CORRELATION BETWEEN SOLAR MICROWAVE BURSTS AND HARD X-RAY FLARES

Q. Fu [1] , Y. Liu [1] , and C. Li [2]

[1] *Beijing Aastronomical Observatory, Chinese Academy of Sciences, Beijing 100080, China*
[2] *Department of Astronomy, Nanjing University, Nanjing 210008, China*

Abstract

The solar microwave bursts with fine structures (FS) at 2.84GHz observed at BAO have been compared with hard X-ray flares recorded with YOHKOH satellite from Oct. 1991 to Dec. 1992. It has been found that during this time interval 12 out of 20 microwave FS events associated with HXB recorded with YOHKOH satellite. The typical are June 7,1992 and April 1, 1992 events. A brief discussion is presented.

1. Introduction

Much attention has been given to the correlation between solar microwave bursts and hard X-ray flares. In particular microwave bursts with FS have close correlation with hard X-ray flares. Now it is widely accepted that acceleration of electrons is a basic feature of the impulsive phase and main process of evergy release in a solar flare. Non-thermal electrons are believed to emit microwave emission by gyro-synchrotron mechanisms in high chromosphere and lower corona and to radiate hard X- ray by bremsstrahlung when electrons precipitate into and impact the roots of loops. For the radiation of microwave FS, such as spike and microwave type III bursts, electron cyclotron maser instability to be caused by energetic electron beam is today's most favored process for spike radiation. The relationship between microwave FS and hard X-ray bursts is still a attractive title for solar physicists. Benz and Kane (1986) made a correlation study between dm (100–1000MHz) type III spike (data with 0.1 sec time resolution) and HXR bursts. There is a close correlation between type III spike and HXB, but there are considerable discrepancies in a peak-to-peak comparison. Takakura et al. (1983) found correlated subsec time structures at hard X–ray and at mm- λ for the first time.

In this paper, we will present some 10cm- λ microwave bursrs with FS associated with hard X-ray flares recorded by YOHKOH. A typical event on June 7, 1992 will be disscussed.

2. Observations

The radiotelescope with fast sampling at 2840 MHz of BAO was improved and renewed in the June of 1989. Since the August of 1990, patrolling msec-observation with a real time distinguishing system and high reliability started to work. After the September of 1991, a new observing mode, which is capable of continuously sampling with 10 msec time constant and changing to the mode with time constant of 1 msec or 5 msec if it is necessary, came into opseration. A number of microwave bursts data with high quality and high time resolution have heen registered. During the time interval of 1991 and 1992, 45 and 8 microwave bursts with FS were recorded respectively .

3. Comparison between microwave FS events and hard X-ray flares

Making comparison of microwave FS events at 2840 MHz of BAO with hard X-ray flares published on " the YOHKOH HXT DATABOOK (I) " (YHD) during time interval from Oct.1991 to Dec.1992, the results are shown in Table 1. 12 out of 20 microwave FS events found their corresponding HXB on YHD, the corresponding rate is 60 % , while the corresponding rate for microwave bursts is 112/423 =26.5 %.

4. The event of June 7,1992

The event of June 7, 1992 occurred at active region NOAA No. 7186 with M2.7/2B is an energetic event. Figure 1 shows its time profile at 2840 MHz. This burst started at 0135UT, peaked at 0143.1UT and lasted about 50 min. The peak flux density is 202 sfu. A type II burst occurred at 0148UT, five minutes after the peak time at 2840 MHz. From Fig.1 it is obvious that there are at least 10 pulses superimposed on the slow change background. The periods of the qusai-period pulses between part A (rising phase and the peak time) and part B (decending phase) are different. Fig.2 and Fig.3 show the FFT of part A and part B with 1sec data respectively. Some major Fourier components are listed on the right upper corner of Figure.

Figure 4 shows the comparison between radio and HXB of June 7, 1992 event. It looks very similar between time profiles at 2840 MHz and HXT-L, in particular for part B.

