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$uvby-\beta$ PHOTOELECTRIC PHOTOMETRY OF THE OPEN CLUSTER α PER

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RESUMEN

Se han obtenido nuevas observaciones de estrellas en la dirección del cúmulo abierto α Per. Estas observaciones se han combinado con las de la literatura en el sistema $uvby-\beta$ de Strömgren. A partir de ellas se ha determinado una membresía fotométrica que se ha comparado con la derivada de los estudios de movimientos propios y de Hipparcos. Se han determinado características físicas para las estrellas y para el cúmulo.

ABSTRACT

Absolute photoelectric photometry of stars in the direction of the Open Cluster α Per has been secured and is presented along with an analysis reinforced with all the available data in Strömgren $uvby-\beta$ photometry compiled from the literature. Cluster membership is analyzed and the physical characteristics of the stars have been deduced. The membership determined in this paper is compared with that of proper motion studies and Hipparcos.

Key Words: **OPEN CLUSTERS AND ASSOCIATIONS: INDIVIDUAL (α PER) — STARS: VARIABLES — TECHNIQUES: PHOTOMETRIC**

1. INTRODUCTION

One of the most important works on the open cluster α Per ($3^{\mathrm{h}}21^{\mathrm{m}}, +49°7'$, 1950) was published by Heckmann, Dieckvoss, & Kox (1956). In their proper motion study they determined the membership probability and established cluster membership for 160 stars; we use their ID nomenclature in the present paper. Another fundamental study of α Per was that of Crawford & Barnes (1974) with four color and Hβ photometry on 89 stars in the direction of the cluster. Cameron (1985) carried out a study of 38 open clusters to determine their distances and metallicities. The values he compiled for α Per are $E(B-V) = 0.070$, [Fe/H]= 0.07 and a distance modulus, DM, $(m-M)_0 = 6.16$.

Boesgaard & Friel (1990) derived the metallicity and age of five open clusters with spectroscopy. In particular, seven stars were observed in α Per. The results they derived for this cluster were an age of (yr)= 5×10^7 and [Fe/H]= -0.054. A study of membership of low mass stars was carried out by Prosser (1992) with combined astrometric, photometric and spectroscopic data of 130 members which, together with those of Heckmann et al. (1956) yield a total number of cluster members of 300 stars. With the isochrones of Prosser (1992), they determined an age of 8×10^7 yr. Meynet, Mermilliod, & Maeder (1993), with models taking into account overshooting and the opacity tables of Rogers & Iglesias (1992), determined, among 30 open clusters, a log age= 7.72, which corresponds to 5.25×10^7 yrs for α Per, a value close to that determined by Maeder & Meynet (1991) in models taking into account the effects of mass loss and core overshooting: log age= 7.85 (7.1×10^7 yr). From models of Iben (1967) and Paczynski (1970), Tsvetkov (1989) determined ages for α Per to be 11.65 and 1.36×10^8 yr, respectively. The compilation of Lang (1991) lists 5.1×10^7 yr for α Per.

In a spectroscopic study Clampitt & Burstein (1997) did spectrophotometry of 237 stars in seven clusters. Their results for α Per show that the majority of the stars are Ap; of the five most luminous stars on the Main Sequence only one is classified as a peculiar giant. All the remaining stars in the hot part of the MS are between classes B3 and B6. The log(age) they assume (5th ed. of Lund-Strasbourg catalogue,

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TABLE 1

OBSERVATION LOG

Date	JD-2451000	Photometry
Sept 27, 1998	83	H501
Sept 29, 1998	85	H906
Sept 30, 1998	86	23 stars
Oct 01, 1998	87	21 stars
Oct 02, 1998	88	25 stars
Oct 03, 1998	89	21 stars
Oct 04, 1998	90	29 stars

1987) is 7.61; they determine a reddening $E(B-V)$ of 0.10 and a metal content of [Fe/H] of 0.10.

The study of nine open clusters by Robichon et al. (1999) gives a nice compilation of the most recent data on the distance and reddening determination of α Per: the range of values varies from 5.94 to 6.4 with a $E(B-V)$ value of 0.09 mag. The value derived from Hipparcos is 6.40 ± 0.08 mag considering a sample of 46 stars.

There are very few studies of the δ Scuti stars in α Per. Some stars were detected as variables by Slovak (1978); one of which, H906 = V465 Per, has reported photometry and period analysis (Kim & Lee 1998). The advantages of studying variables in clusters have been previously emphasized (Peniche & Peña 1986) and this motivated the present study.

2. OBSERVATIONS

The 1998 photometric data observed is of two types: differential and absolute of the variables and absolute photometry of some stars in the direction of the cluster. Both types of photometric data were secured at the Observatorio Astronómico Nacional, México. Table 1 summarizes the log of the observations carried out for $uvby-\beta$ absolute photometry with the 150 cm telescope. In the current paper we present the results of the absolute photometry of the cluster.

2.1. *Data Acquisition*

The instrument utilized was the 150 cm telescope with a spectrophotometer allowing a simultaneous acquisition in the *uvby* filters that define the Strömgren system. Almost simultaneously two more measurements were obtained in the N and W filters that define Hβ. The description of the photometric equipment can be found in Schuster & Nissen (1988).

Since the observations in this season were mostly devoted to the study of the variables o And (Sareyan et al., 2002) and 16 Lac by differential photometry, the acquisition of the data of α Per was a secondary goal. Since Strömgren $uvby-\beta$ photometry provides a unique opportunity to determine both the cluster membership and the physical characteristics of the observed stars if they are properly transformed into the standard system, a few standard stars were also observed on each night; unfortunately as it results, too few.

The reduction to the instrumental system followed the method described by Grönbech, Olsen, & Strömgren (1976). The transformation from the instrumental magnitudes into the standard system was done with the computing package of Arellano-Ferro & Parrao (1988) and Parrao (2000). The first two nights were devoted to the acquisition of the δ Scuti variables H501 and H906 thus increasing the number of data points for these stars.

The standard photometric values originally utilized for the transformation were those of Blumberg & Boksenberg (1996) taken from the Astronomical Almanac but, since these standard stars are only bright stars, a large extrapolation would have to be considered in order to reduce the data for our fainter stars. Hence, because the limitation of the short time span left for the observation of both the cluster stars, twenty each night, as well as the standards stars, it turned out that the few standard stars measured were insufficient to adequately transform the instrumental magnitude of the cluster stars into the absolute photometry of the Strömgren $uvby-\beta$ system. To solve this problem, some stars in the direction of the α Per cluster observed by Mitchell (1960, V magnitude), by Crawford & Barnes (1974, $b-y$ index) and by us were considered as secondary standards. The reduction used on the whole set of standards (primary and secondary) was canonical and has been described elsewhere (see for example, Peña & Peniche 1994). The list of the primary stars considered is short: BS1089, BS1140, BS1144, BS1201, BS1292, and BS1331 and the secondary stars are indicated in Table 6 by an asterisk; emphasis should be made on the fact that the range coverage of the whole set of standard star is $(5.0, 9.2)$ in V, $(-0.02, 0.6)$ in $b-y$; $(0.1, 0.41)$ in m_1; $(0.44, 0.91)$ in c_1 and $(2.5, 2.9)$ in Hβ.

Table 2 presents the transformation coefficients obtained as defined by Crawford & Barnes (1970). D, F, H, and L are the slope coefficients for $b-y$, m_1, c_1, and Hβ respectively; B, J, and I are the color term coefficients of V, m_1 and c_1 of the transformation equations. An estimate of the accuracy was done comparing the $uvby-\beta$ data with that

TABLE 2

OBTAINED COEFFICIENTS IN THE REDUCTION TO THE STANDARD SYSTEM

Coefficient	B	D	F	J	H	I
Value	0.0901	0.9629	0.9314	−0.0382	1.0543	0.0582

of the standard stars considered. The uncertainties were evaluated in the following manner: the average differences (present data minus standard data) were evaluated and provide an error bar measurement for the transformation of the season; these differences are presented in Table 3. The Hβ reduction was done on a nightly basis and the final values are the collection of the calibrations on each night. However, as in the case of the $uvby-\beta$ data, an estimate of Hβ the accuracy was done comparing the Hβ data with that of the standard stars considered. The uncertainties were evaluated in the following manner: the average differences (present data minus standard data) were evaluated and provide an error bar measurement for the transformation of the season. The mean of the differences of all the nights considered is of 0.015 with a standard deviation of 0.006.

