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PHOTOMETRIC STUDY OF TRAPEZIUM-TYPE SYSTEMS

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RESUMEN

Se presenta la fotometría *UBVRI* y el análisis de la misma para 68 objetos múltiples del catálogo de Ambartsumian. Hemos encontrado que la incidencia de trapecios ópticos es mucho mayor que la esperada; asimismo se hacen patentes varios efectos de selección en el catálogo. La muestra no presenta características globales de juventud.

ABSTRACT

UBVRI photometry for 68 multiple systems of Ambartsumian's list is presented and analyzed. We conclude that the incidence of optical systems is much higher than expected; we also find that several selection effects are noticeable in the catalog. No obvious sign of youth seems to be present throughout the sample.

Key words: **PHOTOMETRY — STARS, VISUAL MULTIPLES.**

I. INTRODUCTION

In a classical paper Ambartsumian (1954) published a list of 108 multiple objects, with more than two components, selected according to what has been called "Ambartsumian's filter".* One of the main conclusions of Ambartsumian's work, and the one that has spurred further work, was that trapezia, as they were called, were young objects. In particular, Sharpless (1954) pointed out that trapezia were frequently observed in OB associations; this led to the suggestion that many O-type stars could be part of unresolved multiple systems. The idea that trapezia are young systems has been discussed by several authors. Parenago (1953) concluded that the Orion Trapezium was expanding as a system with positive energy while Ambartsumian (1954) concluded that the trapezium configuration was an unstable one. Although there is no dispute on the youth of the Orion Trapezium, the system does not seem to be expanding as a whole. The positive energy approach has now been abandoned in favor of a scheme in which a multiple system with negative energy evolves by ejecting from time to time a star with positive energy, leaving behind a system in a more stable configuration which can either be a trapezium or a hierarchical system (Allen, Poveda, and Worley 1974).

Although trapezium systems were considered extremely interesting objects as regards their dynamical characteristics and their evolutionary implications, very few observational data are available in the literature. This paper presents the results of a systematic photometric program for the objects in

* Ambartsumian's filter is a combined criterion of angular separation between components and magnitudes; this filter and the definitions of optical trapezium and pseudo-trapezium which will be used in this work, have been clearly stated by Allen and Poveda (1974).

Ambartsumian's catalog. Part of these results were presented and published earlier (Warman and Echevarría 1977).

Section II presents all the observational material gathered in this work, while the discussion and conclusions are presented in §§ III and IV respectively.

II. OBSERVATIONS

Photoelectric photometry in the *UBVRI* bands were obtained for 68 objects in Ambartsumian's list using the 84 cm reflector of the Observatorio Astronómico Nacional at San Pedro Mártir, Baja California, México. The data were obtained during several observing seasons between September 1973 and August 1975. Most of the objects were observed at least twice using a 27″ diaphragm; this implies that some systems, where the angular separation between two or more components was smaller than the diaphragm, were not resolved. In some cases though, when the geometry of the system was suitable, effort was made to isolate the minimum number of components in the diaphragm. The observations are summarized in Table 1. In this table, Column 1 gives the number of the multiple system from Aitken's Double Star Catalog (ADS); Column 2 corresponds to Ambartsumian's number (AMS). Column 3 specifies the components measured in the system (i.e., ABC means that the components A, B, C of the system were not resolved in the photometry, etc.). Columns 4 to 8 give the measured visual magnitude, m_v, and the corresponding color indices. Column 9 is a quality index related to the number of observations and their dispersions; here "*a*" stands for good, "*b*", for average quality and "*c*" indicates usually that only one observation was made. Column 10 shows the spectral type and luminosity class; the values in parentheses indicate that this information was deduced from the photometry. The distance to the object, (estimated from the spectroscopic data) appears in Column 11, where the parentheses have the same meaning as in Column 10. Column 12 indicates whether a trapezium is located within nebulosity (I) or not (O). Column 13 gives the source of previously existing photometric or spectral data.

The average error in the colors is 0.05 magnitudes. Photographic prints of the Palomar Sky Survey were used to determine, for each object, the existence of a nebulosity.

No attempt was made to obtain very precise photometry on any particular object, instead effort was placed on gathering the maximum information on as many objects as possible with the purpose of making a statistical analysis.

III. DISCUSSION

Since Ambartsumian's criterion for selecting multiple objects is fairly sensitive to visual magnitude, the presence of an object in Ambartsumian's list has to be revised whenever new data become available. Allen, Tapia, and Parrao (1977) found that when IDS magnitudes are used, only 68 systems out of the 108 original ones fulfill Ambartsumian's criterion. Using our observations only 55 out of 68 objects do so. Nevertheless we have not eliminated these 13 systems from Table 1. We have rather selected the non-physical systems on other grounds, as explained below.

