Communications

Some Studies on Solar Radio Bursts & SIDs in Relation to Distinctive Visual Features of H_α-Flares

M K DAS GUPTA, T K DAS & S K SARKAR*

Centre of Advanced Study in Radiophysics & Electronics
University of Calcutta, Calcutta 700 009

Received 18 *December* 1978; *accepted* 3 *March* 1979

Solar H_α-Flares reported under a scheme of classification based on their distinctive visual features have been examined for a period of about eight years. Flare-radio burst and flare-sudden ionospheric disturbances (SIDs) association and also the peak flux spectra of the associated bursts have been studied. The following important results are obtained, viz. (i) D-type of flares, compared to other types, are the most predominant and appear to concentrate more towards the disk limb; (ii) flare-burst association is frequency dependent and has the highest and the lowest values for H- and D-types of flares respectively; (iii) peak flux spectra of each type of flares reveal that the flux density shows a definite increase in the decimetric region; (iv) decametric type III bursts generally do not coincide with these types of flares; if they do, they accompany microwave and decimetre wave bursts in 30% and 43% cases respectively and (v) flare-SID association is highest for F-type and lowest for D-type of flares.

Studies on different types of solar radio bursts at different frequencies and on their association with different classes of solar flares and vice versa were made by different workers, the results of which were duly published in monographs.[1,2] However, with a view to a clearer understanding of the enigmatic behaviour of the flare build-up process, the solar flares are being designated at present according to a new scheme of classification based on their distinctive visual features.[3] As far as it is known to the authors, no detailed analysis of the flare-radio burst or of flare-sudden ionospheric disturbance (SID) association on the basis of this new scheme of classification has so far been made.

In the present statistical investigation, the flares grouped under a separate scheme of classification[3] based on their distinctive visual features were examined. The nomenclature of types of flares examined is as follows.

- D Brilliant point
- E Two or more brilliant points
- F Several eruptive centres
- H Flare accompanied by a high speed dark filament

The flares possessing other types of visual indications were not considered as their numbers were insufficient for statistical analysis. In order to categorize the flares under the classifications mentioned above, only group reports of the H_α-flares published in the *Solar Geophysical Data* have been taken into consideration. The data characterizing a particular flare and the data of the same flare-associated multifrequency radio bursts and SIDs have been collected from the same data books. The association of bursts and of SIDs with flares has been considered when each of them occurs within $\pm$ 5 min of the starting time of a flare. In order to cover 24-hr observing period, data of both Manila and Sagamore Hill Radio Observatory have been taken into account. In examining the flare-burst association and the peak flux spectra of the bursts, bursts occurring more or less simultaneously at nine frequencies, viz. 245, 410, 606, 1415, 2695, 4995, 8800, 15400 and 35000 MHz were used. The present analysis covers a period of eight years since July 1970 covering the declining phase of the 20th solar cycle.

The distribution of different types of flares during the period under consideration and their relative percentage values are given in Table 1.

Table 1—Distribution of Different Types of Flares

Visual indications	Number of occurrences	Percentage occurrences
D	375	35·4
E	298	28·1
F	258	24.4
H	47	4·4
Remaining nine types (U,J, K, A, R, L, Z, G & I)	81	7·7

*Present address: Department of Physics, University College of Science, Calcutta University, Calcutta 700 009.

It is apparent from Table 1 that D-type of flares are most numerous in respect of their occurrences.

The distribution of flares on the visible solar disk is presented in Fig. 1. It has been found that about half of the total flares of individual types D, E, F, and H are crowded to the region of the solar disk having the ranges of central distance 0·8-1·0, 0·4-0·8, 0·4-0·8 and 0·6-1·0, respectively, the distance being expressed in units of disk radius. As D-type of flare mostly musters strong in the region of disk limb, it may be looked upon as limb flares.

In investigating the flare-burst association it is seen that a particular flare is followed generally by the same type of radio bursts at various frequencies, the microwave impulsive bursts being most predominant. Multifrequency bursts have been found to be maximum in case of F-type of flares as compared to other types. Next the total number of bursts at any frequency associated with D-, E-, F-, and H-type of flares were found out individually. Percentage of bursts associated with flares of different types were calculated for each frequency. The results are shown in Fig. 2. The following conclusions can be made from these results.

