АСТРОФИЗИКА

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THE OPTICAL OBSERVATIONS OF FLARE STARS IN THE GALAXY

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The observations of flare stars in the Galaxy are considered. The UV Ceti type stars of the solar vicinity and the flare stars in star clusters and associations have almost the same properties. The differences between them are connected with the age. Flare stars are one of richest populations in the Galaxy. The evolutionary path for all flare stars is the same.

1. *Introduction*. Stellar evolution is connected with nonstationary states of stars and stellar groups. This regularity was confirmed when in 1947 Ambartsumian [1] discovered ***stellar systems of a new type - stellar associations***. For the first time it has been established that the star formation process is continuing in the Galaxy.

In 1949 a new type flaring variables are discovered (UV Cet type) among red dwarf stars of solar vicinity. The flares of the UV Cet type stars are similar to outbursts of novae, but happened very frequently.

The observation of Joy and Humason [2] of the spectrum of UV Cet showed that its flare was conditioned by the intensification of its continuum, which was unexpected phenomenon. At present about 100 stars of this type are discovered [3].

Ambartsumian [4] noted that the UV Cet type flare stars showed emission lines and UV-excess during their flares i.e. they are physically similar to the T Tau stars.

However, the T Tau type stars are very young stars, while UV Cet type stars are much older ones. This discrepancy was explained after by Haro and Morgan [5] who detected the first flare stars in the Orion association, which had higher luminosites.

The discovery of flare stars of different ages [see 6,7] allowed to explain the observed differences between their parameters (luminosity, connection with diffuse matter etc.) as a result of their evolution.

In this paper the main results of the study of flare stars in star clusters and associations and in general galactic star field obtained in the Byurakan Astrophysical Observatory are presented.

2. *The UV Cet type flare stars of solar vicinity.* The UV Cet type red dwarf flare stars of solar vicinity have too lower luminosities and are observed separately by photoelectric method.

The physical properties (frequencies, colours, random distribution of flares, forms of light curves, spectral peculiarities and others) of the UV Cet type flare stars were known owing to photometric and spectral observations by Gershberg and Chugainov, Kunkel, Cristaldi and Rodono, Moffett, Moffett and Bopp(see, [6,7]).

However, the evolutionary importance of flare stars was revealed only after the detection of flare stars in star clusters and associations.

3. *The flare stars in star clusters and associations.* The existence of flare stars in associations and then in star clusters has decisive significance for the problem of evolution of red dwarf stars.

For the detection of flare stars of higher luminosities in stellar systems the photographic method with wide-field telescopes is used which allowed to detect at once all enough powerful stellar flares taking place during observations [8]. This search is generally realized by the method of stellar chains. With increasing of exposure time for each image of a star in the chain the time resolution of flare observations is decreasing strongly and the short, even large, flares are lost.

The analysis of this question based on the photoelectric observations of flares of the UV Cet type stars carried out by Moffett [9] showed, for example, that of 297 flares registered in the U-band only 21 and of 342 flares observed in the B-band non could be detected by the photographic method [10]*.

The discovery of numerous flare stars in star clusters and associations was established by photographic observations in the Asiago (Italy), Tonantzintla (Mexico) and Byurakan (Armenia) observatories. Soon the photographic search of flare stars in regions of stellar systems were began in the Abastumani (Georgia), Konkoly (Hungary) and Rozhen (Bulgaria) observatories (see, [6,7]).

4. *Significance of the discovery of red dwarf stars and their distribution in the Galaxy.* The discovery of the first flare star (UV Cet) showed its unusual properties, but it was impossible to predict the importance of this discovery for the problem of evolution of red dwarf stars.

Haro [8] was the first who understood the evolutionary status of flare stars. Taking into account observations he concluded that the T Tau stars are in average younger, than flare stars. Haro [8] suggested a hypothesis according to which flare stars present an evolutionary stage of red dwarf stars following the stage of T Tau type stars.

* *The first flare star in Byurakan Astrophysical Observatory was discovered in 1962, in Orion association [11].*

This hypothesis became a regularity of red dwarf stars evolution when Ambartsumian [12] showed that all or almost all red dwarf stars of lower luminosities in the Pleiades cluster must be flare stars.

From the view of evolutionary connection of the T Tau type stars and flare stars, as stages which pass red dwarf stars there are very important two facts: 1. the flare activity of some T Tau stars (see [13]), 2. the existence of the joint multiple systems of the Trapezium type containing the T Tau type and flare stars together [14]. It is naturally to suppose, that stars are formed in stellar associations, which corresponds to the observed space distribution of flare stars in the Galaxy. Namely, all flare stars having comparatively high luminosities are observed in star clusters and associations whereas the luminosities of flare stars are regulary decreasing, in average, with moving off from their "maternal" systems.

For example, during 180 hours photographic observations of general galactic field only one flare was detected, while in the Pleiades region one flare is observed in every 1-2 hours [6]. This is the reason that the flare activity can be considered as an evidence of the membership of a star in the nearby system. To determine the space distribution of flare stars of lower luminosities in the Galaxy the distribution of UV Cet type flare stars of solar vicinity was used. It has been shown that the results of photographic observations of stellar flares are in complete agreement with the assumption that the UV Cet type stars of solar vicinity are distributed almost uniformly in the galactic disk [10].

The portion of the UV Cet type flare stars among flare stars detected in regions of star clusters and associations is less than 10%.

