ON THE STATISTICAL NATURE OF TYPE I BURSTS

Öystein Elgaröy
Institute of Theoretical Astrophysics
University of Oslo, Norway.

During noise storms narrow-band, short-lived bursts make up an important part of the activity. Frequently the bursts show different characteristic arrangements in the frequency-time plane (Elgaröy, 1977). In the present investigation the frequency of occurrence of single bursts and sequences of bursts has been determined. The work started out as a search for statistical evidence for the occurrence of echoes of type I bursts. As progress was made, more attention was devoted to the general question of what was the frequency distribution of events containing different numbers of bursts and the conclusions that could be drawn from the observed distribution.

1. OBSERVATIONS AND ANALYSIS

For the analysis high resolution spectral records obtained in the bands 150-175 MHz and 310-340 MHz at Oslo Solar Observatory were used. The sensitivity of the spectrographs is such that the quiet sun radiation can be detected, the frequency resolution is 0.3 MHz and the sweep repetition frequency is 50 Hz.

It was necessary to follow definite guidelines when the noise storm records were analysed. Firstly, in order to be regarded as a multiple burst event the bursts should have roughly the same centre frequency, or be aligned along a systematically varying centre frequency. Secondly the time separation between neighbouring bursts should not exceed about 1 s.

The number of events containing 1, 2, 3, ...10 bursts were counted in a frequency interval of 15 MHz in the central part of the film records. Events with more than 10 bursts were all assigned to the same entry.

Sections from eight different records covering the band 150-175 MHz and 11 records from the band 310-340 MHz were analysed in this way. Each section comprised about 500 bursts.

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2. STATISTICS OF BURST GROUPS

It was soon realized that the frequency distribution of groups containing different numbers of bursts followed an exponential function. A relation of the type

$$N = N_o \exp(-\beta n)$$

where N is the frequency of occurrence, N_o and β are constants and n is the number of bursts in the group, was fitted to the data by the method of least squares. The results of the regression analysis using all data were

$$N_{150} = N_o \exp(-0.606n) \ , \quad \rho^2 = 0.987$$

$$N_{300} = N_o' \exp(-0.795n) \ , \quad \rho^2 = 0.998$$

where ρ^2 is the squared coefficient of correlation. In Fig. 1 the data are plotted together with the lines of best fit.

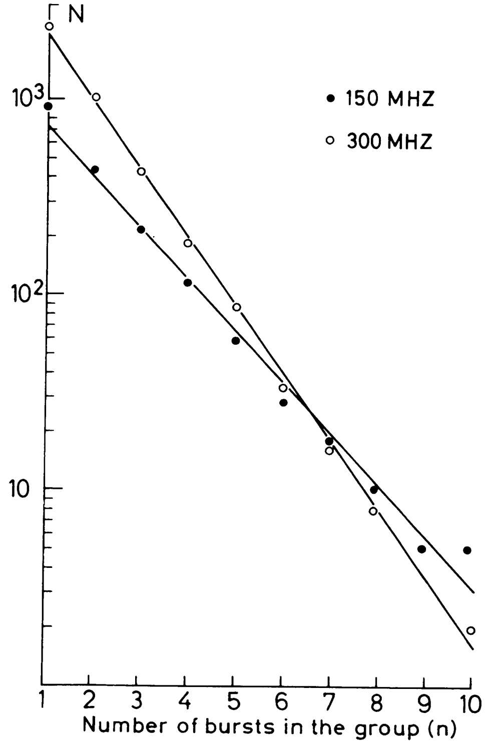

Fig. 1. Distribution of groups containing different numbers of bursts.

One may express the results in an analogous way by the relation

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$$p(n+1) = k \cdot p(n)$$

i.e. the probability of observing a group of n+1 bursts is a constant factor k times the probability for the occurrence of a group containing n bursts. The value of k amounts to 0.55 in the 150 MHz range and 0.45 around 300 MHz, as determined from our observations.

Bursts at lower frequencies have higher chances for a follower than those at higher frequencies. Double bursts (suspected echo events) do not occur more frequently than statistically expected according to the above results.

In the present investigation one started out with the smallest event, the single burst. One may also work from the other end, i.e. from chains of bursts towards single bursts. This was done by de Groot et al. (1976), who determined the distribution of chains with lifetime in the frequency range between 160 and 320 MHz. An exponential distribution of chains of different lifetimes was found, and the probability for a burst to be followed by another decreased with increasing frequency. Thus the results obtained by de Groot et al. (1976) and those found in the present investigation are in agreement.

3. DISCUSSION

In the material which was analysed, and which was collected from several type I storms, no evidence for the occurrence of echoes was found. If echoes frequently occurred, double bursts should be over-represented. As this is not the case, it is likely that type I bursts are generated at a frequency which is close to the plasma frequency at the level of origin. Echoes are then not expected.

Since the observed data closely follow an exponential distribution, it is inferred that the occurrence of groups of bursts are due to chance and that the emission of type I bursts in the direction of the earth is a random process. Thus there is no qualitative difference between the generation mechanism of single bursts and chains. Chains may be regarded as the random clustering of single burst events. Another interpretation is to assume that low frequency wave trains of random lengths take part in the generation process. Single bursts and chains must be explained by the same mechanism. According to this, isolated type I bursts and bursts in chains should show the same properties as were actually found by Elgaröy and Ugland (1970).

References

Elgaröy, Ö. 1977, Solar Noise Storms. Pergamon Press, Oxford.
Elgaröy, Ö., Ugland, O. 1970, Astron.Astrophys., 5, 372.
De Groot, T., Loonen, J., Slottje, C. 1976, Solar Phys., 48, 321.

DISCUSSION

Slottje: Do the chances you found for a burst at 150 MHz and 800 MHz to have a successor fit with those given by De Groot et al. (1976)?

Elgaröy: The two investigations are in very good agreement. The results of de Groot et al. (1976) show the same trend as found in the present investigation. Quantitatively de Groot et al. found a higher probability for a type I burst to have a follower, but his is not surprising when the different approaches are taken into account.

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