Baltic Astronomy, vol. 13, XXX–XXX, 2004.

SEVEN-COLOR PHOTOMETRY OF THE OPEN CLUSTER NGC 2395

J. Zdanavičius[1], K. Zdanavičius[1], A. Kazlauskas[1], C. W. Chen[2], W. P. Chen[2], V. Straižys[1], G. Tautvaišiene[1], K. Černis[1] and R. P. Boyle[3]

[1] *Institute of Theoretical Physics and Astronomy, Vilnius University, Goštauto 12, Vilnius, LT 01108, Lithuania*
[2] *Graduate Institute of Astronomy, National Central University, Chung-Li, Taiwan*
[3] *Vatican Observatory Research Group, Steward Observatory, Tucson, Arizona 85721, U.S.A.*

Received 2004 April 15

Abstract. The area of the open cluster NGC 2395 in Gemini is investigated by CCD photometry in the Vilnius seven-color system. Magnitudes, color indices, photometric spectral types, color excesses, interstellar extinctions and distances are determined for 165 stars down to 16 mag in the 1 square degree area. The membership of the cluster is not definite. Only 10 main sequence stars of spectral classes F5–G2 seem to form a group within a space of 70–100 pc radius, with no extension to fainter stars. Interstellar extinction in the area starts at about 400 pc. At larger distances the extinction of stars is scattered between zero and 0.7 mag. It is possible that NGC 2395 has suffered significantly from the Galactic tidal distortion on its low-mass star content.

Key words: stars: fundamental parameters – clusters: individual (NGC 2395) – methods: photometric – Vilnius photometric system

1. INTRODUCTION

NGC 2395 is a loose group of stars fainter than 10 mag near the Gemini and Canis Minor border with the center coordinates: $\alpha(2000) = 7^{\rm h}27.1^{\rm m}$ and $\delta(2000) = +13°35'$, $b = +14°$. First photographic studies of the cluster by Trumpler (1930) and Collinder (1931) were of low accuracy without good photometric standards. A photographic investigation of the cluster with photoelectric standards in the *UBV* system was published by Chincarini (1963). His *V, B–V* diagram for 53 stars down to 15 mag did not show any sequences, the stars were scattered in *B–V* between 0.3 and 1.4, so the arguments for reality of the cluster were week. From nine stars, supposed to be the main sequence B stars, Chincarini estimated approximate values of color excess and distance modulus of the cluster: E_{B-V}= 0.72 and $(V - M_V)_0 = 10.4$, corresponding to a distance of 1.2 kpc. These parameters of NGC 2395 for a long time were in use in catalogs of open clusters (e.g., Hagen 1970; Becker & Fenkart 1971; Lynga 1987; Battinelli & Capuzzo-Dolcetta 1991).

However, the subsequent investigations of the cluster gave much smaller color excess and much closer distance. Dutra & Bica (2000) derive color excesses from the dust emission at 100 μm observed by IRAS and COBE/DIRBE satellite data. Their value for NGC 2395 is $E_{B-V} = 0.10$ only. From the *Hipparcos* parallaxes of eight cluster members Loktin & Beshenov (2001) obtain a distance of 604 pc. The newest version of the WEBDA open cluster data catalog gives E_{B-V} = 0.12 and r = 512 pc (Mermilliod 2004). The same data are given in the catalog of open clusters of Dias et al. (2002).

Trying to test the reality of the cluster and to determine its interstellar reddening we undertook CCD investigation of the cluster area in the *Vilnius* seven-color photometric system.

2. OBSERVATIONS AND REDUCTIONS

The cluster area was observed with the Maksutov 35/51 cm telescope of the Molėtai Observatory equipped with a VersArray 1300B CCD camera of Princeton Instruments. The imaging array of the CCD chip has 1340×1300 pixels of 20×20 μm size. The linear area of the chip is 26.8×26.0 mm, and this corresponds to the field of view 1.13×1.22 sq. degrees. The chip is cooled by liquid nitrogen to –110 K. A set of round filters of the *Vilnius* system of the 6 cm diameter was used. The *U* and *P* filters are made from glasses, and *X*, *Y*, *Z*, *V* and *S* are the interference filters. More details about the instrumentation are given by Zdanavičius and Zdanavičius (2003).

Observations took place on two nights – 2003 March 2/3 (*U, Z, V* and *S* filters) and March 6/7 (*P, X* and *Y* filters). Exposure time for the *U* filter was 15 min, for *P* and *X* – 10 min, for the remaining filters – from 1 to 3 min. In each filter 2–4 exposures were obtained. The air masses ranged between 1.4 and 1.9.

Magnitudes were obtained by aperture photometry using the standard IRAF program package. Registered CCD counts were corrected for nonlinearity, especially for the counts less than 2000 (Zdanavičius & Zdanavičius 2003). For flat-fielding we used skyflats in each filter, averaged from more than 20 frames taken in evening and/or morning twilight.

