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A Statistical Survey of SCNAs Over Half Solar Cycle

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A study of the characteristics of sudden cosmic noise absorption (SCNA) is made in order to investigate into their variations from IGY to IQSY. The necessary data for the investigation are taken from CRPL—Part B (now NOAA) series as reported by 5 observatories in the American Zone. The entire period of analysis (1958-65) is divided into 3 groups, viz. periods of high, medium and low solar activity, and the optical flares associated with the SCNA are divided into three classes, viz. 1, 2 and 3. The analysis reveals that the SCNA size has an increasing tendency with decreasing solar activity. The growth-time associated with class 1 flares is observed to be decreasing with decreasing solar activity, while for the class 2 and class 3 flares the reverse is the case. The time of decay of the SCNA shows a decrease with decrease in the level of solar activity. No systematic latitudinal variation is observed in the case of the size, growth-time and decay-time of the SCNAs.

1. Introduction

WHEN INFORMATION is sought regarding changes in ionization and processes relating to ionization production and loss, of all the SID phenomena, there is a distinct advantage in using the sudden cosmic noise absorption (SCNA) method. The reason is that the observed changes can be directly translated into changes of electron density at the peak absorption level, in spite of the fact that the concept of such an effective level is necessarily crude. The main characteristics of an SCNA method are: (i) the size, (ii) the time of growth, and (iii) the time of decay. Since the characteristics of SCNA method depend upon the amount and rate of ionization enhancement and the effective loss rate, it is quite likely that these characteristics vary with the level of solar activity and the geographic location of the observatory. The aim of the present investigation is to examine how the SCNA characteristics vary from the IGY to the IQSY period and to see whether there is any latitude dependence, by analyzing the data over eight years, from 1958 to 1965, reported by various observatories.

2. Source of Data and Method of Analysis

The time histories as well as the sizes of SCNAs and the corresponding optical flare data reported by various observatories in the CRPL—Part B series during the period 1958-1965 have been taken for the present investigation. The list of observatories chosen for the analysis is given in Table 1.

The size of SCNA reported in the CRPL-FB series is not the actual excess absorption at the peak of the phenomenon, but the percentage absorption, which is defined as

$$\% \text{ absorption} = \frac{I_n - I_f}{I_n} \times 100$$

where I_f is the equivalent noise diode current at the peak of SCNA phenomenon and I_n is that under normal conditions. The time of ending of the SCNA is the time at which the excess absorption falls to

Table 1—Observatories for which SCNA Data are Available, and Their Geographical Parameters

Name of observatory	Abbreviation	Geogr. lat. °N	Geogr. long. °W	Period over which data are available
Rensslear Polytechnic Institute Observatory, Gerafton, New York	RE	42°47′	77°27′	1958-1962
McMath-Hulbert Observatory Michigan State University	MC	42°00′	88°00′	1958-1965
High Altitude Observatory Boulder, Colorado	BO	40°02′	105°18′	1958-1965
Sacramento Peak, North Mexico	SP	38°30′	121°15′	1958-1960
University of Hawaii, Makapuu Pk., Hawaii	HA	21°18′	157°39′	1958-1965

Table 2—Most Probable and Average Values for Different Levels of Solar Activity in Respect of 3 Distinct SCNA Characteristics

SCNA characteristic	Level of solar activity	Class 1 flares		Class 2 flares		Class 3 flares	
		Most probable value	Average value	Most probable value	Average value	Most probable value	Average value
Size (% absorption)	High	16	24	24	36	75	55
	Medium	18	26	26	36	75	66
	Low	24	29	35	45	...	...
Time of growth (min)	High	7	8	6	7	8	10
	Medium	5	8	7	10	15	13
	Low	4	6	8	11	...	...
Time of decay (min)	High	16	23	22	28	35	37
	Medium	16	23	20	31	...	56
	Low	15	17	16	30	...	...

10% of its peak value. The corresponding optical flares are broadly classified into 3 categories. namely class 1, class 2 and class 3 for convenience in analysis, ignoring the further subclassification of faint, normal and bright or − and + in each class. The entire period of analysis from 1958-1965 is divided into three groups, namely (1) 1958-1959, 1960-1962, and 1963-1965, representing respectively the periods of high, medium and low solar activity. Since the majority of SCNAs are found to occur around local noon, it is assumed that the influence of diurnal cos χ variation on the results of the present investigation is small.

The most probable and average values of all the SCNA characteristics are estimated separately for different classes of flares and during different periods of analysis. The trend of the variation of each of the SCNA characteristics is discussed below.

3. Size of SCNAs

It can be seen from Table 2 that the most probable value of the size of SCNAs has a steadily increasing tendency from the period of high solar activity to that of low solar activity. The effect is predominantly visible in the case of SCNAs resulting from class 1 and class 2 flares. The average values of the SCNA size also exhibit a similar tendency. During the low solar activity period, only 1 SCNA could be associated with a class 3 flare and hence, the most probable and average values could not be obtained. The tendency for the increase in size from high to low solar activity periods is clearly visible in the case of class 3 flares also, for which the average SCNA size has increased from 55% during high solar activity period to 66% during medium solar activity period.

