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uvby-β PHOTOELECTRIC PHOTOMETRY OF THE OPEN CLUSTER NGC 7062

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RESUMEN

Se presenta fotometría fotoeléctrica *uvby*-β del cúmulo abierto NGC 7062. Se ha determinado la membresía de varias estrellas y los resultados concuerdan con estudios previos de movimientos propios efectuados por Jones y van Altena (1970). La determinación de su enrojecimiento y del módulo de distancia dan valores de $E(b-y) = 0.319 \pm 0.064$ y DM = 12.18 ± 1.14, respectivamente.

ABSTRACT

uvby-β photoelectric photometry of the open cluster NGC 7062 has been carried out. Determination of membership of several stars has been established, in agreement with previous determinations through the proper motion study carried out by Jones and van Altena (1970). Determination of the reddening and distance modulus give values of $E(b-y) = 0.319 \pm 0.064$ and DM = 12.18 ± 1.14, respectively

Key words: **CLUSTERS-OPEN – PHOTOMETRY**

I. INTRODUCTION

There are many advantages to studying open usters. In principle at least, chemical composi-on and age can be considered to be the same for ll stars in the cluster. Once it has been established ıat a group of stars belongs to a cluster, the study of ıeir member stars provides a wealth of information bout the initial stages of stellar formation as well as f stellar evolution and pulsation. When age and ıemical composition have been determined, these ata, along with gravity and effective temperature, llow the unequivocal determination of the physics 'hich explains the pulsation mechanisms and evo-ıtion since the differences between one star and nother within the same cluster are due to the origi-al mass from which the stars were formed and the ifferences from cluster to cluster are due to their ıdividual chemical compositions.

With these ideas in mind, a research pro-ram was established at Observatorio Astronómico Iacional at SPM to carry out a systematic and ho-ıogeneous study of open clusters in the *uvby*-β pho-ɔmetric system that would assign membership of a :ar to a cluster, as well as accurately determine values of effective temperature, surface gravity (or absolute magnitude), and metal abundance for each star.

Simultaneously with the observations of stars in the direction of the selected clusters, a continuous monitoring of a few stars within the instability strip limits was carried out in order to detect possible short period pulsators.

In the present paper the photometric data of NGC 7062 is presented. This cluster has been relatively well studied. An excellent review of the previous photometric research has been summarized by Hassan (1973), but it has not been extensively studied in the Strömgren system. Proper motion studies have been carried out by Jones and van Altena (1970), hereinafter (JvA). With the photometric data acquired in the present study, and at times supported by the photometric values given by Hoag *et al.* (1961) and Hassan (1973), new values of interstellar extinction and distance modulus have been obtained. A direct comparison with evolutionary tracks has been made.

II. DATA ACQUISITION

a) *Observations*

All the photometric data were obtained at the Observatorio Astronómico Nacional, México with the 1.5 m-telescope fitted with an *uvby*-β spectro-

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photometer that allows simultaneous observation in two sets of filters: *uvby* and narrow and wide Hβ. A brief description of this equipment can be found in Schuster and Nissen (1988).

The photometric data reported here were obtained from a single observing run. Table 1 presents the dates and objects observed. Most program stars were observed only once with an integration time of 40 s followed by a 10 s integration of the sky. The standard stars, brighter in general, were observed with an integration time of 30 s.

TABLE 1

LOG OF PHOTOELECTRIC OBSERVATIONS OF NGC 7062

Night	No. of Stars Observed	Comments
Sept. 2, 86	25	absolute photometry
Sept. 3, 86	67	absolute photometry
Sept. 4, 86	7	search for variability

The observed stars in the open cluster NGC 7062 reported in the present study follow the notation given by two identification sources. Previous studies by Jones and van Altena (1970) and the compilation by Hoag *et al.* (1961) give different identifiers for the same star. Since more stars than those identified by the latter two sources were observed, they have been specified in Table 3. In this table, column 1 defines the identification followed in the present paper whereas columns two and three follow the notation of Hoag *et al.* (1961) and JvA, respectively, for the same star. Columns four and five provide the coordinates x and y for each star corresponding to the ID chart of Hoag *et al.* (1961). The remaining columns list the photometric values obtained.

In order to be able to transform into a *uvby*-β absolute system, a set of photometric standards were observed along with the program stars. One difficulty arose with the primary standard stars normally utilized to define the absolute sys tem (Crawford and Barnes 1970): their relativel high brightness made them unobservable with th telescopic-photometric system utilized, due both t the high sensitivity of the tubes and the relativel large size of the telescope. Consequently, as i Nissen (1988), secondary standard stars fainter tha magnitude 7.0 were taken from a list by Schuste (1987) which was, in its turn, adapted from the ca talog of Olsen (1983). Slightly brighter standard were also taken from the latter source in such way that larger interval ranges both in magnitud and color were covered. The standard stars wer of luminosity classes V and III and of populations and II. It should be emphasized that the photome tric system defined by these standard stars (Schuste and Nissen 1988) is essentially the same as the *uvb* β system of Crawford and Mander (1966).

b) *Reductions*

The reduction procedure utilized was implemen ed at the IA-UNAM by Arellano and Parrao (1988 with a PC package from a computer program devel oped by Andersen (1987). This reduction proce dure was employed to transform the instrumenta system to the absolute system of Olsen (1983).

In order to decide on the quality and th accuracy of the obtained photometric data th values derived for the observed standards wer compared with those of Olsen (1983).

In doing so, the standard stars considered gav the slope and the color term coefficients of th transformation to the absolute system defined b Olsen (1983) (Table 2). A direct compariso between the derived values of these standard sta and the values reported by Olsen (1983) has bee made and is presented in Figure 1. The dispersio has been evaluated numerically by means of th standard deviation which is also reported in Tabl 2.