TABLE 3

STANDARD DEVIATIONS FOR THE INSTRUMENTAL MAGNITUDES AND COLOR INDEXES

Color	V	$b-y$	m_1	c_1
Value	0.0231	0.0164	0.0131	0.0251

The photometric values obtained at this stage will not be presented now since to reach the goal of this study it was necessary to gather as much observational material as possible. These come from the previously mentioned works of Mitchell (1960) for $V$and Crawford & Barnes (1974) for the Strömgren colors as well as those reported by Mermilliod (2000, in WEBDA, a site devoted for open clusters). The final compilation, with the measured and the photometric values available from the literature will be presented later in this paper.

2.2. *Comparison with Previous Photometric Data*

To test the goodness of our photometric results we compared the photometric values we obtained (1998) with those from papers that have included both UBV and Strömgren absolute photometry. These sources are: Heckmann et al. (1956), Mitchell (1960) for $V$and Crawford & Barnes (1974) for the Strömgren colors. The comparison of the photometric values in V, and $B-V$ was done considering Heckmann et al. (1956). Except for two stars for which large discrepancies were found (H601 and H1164), the agreement was good, with a correlation coefficient of $R = 0.9845$ and 0.9997 respectively for the color index and V magnitude, respectively. A linear fit for the V magnitudes was obtained:

$$V_{\rm SPM} = 0.00279 + 1.00063 V_{\rm Heckmann}$$

for a sample of 45 stars in the intersection of the sets.

The intersection of the data sets with Strömgren photometry (of Crawford & Barnes 1974) plus the V photometry from Mitchell (1960) and the present paper) constituted 45 entries. The comparisons gave a correct matching both in V and for the color indexes. A linear fit in the sense: our value(SPM) $= A + Bx$ value (literature) was done in each case; the coefficients and the correlation coefficients are presented in Table 4. The fit for the data in β was obtained excluding 2 of 38 stars (H557 and H675) whereas H601 was not considered in the color indexes because it does not follow the trend. Analogous behavior was found for that star in the V values of Mitchell (1960). One wonders if this is a misidentification or if it is a variable star. The only other discrepancy in the V values is that of star H1164, where no explanation has been be found.

Since the photometric values for the stars in the direction of α Per are homogeneous in the standard $uvby-\beta$ system, we compiled a final list of all the stars in the direction of α Per with Strömgren data. So the final $uvby-\beta$ photometry on which the analysis will be carried out consists of the previously combined data sets of Mitchell (M, 1960) for V, Crawford & Barnes (C&B, 1974) for the Strömgren colors, and also of those derived from the present study. It should be mentioned that the total number of entries is 168, 87 of which come from C&B and 125 from the present paper. There are 43 in the intersection of both sets. We will also include the values compiled in WEBDA.

Finally, this combined data set was compared to the photometry compiled by Mermilliod (2000) in

TABLE 4

COMPARISON OF THE $uvby-\beta$ PHOTOMETRY WITH THE VALUES FROM THE LITERATURE

Linear Fit	V	$b-y$	m_1	c_1	β
A(M, C&B)	−0.0379	−0.0016	0.0576	0.0172	0.0965
B(M, C&B)	1.0055	0.9703	0.9797	0.9647	0.9604
R(M, C&B)	0.9999	0.9907	0.8577	0.9856	0.9511
Std dev	0.0165	0.0154	0.0342	0.0365	0.0244
N	45	43	43	43	38

TABLE 5

$uvby-\beta$ PHOTOMETRY: COMPARISON WITH THE VALUES FROM WEBDA

Linear Fit	V	$b-y$	m_1	c_1	β
A	0.0176	−0.0073	0.0335	0.0060	0.0054
B	0.9973	0.9676	0.8800	0.9665	0.9904
R	0.9996	0.9913	0.9326	0.9832	0.9722
Std dev	0.0391	0.0186	0.0197	0.0386	0.0239
N	48	49	49	49	45

WEBDA in the sense our value(SPM)= $A+Bx$ value (literature). The compilation of Mermilliod (2000) in WEBDA's $uvby-\beta$ photometry for α Per is a set of 110 entries. When added to the present paper data, it yields a total of 178 measured stars in the direction of the α Per cluster. The linear fits of both sets in the sense our value(SPM)= $A+Bx$ value (literature) gave the coefficients presented in Table 5. Two stars were eliminated from the fit: H167 and H1164. The final list of observed stars in α Per is presented in Table 6 in which Column 1 lists the ID, the number assigned by WEBDA (Mermilliod 2000); Columns 2 to 5 the Strömgren $uvby-\beta$ photometry; Column 6 the β. The remaining seven colums deal with the reported spectroscopic types and will be described later.

3. ANALYSIS AND INTERPRETATION

An attempt to describe the nature of the stars will now be made. $uvby-\beta$ photometry has been compiled (Table 6) and from it, physical parameters such as $\log T_{\rm e}$, $\log g$ for the stars and metallicity and age for the cluster, have been extracted.

Cluster membership was established using the advantages of Strömgren photometry, with Nissen's (1988) calibration, following Crawford (for the A and F stars: 1975, 1979) and Shobbrook (for early type stars, 1984). This has been already employed in previous analyses of open clusters (Peña & Peniche 1994). The spectral type of the stars were determined from the $[m_1]$ vs. $[c_1]$ diagram and then corroborated with the spectral types assigned in the WEBDA catalogue.

Once this was done, average parameters such as reddening $E(b-y)$, and chemical composition [Fe/H] were determined. Once the reddening is known, it is possible to calculate the unreddened colors $(b-y)_0$, m_0, and c_0. Then, the location of each star is shown in the $(b-y)_0$ vs. c_0 diagrams such as those of Lester, Gray, & Kurucz (1986); from these diagrams, the surface temperatures, $\log T_{\rm e}$, and gravities, $\log g$, can be derived for each star.

From the evaluated distance of the stars, a mean distance and a standard deviation were calculated; the criterion for membership was established to within one sigma of the mean. The membership of the stars was compared with the membership probability given by Heckmann et al. (1956), or that given by Smart & Ali (1940, from proper motion studies) and also with the more recent membership derived from Hipparcos.

The age of the cluster was derived once the physical characteristics such as $\log T_{\rm e}$ and $\log g$ were established for each star. The location of the hottest

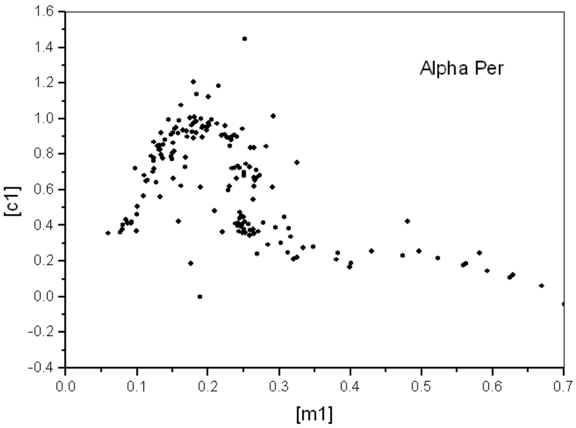

Fig. 1. Location of the compiled stars in the unreddened $[m_1] - [c_1]$ diagram.

stars in the evolutionary track of Meynet et al. (1993) for Alpha Per (their Fig. 17) gives a m-M= 6.36, $E(B-V) = 0.09$, and log age = 7.72.

4. RESULTS

From the abovementioned photometry we will try to derive membership and physical characteristics of the stars.

4.1. *The Cluster*

As already mentioned, in order to apply the calibrations of Nissen (1988) for the A and F stars and those of Shobbrook (1984) for early-type stars, the spectral class of each star was first found from the position of the star in the $[m_1]$ vs. $[c_1]$ diagram (Figure 1).

This was checked by comparing it with the several spectral classifications provided in WEBDA which are listed in Table 6. Since WEBDA lists the sources and since the classification is compiled from three main sources that include the majority of the classified stars, we have kept the same reference numbers: 272 (Morgan, Hiltner, & Garrison 1971, with 111 classified stars); 572 (Abt 1978 with 46 classified stars); and 891 (Petrie & Heard 1970 with 56 classified stars). The remaining classifications, from several other sources are not specified because they merely report one or two stars each. Finally, the last column of Table 6 lists the broad spectral classification derived from the $[m_1]$ vs. $[c_1]$ diagram which separates the stars in four broad classes: early type stars (defined as B) which includes O, B, and early A type stars, medium type stars (defined as A) including only late A and early F type stars, late type stars (defined as F) for which metallicity can be determined and finally, very late type stars (defined as G) for which no reddening and distance determination from the photometry can be done. The correlation among the several spectral classifications is remarkable since each early type star found through our photometry corresponds to a B spectrum. We obtained the same result for the A,F types and, even more outstanding, also for the B, A, or F stars that we did not consider to be MS stars; they were assigned luminosity classes I or II. The stars of later spectral classes given by our photometry were, in fact, classified as G or later from the spectroscopic sources in WEBDA. The spectroscopic compilation of WEBDA contains some stars with discordant classifications; this is unimportant for our study since we are merely interested in a broad classification. Nevertheless, they might be variables because the difference in their classification is larger than normal in spectroscopic classification errors. These inhomogeneous cases are presented in Table 7.

