TRAPEZIUM TYPE MULTIPLE SYSTEMS AND FORMATION OF STARS

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ABSTRACT

By a comparison of Trapezium-type multiple star systems in the Abastumani Catalogue and the famous Catalogue of Stellar Associations and Clusters, it is confirmed that the great number of Trapezium-type multiple stars, which belong mostly to spectral classes O-B2, are found in associations and clusters.

In 13 T-associations, 120 Trapezium-type multiple systems and 182 common multiple and double stars could be detected.

Based on present-day observational data and the author's photographic observations, the kinematic of Trapezium-type multiple stars of spectral class O-B2 is studied.

In studying the problems of stellar formation and evolution, special consideration is given to the investigation of unstable stellar groups and stars at non-stationary states.

The unstable stellar systems in the galaxy are O-associations, Trapezium-type multiple systems and O-type galactic stellar clusters.

In stellar associations, Trapezium-type multiple systems are observed along with galactic stellar clusters. These are the multiple systems, in which, at any rate, three components can be distinguished. The distances between these components are of the same order. Prof. V.A. Ambartsumian regards the greater part of Trapezium-type multiple systems to have a positive energy. This means that such systems must expand. The calculations show that the expansion time is of the order of $2 \cdot 10^6$ years if the system has a negative energy and $\sim 10^5 - 10^6$ years if it is positive. Therefore, in both cases Trapezium-type multiple systems are the youngest objects in associations (Ambartsumian, 1960).

The presence of a great number of Trapezium-type multiple systems in some stellar association or galactic cluster indicates that the

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stellar formation process is either still going on in them, or that it has just ceased.

In the works by Profs. V.A. Ambartsumian and B.E. Markarian (1949, 1950, 1951), the problems concerning the relation of Trapezium-type systems with associations and clusters, are considered; the findings derived need some confirmation, as they rely on the highly scarce statistical material.

In Salukvadze (1978) we reported on the Catalogue of Trapezium-type multiple systems compiled by us on the basis of the Index Catalogue of Visual Double Stars. This Catalogue was used for checking the presence of the above mentioned relations.

The Abastumani Catalogue of Trapezium-type multiple stars was compared with the known card catalogues of associations and clusters (Alter et al., 1970). The results of this comparison are given in Table 1.

Table 1

Spectral Types	Number of Real Trapezia	Number of Trapezia Belonging to		Percentage of Trapezia Belonging to	
		Associ-ations	Clusters	Associ-ations	Clusters
O-B2	33	27	21	82	64
B3-B5+B	16	12	6	89	39
B8-B9	13	8	2	61	15
Unknown Spectral Type	96	32	10	34	13

The first two lines of the Table show that out of the total number of real Trapezia, whose primary stars are of the O-B2 spectral-type, 82% are members of associations and 64% members of clusters. At the same time, the majority of Trapezia are evidently members of both objects mentioned.

The other lines of Table 1 show that among the Trapezia with the primaries of B3-B9 and of unknown spectral types, there is an appreciable quantity of Trapezia belonging to associations; that of cluster members decreases sharply.

Based on the above statement, the following conclusions can be drawn:

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a) Belonging of Trapezia to associations is their common feature;
b) A high percentage of O-B2 spectral type Trapezia represents the nuclei of galactic clusters;
c) In many cases the Trapezia of O-B2 spectral type belong to associations and clusters simultaneously.

Belonging of a great majority of Trapezia to associations, established by us, confirms Prof. Ambartsumian's finding that inside the association not all stars are formed together, but that they originate in separate groups, clusters and Trapezium-type systems (Ambartsumian, 1954).

The presence of Trapezium-type multiple systems in associations is therefore a confirmation of the findings on group formation of stars. From this point of view, the search of Trapezia in T-associations is of great interest.

