PHOTOMETRIC VARIABILITY OF STARS BELONGING TO THE TRAPEZIUM-TYPE SYSTEMS

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Abstract. We report the variability of 21 stars belonging to 17 systems considered to be Trapezium-type systems by Allen *et al.* (1977a). In order to avoid serious problems due to possible light contamination by neighbouring stars, we have only considered systems with angular separations between components equal or greater than five seconds of arc. Among the new variables here reported there are five having ΔV variations greater than $0\overset{m}{.}3$. For six systems we have spectrograms of the individual components. Three of the six systems are probably optical configurations and only two of the variables in the remaining three systems may be physical companions.

1. Introduction

If among the components of a multiple system of three or more stars, three distances of the same order of magnitude (i.e., with ratios larger than $\frac{1}{3}$ but less than 3) can be found, then the system is one of Trapezium-type; if no three distances of the same order of magnitude can be found, then the multiple system is of ordinary type (Ambartsumian, 1954).

Our present knowledge of the nature of the Trapezium-type systems is still very poor. Moreover, some results obtained by different authors seem to be highly contradictory. In fact, while a number of dynamical considerations on Trapezium-type systems have led Allen and Poveda (1974, 1975) to the conclusion that these systems are young or even extremely young (ages between 10^5 and 10^6 yr), no evidence of youth seems to be present among a sample of 68 and 7 Trapezia photometrically studied by Echevarría *et al.* (1979) and Roth *et al.* (1979), respectively. In particular, Echevarría *et al.* (1979) have found that the late-type Trapezia cannot be young. In general, however, the idea that Trapezia are young objects seems to be based on better grounds (Ambartsumian, 1954; Sharpless, 1954; Allen *et al.*, 1977b; Warman and Echevarría, 1977).

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2. Preliminary Results

Although Trapezia are considered very interesting objects as regards their kinematic and dynamical features (Allen and Poveda, 1974, 1975), very few observational data are available in the literature at present. The need for information on Trapezium-type systems of the southern hemisphere encouraged us to plan a straightforward observational program to be carried out from Cerro Tololo (CTIO) and Las Camapanas (LCO) observatories. The project, initiated two years ago, consists in obtaining the *UBV* photometry and classification spectra as basic data to explore the nature of the stars which belong to the Trapezia.

The Trapezium-type systems that we have observed have all been selected from the catalogue compiled by Allen *et al.* (1977a). This catalogue contains 915 Trapezium-type systems, spread out over the sky in a rather uniform way with respect to right ascension. With a few exceptions, the visual magnitudes of the individual components which have been photoelectrically measured range from 8.0 to about 14.0. Only those systems with well-separated components have been observed.

One of the main purposes of this project is to examine the physical reality of these unstudied group of stars. After the completition of the observing program we will discuss the colour-colour and HR-diagrams for each system and attempt to infer their evolutionary stages. A preliminary analysis of the spectrophotometric material collected from CTIO and LCO for 87 systems allowed us to obtain some preliminary results which can be succintly summarized as follows: (1) Most of the observed systems include late-type components, i.e., G and/or K-type stars. (2) No obvious sign of youth seems to be present throughout the sample. (3) The main physical characteristics of the observed systems differ considerably from those of the well-known Orion Trapezium. (4) Nearly 50% of the observed Trapezia are genuine physical systems. Therefore, the incidence of optical systems appears to be much higher than expected.

3. Observations and Results for the Variable Stars

The photometric observations were carried out during various observing runs in 1982–1984 using the 1.0 m telescope of the CTIO and the 60 cm Canadian telescope of the David Dunlap Observatory located in LCO. Mean coefficients were employed in both observatories to correct for atmospheric extinction and nightly observations of about 12 *E*-region primary standards (Cousins, 1973, 1974) were used to transform to the *UBV* system. The external (ε) and internal (σ) mean errors of the *UBV* photometry are summarized in Table I. The mean internal error σ_V is about $0\overset{m}{.}02$, a value being practically independent of the *V*-magnitude and the telescope used. On the other hand, there exists a small increase in the internal errors σ_{B-V} and σ_{U-B} with the *V*-magnitude.