5. Discussion

A close correlation between the time profiles of solar microwave burst at 2840 MHz observed at BAO and hard X-ray flare recorded at YOHKOH stellite on June 7, 1992 was found by the authors. Some peculiar features can be seen from Fig.1 and Fig.4.

1. Peaks of the quasi-periodic pulsations on the time profiles of hard X-ray flares in L band, M1 band and M2 band are closely correlated with those of microwave bursts at 2.84 GHz from 0141UT of June 7,1992 event, in particular for part B of the profiles (the period is about 110 s). At part A, it seems likely, that there are some phase difference between profiles of 2840 MHz and HXR.

2. The quasi-periods of pulsations are shorter before 0143.1UT (part A 20–40 s) than those (>100 s) after it (part B). A wealth of FS with time scale from some tens of msec to 1–2 hundreds of msec were found at part A, but none at part B. It seems that the radiation of part A (rising phase) generated with non-thermal electons, but that of part B did not.

3. The close correlation between the peaks of quasi-periodic pulsations in hard X-ray flares (from L to M2 band) and microwave bursts at 2.84 GHz may be explained as follows: Generally, the HXR flares is accepted as electron bremsstrahlung and microwave bursts as gyro-synchrotron emissions, therefore, these two types of radiation may be considered to be

generated by the same population of non-thermal electrons, trapped in the same magnetic loop, with energies ≥ 52.7 kev. As for quasi-periodic pulsations in these two types of radiation may be due to the MHD oscillation (for example, Alfenic wave) of the magnetic loops. Possibly, the type II burst (starting at 0148UT) play an important role.

4. Under the assuming of Alfven wave mode with quasi-period 107.8 sec found in the part B of 10cm- λ time profile of the event and using formulae in Li et (1993) some parameters of source regions was deduced: $T_e = 1.13\times10^7K$, $N_e = 3.42\times10^{10}cm^{-3}$, *and* $B = 40$ *Gauss*.

It must be pointed out, that digital correlation process between microwave data and HXR data is absolulely necessary.

The authores thank Prof. T.Kosugi for providing " The YOHKOH HXT DATABOOK (I) ". This work was supported by the grant of NSF of China under the program 49391400 and Chinese Academy of sciences.

References

1. Benz, A.Q. and Kane,S.R.: 1986 *Solar Phys.*, **104**, 179.
2. Li,C.S., Qin,Z.H., and Fu,Q.J.: 1993 *Publ. of BAO*, **21**, 14.
3. Takakura,T., Kanfmann,P., Costa,J.E.R., Degaonkar,S.S., Ohki,K., and Nitta,N.: 1983 *Nature*, **302**, 317.

Table 1. FFS Events Vs Hard X-ray B ursts

		S-Burst			X-Ray Burst		
No.	Day 1991.	Start (UT)	Max (UT)	End (UT)	Start HHMM	Max. HHMMSS	End HHMM
1.	Oct.27	0505.0	0542.2	0616.0	0541B	054155U	0850A
2.	Oct.30	0600.0	0619.8	0730.0	0644B	064411U	0649A
3.	Nov.06	0440.0	0449.2	0520.0D	0455B	045500U	0458
4.	Nov.10	0646.0	0650.2	0657.0	0647	064837	0649A
5.	Nov.17	0155.2	0158.1	0218.0	0156	015749U	0208
6.	Dec.26	0630.0	0634.4	0652.0	0637B	063658	0701
	1992.						
7.	Jan.01	0320.0	0330.3	0400.0	0335B	033600	0339A
8.	Apr.01	0046E	0053.1	0116.0	0049	005323	0109
9.	Apr.06	0719.0	0723.8	0731.0	0714	072602U	
10.	Jun.04	0406.0	0415.7	0424.0	0407	040737	0410
11.	Jun.07	0135.0	0143.0	0158.0	0139	014334	0157
12.	Nov.23	0427.5	0432.0	0440.0	0429	043110	0435

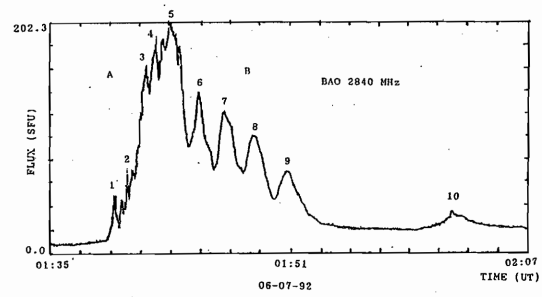

Fig.1. Time profile of the event of June 7, 1992 at 2840MHz (BAO).