Therefore, in the present analysis it can b assumed that the photometric values reported her have an accuracy of $\delta(v, b-y, m_1, c_1, H\beta)$ of (0.009

TABLE 2a

TRANSFORMATION COEFFICIENTS FOR THE SEPTEMBER 1986 SEASON AT THE SAN PEDRO MARTIR OBSERVATORY

	B	D	F	J	H	I	L
SPM	−0.011	0.942	1.111	−0.116	0.916	0.139	1.298

a. The coefficients are defined by the equations given in Crawford and Barnes (1970) and in Crawford and Mander (1968). D, F, H, and L are the slope coefficient for $b-y$, m_1, c_1 and β respectively; B, J, and I the color term coefficients of V, m_1 and c_1.

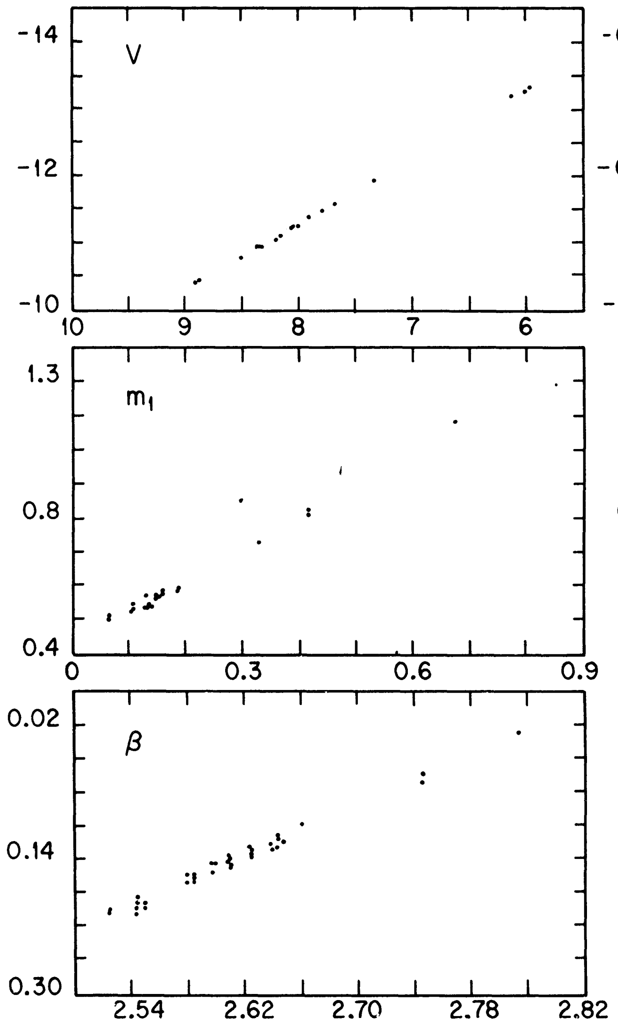


Fig. 1. Comparison between the derived values of the standard stars (Y axis) and values reported by Olsen (1983). (X axis).

0.0089, 0.0091, 0.0104, 0.0071) which, although relatively coarse, will allow the determination of the bulk characterization of the physical parameters of the stars of the open cluster NGC 7062, their reddening and, ultimately, their membership in the cluster.

TABLE 2b

COMPARISON OF THE STANDARDS'*uvby*-β DATA WITH THOSE OF OLSEN (1983)[a]

	V	$b-y$	m_1	c_1	β
σ	9	8	8	11	7
N	19	28	14	18	56

a. σ is the standard deviation and N is the number of overlapping points. Units are 0.001 mag.

A direct comparison between the photometric values found in the present paper and that of Hoag *et al.* (1961) has been made. The agreement is remarkable and is presented in Figure 2.

III. ANALYSIS

The final photometric results obtained utilizing the coefficients of the transformations previously listed are presented in Table 3.

As a part of an extensive study to determine which physical factors cause a minority of stars to vary while others with equal temperature and luminosity remain constant (Peniche and Peña 1987), a search for new short period variable stars in open clusters was also undertaken since pulsating variables provide important information about the physical properties of stars and can be used to test theories of stellar structure and evolution.

The open cluster NGC 7062 was chosen because, according to the photoelectric photometric values reported by Hoag *et al.* (1961), it possesses a large number of stars with $B-V$ values that place them within the instability strip limits.

The photoelectric values determined in the present study (and presented in Table 3) were utilized to obtain accurate values of the reddening of the cluster as well as the distance modulus.

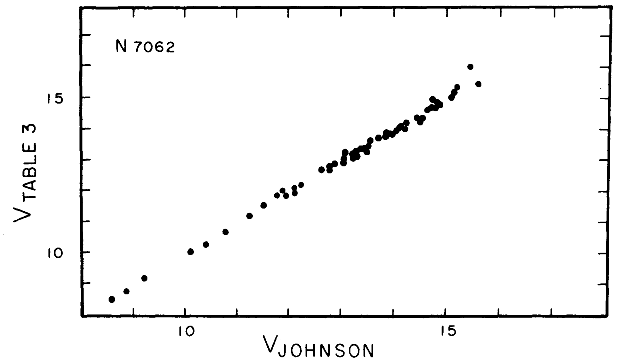


Fig. 2. Comparison between photometric values in the V magnitude found in the present paper (Y axis) and those of Hoag *et al.* (1961), (X axis).

The reduction procedure followed has been utilized by Nissen (1988) in a recent study of *uvby*-β photometry of open clusters. Summarizing his method, it consists of the following: two main groups are defined according to the unreddened β values:

$$\text{A type stars if } 2.72 < \beta < 2.88 \quad ,$$
$$\text{F type stars if } 2.59 \leq \beta \leq 2.72 \quad .$$

For the first group, the intrinsic color index $(b-y)_0$ is calculated by the expression $(b-y)_0 = 2.946 - 1.00\beta - 0.1\ \delta c_0$, with δc_0 the customary $\delta c_0 = c_1 - c_1\mathrm{std}(\beta)$. The standard relations between M_v, c_1, m_1 and β have been taken from Crawford (1975, 1979).

