RECENT DEVELOPMENT OF THE NOBEYAMA 17GHz INTERFEROMETER AND SOME INITIAL RESULTS

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ABSTRACT. We have constructed a 17GHz interferometer of a multi-correlator type at the Nobeyama Solar Radio Observatory. Novel features of the new interferometer are summarized as (i) high time-resolution up to 0.8 s and (ii) "real-time" calibration of the whole system with an accuracy of $\sim$ 2% for amplitudes and $\sim$ 2° for phases. With the aid of these advantages over an interferometer of a conventional drift-scan type we are able to detect and follow rapid time variations of even a faint source (say, $\sim$ 0.5 s.f.u.) on the Sun with a spatial resolution of $\sim$ 40". The interferometer has been put in operation since July 1978. We have recorded hundreds of bursts at 17GHz in a year including some tens of rapidly changing sources which would not precisely be measured so far. We present here some preliminary results of observations such as polarization structures of both rapidly changing and GRF bursts.

The previous 12-element interferometer of a conventional drift-scan type, which had been in operation since 1971 at Nobeyama, was far from a satisfactory resolution in both space and time. The spatial resolution was $\sim$ 3' in the east-west direction and temporal resolution was limited by the time interval during which the Sun drifts successively across one fixed grating lobe to the next. Since impulsive bursts observed at 17GHz had a shorter duration than this time interval, it was required to improve the temporal resolution by an order of magnitude. The phase and amplitude calibration of the interferometer was another severe problem. We observed the Sun, which was assumed to be quiet and symmetric, by successive pairs of antennas of the fundamental spacing to make a correction to the phase and amplitude. It was practically impossible to make the calibration quite often. Even if we did it every day we would be unable to make a correction for differential thermal expansion of the wave guide which was unavoidable during solar observations. Keeping such experiences in mind we have decided to improve the interferometer of a grating type to that of a multi-correlator type. The antenna arrangement is of a compound type. We measure correlations between 4 short-spacing antennas and 10 long-spacing antennas simultaneously ; 40 Fourier components (say, 1d to 40d ; d (fundamental spac-

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ing) = 96 λ) of the Sun's brightness. The maximum spatial resolution is limited only by the sampling rate with the maximum of 0.8 s in the present case. Besides these 40 Fourier components which are necessary to symthesize a solar map, we measure redundant d- and 2d- components between the short-spacing antennas and 4d- components between the long-spacing antennas for the phase and amplitude calibration. Any antenna pairs of the same spacing should give the same amplitude and phase whatever the Sun's brightness (McLean, 1973). The deviation of measured values from it is attributed to errors in phase and amplitude. The spacing between nearby long-spacing antennas is chosen in such a way that the 4-d component has a S-N ratio good enough to make the calibration possible during the most of observing time ($\sim$ 2.5 h before and after the local noon). The present calibration system, which we call a 'real time calibration', has proved to work quite satisfactorily ; the accuracies of the amplitude and phase determination are $\sim$ 2% and 2° respectively. Details of the equipment will be described later (Nakajima et al.). The new interferometer has been put in operation since July 1978. Data are stored in magnetic tapes whilst part of them are processed in real time and displayed on a graphic display tube for monitor of solar activity.

We have so far recorded hundreds of bursts, two events every 5 hours on the average. These figures include many small impulsive bursts which would be missed from a conventional drift-scan observation. We present here two examples of typical microwave events (c.f. Kosugi in this issue). Figures 1 and 2 show a small impulsive burst the polarization structure of which changes in time. The highlight of the event is as follows. The burst shows a relatively high circular polarization (20 $\sim$ 25%) in its initial phase. However the high polarization does not last longer than a minute. Then, the polarization degree decreases rapidly to a few percent. The weak enhancement which immediately follows the impulsive burst and lasts for 25 minutes is nearly unpolarized with a slight tendency of a bipolar structure. It is noted that the high polarization seems to coincide with a non-thermal event observed in the 70 - 600 MHz band. We do not find a systematic shift of the source position or a source expansion, either. The present spatial resolution is obviously not sufficient. However, we have observed an expansion or a shift of the source in several similar examples. We suggest therfore that the impulsive, polarized burst comes from a compact region permeated by both non-thermal electrons and strong magnetic fields while the second weak component (possibly, post-burst) comes from a more extended region with less strong magnetic fields where the gas is heated by some mechanism.