Transformation of magnitudes and color indices to the standard *Vilnius* system is based on 12 brightest stars in the area measured photoelectrically by Kazlauskas & Černis (2003) and on synthetic color indices of the *Vilnius* system, calculated for the mean spectral energy distribution curves of stars of different spectral and luminosity classes from Straižys & Sviderskienė (1972). Response curves of the *Vilnius* standard system were taken from Straižys (1992) and of the CCD instrumental system from Zdanavičius & Zdanavičius (2003). For the transformation, two types of linear equations were used:

$$\begin{aligned} m - V &= a_1 + b_1 \times C_{m-V}(\mathrm{instr}), \\ V &= c_1 + m_V\,(\mathrm{instr}) \end{aligned} \tag{1}$$

and

$$\begin{aligned} m - V &= a_2 + b_2 \times (Y - V) + C_{m-V}(\mathrm{instr}), \\ V &= c_2 + d_2 \times (Y - V) + m_V\,(\mathrm{instr})\ . \end{aligned} \tag{2}$$

The values of coefficients for the transformation of color indices were determined from synthetic color equations, while for the transformation of V magnitudes they were determined using photoelectric standards. The transformation coefficients found here are close to those obtained by Zdanavičius & Zdanavičius (2003) using photoelectric standards in the M 67 cluster.

At the beginning the instrumental magnitudes m(instr) were determined for individual frames in each filter, then they were averaged. The instrumental color indices m–V(instr) were calculated as differences of the corresponding instrumental magnitudes. After applying equations (1) and (2), the average values of magnitudes V and color indices m–V for each star were formed.

The V magnitudes and six color indices for 12 standard stars are given in Table 1. The results of CCD photometry for 165 stars down to 15.75 mag are given in Table 2. The faintest and reddest stars have no ultraviolet color indices. Color indices with standard errors >0.05 mag are marked by a colon (:), and those with the errors >0.10 – by (?). The numbers of stars given in the first column are identified in Figure 1.

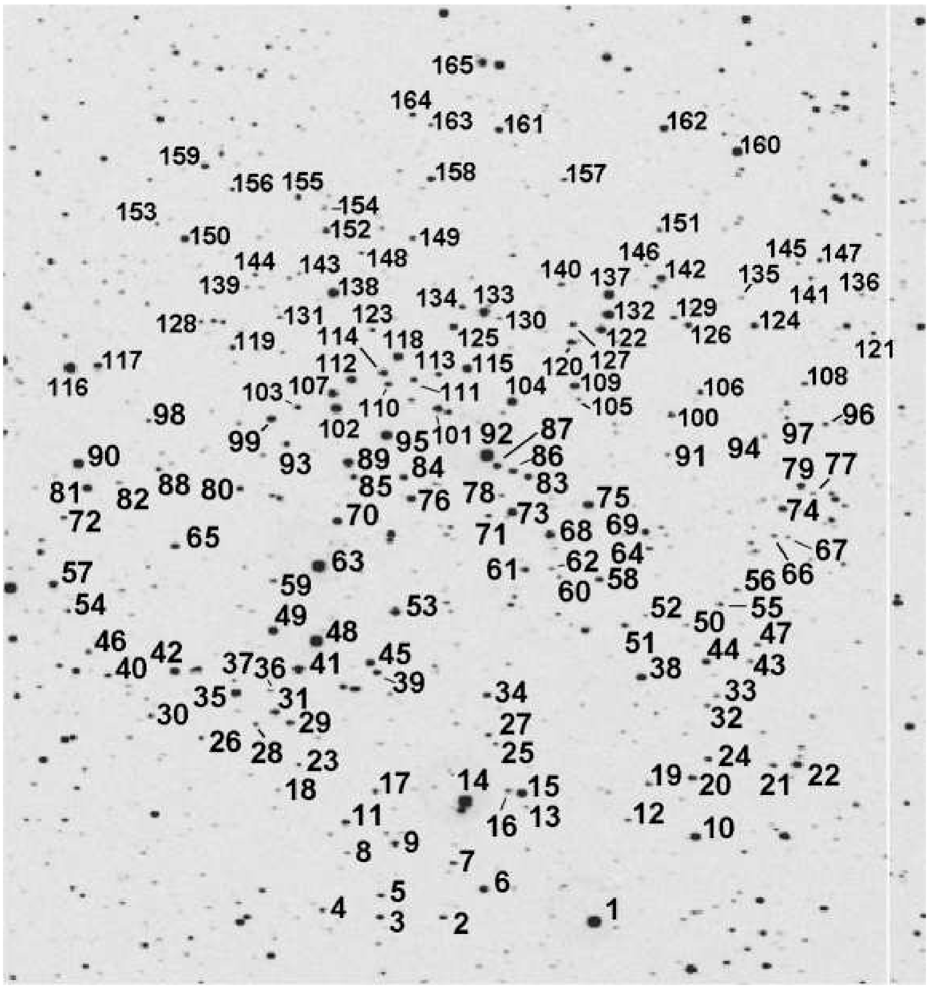

Fig. 1. Identification chart of the NGC 2395 area.

