LONGITUDINAL DISTRIBUTION OF THE HARD X-RAY BURSTS ON THE SUN

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Abstract. The analysis of 315 hard X-ray bursts (HXR) producing solar flares observed by Hinotori satellite shows that the HXR bursts occur most prominently at 110°, 140°, 290°, and 320° longitude, respectively. These longitudes are not only prolific in producing flares in number but also in producing flares with large photon counts.

1. Introduction

Solar flares emit electromagnetic radiations in a very broad range wavelengths from gamma rays to the decameter wavelengths. In general, solar flares produce variety of electromagnetic and particle radiations (Kane *et al.*, 1980). Energetic solar flare particles with energies greater than about 10 keV after interaction with the solar atmosphere result in a great variety of flare phenomena including the hard X-rays (HXR).

According to Peterson and Winckler (1959) the HXR emission is produced by non-thermal electrons through bremsstrahlung mechanism. However Chubb *et al.* (1966) explained their observations on the basis of hot thermal plasma ($> 10^8$ K). Presently, the non-thermal nature of HXR has been generally accepted on the basis of increasing number of facts which confirm the nature of the electrons producing HXR (cf. Švestka, 1976).

The longitudinal distribution of HXR bursts producing flares is not studied yet. Here we present longitudinal distribution of the HXR bursts producing flares on the Sun, based on an analysis of 315 events and we have also attempted to study the longitudinal distribution of the peak flux of HXR bursts during solar flares on the Sun.

2. Observational Data and Analysis

To study longitudinal distribution of the HXR bursts on the Sun, we used HXR data recorded by Hinotori satellite during 1981–82. Hinotori recorded 609 flare time profiles (FTP), observed during solar flares and these were published by Hinotori SXT/HXM team in *Hinotori Satellite Data*, Part I (1982) and II (1983). Each FTP consists of four frames and the four frames correspond to four energy channels. The first frame counts 17–40 keV photons, the second frame counts 40–67 keV photons, the third frame counts 67–152 keV photons and the fourth frame counts 152–359 keV photons. Details about the photon counting for various energy levels are given in the *Hinotori Satellite Data* Part I (1982) and II (1983).

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The spatial location of HXR bursts are unknown while the spatial location of Hα flares are known (*Solar Geophysical Data* (SGD), 1981, 82, 83) in the notations NS and EW. To know the spatial location of the HXR bursts we followed the time correlation procedure used earlier by Swarup *et al.* (1960) and Zirin (1978). Heliographic location of each Hα flare corresponding to each HXR burst (FTP) is given in SGD. From heliographic locations we calculated the longitudes for each HXR burst.

During 1981–82 (i.e. between 26 February, 1981 to 15 December, 1981 and 1 January, 1982 to 30 September, 1982) Hinotori satellite recorded 609 FTP. Out of these, 284 profiles were excluded from our analysis because (1) for 219 events Hα observations have not been reported (ii) for 65 events no flare has been reported in Hα. Finally we were left with only 315 FTP (HXR) for which corresponding Hα flare data is available in SGD.

In the present study, we have used only the first frame/energy channel of HXR data basically because the frequency of events is larger on this channel. Using flare data of 315 flares we plotted a histogram shown in Figure 1. The histogram was plotted for 10°

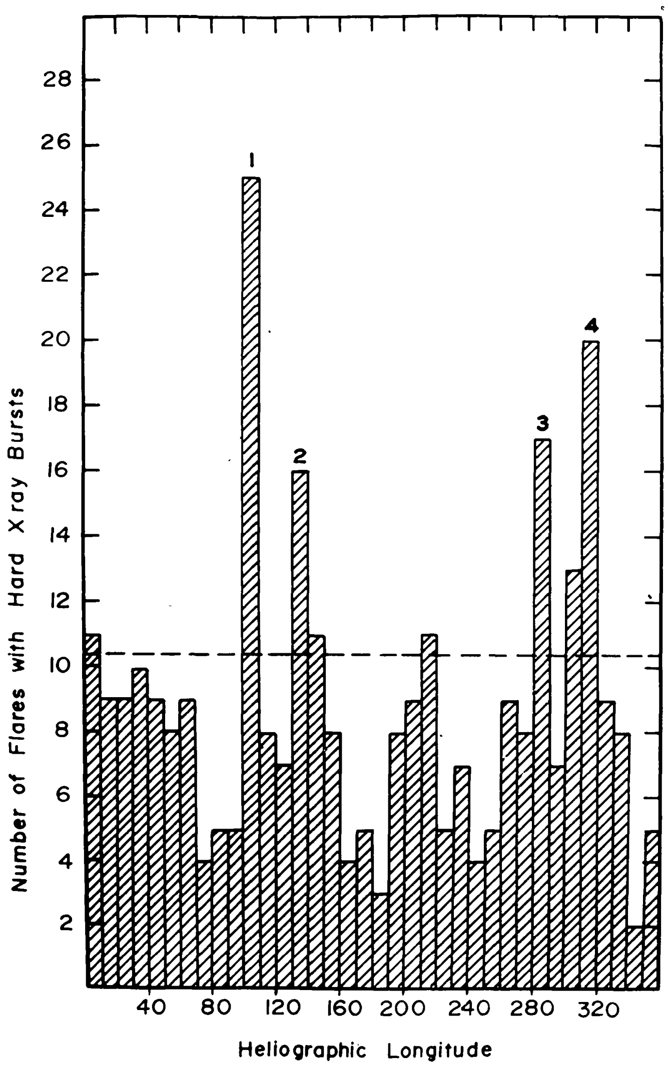

Fig. 1. Plot of number of the HXR bursts with Hα flare versus heliographic longitudes.

