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POSITION MEASUREMENTS OF RAPIDLY FLUCTUATING MICROWAVE BURSTS

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ABSTRACT. We have investigated whether microwave source positions change while the total fluxes of hard X-rays and microwaves show remarkable rapid fluctuations of the order of seconds. The position measurements were made in one dimension (east-west direction) with the 17 GHz interferometer at Nobeyama. Position changes greater than a few arc seconds can be detected. The result shows that significant position changes are found for five of seven bursts but that no position changes greater than 3" are found for the remaining two bursts.

It is crucial for the understanding of the energy release mechanism in solar flares to know whether the flaring occurs repeatedly in a single loop or successively in adjacent different loops during X-ray and microwave bursts of multiple spikes with time scales of seconds. VLA observations show in some cases repeated flarings at the same position (Lang et al. 1981, Kundu, Bobrowsky, and Velusamy 1982) and in some cases rather erratic changes in flaring positions within complex active regions (Kundu, Schmahl, and Velusamy 1982, Wilson and Lang 1984). The spatial resolution of these observations are a few arc seconds, but the time resolution is 10 seconds. High time resolution observations with the WSRT reveal complex changes in flaring positions in the east-west direction; the source of spiky components often shows position shifts of the order of the source size (Kattenberg and Allaart 1983).

In this report we present time variations of circular polarization, position and size of the source of rapidly fluctuating microwave bursts simultaneously recorded with the HXRBS on SMM and the 17 GHz interferometer at Nobeyama. We are interested in particular to know if the position changes from one peak to the next of multiple spike bursts with time scales of seconds. The interferometer operated on a regular babis, ~5h a day, so that we had greater oppotunity of simultaneous recording of flares with the HXRBS

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or the HXM on Hinotori.

The interferometer is one-dimensional in the east-west direction, and its maximum spacings are 3856λ and 7712λ before and after July 1981, which correspond to 50" and 25" respectively (Nakajima et al. 1980, 1984). Although these resolution are still poor, we can determine the source position or estimate the source size with an accuracy of a few arc seconds using all the observed Fourier components (Kosugi 1982): if the source shifts by more than a few arc seconds, we could detect them. The maximum recording rate of Fourier components is once per 0.8s for both RH and LH circular polarizations.

We present below the results of analysis of 7 microwave bursts with rapidly fluctuations of a few seconds. We have selected those bursts whose flux density is greater than 100 sfu at 17 GHz, recorded simultaneously with both the 17 GHz interferometer and the hard X-ray spectrometer on SMM (HXRBS). The selection was by no means complete in the present report. Examples are shown in Figures 1 to 3.

The first burst on 7 June 1980

This is a moderately strong burst occurring from an active region that gave rise to the 'famous' June 7 flare. In Figure 1(a) is shown the comparison between 17 GHz flux and 54-125 keV X-ray flux obtained with the HXRBS. The 17 GHz flux was recorded with the polarimeter with time constant of 0.3 s. The result of analysis of the interferometer data is illustrated in Figure 1(b): flux density, degree of circular polarization, east-west position, and source size. The observed source structure is simple and unipolar. However the east-west position of the centroid of the source shifts westward by ~ 5" at peaks relative to those at valleys. In addition the polarization degree becomes lower at peaks. On the other hand there are no changes in the estimated source size between peaks and valleys. The position and size were estimated by a model-fitting method developed by Kosugi (1982).

The second burst which occurred ~ 2 h later (0312 UT) shows no changes in position greater than 3" (p-p) between peaks and valleys but shows similar changes in the polarization degree. as previously described by Kane et al (1983).