Individual values of color excess and absolute

TABLE 3

PHOTOELECTRIC PHOTOMETRY OF NGC 7062

ID	Hoag	JvA	X	Y	*V*	*b*–*y*	m_1	c_1	β
1			2.25	-13.00	15.548	0.410	0.165	1.009	3.045
2		192	2.87	-4.64	13.296	0.395	-.018	1.206	2.973
3	22		-5.54	0.05	14.991	0.254	0.170	1.008	2.968
4		212	5.92	1.68	13.904	0.337	0.160	0.949	2.963
5		193	3.02	-3.97	13.359	0.354	0.065	1.028	2.943
6		231	10.11	-7.34	13.174	0.506	-.002	1.204	2.924
7		113	-7.88	-12.08	13.109	0.403	-.002	0.995	2.920
8		183	1.77	1.88	13.755	0.324	0.147	1.001	2.914
9			-4.27	1.95	15.113	0.783	-.205	0.550	2.914
10		139	-2.67	-7.31	13.899	0.343	0.101	1.067	2.914
11		205	4.57	-8.09	13.809	0.444	0.023	1.075	2.902
12			1.95	-2.22	14.419	0.382	0.113	1.034	2.898
13	17	176	1.20	-2.24	13.174	0.367	0.052	1.132	2.894
14		198	3.37	-1.57	13.378	0.383	0.035	1.088	2.876
15		190	2.55	-4.14	12.873	0.387	0.042	1.186	2.872
16		187	2.52	-5.29	13.401	0.459	-.049	1.213	2.866
17	16	168	0.00	0.00	13.026	0.340	0.067	1.111	2.862
18		228	8.50	-14.19	12.527	0.510	-.021	1.025	2.857
19			-4.75	-1.47	14.883	0.459	0.019	1.095	2.857
20	5	141	-2.02	-3.89	10.085	0.107	0.263	0.829	2.851
21		211	5.77	-2.17	12.765	0.398	0.046	1.156	2.842
22	4	95	-12.49	3.67	9.236	0.155	0.127	0.949	2.827
23		165	-0.40	-4.14	13.227	0.328	0.024	0.925	2.825
24			-2.62	-10.68	15.403	0.321	0.247	1.032	2.820
25			-1.70	-5.80	14.282	0.385	0.138	1.018	2.819
26		186	2.42	-1.30	14.044	0.398	0.024	1.227	2.815
27		128	-5.12	1.70	14.371	0.462	-.058	1.104	2.811
28		135	-3.18	9.93	12.666	0.320	0.061	1.110	2.809
29		206	4.27	-0.15	14.411	0.470	0.033	1.019	2.807
30			3.97	-6.34	14.814	0.428	0.090	1.061	2.801
31		172	0.55	-3.89	14.255	0.573	0.032	0.371	2.798
32		163	-0.75	1.75	14.449	0.447	0.055	1.115	2.796
33		173	0.70	0.15	13.975	0.382	-.055	1.217	2.781
34			-8.48	-11.10	13.742	0.593	-.057	0.846	2.771
35		179	1.60	-1.72	14.117	0.478	-.040	1.078	2.770

TABLE 3 (CONTINUED)

ID	Hoag	JvA	X	Y	V	$b-y$	m_1	c_1	β
36		232	10.71	-9.21	13.902	0.609	-.017	0.974	2.759
37		224	7.88	17.50	13.345	0.345	0.173	0.797	2.736
38		210	5.62	-4.07	13.220	0.986	0.137	0.651	2.731
39		161	-0.70	-12.28	14.078	0.511	0.334	0.429	2.728
40			-5.64	-7.14	14.709	0.493	-.154	0.957	2.716
41	8	262	19.35	5.40	10.779	0.455	-.025	0.803	2.711
42	20	207	4.87	2.30	14.161	0.510	0.062	0.449	2.705
43		263	19.28	13.10	12.196	0.530	-.028	0.920	2.703
44		199	2.22	-3.27	13.903	0.491	0.102	0.868	2.702
45			3.64	-2.29	13.101	0.960	0.170	0.448	2.696
46			2.42	4.02	13.921	0.444	0.141	0.646	2.691
47			2.62	0.00	15.480	0.629	-.173	1.129	2.690
48		248	14.65	-2.20	10.492	0.289	0.192	0.483	2.683
49		177	1.37	-4.12	13.015	0.904	0.270	0.374	2.67
50		149	-1.62	1.70	14.113	0.699	-.093	0.588	2.661
51		208	5.28	-7.66	13.702	0.560	0.062	0.516	2.655
52		158	-3.00	-2.60	12.441	0.438	0.083	0.525	2.654
53	2	107	-9.64	10.54	8.570	0.298	0.124	0.430	2.632
54			-8.85	-11.70	14.802	0.681	0.303	0.284	2.631
55			5.79	-0.60	16.044	0.139	0.518	0.596	2.629
56	11	202	3.79	12.31	11.957	0.378	0.193	0.362	2.627
57		185	2.35	-0.37	12.017	0.466	0.201	0.420	2.626
58		133	-3.35	-6.99	12.734	0.951	0.179	0.542	2.613
59		144	-7.52	-5.62	12.230	0.412	0.241	0.363	2.609
60		137	-3.05	-8.11	12.081	1.149	0.521	0.597	2.609
61		116	-7.28	-13.50	13.775	0.483	0.046	0.339	2.607
62		145	-1.90	6.30	14.339	0.491	0.126	0.635	2.600
63		120	-6.42	-16.60	10.888	0.279	-.021	0.365	2.600
64	10	253	16.63	-5.02	11.574	0.338	0.176	0.374	2.587
65	3	252	16.50	17.66	8.854	0.559	0.375	0.318	2.583
66	9	188	2.52	-6.61	11.246	0.856	0.315	0.402	2.579
67	12	142	-1.77	-11.23	12.080	0.904	0.159	0.494	2.578
68		164	-0.70	10.68	12.260	1.043	0.496	0.265	2.572
69		222	7.49	15.00	13.817	0.533	0.154	0.422	2.572
70	6	218	6.57	-4.57	10.346	0.434	0.241	0.286	2.570
71			1.35	4.50	14.755	0.571	0.095	0.515	2.558
72	15	127	-5.05	-2.34	12.888	0.927	0.240	0.560	2.537
73			-4.07	-1.12	15.247	0.807	-.178	0.753	2.535
74			-3.55	-8.79	15.431	0.256	0.179	0.794	2.535
75		195	3.10	10.80	12.346	0.894	0.479	0.206	2.527
76		200	4.02	-5.19	11.924	0.619	0.469	0.211	2.503
77	21		5.84	-12.01	14.639	0.882	0.040	0.511	2.501
78		146	-1.70	10.88	13.414	0.942	0.399	0.282	2.443
79	19	197	3.37	4.77	13.640	0.899	0.487	0.314	2.338
80	18		-10.64	16.93	13.525	0.414	-0.008	0.620	