a) *Optical Systems*

In order to extract from the sample the optical systems, i.e., those systems for which the components are physically uncorrelated and appear as trapezia due to projection effects, we analyzed our data with reference to inconsistencies in which a secondary (fainter) star of the system showed a higher surface temperature than the primary. This case is obviously in contradiction with a common distance to the system and leads clearly to the conclusion that the system is a projection of uncorrelated objects. This procedure cannot differentiate between a true trapezium and a pseudotrapezium, because in the latter case, the difference in distance between the solar system and the hierarchical projected system for the different components is too small. Figure 1 shows as an example, the flux diagrams of two systems which were detected in our photometry as optical systems. We have found 9 such optical systems (AMS 80 was previously reported to be optical by Roth *et al.* 1979). This figure is a lower limit to the number of optical systems in the sample as more such objects might exist, especially among the unresolved trapezia, where this procedure is obviously not applicable and among those systems which are immersed in a nebu-

TABLE 1

UBVRI PHOTOMETRY OF TRAPEZIUM TYPE SYSTEMS

ADS (1)	AMS (2)	(3)	m_V (4)	B-V (5)	U-B (6)	V-R (7)	R-I (8)	Q (9)	Sp (10)	d(pc) (11)	NEB (12)	Notes (13)
202	1	ABC	10.02	1.06	1.20	0.52	0.60	b	(K5V)	(25)	O	
1209	7	A†	7.14	0.28	-0.37	0.10	0.27	b	B5Ib	2187		1
		BC†	9.62	0.28	-0.58	0.02	0.17	b	....	....		
1823	10	AB	10.74	0.83	0.51	0.61	0.46	b	(K0V)	(93)	O	
1869	11	ABC	10.34	0.39	-0.26	0.10	0.41	b	....	....	I	
1877	12	A	8.36	0.33	-0.39	0.03	0.28	b	B5V	396	I	2
		B	11.51	0.22	0.17	0.53	0.27	b	....	....		
		A'	9.84	0.39	0.14	0.00	0.36	c	....	....		
		B'	11.02	0.51	0.19	0.30	0.39	b	....	....		
1920	13	AB	7.84	0.53	-0.56	0.14	0.39	b	O5.OIII	2280	I	3
		AC	7.90	0.58	-0.62	0.10	0.38	b	....	....		
		D	13.10	0.63	-0.23	0.44	0.56	b	....	....		7
2159	15	A†	3.59	-0.08	-0.36	-0.06	-0.08	b	B8V	30		4
		B†	10.18	0.36	-0.81	-0.20	-0.16	c	....	....		
		C†	10.35	0.32	-0.73	0.08	0.62	b	....	....		
		D†	8.60	1.10	1.26	0.46	0.57	b	....	....		6,7
2165	17	ABC	8.16	0.31	-0.61	-0.06	0.21	c	O9.OV	2280	I	3
		CD	10.72	0.54	-0.59	0.37	0.47	c	....	....		
2843	20	A	2.80	0.15	-0.81	0.13	0.04	a	B1Ib	345	O	4
		AB	2.79	0.15	-0.82	0.13	0.02	a	....	....		
3579	23	A†	6.19	-0.02	-0.26	-0.16	0.04	a	B6V	240		4
		B†	7.64	0.00	-0.23	-0.20	0.08	a	B6IV	580		1
		C†	9.80	0.13	0.09	-0.11	0.20	b	....	....		7
3684	24	A†	7.38	0.09	-0.20	0.10	0.06	a	B9(V)	(220)		5
		B†	11.46	0.37	0.24	0.44	0.34	a	....	....		
		C†	12.07	1.22	0.92	0.94	0.86	a	....	....		7
		A'†	13.81	1.02	0.78	1.13	0.59	a	....	....		7
3940	25	AD	8.67	0.06	-0.60	-0.43	0.14	b	B3(V)	(818)	I	4
		B	9.80	0.01	-0.49	-0.16	0.07	b	....	....		
		C	9.78	0.07	-0.42	-0.12	-0.01	b	....	....		
4053	27	ABC	8.89	0.18	-0.68	0.23	0.14	b	O9.5V	2060	I	3
		DE	10.82	0.17	-0.73	0.33	0.10	b	....	....		
		F	12.40	0.41	0.20	0.48	0.35	b	....	....		7
4112	28	ABCD	10.48	0.43	-0.46	0.58	0.50	b	....	....	I	
		D	14.52	0.20	0.13	0.01	0.05	b	....	....		7
4164	29	ABC	10.13	0.81	0.59	0.20	0.47	b	(K0V)	(122)	O	
4241	31	AB	3.77	-0.31	-1.02	0.04	-0.21	a	O9.5V	460	I	3
		E	6.61	-0.11	-0.84	-0.23	-0.24	b	....	....		6,7
4728	32	AB	6.93	-0.11	-0.87	-0.30	-0.08	a	B2(V)	(639)	O	5
		C	11.00	0.11	-0.24	-0.33	0.12	b	....	....		
		D	8.10	-0.10	-0.77	-0.34	-0.04	b	....	....		
		E	9.19	0.02	-0.54	-0.24	0.03	b	....	....		
4884	33	AB†	10.23	0.67	0.27	0.62	0.44	b	....	....		
		C†	11.64	0.15	0.11	0.17	0.10	b	....	....		7
4962	34	A	7.31	-0.12	-0.36	-0.41	-0.10	b	B8(V)	(260)	O	
		B	9.12	0.00	0.00	-0.59	0.49	b	....	....		
		C	12.32	0.41	0.03	0.27	0.24	b	....	....		7
		D	7.67	0.01	0.02	-0.35	0.08	b	....	....		6,7
		E†	11.99	1.73	2.08	1.45	1.34	b	....	....		7
5008	35	AB	9.67	0.78	0.46	0.28	0.52	a	(K0V)	(98)	O	
		ABC	9.60	0.79	0.45	0.28	0.50	a	....	....		
5322	36	AB	4.68	-0.27	-1.05	-0.09	-0.09	a	O8.OIII	790	I	3
		D	12.14	0.42	-0.27	0.58	0.45	a	....	....		7
		E	8.90	-0.09	-0.50	-0.05	-0.22	a	....	....		6
		F	9.06	-0.13	-0.50	-0.02	-0.13	a	....	....		6,7
		G	10.04	0.13	0.11	0.27	0.16	a	....	....		6
		Ad	11.40	0.23	0.14	0.23	0.08	a	....	....		6,7
5682	37	A	10.56	0.12	0.20	0.27	0.07	a	(A7V)	(492)	O	
		BC	9.95	0.23	0.25	0.12	0.23	a	....	....		

