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VISUAL AND INFRARED OBSERVATIONS OF TRAPEZIUM-LIKE OBJECTS

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RESUMEN

Se presentan mediciones fotométricas en las bandas UBVRIKLMQ de siete objetos previamente reportados como sistemas tipo trapecio con flujo infrarrojo anómalo. De los resultados se concluye que en cuatro casos la fuente infrarroja asociada no coincide con el trapecio en cuestión y que en los tres casos restantes, el flujo proviene de estrellas muy frías y luminosas. Se discuten las implicaciones de estos resultados.

ABSTRACT

UBVRIKLMQ observations are presented on seven trapezium like objects, previously reported to have abnormally high infrared fluxes. We conclude that in four cases the source responsible for the infrared flux does not correspond to a member of the trapezium system under consideration; in the three remaining cases, the infrared fluxes are due to the presence of bright and very cool stars. These results and their consequences are discussed.

Key words: **INFRARED-SOURCES — PHOTOMETRY — STARS-STELLAR DYNAMICS — STARS-VISUAL MULTIPLES.**

I. INTRODUCTION

Dynamical considerations on trapezium-like systems have led to the conclusion that these systems are young objects (i. e., 10^6 yr) and that some of them should indeed be very young (10^5 yr), the Orion trapezium being the best known example (Allen and Poveda 1974, 1975).

In a recent paper Poveda, Allen and Warman (1977, hereinafter PAW) selected 13 trapezium-like objects which were identified by means of positional coincidences, with a source reported in the "2.2μ Sky Survey" (IRC) (Neugebauer and Leighton, 1965). These 13 objects were reported to have infrared excesses, i. e., their (V-K) colors were abnormally high when compared with normal stars of the same spectral type. This criterion selected these objects from other systems which were bright enough as to have a K-magnitude of 3 or brighter. (The IRC is complete to $m_K = 3$). PAW's conclusion, derived from the infrared magnitudes of the IRC, was that the objects in this list were very young (the Orion trapezium and VY CMa are contained in the list).

The need for more information on these objects led us to undertake and observational program using broad band, visual and infrared photometry.

II. OBSERVATIONS

The observations were made at the 60″ and 33″ reflecting telescopes of the Observatorio Astronómico Nacional at San Pedro Mártir (Baja California, México), in two different observational periods during October and November, 1977. The infrared photometer used is described by Roth *et al.* (1978) and the standard UBVRI photometric system has been described by Johnson (1964). The infrared measurements were made using the absolute calibration given by Low and Rieke (1974) The inter-

