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uvby-β PHOTOMETRY OF OPEN CLUSTERS. IV. NGC 1444, NGC 1662, NGC 2129, NGC 2169, AND NGC 7209

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RESUMEN

Se presenta fotometría *uvby*-β de los cúmulos abiertos NGC 1444, NGC 1662, NGC 2129, NGC 2169 y NGC 7209. Del análisis de los datos se determina enrojecimiento, temperatura y gravedad para cada estrella y de la distancia y el enrojecimiento de cada una se determina el módulo de distancia y el enrojecimiento del cúmulo. La edad de cada cúmulo se determina por comparación directa con modelos teóricos. Para NGC 2129 no se ha encontrado ninguna acumulación estelar.

ABSTRACT

uvby-β photoelectric photometry of the open clusters NGC 1444, NGC 1662, NGC 2129, NGC 2169, and NGC 7209 is presented. From the analysis of the data reddening, distance, temperature and gravity are determined for each star and, from the distance and reddening of each, reddening and a mean distance modulus to the clusters is assigned. Numerical value of age for each is determined through direct comparison with theoretical models. No star clustering has been found in the direction of NGC 2129.

Key words: OPEN CLUSTERS AND ASSOCIATIONS — TECHNIQUES - PHOTOMETRIC

1. INTRODUCTION

This is the fourth paper of a series (Peniche et al. 990, Peña et al. 1994, Peña et al. 1993; Papers I, I, and III, respectively) which has the purpose of xamining the nature of the stars belonging to open lusters. The aims of this series are, among others: to study short period pulsating stars, mainly of the Scuti type, by first establishing the membership f each star to the cluster, *ii)* to determine the bundance of the Be and Ap phenomena and blue tragglers in open clusters for clusters of different ges and metallicities, and eventually, *iii)* to study he chemical enrichment of the Galaxy when age, ynamics, and metallicity are known for a fair umber of clusters.

In the present study, an analysis of the open clus- ers NGC 1444, NGC 1662, NGC 2129, NGC 2169, nd NGC 7209 is presented. These clusters were elected because they seem to have a relatively large umber of young stars. This conclusion is sup- orted by the photometric studies in *UBV* presented y Hoag et al. (1961).

2. OBSERVATIONS

The observations were carried out at the Observatorio Astronómico Nacional (OAN) of UNAM. For the acquisition of the photometric data, the 1.5-m telescope at the OAN was used with a multi-channel spectrophotometer that allows the simultaneous observation in the *uvby* filters and in the narrow and wide filters that define Hβ.

The characteristics and procedures of the observations in the 1989 season were presented in Paper II. A total of 25 stars in the direction of the NGC 1444 cluster, 42 in the direction of NGC 1662, 37 in the direction of NGC 2129, 20 in the direction of NGC 2169, and 54 in the direction of NGC 7209 were observed.

3. DATA REDUCTION

The reduction of the photometric data follows the procedure that has been described previously in Paper I. Paper II presented the reduction of the photometric data of the 1989 season to the standard system, the dispersion of the indexes of the observed standard stars with respect to the standard star values (Olsen 1983), and the errors due to the star flux measured in each filter as a function of magnitude. The uncertainties were as follows: the coefficients are defined by the equations given in Crawford & Barnes (1970) and in Crawford & Mander (1966). 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. The obtained values were: (BDFJHIL) = (0.010, 1.001, 0.940, 0.013, 1.006, 0.078, 1.258). An estimate of the accuracy was determined by comparing the *uvby*-β data with those of Olsen (1983) and Gronbech & Olsen (1977). The average differences, present data minus Olsen's data, were obtained with more than 118 overlapping stars in the *uvby* and 67 stars in Hβ. The obtained mean differences are $(\delta V, \delta(b-y), \delta m_1, \delta c_1, \delta\beta)$ = (0.012, 0.007, 0.011, 0.011, 0.009) mag. The photometric values in the standard system of all the observed stars are presented in Table 1. Column 1 lists a sequential number of the observed stars in decreasing β; column 2, the identification numbers of each star by Hoag et al. (1961). Whenever possible, the nomenclature previously given will be used in the rest of the text and denoted by a prefix H. For those stars that have not been previously observed photometrically, positions were determined from the identification chart of Hoag et al. (1961); columns 8 and 9 list their reported or measured coordinates in their units. In these columns, numbers with two decimal figures are taken directly from the photoelectric and photographic list of Hoag et al. (1961); numbers with only one decimal figure were determined from the chart. The rest of the columns list the photometric values presented. A comparison of the V magnitude for those program stars reported in the present paper which are in common with Hoag et al. (1961) was evaluated along with the relationship $(B-V)-(b-y)$.

TABLE 1

uvby-β PHOTOMETRY OF THE OBSERVED STARS

Id.	Hoag	V	$b-y$	m_1	c_1	β	X	Y
				NGC 1662				
01	13	10.631	0.245	0.129	1.022	2.908	09.14	13.06
02		9.797	0.239	0.141	1.029	2.900	02.1	04.0
03		10.721	0.246	0.148	1.035	2.899	30.9	-01.7
04		10.750	0.278	0.156	1.001	2.896	-00.5	30.4
05		10.207	0.290	0.097	1.092	2.893	-32.1	20.1
06		10.671	0.283	0.130	1.040	2.890	27.7	-25.7
07		9.476	0.218	0.118	1.120	2.890	00.7	04.0
08	9	9.675	0.268	0.124	1.064	2.881	27.56	-18.47
09	14	10.740	0.262	0.162	1.020	2.878	01.49	-12.33
10	10	10.091	0.214	0.144	1.062	2.877	-11.34	07.67
11	4	9.102	0.221	0.120	1.135	2.867	31.23	13.26
12	5	9.070	0.233	0.085	1.130	2.856	-03.95	15.76
13	11	10.471	0.340	0.167	0.947	2.855	-20.60	-04.17
14	3	8.915	0.226	0.111	1.110	2.851	05.51	07.32
15	7	9.304	0.200	0.110	1.059	2.850	10.66	09.37
16		10.319	0.259	0.134	1.087	2.847	02.1	05.2
17		9.566	0.290	0.093	1.170	2.838	-25.9	-24.2
18		11.250	0.325	0.158	0.812	2.838	-08.2	-08.7
19		11.044	0.265	0.171	0.948	2.836	02.1	-06.5
20		11.251	0.307	0.153	0.926	2.828	-04.4	14.6
21		9.221	0.223	0.113	1.159	2.820	09.0	-02.0
22	15	10.866	0.263	0.145	0.986	2.812	01.24	15.19
23	17	11.286	0.340	0.156	0.894	2.808	16.28	-16.45
24	24	11.829	0.411	0.160	0.785	2.779	15.90	-20.80
25	21	11.580	0.433	0.124	0.699	2.772	02.59	14.19
26	20	11.444	0.368	0.125	0.894	2.772	-14.81	-00.94
27	23	11.869	0.415	0.158	0.736	2.752	00.00	00.00
28	26	12.298	0.455	0.119	0.542	2.742	10.28	-05.11
29		11.937	0.431	0.140	0.622	2.730	25.6	-07.0
30		12.661	0.486	0.128	0.690	2.725	06.8	05.2