TABLE 1 - Continued

ADS	AMS		m_V	B-V	U-B	V-R	R-I	Q	Sp	d(pc)	NEB	Notes
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
6205	42	A	4.70	0.00	-0.30	-0.04	-0.14	b	B8(V)	(90)	O	4
		B	9.22	0.40	0.20	-0.13	0.26	b	....	....		
		C	10.49	1.21	1.22	0.34	0.48	b	....	....	O	
6366	44	A	8.32	-0.02	-0.12	0.04	-0.08	a	B9(V)	(397)	O	5
		B	9.27	0.07	0.05	-0.24	0.00	a	....	....		
		C	12.33	0.34	-0.06	0.27	0.09	a	....	....		7
7474	47	AB	9.49	0.75	0.52	0.43	0.46	b	(G8V)	(60)	O	
		AC	9.92	0.82	0.50	0.53	0.55	b	....	....		
10637	49	A	10.38	0.57	0.04	0.51	0.06	b	(F8V)	(188)	O	
		BC	11.23	0.97	0.80	0.90	0.40	b	....	....		
10841	50	ABC	9.28	1.18	1.07	0.52	0.70	b	(K2V)	(40)	O	
10991	51	AB	7.24	-0.11	-0.95	-0.39	0.02	b	07.0I	1590	I	3
		CDE	7.38	0.19	-0.25	-0.08	0.01	b	....	....		
		G	13.17	0.17	-0.03	0.55	0.35	b	....	....		7
11136	52	AB	9.76	0.38	-0.49	0.23	0.39	b	B0V	2312	I	2
		C	11.61	0.35	-0.22	0.05	0.07	b	....	....		7
11169	54	A	3.88	0.22	-0.52	0.32	0.15	b	B8Iap	1061	O	4
		B	8.04	-0.04	-0.11	-0.52	0.24	b	....	....		
		C	10.99	0.23	-0.30	1.26	0.16	b	....	....		
		D	9.63	0.11	-0.57	0.26	0.00	b	....	....		
		E	9.25	0.04	-0.67	0.16	-0.03	b	....	....		
11179	55	A	10.17	0.43	0.19	-0.02	0.27	b	(F5V)	(226)	O	
		B	10.34	0.40	-0.02	-0.10	0.33	b	....	....		
11263	58	AB	11.15	0.60	0.07	0.44	0.27	a	(G2V)	(195)	O	
		C	10.72	0.52	0.06	0.44	0.29	a	....	....		7
		D	10.73	0.60	0.02	0.42	0.33	a	....	....		
11344	59	ABC	7.15	0.84	0.46	0.65	0.43	b	(K0V)	(18)	O	
11421	60	A†	9.22	0.61	0.10	0.43	0.33	a	....	....		
		B†	11.53	0.49	-0.06	0.59	0.09	b	....	....		7
		C†	10.90	1.14	0.96	0.75	0.64	a	....	....		
12092	61	ABCD	9.55	0.50	0.22	0.07	0.31	b	(F8V)	(129)	O	
12100	62	ABC	11.61	1.01	0.91	0.55	0.49	b	(K2V)	(115)	O	
13292	67	AAaC	9.00	0.32	-0.47	-0.24	0.28	b	B2(V)	(920)	I	5
		BBb	10.58	0.62	-0.41	-0.19	0.37	b	....	....		
		D	12.08	0.44	-0.36	0.17	0.35	b	....	....		7
		Aa	9.15	0.31	-0.53	-0.06	0.36	b	....	....		
13312	68	AB	6.63	0.10	-0.71	0.12	0.11	a	09.5III	2730	I	3
		C	9.71	0.17	-0.53	0.27	0.17	a	....	....		
		D	12.90	0.19	-0.57	0.57	0.07	b	....	....		7
13368	69	A	10.88	0.41	0.10	-0.05	0.21	b	B0pe(II)	....	I	2
		ABCE	10.16	0.52	0.04	-0.04	0.52	b	....	....		
		AD	10.66	0.57	0.15	0.04	0.37	b	....	....		
		BC	11.71	0.50	0.07	0.01	0.32	b	....	....		7
13374	70	A	6.67	0.17	-0.72	0.15	0.09	b	WN5+09.5III	...	I	
		ABCD	6.69	0.13	-0.76	0.04	0.11	a	....	....		
		FG	7.30	0.23	-0.64	0.18	0.14	a	....	....		6
		FGH	7.31	0.22	-0.59	-0.10	0.15	b	....	....		6
13610	72	AC	7.27	1.55	1.94	1.07	1.26	a	Ma	....	O	5
		D	12.45	0.61	0.22	0.53	0.40	b	....	....		7
13626	73	AAaAb	8.45	0.36	-0.50	0.34	0.29	b	B0.5IV	....	I	5
		BBdBg	8.38	0.45	-0.02	0.11	0.42	c	....	....		
		C	8.85	0.40	-0.47	0.28	0.26	b	....	....		
		CbCg	10.66	0.46	-0.48	0.28	0.21	b	....	....		6,7
		Ch	12.68	0.40	-0.01	0.51	0.28	b	....	....		6,7
14000	76	AB	8.69	1.25	0.27	0.70	1.13	b	06.0Ib	1100	I	3
		C	12.13	1.37	0.38	0.95	1.20	b	....	...		7
14071	78	ABC	10.40	0.63	0.17	0.06	0.35	b	(G2V)	(138)	O	
		D†	12.15	0.53	0.09	0.35	0.37	b	....	....		7
14330	79	ABC	8.87	0.22	0.18	-0.21	0.16	b	(A7V)	(196)	O	