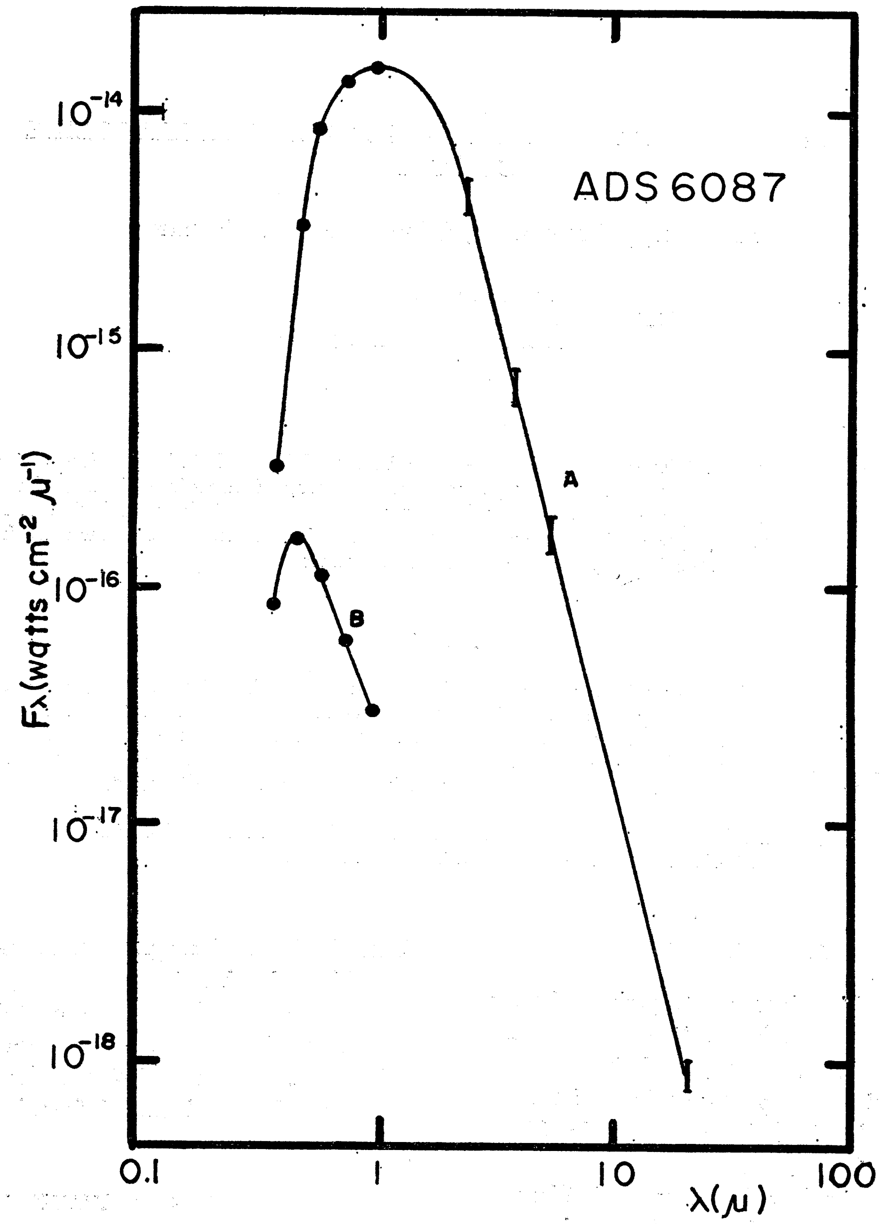

FIG. 1. Energy distributions for ADS 6087.

nal error in the UBVRI photometry is of the order of 1%, while the infrared photometry has an internal error of 2% in K and L, 3% in M and of the order of 10% in Q. Due to instrumental reasons 10μ data are not available at the moment.

Table 1 summarizes our observations. Column 1 identifies the multiple system by its ADS (*Aitken Double Star Catalog*) number. Column 2 lists the components of the system. Column 3 gives the visual magnitude V, and spectral type, Sp, taken from PAW (this corresponds to V and Sp of the primary in all cases). Column 4 shows the measured V and the following columns, 5 through 12, give the measured colors; dots indicate that the infrared magnitudes

TABLE 1

UBVRIKLMQ PHOTOMETRY OF MULTIPLE SYSTEMS

System	Comp.	V	Sp.	V	U-V	B-V	V-R	V-I	V-K	V-L	V-M	V-Q
6087		6.9	K5	....	....	....	....	....	....	....	....	...
	A	...		6.71	3.73	1.68	1.33	2.40	4.19	4.20	4.0	4.6
	B	...		8.97	3.78	.24	.230	.33	....	....	....	...
14338		10.7	K	....	....	....	....	....	....	....	....	...
	A	...		9.01	3.27	2.59	1.89	3.36	7.15	6.7	....	...
	B	...		10.79	1.37	.89	.79	1.41	....	....	....	...
	C	...		9.50	3.31	2.72	2.15	3.67	7.0	7.0	....	...
16982		7.1	K0	....	....	....	....	....	....	....	....	...
	A+B	...		7.02	1.85	1.04	.76	1.36	1.89	2.2	....	...
	C	...		9.86	3.27	2.12	2.85	5.33	8.05	8.15	7.93	8.1
	D	...		10.95	.85	.70	.58	.92	....	....	....	...
1918	...	9.9	A0*	....	....	....	....	....	....	....	....	...
11078	...	9.0	B5*	....	....	....	....	....	....	....	....	...
13312	...	7.2	Oe*	....	....	....	....	....	....	....	....	...
15460	...	8.4	F2*	....	....	....	....	....	....	....	....	...

* Do not correspond to IRC entries.