3. CLASSIFICATION, COLOR EXCESSES AND DISTANCES

The stars of Table 2 were classified in MK spectral types using the photometric classification method based on a comparison of 14 reddening-free Q-parameters of the program stars with about 8000 stars with known spectral classification. The method is described in more details in our earlier papers (see, e.g., Laugalys & Straižys 2002; Straižys et al. 2002). The accuracy of the method for normal solar composition stars is ±1 spectral subclass. The accuracy of luminosity classes is dependent on spectral class: for B, A, F and early G subclasses the accuracy is about ±1 luminosity class but for late G and K–M stars the accuracy is much higher. For the majority

Table 1. Photoelectric standards in NGC 2395 measured in 2003 with the 1.5 meter telescope of the Steward Observatory on Mt. Lemmon, Arizona.

ID	α (2000)	δ (2000)	V	U–V	P–V	X–V	Y–V	Z–V	V–S	n
48	07 27 28.6	+13 30 13	10.317	2.243	1.688	1.082	0.467	0.168	0.464	
			0.017	0.016	0.014	0.014	0.004	0.005	0.008	3
53	07 27 18.6	+13 31 05	11.992	2.290	1.816	1.246	0.520	0.204	0.517	
			0.019	0.017	0.014	0.014	0.008	0.008	0.014	4
63	07 27 28.2	+13 32 31	10.049	3.496	2.890	1.988	0.788	0.301	0.753	
			0.028	0.020	0.017	0.014	0.006	0.005	0.008	2
75	07 26 53.9	+13 34 21	11.841	2.266	1.791	1.229	0.505	0.191	0.515	
			0.017	0.016	0.014	0.013	0.006	0.007	0.017	3
89	07 27 24.4	+13 35 43	11.942	3.637	3.048	2.072	0.784	0.324	0.765	
			0.015	0.016	0.013	0.013	0.006	0.006	0.007	2
92	07 27 06.8	+13 35 54	9.963	4.912	4.142	2.855	1.050	0.464	0.985	
			0.016	0.016	0.013	0.013	0.005	0.006	0.009	3
95	07 27 19.6	+13 36 33	11.534	3.577	2.987	2.056	0.776	0.315	0.782	
			0.018	0.016	0.022	0.014	0.016	0.020	0.007	2
101	07 27 13.0	+13 37 20	12.369	3.656	3.045	2.076	0.804	0.311	0.768	
			0.015	0.017	0.014	0.013	0.004	0.005	0.007	2
102	07 27 25.9	+13 37 23	11.381	2.341	1.668	0.807	0.308	0.111	0.268	
			0.015	0.015	0.013	0.014	0.004	0.006	0.008	3
122	07 26 52.2	+13 39 45	12.169	2.179	1.668	1.063	0.443	0.156	0.451	
			0.016	0.015	0.015	0.018	0.017	0.007	0.012	2
137	07 26 51.2	+13 40 50	11.947	2.288	1.775	1.157	0.479	0.180	0.469	
			0.017	0.015	0.014	0.013	0.014	0.010	0.006	2
138	07 27 26.2	+13 40 57	11.724	2.434	1.749	0.954	0.379	0.141	0.354	
			0.016	0.015	0.014	0.012	0.005	0.006	0.012	3

of stars the absolute magnitude error is <0.5 mag. The results of photometric classification of stars are given in the 2nd column of Table 2. In some cases the selected comparison stars were of different luminosity classes. In this case only spectral class is given. For a part of stars fainter than 15th mag the classification accuracy was too low: for them only an approximate spectral class is given.

The color excesses E_{Y-V} of stars were calculated as the differences between the observed Y–V and the intrinsic color indices $(Y\text{–}V)_0$ for various spectral and luminosity classes, taken from Straižys (1992, Tables 66–69 and 73). The distances of stars were calculated by the equation:

$$5 \log r = V - M_V + 5 - A_V, \tag{3}$$

where $A_V = 4.16 E_{Y-V}$. The absolute magnitudes were taken from Straižys (1992) tabulation according to the spectral and luminosity classes, with a correction of –0.1 mag, bringing the M_V scale to the

Table 2. The results of CCD photometry of NGC 2395. Identification numbers correspond to the chart given in Figure 1.