Table 1 - Continued

ADS (1)	AMS (2)	(3)	m_v (4)	B-V (5)	U-B (6)	V-R (7)	R-I (8)	Q (9)	Sp (10)	d(pc) (11)	NEB (12)	Notes (13)
14338	80	A†	9.01	2.59	0.68	1.89	1.47	a	....	....		
		B†	10.79	0.89	0.48	0.79	0.62	a	....	....		
		C†	9.50	2.72	0.59	2.15	1.52	a	....	....		
14438	81	AB	10.10	0.46	0.22	-0.08	0.13	b	....	....	I	
		C	12.34	0.64	0.34	1.18	-0.08	b	....	....		
14526	82	A†	4.93	-0.14	-0.95	0.05	0.05	a	B3ne	....		5
		B†	9.35	0.15	-0.29	-0.07	0.19	b	....	....		
		C†	11.11	-0.10	-0.92	0.45	0.40	a	....	....		
		D†	12.72	-0.34	-1.08	0.45	0.14	a	....	....		7
14545	83	AAaBBb	9.64	0.44	0.08	0.27	0.30	b	(F5V)	(177)	0	
14825	84	ABC	10.24	1.12	1.05	0.76	0.59	b	(K5V)	(28)	0	
14969	88	A	5.91	-0.12	-0.90	-0.04	-0.11	b	B0Ib	276	0	4
		B	12.15	0.70	-0.58	0.97	0.48	b	....	....		7
		C	10.61	0.47	-0.00	0.49	0.29	b	....	....		7
15014	89	AB	9.46	1.40	1.20	0.75	0.78	b	(M0V)	(11)	0	
		AAaC	9.24	1.50	1.75	0.72	0.81	b	....	....		
15184	90	AB	5.59	0.22	-0.74	-0.12	0.16	a	O6.5V	820	I	3
		ABC	5.50	0.23	-0.73	-0.10	0.15	a	....	....		
		D	7.98	0.23	-0.72	-0.00	0.12	a	....	....		
15220	91	AB	7.53	1.86	1.55	2.39	2.40	b	Mc	....	0	5
		C	11.21	0.35	0.30	1.29	1.42	b	....	....		
15260	92	ABC	9.30	0.56	0.22	0.26	0.32	b	(G0V)	(95)	0	
15469	93	AB	10.29	0.42	0.47	0.10	0.29	a	(F5V)	(239)	0	
		ABC	10.21	0.39	0.45	0.15	0.29	a	....	....		
15561	94	ABAb	9.46	0.30	0.41	0.13	0.25	b	(F0V)	(235)	0	
		C	10.80	0.56	0.07	0.48	0.35	b	....	....		
		DE	12.61	0.83	0.34	0.73	1.22	b	....	....		7
15664	95	ABC	10.88	0.67	0.29	0.52	0.43	b	(G5V)	(136)	0	
15679	96	A	6.77	-0.13	-0.20	-0.14	-0.02	a	B9(V)	(1148)	0	
		B	10.06	0.25	0.20	0.21	0.13	a	....	....		
		C	13.53	0.73	0.38	0.76	0.62	c	....	....		7
		D	6.67	-0.02	-0.25	-0.29	-0.06	b	....	....		6
	98	ABCD	8.77	0.98	0.87	0.55	0.64	b	(K2V)	(31)	0	
		ABC	8.66	1.11	0.99	0.39	0.71	c	....	....		
15789	99	ABD	9.37	0.67	0.57	0.29	0.37	b	G0III	....	I	2
		ACE	9.34	0.65	0.53	0.32	0.42	b	....	....		
15834	100	ABC	9.50	0.48	-0.61	0.16	0.38	b	....	....	I	
		D	12.56	0.51	-0.31	0.22	0.54	b	....	....		7
		E	12.98	0.66	-0.15	0.62	0.61	b	....	....		7
15847	101	AB	5.29	0.00	-0.53	-0.07	-0.01	b	B5III 4	....	0	
		C	11.11	0.36	-0.11	-0.25	-0.07	b	....	....		
16095	102	A	5.67	-0.15	-0.91	-0.21	-0.18	a	B1Vnc †	602	0	
		B	6.35	-0.09	-0.85	-0.11	-0.23	a	B2V	....		
		CCc	10.77	0.55	-0.10	0.61	0.37	a	....	....		
		DDd†	9.06	-0.03	-0.26	0.05	0.00	a	....	....		6
16474	103	A	6.50	-0.15	-0.55	0.00	0.05	a	B9(V) 4	(219)	0	
		B	10.37	0.27	-0.12	0.20	0.21	a	....	....		
		C	10.77	0.44	0.07	0.46	0.20	a	....	....		7
16795	104	AB	4.90	-0.16	-0.03	-0.10	-0.07	a	B3V 4	197	0	
		CD	7.10	-0.07	-0.11	-0.09	-0.00	a	....	....		
		FG†	10.26	0.55	0.16	0.17	0.29	a	....	....		
		E†	11.35	0.41	-0.31	0.55	0.51	a	....	....		7
		H†	12.72	0.66	-0.24	0.96	0.08	b	....	....		6,7
16953	105	A	10.77	0.20	0.40	0.33	0.11	b	(A7V)	472	0	
		BC	11.64	0.45	0.54	0.14	0.37	b	....	....		7
		DE†	10.68	0.97	0.17	1.08	1.21	b	....	....		
17093	106	A†	9.67	0.32	0.48	0.08	0.19	b	....	....		
		BC†	12.16	1.01	0.76	0.83	0.51	b	....	....		
		Aa†	11.59	0.39	0.16	0.23	0.39	b	....	....		6
17124	107	ABC	10.06	0.24	0.10	0.26	0.39	b	(A7V)	(340)	0	