The burst on 16 July 1982

The burst shows rapid fluctuations of a few seconds (Figure 2(a)). The source is single and of simple structue, and its center position remains at a fixed position at 0.8' west of the sun's center throughout the burst, as shown in Figure 2(b). The peak positions of RH and LH circular polarizations coincide to within errors of absolute position determination. There are no significant changes greater than 3" in the east-west direction, except the decay phase (> 03 22 30) when the source shows a progressive shift to west by ~ 2". The source size is estimated to be less than 8". However the degree of circular polarization significantly changes between 20 % and 40 % : it is

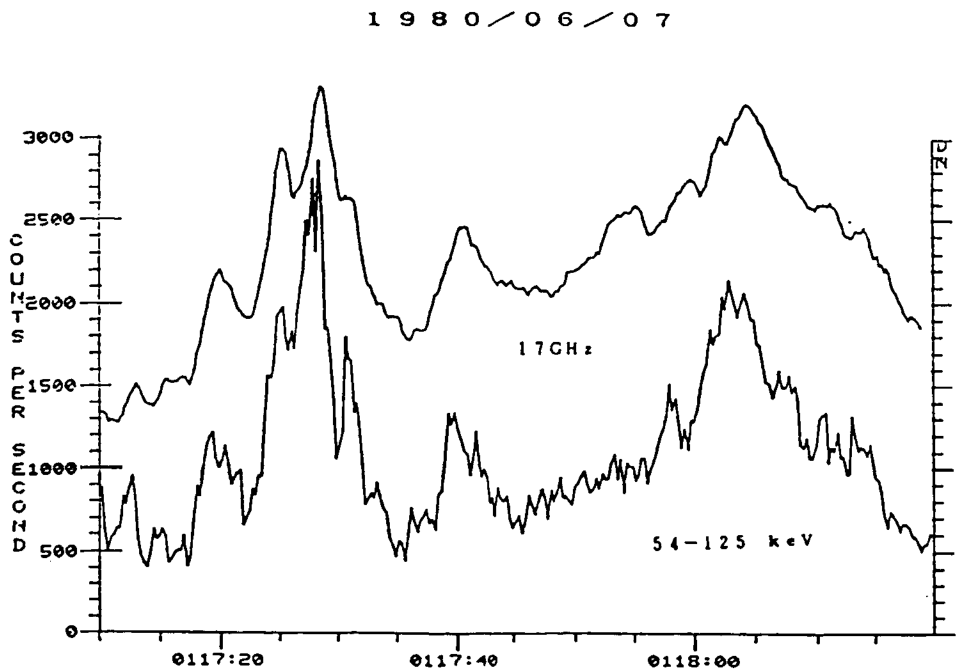

Fig.1(a) Time plots of 17 GHz flux and hard X-ray(54-125 keV) flux for the first burst on 7 June 1980.

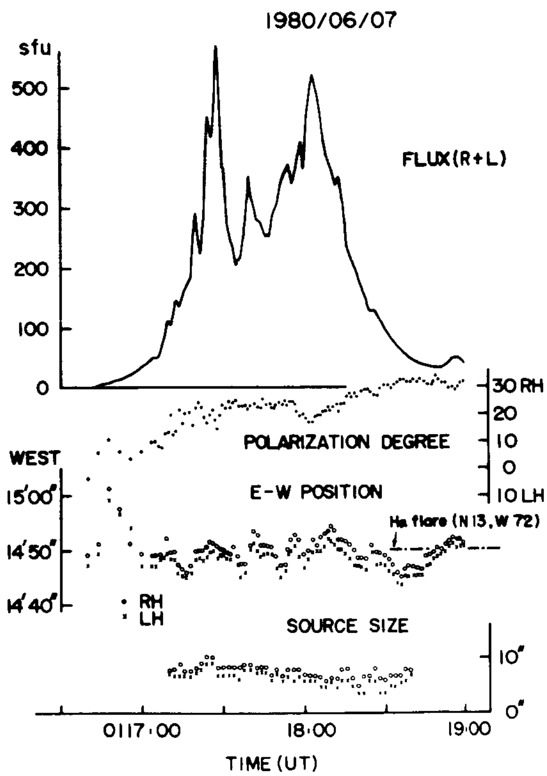

Fig.1(b) Time plots of flux, degree of circular polarization, east-west position, and source size, measured with the 17 GHz interferometer. The east-west position of the associated Hα flare center is indicated by dash-dot line.

