4		239/106
		01:28:20 –01:28:28	30/13	0.1-0.5s		0136.7	0146.0	190/84
39	Nov.10	06:48:20.5 –06:48:22.5	26/11.6	0.3-1.0s	0646.0	0650.2	0657.0	150/66.7
		06:48:31.8 –06:48:35.8	16/7	0.1-0.2s				
		06:50:07 –06:50:13	10/4.4	1 s				
40	Nov.17	01:57:44.2 –01:57:46.1	29/16.1	0.2 s	0155.2	0158.1	0218.0	807/448
		01:57:57 –01:57:58.4	11/6.1	1.2 s				
		01:58:26 –01:58:28	23/12.8	1 s				
41	Nov.30	03:45:25 –03:45:27.5	68/38.6	0.1-0.2s	0337.0	0345.2	0355.0	321/183
		03:45:34 –03:45:36	49/27.8	0.2 s				
		03:45:59.8 –03:46:01.2	11/6.2	1.5 s				
		03:46:13.8 (peak)	11/6.2	1.5 s				
		03:46:27.8 –03:46:29.2	17.2/9.8	1.5-2.0s				
		03:47:32 –03:49:20	48/27.3	0.16-1s				
42	Dec.13	03:50:51 –03:53:21	16/6	Oscil. 16-17s	0340.0	0354.2	0430D	422/159
		03:55:12 –03:55:15.1	31/10	3 s				
43	Dec.14	01:03:49 –01:03:54.4	10/8	1 s	0045.0	0103.6	0111.0	178/68.2
44	Dec.17	06:23:52 –06:24:23	365/168	0.1-1 s	0616.0	0623.9	0640.0	576/265
45	Dec.26	06:34:11 –06:34:53	24/8	0.2-1.0s	0630.0	0634.4	0652.0	307/108