TABLE 1 (CONTINUED)

Id.	Hoag	V	$b-y$	m_1	c_1	β	X	Y
31		12.669	0.582	0.103	0.384	2.691	-22.2	-19.8
32	25	11.844	0.509	0.104	0.481	2.669	09.32	12.11
33		11.414	0.484	0.143	0.503	2.647	02.0	04.1
34		13.714	0.487	0.203	0.510	2.628	-11.5	11.5
35		13.647	0.574	0.066	0.400	2.599	-10.8	-01.5
36	28	12.516	0.701	-.087	0.281	2.588	-17.46	-01.17
37		13.087	0.503	0.233	0.231	2.586	23.8	-16.0
38	2	8.775	0.747	0.299	0.324	2.582	04.24	09.72
39	1	8.300	0.763	0.337	0.310	2.565	03.09	05.32
40		11.469	0.938	0.259	0.065	2.555	-32.0	-26.0
41	22	11.632	0.856	0.426	0.311	2.548	18.85	-04.84
42	29	13.254	0.627	0.197	0.329	2.504	-04.5	06.57
				NGC 1444				
01	3	10.310	0.266	0.150	0.945	2.875	-05.32	-02.05
02	12	13.546	0.590	0.068	0.637	2.875	03.07	-01.32
03	8	12.765	0.449	0.044	0.789	2.855	-01.38	01.55
04		13.183	0.493	0.104	1.059	2.827	-04.1	-03.0
05	11	13.335	0.364	0.035	0.426	2.825	00.10	02.63
06	7	12.694	0.400	0.011	0.669	2.801	05.19	02.87
07		12.817	0.611	-.048	1.029	2.798	09.9	08.0
08	13	13.681	0.567	0.105	0.512	2.789	-00.30	-01.49
09		12.481	0.521	0.115	0.444	2.778	05.7	10.8
10		11.757	0.451	-.032	0.586	2.753	00.5	03.1
11		13.039	0.480	-.009	0.801	2.737	-02.2	03.8
12	9	12.801	0.415	-.019	0.646	2.733	-00.63	02.28
13	10	13.111	0.397	0.110	0.315	2.726	00.00	00.00
14	5	12.355	0.515	0.077	0.552	2.721	-01.05	-09.78
15		13.573	0.360	0.075	0.384	2.695	02.8	02.9
16		13.617	0.513	0.178	0.885	2.691	03.0	10.1
17		11.419	0.524	0.157	0.436	2.640	-08.0	00.3
18	4	11.826	0.544	0.134	0.509	2.632	-02.13	-05.19
19		13.971	0.596	-.003	0.588	2.592	-01.5	-00.2
20	14	14.025	1.049	0.301	1.016	2.573	-01.88	-04.14
21	1	6.771	0.397	-.085	0.025	2.565	01.50	01.28
22	6	12.715	1.085	0.230	0.616	2.550	-02.13	-03.02
23		12.519	1.039	0.349	0.366	2.537	08.5	10.5
24		13.611	0.568	0.359	0.537	2.508	10.2	02.9
25	16	14.031	0.639	0.242	0.449	2.472	-02.5	-05.76
				NGC 2169				
01	17	11.629	0.151	0.151	1.098	2.909	-04.25	-03.07
02	15	11.060	0.122	0.135	0.926	2.880	-05.22	-11.06
03	21	12.534	0.151	0.229	1.005	2.860	-06.47	-00.63
04	14	10.934	0.157	0.109	1.004	2.857	01.55	-05.67
05	16	11.216	0.126	0.105	0.805	2.788	07.09	06.97
06	10	10.095	0.043	0.102	0.662	2.745	-04.32	02.50
07	12	10.830	0.086	0.103	0.475	2.730	-15.03	02.25
08		11.330	0.029	0.045	0.442	2.721	01.9	-00.5
09	11	10.572	0.082	0.109	0.501	2.720	-01.35	06.94
10	13	10.769	0.077	0.083	0.608	2.709	04.89	07.76
11	3	8.377	0.664	0.110	1.142	2.691	-06.52	03.32
12	6	9.132	0.079	0.072	0.317	2.685	-07.12	06.34
13	9	9.998	0.071	0.081	0.288	2.681	03.37	-11.56
14	2	8.099	0.061	0.064	0.221	2.662	-00.88	04.12
15	22	12.798	0.347	0.263	0.351	2.654	-05.82	-03.12
16	7	9.321	1.200	0.710	1.648	2.635	-01.23	06.34

TABLE 1 (CONTINUED)