ID	Ph.sp	*V*	*U–V*	*P–V*	*X–V*	*Y–V*	*Z–V*	*V–S*
1	F5 V	10.085	2.214	1.688	1.145	0.466	0.176	0.470
2	F	14.367	2.622	1.797	1.133	0.495	0.176	0.475
3	G0 V	14.187	2.453	1.982	1.400	0.600	0.210	0.582
4	K3 V	14.854		2.895	2.008	0.719	0.422	0.772
5	G0 V	14.552	2.700	2.093	1.435	0.600	0.225	0.625
6	F8 V	12.949	2.314	1.818	1.283	0.520	0.213	0.532
7	G8 V	14.512	3.036	2.451	1.755	0.709	0.298	0.715
8		15.644		2.380	1.628	0.639	0.184	0.717
9	G0 V	13.325	2.370	1.899	1.338	0.544	0.221	0.547
10	G9 IV:	12.432	3.674	3.082	2.144	0.843	0.342	0.804
11	F-G	13.855	2.303	1.847	1.367	0.594	0.205	0.572
12	F7 V	15.268	2.196	1.763	1.211	0.484	0.113	0.522
13	F8 V:	15.739		2.121	1.455	0.619	0.168	0.634
14	K1 V	9.685	3.020	2.575	1.732	0.644	0.308	0.671
15	F5 V	12.434	2.070	1.569	1.058	0.443	0.161	0.439
16		15.072	2.337	2.092	1.510	0.631	0.181	0.689
17	F9 V	14.677	2.323	1.875	1.277	0.554	0.189	0.553
18	MDGE-G5	15.743		1.701	1.198	0.508	0.161	0.526
19	MDGE-G5	14.828	2.592	1.952	1.316	0.554	0.227	0.566
20	G5 V	13.380	2.622	2.173	1.483	0.583	0.247	0.592
21	K2.5 III	14.360		3.543	2.734	1.034	0.457	0.991
22	G8 V	12.011	2.776	2.345	1.591	0.611	0.265	0.634
23	G8 V	15.129		2.629	1.748	0.688	0.315	0.680
24	G8 V	14.736	2.759	2.390	1.659	0.668	0.284	0.662
25	F-G	15.288	2.050	1.998	1.383	0.589	0.231	0.551
26	G	15.078		2.274	1.680	0.653	0.289	0.712
27	F5 V	14.972	2.236	1.706	1.124	0.491	0.155	0.477
28	F	15.219		2.154	1.508	0.631	0.140	0.605
29	F8 IV	13.529	2.563	2.021	1.396	0.599	0.235	0.560
30	G5 V	15.344		2.261	1.590	0.665	0.304	0.683
31	K1 III	12.999	3.829	3.310	2.220	0.840	0.353	0.833
32	G	15.617	1.996	1.785	1.267	0.480	0.256	0.576
33	MDGE-G5	15.664		1.958	1.345	0.548	0.167	0.584
34	F	14.374	2.422	1.759	1.173	0.491	0.190	0.475
35	F9 IV-V	12.416	2.573	2.045	1.406	0.567	0.220	0.565
36	F-G	15.737		1.862	1.289	0.554	0.124	0.621
37	G	15.523		2.205	1.547	0.636	0.201	0.677
38	MDG-G	12.410	2.195	1.661	1.140	0.466	0.182	0.456
39	F8 V	14.379	2.309	1.781	1.248	0.532	0.193	0.530
40	G0 V	14.710	2.628	2.093	1.417	0.587	0.243	0.621
41	F8 V	11.959	2.217	1.740	1.188	0.482	0.181	0.495
42	G8 V	13.027	2.966	2.440	1.648	0.649	0.288	0.652
43	G	15.665		2.387	1.616	0.621	0.205	0.662
44	F-G	13.985	2.556	1.906	1.316	0.553	0.201	0.523
45	F8 V	13.220	2.337	1.776	1.262	0.547	0.210	0.531

Table 2. (continued)