(i) The percentage association is highest for H-type of flares and least for D-type of flares at almost all the observed frequencies of the bursts.

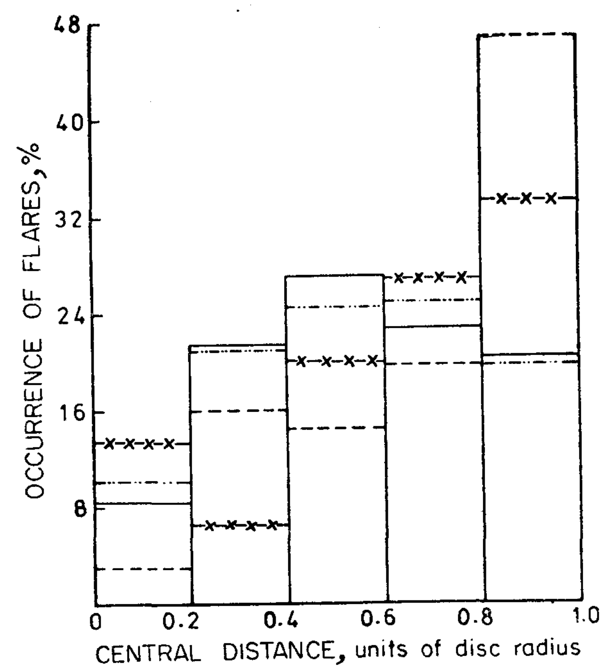

Fig. 1—Histograms showing percentage occurrences of the different types of flares in various ranges of central distance measured in units of disk radius [-----(D),—— (E), —..—..— (F) and -×-×- (H) represent flare types.]

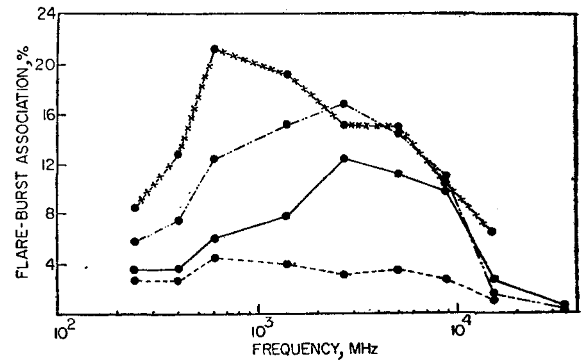

Fig. 2—Curves showing the dependence of flare-burst association with the frequency of bursts for different types of flares. (Types of flares are designated by the same symbols as used in Fig. 1)

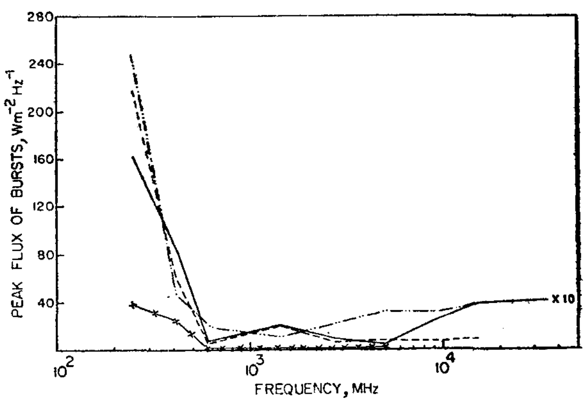

Fig. 3—Curves showing the average peak flux against the frequency of bursts associated with different types of flares. (The symbols used are the same as in Fig. 1. The plotted values of average peak flux in case of E-type (———) flare have been reduced in scale by a factor of 10)

(ii) The peak of the association occurs around 600 MHz for D- and H-types and around 2700 MHz for E- and F-types of flares.

(iii) The nature of the curves shows that flare-burst association becomes effectively zero both at high and low frequencies.