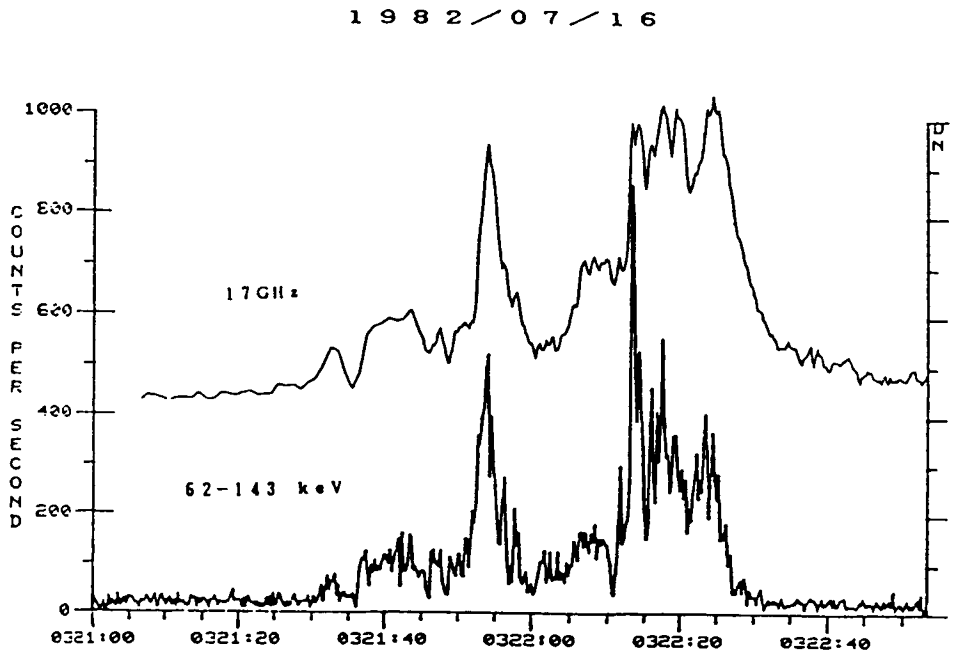

Fig.2(a) Time plots of 17 GHz flux and hard X-ray(62-143 keV) flux for the burst on 16 July 1982.

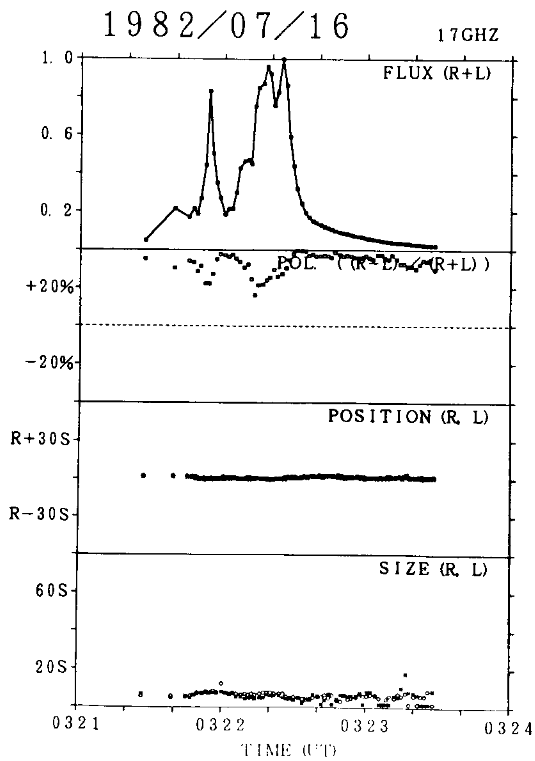

Fig.2(b) Time plots of flux, degree of circular polarization, east-west position, and source size. The position reference is 0.8' west.

smaller at peakes and larger at deep valleys.

The burst on 5 June 1982

The burst also shows rapid fluctuations of a few seconds. The source is single but slightly asymmetric with an extension on the east side, and the polarization structure is bipolar. As shown in Figure 3 the estimated source size is $\sim 30''$, much larger than the estimated sizes for the remaining bursts. Thereore it is likely that two sources of opposite polarizations are unresolved to be observed as an apparently single source. The east-west position changes from one pulse to the next and also between peaks and valleys.