ID	Ph.sp	V	$U–V$	$P–V$	$X–V$	$Y–V$	$Z–V$	$V–S$
46	G0 V	15.076	2.451	2.079	1.438	0.625	0.254	0.495
47	F-G	14.805	2.314	1.733	1.213	0.504	0.205	0.511
48	F5 IV	10.331	2.213	1.644	1.077	0.453	0.161	0.462
49	G8 III	12.740	3.675	3.033	2.086	0.858	0.332	0.782
50	G-K	15.661		1.915	1.428	0.587	0.337	0.470
51	MDGE-G5	13.919	2.476	1.913	1.386	0.598	0.213	0.562
52	G6 III	15.665			1.739	0.710	0.411	0.635
53	F9 V	11.980	2.268	1.795	1.250	0.512	0.197	0.509
54	K0 IV	14.879		2.679	1.771	0.685	0.304	0.638
55	K2 III	14.618			2.631	0.998	0.436	0.914
56	K0 IV	14.884		3.022	2.084	0.809	0.328	0.822
57	K1 IV	13.069	4.207	3.645	2.456	0.920	0.416	0.869
58	K1 V	13.803	3.608	3.046	2.083	0.808	0.380	0.775
59	F-G	14.917	2.326	1.720	1.178	0.510	0.121	0.569
60	G1 V	15.659		1.912	1.422	0.559	0.197	0.630
61	G9 III	13.805	3.718	3.173	2.152	0.835	0.310	0.833
62	F-G	15.563		1.826	1.316	0.571	0.154	0.579
63	G7 III	10.030	3.461	2.886	1.990	0.783	0.301	0.748
64	G0 III	14.595	2.746	2.109	1.519	0.616	0.233	0.679
65	F5 V	13.303	2.300	1.766	1.181	0.501	0.183	0.485
66	G9 V	15.613		2.383	1.625	0.641	0.289	0.666
67	F5 IV:	15.186	2.395	1.779	1.223	0.514	0.193	0.481
68	G9 IV	12.777	3.328	2.788	1.931	0.775	0.323	0.745
69	K0 IV-V	13.498	3.080	2.602	1.733	0.654	0.296	0.660
70	K2 V	13.296	3.291	2.803	1.898	0.682	0.343	0.761
71	F8 V	14.972	2.336	1.843	1.339	0.587	0.252	0.503
72	G0 V	14.988	2.623	1.835	1.286	0.531	0.201	0.509
73	F7 V	12.223	2.358	1.828	1.256	0.526	0.189	0.515
74	G5 IV	13.823	2.700	2.202	1.528	0.597	0.243	0.621
75	F9 V	11.836	2.275	1.781	1.240	0.505	0.189	0.505
76	G	13.429	3.591	2.897	2.269	1.002	0.438	1.066
77	G	15.724		1.887	1.415	0.555	0.304	0.647
78	G	15.565		2.449	1.623	0.597	0.167	0.712
79	F8 V	13.921	2.485	1.916	1.359	0.579	0.223	0.530
80	F8 V	14.774	2.438	1.905	1.323	0.560	0.181	0.630
81	K1 III	13.003	4.154	3.481	2.374	0.925	0.374	0.886
82	G0 V	15.572		2.135	1.514	0.642	0.246	0.621
83	F2 III	13.675	2.450	1.712	1.037	0.406	0.140	0.393
84	F5 V	14.070	2.294	1.747	1.195	0.519	0.169	0.526
85	G2 V:	14.484	2.459	2.153	1.485	0.608	0.200	0.622
86	G2 IV-V	13.188	2.548	2.061	1.444	0.570	0.215	0.585
87	G2 V:	14.022	2.575	2.113	1.486	0.617	0.274	0.605
88	MDGE-G8	14.684	2.520	1.811	1.251	0.529	0.192	0.577
89	K0 III-IV	11.946	3.677	3.065	2.072	0.792	0.332	0.765
90	B8/A7	11.559	2.093	1.423	0.655	0.258	0.085	0.203

Table 2. (continued)

ID	Ph.sp	V	U–V	P–V	X–V	Y–V	Z–V	V–S
91	F-G	15.662	2.075	1.805	1.227	0.525	0.160	0.477
92	K3 III	9.967	4.933	4.156	2.860	1.056	0.467	1.000
93	F9	14.331	2.762	2.088	1.471	0.615	0.246	0.618
94	K3 V	15.475			1.988	0.707	0.407	0.766
95	G8 IV	11.528	3.596	2.986	2.053	0.805	0.326	0.789
96	G0 V:	15.463	2.046	2.113	1.464	0.628	0.225	0.663
97	sdG3	15.056	2.268	1.998	1.414	0.615	0.253	0.590
98	F-G	15.234	2.319	1.841	1.350	0.564	0.174	0.537
99	K1 III	12.846	4.242	3.630	2.509	0.956	0.394	0.916
100	F-G	14.280	2.483	1.874	1.285	0.563	0.193	0.568
101	G8 III	12.362	3.650	3.053	2.072	0.809	0.310	0.775
102	A8 IV:	11.390	2.316	1.607	0.807	0.306	0.115	0.268
103	G	13.990	3.194	2.492	1.741	0.731	0.290	0.703
104	F9 V	12.388	2.355	1.881	1.310	0.537	0.208	0.542
105	F7 V	15.336		2.109	1.505	0.656	0.185	0.599
106	F9 V	14.382	2.480	1.994	1.391	0.593	0.224	0.573
107	K2 III	12.254	4.454	3.818	2.544	0.950	0.418	0.893
108	F8 V	14.904	2.386	1.852	1.311	0.567	0.221	0.523
109	G2 III	12.634	3.160	2.569	1.827	0.749	0.291	0.723
110	F2 III	14.078	2.299	1.661	1.065	0.440	0.145	0.450
111	F5 V	14.983	2.213	1.690	1.166	0.500	0.133	0.493
112	G2 V	12.945	2.538	2.094	1.462	0.597	0.233	0.594
113	F6 V	13.998	2.304	1.801	1.241	0.547	0.215	0.460
114	G0 V	12.764	2.631	2.086	1.478	0.622	0.223	0.610
115	K0 III	12.818	4.019	3.373	2.333	0.895	0.356	0.859
116	F8 V	11.096	2.330	1.823	1.243	0.519	0.189	0.503
117	G0 V md	13.214	2.241	1.765	1.260	0.543	0.194	0.540
118	G5 IV	12.299	3.034	2.538	1.759	0.733	0.277	0.670
119	G8 III-IV	14.578		3.137	2.158	0.864	0.349	0.773
120	G8 III-IV	13.118	3.509	2.863	1.998	0.807	0.316	0.767
121	F-G	15.025	2.394	1.821	1.304	0.550	0.270	0.474
122	F5 IV-V	12.137	2.210	1.662	1.099	0.464	0.172	0.450
123		14.718	2.447	2.016	1.465	0.596	0.159	0.616
124	G8 IV-V	13.538	3.114	2.671	1.866	0.773	0.302	0.748
125	G2 Ib	13.652	3.728	2.996	2.129	0.837	0.321	0.781
126	K0.5 IV	14.157		3.322	2.209	0.857	0.370	0.868
127	K1 IV	14.861		3.307	2.155	0.822	0.380	0.760
128	K2 V	15.197		2.870	1.967	0.723	0.353	0.773
129	F5 V	14.588	2.216	1.811	1.163	0.508	0.173	0.458
130	F8-G1	15.607		1.943	1.367	0.592	0.223	0.554
131	K4.5 V	15.109			2.303	0.764	0.487	0.870
132	G1 V	12.226	2.419	1.930	1.361	0.550	0.220	0.562
133	K1.5 III	11.719	4.377	3.734	2.566	0.974	0.414	0.930
134	F-G	14.252	2.610	2.027	1.426	0.603	0.203	0.619
135	G5 III:	15.758		2.431	1.720	0.641	0.226	0.688

