POLARIZATION STRUCTURE OF NOISE STORMS

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Abstract: The results of simultaneous, high time-resolution observations of spectra (181—224 MHz) and polarization (204 MHz) of noise storms, performed in 1972, are presented. The polarization structures of isolated bursts, chains and a group of type I bursts are investigated. A detailed comparison of the spectral and polarization features of the individual bands in the chains of type I bursts with small band-splitting is carried out.

Noise storms are one of the most typical solar radio phenomena in the metre wavelengths. They have been intensively investigated for more than 20 years. However, the nature of both the continuum component and the type I bursts has remained obscured [1, 2]. To solve this problem an analysis of the microstructure of noise storms is essential, as well as the investigation of noise storm characteristics as a whole (spectrum, directivity, association with the peculiarity of active region development, etc.). In particular, the analysis of the polarization structure is important.

The present report, a continuation of our previous paper [3], deals with the peculiarities of noise-storm polarization, mainly of its burst component: isolated bursts and chains of type I bursts. Special attention is paid to the investigation of the dependence of the polarization degree on time in the course of individual type I bursts and of polarization of the band splitting chains.

The investigation is based on the observations (performed at IZMIRAN) with a spectrograph (180—220 MHz) and polarimeter (204 MHz) during the period June 14—22, 1972 [4]. The spectrograph yielded a frequency resolution of 0.25 MHz and a tome resolution of 0.02 s for bursts with flux densities of more than 3×10^{-22} Wm^{-2} Hz^{-1}. The polarization has been measured with a time constant of 0.019. The spectra and polarization were recorded on film, running at a speed of 10 mm/s. The data processing has been carried out by means of measuring the intensity of clockwise I_R and anticlockwise I_L polarized components with ten fold magnification of the image and with subsequent calculation by computer.

1. The degree of polarization of the burst was determined by the following expression:

$$P = \frac{(I_L - I_L^\circ) - (I_R - I_R^\circ)}{(I_L - I_L^\circ) + (I_R - I_R^\circ)},$$

where I_L° and I_R° are background intensities of the anticlockwise left and clockwise polarizations, respectively. It is natural that the intensity of the background and total intensity in both the channels are determined with an error due to the receiver noise. If one admits that the values I_L, I_R, I_L°, and I_R° are measured with the same absolute error Δ, the expression for the resulting absolute error is

$$\Delta P = \pm \frac{2\Delta}{I}(1+P)$$

(here I is the burst intensity). This imposes definite limitations, mainly upon the burst intensity, with which the polarization degree may be determined with a sufficient accuracy. According to the measurements, Δ corresponds to the response to a calibrating signal of 1 mA. The dependence of the minimum intensity of the polarization degree on actual values of the absolute error si shown in Figure 1. It follows that the analysis of the variation of the polarization degree in the course of individual bursts can only be carried out along the part of the time profile near the maximum of the burst intensity. Below we shall analyse (except for some special events) those values of polarization for which $\Delta p = \pm 10\%$ only: for $p = 0$ this condition is satisfied at $I \geqq 20$ mA and for $p=1$ at $I \geqq 40$ mA. The value $\pm 5\%$ has been adopted as the minimum of Δp. According to estimates, precisely this error in the determination of the polarization is conditioned by parasitic effects.

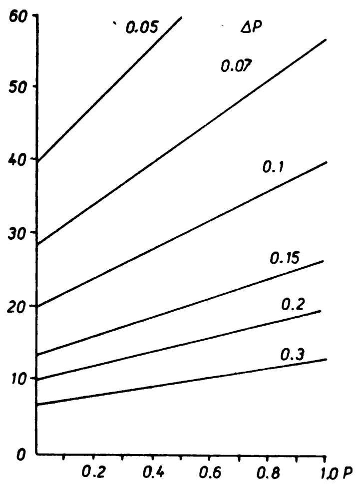

Fig. 1. The minimum burst intensity versus the degree of polarization for definite values of absolute errors.