† Optical System.
1. UBV Photometry Catalogue (Blanco, Demers, Douglass and FitzGerald 1968).
2. Catalogue of Stellar Spectra (Jaschek, Conde, and Sierra 1964).
3. Catalogue of Galactic O Stars (Cruz-González, Recillas-Cruz, Costero, Peimbert, and Torres-Peimbert 1974).
4. Abt and Biggs, 1972.
5. Ambartsumian's list of trapezia (Ambartsumian 1954).
6. Companion not included in Ambartsumian's list.
7. Rejected by Ambartsumian's filter using photoelectric magnitude.

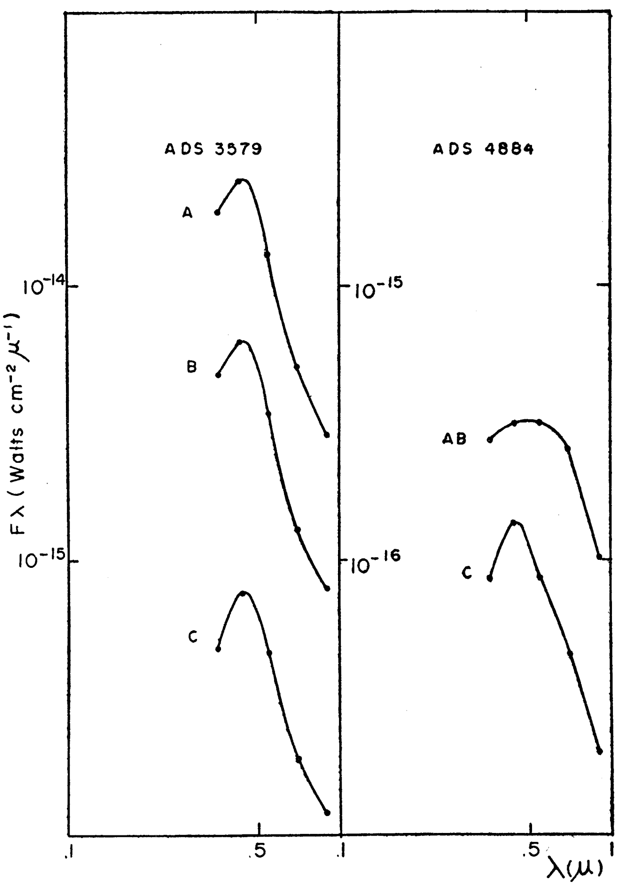

FIG. 1. Flux diagram for two optical systems. Note in ADS 3579 that for the same surface temperature the fluxes differ by more than an order of magnitude.

losity, because as will be seen below, the photometric data do not allow this kind of analysis.

b) *Systems Associated with Nebular Regions*

After checking the positions of the 68 systems under consideration, 21 of them appeared to be located within the limits of nebular regions on the photographic prints of the Palomar Sky Survey. Most primaries of these objects are of spectral type O-B. Nine of these primaries are of luminosity class V, seven are giants or supergiants, one is a Wolf-Rayet star and four have unknown spectral type. For these spectral types and luminosities, we have to rely entirely on previous observations, since spectral determinations from the photometry are unreliable because the measured colors show not only the effects of circumstellar and intra-nebular reddening, but also effects of possible stellar emission lines. Figure 2 shows the color-color diagram (*U-B* versus *B-V*) for this class of systems.