The high percentage of double and multiple stars among the objects in T-associations was first studied by Prof. V.A. Ambartsumian. Further, at the beginning of the sixties, many investigators of variable stars (Kukarkin, Herbil, et al.) pointed to the necessity of studying stellar duplicity in T-associations. Just then the first lists of wide pairs in T-associations appeared (Badalian, 1962; Baize, 1962; Perova, 1963, Zakirov, 1975).

We set a task to search for the Trapezium-type multiple stars in T-associations involving the groupings of T Tau variable stars from Kholopov's (1970) list up to a distance of 500 pc. There are 19 such associations, but we succeeded in searching only 12.

The method and the criteria for excluding optical systems is described in Salukvadze (1980). The result is that about 85% of Trapezia are physical systems.

Assuming that Trapezium-type systems are unstable systems, V.A. Ambartsumian suggested a hypothesis for the formation of stars from a so-called "protostar" of a rather high density; it is split by some presently unknown mechanism. As a consequence, fast expanding Trapezium-type systems are formed. From this we can conclude that kinematic behavior of Trapezium-type multiple systems provides valuable information on the initial conditions under which stars are formed.

Based on the present-day observational data including our own photographic observations, we have analyzed the stability of the Trapezium-type systems. Twenty-six such systems were considered with O-B2 spectral type primaries. From these, 13 are fairly well observed.

Table 2

No.	ADS	Components	$\frac{dD}{dt}$ Over 100 years		Associations, Clusters	Distances in pc	Vt $km \cdot sec^{-1}$
1	719	AB	0.″057	0.″012	NGC 281	1100	3.0
		AC	0.314	0.016			16.4
		AD	0.490	0.061			23.2
		AE	0.986	0.322			51.4
2	2783	AB	0.276	0.041	NGC 1444	800	10.4
3	2843	AB	0.295	0.031	Per OB2	330	4.6
		AC	0.510	0.044			8.0
4	3709	AB	4.036	0.112			
		AC	0.971	0.040			
5	4241	AC	0.325	0.035	Orion OB1	460	7.1
		AD	0.064	0.014			1.4
6	4728	AB	0.165	0.014	NGC 2169	850	5.8
		AE	0.204	0.041			8.2
7	5322	AB	0.102	0.013	Mon OB1	760	3.8
		AC	0.056	0.028	NGC 2264		2.0
8	5977	AB	0.430	0.048	NGC 2362	1500	30.6
		AC	0.361	0.067			25.6
9	13374	AB	0.299	0.060	Cyg OB3, NGC 6871	1580	22.4
		AC	3.499	0.108			262.0
		AD	0.270	0.055			20.2
10	14526	AB	0.062	0.017	Cyg OB2	300	0.9
11	14831	AB	0.175	0.084	Cyg OB4	345	2.9
		AC	0.484	0.042			7.9
12	15184	AC	0.119	0.013	Cep OB2, IC 1396	700	4.0
13	16381	AB	0.098	0.030	Lac OB1	600	2.8

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For each of these 13 Trapezia, the measured distances between the primary and its components are plotted versus time. The observational data used in most cases cover a time interval of more than 100 years. The observations are performed at different times by different authors. Various observers were assigned different weights depending on the internal agreement of their measurements. Then the observations were treated by the least square method.

Having carefully inspected all the plots and considered the results of calculations, it is found that out of 13 studied Trapezia, six show expansion for all components.

Table 2 gives the variations of the distances for 13 Trapezia under investigation in a time span of 100 years.

As the sampling of these 13 Trapezia was based only on the availability of a considerable number of measurements over a long period of time, i.e., as the criteria of the sampling was not related to the character of the observational motions, the derived predominance of positive values in the distance measurements over negative indicates that the Trapezia components showing relative motions are not field stars. If the velocities are equal to zero, then one can hardly find systematic errors, which seems to imply that the component always moves away from the primary.

Table 2 also shows the results of computed tangential velocities over 100 years with the rms errors.

Hence, the results of our investigations, based on the treatment of observational data, confirm the suggestion that a considerable number of Trapezium-type multiple systems are unstable systems. The latter statement favors the hypothesis for the formation of stars from superdense protostars.

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