magnitude are given by the relations $E(b-y) = (b-y) - (b-y)_0$ and $M_v = M_v\mathrm{std}(\beta) - f\,\delta\, c_0$ with an assumed value of f = 9 for A type stars. The distance modulus DM requires the unreddened value of V_0, given by $V_0 = V - 4.3\, E(b-y)$ and finally $DM = V_0 - M_v$ for each star.

In the reduction procedure of the F type group two differences with the previous reduction method are considered. The first one is the determination of the intrinsic color index $(b-y)_0$ which is calculated by the expression

$$(b-y)_0 = k + 1.11\,\Delta\beta + 2.7\,\Delta\beta^2 - 0.05\,\delta c_0 - (0.1 + 3.6\,\Delta\beta)\delta\, m_0 \quad ,$$

with $k = 0.2184$, $\Delta\beta = 2.72 - \beta$ and $\delta\, m_0$, given by

$$m_0 = m_1 + 0.3\,E(b-y) \quad ,$$

$$\delta m_0 = m_{1,std}(\beta) - m_0 \quad .$$

An iterative procedure was carried out since, in the beginning $E(b-y)$ is unknown. Therefore, m_0 is taken as m_1 for an initial value and $E(b-y)$ converges after three or four iterations.

The second difference between both groups is established by the procedure in which the absolute magnitude value is determined. In this case, Nissen (1988) proposes:

$$M_v = M_v std(\beta) - f\delta\, c_0 \,, \quad \text{with } f = 9 + 50\Delta\beta \ .$$

The application of the previously defined formulae to the photometric data obtained and reported in Table 3 gave the following: From the β limits, 26 A type stars and 23 F type stars were observed and for each one reddening and distance modulus were determined and reported in Table 4. These values were then utilized to establish the membership of each star in the cluster. Figure 3 represents a histogram of the DM obtained for both A and F type stars.

If one considers the distribution in the histogram of the A type stars only, it shows a clearly discernible peak that lies in the interval of DM between 10 to 14 mag with an abrupt rise at DM equal to 12 mag. Therefore it can safely be concluded that the remaining A type stars with DM less than 10 mag or greater than 14 mag are not cluster members, but field A type stars.

On the other hand, in the histogram the distribution of the F stars shows a completely different scenario since the bulk of the F stars lies between DM 6 and 11 mag. This histogram can be interpreted in the following way: clearly the majority of the F type stars measured are not cluster members, but field stars lying between the distant cluster NGC 7062 and the Sun. Not many A type stars are shown in this interval since they evolve more rapidly than F type stars. For detection of cluster F type stars, fainter stars have been observed, but the searches in the present study reached an observed limiting magnitude around 14, not weak enough to touch the lower part of the Main Sequence. This conclusion can readily be seen if Figure 4 is analyzed as a

TABLE 4

REDDENING AND UNREDDENED VALUES FOR THE A AND F STARS MEASURED IN THE DIRECTION OF NGC 7062

ID	$E(b-y)$	$(b-y)_0$	c_0	V_0	M_V	DM	Fe/H
14	0.330	0.053	1.022	11.961	0.846	11.115	...
15	0.340	0.047	1.118	11.410	-0.068	11.478	...
16	0.410	0.049	1.131	11.638	-0.359	11.997	...
17	0.278	0.062	1.055	11.832	0.527	11.305	...
18	0.435	0.075	0.938	10.656	1.252	9.404	...
19	0.391	0.068	1.017	13.201	0.622	12.579	...
20	0.008	0.099	0.827	10.052	2.950	7.102	...
21	0.324	0.074	1.091	11.371	-0.092	11.463	...
22	0.048	0.107	0.939	9.030	1.612	7.418	...
23	0.217	0.111	0.882	12.295	1.808	10.487	...
24	0.216	0.105	0.989	14.473	0.792	13.681	...
25	0.278	0.107	0.962	13.087	0.903	12.184	...
26	0.309	0.089	1.165	12.717	-1.038	13.755	...
27	0.357	0.105	1.033	12.835	0.009	12.826	...
28	0.214	0.106	1.067	11.745	-0.075	11.820	...
29	0.353	0.117	0.948	12.891	0.714	12.177	...
30	0.311	0.117	0.999	13.477	0.246	13.231	...
31	0.384	0.189	0.294	12.602	6.411	6.191	...
32	0.331	0.116	1.049	13.024	-0.315	13.339	...
33	0.264	0.118	1.164	12.838	-1.458	14.296	...
34	0.430	0.163	0.760	11.891	1.731	10.160	...
35	0.338	0.140	1.010	12.664	-0.372	13.036	...
36	0.450	0.159	0.884	11.969	0.400	11.569	...
37	0.150	0.195	0.767	12.700	1.633	11.067	...
38	0.773	0.213	0.496	9.895	2.829	7.066	...
39	0.274	0.237	0.374	12.899	4.757	8.142	...
40	0.316	0.177	0.894	13.349	-0.331	13.680	-3.404
41	0.255	0.200	0.752	9.682	0.933	8.749	-1.691