As was already mentioned, spectroscopic observations for a few of the systems with stars that turned to be variables were obtained using the spectrograph of the 60 cm telescope of David Dunlap Observatory at Las Campanas. The VARO image tube was used during the observations. The dispersion of the spectrograms is 120 Å mm^{-1}.

TABLE I
Mean errors of the *UBV* photometry

		External mean errors		
		ε_V	ε_{B-V}	ε_{U-B}
60 cm (LCO)		0.010	0.009	0.009
100 cm (CTIO)		0.008	0.006	0.009
		Internal mean errors		
		σ_V	σ_{B-V}	σ_{U-B}
60 cm (LCO)	$V \leq 8.0$	0.018	0.013	0.014
	$8.0 < V \leq 9.0$	0.021	0.012	0.019
	$9.0 < V \leq 10.0$	0.015	0.014	0.019
	$10.0 < V \leq 11.0$	0.019	0.017	0.022
	$11.0 < V \leq 12.0$	0.020	0.021	0.021
	$12.0 < V$	0.019	0.021	0.030
100 cm (CTIO)	$8.0 < V \leq 9.0$	0.014	0.005	0.012
	$9.0 < V \leq 10.0$	0.012	0.006	0.014
	$10.0 < V \leq 11.0$	0.022	0.010	0.015
	$11.0 < V \leq 12.0$	0.018	0.011	0.021
	$12.0 < V \leq 13.0$	0.018	0.016	0.021
	$13.0 < V$	0.018	0.018	0.021

The purpose of this paper is to report the variability of 21 stars belonging to 17 systems considered to be Trapezium-type systems by Allen *et al.* (1977a). We have considered a star to be a photometric variable when its individual V measures during different nights displayed variations greater than five times the mean internal error, i.e., $\Delta V \geq 0\overset{m}{.}1$.

Several systems catalogued by Allen *et al.* have components whose angular separations are very small. Consequently, the photoelectric measurements of such components are very difficult as they include generally a certain degree of light contamination. In the present work, however, we have only taken into account the individual variations of components belonging to systems whose angular separations are equal or greater than five seconds of arc. In this way, we have avoided the problems due to light contamination by neighbouring stars.

Among the new variables detected there are five having V amplitudes greater than $0\overset{m}{.}3$ while the other 16 have ΔV variations in the interval $0\overset{m}{.}10 \leq V \leq 0\overset{m}{.}30$.

The individual *UBV* observations of the new variables are listed in Table II. Columns (1) and (2) give the star identification from Allen *et al.* (1977a). Column (3) lists the present MK classification. The spectral type given in parenthesis means that an MK type is not available and it has been estimated from the *UBV* colours. The heliocentric Julian Date is listed in column (4), while columns (5–7) give the magnitudes and colours in the *UBV* system. Identification charts of the 21 new variables will be published, in a short time, in a more extensive paper.

