COMPLEX OF ACTIVITY AND LARGE SOLAR FLARES

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ABSTRACT. We discuss the main results derived from a study of large solar flares for 13, 14 and 16 May 1981 by comparing them with the structure of the complex of activity (CA). The main results may be summarized as follows. Chromospheric flares, and other large activations are associated with the CA polarity inversion line. The flare structure undergoes a substantial influence of cellular structures of the size of both a supergranule and large-scale structures (as large as 360 thousand km). The analysis of observational data suggests the conclusion that large flares are, seemingly, the result of global disturbances of large-scale structures (of part of the CA, the entire CA or oven of a system of CAs) rather than of local processes in the region of the flare itself.

КОМПЛЕКС АКТИВНОСТИ И БОЛЬШИЕ СОЛНЕЧНЫЕ ВСПЫШКИ: Обсуждаются основные результаты исследования крупных солнечных вспышек 13,14 и 16 мая 1981 г. в сопоставлении со структурой комплекса активности (КА). Основные результаты сводятся к следующему. Хромосферные вспышки и другие мощные активизации связаны с линией раздела полярностей КА. На структуру вспышки оказывают существенное влияние ячеистые структуры с размерами как порядка размера супергранулы, так и крупно,асштабные (до 360 тыс. км). Анализ данных наблюдений позволяет сделать вывод о том, что крупные вспышки, по-видимому, являются результатом глобальных возмущений крупномасштабных структур (части КА, всего КА или даже системы КА), а не локальных процессов в области самой вспышки.

KOMPLEX AKTIVITY A VEĽKÉ SLNEČNÉ ERUPCIE: Mohutné slnečné erupcie, pozorované 13., 14. a 16. mája 1981 sú zhodnotené z hľadiska štruktúry komplexu aktivity (KA). Boli získané nasledovné výsledky: Erupcie a iná chromosférická aktivita je lokalizovaná pozdĺž neutrálnej čiary komplexu aktivity. V štruktúre erupcií sa výrazne prejavuje supergranulárna sieť, ale aj elementy väčších rozmerov (do 360 tisíc km). Veľké erupcie sú dôsledkom globálnych porúch veľkorozmerných štruktúr (buď časti KA, celého KA, alebo dokonca sústav KA a nie iba lokálnych procesov v oblasti samotnej erupcie.

## 1. INTRODUCTION

Flare activity on the Sun is usually being associated with active regions. Such a treatment is supported by a sufficient number of factors such as the flare localization itself, the correlation of their occurence frequency and importance with sunspot group characteristics, etc. Flares are associated in a most close manner with the polarity inversion line (PIL) of the longitudinal component of the active region magnetic field. This fact was established by Severny (1) and bears a fundamental character; it is widely used in simulations of the flares and in methods of predicting them.

Besides flares are also able to develop in relatively quiet regions in which no sunspots are present. The percentage of such cases is fairly high (2). It is also known that during flares different kinds of activation frequently occur far away from active regions. Such circumstances induce us to modify our view of the flare problem.

In this paper we attempt to discuss briefly and in rather general form the local and global aspects of flare activity. For that purpose, we will be using results of the investigations we have carried out on large flares of May 1981 (3-6), on a number of other events, as well as data reported in the literature. By local factors we understand the conditions in a given active region or in part of it while by global factors we mean those in larger-scale structures.

## 2. GLOBAL DISTURBANCES DURING FLARES

One of the complexes of activity in May 1981 consecutively showed three large flares (on 13, 14 and 16 May). Each time it was possible to observe disturbances over an extent which substantially exceeded the size of the active region. Figure 1 shows an example of filament (and other structures) activation as seen in H-alpha during the 13 May flare. The disturbances started not less than 30 minutes before onset and covered almost the entire boundary of the central region of the complex. "Stationary" filaments exhibited variations in brightness, and shape as well as Doppler effects corresponding to velocities of up to 30 - 40 km $s^{-1}$ and flare-type brightenings in places of discontinuities. In other places there occurred giant "trans-regional" loops connecting one of the flare ribbons to a neighbouring sunspot group as well as some kind of "intrusion" of dark structures into the neighbouring old complex and the related flare-like brightening of chromospheric features. To a certain extent a similar picture was also observed during the 14 and 16 May flares. As compared to these disturbances, the flares looks like a rather ordinary event and they distinguish themselves only by their specific form of manifestation.

