SUDDEN COSMIC NOISE ABSORPTION AT 29 Mc/s*

By M. Krishnamurthi,† G. Sivarama Sastry,‡ and T. Seshagiri Rao‡

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Summary

Cosmic radio noise observations at 29 Mc/s made at Hyderabad, India (17° 26′ N., 78° 27′ E.), have been compared with solar flare data for the year 1958. For flares of importance 3 or 3±, there is a correlation of 84% with regard to related effects observed in the cosmic noise records. These effects are either enhanced radio emission or SCNA's. Particular study of the 9 SCNA's observed during the year and comparison with results of Bhonsle working at Ahmedabad, India (23° 02′ N., 72° 38′ E.), reveal that (*a*) even in the case of intense flares initial conditions in the terrestrial atmosphere govern the production and maintenance of an SCNA, and (*b*) therefore, at least at frequencies above 25 Mc/s, SCNA's cannot be used for patrolling even intense solar flares.

I. Introduction

Single-frequency observations of solar radio emission and dynamic spectra observed by the swept-frequency technique have been compared with optical solar flare data by Dodson (1958) over a period of 8 years and a close correlation has been established between major radio outbursts at frequencies below 200 Mc/s and solar flares. Besides such major radio outbursts, cosmic radio noise observations give another indication of the advent of a solar flare at frequencies of the order of 30 Mc/s and lower. These are the sudden cosmic noise absorption (SCNA) phenomena. Shain and Mitra (1954) working at 18·3 Mc/s established a close correspondence between SCNA's and solar flares. Recently Bhonsle (1960) has given an analysis of several SCNA's observed at Ahmedabad, India (23° 02′ N., 72° 38′ E.), over a period of 3 years. He has also found that every SCNA can be associated with a solar flare.

II. Experimental Results

Since January 1958, the authors have been continuously recording the cosmic noise using a radio telescope at 29 Mc/s at Hyderabad, India (17° 26′ N., 78° 27′ E.). The equipment and aerial array have been described in detail in an earlier paper (Krishnamurthi, Sivarama Sastry, and Seshagiri Rao 1958). For the period January to December 1958, which forms part of the IGY, an attempt has been made to correlate observed solar radio bursts and SCNA's with solar flares. For the present purpose, only flares of importance 3^-, 3, or 3^+ are dealt with. The data regarding such flares are taken from the CRPL

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† Director's Research Laboratory, Indian Institute of Science, Bangalore–12, India.

‡ Department of Physics, Osmania University, Hyderabad–7, India.

bulletins on solar activity. It must, however, be pointed out that for the same flare, the importance has been reported differently by different observers. In the present case, even if one observer has assigned importance 3 for a given flare, it has been taken into consideration. At the same time the importance of flares for which no corresponding severe ionospheric fade-out is reported is regarded as uncertain. Table 1 gives a summary of the results of correlation studies between reported optical flares of importance 3 or $3^{\pm}$ and cosmic noise observations made in the present study.

TABLE 1

SOLAR FLARES OF IMPORTANCE 3 OR $3^{\pm}$ AND CORRESPONDING COSMIC RADIO NOISE OBSERVATIONS AT 29 MC/S FOR THE YEAR 1958

1.	Total number of flares of importance 3 or $3^{\pm}$ reported during the calendar year 1958	50
2.	Flares for which the importance is uncertain	10
3.	Flares which occurred when the Sun was out of aerial beam	10
4.	Flares not recorded due to local interference or instrumental failure	5
5.	Flares for which enhancement or outbursts of radiation have been recorded	12
6.	Flares for which SCNA's have been recorded	9
7.	Flares for which no radio event has been recorded	4

Out of 21 occasions when the reported solar flares produced detectable effects in the cosmic noise records, 12 resulted in the usual types of enhanced solar radio emission and 9 in sudden cosmic noise absorption. The duration of each SCNA, the amount of absorption in decibels at the maximum phase, and data for the corresponding solar flares are given in Table 2.

III. DISCUSSION

It can be seen from Table 1 that the percentage of solar flares of importance 3 for which corresponding radio events have been recorded is 84, which compares very well with 90% given by Dodson (1958) for this type of flare. The present paper particularly deals with the nine occasions when SCNA's have been observed. The general characteristics of these SCNA's are as follows:

(1) The SCNA's have the characteristic feature of a solar flare, namely, sudden commencement and gradual tapering off of the absorption.
(2) The time of start of the SCNA is in good agreement with the corresponding solar flare time. The time of maximum phase of the SCNA also agrees in each case quite closely with the corresponding phase of the solar flare.
(3) The amount of absorption depends in a general way on the zenith angle of the Sun and the importance of the flare. The absorption has varied from $1 \cdot 2$ to $\gg 7 \cdot 8$ dB.
(4) On all occasions, corresponding short-wave radio fade-outs and magnetic storms have been reported.
(5) The SCNA invariably disappears earlier than the associated solar flare.