Id.	Hoag	V	$b-y$	m_1	c_1	β	X	Y
17	5	8.737	0.040	0.057	0.193	2.616	-03.72	-00.73
18	4	8.627	0.040	0.074	0.037	2.613	00.82	04.47
19	1	6.914	0.033	0.042	-.008	2.603	00.00	00.00
20	8	9.893	0.696	0.412	0.340	2.542	03.14	-00.25
				NGC 2129				
01		12.893	0.399	0.056	0.905	3.042	-04.2	02.2
02		14.183	0.469	0.022	0.813	3.021	02.0	-00.8
03		13.493	0.613	-.121	0.659	2.836	00.8	10.6
04		10.876	0.245	0.047	0.981	2.825	-14.5	-10.5
05		12.766	0.484	-.012	0.483	2.818	01.8	11.0
06		9.646	0.223	0.074	1.158	2.808	-16.2	-05.0
07		13.414	0.579	-.151	0.715	2.787	-02.8	02.0
08	12	12.662	0.281	0.169	0.826	2.771	-15.03	02.25
09		12.247	0.392	-.026	0.476	2.753	-13.5	08.2
10		11.793	0.323	0.157	0.510	2.732	-01.1	-01.8
11		12.832	1.215	-.603	0.601	2.703	13.0	-04.3
12	14	12.848	0.327	0.140	0.650	2.691	01.55	-05.67
13	10	12.509	0.386	-.002	0.237	2.665	-04.32	02.50
14		10.723	0.323	0.183	0.405	2.660	-16.7	11.5
15		11.520	0.427	-.050	0.166	2.659	04.8	02.7
16		12.867	0.402	-.041	0.457	2.657	-07.8	12.7
17		12.167	0.485	-.030	0.274	2.655	-00.7	1.5
18	11	12.582	0.419	0.001	0.299	2.650	-01.35	06.94
19	5	11.297	0.291	0.145	0.558	2.643	-03.72	-00.73
20		12.727	0.389	0.215	0.387	2.642	09.4	-04.8
21		12.157	0.450	0.018	0.242	2.641	-02.0	-00.6
22	3	10.068	0.386	-.055	0.107	2.620	-06.52	03.32
23	7	11.415	0.374	-.007	0.135	2.618	-01.23	06.34
24		11.449	0.406	0.181	0.343	2.617	-06.6	11.0
25		12.520	0.449	-.012	0.233	2.599	01.5	06.8
26		12.342	0.478	0.214	0.333	2.597	-01.0	-06.9
27		13.277	0.519	0.059	0.429	2.596	02.5	-10.3
28		12.073	0.447	-.002	0.235	2.591	-01.3	02.9
29	8	12.192	0.421	-.008	0.222	2.589	03.14	-00.25
30		12.886	0.435	0.039	0.398	2.584	04.9	-00.2
31	9	12.422	0.867	0.315	0.320	2.568	03.37	-11.56
32	2	8.230	0.490	-.059	0.172	2.567	-00.88	04.12
33	1	7.380	0.529	-.080	0.272	2.563	00.00	00.00
34		13.127	0.439	0.222	0.254	2.554	05.1	-09.0
35	6	11.387	0.563	0.518	0.266	2.514	-06.9	-04.8
36		13.721	0.516	-.007	0.474		-02.5	-00.5
37	4	10.431	0.483	-.044	0.124		00.82	04.47
				NGC 7209				
01		12.365	0.171	0.169	1.051	3.021	-12.2	-00.9
02		11.198	0.151	0.155	1.098	2.904	-07.8	09.1
03	8	10.707	0.118	0.138	1.119	2.900	-10.36	05.59
04		11.110	0.145	0.125	1.155	2.890	16.8	-00.6
05		11.488	0.166	0.098	1.067	2.885	-13.4	10.3
06	6	10.682	0.219	0.146	0.997	2.877	00.70	-10.87
07		11.636	0.184	0.170	1.005	2.877	-02.3	07.31
08		11.296	0.189	0.150	1.187	2.877	-13.9	-10.1
09	11	11.138	0.228	0.120	1.279	2.876	- 0.45	-10.54
10		11.037	0.102	0.131	1.087	2.876	-01.1	16.0

TABLE 1 (CONTINUED)

Id.	Hoag	V	$b-y$	m_1	c_1	β	X	Y
11		12.092	0.160	0.156	0.998	2.866	-13.8	10.2
12		12.621	0.166	0.212	0.979	2.866	00.7	07.8
13		11.594	0.131	0.128	1.074	2.865	08.5	08.4
14	3	9.938	0.120	0.135	1.246	2.864	-08.39	07.86
15		11.082	0.251	0.128	1.093	2.861	10.0	-12.1
16	4	10.100	0.122	0.130	1.153	2.861	-12.56	-07.00
17		11.810	0.128	0.144	1.100	2.857	-12.6	13.5
18	5	10.297	0.138	0.124	1.203	2.857	02.70	-08.57
19		11.867	0.102	0.166	1.085	2.855	-04.7	02.4
20		11.546	0.212	0.120	1.225	2.854	-01.6	-02.7
21		10.731	0.115	0.119	1.121	2.852	-08.1	06.5
22	10	10.970	0.124	0.129	1.123	2.851	-16.41	-12.14
23	7	11.845	0.136	0.148	1.124	2.849	-01.95	-06.30
24		10.923	0.146	0.118	1.201	2.843	07.9	09.5
25		11.685	0.184	0.185	0.999	2.843	06.3	02.8
26		10.761	0.167	0.181	0.884	2.838	-23.0	-15.9
27		12.619	0.203	0.166	1.018	2.837	-08.7	08.9
28		10.720	0.150	0.117	1.136	2.830	02.4	-00.4
29		12.084	0.228	0.123	1.036	2.827	-00.5	08.2
30		11.929	0.269	0.145	1.074	2.825	06.1	-03.1
31		11.113	0.136	0.107	1.119	2.816	01.5	04.7
32		12.149	0.164	0.162	1.037	2.813	20.0	-15.9
33		11.398	0.178	0.103	1.213	2.799	08.46	-03.82
34	15	11.633	0.196	0.195	0.945	2.798	-14.86	07.91
35		10.729	0.203	0.118	1.198	2.793	-06.6	-06.7
36	1	8.524	0.193	0.239	0.772	2.783	-23.10	-15.88
37		11.917	0.177	0.139	1.028	2.777	-02.3	14.6
38		11.814	0.176	0.134	1.084	2.771	-09.4	-12.2
39		13.698	0.397	0.127	0.522	2.739	07.3	-00.5
40		11.808	0.396	0.215	0.716	2.715	-12.3	-01.6
41		14.205	0.271	0.240	0.402	2.695	-21.4	-15.8
42	19	11.382	0.261	0.176	0.628	2.691	00.57	-07.54
43	9	10.974	0.280	0.152	0.528	2.682	-06.29	-11.17
44		11.873	0.262	0.168	0.620	2.675	-00.2	-06.7
45		12.231	0.416	0.094	0.488	2.646	-14.1	-10.2
46	18	12.709	0.490	0.056	0.634	2.604	-00.30	-08.94
47		11.262	0.405	0.186	0.336	2.592	-15.7	08.1
48	20	13.125	0.233	0.178	0.908	2.591	-07.57	04.42
49		11.428	0.457	0.194	0.401	2.572	03.4	-00.2
50		10.505	0.706	0.390	0.272	2.568	01.6	06.2
51		8.962	1.149	0.758	0.212	2.562	14.4	-03.5
52	17	12.518	0.463	0.092	0.393	2.553	02.30	02.49
53		11.102	0.697	0.323	0.316	2.535	02.4	03.7
54		13.732	0.434	0.062	0.765	2.516	08.3	08.1

4. DISCUSSION

Since the aim of the present paper is to establish hysical and geometrical characteristics of the clus-er stars, the first step was to determine membership f the observed stars to each of the clusters. The ame approach to determine the distance modulus ia Stromgren photometry, as in Paper II, was fol-owed:

We first defined which stars were main sequence ars and the broad spectral regions to which they elonged by constructing a $[m_1]$ – $[c_1]$ diagram. It defines three main spectral regions: early type stars of class B and early A; A and F stars; and late type stars. The distance for each group has been calculated separately.

The calibration of the A and F stars follows a procedure proposed by Nissen (1988) which is based on Crawford's (1975, 1979) calibrations (Paper I); for the B and early A type stars, a method for the determination of the reddening, proposed by Shobbrook (1984) was used as in Paper III.