TABLE 4 (CONTINUED)

ID	E(b − y)	(b − y)$_0$	c_0	V_0	M_V	DM	Fe/H
42	0.274	0.236	0.394	12.981	4.186	8.795	-0.295
43	0.328	0.202	0.854	10.786	-0.487	11.273	-1.347
44	0.267	0.224	0.815	12.754	-0.013	12.767	0.259
45	0.673	0.287	0.313	10.207	4.020	6.187	2.924
46	0.193	0.251	0.607	13.090	1.830	11.261	0.503
47	0.450	0.179	1.039	13.543	-3.277	16.820	-2.742
48	0.020	0.269	0.479	10.405	3.352	7.053	0.490
49	0.549	0.355	0.264	10.655	4.372	6.283	3.483
50	0.455	0.244	0.497	12.155	1.689	10.467	-1.474
51	0.275	0.285	0.461	12.521	2.420	10.101	-0.258
52	0.157	0.281	0.494	11.766	2.286	9.480	-0.431
53	-0.007	0.305	0.431	8.601	3.150	5.452	-0.592
54	0.259	0.422	0.232	13.690	5.099	8.591	2.186
55	-0.293	0.432	0.655	17.303	0.856	16.447	2.681
56	0.030	0.348	0.356	11.830	4.002	7.827	0.234
57	0.106	0.360	0.399	11.562	3.195	8.367	0.550
58	0.529	0.422	0.436	10.461	1.229	9.232	1.459
59	0.019	0.393	0.359	12.147	3.738	8.409	0.523
60	0.549	0.600	0.487	9.721	0.333	9.388	4.758
61	0.164	0.319	0.306	13.072	4.061	9.010	-0.949
62	0.142	0.349	0.607	13.727	-0.475	14.202	-0.297
63	0.015	0.264	0.362	10.822	3.575	7.247	-2.000

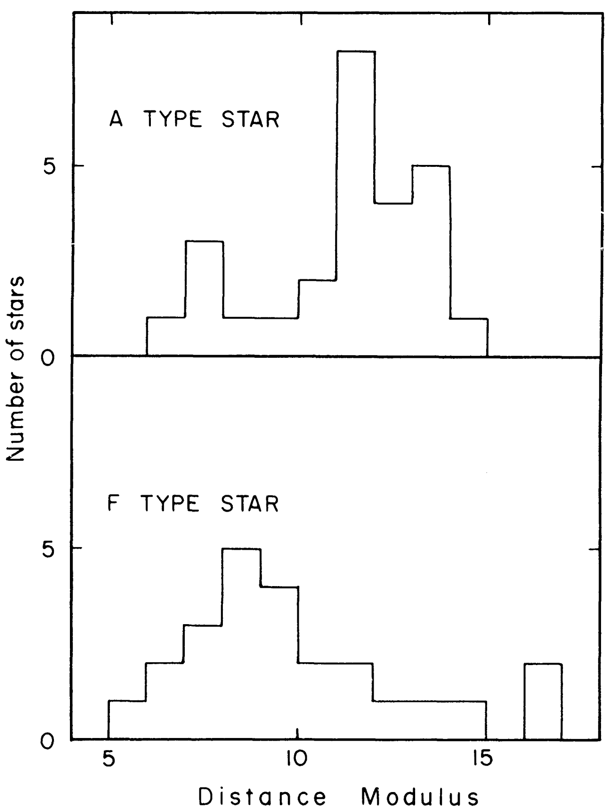


Fig. 3. Histograms of the DM obtained for both A and F type stars.

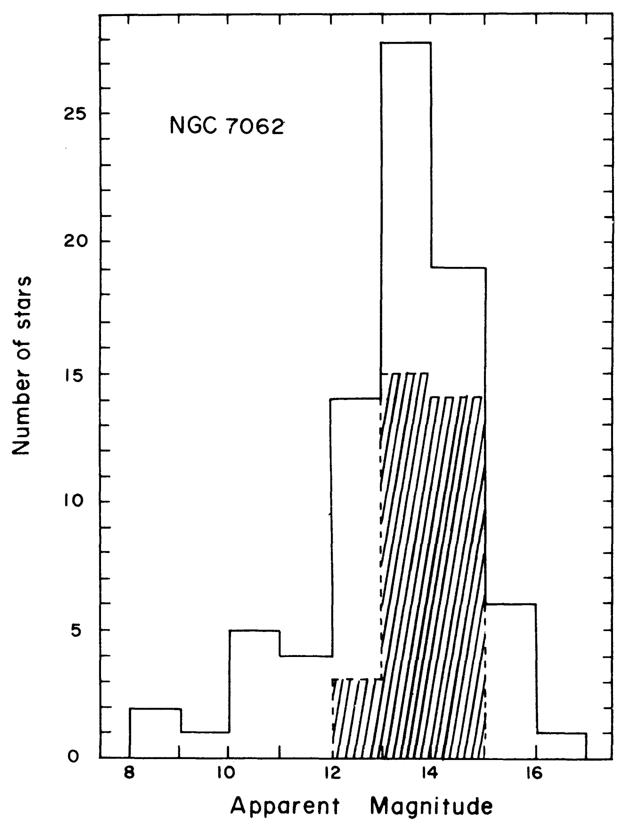


Fig. 4. Histogram of the distribution of the observed stars as a function of apparent magnitude.

histogram of the distribution of the observed stars as a function of apparent magnitude. No star brighter than magnitude 12 seems to belong to the cluster and the majority of the cluster members (in the shaded areas) appear to be within the interval of magnitude 12 and 14 mag. They represent only a minority of the observed stars in this direction.