2. The analysis of some tens of type I bursts showed that in a given noise storm the polarization degree did not change (along the part of the time profile where $\Delta p = \pm 10\%$) in the overwhelming majority of individual bursts. This is characteristic of different stable and drifting bursts with weak, moderate and strong polarizations (Fig. 2). However, in some events the obvious variations of the polarization degree with time were observed, the maximum values of the polarization being recorded near the maximum of the burst intensity (Figs 3 a and 3 b).

The sole event in the given noise storm with a change of sign of polarization is shown in Figure 3c. As the dynamical spectrum and time profile indicate, the event probably represents a combination of two bursts. The fact that no activity was observed either before or after this event for some time indicates that this combination of bursts is not accidental. It is interesting to note that the first burst is clockwise polarized, while the second burst is anticlockwise polarized. The latter sense of polarization is typical practically for all events in the given noise storm.

It may be noted that bursts, whose degree of polarization varies with time, have also been observed during the noise storm of may, 1969 [3]. However, in the present investigation this result has been obtained with a more correct calculation of the possible errors.

3. It may be determined in the present case that

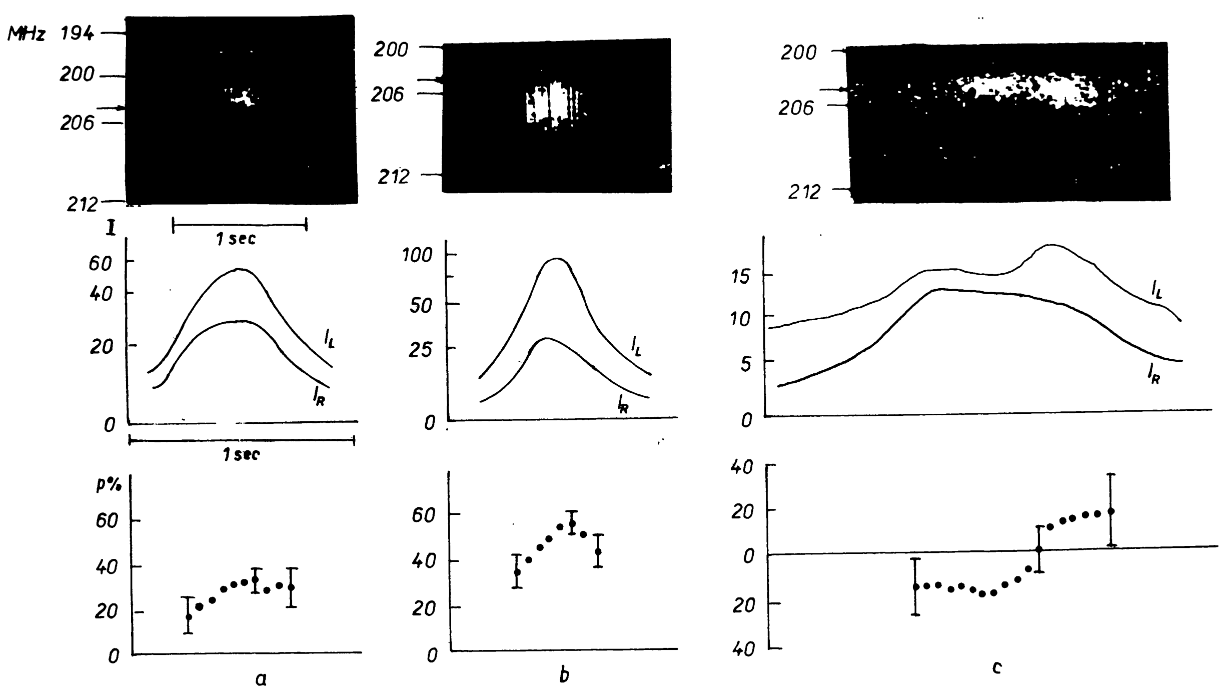

Figure 3. The dynamic spectra and time profiles of intensity and polarization. a) and b) The burst with a variation of the degree of polarization for June 16. c) The event with a change of polarization sense for June 14.