For the determination of the absolute magnitude

TABLE 2

REDDENING VALUE AND UNREDDENED PARAMETERS OF THE CLUSTER MEMBERS

Id.	$E(b-y)$	$(b-y)_0$	c_0	β	m_0	M_V	DM	Dist. (pc)
				NGC 1662				
				B and early A type stars				
H13	0.264	-0.019	0.972	2.908	0.216	1.35	8.15	426
02	0.256	-0.017	0.980	2.900	0.226	1.27	7.42	305
03	0.262	-0.016	0.985	2.899	0.235	1.26	8.33	464
04	0.293	-0.003	1.036	2.893	0.194	1.18	7.77	358
06	0.300	-0.017	0.983	2.890	0.229	1.18	8.21	437
07	0.205	0.013	1.081	2.890	0.185	1.11	7.48	313
H9	0.278	-0.010	1.011	2.881	0.216	1.07	7.41	302
H10	0.222	-0.008	1.020	2.877	0.217	1.03	8.11	418
H4	0.201	0.020	1.097	2.867	0.186	0.86	7.38	299
H5	0.216	0.017	1.089	2.856	0.156	0.74	7.40	302
H3	0.218	0.008	1.069	2.851	0.183	0.70	7.28	286
H7	0.208	-0.008	1.020	2.850	0.179	0.73	7.68	343
16	0.262	-0.003	1.037	2.847	0.220	0.68	8.51	504
17	0.257	0.033	1.121	2.838	0.178	0.47	7.99	395
21	0.189	0.034	1.123	2.820	0.175	0.22	8.18	433
				A type stars				
H14	0.203	0.059	0.979	2.878	0.223	1.47	8.39	476
H11	0.256	0.084	0.896	2.855	0.244	1.93	7.44	307
18	0.213	0.112	0.769	2.838	0.222	2.96	7.37	297
19	0.165	0.100	0.915	2.836	0.221	1.72	8.62	528
20	0.198	0.109	0.886	2.828	0.213	1.83	8.57	517
H17	0.212	0.128	0.852	2.808	0.220	1.85	8.52	506
H24	0.249	0.162	0.735	2.779	0.235	2.40	8.36	469
H21	0.256	0.177	0.648	2.772	0.201	3.07	7.41	303
H23	0.226	0.189	0.691	2.752	0.226	2.44	8.45	490
H26	0.239	0.216	0.494	2.742	0.191	4.05	7.22	278
29	0.215	0.216	0.579	2.730	0.204	3.07	7.95	388
				F type stars				
H25	0.229	0.280	0.435	2.669	0.173	3.11	7.75	354
33	0.171	0.313	0.469	2.647	0.194	2.42	8.26	447
				NGC 1444				
				B and early A type stars				
H8	0.493	-0.044	0.695	2.855	0.207	0.91	9.73	884
07	0.640	-0.029	0.907	2.798	0.163	0.18	9.88	948
10	0.511	-0.060	0.489	2.753	0.137	-0.20	9.76	896
H3	0.517	-0.120	-0.073	2.565	0.086	-5.21	9.75	892
				NGC 2169				
				B and early A type stars				
H17	0.142	0.009	1.071	2.909	0.198	1.31	9.71	876
H15	0.152	-0.030	0.897	2.880	0.185	1.12	9.29	719
H14	0.176	-0.019	0.971	2.857	0.167	0.85	9.33	733
H10	0.090	-0.047	0.645	2.745	0.132	-0.36	10.06	1030
H3	0.430	-0.234	1.056	2.691	0.239	-3.35	9.88	947
H6	0.163	-0.084	0.286	2.685	0.126	-1.28	9.71	876
H2	0.157	-0.096	0.191	2.662	0.116	-1.79	9.21	696
H1	0.150	-0.117	-0.037	2.603	0.092	-3.69	9.96	982
				F type stars				
H3	0.430	0.234	1.056	2.691	0.239	-3.35	9.88	947

TABLE 2 (CONTINUED)

Id.	$E(b-y)$	$(b-y)_0$	c_0	β	m_0	M_V	DM	Dist. (pc)
				NGC 7209a				
				B and Early A stars				
02	0.142	0.009	1.071	2.904	0.202	1.26	9.33	734
03	0.096	0.022	1.101	2.900	0.170	1.20	9.10	659
04	0.104	0.041	1.135	2.890	0.159	1.07	9.59	828
05	0.169	-0.003	1.035	2.885	0.154	1.10	9.66	855
10	0.093	0.009	1.069	2.876	0.162	0.98	9.66	853
H3	-0.012	0.132	1.248	2.864	0.131	0.65	9.34	738
15	0.251	0.000	1.045	2.861	0.211	0.84	9.17	681
H4	0.080	0.042	1.138	2.861	0.156	0.74	9.01	634
H5	0.057	0.081	1.192	2.857	0.143	0.63	9.42	765
21	0.091	0.024	1.104	2.852	0.149	0.67	9.67	857
H10	0.100	0.024	1.104	2.851	0.162	0.66	9.88	945
28	0.122	0.028	1.113	2.830	0.157	0.38	9.82	919
				A type stars				
07	0.123	0.061	0.980	2.877	0.207	1.60	9.51	796
39	0.177	0.220	0.487	2.739	0.180	4.18	8.76	565
				F type stars				
H19	0.013	0.248	0.625	2.691	0.180	2.02	9.31	726
45	0.124	0.292	0.463	2.646	0.131	2.60	9.10	660
				NGC 7209b				
				B and Early A type stars				
H11	0.073	0.155	1.265	2.876	0.144	0.77	10.05	1023
11	0.180	-0.020	0.964	2.866	0.216	0.95	10.37	1183
13	0.130	0.001	1.049	2.865	0.171	0.88	10.16	1076
17	0.116	0.012	1.078	2.857	0.182	0.76	10.55	1290
19	0.094	0.008	1.067	2.855	0.197	0.75	10.72	1390
20	0.123	0.089	1.202	2.854	0.161	0.58	10.44	1222
H7	0.113	0.023	1.103	2.849	0.185	0.64	10.72	1394
24	0.069	0.077	1.188	2.843	0.141	0.45	10.17	1083
29	0.243	-0.015	0.990	2.827	0.203	0.48	10.56	1292
30	0.276	-0.007	1.022	2.825	0.236	0.42	10.32	1158
31	0.116	0.020	1.097	2.816	0.145	0.20	10.41	1210
35	0.138	0.065	1.172	2.793	0.164	0.28	10.41	1210
				A type stars				
08	0.146	0.043	1.158	2.877	0.194	0.04	10.70	1383
12	0.094	0.072	0.960	2.866	0.240	1.75	10.47	1242
25	0.095	0.089	0.980	2.843	0.214	1.33	9.94	974
H15	0.065	0.131	0.932	2.798	0.214	1.25	10.11	1051
				F type stars				
44	-0.002	0.264	0.620	2.675	0.167	1.66	10.23	1110

e method proposed by Balona & Shobbrook 984) was employed. The distance moduli and stance were evaluated in the customary ways. ıble 2 lists the reddening and unreddened paramers of the member stars in the cluster. Also the ›solute magnitude distance modulus and distance ı pc) are given. Histograms of the distances in ırsecs for each cluster were constructed for each 'oup of stars for which the distances were deterined (Figure 1) i.e., B and early A, A and F type ırs, as well as for the whole sample. A membership probability has been defined from this histogram by adjusting a Gaussian distribution to it.