The peak flux spectra of the flare-associated bursts covering the whole range of observed frequencies were drawn for each type of flares. As the peak flux spectrum for each of the multifrequency event shows the same nature of variation, the average spectrum were drawn for the respective type of flares as shown in Fig. 3. It is interesting to note that the peak flux density is comparatively very high at 245 MHz and with the published data available, it is difficult to suggest whether there may be any major maxima occurring beyond the decimetric wavelength region. However, if one considers only the microwave region, the spectra shown in Fig. 3 resemble more or less those of earlier results.[4-6]

Table 2—Association of D-,E-,F-, and H-types of Flares with Decametric Type III Bursts

Type of flares	No. of flare-associated type III decametric bursts	Flare-associated type III bursts accompanied with decimetric bursts	Flare-associated type III bursts accompanied with microwave bursts
D(375)	22	9	4
E(298)	17	8	7
F(258)	10	3	4
H(47)	3	3	2
Remaining types together (81)	4	1	—

(Figures in parentheses in the first column represent the number of flares.)

The flares were also examined in relation to the occurrences of the decametric type III bursts. The results are shown in Table 2.

The overall percentage association of flares with these types of bursts is 5·3% only. Again amongst the flare related decametric type III bursts, about 43% and 30% are accompained with the decimetric and microwave bursts, respectively. These results conform partly with that of Pick.[7]

Lastly, the individual type of flares were associated with the SIDs. The flare-SID associations for D-,E-,F- and H-types are, respectively, 12·3, 19·8, 27·1 and 21·3% only. Again, most of the associated SIDs are of importance 1; where the SIDs have been designated under the importance rating based on a scale of 1, the least, to 3, the most important, producing intense ionization in the ionospheric D-layer.

References

1. Kundu M R, *Solar radio astronomy* (Interscience Publishers, New York), 1965.
2. Zheleznyakov V V, *Radio emission of the sun and the planets* (Pergamon Press, London), 1970.
3. NOAA, *Solar geophysical data,* No. 390 (U. S. Department of Commerce, Washington), 1977.
4. Hachenberg O, *Solar system radio astronomy* (Plenum Press, New York), 1965.
5. Castelli J P, Aarons J, Michael G A, Jones C & Ko HC, *Solar flares and space research* (North-Holland Publishing Co. Ltd., Amsterdam), 1969.
6. Das Gupta M K & Sarkar S K, *Solar radiations and the earth,* edited by J N Tandon (Hindustan Publishing Corpn, Delhi), 1973.
7. Pick M, *Solar Phys.,* **53** (1977), 241.

Fading of Simultaneous lf Radio Signals for Two Propagation Paths with the Same Effective Height

S K Sen

K N College, Berhampore, West Bengal

and

S K Trehan & A K Sen

Institute of Radio Physics and Electronics, University of Calcutta, Calcutta 700 009

Received 8 *January* 1979; *revised received* 22 *February* 1979

Simultaneous observations of the field strength of lf radio signals on 332 and 280 kHz propagated over two paths for which the effective heights of reflection are the same, have been made at Berhampore, West Bengal. A preliminary analysis of the data indicated that the fadings at the two frequencies are independent, the depth of fading being more at night than in daytime. There is a tendency for the fading depth at night to decrease abruptly after midnight, particularly for the propagation path at 332 kHz. The results have been critically examined in the light of the current knowledge about radio wave propagation in the lower ionosphere.

Radio navigational signals in the lf band are widely used for homing of aircrafts towards various airports. A knowledge of the fading characteristics is important for the setting up and successful operation of the homing links. It is expected that the fading characteristics would be a function of the effective frequency as given by $f_v = f \cos i$, where, i is the angle of incidence on the ionosphere and f is the frequency of transmission. For the last few years, we have been recording simultaneously the field strength of two radio signals in the lf band on 280 kHz (call sign JR and CHB) and 332 kHz (call sign EA) for which the effective frequencies are of the same order. The fading of the signals exhibits certain interesting characteristic features. The results obtained from a preliminary analysis of the data are presented in this communication.

The signal at 332 kHz is transmitted from Calcutta (lat., 22°34′N; long., 88°24′E) while that at 280 kHz for the daytime period is due to a transmission from Jessore (lat., 23°10′N; long., 89°10′ E) in Bangladesh. At night this daytime transmission is stopped when a signal at the same frequency is received throughout the night from China Bay (lat., 9°11′N; long., 81°11′E) in Ceylon. Two typical records of the nighttime field strengths on 332 and 280 kHz exhibiting the fading are reproduced in Fig. 1. In the upper record [Fig. 1(a)], which is due to the 280 kHz transmission (CHB), the fading is quite marked. In the lower record [Fig. 1(b)], due to the 332 kHz