We have made similar analyses for the remaining bursts. The result is summarized in Table 1. There are no significant ($> 3''$) position changes in the microwave sources for two bursts (the second burst on 7 July 1980 and the burst on 16 July 1982), although these two bursts show large amplitude fluctuations in both microwaves and hard X-rays. Even in these cases the degree of circular polarization changes in a systematic way : lower at peaks and higher at valleys. For the burst on 31 July 1981 there is a position shift of $\sim 5''$ between an initial small spike and the following main spikes, though no systematic shifts are found between peaks and valleys within the main spikes. The remaining four bursts show significant ($8'' - 12''$) position changes during rapid fluctuations. Systematic position shifts between peaks and valleys are seen for the first burst on 7 June 1980 and less clearly for the burst on 26 June 1982. Position shifts from pulse to pulse are found for the bursts on 26 June 1982 and 26 July 1981.

As far as the circular polarization is concerned, there is a systematic change: the polarization degree is lower at peaks and higher at valleys (c.f. Kundu et al., 1981). This tendency can be explained by the variation of optical depth τ of the source: $\tau > 1$ at peaks and $\tau < 1$ at valleys. Or alternatively there might be two unresolved components: one is less polarized and spiky, and the other more polarized and smoothly arying (c.f. Kattenberg and Allaart, 1983).

From the present observational evidence alone we cannot draw a general conclusion that microwave emission corresponding to different spikes always originates in different loops, because there are some bursts for which emission comes consistently at the same position. The latter case may be attributed to a limitted spatial resolution of the 17 GHz interferometer, because the two bursts showing no position changes have small source sizes ($< 3''$).

Finally we mention about spatial structures of impulsive flares observed in UV (Cheng et al., 1981, 1984). From the analysis of four impulsive flares observed with the UVSP on SMM, they presented diversity and complexity of temporal and spatial structures of the flares: in some flares there are several bright kernels which show different time behaviour and in some flares bright regions extend over many pixels all of which show a similar time behaviour.

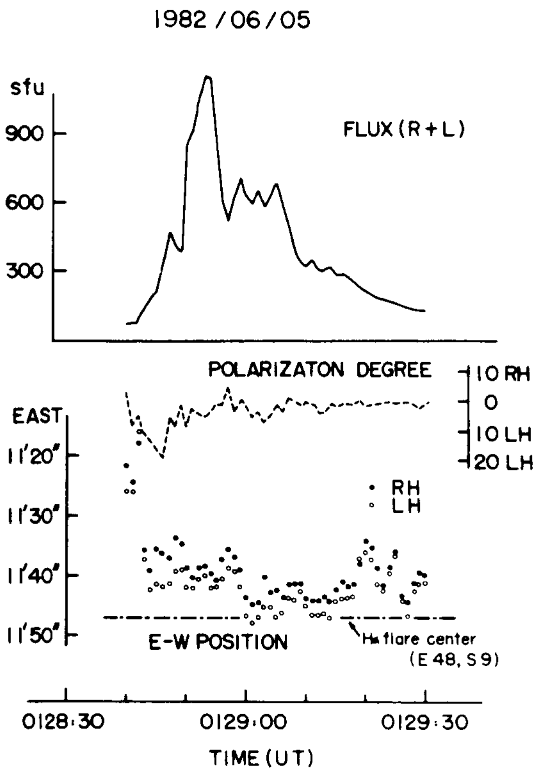

Fig.3 Time plots of flux, degree of circular polarization, and east-west position.

Table 1. Summary of Result

Date	Time	Position Change (p-p)		Size	Change of Pol.Degree
1980 June 7	0117-0119	yes	5"	8"	yes
1980 June 7	0312-0313	no	<3"	<5"	yes
1981 July 26	0411-0412	yes	10"	10"	yes
1981 July 31	0053-0054	yes	5"	9"	no
1982 June 5	0128:40-0129:30	yes	12"	30"	yes? (bipolar)
1982 June 26	0044-0048	yes	8"	20"	yes?
1982 July 16	0321:30-0322:40	no	<3"	<8"	yes

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