TABLE 2

SCNA AND THE CORRESPONDING SOLAR FLARE DATA

S. No.	Date	Importance	SCNA Observed (U.T.)			Maximum Absorption (dB)	Solar Flare Observed (U.T.)			Short-wave Radio Fade-out (U.T.)	
			Start	End	Max. Phase		Start	End	Max. Phase	Start	End
1	3. iii.58	3	10·10	11·02	10·21	2·3	10·07	11·09	10·21	10·15	11·00
2	23. iii.58	3^+, 3, 2^+, 2	09·51	11·45	10·04	$\geqslant$7·4	09·50	12·45	10·03	09·55	12·00
3	5. v.58	3, 1^+	04·10	04·36	04·16	3·0	04·12	04·44	04·16	04·15	04·25
4	6. vi.58	3, 2	04·36	05·15	04·39	1·2	04·36	05·26	04·39	SWF reported	
5	29. vii.58	3	03·00	03·45	03·08	6·0	02·59	04·08	03·04	03·00	04·00
6	16.viii.58	3^+	04·33	05·20	04·39	>7·8	04·33	06·14	04·40	04·32	07·20
7	14. ix.58	3^+, 2^+, 2	08·33	09·38	09·05	3·7	08·32	09·35	09·05	08·51	09·49
8	19. x.58	3, 2^+, 2, 1	06·34	07·53	07·30	1·5	06·34	08·13	07·26	07·20	07·50
9	3. xii.58	3, 2, 1	07·02	07·30	07·06	1·5	07·02	07·33	07·06	07·03	07·23

(6) An interesting feature is the occurrence of a number of short duration outbursts of enhanced radio emission during the period of absorption headed by an outburst lasting about 2–4 min. This leading outburst is considered to be a type II burst and provides means of studying the speed of the shock wave front in the solar corona. A detailed analysis of this feature is being published separately.

It is now generally accepted that X-rays of shorter wavelength than usual are emitted during an intense solar flare and these penetrate the Earth's atmosphere, causing intense ionization at *D*-layer heights of the order of 80 km. It is this layer that is supposed to cause the SCNA. This hypothesis is corroborated by the coincidence of the times of start and maximum phase of the SCNA and the corresponding solar flare as shown in Table 2, provided one makes the reasonable assumption that the X-rays are emitted at the same time as the visible radiation.

From Table 1, it is seen that while every SCNA is associated with a solar flare, the reverse is not true. This shows that besides the occurrence of an intense solar flare, some other conditions have to exist in the terrestrial atmosphere itself to give rise to an SCNA. In this connexion a comparative study has been made of SCNA's reported in this work with those reported by Bhonsle (1960). Bhonsle has listed as many as 12 SCNA's for the period January–September 1958. Six of them have not been observed by the present authors. At the same time two reported in this work on March 3 and August 16 have not been observed by Bhonsle. In five cases reported by Bhonsle and in the present work, there is good agreement regarding times of occurrence. The amount of absorption is usually higher at Ahmedabad than at Hyderabad, where the present work was carried out. This can be ascribed to the lower frequency employed by Bhonsle, namely, 25 Mc/s compared with 29 Mc/s at which observations were made in the present case. On the other hand, it will also depend on the Sun's zenith angle at the time of the flare. Assuming that the amount of ionization produced and hence the cosmic noise absorption varies directly as the cosine of the zenith angle of the Sun, an attempt has been made to correct for the difference in zenith angles at the two places. After such a correction is made, if the only other governing factor is the observation frequency, one should expect a constant difference in decibels between the maximum values of absorption at the two places on all occasions. This is not so. This also points to the influence of local terrestrial conditions on the intensity of the SCNA, even when it is observed to occur at both stations.

Another feature of interest is the ending time of the SCNA in relation to the ending time of the optical flare itself. The SCNA invariably ends before the flare, the time difference being in the range 3–60 min. This result would indicate that the rate of recombination of ions and electrons is much higher than their production once the maximum phase of the flare is passed. It may be that the ionizing radiation in the X-ray region is not emitted for as much time as the optical radiation during the flare.

It would be interesting to study the conditions such as temperature, pressure, winds, and the extent of ionization obtaining in the *D* layer just prior to the advent of an SCNA. For the present it has to be concluded that at least at the frequencies of the order of 25 Mc/s and above, SCNA's cannot be used for patrolling flares of importance 3 or $3^{\pm}$ even.

IV. References

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