TABLE II

Individual *UBV* data of new variable star

System	Component	Sp. type	Hel. J.D. 2440000.+	V	$B-V$	$U-B$	Comments
Allen 23	A	(K4)	5293.5986	8.610	1.436	1.672	
			5287.6232	8.509	1.434	1.617	
			5291.6065	8.538	1.420	1.621	
	B	(K1)	5292.6042	13.503	1.119	0.781	
			5294.5960	14.144	1.025	–	
			5296.6110	13.869	0.905	0.558	
Allen 30	A	(K2)	5286.6921	7.736	0.949	0.691	
			5287.6362	7.718	0.965	0.715	
			5288.6370	7.698	0.970	0.716	
			5290.6662	7.798	0.988	0.679	
Allen 38	C	(F7)	5293.6089	12.666	0.527	0.013	
			5294.7708	12.786	0.537	0.004	
Allen 61	C	–	4927.7222	13.538	0.749	0.305	Comp. A, F4V, $V = 6.83$
			4928.5903	13.422	0.689	0.565	Comp. B, F5V, $V = 11.48$
			4933.5628	13.196	0.726	0.396	Probably an optical system
			4933.5903	13.352	0.527	–	
Allen 108	B	(G0)	4927.6319	12.828	0.483	0.108	Comp. A, M6III, $V = 5.61$
			4933.6125	12.940	0.423	0.162	Comp. B may be a physical
			4934.5806	12.688	0.657	0.290	companion
Allen 108	B	(G0)	4934.6001	12.686	0.665	0.267	
			5287.5556	12.601	0.674	0.106	
			5293.5903	12.704	0.635	0.081	
Allen 108	C	G8III	4927.6181	11.811	0.712	0.507	Comp. C may be optical
			4933.5736	11.828	0.731	0.476	
			5287.5764	11.659	0.861	0.472	
			5293.5860	11.734	0.810	0.474	
Allen 124	C	(F7)	5292.6389	12.689	0.498	−0.023	
			5293.6319	12.588	0.555	0.020	
Allen 147	D	(F2)	4927.6597	11.648	0.400	0.086	Comp. AB, B8V, $V = 6.44$
			4929.6391	11.629	0.425	0.130	Comp. C, A2V, $V = 8.76$
			4933.6743	11.587	0.444	0.176	Comp. E, K5III, $V = 7.83$
			5294.6252	11.534	0.415	0.059	Comp. F, F5IV–V, $V = 8.25$
Allen 163		(G5)	5294.6875	12.631	0.666	0.184	
			5295.6840	12.441	0.676	0.149	
Allen 168	P	(G8)	5287.7014	13.319	0.650	0.320	
			5295.6668	13.512	0.763	0.452	
Allen 169	C	(F8)	5292.7152	12.867	0.553	−0.049	
			5295.6806	12.751	0.568	−0.066	
Allen 205	B	(B7)	5296.7639	9.290	−0.002	−0.380	
			5297.7847	9.154	−0.007	−0.367	
	C	(B6)	5296.7800	9.519	0.016	−0.409	
			5297.7991	9.418	−0.019	−0.423	

Table II (continued)

System	Compo-nent	Sp. type	Hel. J.D. 2440000.+	V	$B-V$	$U-B$	Comments
Allen 210	C	(K3)	5291.7222	13.159	1.198	0.946	
			5292.7013	12.960	1.168	0.841	
Allen 901	A	(B5)	5287.6056	5.450	−0.054	−0.464	
			5291.6071	5.348	−0.032	−0.473	
Allen 902	C	(K0)	4927.5069	12.342	1.052	0.663	Comp. A, A1V, $V = 7.98$
			4928.5139	12.281	1.007	–	Comp. B, A2V, $V = 8.43$
			4930.5301	12.169	0.887	0.400	Probably a physical
			4933.5069	12.144	0.898	0.459	system
Allen 920	A	(F7)	5287.5572	11.747	0.629	0.122	
			5291.5727	11.525	0.580	0.098	
			5294.5547	11.414	0.653	−0.039	
Allen 937	B	K31b	4929.5314	12.050	0.728	0.495	Comp. A, F3IV, $V = 9.15$
			4930.5347	12.125	0.862	0.227	Comp. C, $V = 13.10$
			4931.5382	11.147	0.722	0.372	Probably an optical
			5294.5139	12.178	0.787	0.321	system
Allen 937	D	(F6)	4929.5501	13.458	0.370	0.012	
			4930.5548	13.532	0.410	–	
			4931.5600	13.670	0.404	−0.059	
			5294.5361	13.580	0.518	−0.010	
			5297.6089	13.406	0.538	0.070	
Allen 948	B	G5III	4933.5486	11.720	0.620	0.125	Comp. A, F8IV, $V = 9.51$
			4934.5556	11.863	0.617	0.321	Probably an optical
			5294.5417	11.795	0.585	0.071	system
			5296.5556	11.906	0.756	0.242	

In the comments in the last column of Table II there are indications concerning with the probable physical nature of the systems. In those cases with available MK types it is clear that several of the variables may be optical companions. For six systems we have spectra of the individual components or at least of some of them. Three systems seem to be optical and in the remaining three there are two variables which may be physical companions. However, more observational work is needed to clarify the point.

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