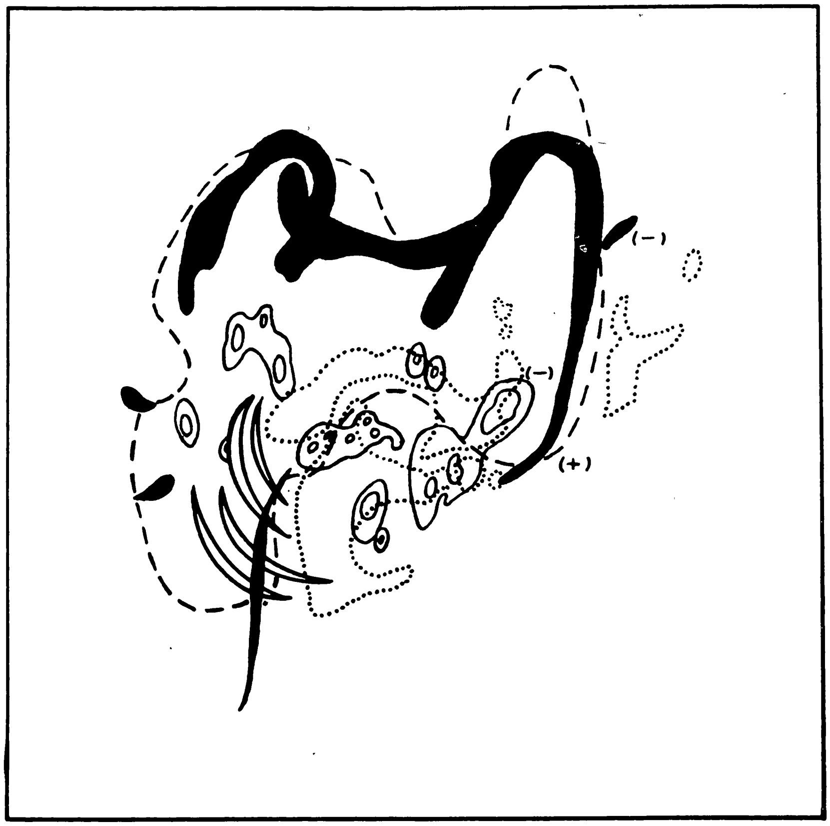


Fig. 1: Global disturbances of a complex of activity during the flare on 13 May 1981. (-,+) - parts of the filaments which underwent Doppler shifts, (---) - the large-scale internal PIL of the complex of activity, and (...) - contours of the flare.

3. RELATIONSHIP OF FLARES WITH LARGE_SCALE PILs

The May complex of activity may be visualized as consisting of a central core of positive magnetic polarity surrounded by a ring-like area of negative polarity. The boundary between them may be regarded as the main internal PIL of the complex. The main PIL of the active region is only a portion of it.

It has become apparent that all observable chromospheric activity, and also the active region with which the flares were associated, produce the impression of being threaded round this line. The flare of 14 May was of particular interest in this regard. It appeared in a spotless region but precisely along the main internal PIL of the complex of activity.

This evidence suggests a quite logical inference that the PIL of the complex of activity represents a unified "electromagnetic circuit" associated with the existence and interaction of large-scale magnetic features (the complex of activity in the May case considered). The circuit is not uniform, and the measure of nonuniformity can, possibly, be represented by brad $H_{\parallel}$. In plathe measure of nonuniformity can, possibly, be represented by grad $H_{\parallel}$. In places where strong magnetic fields make contact, grad $H_{\parallel}$ appears to be higher as compared with other places. It is known that chromospheric activity is correlated with the value of grad $H_{\parallel}$ so that when it is high, the probability of high-importance flare occurrence increases (7); depending on the value of grad $H_{\parallel}$, the visibility of filaments varies (8,9).

All the afore-going induces us to draw a natural, we believe, conclusion that large flares together with other powerful chromospheric activations represent a unified event that is associated with disturbances of part of or the entire complex of activity, or even of a more complicated structure. The activations are all arranged along the large-scale PIL and the character of their manifestation depends on the magnetic situation in a given area along this line. In order to describe the conditions along the PIL, grad $H_{\parallel}$ can be used, although it seems to be far from a universal parameter.

In addition to the main PIL, a whole system of secondary PILs exists in complexes of activity. Chromospheric activations, and also flares are able to develop along them. However, their power is usually substantially smaller as compared to the events along the main PIL. For example, the central core of the May complex of activity involved rather large sunspot groups with a complex magnetic configuration and rapid variations in the number and area of sunspots. Nonetheless, they showed no appreciable flare activity.