Regarding the production mechanism of an SCNA, it is fairly well established that hard X-rays in the range of 2-8 Å emitted during a solar flare are mainly responsible for the extra ionization at the D-region levels. If it is accepted that the amount of hard X-ray flux emitted during a flare is a measure of the size of the SCNA produced, then the results of the present investigation according to which the flare effect is more during low solar activity period, require an explanation.

A possible explanation for this may be the fact that, for the D-region levels, the electron density N varies as the square root of the rate of production of ions (q). Thus q versus N plot will be a parabola, which shows a large increase in N at low levels of q and less increase in N for large values of q. Since q, in general, is low during low solar activity period, the flare effect which enhances q produces a large change in N leading to a large size of SCNA. But, during high solar activity period, the pre-flare value of q itself is high and any further enhancement in q due to a solar flare produces less change in N leading to low values of SCNA size.

No systematic latitudinal variation is observed in the SCNA sizes. For all the observatories, the average SCNA sizes are found to be around 30% for class 1 flares, 40% for class 2 flares and 60% for class 3 flares.

4. Time of Growth of SCNAs

The difference between the times of beginning and maximum of an SCNA is taken as the time of growth. The time of growth of an SCNA, even though governed to some extent by the time of growth of the associated solar flare, is a function of the rate of variation of electron density and as such may be affected by changes in normal pre-flare electron content due to changes in the level of solar activity. It can be seen from Table 2 that the times of growth of SCNAs resulting from class 1 flares have a decreasing trend with the decrease in solar activity, whereas the times of growth of SCNAs associated with class 2 and class 3 flares show an increasing trend with the decrease in solar activity.

It has been shown in the preceding section that the size of SCNA increases with the decrease of solar activity for all classes of flares. Since the size of a

SCNA is a measure of the amount of ionization enhancement, it means that the ionization enhancement increases with decline of solar activity. If the ionization enhancement is large, for particular rates of ion production and loss, the time of growth of the SCNA will obviously be large. This is probably the reason for the observed increase of the time of growth of SCNAs produced in class 2 and class 3 flare with decrease in the level of solar activity. A similar argument should hold good for class 1 flares also, but it has been observed that the time of growth of SCNAs resulting from class 1 flares decreases with the decrease of the level of solar activity. Following Appleton and Piggot[1], the rate of variation of excess electron density N_x due to a flare can be expressed as

$$\frac{dN_x}{dt} = q_x - \alpha(N_x^2 + 2\, N_0 N_x)$$

where q_x is the rate of production of excess ionization, α, the recombination coefficient and N_0, the normal pre-flare electron content. For class 1 flares, the excess electron density N_x is itself small and so, for a particular rate of production q_x appropriate to class 1 flares, the rate of variation of N_x is largely dependent on N_0, the normal pre-flare electron content. As the level of solar activity decreases, N_0 decreases or dN_x/dt increases. It is obvious that the time of growth of an SCNA will decrease if the rate of ionization enhancement increases. This is probably the reason for the observed decrease of the times of growth of SCNAs with decrease in solar activity for class 1 flares.

No systematic latitudinal variation has been observed in the times of growth of SCNAs.

5. Time of Decay of SCNAs

The interval between the times of maximum and ending of an SCNA is taken as the time of decay. It can be seen from Table 2 that, even though the average values of the times of decay do not exhibit any systematic variation with the level of solar activity, the most probable values in the case of SCNAs resulting from class 1 and class 2 flare show a decreasing tendency from the period of high solar activity to that of low solar activity. The most probable values for SCNAs resulting from class 3 flare could not be assessed during the periods of medium and low solar activity because of the small number of SCNAs during these periods. Even though the decrease of the time of decay from 16 to 15 min is not significant enough to attach any importance, the same is considerable in the case of SCNAs resulting from class 2 flares, for there is a decrease of about 25% in the time of decay from high to low solar activity periods. This decreasing tendency suggests that the rates of processes which contribute to the loss of ionization are higher in the period of low solar activity.

No systematic latitudinal variation of the decay times is observed.

6. Conclusions

(1) The SCNA size has an increasing tendency with decreasing solar activity.

(2) The time of growth of SCNAs resulting from class 1 flare have a decreasing tendency with the decrease in solar activity, whereas the times of growth of SCNAs resulting from class 2 and class 3 flares show an increasing trend with decreasing solar activity.

(3) The times of decay of SCNAs show a decreasing tendency with the decrease in the level of solar activity. The magnitudes of the decay times are found to increase consistently with the intensity of the flares responsible for the SCNAs.

References

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