Table 2. (continued)

ID	Ph.sp	V	U–V	P–V	X–V	Y–V	Z–V	V–S
136		15.628		1.609	1.174	0.516	0.110	0.480
137	F8 IV-V	11.948	2.289	1.742	1.170	0.476	0.174	0.472
138	F2 III	11.724	2.422	1.692	0.961	0.379	0.140	0.346
139	K1 V	15.749			1.906	0.725	0.348	0.706
140	G0 III-IV	14.572	2.682	2.134	1.478	0.600	0.208	0.588
141	MDGE-G2	15.061		2.457	1.751	0.729	0.259	0.698
142	G0 V	12.959	2.369	1.900	1.350	0.553	0.221	0.568
143	G	15.596		2.397	1.679	0.663	0.260	0.514
144	K	15.041		2.071	1.968	0.736	0.385	0.743
145	F	15.538		2.061	1.374	0.572	0.111	0.692
146	F-G	15.142	2.363	1.734	1.248	0.557	0.206	0.521
147		14.964	1.145	2.215	1.523	0.635	0.202	0.529
148	F5 V	15.214	2.262	1.702	1.128	0.478	0.154	0.467
149	G1 V	15.079	2.363	1.996	1.411	0.600	0.234	0.605
150	F7 V	13.650	2.305	1.840	1.263	0.555	0.178	0.542
151	F5 V:	15.017	2.473	1.795	1.257	0.532	0.177	0.438
152	F5 V	14.065	2.373	1.798	1.242	0.532	0.173	0.535
153	F5 IV-V	15.475	2.239	1.776	1.131	0.490	0.204	0.449
154	G	15.575		2.349	1.814	0.808	0.392	0.965
155	K7-M0 V	14.349		3.593	2.502	0.870	0.579	1.056
156	F-G	14.805	2.632	2.043	1.371	0.573	0.174	0.604
157	G	15.180		2.205	1.673	0.686	0.294	0.741
158	G2 IV-V	13.470	2.892	2.335	1.612	0.667	0.264	0.658
159	MDGE-G8	13.778	3.512	2.742	1.938	0.792	0.274	0.776
160	F8 V	11.981	2.447	1.903	1.331	0.547	0.205	0.540
161	G2 V	14.191	2.592	2.117	1.478	0.624	0.209	0.619
162	F8 V	13.291	2.303	1.795	1.244	0.522	0.194	0.500
163	G1.5 V:	15.096	2.434	2.019	1.421	0.601	0.278	0.538
164	K0 III	14.819		3.179	2.139	0.832	0.335	0.788
165	G7 III	12.375	3.567	2.929	2.056	0.821	0.320	0.790

new distance modulus of the Hyades (V–M_V = 3.3, Perryman et al. 1998).

