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Solar Flare Surges in relation to Active Prominences and Sunspots

T. K. Das, T. N. Chatterjee and A. K. Sen

Eastern Centre for Research in Astrophysics,
Institute of Radio Physics and Electronics,
92, A.P.C. Road, Calcutta 700 009, India.

Abstract

A study has been made of flare surges (FS) after correlating them with prominences and sunspots. Results obtained are: (i) the duration of the 88% events lies between 0–40 min; (ii) in most cases the distance between FS and filaments ranges from $0 \cdot 03R_0$ to $0 \cdot 12R_0$ whereas that between FS and sunspots ranges from $0 \cdot 05R_0$ to $0 \cdot 25R_0$; (iii) there are several active regions which can produce sympathetic FS; and (iv) the number of FS from a particular sunspot group is proportional to the number of X-ray flares from the same active region.

1. Introduction

Flare surges (FS) are straight or slightly curvilinear spikes which, in general, grow rapidly from small roundish luminous knots of diameter about 20,000 km. These knots form the basis, possibly even the source, of the surges (Giovanelli and McCabe 1958). Unlike coronal mass ejections (CME), flare surges are small-scale phenomena which are generally confined events and which do not escape from the corona. Several studies on CMEs which escape from the solar corona have, however, been performed from time to time by various workers (Martens and Kuin 1986; Kalhler 1987; Gopalswamy and Kundu 1990). As there has been no systematic study on flare surges, an attempt is made in this research note to investigate some aspects of this phenomenon in the solar atmosphere in relation to active prominences and sunspots.

2. Data Collection and Method of Analysis

About 140 FS events which occurred during 1988 were collected from Solar Geophysical Data Bulletins published by NOAA (US Department of Commerce). We considered only those events which occurred far inside the solar disk, as it was not possible to get any information about the surge or associated sunspots situated near the limb.

As the locations of FS are given in R.A. and $R/R_0 = r$ coordinates, we converted them to LAT. and CMD with the help of requisite relations. The distances between FS and active prominences, as well as between FS and sunspots, were evaluated from similar formulae.

In associating the active prominences with the FS, it was observed that in about 137 cases they were temporally and spatially connected, each having the same starting and ending times. A sunspot was said to be correlated with an

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FS when they occurred within $0 \cdot 5R_0$ with respect to each other, and about 131 such cases were found from the above-mentioned surges.

3. Results

Duration of Flare Surges

The durations of the various surge events were studied and the results are shown in Fig. 1*a*. It is observed that in about 88% of cases the duration lies between 0 and 40 min. In the next phase we attempted to find out whether this duration was influenced by a variation in the area and magnetic field of the associated sunspot. They were, however, found to be very poorly correlated, signifying that the lifetime of a surge is not governed by the strength of the underlying magnetic field, or by the area of the nearby active region.

Coexistence of Surge, Filament and Sunspot Group

The separations between surge and filament and also surge and sunspot group were separately evaluated by employing proper latitude corrections. The results are displayed in Figs 1*b* and 1*c*. From Fig. 1*b* it is evident that in about 86% of cases the distance between surge and filament ranges from $0 \cdot 03$ to $0 \cdot 12R_0$. Similarly, from Fig. 1*c* it appears that the distance between surge and sunspot varies between $0 \cdot 05R_0$ and $0 \cdot 25R_0$ in about 86% of cases.

Sympathetic Flare Surges

While associating FS with sunspots, it is observed that the same sunspot group may produce several surges in a sequence, at different intervals of time. These may be termed 'sympathetic' surges, similar to sympathetic flares and radio

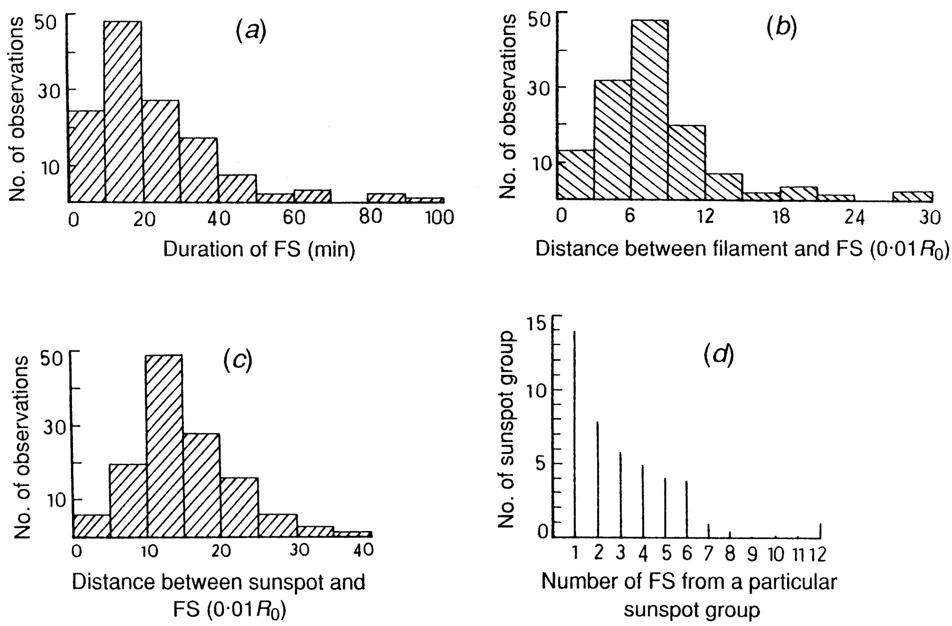

Fig. 1. Histograms showing the frequency distribution of (*a*) the duration of flare surges (FS), (*b*) the distance between sunspots and FS, (*c*) the distance between filaments and FS, and (*d*) a bar diagram showing sympathetic FS from a particular sunspot group.

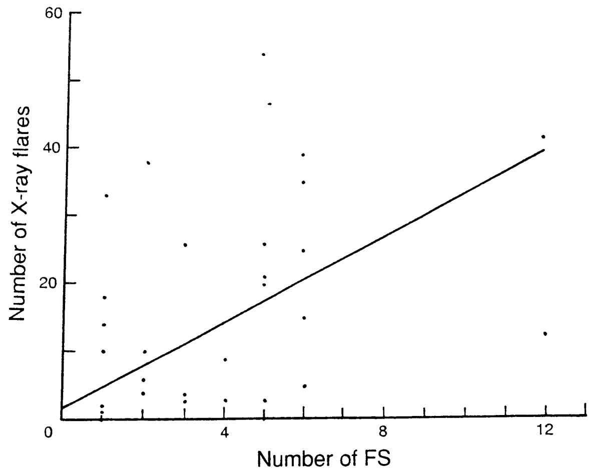

Fig. 2. Regression line giving the variation of the number of X-ray flares with that of flare surges associated with a particular active region.

bursts. The bar diagram in Fig. 1*d* gives some idea of the surge productivity of sunspot groups. It is found that there is a considerable number of sunspots whose surge productivity is quite high.

Association with X-ray Flares

We have observed that there is no temporal or spatial coherence between surge and X-ray flares, but the sunspot groups which were more surge productive were found to be very active in generating X-ray flares. For this study we noted that the number of FS, as well as the respective number of X-ray flares, occurred from a particular sunspot group possessing higher activity. It is observed from Fig. 2 that the number of FS from a particular sunspot group increases linearly with the number of X-ray flares from the same sunspot group. In this case a correlation of about 52% has been obtained, and the best fit gives the following empirical relationship:

$$\text{Number of X-ray flares} = 3\times(\text{Number of surges}) + 1\cdot 5\,.$$

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