## 4. RELATIONSHIP OF FLARES WITH CELLULAR STRUCTURES

In the May complex of activity, and also in other events the flares show a relationship with cellular structures of different scales. An examination of separate fragments of the flares themselves one finds that they show a quite clear tendency to be positioned along circular or ellipsoidal curves with typical sizes of a supergranule. The picture of this situation may be quite diversiform but the essence of the phenomenon is the same: the flares are decelerated on the cell boundaries or skirt them without penetrating inwards. The flares of 29 May 1981 and 14 March 1984, for example, immediately show their location along the boundaries of substantially larger cells (Figure 2a, b) with the size of $134.10^3 \times 94.10^3$ and $146.10^3 \times 130.10^3$ km, respectively.

The situation presented in Figure 3, demonstrates the association of the flares with large-scale cells for the case of May 1981 events. Triple lines represent a segment of the PIL along which the 13 and 16 May flares were developing and double lines mark the area of the 14 May flare; a solid single line shows the intermittently appearing filament. At least two cells, I and II, are identifiable, of a size of $365.10^3 \times 210.10^3$ and $226.10^3 \times 140.10^3$ km, respectively. They have a contact region in which sunspots of a -configuration were located. Another similar configurations of the sunspots was locater in It might be anticipated that also is a region of "collision" of the cells but the situation here is not so well defined as compared to the forst case and we will, for the moment, leave it out from our discussion. As far as cells

Fig. 2: a/ the flare of 29 May 1981, 03:08 UT

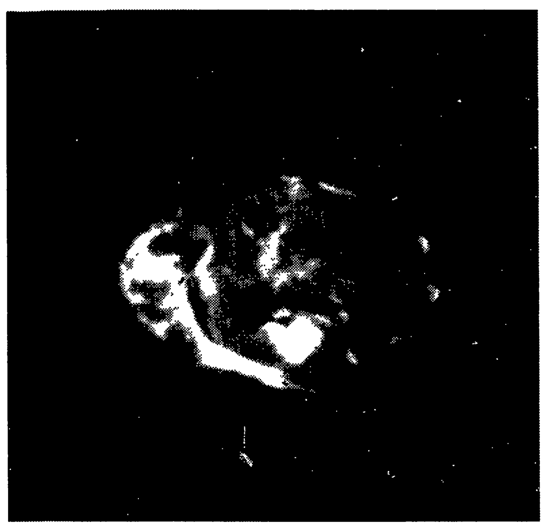

Fig. 2: b/ the flare of 14 March 1984, 03:22 UT.

I and II are concerned, however, their evolution is, to a certain extent, traceable in relation to flares. The development of the 13 and 16 May flares coincided with the processes of some kind of "isolation" of the cells. As the preliminary conclusion it is possible to believe that the disturbances with which the flares were associated, were caused by a "break" in the cell linkage.