the burst component polarization is universal during the final stage of development of the noise storm. This means that the sense of polarization and, to some extent, the degree of polarization are identical for all forms of burst activity for a given day. This is illustrated by Figures 4—6 where the dynamic spectra and profiles of I_L and I_R are shown for different chains, observed on June 16, 17 and 21. In particular, the simple arch-like and drifting chains, shown in Figure 4 have small polarization single sign. The isolated type I bursts, during a given day, also have the same character of polarization (see Fig. 2a). An analogous conclusion can be drawn concerning the periods with strong burst polarizations (see Figs 5, 6 and 2b).

The band-splitting chains, in which the bands of emission are separated by a frequency interval equal to about the bandwidth of the individual

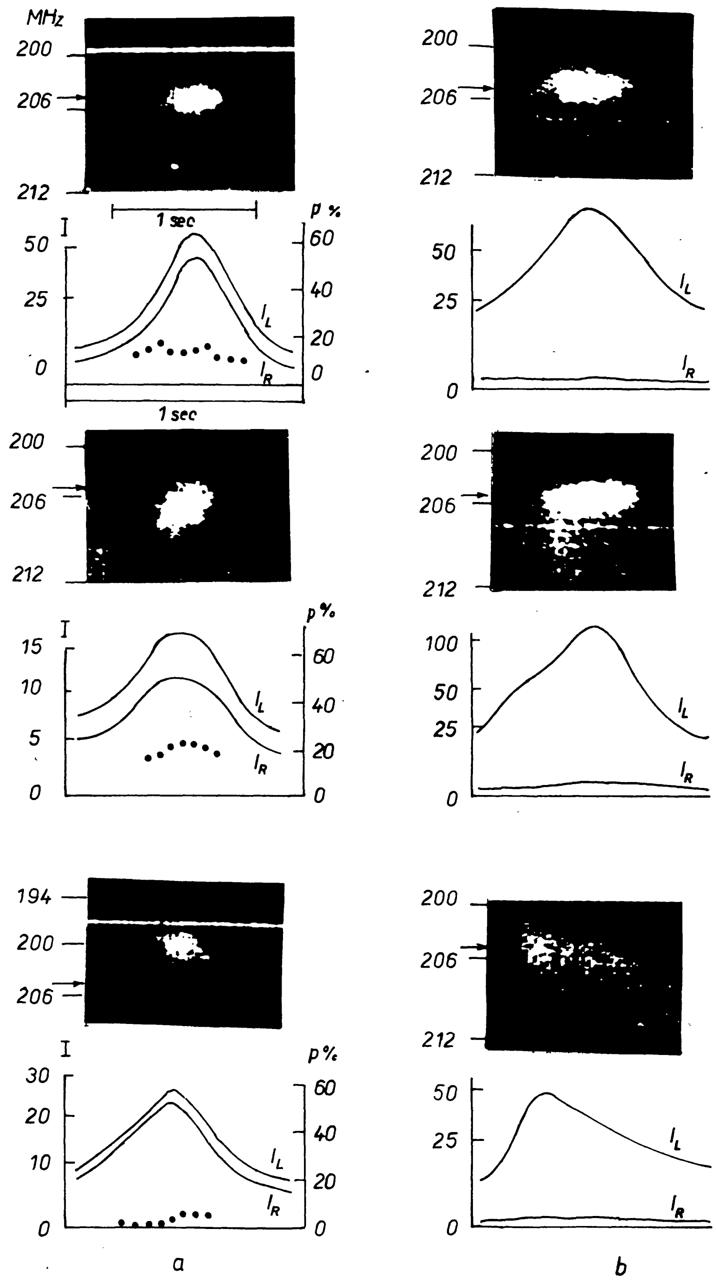

Fig. 2. The dynamic spectra and time profiles of polarized components of individual type I bursts.
a) The bursts of June 16 with a small unchanging degree of polarization.
b) The fully polarized bursts of June 20 and 21. Horizontal arrows at the dynamic spectrum indicate the frequency of 204 MHz.

