PAPER 70

SOME PROPERTIES OF SOLAR RADIO-TRANSIENTS ON FAST 200 MC./S. RECORDS

C. DE JAGER AND F. VAN 'T VEER
Astronomical Observatory, Zonnenburg, Utrecht, Netherlands

Some 6 km. of high-speed (Brush) records of the solar radio radiation at 200 Mc./s. made at Cornell University by Ch. L. Seeger in 1949 and 1950 have been kindly put at our disposal. They were made with a paper speed of 0·5 cm./sec., sometimes with 2·5 cm./sec. The response time of the recording pen was $0^{s}\cdot02$. Some records have been made simultaneously at 205 Mc./s. and at 200 Mc./s. This paper gives some results of a discussion

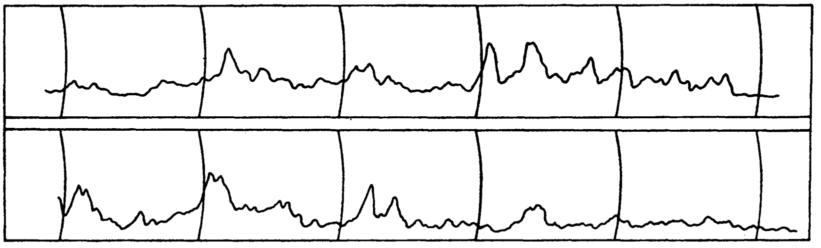

Fig. 1. Typical specimen of a record made on 200 (lower part) and 205 Mc./s. (upper part). Time increases from right to left. The vertical lines are 10 sec. apart. Date: 30 April 1950.

of these records. The properties that were studied are: the clustering tendencies among the radio-pips, their band-widths, the echo-phenomena and the duration of the pips.

A typical example of the records is given in Fig. 1. The figure suggests that the basic phenomenon of the burst activity of the sun consists of radio-pips of very short duration with, in the great majority of the cases, a duration shorter than 1 sec. Such pips are hardly detectable on records obtained by means of a slower recording instrument. As a 'pip' we consider every measurable transient phenomenon on the records; in order to be measurable it appears that the top intensity must be greater than about 0·5 mm. We note for comparison that the base-level intensity of the quiet sun is generally of the order of 5 to 10 mm.

I. CLUSTERING TENDENCY

A glance at Fig. 1 suggests that the pips cluster together. Quantitatively this can be shown by dividing the record into equal time-intervals and by making a histogram showing the frequency of occurrence of time intervals containing *n* pips (see Fig. 2; discontinuous curve). In all our counts the unit time-interval has been chosen equal to 30 sec. The smooth curve in the same figure shows the probability distribution for the same record computed according to Poisson's law, which corresponds to a random distribution of the pips. The observed curve differs from the computed one

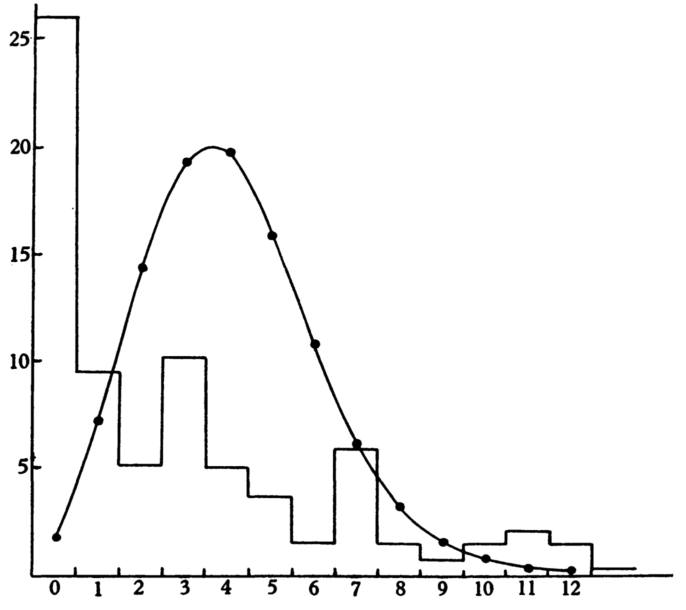

Fig. 2. Example of a histogram of the number of pips counted in time intervals of 30 sec. The smooth curve gives the corresponding Poisson distribution. Date: 15 May 1950.

in two respects: the number of intervals with many pips is much greater than follows from Poisson's law and the same is true of the intervals without any pips.

The difference can be explained by assuming that the pips occur in groups. We assumed: (*a*) that all pips occur in groups, the number of pips per group being distributed according to Poisson's law; (*b*) that the number of groups per unit time-interval is also defined by Poisson's law. A statistical formula was derived, based on these hypotheses. The discussion of a number of records showed that the average number of pips per group remains practically constant and has the mean value of 2·2.

Interpreting this formally with Poisson's law, this means that about ten per cent of all pips occur singly and the others in groups. Two comparisons with observed distributions are shown in Fig. 3. Close examination of this figure shows, however, that deviations still occur for large values of n. This probably means that apart from groups consisting of 2 or 3 members, there occurs also another kind of group consisting of a much larger number of members.