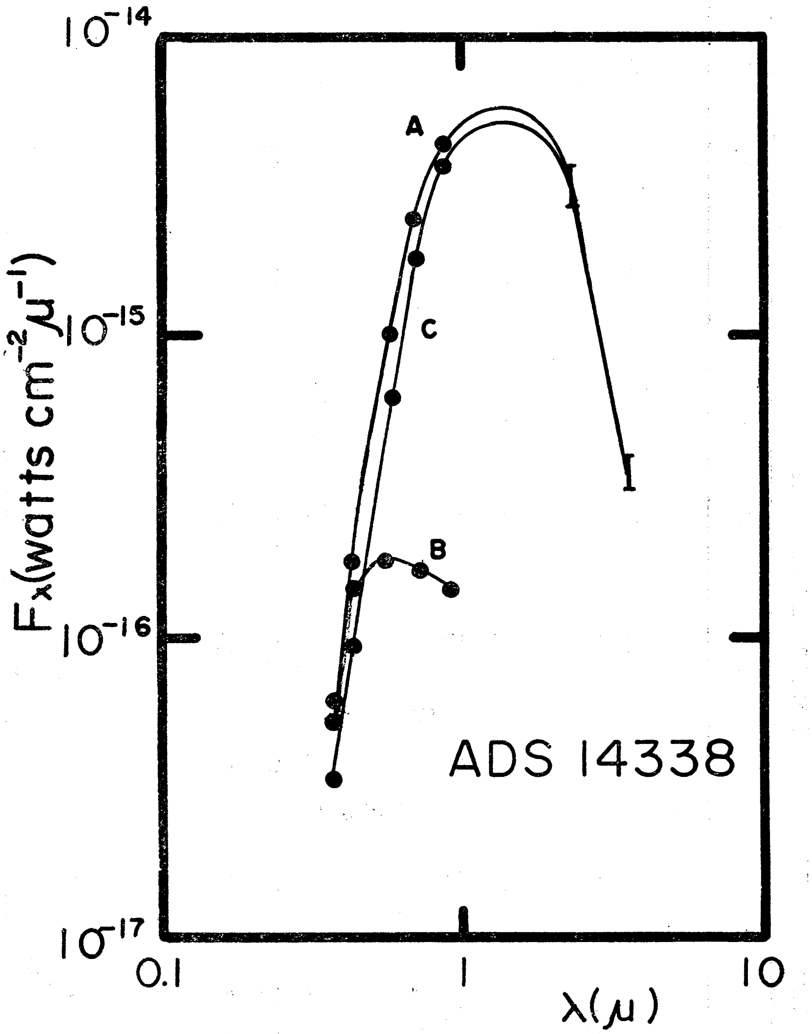

FIG. 2. Energy distributions for ADS 14338. The infrared flux is unresolved for componentes A and C.

were fainter than our detection limits for short-time integrations, (typically 40 sec.) i. e., K=5.5, L=5.0, M=4, Q=1.0.

III. CONCLUSIONS

From the seven objects in question, only three were infrared sources; these corresponded to the identified sources in the IRC. The remaining four systems did not show the expected infrared fluxes; in three of these, the IRC entry was found to be a nearby star and in one case no search was made. This can be understood by noting that PAW's identification lies within the resolution of the IRC, i. e., a region 4′ across.

If one considers the spectral types reported by PAW, a clear distinction can be drawn between "true" infrared sources and those systems which have a nearby infrared source; although a statistical argument based on such a small sample would not be fair, it is apparent that of the systems studied in this work, *all* those which have the expected infrared flux have Sp later than K0 and, *all those which do not* have high infrared flux, correspond to early or intermediate spectral types. In what