The V magnitudes of the stars and the photometric spectral types are repeated in Table 3. The table also contains absolute magnitudes M_V, color excesses E_{Y-V}, extinctions A_V and distances r. The values of distances at $r > 200$ pc are rounded to the nearest number multiple of 10.

4. INTERSTELLAR EXTINCTION VS. DISTANCE

Figure 2 shows the plot of interstellar extinction A_V against distance r in parsecs. The following conclusions can be made.

1. The stars with zero extinction are distributed up to 2 kpc

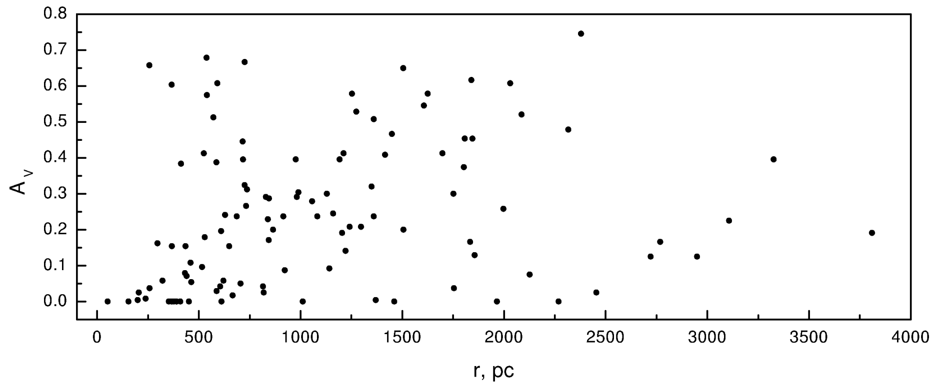

Fig. 2. Interstellar extinction vs. disctance in the NGC 2395 area.

distances. Probably, they are seen through transparent windows in the Galactic dust layer.

2. The rise of interstellar extinction takes place at 400 pc. It is an imperession that approximately at this distance a dust cloud or a group of smaller clouds is present. This cloud gives a maximum extinction of 0.7 mag. At a distance of 400 pc and a Galactic latitude of 14° the cloud should be about 100 pc above the Galactic plane.

3. The most distant stars of solar chemical composition in the area are: No. 135 (V = 15.76, G5 III, 9.4 kpc), No. 52 (V = 15.67, G6 III, 8.3 kpc), No. 164 (V = 14.82, K0 III, 5.9 kpc), No. 55 (V = 14.62, K2 III, 4.9 kpc) and No. 21 (V = 14.36, K2.5 III, 4.4 kpc). Seven stars in the area (Nos. 18, 19, 38, 51, 88, 141, 159) were classified as metal-deficient giants of spectral class G (see Table 2). Some of them are fainter than 14th mag. They may be among the most distant stars, but we do not know their absolute magnitudes.

4. The exponential Parenago formula with the coefficients A_0 = 1.5 mag/kpc and $\beta = 0.11$ kpc (Parenago 1945; Sharov 1963) for this sky position gives the maximum extinction of 0.69 mag and with A_0 = 1.0 mag/kpc and the same β the maximum extinction is 0.46 mag. These values are consistent with the observed distribution of points.

5. The IRAS and COBE/DIRBE 100 μm dust emission map of the area (see Schlegel et al. 1998 and http://skyview.gsfc.nasa.gov) shows somewhat uneven distribution of the dust emission in our area: the largest dust concentration is seen in its south-western part. However, our results fail to show any extinction differences in different parts of the area on macro scale. The main source of the observed extinction differences in Figure 2 probably is related with the well-known cloudy structure of interstellar dust.

Table 3. Photometric classification, extinctions and distances.