IV. DISCUSSION

Once the distance modulus and the reddening for each star has been determined, it becomes desirable to compare the findings of this paper with those obtained by other authors who have used different photometric systems as well as different techniques to establish cluster membership. The main works that will be employed are those of Hoag *et al.* (1961) and Hassan (1973).

The criteria for membership utilized in the present paper were the following:

1) The Distance Modulus Criterion, which is based on *uvby*-β photometry. Here, membership probability is defined from the the construction of a histogram of the distance moduli. The results obtained in the present paper are presented in Table 5. Figure 3 shows the histogram for the A and F type stars. It can easily be concluded that the cluster must lie within the distance modulus limits of 10 mag and 14 mag. Only A type stars (a total of 20) were considered in this interval. A normal distribution was fitted to these observational data, resulting in a mean DM of 12.18 mag and a standard deviation of 1.14 mag (see Figure 3). A correlation coefficient for the fitting of 0.992 was obtained, which indicated that the assumed normal distribution is correct. Furthermore, the probability that a certain star lies within *ns* from the mean value (where *n* is a real number and *s* is the standard deviation) will be given by the area under the gaussianan curve. Therefore, the

TABLE 5

MEMBERSHIP DETERMINATION OF THE STARS IN THE DIRECTION OF THE OPEN CLUSTER NGC 7062

ID	Hoag	JvA	%JvA	%DM	E(b − y)	DM	ST	Comment	Class
14	...	198	52	35	0.330	11.115	A	Member	1
15	...	190	83	54	0.340	11.478	A	Member	1
16	...	187	60	87	0.410	11.997	A	Member	1
17	16	168	84	44	0.278	11.305	A	Member	1
19	...	...	...	73	0.391	12.579	A	Member	1
21	...	211	68	53	0.324	11.463	A	Member	1
25	...	...	...	99	0.278	12.184	A	Member	1
27	...	128	80	57	0.357	12.826	A	Member	1
30	...	...	...	35	0.311	13.231	A	Member	1
33	...	173	83	33	0.264	14.296	A	Member	1
43		263	...	43	0.328	11.273	F	Member	1
46	...	...	...	42	0.193	11.261	F	Member	1
28	...	135	0	76	0.214	11.820	A	Possible	2
29	...	206	0	100	0.353	12.177	A	Member	2
32	...	163	0	31	0.331	13.339	A	Possible	2
35	...	179	0	45	0.338	13.036	A	Member	2
36	...	232	0	59	0.450	11.569	A	Member	2
37	...	224	1	33	0.150	11.067	A	Possible	2
44	...	199	0	60	0.267	12.767	F	Member	2
23	...	165	86	14	0.217	10.487	A	Member	3
26	...	186	76	16	0.309	13.755	A	Member	3
38	...	210	82	0	0.773	7.066	A	Non Member	3
45	...	...	84	0	0.673	6.187	F	Non Member	3
49	...	177	86	0	0.549	6.283	F	Non Member	3
52	...	158	87	2	0.157	9.480	F	Non Member	3
2	...	192	78	..	...	...	..	Member	4
3	...	22	...	..	...	...	..	Member	4
4	...	212	27	..	...	...	..	Member	4
6	...	231	84	..	...	...	..	Member	4
8	...	183	78	..	...	...	..	Member	4
10	...	139	76	..	...	...	..	Member	4
11	...	205	60	..	...	...	..	Member	4
12	...	...	...	..	...	...	..	Member	4
13	17	176	67	..	...	...	..	Member	4
71	...	...	...	..	...	...	..	Member	5

nembership probability would be defined by the lifference between 100% and the probability given)y the standard normal distribution. Thus, for a .tar with *s*/2 the probability of membership is 68%, 'or *s*, 32%, etc.

2) Kinematics. This criterion is based on a study)f proper motions carried out by JvA (1970). In ι study to determine the membership of a large ıumber of stars in the direction of the cluster,)ased on two Yerkes 40-inch plate pairs, the relative)roper motion for 334 stars up to V = 14.5 in he vicinity of the cluster was derived. The results)btained showed that from the measurements of 146 stars up to 12' from the apparent center of the :luster, only 36 stars had high probability of being :luster members and that the cluster occupied only he central region of the plate.

The A and F type stars that, according to the wo aforementioned criteria belong to the cluster NGC 7062, are listed in Table 5 under class 1. The ID columns are those of the present paper,)f Hoag *et al.* (1961) and of JvA. Also shown ıre the probabilities of membership according to he two criteria described before. The reddening 'alues and the distance modulus of each star are ılso shown, as well as the spectral type. The next :olumn assigns the final decision made with the)reviously described criteria with respect to the :luster membership of each star. Table 5, class 1 ılso lists some stars that were not measured by JvA. In those cases membership was assigned by the first :riterion only; the last column specifies the class lefined by the criteria to which those stars belong.

The existence of a contradiction with respect o the membership of some stars, namely that)ne criterion assigns high membership probability vhereas the other gives low or non-membership, aused an alternative criterion to be employed. This hird criterion is based on the photometric system of Johnson for those stars that have been measured .nd reported by Hoag *et al.* (1961). Specifically, he principal discriminators will be the location of :ach star in the color-magnitude diagram, Figure ›a and color-color diagram, Figure 5b. In view of he fact that some observed stars do not have a V nagnitude value reported by Hoag *et al.* (1961); onsidering the excellent agreement between the esults presented in the present paper and those of Ioag *et al.* (1961) Figure 2, the V values for those ınmeasured stars were obtained in the present tudy.