The methods used to determine reddening from Strömgren photometry also yield the unreddened color indexes as well as the M_v value and, from this, the distance to each star. These values are presented in Table 8. Mean values of $E(b-y)$, distance modulus, (DM) distance (in pc) and [Fe/H] for the stars in the DM interval of $[6.15, 6.65]$ are, respectively: 0.073±0.038, 6.405±0.245, 192±22 and 0.002±0.235. We preferred to recalculate this last figure, due to larger discrepancies for some stars which might bias the mean value: we made the histogram of the metallicities and adjusted a Gaussian fit. The result is [Fe/H]= 0.011 with a standard deviation of 0.126. This [Fe/H] value, although numerically equal to the mean reported before, has a narrower spread and is therefore, more precise.

The distances were utilized to construct histograms that show where the majority of the stars lie. These histograms are presented in Figure 2. A Gaussian fit to the DM gives the following distance modulus: DM= 6.45 ± 0.46 mag.

It is interesting to note that for the cluster Strömgren photometry allows us to separate early, intermediate and late type stars, and in our present study all the three groups lie at the same distance. This fact, the obtainment of the same distance for early and late type stars, confirms the validity of the calibrations beyond any doubt. The histograms for the B and AF stars are presented in Figure 3. Their mean values, given the standard deviations, can be considered to be the same for the A and F stars. The difference can be explained by measurements of the larger spread for the B type stars.

TABLE 6

COMPILED STRÖMGREN $uvby-\beta$ PHOTOMETRY AND SPECTROSCOPY OF THE STARS IN THE DIRECTION OF α PER

No.	V	$b-y$	m_1	c_1	Hβ	phtm	Spectral MK	Classif.		
12	10.090	0.350	0.012	0.787	2.716	F	F6 V			
44	4.025	0.389	0.192	0.415	2.614	F	G0 V	G0 V	G4 V	
50	8.050	0.308	0.165	0.441	· · ·	F				
61	8.530	0.228	0.125	0.980	2.812	B				
93	11.090	0.469	0.175	0.314	2.609	F				
104	8.630	0.241	0.151	0.646	2.712	F	F2 Vn	F0 V	A5 V	
135	9.710	0.328	0.143	0.472	2.683	F	F5 V			
138	6.337	0.872	0.567	0.255	2.538		K2 V	K5 III		
143	10.470	0.475	0.143	0.481	2.638	F	F8 IV-V			
145	6.900	0.046	0.083	0.730	2.771	F				
151	8.970	0.213	0.166	0.763	2.765	F	F0 Vn	A9 V	F0 V	
167*	8.462	0.076	0.141	0.951	2.861	B	A0 Va	A0 Vsp:	A1 V	B9.5V
172	8.140	0.480	0.229	0.340	2.558	F				
175*	5.917	0.590	0.393	0.365	2.576		G9 III	K0 III	G8 III	
176	7.382	0.558	0.345	0.327	2.531					
199	7.690	1.069	0.605	0.188	2.552					
208	7.719	0.117	0.114	0.887	2.682	B				
212*	7.153	0.050	0.113	0.858	2.784	B	B9 V			
215	9.071	0.171	0.123	0.958	2.739	B				
220*	9.161	0.208	0.187	0.787	2.762	F	A9 IV	A7 V		
225	8.965	0.379	0.204	0.830	2.695	F	F4 III			
226	7.860	0.272	0.157	0.494	· · ·	F				
228	9.950	0.313	0.140	0.727	2.759	F	F0 V			
235	7.947	0.045	0.117	0.832	2.751	B				
241	8.252	0.209	0.148	1.225	2.754					
247	7.887	0.264	0.105	0.668	2.567		B5 Ve			
248	8.215	0.195	0.138	1.162	2.855					
261	8.859	0.112	0.114	0.830	2.725	F				
268	9.213	0.352	0.108	0.435	2.605	F				
270	10.110	0.342	0.143	0.426	2.660	F	F7 V			
273	8.322	0.712	0.401	0.265	2.533					
283	8.465	0.997	0.563	0.284	2.539					
285*	8.096	0.151	0.145	0.987	2.845	B	A0p	Am	A1 V	
291	8.978	0.187	0.108	0.766	2.639	F				
295	6.445	0.086	0.152	0.907	2.811	B				
308	5.055	0.718	0.363	0.287	2.593		G6 Ib-Ia	G5 II	G9 III	
309	9.960	0.336	0.141	0.426	2.656	F	F5 V			
311	8.160	0.354	0.156	0.312	· · ·	F				
312	7.833	0.720	0.394	0.252	2.543		G9 II			
314	9.250	0.274	0.163	0.754	2.736	F	F2 V			
320	8.713	0.347	0.078	0.068	2.512					
328	8.739	0.782	0.419	0.217	2.516					
331	8.698	0.132	0.120	0.649	2.695					
333*	7.185	0.057	0.105	0.773	2.775	B				
337	9.672	0.587	0.293	0.541	2.586					
341	7.522	0.066	0.115	0.792	2.709	B				
350	11.060	0.453	0.167	0.338	2.610	F				
354	9.532	0.241	0.099	0.235	2.584					
361	9.680	0.292	0.158	0.478	2.686	F	F4 V			
365	9.900	0.345	0.133	0.435	2.657	F	F6 V			
367	8.888	0.246	0.191	0.720	2.708	F				
376	7.928	0.563	0.294	0.342	2.544					
377	9.234	0.649	0.289	0.386	2.530					
378	8.270	0.242	0.189	0.703	2.717	F				
379	8.038	0.111	0.165	0.998	2.886	B				
383	5.120	0.002	0.076	0.361	2.681	B	B4 IV	B3 IV	B3 V	
386*	7.930	0.067	0.160	1.022	2.869	B	A1 Van	A2 V	A1 V	A1 V
401	5.020	−0.006	0.082	0.402	2.673	B	B5 IV	B5 Vn	B5 V	
421*	9.245	0.298	0.169	0.604	2.695	F	F2 V	F3 V		

TABLE 6 (CONTINUED)