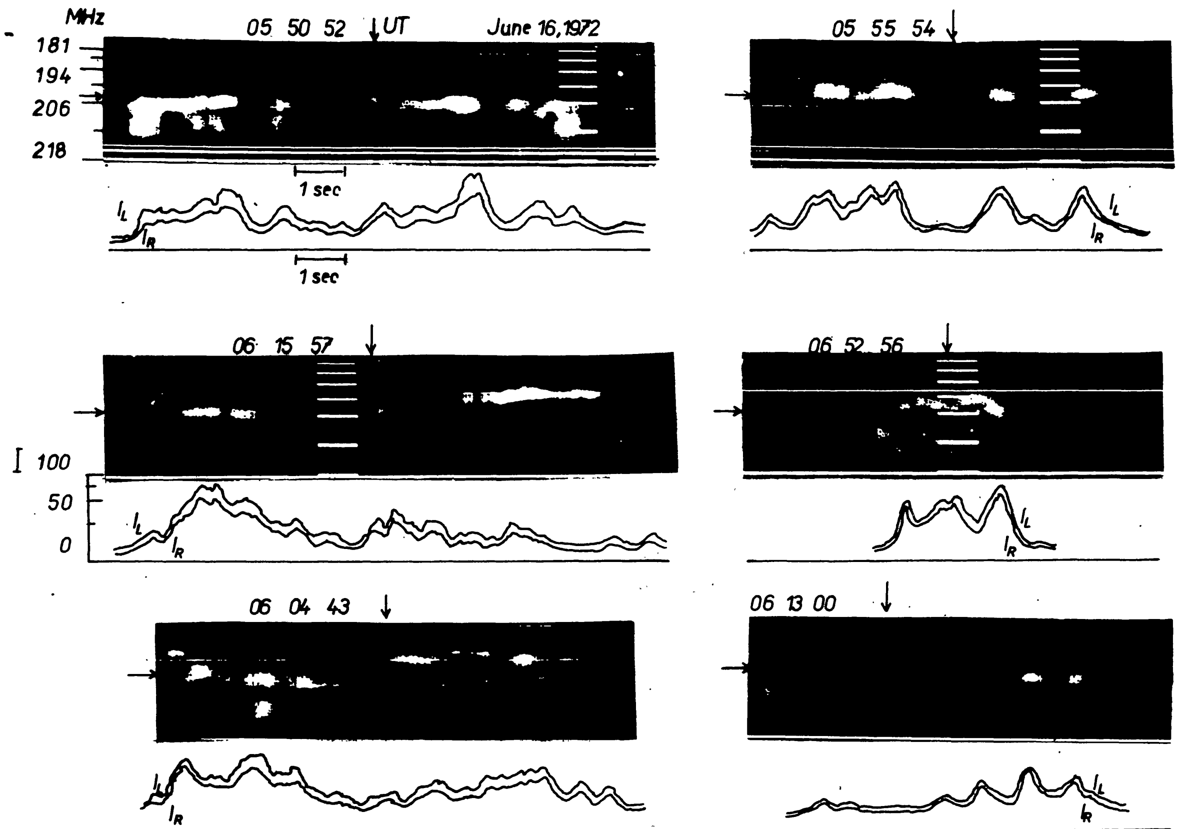

Fig. 4. The chains of type I bursts of June 16 with small polarization.

