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Flare Stars in Star Clusters and Associationes

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Introduction.

The most significant investigations on the study of flare stars and phenomenon of stellar flares have been fulfilled during last two decades. They brought much news in the problem and put it forward on one of the first places in modern astrophysics.

The most important consequence of these investigations, perhaps, is the establishment of the flare activity stage in stellar evolution ([1]).

Highly significant results were obtained on the physical properties of stellar flares. At the present time there is no doubt, that the flare stars in star clusters and associations and the UV Ceti stars in the solar vicinity represent the same class of non-stable stars and the differences observed between them are explained by the differences of their ages ([2]).

In this paper an attempt is made to present the nowadays state of the flare stars problem on the basis of flare star observations.

Flare Stars in Systems.

There are some grounds to beleive that all young flare stars, possessing in the average higher luminosities are observed in star clusters and associations. By photographic observations with wide-angle cameras, carried out during 7500 hours, approximately 1300 flare stars were found in the nearest systems.

In Table 1 the striking fact is, that the majority of known flare stars (about 70%) during the observations showed only one single flare-up. It can be explained by the too low mean frequency of flares for their majority. Really, as the distribution function of mean flare frequency for the stars of Pleiades cluster, derived by Ambartsumian ([5]) shows that the mean flare frequency for the majority of stars is very low. This conclusion is true for other systems too. For example, as the mean flare frequency function shows it is true for flare stars of the Orion association ([6]). As a result of this less than one third of all flare stars is discovered up to now in the systems studied.

Flare Stars in some Nearest Star Clusters and Associations

System	t (hours)	n	n_1	N
Pleiades	3175	546	287	994
Orion I	1406	482	380	1471
Taurus Dark Clouds	937	102	88	532
Cygnus (NGC 7000)	938	67	58	403
Praesepe	698	54	44	215
Monocerotis 1	105	42	40	442
(NGC 2264				
Around Cygnus	324	16	15	129
Total	7583	1309	912	4186

If we take into account that the estimations of total number of flare stars in systems N, presented in Table, correspond to the lower limit of this magnitude, then it must be confessed that for the present we know only a small part of all flare stars even in comparatively better studied systems like the Pleiades and the Orion.

Evolutionary Stage of Flare-Activity.

The physical similarity between the emission of T Tauri type stars and the emission appearing during stellar flares, revealed by Ambartsumian ([7,8]), gave him a reason to conclude, that the non-stable stars of these two classes are related.

Later on Haro and Chavira (9) on the basis of the results of flare stars photographic observations in associations and clusters stated an idea, that the stage of flare stars follows the stage of T Tau stars. A telling argument in favour of the evolutionary connection between these two stages was the discovery by Haro and Chavira and by Rosino et al ([10]) of some T Tau type stars showing classical flare-ups in the Orion and the Monocerotis associations.

This discovery has shown that the evolutionary stages of T Tau and UV Cet partly cover each other in time. During the period of coverage the star is of the T Tau type and flare star, simultaneously.

The statistical study of observational data concerning to the Orion association has shown ([11]) that the time of coexistence of these stages is equal to approximately one fourth of the duration of the T Tau stage. Recent estimations show that this time is somewhat longer about 40% of the T Tau stage duration ([12]). The duration of the flare activity stage itself varies in large limits: 10^6 - 10^9 years.

Thus, in the Orion association (age ~ 10^6 years ([13])) there are stars of high enough luminosities which don't already show a flare activity, at least available for photographic observations. In the older systems, as Pleiades (age ~ 7×10^7 years), Hyades and Praesepe (age higher than 10^8 years) there are still some flare stars as well as the stars of high luminosities which already lost their flare activity. At last, between stars of the Solar vicinity there are flare stars the ages of which exceed 10^9 years ([14,15]). A direct dependence has been found between the mean energy of flares and the age of flare stars, which gives possibility to obtain the ages of stellar aggregates and single flare stars ([14]).

It can be assumed that for a separate star the initial and ending phases of flare activity depend on its luminosity (mass): the higher the luminosity the earlier the flare activity begins and correspondingly it ends.

In the case of the ending of flare activity phase this regularity is confirmed by the data, related to the mean luminosities of flare stars in the systems of different ages ([16]). They show that the older the system (flare stars) the lower is the mean luminosity of flare stars in it. This regularity can explain the fact, that there are practically no flare stars of comparatively high luminosities in the general galactic field.

The reverse correlation existing between the mean luminosity offlare stars and the age of the system, to which they belong, can be considered as a direct observational evidence in favour of the idea, that the evolution rates of stars depend directly on their luminosities (masses): the stars possessing higher luminosities evolve more quickly compared with the stars of lower luminosities.

Thus, the observational data allow to outline the following, evolutionary sequence of dwarf stars: T Tau stars - T Tau stars, possessing flare activity - flare stars - stars of practically constant brightness.

Certainly, some questions connected with the presented evolutionary sequence haven't obtained yet their final decision. For example, the transition from the T Tau stage to the flare star stage is apparently connected with the difficulty connected with the problem of masses.

The important question whether all stars, at least dwarfs, pass through flare activity stage, has not yet a final solution. For example, the observations of flare stars in the Pleiades testify that the positive answer to this question needs to assume that flare activity of stars has a cyclic nature: the periods of high flare activity alternate with the periods of comparatively low activity ([17]).

However, it is not likely that new studies can bring to the essential changes of foregoing main evolutionary sequence.

Optical Manifestations of Flare Activity.

The photoelectric observations of flares of the UV Cet type stars carried out with high time resolution brought to the idea, that the stellar flare is a complex phenomenon and, in the general case, represents a multiple appearance of the additional energy released during the flare ([18]). Though the shape of the light-curve does not depend on power of the flare (very powerful flares,which have spike-like light-curves and small flares with complex shape of light-curves have been observed ([19]) however, there are some evidences showing that the powerful is a flare, in average, the higher is probability to observe the complex shape of light-curve ([20]).