							Spectral	Classif.			
No.	V	$b-y$	m_1	c_1	Hβ	phtm	MK				
423*	7.644	0.063	0.125	1.008	2.854	F	A0 Vn	A1 Vn	A0 V	A0 V	
441	7.054	0.030	0.143	0.821	2.816	B	B9 V				
472	7.805	0.076	0.150	1.018	2.799	B					
481	9.180	0.249	0.157	0.772	2.763	F	F1 IVn	A7 V			
490	9.590	0.294	0.151	0.533	2.696	F	F3 IV-V				
497	6.024	0.278	0.189	0.471	2.647	F	F6 V				
501	9.075	0.181	0.201	0.764	2.747	F	F0 IV	F0 V			
520	11.680	0.500	0.239	0.267	2.578	F					
522	0.000	0.192	0.172	0.936	2.868	B	A7 Vn	A4 V			
553	7.820	0.348	0.173	0.361	···	F					
557*	5.307	−0.011	0.096	0.418	2.746	B	B4 V	B5 V	B5 V		
575	7.850	0.075	0.131	0.965	2.886	B	A0 Va	A0 V	A1 V	A1 V	
581*	6.988	0.012	0.130	0.799	2.812	B	B9 V	B9 Va+	B8.5 V	B9 V	B9 V
588	10.010	0.379	0.138	0.450	2.664	F	F5 V				
595	10.360	0.350	0.125	0.978	2.790	B	F1 IVn				
601	9.638	0.114	0.091	0.665	2.687	B					
605	1.800	0.302	0.195	1.074	2.677		F5 Ib	F5 Ib	F5 Ib		
606	8.980	0.207	0.178	0.765	2.775	F	A8 V	Am	F0 V		
609	9.220	0.284	0.151	0.789	2.755	F	F1 Vn				
612	7.870	0.058	0.161	0.987	2.911	B	A1 Va	A1 V	A2 V	A2 V	
621	9.860	0.327	0.137	0.463	2.672	F	F4 V				
622	11.620	0.500	0.241	0.288	2.664	F					
623	8.501	0.521	0.263	0.358	2.522	F					
625*	7.648	0.094	0.128	0.937	2.866	B	B9.5 V	B9 Va	B9.5 V n	A0 V	A1 V
629	8.426	0.098	0.117	0.928	2.788	B					
632	9.720	0.312	0.157	0.469	2.674	F	F4 V				
635	9.050	0.215	0.182	0.721	2.758	F	F0 V	A8 V			
639	8.150	0.062	0.185	1.007	2.896	B	A3 Vn	A2 Vn	A1 V		
651	8.420	0.108	0.178	0.993	2.862	B	A5 Vn	A3 Vn	A2 V		
658	9.250	0.253	0.184	0.888	2.850		A8 V	A5 V			
665	8.953	0.171	0.176	0.881	2.821	B	A7 V				
672	7.320	0.343	0.149	0.413	2.621	F					
675*	6.062	−0.032	0.110	0.457	2.681	B	B5 IV	B7 V	B7 V	B7 Vsn	B6 V
682	7.097	0.278	0.163	1.503	2.753		A3 II				
692*	7.499	0.016	0.146	0.923	2.859	B	B9.5IVn	B9.5 V	A0 V	A0 V	
694*	8.515	0.092	0.203	0.911	2.891	B	A5 V	Am	A3 V		
704	8.340	0.308	0.152	0.441	···	F					
705	8.172	0.120	0.152	1.023	2.881	B					
715	9.730	0.321	0.140	0.477	2.663	F	F4 V				
721	9.660	0.333	0.158	0.686	2.730	F	F2 Vn				
729*	7.733	0.085	0.127	0.959	2.863	B	B9 V				
733	9.940	0.344	0.137	0.463	2.666	F	F6 V				
735*	6.832	0.007	0.119	0.791	2.765	B	B8.5 Vn	B8.5 Vn	B9 V		
747	6.907	−0.019	0.138	0.847	2.892	B	B9 V				
749	8.394	0.856	0.427	0.129	2.548						
755	8.598	0.196	0.106	0.821	2.693	F					
756*	7.953	0.050	0.183	0.964	2.902	B	A1.5 V	A1 V			
772	4.989	−0.015	0.097	0.409	2.585	B					
774	4.970	−0.028	0.096	0.407	2.705	B	B4 V	B5 V	B5 V	B3 V	
775*	7.262	0.060	0.105	0.792	2.798	B	A0 V	B8 V	B8.5 V		
780*	8.095	0.091	0.164	0.991	2.891	B	A1 Vn	A1 V			
798	7.601	0.313	0.191	0.679	2.692	F					
799	9.660	0.312	0.139	0.472	2.673	F	F4 V				
802	8.410	0.088	0.196	0.976	2.893	B	A2 V	A5 Vn	A2 V		
810	5.578	0.001	0.100	0.506	2.685	B	B6 Vn	B7 Vn	B5 Vn	B6 V	
816	8.111	0.813	0.519	0.147	2.546		K0 II-III				
817*	7.464	0.059	0.158	0.973	2.832	B	A1 V	A1 Vn	A1 Vn	A0.5 IVn	
823	7.618	0.316	0.170	0.429	2.615	F					
829	8.051	0.974	0.430	−0.062	2.574						
831*	7.362	0.006	0.139	0.809	2.833	B	B9 V	B9 V	A0 V		
833	10.030	0.338	0.157	0.423	2.660	F					
835*	4.657	−0.019	0.088	0.402	2.712	B	B5 V	B3 V	B3 V	B3 IV	
836	9.165	0.367	0.190	0.520	2.637	F					

TABLE 6 (CONTINUED)

No.	V	$b-y$	m_1	c_1	Hβ	phtm	Spectral MK	Classif.			
856	8.950	0.380	0.259	0.285	2.510	F					
861*	6.219	0.117	0.096	0.585	2.700	B	B6 V	B7 V	B7 Vne	B6 Ve	B5 V
868*	7.284	0.049	0.156	0.908	2.858	B	A1 IV-V	A1 IVn	A1 V	A2 V	A0 V
875*	7.674	0.077	0.135	1.004	2.857	B	A0 Vn	A0 Vn	A0 V		
876	9.527	0.351	0.201	0.455	2.643	F					
878	8.139	0.145	0.180	0.923	2.816	B					
885	8.790	0.156	0.210	0.867	2.856	F	Am	A7 V	A7 IV		
890	8.777	0.247	0.189	0.760	2.755	F					
896	8.290	0.095	0.128	0.440	2.655						
900	4.350	0.801	0.563	0.170	2.541		K3 III	K1 III			
903	7.053	0.107	0.115	0.792	2.714	B					
904*	5.819	−0.006	0.113	0.680	2.748	B	B7 V	B8 Vnn	B8 V	B8 III-Ivn	B8 Vn
906*	8.784	0.156	0.183	0.911	2.855	F	A3 V	A6 Vn	A3 V		
910	9.420	0.284	0.118	0.538	2.765						
911	7.366	0.106	0.215	0.963	2.877	B	Am				
917	11.000	0.452	0.176	0.302	2.606	F					
921*	8.636	0.103	0.191	0.933	2.875	B	A2.5 V	A6 Vn	A2 V		
928	7.676	0.913	0.579	0.061	2.532		G8 I				
931	8.769	0.140	0.196	0.926	2.890	B	A6 V	A3 V	A2 V		
934	6.282	0.041	0.149	1.083	2.847	B	A0 Vp	A0 Vn	A0 V	B9 V	
937	8.310	0.366	0.231	0.353	2.527	F					
944	9.620	0.290	0.157	0.506	2.687	F	F3 V				
954	6.407	0.099	0.093	0.889	2.702	B	B9 III	B9 III	B7 V	B8 III	
955*	6.773	0.005	0.122	0.702	2.742	B	B8.5 V	B8 Ve	B8.5 V	B9 V	B8 Ve
956	8.106	0.044	0.137	0.671	2.729	B					
958*	9.209	0.238	0.189	0.716	2.733	F	F1 V	A7 V			
965*	6.622	0.007	0.113	0.656	2.750	B	B8 V	B8 V	B8 V		
970*	8.205	0.086	0.203	0.909	2.881	B	A5 V	A4 V			
976	8.664	0.086	0.156	0.936	2.829	B					
985*	5.469	−0.039	0.112	0.360	2.691	B	B5 Vp	B7 IIIp	B8 IIIp	B8 III	B9 III
1005	9.610	0.301	0.151	0.515	2.688	F	F3 V				
1047	6.590	0.210	0.163	0.663	2.679	F					
1050	9.480	0.250	0.202	0.893	2.834	F	A M	A5p			
1056	8.216	0.085	0.165	0.964	2.870	B					
1082*	7.337	0.037	0.125	0.861	2.827	B	B9 V	B9 Va	B9 V	A0 V	
1090	9.265	0.138	0.148	0.922	2.834	B	A0 V				
1127	9.596	0.359	0.219	0.345	2.581	F					
1153	6.877	0.013	0.109	0.654	2.763	B	B8 IV: sn	B8 V			
1164*	5.526	−0.004	0.061	0.356	2.482	B	B5 Ve	B5 IIIe +shell	B5 Ve + shell	B5 IIIe	
1193	8.466	0.659	0.348	0.309	2.542						
1209	9.266	0.086	0.142	0.947	2.854						
1210	7.740	1.122	0.638	0.206	2.551						
1218*	9.173	0.260	0.190	0.732	2.734	F	F3 IV	F3 V			
1225	8.880	0.328	0.160	0.420	2.651	F	F7 IV-V	F6 IV	F5 V		
1235	7.183	0.022	0.102	0.570	2.716	B					
1245	6.838	0.066	0.113	0.933	2.826	B					
1259*	7.449	0.016	0.135	0.886	2.850	B	A0 Vp	A0 V			
1260	8.625	0.142	0.174	0.932	2.826	B					
1262	9.082	0.642	0.357	0.315	2.737						
1314	8.105	0.162	0.128	1.239	2.812						
1334	9.147	0.172	0.129	1.172	2.816						
1343	8.200	0.394	0.176	0.381	2.594	F					

4.2. *Membership*

Distance and distance modulus are presented in the histograms (Fig. 2) and a Gaussian distribution was evaluated. Stars with distances within one sigma of the mean were considered members. In relation to the reddening $E(b-y)$ and metallicity [Fe/H], a mean value for the member stars only was determined from a Gaussian distribution. These mean values are $E(b-y) = 0.073 \pm 0.038$ mag and the mean metallicity [Fe/H] is 0.002 ± 0.235.