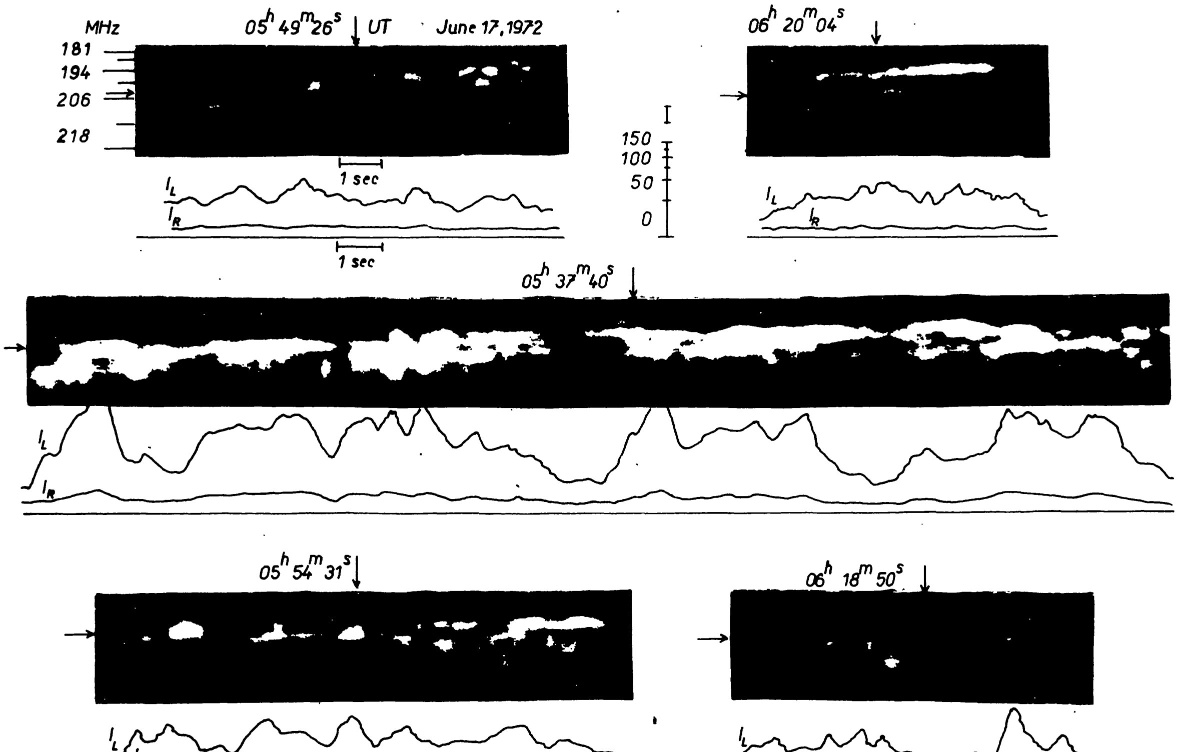

Fig. 5. The strongly polarized chains of type I bursts of June 17.