The apparent magnitudes of those stars with high probability of membership in the cluster have been represented in a histogram along with the observed stars to infer the range in which the apparent magnitude of the cluster members of B, A and F type stars lie.

To separate binaries from single stars a $\beta - V_0$ diagram of the data presented was constructed for each cluster (Figure 2).

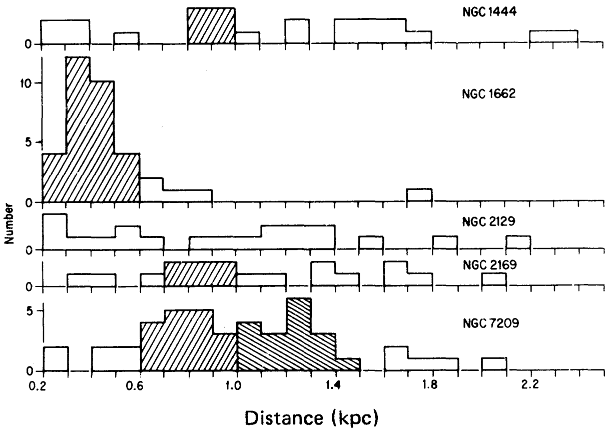


Fig. 1. Histogram of the distances obtained for a) NGC 1444, b) NGC 1662, c) NGC 2129, d) NGC 2169, and e) NGC 7209.

To determine the membership of the cool stars to the cluster, a $(b-y)-V$ diagram was built using only those BAF stars for which a high probability of membership was established. Then, all the cool stars were located on this diagram and those stars that lie in the extension of the previously defined MS into the cooler zone were regarded as stars with a high probability of membership (Figure 3).

In order to estimate the age of the cluster the following procedures were undertaken:

An estimation of the turn-off point was carried out by first determining the temperature and gravity of the member stars, plotting them in the $(m_1 - c_1)$ theoretical grids of Relyea & Kurucz (1978). Second, their log $L/L_\odot$ were determined from the M_v values reported and the bolometric corrections taken from Lang (1991). With these values and an average metallicity value characteristic of these clusters, [Fe/H] = 0.0, a direct comparison was made with the theoretical models of Meynet, Mermilliod, & Maeder (1993) which take into account mass loss and moderate overshooting and that used recent mean opacities.

An alternative procedure for verifying the temperature of the B stars was followed from the calibration between $[u-b]$ and θ_e. We have followed Pérez et al. (1989) who used the calibrations of Philip & Newell (1975) who define four linear segments over the entire $[u-b]$ range.

The determination of the Ap abundance was carried out through *uvby-β* photometry since it is well-known that the Ap stars lie in a specifically defined zone in the $[m_1] - [c_1]$ diagram. In these zones the Ap Sr-Cr-Eu and Sr-Cr stars are clearly marked.

The uncertainties of each reported figure were evaluated in the following manner: the main source of error consisted in the residuals of the standard stars observed with respect to the standard index values. To determine the uncertainties of the m_0, c_0 values, i.e., to determine the temperature limits of the stars, propagation of errors through the standard definitions were done, and the obtained results are of 0.014 and of 0.015 for m_0 and c_0, respectively.

5. RESULTS

The application of the previously described techniques to the observations yielded the following results for each cluster:

5.1. NGC 1662

The $[m_1] - [c_1]$ diagram gave the following number of stars that belong to each range of spectral types: 15 B and early A, 8 A and 3 F stars. The distance was determined for each star and its histogram constructed and shown in Figure 1. It can be immediately seen that there is a conspicuous clustering of early type stars and that the cluster must lie in the distance range 250 to 550 pc with a mean value of 381 ± 110 pc. The probability of membership was evaluated considering these limits. The histogram of the apparent magnitudes indicates that, in order to reach the stars of later spectral types, stars fainter than magnitude 1[?] should be observed. A mean value of $E(b-y)$ equal to 0.231 ± 0.034 has been found.

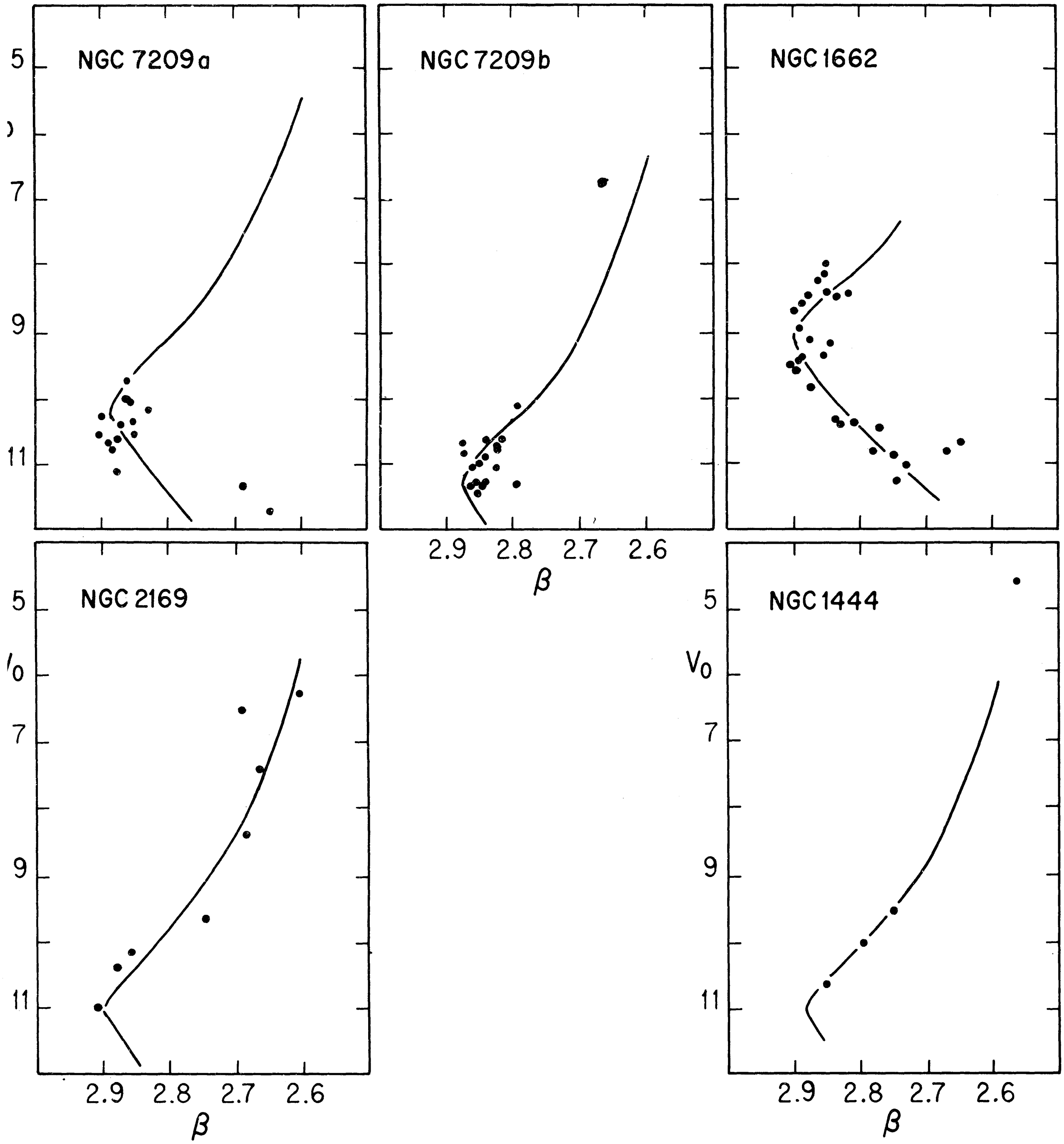
The binaries have been determined from the β V_0 diagram and four have been found: H25, 22, 33 and 36, although only two, H25 and 33, are cluster members.