5. *Some evidences indicating the physical and evolution similarity of all red dwarf flare stars.* We have some evidences in favour of the physical similarity of all red dwarf flare stars. The observations of flare stars show that there is no essential difference between light curves of the UV Cet stars and flare stars in associations and star clusters [15]. The colours of flare emission is practically the same for flares in both groups. Haro's [16] division of all observed flares into two groups by the flare rising time - "fast" and "slow" is general property of flares for all flare stars. The Herzsprung-Russell diagram is similar for both groups [13]. The energetic spectra of red dwarf flare stars in star clusters and associations are the natural continuation of the energetic spectra of the UV Cet type flare stars of the solar vicinity [17]. The flare frequencies of flare stars in the star clusters and associations are depend on their luminosities, in both cases. At last, the spectra of flare stars in the star clusters and associations and of the UV Cet type flare stars of solar vicinity are completely the same [18].

6. *Variations in flare systems with their aging.* Comparison of flare star systems of different ages show that the properties of flare stars change with aging. For example, the mean luminosities of them in systems of various ages are quite different.

Table 1 constitutes the results of photographic observations of flare stars in nearest star clusters and associations obtained mainly by the post-graduated students of the Byurakan observatory (I.Jankovicz, M.K.Tsvetkov, H.S.Chavushian, N.D.Melikian, A.S.Hojaev, R.Sh.Natsvlishvili, V.V.Hambarian) (see [6,7]). The total number of flare stars in them at present exceeds 2000.

Table 1

MEAN LUMINOSITIES AND AGES OF FLARE STARS
IN THE NEAREST STELLAR SYSTEMS

System	n	M_{pg}	T(yr)
Orion	473	7.7	3×10^5
Cygnus(NGC 7000)	56	8.1	2×10^6
Monocerotis(NGC 2264)	29	6.3	6×10^6
TDC	58	9.1	10^7
Pleiades	191	9.7	7×10^7
Preasepe	14	10.1	4×10^8
UV Ceti region	16	10.0	10^8-10^{10}

Note- n-is the number of the used flare stars, M_{pg} - mean photographic magnitude and T(yr) -estimated age of the system in years. TDC - Taurus Dark Clouds.

Comparison of numbers presented in two last columns show the regular decrease of the mean luminosity of flare stars (Fig.1).

Only in NGC 2264 association the mean luminosity deviates from the normal correlation, which may be explained by errors in determination of distance or age of this system.

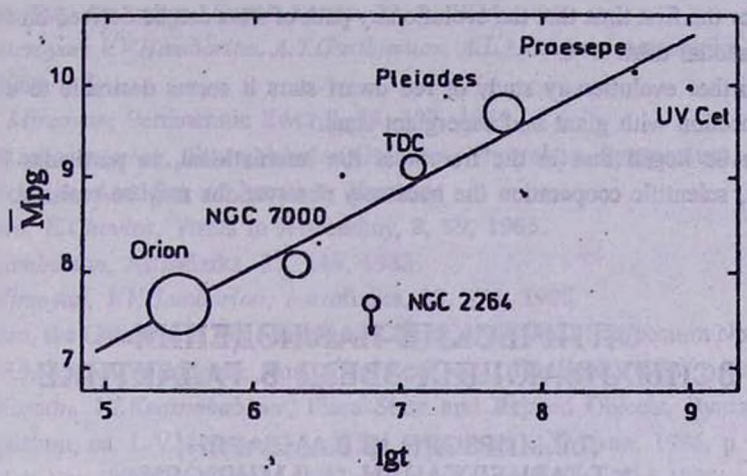

Fig.1. The observed correlation between the mean luminosity of flare stars in star clusters and associations with their aging.

It is seen that with aging of the system the mean luminosity of flare stars is regularly decreasing.

The observed correlation includes the observational selection: as farther is the system as larger is this selection. This selection can change the inclination of this correlation but not sharply. The correlation (M_{pg} , lgt) shows the real direction of variations of mean luminosities in stellar systems with aging (see [19]).

7. *Conclusion.* The optical observations of flare stars in the Galaxy, in particular in regions of star clusters and assotiations revealed the evolutionary importance of these stars in evolution of red dwarf stars.

There are evidences that the evolutionary path of red dwarf stars can be state on the base of observational data. Namely, it is very probable the following evolutionary path of these stars [7].

T Tau Stars - Flare Stars - Red Dwarf Stars of Constant Radiation.

The photographic observations showed that all flare stars are formed in star clusters and associations and then have left their "maternal" systems owing to their motions and disintegration of these systems. At the same time with the aging they continuously lost the flare activity and constitute the population of galactic disk. The UV Cet type flare stars are members of the disk population. This is the reason that the stars of lowest luminosities in the Galaxy are among flare stars.

It is for the first time that the evolutionary path of stars can be derived on the base of observational data.

For further evolutionary study of red dwarf stars it seems desirable to examine their connection with giant and supergiant stars.

It can be hoped that in the frames of the international, in particular French-Armenian, scientific cooperation the necessary observations may be realized.

ОПТИЧЕСКИЕ НАБЛЮДЕНИЯ ВСПЫХИВАЮЩИХ ЗВЕЗД В ГАЛАКТИКЕ

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Обсуждены наблюдения вспыхивающих звезд в Галактике. Звезды типа *UV* Кита окрестности Солнца имеют почти одинаковые свойства, что и вспыхивающие звезды в звездных скоплениях и ассоциациях. Различия между ними связаны с возрастом. Вспыхивающие звезды являются одним из богатых звездных населений Галактики. Эволюционный путь одинаков для всех вспыхивающих звезд.

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