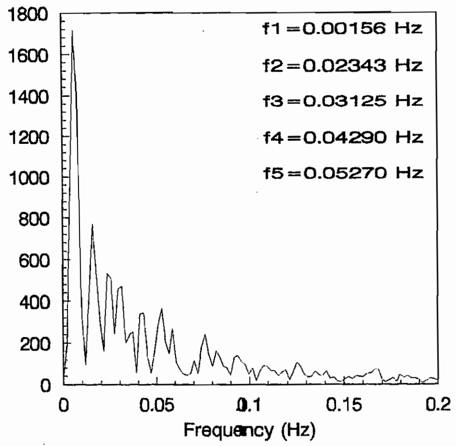

Fig.2. FFT of part A of June 7, 1992 event at 2840MHz.

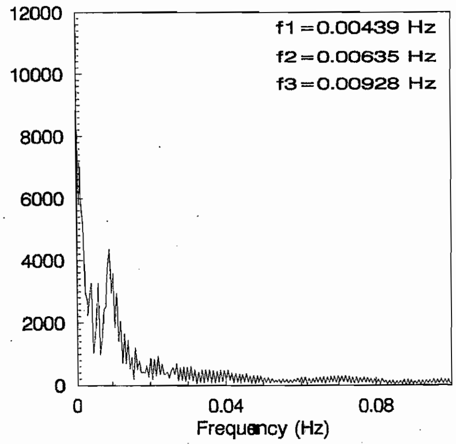

Fig.3. FFT of part B of June 7, 1992 event at 2840MHz.

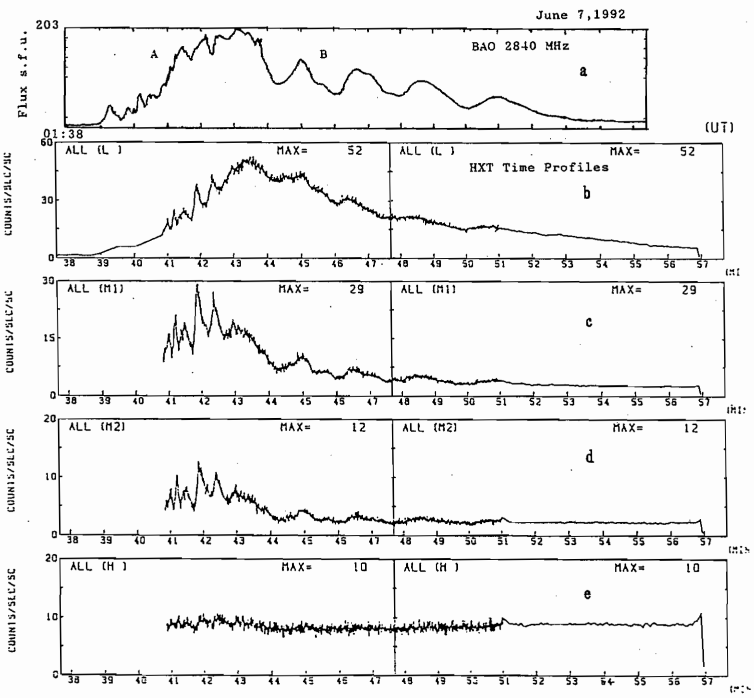

Fig.4. Time profiles of the June 7, 1992 event.

a. 2840 MHz.

b-e. hard X-ray.