Since there are other studies devoted to the membership of the stars, a comparison of the results was desirable. As has been stated in the introduction, the works dealing with membership identification are

TABLE 7

INHOMOGENEOUS SPECTRAL CLASSIFICATIONS FOR THE α PER STARS REPORTED IN WEBDA

ID	272	572	891	Other
104	F2 Vn	F0 V	A5 V	
308	···	···	···	G6 Ib-IIa, G9 III
481	F1 IVn	···	A7 V	
651	A5 Vn	A3 Vn	A2 V	
906	A3 V	A6Vn	A3V	
921	A2.5 V	A6 V	A2 V	
931	A6 V	A3 V	A2 V	
1164		B5 Ve + shell	···	B5 IIIe + shell

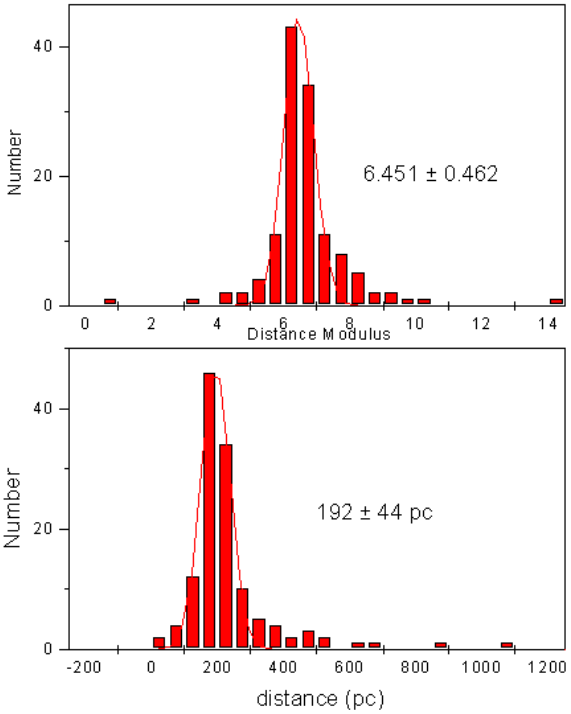

Fig. 2. Distance (lower) and distance modulus (upper) histograms for the stars in the direction of α Per. The mean value and standard deviation are presented.

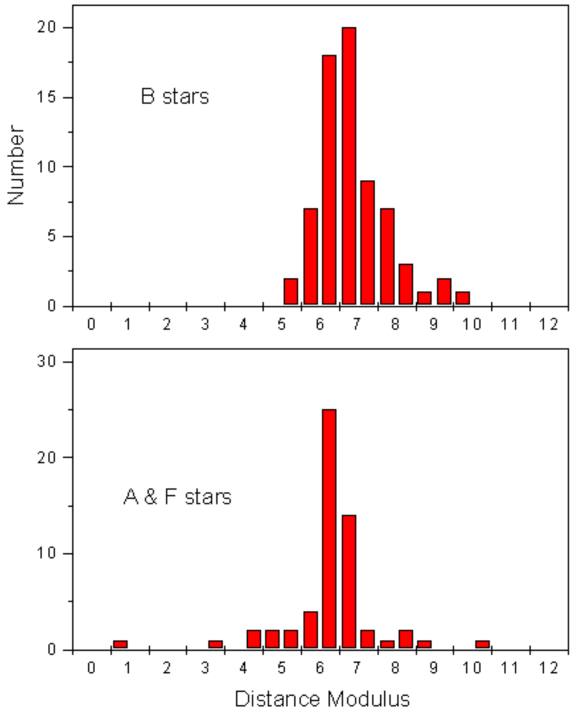

Fig. 3. Distance modulii for each spectral class considered.

those of Prosser (1992), Heckmann et al. (1956), Roman & Morgan (1950), and Smart (1940), yielding a total of 300 cluster member stars. Finally, the results from Hipparcos were taken into consideration. These membership probabilities are listed in the last columns of Table 8.

Comparing with the work of Heckmann et al. (1956), the agreement is remarkable. Sixty stars coincide in membership. However, some of the declared members by HDK were found to be non-members by our analysis. Given the previous numbers, we can draw the following conclusions: out of 75 stars in the membership interval, 53 are assumed to be members by HDK and there is disagreement on three.

A more recent study of the membership of the stars in the direction of α Per is that of Prosser

TABLE 8

REDDENING, UNREDDENED COLORS AND MEMBERSHIP TO THE CLUSTER OF THE OBSERVED STARS

ID	$E(b-y)$	$(b-y)_0$	m_0	c_0	β	V_0	M_v	DM	DST	[Fe/H]	Member WEBDA	Member HDK	Member Prosser	ID HIP	V	Parallax	dst HIP	Member HIP	PP
44	0.028	0.361	0.200	0.409	2.614	3.90	3.07	0.84	15	0.116	N	...	...	14632	4.05	94.93	11	N	N
497	0.000	0.313	0.189	0.471	2.647	6.02	2.83	3.20	44	0.23	N	...	...	15669	5.94	21.86	46	N	N
665	0.012	0.331	0.153	0.411	2.621	7.27	3.21	4.05	65	−0.317	...	...	...	...	...	...	...	...	N
1047	0.000	0.174	0.045	0.756	2.771	7.45	2.77	4.68	86	...	...	...	M	...	...	...	...	...	N
295	0.000	0.345	0.170	0.429	2.615	7.62	2.89	4.73	88	−0.178	...	...	...	...	...	...	...	...	N
958	0.020	0.374	0.182	0.377	2.594	8.11	3.24	4.87	94	−0.229	...	...	...	...	...	...	...	...	N
890	0.052	−0.071	0.104	0.392	2.712	4.43	−0.80	5.23	111	...	...	M	M	16244	4.67	5.84	171	M	N
401	0.025	0.303	0.168	0.415	2.651	8.77	3.52	5.25	112	0.003	...	M	N	...	...	...	...	...	N
911	0.000	0.256	0.163	0.663	2.679	6.59	1.28	5.31	116	0.027	...	...	...	16570	6.60	10.64	94	N	N
383	0.058	−0.069	0.114	0.407	2.746	5.06	−0.33	5.39	119	...	...	RS	M	15770	5.32	5.22	192	M	N
441	0.029	0.012	0.158	1.077	2.847	6.16	0.64	5.52	127	...	N	...	...	...	...	...	...	...	M:
868	0.117	−0.031	0.187	0.885	2.811	5.94	0.38	5.56	130	...	N	...	...	15193	6.46	7.9	127	N	M:
775	0.169	0.331	0.292	0.254	2.664	10.89	5.30	5.59	131	1.593	...	M	M	...	...	...	...	...	M:
692	0.016	−0.035	0.143	0.844	2.892	6.84	1.24	5.60	132	...	...	...	...	16118	6.93	5.83	172	M	M:
810	0.042	−0.070	0.109	0.399	2.705	4.79	−0.90	5.69	137	...	...	M	M	16211	7.47	5.86	171	M	M
774	0.130	−0.024	0.254	0.938	2.877	6.80	1.08	5.73	140	...	N			16394	7.37	6.74	148	N	M
835	0.063	0.250	0.210	0.666	2.692	7.33	1.52	5.81	145	0.653	...	...	...	16196	7.61	5.75	174	M	M
747	0.064	0.092	0.229	0.854	2.856	8.51	2.66	5.85	148	...	...	M	M	...	...	...	...	...	M
798	0.094	−0.028	0.141	0.915	2.826	6.44	0.54	5.90	151	...	...	...	...	16986	6.87	2.32	431	N	M
378	0.067	0.261	0.163	0.459	2.683	9.42	3.47	5.95	155	0.023	...	M	M	...	...	...	...	...	M
861	0.039	−0.045	0.125	0.673	2.748	5.65	−0.33	5.98	157	...	...	M	M	16340	5.80	3.75	267	N	M
985	0.079	−0.030	0.180	0.893	2.858	6.94	0.91	6.03	161	...	...	M	M	16277	7.28	6.1	164	M	M
675	0.033	0.259	0.168	0.471	2.686	9.54	3.47	6.06	163	0.085	...	M	M	...	...	...	...	...	M
212	0.077	0.375	0.199	0.287	2.606	10.67	4.59	6.08	164	0.035	N	M	M	...	...	...	...	...	M
970	0.079	−0.077	0.100	0.346	2.681	4.78	−1.33	6.11	166	...	...	M	M	15404	5.16	6.18	162	M	M
875	0.020	0.221	0.157	0.642	2.712	8.54	2.44	6.10	166	−0.14	...	...	M	...	...	...	...	...	M
557	0.025	0.217	0.196	0.698	2.717	8.16	2.03	6.13	169	0.425	...	...	...	15410	8.28	5.72	175	M	M
423	0.122	−0.028	0.165	0.914	2.866	7.12	0.98	6.14	169	...	...	M	M	...	...	...	...	...	M
379	0.077	−0.019	0.184	0.972	2.911	7.54	1.37	6.17	171	...	...	M	M	...	...	...	...	...	M
215	0.045	0.293	0.171	0.414	2.660	9.84	3.64	6.19	173	0.078	...	M	M	...	...	...	...	...	M
1056	0.042	0.270	0.152	0.464	2.673	9.48	3.29	6.19	173	−0.125	...	M	...	...	...	...	...	...	M
1260	0.056	0.289	0.150	0.424	2.657	9.66	3.45	6.21	175	−0.186	...	M	M	...	...	...	...	...	M
965	0.039	0.273	0.169	0.461	2.674	9.55	3.34	6.22	175	0.094	...	M	M	...	...	...	...	...	M
421	0.094	0.285	0.166	0.431	2.664	9.61	3.39	6.22	175	0.037	...	M	M	...	...	...	...	...	M
1153	0.050	0.244	0.166	0.523	2.696	9.38	3.15	6.22	176	0.04	...	M	M	...	...	...	...	...	M
955	0.066	−0.072	0.102	0.390	2.673	4.74	−1.49	6.23	176	...	...	M	M	15444	5.05	6.78	147	N	M
1259	0.096	0.373	0.204	0.295	2.609	10.68	4.45	6.23	176	0.107	...	M	M	...	...	...	...	...	M
333	0.044	0.292	0.154	0.417	2.656	9.77	3.54	6.23	176	−0.137	...	M	M	...	...	...	...	...	M
1235	0.068	0.088	0.203	0.897	2.855	8.49	2.26	6.24	177	...	...	M	M	...	...	...	...	...	M
904	0.063	0.184	0.208	0.747	2.755	8.51	2.27	6.24	177	...	...	...	...	16224	6.29	6.97	143	N	M
1082	0.055	0.272	0.154	0.452	2.672	9.62	3.37	6.25	178	−0.101	...	M	M	...	...	...	...	...	M
341	0.029	0.186	0.191	0.715	2.758	8.92	2.66	6.26	179			M	M						M