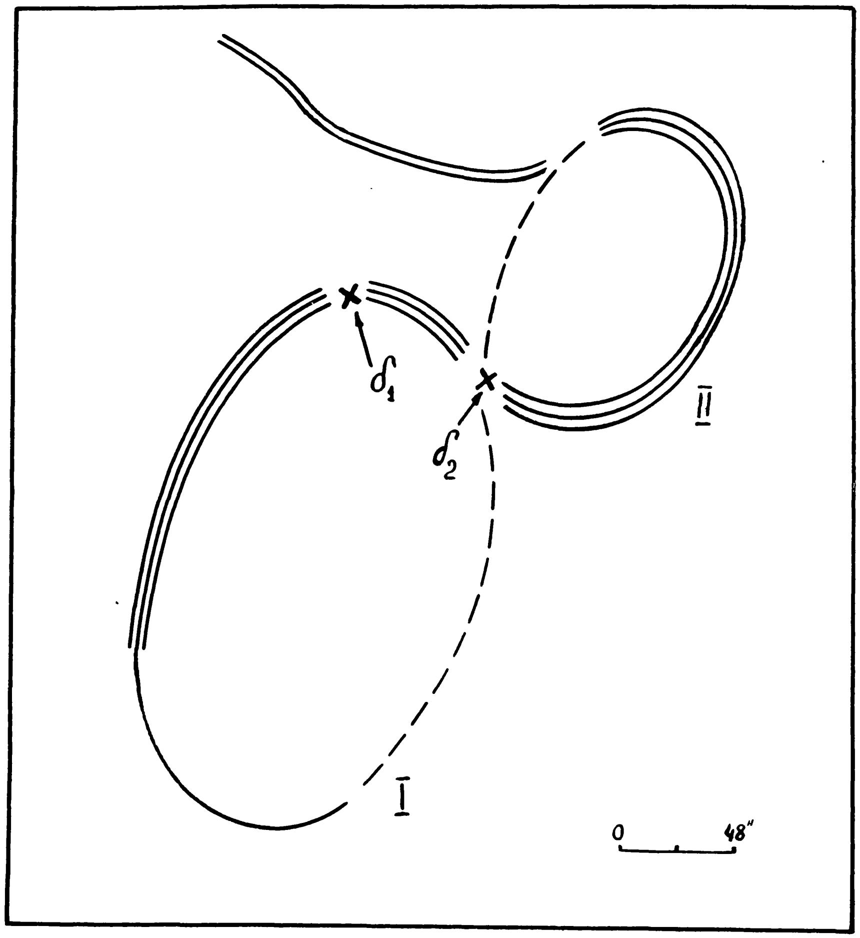


Fig. 3: The scheme of large-scale cells in the complex of activity of May 1981. For explanations see the text.

## 5. THE ROLE OF DIFFERENT DISTURBANCES IN FLARE ACTIVITY

We have presented only a few, the most prominent lines of evidence which indicate a relationship of flares with large-scale structures and their disturbances. A closer examination of the observational data provides broad lines of alternative evidence in support of this view (3-6). There can be no doubt that large flares should be regarded not only, and possibly, not so much as the result of a separate active region but also within a broader context. At present the role of global factors has to be discussed in general, although there have been some attempts to develop flare mechanisms with global effects included; see, e.g. (10).

Let us emphasize several points the solution on which will, possibly, be found by recourse to global factors.

Sympathetic and homologous flares. Within the framework of the concept formulated above the appearance of several flares along a global PIL seems to be quite natural. In a usual treatment these flares will be ascribed to the class of sympathetic ones, although, strictly speaking, they should be called simultaneous flares. The homologousness may be associated with a high stability of magnetic configurations of global structures. The global component will persist and will ensure homologousness, even if the local variations are severe.

Trigger mechanisms. It seems appropriate to abandon attempts to substantiate them by various "exotic" local processes and to transfer the quest into a region of global effects.

Relationship with sunspot group characteristics.

If flares occur predominantly in sunspot groups located along large-scale PILs, the approach to the study of flare relationships should be altered substantially depending on the class of groups. First of all, samples should be carried out according to the signature of belonging to large-scale PILs and only then the relationship "class of the group - flare activity" should be considered.

Such reasoning could be extended.

There are still many unclear points in the relationship of global and local factors. The active region possesses a fairly high energetics of its own; therefore, its independent role in the flare development cannot be excluded in advance. At the same time, if the active region is one of the components of a larger physical system, its energetics will depend on the state of this system. These questions all need solution.

## 6. CONCLUSION

Bumba and Howard, in a 1965 paper (11), defined a complex of activity on the photosphere as unified systems of active regions and described the typical features of their evolution. Thus, the idea of a "collective" development of activity received a firm basis, which opened up new prospects for understanding the solar activity problems.

The development of complexes of activity in the corona was discussed by Howard and Švestka in 1977 (12).

Our paper is devoted essentially to the study of manifestations of complexes of activity at the chromospheric level. It was possible to formulate this problem after the observations were organized at the Baikal astrophysical observatory with a new chromospheric telescope at high spatial resolution. We have discussed some questions concerning the identification of complexes of activity, their structure, and of particular manifestations of chromospheric activity. In this study, the results of flare activity investigations in a complex of activity have been summarized. The main conclusion is that large flares seem to be, indeed, the product of activity of the entire complex of activity as a unified physical system.

With such a formulation of the problem, the study of flares is transferred largely into an hierarchically higher region of structures, viz. complexes of activity or even their systems. This offers new possibilities of searching for flare mechanisms since the analysis insorporates external factors with respect to the active region.

Of course, the flare problem does not become a simple one at once. Its analysis by taking global factors into account might become as complicated and labor-consuming as in schems with purely local links. It is important, however, that the difficulties be overcome in a correctly chosen direction of research.

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