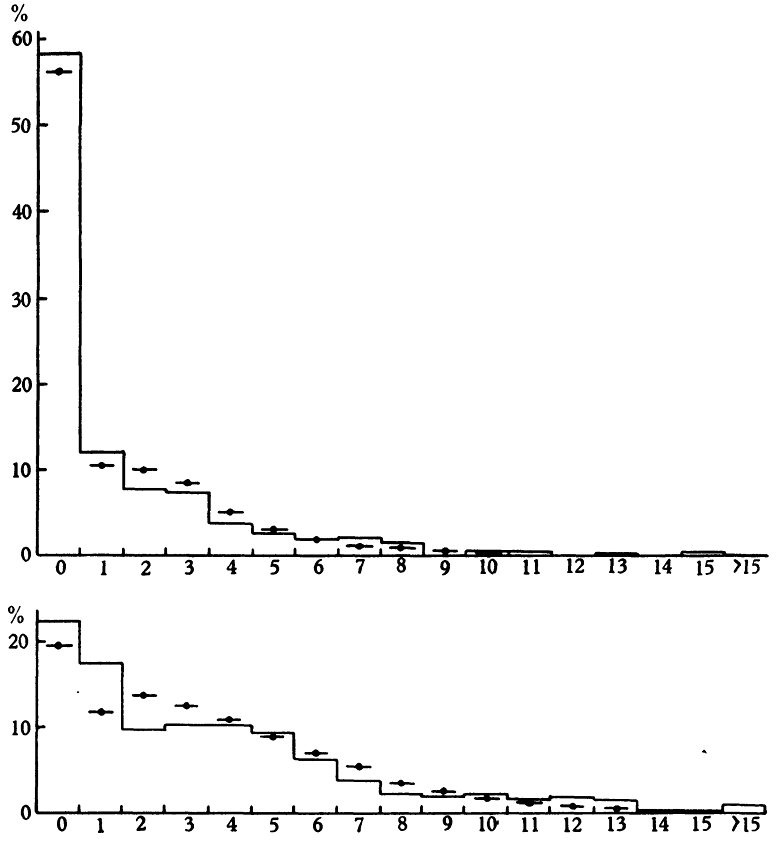

Fig. 3. Two histograms (discontinuous curves) compared with the distribution computed from a formula based on the assumption of clustering. Date: 5 May 1950.

2. BAND-WIDTH

Fig. 1 gives two simultaneous records; one made at 200 Mc./s. and the other at 205 Mc./s. Although most pips can be identified on both records, it is also clear that the ratio between the intensities of the same pip, observed in each of these frequencies, changes considerably from one pip to another. We interpret this observation by the obvious assumption that the pips have a small band-width.

Computations of the statistical distribution of the intensity ratios of the pips observed on both frequencies were made, assuming a gaussian spectrum of the pips. The best agreement with the observed results was obtained for a band-width of about 7 Mc./s.

3. ECHO PHENOMENA

If the burst of radio noise is emitted by gas masses above the layer of zero refractive index for the frequency of our observations, we can expect to observe two signals: the direct and the reflected one. The time difference between the reception of both signals may be up to some seconds. It depends on the location of the emitting source above the reflecting surface. A short computation shows that the intensity of the reflected signal will, in general, not be negligible compared to the direct signal (De Jager and Van 't Veer, in the Press) [1]. In order to examine whether any such phenomena occur on our records we have selected all isolated and well-pronounced pips. These pips, which have been called by us central pips, have been selected in such a way that another pip with an intensity of only 10 % of the 'central pip' should still be measurable on our records. The total number of the pips selected in this way was about 600.

We have looked carefully in all available records for all pips in an interval of time from 5 sec. before to 5 sec. after the central pip.

There seems to be no indication that the number of pips following the central one would be greater than that preceding it. In the following table we give the counted numbers of pips in equal time-intervals around the central pip.

	Interval in seconds, before or after central pip		
	0·25–1·75	1·75–3·25	3·25–4·75
No. of pips before central pip	233	228	184
No. of pips after central pip	263	224	189

Echoes are most likely to occur in the first seconds after the central pip. The slight preponderance observed in the first interval after as compared with the first interval before the central pip does not seem to be significant. However, since echoes will principally be produced by limb sources it may be interesting to repeat this investigation with a selected material consisting of pips produced by limb sources.

Our conclusion must be that these records do not show the echo effect.

This may lead to the conclusion that the pips are produced in the layer where the plasma frequency is equal to the frequency of the pips.

4. THE DURATION OF THE PIPS

On sixteen of our records the 'e-widths', defined as the width of a pip at $1/e$ times the top intensity, were measured for all measurable pips. For each of these records a histogram has been constructed showing the distribution of the measured e-widths. We were struck by the fact that the histograms thus obtained may vary considerably from one day to the other, a fact that has already been studied earlier by Dr Seeger (personal communication). In general, maxima in the e-width distributions are observed at values of $0^s{\cdot}4$ and $0^s{\cdot}6$ and sometimes at $1^s{\cdot}0$. In a few other cases we observed very broad pips having an e-width of the order of 2 sec. There are indications that these pips of long duration may be associated with the first stage of the flare-associated radio phenomena, but this observation is based on too small a number of data and needs further confirmation.

At any rate Reber's (1955) [2] observation that the half-width of radio-pips expressed in seconds should be equal to the wave-length in metres is not confirmed by our observations: Reber's law would predict a mean half-width of 1·5 sec. while we observed only in very few cases an e-width of about 2 sec. of time. The great majority of the pips at 200 Mc./s. has an e-width of $0^s{\cdot}5$, and a still smaller half-width.

Note added in proof.

Solar noise measurements by T. de Groot during 1956 at the Dwingeloo Radioastronomical Observatory at 400 Mc./s. yielded an average half-width of $0^s{\cdot}18 \pm 0^s{\cdot}03$. The sample consisted of about 500 pips. There was no indication of a second maximum in the histogram.

REFERENCES

[1] Jager, C. de and Veer, F. van 't. *B.A.N.* (in the Press).
[2] Reber, G. *Nature*, **175**, 132, 1955.