c) *Other Systems*

In Figure 3 we have plotted the color-color diagram for all the objects which are not located within a nebulosity. Of this group, 12 primaries are reported

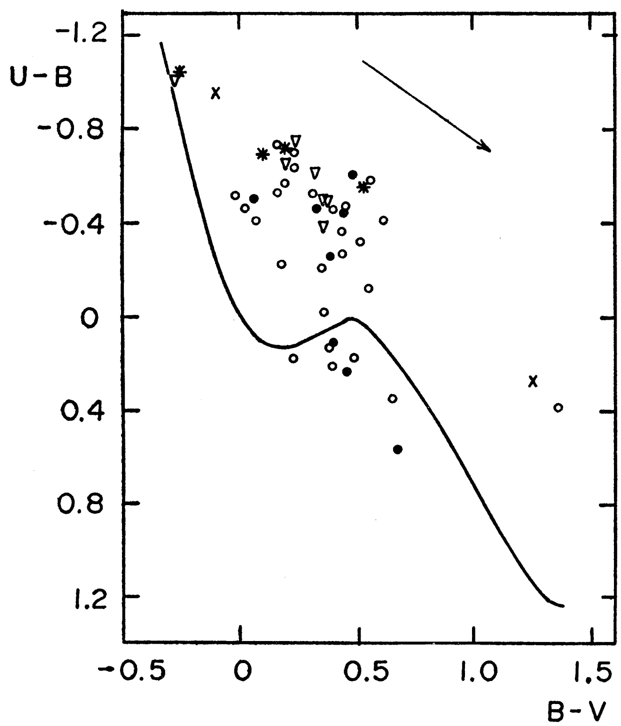

FIG. 2. Color-color (U-B versus B-V) diagram for trapezia located inside nebulous regions. Straight line with an arrow indicates the reddening line. Crosses are super-giant primaries; asterisks, giant primaries; triangles, main sequence primaries; filled circles, other primaries; open circles, secondaries.

to be main-sequence stars, five are giants or supergiants and 25 are assumed to be main-sequence stars, based on the photometry, though this assumption is acceptable for statistical purposes only. We can interpret this group as a continuous distribution of surface temperatures reaching from early to late spectral types. We would like to point out that among this group of objects we find two apparent subgroups.

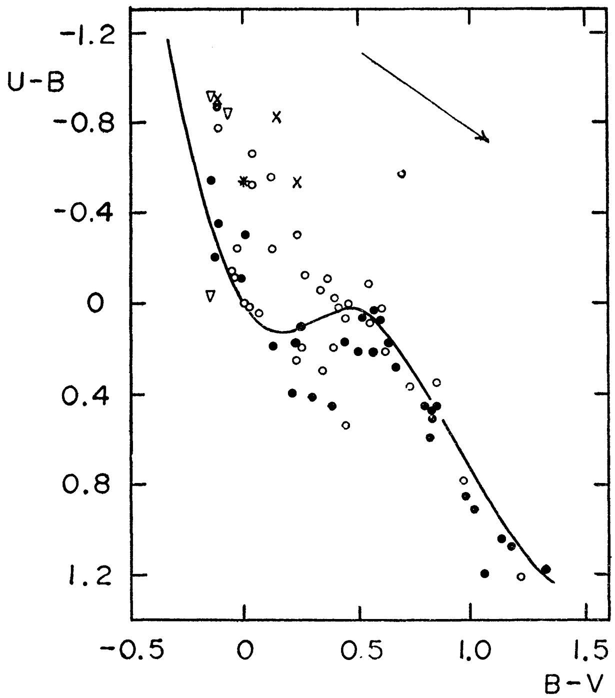

FIG. 3. Color-color (U-B versus B-V) diagram for trapezia with no nebulosity. The symbols have the same meaning as in Figure 2.

i) Late Spectral Type, Closed Systems.

Figure 4 shows the color-color diagram of a subgroup of systems of late spectral type characterized as "closed" systems, i.e., groups of three of four stars with small angular separations and which were not resolved in the observations. The galactic distribution of this subgroup (and for all the other systems) is depicted in Figure 5; we can easily notice that these objects lie 10° above or below the galactic plane. At these galactic latitudes the amount of reddening cannot be significant, therefore we conclude that these objects are true late type systems.

We have investigated the possible effects of the unresolved photometry. Figure 6 shows the flux diagrams for four such systems and the corresponding flux diagram of a late type main sequence star. We find the agreement sufficiently satisfactory to conclude either that one of the stars in the group dominantes all the others or that all of them have similar surface temperatures. On the other hand, visual magnitudes are very similar for all the components and if these systems are true trapezia we can assume their components to be main-sequence stars. (The probability of observing a group composed of evolved giants or super-giants would imply serious limitations on the formation of these stars). Based on this assumption, we have calculated an average distance to the sun of this subgroup to be 100 pc and an average distance z of 23 pc.

ii) Early and Intermediate Type, Open Systems.