TABLE 8 (CONTINUED)

ID	$E(b-y)$	$(b-y)_0$	m_0	c_0	β	V_0	M_v	DM	DST	[Fe/H]	Member WEBDA	Member HDK	Member Prosser	ID HIP	V	Parallax	dst HIP	Member HIP	PP
1245	0.067	−0.037	0.163	0.808	2.816	6.76	0.49	6.27	179	…	…	…	M	15531	7.07	6.11	164	M	M
954	0.098	−0.023	0.160	0.946	2.886	7.43	1.16	6.27	179	…	…	M	M	…	…	…	…	…	M
1218	0.053	0.289	0.159	0.415	2.660	9.88	3.61	6.27	180	−0.064	…	M	M	…	…	…	…	…	M
672	0.034	0.256	0.167	0.499	2.687	9.47	3.20	6.28	180	0.073	…	M	M	…	…	…	…	…	M
145	0.047	0.254	0.165	0.506	2.688	9.41	3.12	6.28	181	0.043	…	…	M	…	…	…	…	…	M
823	0.039	0.168	0.190	0.757	2.775	8.81	2.52	6.29	181	…	…	M	M	…	…	…	…	…	M
343	0.050	−0.038	0.145	0.789	2.812	6.77	0.46	6.31	183	…	…	M	M	…	…	…	…	…	M
225	0.110	−0.025	0.160	0.938	2.863	7.26	0.94	6.33	184	…	…	M	M	…	…	…	…	…	M
934	0.129	−0.018	0.204	0.973	2.886	7.48	1.15	6.34	185	…	…	…	…	15388	8.04	5.05	198	M	M
622	0.073	−0.023	0.205	0.950	2.902	7.64	1.30	6.34	185	…	…	M	M	…	…	…	…	…	M
885	0.000	0.079	0.120	1.011	2.854	7.71	1.37	6.34	185	…	…	M	M	15505	7.66	5.2	192	M	M
135	0.065	0.279	0.156	0.450	2.666	9.66	3.27	6.39	190	−0.078	…	M	M	…	…	…	…	…	M
361	0.044	−0.028	0.159	0.915	2.859	7.31	0.91	6.40	191	…	…	M	M	16011	7.50	6.01	166	M	M
917	0.048	−0.032	0.149	0.877	2.850	7.24	0.83	6.41	191	…	…	…	M	16966	7.45	4.45	225	M	M
104	0.037	0.176	0.177	0.756	2.765	8.81	2.39	6.42	192	…	…	M	M	…	…	…	…	…	M
625	0.071	−0.034	0.146	0.847	2.827	7.03	0.60	6.43	193	…	…	M	M	16649	7.35	3.59	279	N	M
612	0.110	−0.019	0.197	0.970	2.891	7.62	1.19	6.43	193	…	…	M	M	…	…	…	…	…	M
799	0.093	−0.016	0.163	0.986	2.857	7.28	0.84	6.44	194	…	…	M	M	16275	7.67	5.3	189	M	M
833	0.025	0.326	0.209	0.450	2.643	9.42	2.98	6.44	194	0.428	…	…	…	…	…	…	…	…	M
365	0.037	−0.076	0.123	0.353	2.691	5.31	−1.15	6.46	195	…	…	M	M	16470	5.47	5.57	180	M	M
490	0.044	−0.038	0.152	0.801	2.833	7.17	0.69	6.49	198	…	…	M	M	…	…	…	…	…	M
588	0.025	0.327	0.116	0.430	2.605	9.10	2.62	6.49	198	−0.763	…	…	…	…	…	…	…	.	M
632	0.040	0.281	0.152	0.469	2.663	9.56	3.05	6.51	200	−0.14	…	M	M	…	…	…	…	…	M
93	0.133	−0.013	0.192	0.998	2.881	7.60	1.08	6.52	201	…	…	…	…	…	…	…	…	…	M
309	0.099	−0.039	0.135	0.773	2.798	6.83	0.30	6.54	203	…	N	M	M	16137	7.27	6.07	165	M	M
906	0.171	−0.054	0.147	0.553	2.700	5.48	−1.06	6.55	204	…	N	…	N	16252	6.21	5.66	177	M	M
621	0.080	−0.021	0.182	0.958	2.832	7.12	0.58	6.54	204	…	…	M	M	…	…	…	…	…	M
635	0.117	−0.031	0.238	0.887	2.881	7.70	1.13	6.57	206	…	…	M	M	16452	8.20	5.34	187	M	M
270	0.087	0.366	0.193	0.321	2.610	10.69	4.11	6.57	206	0.014	N	M	M	…	…	…	…	…	M
575	0.076	−0.014	0.208	0.992	2.896	7.82	1.23	6.59	208	…	…	M	M	…	…	…	…	…	M
944	0.073	0.176	0.179	0.757	2.763	8.87	2.28	6.59	208	…	…	…	M	…	…	…	…	…	M
1005	0.173	−0.022	0.197	0.954	2.845	7.35	0.73	6.62	211	…	…	M	M	…	…	…	…	…	M
606	0.053	0.245	0.185	0.593	2.695	9.02	2.40	6.62	211	0.305	N	RS	M	15499	9.24	4.74	211	M	M
581	0.061	−0.060	0.118	0.494	2.685	5.32	−1.32	6.63	212	…	…	RS	M	16210	5.58	5.89	170	M	M
729	0.123	0.210	0.195	0.661	2.730	9.13	2.49	6.64	213	…	N	M	M	…	…	…	…	…	M
756	0.078	−0.011	0.183	1.007	2.869	7.60	0.95	6.64	213	…	…	M	M	…	…	…	…	…	M
733	0.054	−0.047	0.129	0.646	2.750	6.39	−0.28	6.67	216	…	…	M	M	16540	6.60	4.9	204	M	M
151	0.143	0.107	0.245	0.864	2.834	8.86	2.19	6.67	216	…	…	M	M	…	…	…	…	…	M
780	0.060	−0.047	0.127	0.643	2.763	6.62	−0.09	6.71	220	…	…	R	M	16782	6.89	4.56	219	M	M
876	0.005	0.193	0.226	0.729	2.747	9.14	2.43	6.72	220	…	…	M	M	…	…	…	…	…	M
268	0.110	−0.022	0.229	0.955	2.893	7.94	1.22	6.72	221	…	…	…	M	…	…	…	…	…	M
831	0.085	−0.035	0.138	0.842	2.784	6.79	0.05	6.73	222	…	…	M	M	15040	7.16	5.383	186	M	M
715	0.109	−0.024	0.198	0.943	2.870	7.75	1.00	6.74	223	…	…	…	…	16574	8.21	5.01	200	M	M
705	0.057	0.203	0.207	0.721	2.734	8.93	2.17	6.76	224		N	M	M	16885	9.18	1.26	794	N	M