The cool stars with a high probability of belonging to the cluster have been determined from the HR diagram. The four cool stars assumed to belong to the cluster are: 34, 35, 37, and 42. Two are of the giant class: H1 and H2, the first of which appears a binary in the ADS catalogue. A confirmation of this was given by Tiangxing, Kenneth, & Bania (1989).

The temperatures were derived from the m_1 - c_1 diagram of Relyea & Kurucz (1978). Accurate numerical values were obtained from the $[u-b] - \theta$ calibration described by Pérez et al. (1989).

Both methods yield equal star temperatures. The estimated age is of 4.86×10^8 yr in agreement with that reported by Lang (1991). However, due to the large uncertainty in the temperature range, the age is within the range 3.2 to 6.3×10^8 years. The uncertainty due to the magnitude was negligible.

The number of Ap stars in the direction of NGC 1662 is high: six, all of which are cluster members. One of these H4, had been previously reported as A1p Sr-Cr by Young & Martin (1973). Another non-member star, H6, has been reported as peculiar in a study by Renson (1988).



ig. 2. $\beta - V_0$ diagram of the B, A and F stars established as cluster members for the clusters considered. Those stars above ie main sequence were regarded as binaries. The continuous line delineates the main sequence from the photometric alibration by Crawford (1978).

5.2. NGC 1444

The $[m_1] - [c_1]$ diagram shows very few MS tars, with most of them in the early stages. Howver, the distances determined show a large spread hat can hardly be interpreted as representing a ensely populated cluster. Only six stars, H1, H8, H12, 8, 10, and 11 were found in a close distance range centered at 906 ± 29 pc with an $E(b-y) = 0.540 \pm 0.067$. One binary has been detected from the $\beta - V_0$ diagram which shows all stars to be in the early type branch.

The position of the six stars in the diagram of

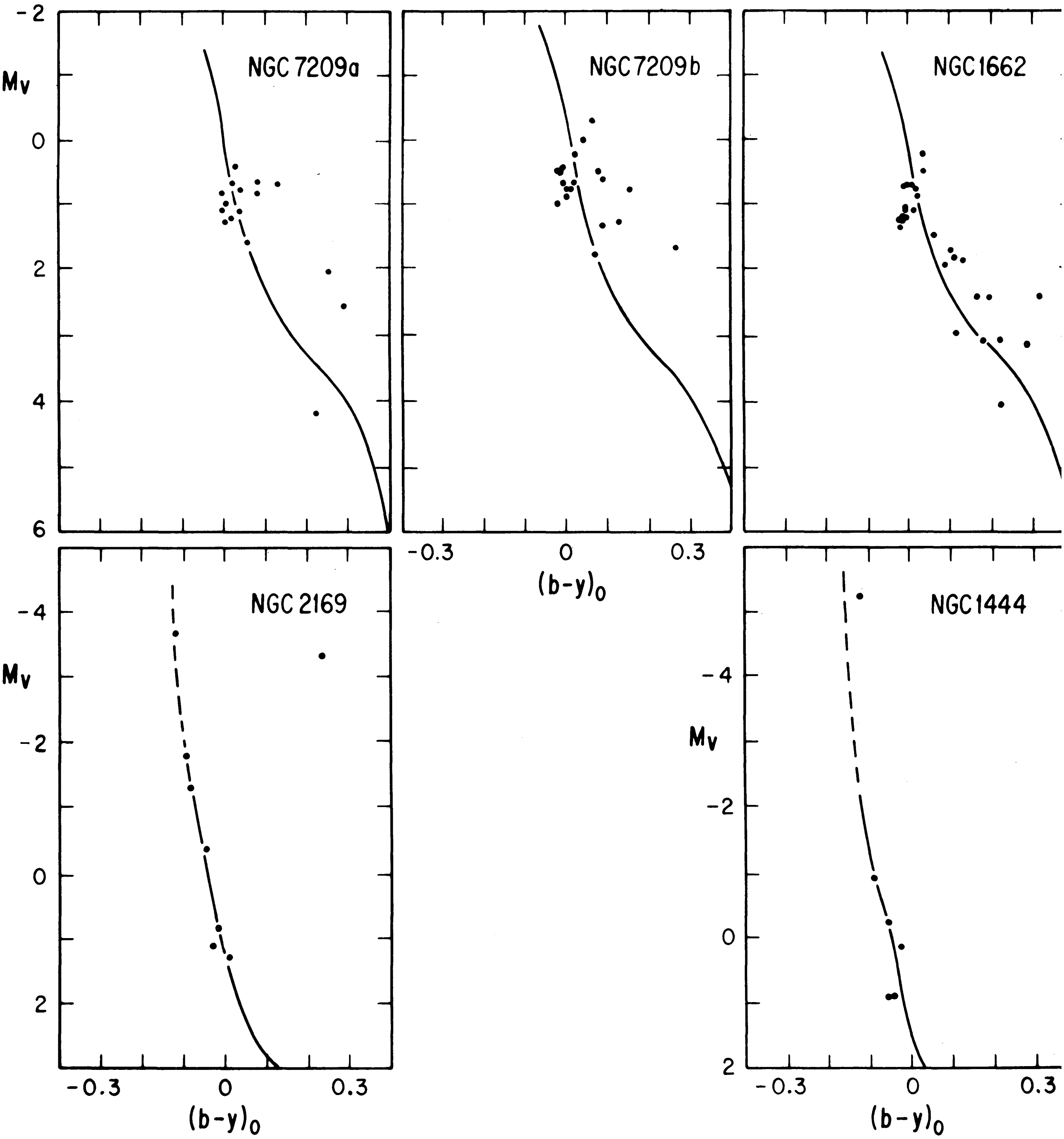


Fig. 3. H-R diagrams of the B, A, and F stars that have been regarded as members of each cluster.