In the color-magnitude diagram the unreddened ZAMS was traced using the color excess determined rom the average value for the established members. ι mean value E($b-y$) of 0.319 was obtained with .n uncertainty of 0.064. Since E($B-V$) = E($b-$)/0.7 this yields a value of E($B-V$) = 0.456±0.091. The width of the ZAMS is established by the strip

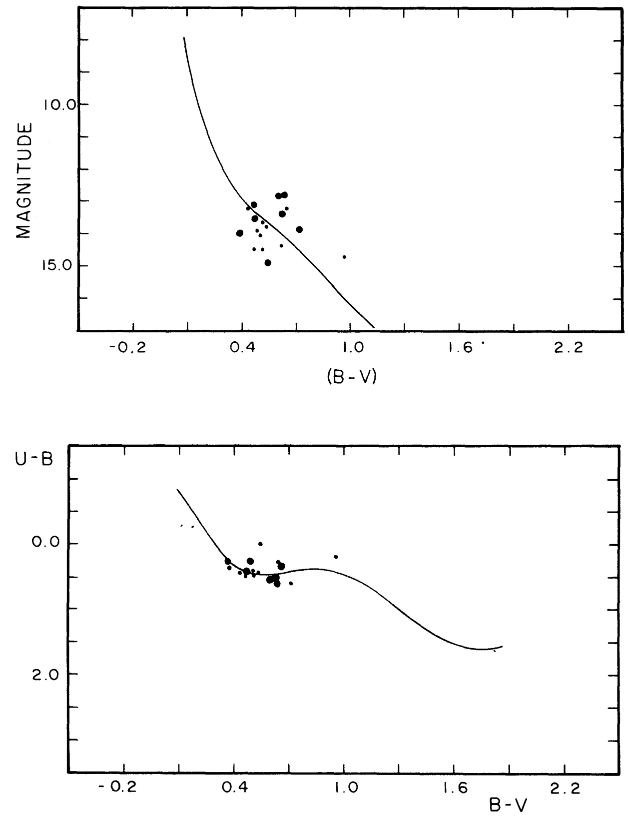


Fig. 5. Magnitude-Color and Color-Color Diagrams for the observed stars in the direction of NGC 7062. Figures 5a and 5b show the stars that according to the two criteria belong to the cluster (large dots). Small dots referred to the stars whose membership is in contradiction between the obtained data in the present paper and that of Jva (1970) or those whose membership was established merely by their location in these diagrams.

defined by those stars that unquestionably belong to the cluster (Table 5, class 1). This is shown in Figure 5a.

On the other hand, the unreddened main sequence employing the reddening values previously reported was also traced in the color-color diagram. The stars listed in Table 5, class 1 were plotted defining thus the width of the main sequence. This is shown in Figure 5b.

Table 5, class 2 lists the A and F stars that, according to JvA (1970) have zero probability of membership in cluster NGC 7062, but that have been found in the current research to have a distance modulus that fixes them to be cluster members since the probability of membership is higher. The location of these stars in the aforementioned diagrams (Figures 5a and 5b) shows that two stars, 29, 35, 36 and 44 lie within the strip that defined the main sequence. Therefore, it can safely be concluded that, despite the negative findings of JvA, they could belong to the cluster. Since no *UBV* photometric values were obtained for stars 28, 32 and 37, their membership in the cluster cannot be established.

Table 5, class 3 lists another group of stars whose membership to NGC 7062 is problematic since the probabilities given in JvA and the present paper differ. For the stars in this group JvA (1970) have assigned a high probability of membership, whereas the results obtained in the present study contradict their results given that the computed probability is less than 17% or, at times, even close to zero. From their location on the diagrams in Figures 5a and 5b, it can be established that stars 23, and 26 could be regarded as cluster members since they lie within the limits of the broad strips that define the main sequence in both cases. On the other hand, stars 38, 45 and 49 possess higher reddening values than the mean value reported for the stars in the cluster. The location of these stars in the diagrams indicates that they should be giant stars, although not necessarily cluster members. Star 52 was not measured in the *UBV* system by Hoag *et al.* (1961), so its photometric values were obtained from Hassan (1973), and its position in Johnson's diagrams indicates that this star does not belong to the cluster.

Table 5, class 4 lists the observed stars with $\beta >$ 2.87 which, because of their position in Johnson's diagrams (Figures 5a and 5b), could be regarded as main sequence stars belonging to the cluster. The entire sample is composed of thirteen stars of which only nine can be regarded as cluster members. Of the remaining five stars, two of them, 5 and 9, do not lie on the main sequence and another two, 1 and 7, were not observed in the *UBV* system by Hoag *et al.* (1961) or by Hassan (1973). Due to the apparent faintness of star 1, it is very unlikely that it is a cluster member.

The sample of stars with β < 2.59 that were observed is composed of 16 stars which are listed in Table 3. The membership of these stars, as in the previous cases, will be established via their location in Johnson's diagrams (Figures 5a and 5b) if they lie within the limits of the main sequence determined by those stars whose membership is certain (Table 5, class 1). The *UBV* values for these stars were obtained from Hoag *et al.* (1961) and only one, 71 (Table 5, class 5), lies within the assigned limits making it a probable member. The remaining 15 stars cannot be main sequence cluster members, but simply field stars or, in some cases, such as stars 64, 65, and 70, they could be member stars belonging to the giant class branch.

Table 3 lists one star, 80, for which β measurements were not obtained. Consequently, no membership probability was assigned in the present paper. However, JvA reported a very low membership probability. Futhermore, since Hoag *et al.* (1961) reported *UBV* measurements, the location of this star in Figures 5a and 5b can be established. The findings show that star 80 does not lie in a position suitable for cluster membership in the aforementioned figures.

TABLE 6

RATIO OF MEMBER VERSUS OBSERVED STARS FOR EACH CLASS IN THE DIRECTION OF NGC 7062

	β >2.88	A	F	β <2.55	Total
Members	9	15	3	1	28
Observed	13	26	24	17	80

Concluding from the previous discussion, it can safely be stated that there are 28 stars (see Table 6) that can be assumed to belong to cluster NGC 7062 and that are distributed in the following way: fifteen A type stars, three F type stars, nine stars with $\beta >$ 2.88 and one star with β < 2.59.