TABLE 8 (CONTINUED)

ID	$E(b-y)$	$(b-y)_0$	m_0	c_0	β	V_0	M_v	DM	DST	[Fe/H]	Member WEBDA	Member HDK	Member Prosser	ID HIP	V	Parallax	dst HIP	Member HIP	PP
817	0.097	−0.040	0.134	0.754	2.775	6.77	0.00	6.76	225	...	...	M	M	15259	7.20	4.37	229	M	M
350	0.123	−0.031	0.240	0.888	2.891	7.99	1.22	6.76	225	...	...	M	N	...	...	...	...	...	M
481	0.103	0.181	0.182	0.768	2.755	8.78	2.01	6.77	226	...	...	M	M	...	...	...	...	...	M
639	0.129	0.184	0.179	0.701	2.759	9.40	2.62	6.77	226	...	N	M	...	...	...	...	...	...	M
285	0.033	0.205	0.199	0.709	2.733	9.07	2.29	6.78	227	...	...	M	M	16455	9.21	7.11	141	N	M
386	0.046	−0.039	0.133	0.782	2.765	6.63	−0.17	6.80	229	...	...	M	M	...	...	...	...	...	M
721	0.170	−0.030	0.247	0.894	2.890	8.04	1.21	6.82	232	...	...	M	M	...	...	...	...	...	M
1050	0.032	0.176	0.197	0.781	2.762	9.02	2.13	6.90	239	...	...	M	M	...	...	...	...	...	M
501	0.075	0.199	0.185	0.739	2.736	8.93	2.02	6.91	241	...	N	M	M	...	...	...	...	...	M
802	0.176	−0.031	0.233	0.890	2.816	7.38	0.44	6.95	245	...	...	...	...	...	...	...	...	...	M
694	0.039	0.328	0.202	0.512	2.637	9.00	2.04	6.96	247	0.308	...	...	...	...	...	...	...	...	M
228	0.127	−0.019	0.216	0.969	2.862	7.87	0.91	6.97	247	...	...	M	M	...	...	...	...	...	M
609	0.132	−0.029	0.230	0.908	2.875	8.07	1.07	7.00	251	...	...	M	M	...	...	...	...	...	M
735	0.049	−0.044	0.137	0.693	2.742	6.56	−0.44	7.01	252	...	...	M	M	16430	6.77	4.55	220	M	M
931	0.254	−0.026	0.201	0.932	2.812	7.44	0.35	7.09	262	...	...	...	...	...	...	...	...	...	M
220	0.101	−0.025	0.171	0.932	2.861	8.03	0.92	7.11	264	...	...	M	M	...	...	...	...	...	M
314	0.222	−0.030	0.239	0.894	2.868	8.17	1.01	7.17	271		N	M	M		...	...	...	...	M
878	0.019	0.227	0.197	0.716	2.708	8.81	1.63	7.17	272	0.458	...	...	...	...	...	...	...	...	M
836	0.152	0.323	0.189	0.451	2.638	9.82	2.57	7.25	282	0.169	...	M	M	...	...	...	...	...	M:
651	0.032	−0.064	0.120	0.451	2.681	5.92	−1.36	7.28	286	...	...	RS	M	15988	6.09	5.41	185	M	M:
921	0.172	−0.030	0.225	0.899	2.826	7.89	0.55	7.34	293	...	...	...	...	16995	8.64	5.01	200	M	M:
61	0.088	−0.012	0.176	1.001	2.799	7.43	0.08	7.34	294	...	...	...	...	...	...	...	...	...	M:
167	0.132	−0.033	0.133	0.864	2.702	5.84	−1.56	7.40	302	...	N	...	...	16447	6.41	1.52	658	N	M:
367	0.147	−0.040	0.159	0.764	2.714	6.42	−1.07	7.50	316	...	N	...	...	...	...	...	...	...	M:
522	0.206	−0.035	0.238	0.842	2.821	8.07	0.53	7.53	321	...	N	M	M	15971	8.90	12.35	81	N	M:
143	0.114	−0.028	0.190	0.914	2.829	8.17	0.58	7.60	331	...	...	...	...	...	...	...	...	...	M:
472	0.076	−0.054	0.125	0.556	2.716	6.86	−0.77	7.62	335	...	...	...	...	16962	7.18	4.05	247	N	M:
903	0.127	−0.029	0.155	0.904	2.788	7.88	0.04	7.84	369	...	...	...	...	...	...	...	...	...	N
976	0.169	−0.031	0.199	0.890	2.834	8.54	0.65	7.89	378	...	N	...	N	...	...	...	...	...	N
629	0.040	−0.020	0.179	0.965	2.776	7.69	−0.23	7.92	384	...	...	...	...	...	...	...	...	...	N
1090	0.082	−0.037	0.142	0.816	2.751	7.60	−0.44	8.03	404	...	...	...	...	...	...	...	...	...	N
601pp	0.000	0.199	0.088	0.847	2.725	9.23	1.08	8.15	427	...	...	...	...	...	...	...	...	...	N
235	0.152	0.198	0.057	0.757	2.716	9.44	1.23	8.21	438	−1.655	...	M	M	...	...	...	...	...	N
261	0.105	−0.039	0.147	0.772	2.709	7.07	−1.20	8.27	450	...	...	...	...	15322	7.53	2.72	368	N	N
12	0.134	0.245	0.244	0.803	2.695	8.39	0.08	8.31	459	1.132	N	M	N	...	...	...	...	...	N
225	0.090	−0.046	0.164	0.654	2.729	7.72	−0.63	8.34	466	...	...	...	...	...	...	...	...	...	N
956	0.000	0.221	0.106	0.821	2.693	8.60	0.09	8.51	504	−0.784	...	...	...	...	...	...	...	...	N
755	0.379	−0.029	0.239	0.906	2.790	8.73	0.07	8.66	540	...	N	M	M	...	...	...	...	...	N
595	0.198	−0.027	0.182	0.920	2.739	8.22	−0.83	9.05	646	...	...	...	...	15044	9.08	5.05	198	M	N
208	0.151	−0.034	0.159	0.858	2.682	7.07	−2.12	9.19	688	...	...	...	...	...	...	...	...	...	N
772	0.055	−0.070	0.114	0.398	2.585	4.75	−5.01	9.76	895	...	...	...	...	...	...	...	...	...	N
291	−0.080	0.267	0.084	0.782	2.639	9.32	−1.14	10.46	1235	−0.99	...	...	...	...	...	...	...	...	N
601	0.291	−0.083	0.102	0.301	2.597	10.16	−3.84	...	...	...	N	M	N	...	...	...	...	...	N

(1992). His results have been presented in Table 8. A few comments on the results: as for Heckmann et al. (1956) as well as for those derived from the $uvby - \beta$ photometry, the matching is more than adequate. Out of 75 stars which we have defined as member stars, only three are non-members according to Prosser (1992), although two were established as members by Heckmann et al. (1956). There is strong disagreement with the photometric magnitude for H601 between WEBDA and the photometry in the present paper. In view of this, its values have not been averaged and we have kept both values. The photometry we obtained, listed as H601pp, shows that H601 is an A star and not a member of the cluster.

With the reported list of non-member stars in WEBDA (pointed out as N in the corresponding column of Table 8) we did not get good correlation. Since we do not know the criteria used by WEBDA, very little can be said. Furthermore, most of those stars which we do find to be members and that WEBDA reports as non-members, are also given as members either by Heckmann et al. (1956) and/or Prosser (1992).

A final comparison of membership was done with the data of Hipparcos and Tycho catalogues on proper motions. Among the sample of stars we observed, 58 have measurements in these catalogues. In Table 8 we listed both the HIP number and the parallax. Then the distance has been calculated and the membership established with the same criteria as those retained for our photometrically-determined distances. Only a few stars in the catalogues did not belong to the $uvby$ data sample. Given the data in both sets, histograms were constructed for each determined distance technique: Hipparcos and $uvby$ photometry (Figure 4). The results of a Gaussian fit to the histograms of the distance gave: a mean parallax of 5.63 mas with a standard deviation of 1.4 mas from the Hipparcos catalogue, and a mean of 195 pc with a standard deviation of 35 pc from the $uvby$ photometric data. Assuming membership for those stars within the one sigma criterion, the coincidences are remarkable: only three (H215, H557, and H835) of the stars that we suppose to be non-members could be members according to the Hipparcos results. For the stars that we consider to be members, only seven are not assigned cluster membership according to the Hipparcos measurements. Of these seven stars, all but two have been considered to be members by HDK and Prosser (1992).