Relyea & Kurucz (1978) shows that they are hot stars, H1 being the hottest. The age of the cluster has been found to be 1.7×10^8 yr in the range 1.0 and 2.0×10^8 yr if the temperature limits are not taken from this latter star. This star, H1, although within the distance limits determined for th cluster, is much brighter and hotter and would giv an age of 12×10^6 yr; this makes it a blue straggle candidate. It has been listed as 2783AB in the AD catalogue.

Only one Ap star, 16, from the entire sample ob-:rved in the direction of NGC 1444 lies in the box ıat defines the Sr-Cr-Eu peculiarity, but it does not elong to the cluster.

5.3. NGC 2169

A comparison of the reduced data with the ublished values of Perry, Lee, & Barnes (1978) 'as done in order to verify the quality of the bservations. Out of thirteen stars observed in ommon, the standard deviations of the differences ı the photometry were of $\Delta(b-y, m_1, c_1)$ of (0.009, .019, 0.019) and two more, H7 and H17 showed nomalously large differences that might be due to ıe fact that they are cool giants and, hence, likely ɔ suffer significant changes in long periods of time.

A large percentage of the observed stars in the irection of NGC 2169 lie in the $[m_1]-[c_1]$ diagram ı the early type stars branch and the distance deter-ıined for each one, shown in a histogram, indicates ıat eight stars belong to the cluster at a distance f 858 ± 128 pc with $E(b-y)$ = 0.182 ± 0.0103 nd none of them are binaries (Table 2), although I2 and H6 have been reported as spectroscopic inaries by Perry et al. (1978) and Tiangxing et al. 1989), respectively.

The H-R diagram indicates that from the ob-:rved MS cool stars none could belong to the luster and that there are two giants, H3 and H8 ıat might belong to the cluster. The temperature f the member stars has been determined from their ositions in the diagram of Relyea & Kurucz (1978), ıdicating that this is indeed a young cluster. Its ge, from the models of Meynet et al. (1990) is entered at 5.0×10^7 yr within the limits of 3.2 and .3×10^7 yr. This numerical value was evaluated 'ithout considering star H1, the hottest star which, lthough within the distance limits of the cluster, eems to be as in the case of H1 in NGC 1444, a blue traggler listed as 4728AB in the ADS catalogue.)nly one Ap star, H21, was found in the direction f NGC 2169, but it does not belong to the cluster. ınother star, H12, has been reported as an Ap star y Young & Martin (1973) but, again, it does not elong to the cluster. However, due to the relative aintness of the observed stars very few of the A and ' stars were included and, hence, very little can be oncluded with respect to the Ap phenomenon in his cluster.

5.4. NGC 2129

Although a fair number of bright stars were ob-:rved in the direction of NGC 2129 (Table 1) and ıe $[m_1]-[c_1]$ diagram shows that there are several arly type stars as well as several late type MS :ars, the determined distance represented in the istogram, Figure 1, does not show the presence of a clustering of stars, raising doubts on its existence. A small inconspicuous clustering of six stars has been found at a distance of 1200 pc, very far from the assumed value of 2000 pc (Lang 1991). No further analysis was carried out, except that one Ap star, H12, has been found in its direction.

5.5. NGC 7209

The $[m_1]$ – $[c_1]$ diagram indicates that the majority of the stars belong to the early type A class, with a few F type stars. The distances were obtained and the histogram constructed. The stars are distributed with two peaks at distance ranges 550 and 950 pc and 950 and 1400 pc respectively, suggesting the existence of two clusters. If only one cluster is assumed, then it would have unreasonable physical limits. Hence, two clusters, NGC 7209a and b are assumed to exist. A mean interstellar extinction $E(b-y)$ was evaluated for each cluster and numerical values of 0.108 ± 0.062 and 0.122 ± 0.066 were obtained for a and b, respectively and at distances of 764 ± 108 and 1194 ± 130 pc. This is consistent with the determined distances since a larger extinction value is obtained for the more distant cluster. Several binaries were detected from the β – V_0 diagram but only one, 35, belongs to NGC 7209b. With respect to the Ap stars, seven stars are within the limits that define the peculiarities but only one has been determined to be a member of NGC 7209a, whereas there are two in the other cluster.

The hottest stars for both clusters give basically the same temperature of T_{eff} = 9750 and 9400 K for a and b, respectively, although the first one has only one star which is located at a position of much hotter temperature, T_{eff} of 14000 K. The determination of the cool stars was not carried out since it would be impossible to distinguish from the method employed to which cluster they would belong. The age for each cluster was estimated as 5.0×10^8 yr with limits between 4.0×10^8 yr and 6.3×10^8 yr for NGC 7209a and of 7.1×10^8 yr with uncertainties within the range 5.0×10^8 yr and 7.9×10^8 yr for NGC 7209b.

6. CONCLUSIONS

We have presented the results obtained for five young open clusters having a fair number of observed stars with high quality intermediate band photometry (see Table 3). We have also drawn several conclusions with regard to the number of Ap stars that lie in the direction of each cluster, as well as to the number of early type stars and blue stragglers. However, before assuming such values as definitive we must convince ourselves that the sampling of stars is complete enough to draw these statistical conclusions.

TABLE 3

COMPILATION OF RESULTS (BASIC AND DERIVED)

Cluster	Obs. Stars All	Obs. Stars Mbr.	Ap All	Ap Mbr.	Dist. (pc)	$E(b-y)$	Age (10^6 yr)	Binaries All	Binaries Mbr.	Blue Strg.	[Fe/H]
NGC 1662	42	28	6	6	380	0.230	490	4	2	0	0.215
NGC 1444	25	4	1	0	900	0.540	170	0	0	1	...
NGC 2169	20	8	2	0	860	0.182	50	0	0	1	...
NGC 2129	37	..	1	..	...	...	...	..	..	..	...
NGC 7209a	54	16	7	1	760	0.108	500	1	0	0	...
NGC 7209b	54	17	7	2	1190	0.122	710	1	1	0	...