The photometric values obtained for each star can be transformed into log L/L_0 and log T_e. In order to be able to carry out such a comparison, the first step is to unredden the photometric values of all the observed stars. Table 4 lists the reddening values as well as the unreddened photometric values determined for each of the A and F stars observed.

In 1978 Relyea and Kurucz published a paper devoted to obtaining theoretical Strömgren *uvby* and Johnson-Morgan *UBV* colors from the calibrated Kurucz grid of model atmospheres for O, B, A, F, and G stars, in order to investigate physical conditions in stellar atmospheres. Although the grids they constructed are most accurate for stars with $T_{eff} \leq 8500$ K, the calibrated photometric grids they present allow the derivation of log g, and T_{eff} from photometric observations in the *uvby* system.

The unreddened values obtained for the cluster stars determine the location of these stars in the $(b-y)_0-(c_0)$ diagram of Relyea and Kurucz (1978); this location provides an indirect determination of the stars' temperature and gravity. Figure 6 presents the theoretical grids of Releya and Kurucz (1978) along with the position of member stars determined in the present study. As can be seen, the hottest stars are around 8500 K (log T_e = 3.929, log g = 3.75) and the sample consists of stars which have been established unambiguously as cluster members.

The metallicity for the cluster can be inferred from the derived [Fe/H] for the F type stars. This sample is formed by only three F member stars (42, 43 and 46) and the assumed [Fe/H] is their mean, which has a value of -0.352 ± 0.709. For a more accurate determination of the metal content more F stars have to be measured.

TABLE 7

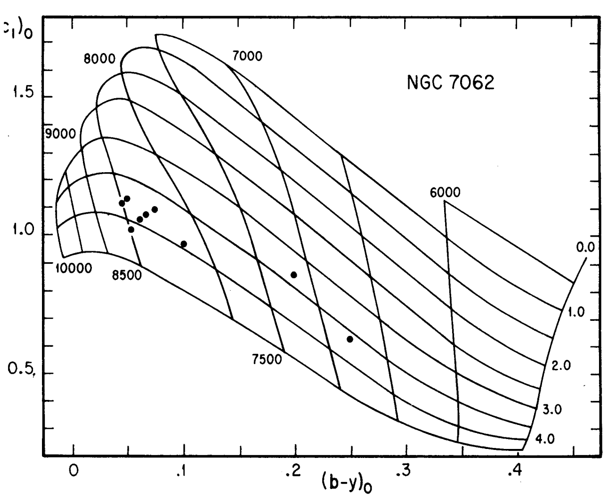
OBSERVED STARS FOR VARIABILITY IN NGC 7062

ID	V		$b-y$		m_1		c_1		N
22	9.235	0.004	0.155	0.002	0.125	0.010	0.951	0.013	15
53	8.535	0.005	0.300	0.003	0.125	0.008	0.418	0.011	14
20	10.082	0.005	0.106	0.006	0.264	0.010	0.829	0.010	15
80	13.525	0.028	0.414	0.032	-0.008	0.054	0.620	0.136	14
13	13.173	0.021	0.366	0.022	0.053	0.027	1.129	0.032	15
17	13.026	0.024	0.339	0.026	0.068	0.042	1.111	0.032	15
check	9.205	0.009	0.154	0.004	0.207	0.009	0.846	0.013	15

With the temperature limit estimated above, a lirect comparison with theoretical isochrones can e carried out in order to determine the age of he cluster. Among the several possibilities are he theoretical isochrones of Vandenberg (1985), in vhich are presented stellar evolutionary sequences nd isochrones in Johnson's *UBV*, and Cousins' RI hotometric systems. For an assumed chemical omposition z = 0.0030 and considering the log -log T_{eff} upper limits derived in the present nalysis, an age estimate of 7.0×10^8 yr is found.

However, one problem remains: the short period ariability of stars within the instability strip limits.)n the night of September 4, 1986 a continuous nonitoring of seven stars was carried out simultaeously in the *uvby* system for three and half hours. The technique followed has been used regularly by wo of the authors (see, for example, Peniche and eña 1987). During this interval of time, more than en points for each star in the cycle were obtained. Table 7 summarizes the observed stars, their phoometric values and the standard deviations of each ne. As can be seen, these standard deviations are of the order of thousandths of a magnitude, which is the photometric accuracy reported, except for stars 13, 17 and 80 which show an abnormally high dispersion which is not attributable to photometric errors. Therefore, judging from their photometric characteristics such as: short period of pulsation, location in the H-R diagram and small amplitude shown, they are most likely, star pulsators of a Delta Scuti nature. The others, although constant, are apparently not cluster members and have served only to fulfill the usual criteria of differential photometry.

From the analysis carried out in the present paper the following might be concluded: as JvA previously reported, the cluster is not densely populated (28 stars); its reddening is 0.319, the distance modulus is 12.18, the age of the cluster is 7.0×10^8 yr and three stars belonging to the cluster are short period variables. A summary of distances and colour excesses of NGC 7062 determined by different authors can be found in Table 8.



ig. 6. $(b-v)_0 - (c_1)_0$ diagram of Relyea and Kurucz 1978) with the member stars specified.

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TABLE 8

DETERMINED DISTANCES AND COLOR EXCESS OF THE OPEN CLUSTER NGC 7062

d(pc)	E($B-V$)	Reference
1950	...	Trumpler (1930)
2400	...	Shapley (1930)
5000	...	Collinder (1931)
1260	...	Barkhatova (1950)
1760	...	Johnson *et al.* (1961)
1760	...	Schmidt (1963)
2240	0.450	Fenkart (1965)
1820	...	Hoag (1966)
2240	0.450	Becker and Fenkart (1971)
1786	0.480	Hassan (1973)
2726	0.456	Present Paper (1990)

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