Contrary to impulsive bursts gradual rise and fall (GRF) bursts are observed quite often. The source of many GRF bursts shows a bipolar structure. The peak of the total intensity (R + L) profile falls in the region where the sense of circular polarization changes from R to L. The structure does not qualitatively change even if we process the data putting heavier weight on higher Fourier components. Therefore we consider the apparent bipolar structure to be genuine. It is suggested that hot dense material exists at the top of a magnetic arch. The above result seems to be compatible with that obtained from

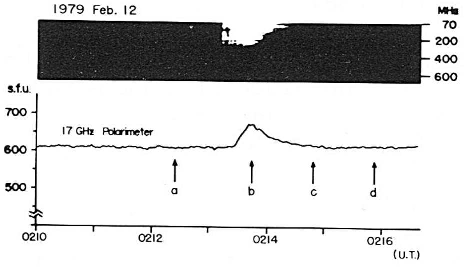

Figure 1. An impulsive burst showing polarization change (1979 Feburary 12). Upper : the dynamic spectra of the associated m- and dm-bursts. Lower : the total flux record obtained with the 17GHz polarimeter.

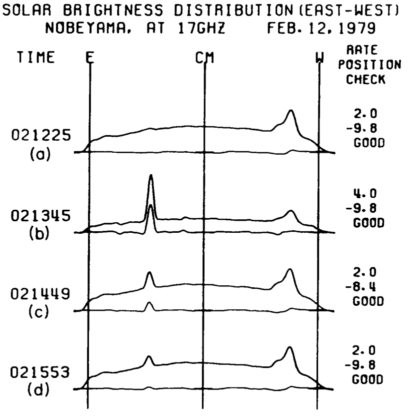

Figure 2. The distribution of R+L and R-L for the impulsive bursts shown in Figure 1. The contours a, b, c and d are for the times indicated by arrows in Figure 1. The vertical scale for R-L (thin line) is three times that for R+L (thick line).

the SKYLAB X-ray experiment (Pallavicini et al., 1977). It is to be noted that very few GRF bursts are associated with non-thermal phenomena observed in m-wavelengths. This suggests that GRF bursts are of a purely thermal origin. The problem why the top of a magnetic arch brightens in both radio and X-ray is left unsolved.

REFERENCES

McLean, D. J. : 1973, Proc. I.E.E.E. 61, pp. 1318-1320.
Pallavicini, R., Serio, S. and Viana, G. S. : 1977, Ap. J. 216, pp 108-122.

DISCUSSION

Kundu: I am very pleased to see that your 17 GHz interferometric results confirm the results that I obtained at 3 cm with regard to impulsive phase and postburst, more than 20 years ago.

Wiehl: What was the peak frequency for the burst of 1979 February 12? What was the circular polarization below f_{peak}?

Kai: I have not checked the spectrum for this specific event yet. Generally the peak frequency of μ-impulsive bursts lies between 4 and 9 GHz. The circular polarization is lower at the peak frequency than at 17 GHz. We could explain this burst in terms of high temperature thermal electrons unless we know other informations such as radio spectra at much higher frequencies and non-thermal events at m-wavelengths and so on.

Wiehl: In this case maybe this burst could also be explained by a thermal model (c. Mätzler, 1978, Astron. Astrophys. 70, 181).

Alissandrakis: What is the expansion velocity of the burst?

Kai: The projected velocity of the source expansion is of the order of some tens of km/s.

Lang: Is there any evidence for changes in the Stokes parameter V, at high angular resolution before (30 sec to 1 min) the bursts seen at Stokes parameter I or at Hα wavelengths? Also, how do changes in V before and during the bursts depend on angular resolution.

Kai: As far as I know, weak enhancements which immediately precede impulsive bursts have not been observed. This might be due to low sensitivity of the present equipment. The deduced polarization degree depends on how to process observed Fourier components; the flat tapering gives in general higher V than a hamming tapering does.

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