This subgroup, which seems to be complementary to the one discussed in *i*) points out a purely observational effect, i.e., that the components of these have angular separations which allow them to be measured separately. The color-color diagram for this subgroup is presented in Figure 3, where the late-type, closed systems are also shown, occupying the lower part of the figure. No particular feature is exhibited by this group. The distribution of these objects (Figure 5) shows concentration towards the galactic plane, which implies that they undergo a somewhat higher reddening. We assume that this reddening is responsible for the scatter in the color-

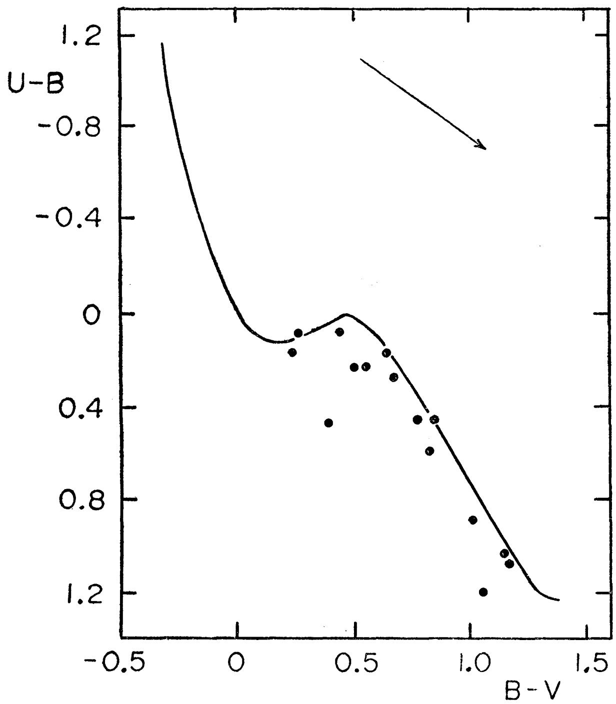

FIG. 4. Color-color (U-B versus B-V) diagram for "late-type closed systems". See text for explanation.

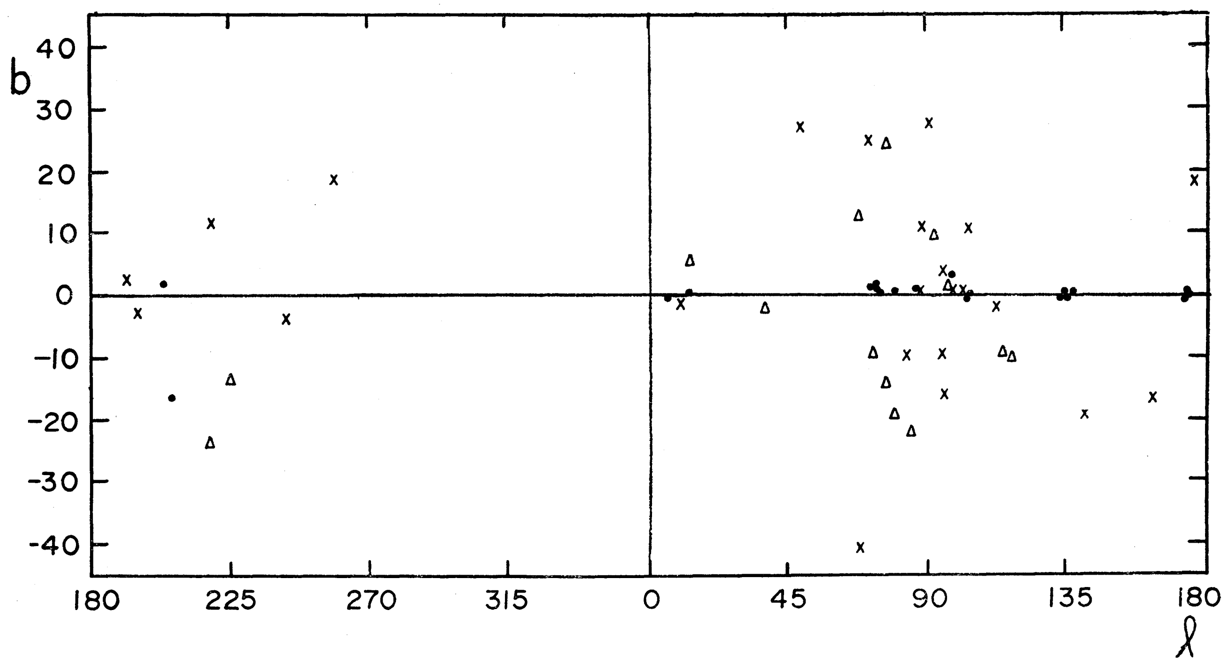

FIG. 5. Galactic distribution of the observed systems. Filledcircles, systems with nebulosity; triangles, "late-type, closed systems"; crosses, others.

color diagram. If we assume again these objects to be main-sequence stars (with the exception of those reported otherwise), the calculated average distance to the sun and to the galactic plane would be 1000 pc and 70 pc respectively.

d) *Selection Effects in Ambartsumian's List*

We believe that the subgroup discussed in *i*) and *ii*) constitute an artificial division in Ambartsumian's sample, due to selection effects. The following arguments illustrate this statement:

1. The noticeable absence of closed systems of early spectral types has the following explanation: the average distance to the early and intermediate objects (1000 pc) is too large to allow the optical detection of a multiple systems with angular separations of less then 25 000 AU (for 0.5″); this gives support to Sharpless's remark that many O type stars could be part of unresolved multiple systems as mentioned before.