Cluster	BAF Mbr/Obs	Ap/BAF All	Ap/BAF Mbr.	Binaries/Obs. All	Binaries/Obs. Mbr.	$E(b-y)$ (mag/kpc)
NGC 1662	0.80	0.17	0.21	0.09	0.07	0.61
NGC 1444	0.15	0.04	0	0	0	0.60
NGC 2169	0.42	0.11	0	0	0	0.17
NGC 7209a	0.32	0.14	0.06	0	0	0.14
NGC 7209b	0.34	0.14	0.12	0.02	0.06	0.10

In retrospect, this being the fourth paper in a series, a more careful procedure was undertaken to select the stars to be observed. Concentric circles were drawn on the identification charts of Hoag et al. (1961). Starting from this origin, we observe only the brightest stars in each circle assuring us that the sample is complete. Hence we are certain that the majority of the brightest stars in the direction of each cluster were observed. Furthermore, after the analysis a direct comparison of the observed stars with the lists for each cluster provided by Hoag et al. (1961) was carried out. The list of stars in the intersection of each set are provided in columns 1 and 2 of Table 1. Later, we examined which of those stars in Hoag et al. (1961) were bluer than $B-V < 0.6$, i.e., those stars that were candidates for either belonging to the spectral class B, or that might belong to the δ Scuti class or be Ap stars. Those that do not belong to the intersection, that is, that were not observed in the present work, were carefully analyzed. For each cluster the following was found:

NGC 1444. In this paper we present observations of 25 stars, whereas Hoag et al. (1961) presented *UBV* data for 24 stars. The intersection of both sets is constituted by 14 stars and in the complement only one had a $B-V$ low enough so that it could be early enough to be important in the present analysis. However, from its $U-B$ values also reported by Hoag et al. (1961) it can safely be assumed to belong to the giant class.

NGC 1662. Forty two stars were observed in the *uvby* and 35 in the *UVB* systems, with an intersection of 22. Of the remaining, six are earlier than the (class but three are too faint to belong to the cluste

NGC 2129. Thirty seven stars were observed i the *uvby* system, 29 in the *UBV*, with 14 intersectin; None of the remaining stars in the complement ha a $B-V$ value numerically smaller than the fixed lim of $B-V < 0.6$ mag.

NGC 2169. In this cluster basically all the sta (20) in the *uvby* were observed by Hoag et al. (1961 Their sample consists of 25 stars and there are 1 in the intersection. Six stars of the complemen have $B-V$ in the desired range, but all are too fain Hence they cannot be cluster members.

NGC 7209. This was the most completely ol served cluster since 54 stars were observed. Ther fore, we can be sure that all the early type stars we observed.

In view of this, the most important results ha been summarized in Table 3 and several conclusio can be drawn:

Reality of Existence. The apparent richness of th clusters vary. Although roughly the same numb of stars have been observed in each one, the nun ber of member stars varies enormously, from th highest number for NGC 1662 to the lowest possib number, zero, for NGC 2129. For two of the r ported clusters the photometry was not exhaustiv However, in the past, doubts were raised wheth or not both NGC 1444 and NGC 2129 were cluster In particular Lynds (1967) already discussed the e istence of NGC 1444. Hence, from the results pr sented here and those already mentioned one mig wonder what kind of object one is dealing with.

ems that there is only a small association of early pe stars instead of a densely populated cluster like GC 1662.

On the other hand, with respect to NGC 2129 e decision taken that it is not a cluster was correct nce not much can be said about its existence unless uch fainter stars were to be observed. Further-ore, from the histogram presented one could isily question its existence. Emphasis should be ut on the results of Schmidt-Kaler (1966) about s dispersion in absolute magnitude. The same onclusion can be reached inspecting the two color iagram by Hoag et al. (1961). All these results sup-ort the findings of the present analysis.

The open cluster NGC 7209 might be a projec-on of two clusters at distances of 779 and 1173 pc. he reddening of the more distant one is larger, as xpected.

On discussing the other two clusters one should e aware that NGC 1662, the highly populated uster, is the nearest and oldest. Hence we are oking at a fainter region of the MS whereas for GC 2169, being at a distance double that of GC 1662, only the bright stars are seen. Never-ieless, its existence as a cluster is beyond doubt.

Ap Stars. As discussed in Peña et al. (1994), ased on a compilation of the articles of Young & lartin (1973) and Hartoog (1976) on Ap stars in pen clusters, a ratio of 0.051 for the frequency of p stars in the clusters and of 0.070 for field stars as determined.

From the results obtained in the present paper, higher value is determined for NGC 1662 which ives values of 0.24 and 0.20 for cluster and field, espectively. Better agreement is obtained in the irection of NGC 1444 and NGC 2169 where a ratio f 0.04 and 0.11 is obtained in each case. As was reviously mentioned, no Ap stars members were etected, but that was because we did not reach faint nough magnitudes. NGC 7209 gives, for a and b espectively, a ratio of 0.06 and 0.12 and of 0.14 for ll the Ap stars and the whole sample of the BAF ars.

Blue Stragglers. Mermilliod (1982) has compiled n exhaustive work on blue stragglers in young pen clusters. He has found 39 stars lying to the ft of the MS of 75 open clusters younger than the lyades and conclude that the blue stragglers ap-ear to be a feature common to all open clusters hatever their age may be and that their number icreases with age.

From the results of the present work two blue ragglers have been found, one in NGC 1444 one in IGC 2169 and none in NGC 1662 and NGC 7209. oth stragglers are within the distance limits of the luster and share the same reddening value. Hence, ractically beyond any doubt, one might conclude iat they belong to the cluster. Unfortunately, no spectroscopy has been done on these objects to determine if they belong, as Mermilliod (1976) states, to the Be or Of type. Since the blue stragglers found belong to the early type, either careful *uvby*-β photometric calibrations have to be developed to be able to detect their peculiarities or spectra should be taken to detect such anomalies.

Metallicity. In his work Nissen (1988) established a prescription to determine the [Fe/H] index for F type stars. This technique has been followed here. Unfortunately, as has been previously stated and can be seen from the Table 2, only NGC 1662 has enough F type stars belonging to the cluster to evaluate this index. The determined value is characteristic of clusters of its age and distance.

Future Work. We will try to carry out and encourage the following: *i)* Differential photoelectric photometry to detect small amplitude, fast changes encountered in the δ Scuti or B type stars for those stars that belong to the cluster and that are within the spectral limits of such variables. *ii)* Spectroscopic studies in the B type stars to detect any anomalies such as those presented by the Be stars. Also, spectroscopic confirmation of the Ap stars determined here is desirable. *iii)* Absolute multicolor photometry to delineate the lower region of the MS for those cluster of which only the upper part of the MS was observed is needed. In this case, CCD observations that provide larger and deeper samples might be useful to delineate where the cluster is. The membership probability might be reinforced by alternative means like proper motions or radial velocities.

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