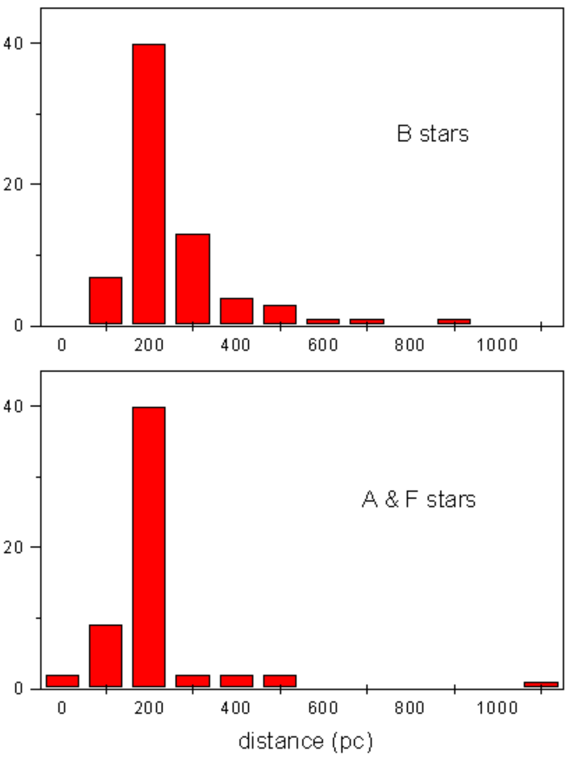

Fig. 4. Calculated distance of α Per by HIP parallaxes and $uvby - \beta$ photometry.

On the other hand, 33 stars that Hipparcos measurements assign membership are also clearly members according to our analysis.

With respect to the age of the cluster, first the stars were plotted in the theoretical photometric indices on the Strömgren and β systems for the published and unpublished grids of Kurucz, (Lester et al. 1986) in order to determine their temperatures and surface gravities. Then, we followed the prescription for determining age of Meynet et al. (1993) who developed a new set of isochrones for solar metallicity computed from models taking into account mass loss and moderate overshooting and with recent opacity tables. For the temperatures of the hottest member stars around 17,000 K, we applied the numerical relation from Meynet et al. (1993): $\log(\mathrm{age}) = -3.611 \log T_{\mathrm{eff}} + 22.956$ for the blue turn off. This relation is adequate for a temperature range in the interval $\log T_{\mathrm{eff}}$ (3.98, 4.25). For the temperature of the BTO determined of $\log T_{\mathrm{e}} = 4.23$, it thus gives us $\log(\mathrm{age}) = 7.680$ which is close to the value they reported specifically for α Per of $\log \mathrm{age} = 7.72$. The difference may be due to the assumed temperature

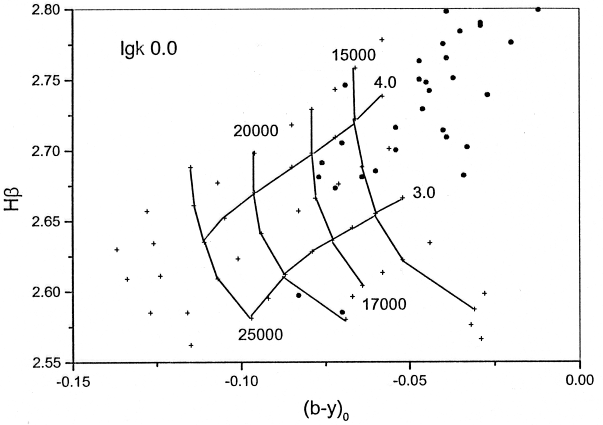

Fig. 5. Location of the unreddened stars (filled circles) in the theoretical grids of Lester et al. (1986).

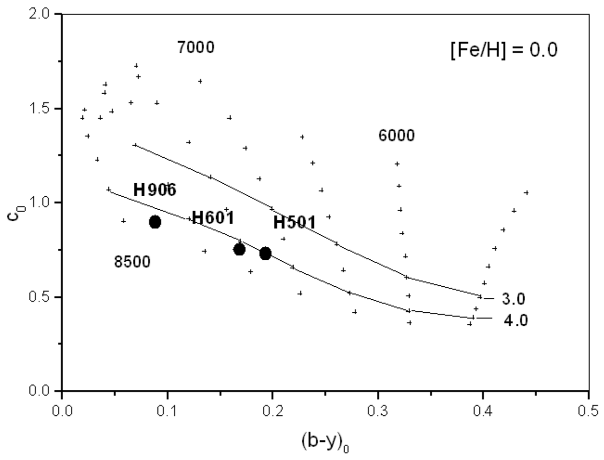

Fig. 6. Location of the Delta Scuti stars on the grids of LGK.

of the hottest stars. To match his age determinations, a temperature of 16,500 K would be needed, which is close, but not identical to that which is derived from the grids. The small difference in age is due to the temperature determination, which might be more accurate through our Strömgren photometry. Also, one should keep in mind that the study of Meynet et al. (1993) does not consider the membership of the stars to the cluster.

4.3. *The Delta Scuti Stars*

Given the above mentioned physical characteristics of the cluster, it is quite interesting to determine the physical characteristics of the Delta Scuti stars, H501, H606, and H906, found by Slovak (1978) in the direction of α Per, provided they do belong to the cluster. They may be considered member stars if the distance modulus criterion assumed previously is fulfilled.

Their temperatures were measured from the LGK grids shown in Figure 6, along with the positions of the stars. Recall (Table 6) that there was a difference in the reported spectroscopic classification of H906. The temperature we determine here corresponds more precisely to the earlier A3V type rather than to the later A6Vn given by WEBDA's reference 272.

We determined the pulsation mode from the well-known relation (Petersen & Jorgensen 1972; Breger et al. 1990) in which we introduced the main period for each of these stars as reported in the literature (López de Coca et al. 1990; Kim & Lee 1998 for V465 Per):

$$\log Q = -6.454 + \log P + 0.5 \log g + 0.1 M_{\rm bol} + \log T_{\rm e} \quad (1)$$

From the unreddened indexes and derived distances, Table 8, plus the compiled period in the literature, we obtain the physical quantities listed in Table 9. It is interesting to note that H906 is at the hot edge of the instability strip, and probably pulsating in the 3^{rd} overtone, whereas H501 is at the other extreme, at the cool edge and also pulsating in the 3^{rd} overtone.

The results derived in the present paper are still in agreement with Breger's (1980) basic conclusion: *"it is interesting to speculate that the preference for the second and third overtone may be connected with the position of the star in the hot part of the instability strip, where theoretical models have predicted pulsation in overtones (Stellingwerf, 1979)"*. The numerical values obtained are also in agreement with those previously determined. The position of both stars lies adequately on the PLC relation of Breger (1979).

5. CONCLUSIONS

The most important contribution of this paper is that a compilation of absolute $uvby-\beta$ photometry provides an opportunity to derive the membership of each star to the cluster, as well as to describe the physical characteristics of the stars. Since the

TABLE 9

PHYSICAL PARAMETERS OF THE DELTA SCUTI STARS CONSIDERED

ID	P[a] (d)	$\log g$	M_v	BC	$M_{\rm bol}$	$T_{\rm e}$	$\log T_{\rm e}$	Q
H501	0.0373	4.0	2.12	−0.238	1.88	7250	3.860	0.015
H906	0.0322	4.2	2.26	−0.185	2.08	8250	3.917	0.019

[a] López de Coca et al. (1990)

α Per cluster may be considered to be a test probe, the technique we have extensively used, although questioned at times, has proven adequate. Consequently, membership can be established in the same fashion through Strömgren $uvby-\beta$ photometry for other open clusters. With respect to the variable stars, it was found that they do belong to the cluster and hence, it means that their metallicity is known. M_v, $\log T_{\rm e}$, and $\log g$ are also determined for each star but, unfortunately, as is common for most short period variables, inaccurate periodic content is the rule. It is unnecessary at this stage to encourage well-coordinated campaigns for each variable star before definite frequencies sets are assigned in order to correctly describe their pulsational nature.

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