2. On the other hand, the absence of early-type trapezia in the solar vicinity is self explanatory: there are no early-type objects in our vicinity.

3. Distant late-type trapezia are fainter than $m_v = 12.5$ and were therefore excluded by Ambartsumian.

4. The companions of late-type primaries are necessarily of similar masses or smaller. The reason for the "late-type, closed systems" is that much fainter companions would either go unobserved or would be fainter than $m_v = 12.5$.

IV. CONCLUSIONS

From our photometric analysis we derive the following conclusions:

1) The number of optical systems is much higher than predicted. In our sample, 13.2% of the objects are optical while Ambartsumian's prediction is closer to 0.2%. It should be kept in mind that our figure is a lower limit.

2) Despite the fact that multiple systems with spectral types ranging from A0 to K5 had to be left out in Ambartsumian's list because they had a very high probability of being pseudo-trapezia, it is obvious

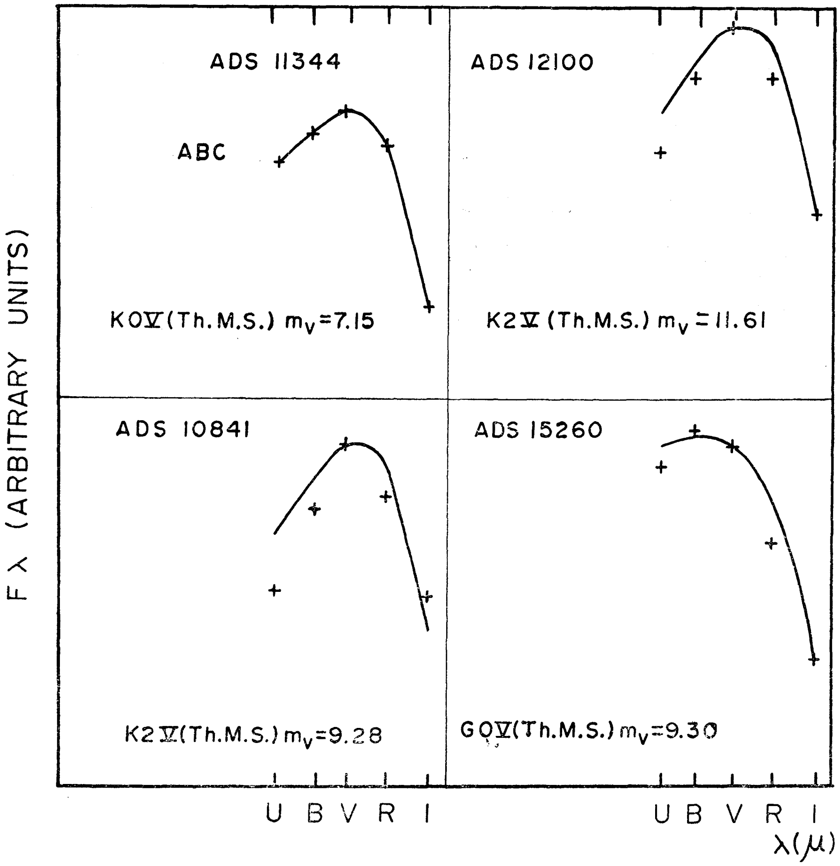

FIG. 6. Flux diagrams of four "late-type", closed systems" Crosses correspond to the observed flux values. The continuous lines correspond to the flux of the star indicated in each case (Johnson, H. L. 1966).

that the inclusion of a high number of objects with unknown spectral type led to the actual distribution of spectral types; so, according to Ambartsumian, a high number of pseudo-trapezia should be found in our sample. The incidence of pseudo-trapezia for intermediate spectral types has been revised by Allen *et al.* (1977), who found it to be appreciably smaller; nevertheless, this point remains open since we have no way of discriminating pseudo from true trapezia.

3) We find that the apparent grouping in Ambartsumian's catalog is a consequence of the superposition of several selection effects, with the exception of those trapezia which are located within nebulosities.

4) We find no evidence of youth among the sample, with the possible exception, again, of trapezia immersed in nebulosity. These could be young systems comparable in all respects to the Orion Trapezium. For late-type objects we find that the idea of trapezia being very young is untrue. This was indicated by Allen and Poveda (1974) as a conclusion of their calculations for massive trapezia. Obviously the contraction times for the intermediate and the late-type trapezia are inconsistent with alleged dynamical ages of the order of 10^6 years. This implies, once more, that trapezia can be stable configurations.

This work has been lengthy in time. Many people have helped, either by expressing their opinions or by actually assisting throughout the process of compiling the data. We sincerely acknowledge fruitful discussions with Dr. A. Poveda and R. Costero. We are indebted to Sükrü Bozkurt, G. Reséndiz and M. Tapia for observational assistance. The assistance of the personnel of the National Observatory is gratefully acknowledged.

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