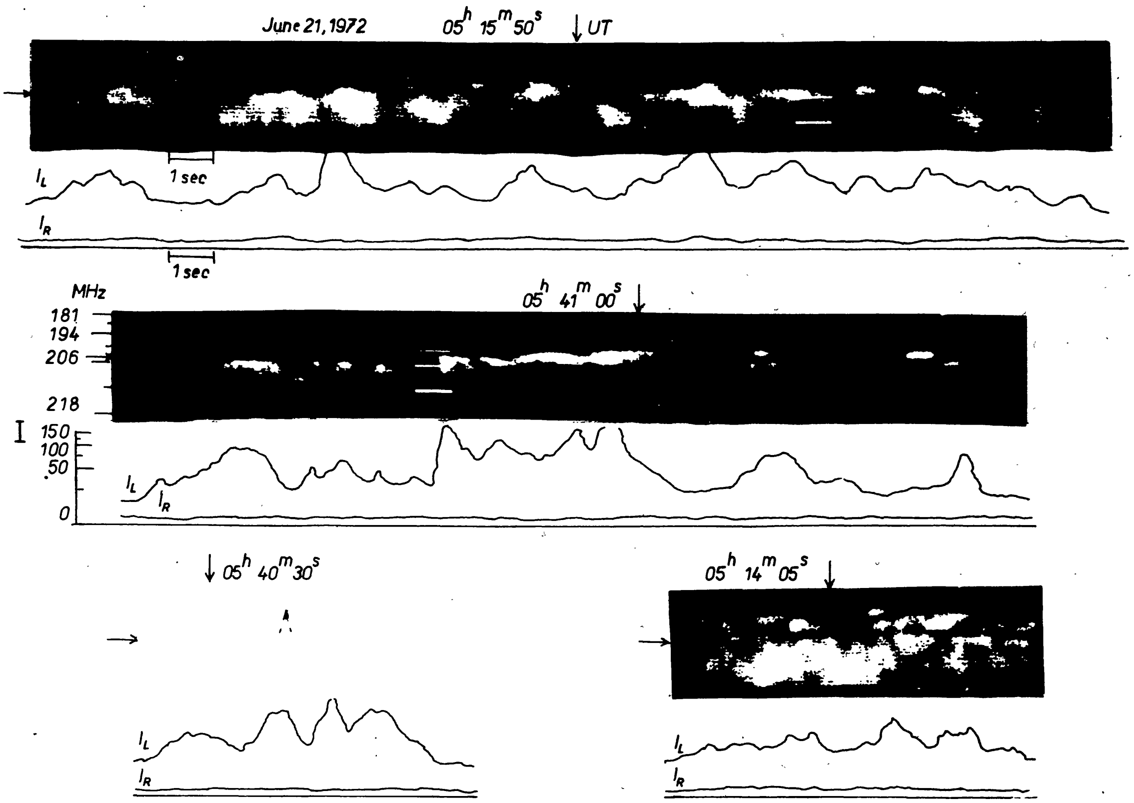

Fig. 6. The fully polarized chains of June 21.

type I burst (4—7 MHz), are of especial interest. The band splitting chains were first described in [5]. But the chains with micro-band splitting differ from the chains, analysed in [6], where the splitting is much larger (20—25 MHz). The observational data of the given noise storm permit one to draw the conclusion that the polarization characteristics of the splitting components of chains coincide. This concerns both the sign and degree of polarization. This is clearly manifested in the cases where the band-splitting chain with a frequency drift crosses the polarimeter frequency at first with one component, and then with the other component (Fig. 5 ($05^h37^m40^s$ UT) and Fig. 6 (05^h41^m UT). The analysis of a great number of band-splitting chains, crossing the polarimeter frequency with a single band only, yields the same conclusion.

4. Thus, the performed investigation permits one to draw the following conclusions:

(A) The bursts with a constant value of the polarization degree, not far from the maximum intensity, are typical for the given noise storm. However, the presence of several bursts, whose degrees of polarization vary, indicates the necessity of further investigations of this problem.

(B) The polarization characteristics of both the components of the band-splitting chains are identical. The coincidence of the sense of polarization of the band-splitting chains indicates that it is impossible to interpret the band splitting as an emission of different modes. Further, the coincidence and constancy of the polarization degree testify that the generation of the band-splitting components takes place in the sources with approximately equal magnetic field strength.

(C) The important property of the given noise storm is the universal character of polarization of the burst component. According to our observational data, the majority of noise storms have burst components with a single sense of polarization only. On the other hand, the results of the interferometric [7] and radioheliographic [8, 9] observations indicate that the noise storm sources are, as a rule, of either bipolar or multipolar structure. The question then arises as to why the presence of the sources of continuum emissions with different polarities is not accompanied by the generation of bursts with different senses of polarization. Apparently, this is due to the bursts being generated in one source which is localized apart from the sources of the continuum emission in the region where the direction of the magnetic field is determined by the magnetic polarity predominant in the spot group and corresponds to the resulting continuum polarization. The result of eclipse observations testify in favour of this statement. According to the latter, the continuum and burst sources are separated in space [10, 11].

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