Very essential property of stellar flares has been discovered by Haro ([21]). He has divided all flares into two groups "fast"and "slow", according to the flare rise time, using his multiexposure photographic observations. For the majority of flares the rise time was very short ("fast"), while there are rare flares for which the flare rise time reaches 20-30 and more minutes ("slow"). Probably the "fast" and "slow" flares differ from each other apparently by colours too ("slow" flares are, in average, redder than the "fast" ones ([21]).

The difference between "fast" and "slow" flares can be successfully explained, if one following to Ambartsumian ([9,10]) assumes, that the flare rise time is determined by the depth of stellar atmospheric layers, where the flare takes place: the larger this depth the longer the flare rise time is. The observations of "slow" flares in the Orion and the Pleiades show, that the larger the energy of "slow" flare the shorter its rise-time in agreement of this idea on the flare nature is ([22]).

At present it can be said that Haro's classification which was very fruitful, actually is a conditional one and is determined by the method of his observations. In the reality the distribution of flare rise time durations is continuous: there is no sharp transition betweer- "fast" and "slow" flares. In favour of the idea that the flare rise time indeed is determined by the characteristics of those layers of stellar atmosphere where the flare occurs the important fact can be considered that the majority of stars which have shown the "slow" flares were also observed in "fast" flare.

The fuor-like variations of star brightness (FUOri phenomenon) can be considered as a remarkable manifestation of flare activity. After the brightnening, of V 1057 Cyg, having before the T Tau type spectrum, it has been revealed that such wonderful variations take place with some T Tau type stars (see, for example, ([23]). Ambartsumian ([24]) proceeded from the idea on the liberation of excess flare energy in the surface layers of stars having different depths, has shown that a definite parallel exists between the differences in radiation of a prefuor and a postfuor, on the one hand, and the differences between radiation of "fast" and "slow" flares, on the other hand.

As some confirmation of this point of view one can consider the results of observations obtained for the objects Chanal and Sugano Ab 24 (see, for example, ([25,26])). They show that fuor-like variations of star brightness in a smaller scale can occur in the flare activity stage. These observations give some reason to assume that the phenomena which occur during fuor-like variations of star brightness and during "slow" flares have the same physical nature.

It can be added that fuor-like variations of star brightness are connected apparently with the ejection of some noticeable quantity of matter by a star bringing to the formation of an envelope. Ambartsumian's ([24]) interpretation of the fuor phenomenon is based namely on this assumption. There are indications of the appearance of a gas envelope around the star V 1057 Cyg after its brightening ([27,28]).

Optical Observations of Flare Emission.

For determination of the nature of the emission, originated during stellar flares it is important to obtain spectral composition and its variations during the flare.

The optical spectrum of flare emission is unusual. The colour indecies U-B and B-V of the flare radiations correspond to the different temperatures.

In the flare maximum they are, in average, equal to ([29]):

$$U\text{-}B \sim 1.0\,, \quad B\text{-}V \sim +0.3.$$

These colour indecies varies for different flares and vary somewhat irregularly during given flare. The spectral observations of the UV Cet flare stars, have confirm also the dominate role of the continuous emission, mainly at short waves, in the sharp increase of brightness at the beginning of the flare, noted already in the pioneer paper by Joy and Humason ([30]).

This significant result has been confirmed with a special clearness by parallel spectral and photoelectric flare observations of the UV Cet stars, carried out by Moffett and Bopp ([19,31]), showing that the continuous emission is primary one compared with the line emission, at least.

It should be added that at present the essential observational data were obtained on the flare radiation and the radiation of flare stars, in general, in radio and X-ray spectral regions. Parallel observations of stellar flares in different spectral regions didn't shows any correlation between obtained results ([32]). This fact shows large diversity of flare emission spectrum.

Conclusion.

The results of the flare star study obtained during last decades turned completely unexpected for the existing theoretical stellar models.

This concerns, first of all, to the conclusion that flare stars represent an evolutionary stage, obtained on the basis of their observations in star clusters and associations. No stellar evolution theory doesn't suspect this.

This concerns also the results of study of physical peculiarities of flare emission and, in general, of stellar flare phenomenon. The observational data in some cases contradict the theoretical calculations. The difficulties in this field increased essentially after the space observations of flare stars. Recent new CAII, UV and X-ray Observations have shown that-behaviour of "activity" on stars is substantially more complex than hitherto suspected ([33]).

Therefore, we have some grounds to hope, that the further studies in this actual branch of the astrophysics can bring to the esentially new consequences in physics and evolution of stars.

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Բռնկվող աստղերն աստղակույտերում և աստղասփյուռներում

Աշխատանքը հանդիսանում է համառոտ ակնարկ՝ նվիրված աստղակույտերում և աստղասփյուռներում աստղային բռնկումների ուղղությամբ ստացված դիտողական արդյունքներին: Առավել կարևոր եզրակացությունն այն է, որ բռնկումային ակտիվությունն աստղային ագրեգատների և արեգակի շրջապատի թզուկ աստղերի էվոլյուցիայի փուլ է հանդիսանում:

Академик НАН Армении **Л. В. МИРЗОЯН**, Э. С. ПАРСАМЯН

Звездные вспышки в звездных скоплениях и ассоциациях

Работа является кратким обзором наблюдений звездных вспышек в звездных скоплениях и ассоциациях. Наиболее важным является вывод о том, что вспышечная активность представляет собой эволюционный этап в жизни звезд-карликов в звездных агрегатах и в окрестности солнца.

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