longitude intervals only. In figure 1 the horizontal dashed line shows an upper mean level with 95% confidence and only peaks above this are considered significant. Above this upper mean line HXR activity is found to be prominent at 110°, 140°, 290°, and 320° longitudes, respectively. Activity is also found to be enhanced at 10°, 150°, and 220° longitudes, respectively, however the level of activity is not significant when compared with the above four longitudes. Also HXR bursts are associated with solar flares which occur in active regions. Thus, for HXR bursts also we infer that there are four active longitudes.

To study the dependence of the peak flux HXR bursts observed during solar flares on heliographic longitude we plotted Figure 2. Here we have plotted the observed peak

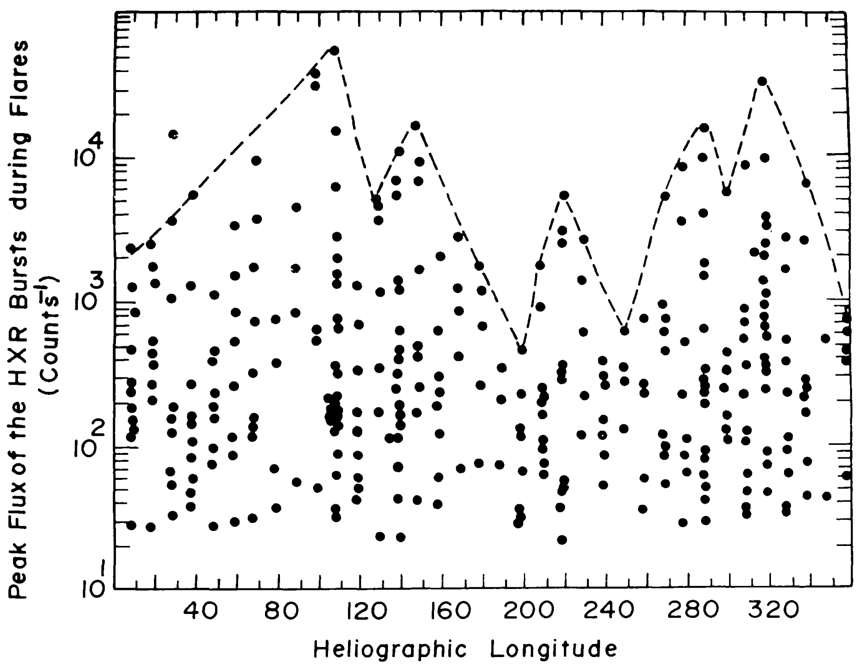

Fig. 2. Plot of peak flux of the HXR bursts during flares versus heliographic longitudes.

flux (counts s^{-1}) of HXR emission versus heliographic longitude. We fitted a freehand dashed line of peak envelope as shown in Figure 2. This peak envelope shows approximate variation of peak flux of HXR bursts with heliographic longitudes on the Sun.

From Figure 2 very qualitatively we infer that the flares of large occur at 110°, 150°, 220°, 290°, and 320° longitudes, respectively. In Figure 2 the peak at 150° longitude is differing by 10° from the peak at 140° in Figure 1. In contrast, rest of the peaks occur at the same longitude in both the figures and comparing Figure 1 and Figure 2 we say that 110°, 140°, 290°, and 320° longitudes are apparently active longitudes. These longitudes are prone not only in producing more number of flares but also flares with large peak photon counts.

We suggest that such observations be continued to work out the probability of occurrence of flares with various HXR burst peak fluxes at various longitudes so that some quantitative conclusions could be drawn from a plot like the one given in Figure 2. However, Figure 1 seems to support our qualitative approach.

3. Discussion

The above results show that the HXR bursts are most prolific at 110°, 140°, 290°, and 320° heliographic longitudes on the Sun. The present investigation based on the analysis of 315 solar HXR bursts (flare) shows that the HXR bursts which are of non-thermal origin (electrons) are most prolific at four longitudes as shown in Figure 1. The separation between the peaks 1, 3 and 2, 4 is 180° and the separation between peaks 1, 2 and 3, 4 is 30° only. It is also clear that longitudes exist in two groups in the peaks 1, 2 called as *A* group and the peak 3, 4 called as *B* and the centroids of the groups are separated by 180° in longitudes.

The variation of peak fluxes HXR bursts (count s^{-1}) with heliographic longitudes shows that large flares also occur at or around these four active longitudes, which tends to confirm that these four active longitudes are really active longitudes because these longitudes not only generate more number of HXR flares but also produce flares with large photon count s^{-1} (Figure 2).

Warwick (1965), Švestka (1968), and Bogart (1982) and others indicated the existence of two active longitudes on the Sun separated by 180°. However, our results show that in addition two more active longitudes exist on the Sun and supports the earlier results of Verma (1984).

4. Conclusions

The salient results of the present investigation are as follows:

(1) The HXR burst producing solar flares are most prolific at 110°, 140°, 290°, and 320° longitudes, signifying that four active longitudes exist on the Sun.

(2) The four active longitudes not only produce larger number of flares but also produce flares with larger photon counts.

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