Solar gamma-ray flares that occur before low-power optical flares

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Independent

Abstract

Solar gamma-ray flares occurring within a few minutes before an optical flare on the Sun were studied. It was found that the intensity of gamma-ray flares per optical flare varies over the 11-year solar cycle and reaches a minimum near the maximum activity in the cycle. A possible cause for this phenomenon is discussed

Studies show [1] that low-power optical flares are accompanied by bursts of X-ray radiation. To study this phenomenon, data provided by NOAA [2] were used. The data were processed for annual time intervals from 1997 to 2024. In the selected year, the times t_F of the onset of FLA flares of the SF class and the times t_X of the onset of XRA flares of all classes and intensities were first selected and stored in the computer memory. The units of measurement for t_F and t_X are minutes. For each pair of FLA and XRA, the difference was calculated

$$\mathbf{dt = t_X - t_F} \quad \mathbf{(1)}$$

and for values |dt|<90 the dt distribution was collected. For all years these distributions had a similar appearance, its main feature was a peak in the region of several minutes to the left of zero. Figure 1 show such a distribution for 2000.

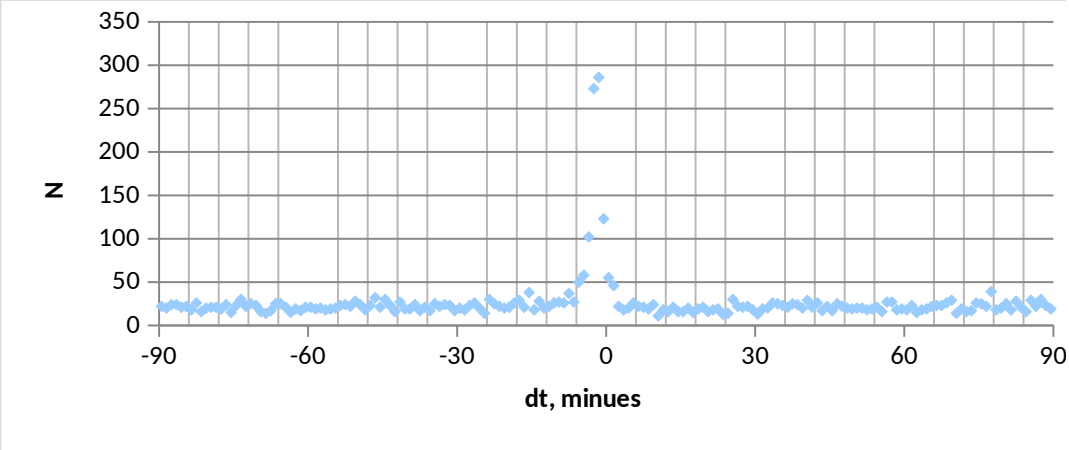

Fig. 1. Distribution of the value of dt for the year 2000

It is reasonable to assume that the XRA bursts that form the peak occur near the corresponding FLA. Next, the number of events in the peak was summed up, and the number of background events was subtracted from it. The number of background events was determined by the number of events outside the peak and by the number of time channels in the peak and outside the peak. The obtained result N_{xra} gave the number of XRA flares emitted near all FLA flares, the number of which we will denote by N_{fla}. From these values, Wxra was calculated the probability of emitting an XRA flare near a FLA flare according to formula (2)

$$\mathbf{W_{xra} = N_{xra} / N_{fla}} \quad \mathbf{(2)}$$

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Fig. 2 shows the dependence of W_{xra} on time during the 23rd, 24th and 25th solar activity cycles. The N_{fla} values for each year are also presented there as a characteristic of solar activity.

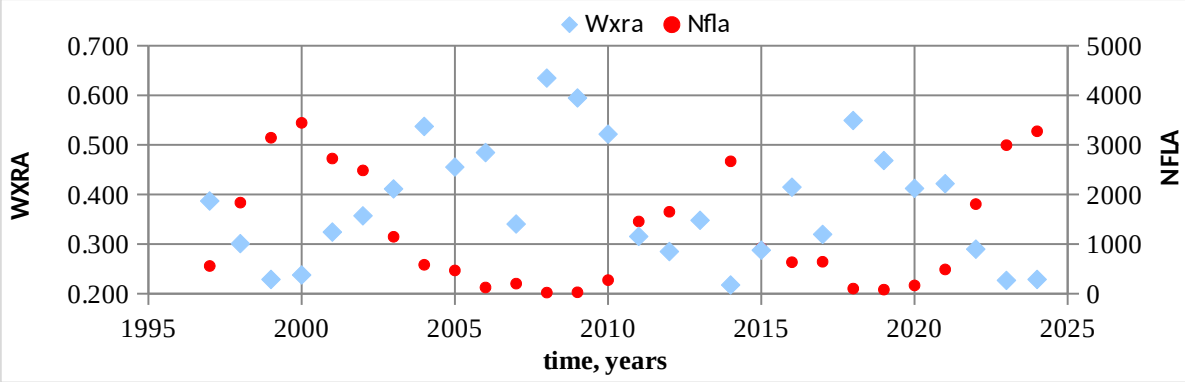

Fig. 2. Dependence of W_{xra} on time

It is evident from Fig. 2 that W_{xra} is not constant during solar activity cycles, with the minimum of W_{xra} being reached in the region of maximum solar activity. Since XRA flares occur during the deceleration of charged particles accelerated by the dynamics of solar magnetic fields [3], it can be assumed that in the region of low-power optical flares the structure and dynamics of magnetic fields during maximum solar activity are not favorable for the acceleration of charged particles. In this regard, the value of W_{xra} can serve as a characteristic of the magnetic fields structure near optical flares.

REFERENCES

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3. A L Lysenko, D D Frederiks, G D Fleishman et al, X-ray and gamma-ray emission from solar flares; Uspekhi Fizicheskikh Nauk, Russian Academy of Sciences 63 (8) 818 ± 832 (2020)