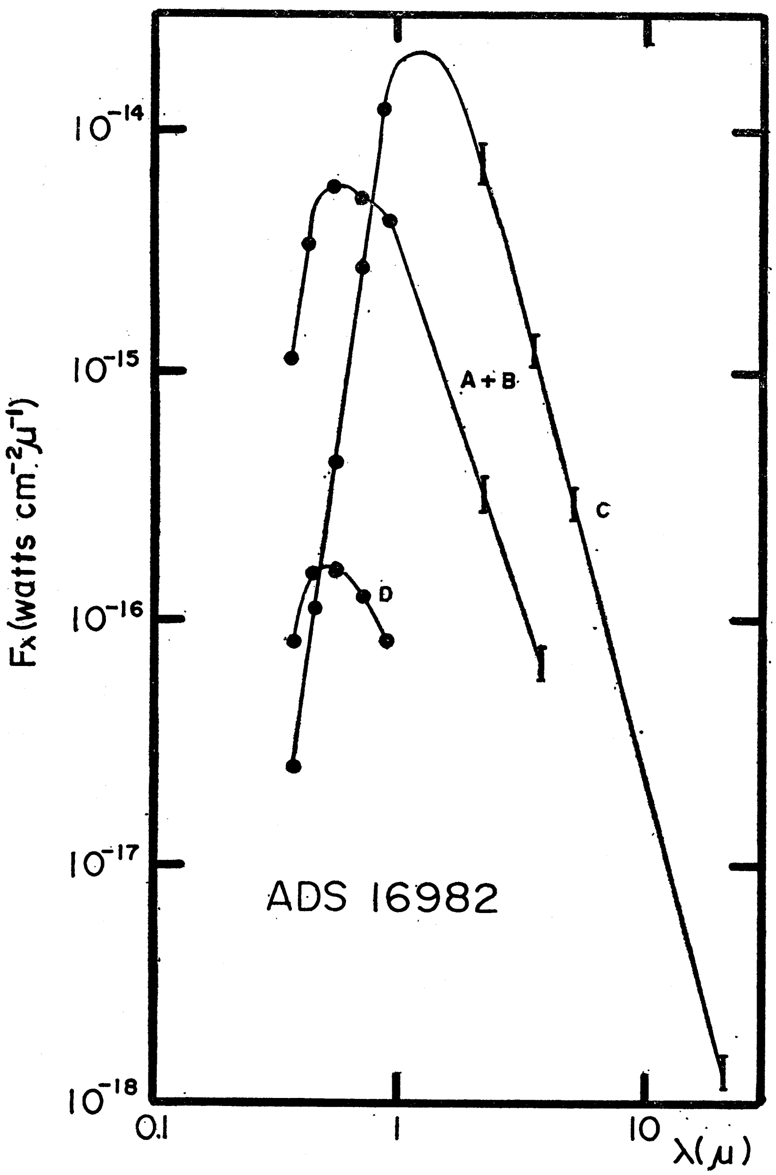

Fig. 3. Energy distributions for ADS 16982. Visual and infrared fluxes are unresolved for components A an B.

follows, we will only refer to the objects which showed the expected infrared flux.

The energy distributions are plotted in Figures 1 through 3 for the multiple systems. Infrared objects show, within the error bars, a wavelength dependence of λ^{-4} for wavelengths above 2.2μ, indicating blackbody radiation. Young objects show spectral distributions which strongly deviate from that of a blackbody (Cohen 1973*a*, *b*, *c*). Figures 1 to 3 do not show the presence of any young peculiar object unlike that concluded by PAW; instead, the infrared objects resemble very cool giant stars (Dyck *et al.* 1974), with temperatures in the range from 3200°K to 2200°K. It should be pointed out that the lack of 10μ data and the low accuracy of 20μ data may conceal the presence of a small circumstellar shell. If this is the case, such a circumstellar shell would rather be associated with mass less (typical of evolved stars), than with the remnant of a contracting nebula.

TABLE 2

DERIVED SPECTRAL TYPES AND DISTANCES FOR INDIVIDUAL STARS

System	Component	Most Probable Sp.	r (kpc)
6087	A	M2 I	5.5
	B	A9 V	.195
14338	A	>M5 I*	.63–1.8
	B	K2–5V	.09
	C	>M5 I*	.6–2.2
16982	A+B	K0 III	.251
	C	>M5 I*	1–2.7
	D	G5 V	.154

* The colors correspond to very red stars. The indetermination of the distance originates in the indetermination of the absolute magnitude of these stars.

The spectral types and luminosity classes, together with the estimated distances to the sun are listed in Table 2. Spectral types and luminosity classes are derived from the spectral distributions according to Johnson (1966), while distances are estimated from their absolute magnitudes. The distances to different components of the reported systems are not compatible with gravitationally related objects. It appears also very difficult to understand the presence of late-type supergiants with intermediate main sequence objects in systems of common origin; we have to assume that these might not be true trapezium-like systems.

The following two conclusions can be drawn from the above arguments and data:

1) The systems discussed here are not young systems in the sense of PAW.

2) Most probably, these systems are not dynamically related but appear as multiple systems due to projection effects, although ADS 16982 might still be a true trapezium if one leaves out the infrared object.

An explanation has to be given of the fact that these objects did fall into a carefully selected list of objects. In the case of the systems which did not show the assumed IR fluxes, the reason is obvious: the computed (V − K) corresponds to one object for the V value and another one for the K value. For the "true" infrared sources, we can safely assume that the colors given by PAW are anomalous because the spectral types and luminosity classes are not well determined. The spectral types that we infer from the protometry are systematically later types than the ones reported by PAW. Even in this case, we find one object where (V − K) was computed from two different stars, i. e., ADS 16982, where the bright infrared source is not visually the brightest (and therefore primary) component of the system for which m_v and S_p are known. It is because of these facts (positional misidentification and unavailability of spectral types and luminosities) that PAW's list seems to have selected mainly very red objects (the brightest component of ADS 14338 has been reported by Jaschek *et al.* (1964) to be an N type carbon star).

Careful photometric and spectroscopic observations of a list of multiple systems associated with age indicators such as molecular clouds and H II regions, should shed more light on the age of trapezium-like systems.

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