ID	Ph.sp	M_V	$Y{-}V$	E_{Y-V}	A_V	r (pc)	V
1	F5 V	3.50	0.466	0.006	0.025	205	10.085
3	G0 V	4.30	0.600	0.070	0.291	830	14.187
4	K3 V	6.60	0.719	0.019	0.079	432	14.854
5	G0 V	4.30	0.600	0.070	0.291	982	14.552
6	F8 V	4.00	0.520	0.010	0.042	605	12.949
7	G8 V	5.50	0.709	0.099	0.412	525	14.512
9	G0 V	4.30	0.544	0.014	0.058	621	13.325
10	G9 IV	3.10	0.843	0.163	0.678	538	12.432
12	F7 V	3.80	0.484	–0.016	0.000	1966	15.268
13	F8 V	4.00	0.619	0.109	0.453	1808	15.739
14	K1 V	6.10	0.644	–0.006	0.000	52	9.685
15	F5 V	3.50	0.443	–0.017	0.000	612	12.434
17	F9 V	4.10	0.554	0.034	0.141	1222	14.677
20	G5 V	5.00	0.583	0.013	0.054	463	13.380
21	K2.5 III	0.55	1.034	0.150	0.620	4356	14.360
22	G8 V	5.50	0.611	0.001	0.004	200	12.011
23	G8 V	5.50	0.688	0.078	0.324	726	15.129
24	G8 V	5.50	0.668	0.058	0.241	629	14.736
27	F5 V	3.50	0.491	0.031	0.129	1856	14.972
29	F8 IV	2.70	0.599	0.099	0.412	1212	13.529
30	G5 V	5.00	0.665	0.095	0.395	977	15.344
31	K1 III	0.70	0.840	0.030	0.125	2722	12.999
35	F9 IV -V	3.40	0.567	0.047	0.196	610	12.416
39	F8 V	4.00	0.532	0.022	0.092	1142	14.379
40	G0 V	4.30	0.587	0.057	0.237	1083	14.710
41	F8 V	4.00	0.482	–0.028	0.000	391	11.959
42	G8 V	5.50	0.649	0.039	0.162	297	13.027
45	F8 V	4.00	0.547	0.037	0.154	650	13.220
46	G0 V	4.30	0.625	0.095	0.395	1192	15.076
48	F5 IV	2.50	0.453	–0.007	0.000	368	10.331
49	G8 III	0.80	0.858	0.148	0.616	1840	12.740
52	G6 III	0.90	0.710	0.040	0.166	8313	15.665
53	F9 V	4.10	0.512	–0.008	0.000	377	11.980
54	K0 IV	3.10	0.685	–0.015	0.000	2269	14.879
55	K2 III	0.60	0.998	0.138	0.574	4884	14.618
56	K0 IV	3.10	0.809	0.109	0.453	1846	14.884
57	K1 IV	3.10	0.920	0.160	0.666	726	13.069
58	K1 V	6.10	0.808	0.158	0.657	257	13.803
60	G1 V	4.40	0.559	0.009	0.037	1755	15.659
61	G9 III	0.80	0.835	0.095	0.395	3326	13.805
63	G7 III	0.80	0.783	0.093	0.387	587	10.030
64	G0 III	1.50	0.616	0.046	0.191	3810	14.595
65	F5 V	3.50	0.501	0.041	0.171	844	13.303
66	G9 V	5.70	0.641	0.021	0.087	923	15.613
67	F5 IV	2.50	0.514	0.054	0.225	3107	15.186

Table 3. (continued)

ID	Ph.sp	M_V	$Y–V$	E_{Y-V}	A_V	r (pc)	V
68	G9 IV	3.10	0.775	0.095	0.395	718	12.777
69	K0 V	5.90	0.654	0.014	0.058	322	13.498
70	K2 V	6.40	0.682	0.002	0.008	239	13.296
71	F8 V	4.00	0.587	0.077	0.320	1350	14.972
72	G0 V	4.30	0.531	0.001	0.004	1370	14.988
73	F7 V	3.80	0.526	0.026	0.108	460	12.223
74	G5 IV	3.00	0.597	–0.013	0.000	1461	13.823
75	F9 V	4.10	0.505	–0.015	0.000	353	11.836
79	F8 V	4.00	0.579	0.069	0.287	845	13.921
80	F8 V	4.00	0.560	0.050	0.208	1298	14.774
81	K1 III	0.70	0.925	0.115	0.478	2317	13.003
82	G0 V	4.30	0.642	0.112	0.466	1450	15.572
83	F2 III	1.70	0.406	0.006	0.025	2455	13.675
84	F5 V	3.50	0.519	0.059	0.245	1161	14.070
85	G2 V	4.60	0.608	0.048	0.200	865	14.484
86	G2 IV -V	3.75	0.570	0.010	0.042	816	13.188
87	G2 V	4.60	0.617	0.057	0.237	687	14.022
89	K0 III-IV	1.90	0.792	0.057	0.237	916	11.946
92	K3 III	0.50	1.056	0.146	0.607	591	9.967
94	K3 V	6.60	0.707	0.007	0.029	588	15.475
95	G8 IV	3.10	0.805	0.145	0.603	367	11.528
96	G0 V	4.30	0.628	0.098	0.408	1416	15.463
99	K1 III	0.70	0.956	0.146	0.607	2031	12.846
101	G8 III	0.80	0.809	0.099	0.412	1698	12.362
102	A8 IV	1.80	0.306	0.006	0.025	819	11.390
104	F9 V	4.10	0.537	0.017	0.071	440	12.388
105	F7 V	3.80	0.656	0.156	0.649	1505	15.336
106	F9 V	4.10	0.593	0.073	0.304	990	14.382
107	K2 III	0.60	0.950	0.090	0.374	1803	12.254
108	F8 V	4.00	0.567	0.057	0.237	1360	14.904
109	G2 III	1.00	0.749	0.139	0.578	1626	12.634
110	F2 III	1.70	0.440	0.040	0.166	2769	14.078
111	F5 V	3.50	0.500	0.040	0.166	1834	14.983
112	G2 V	4.60	0.597	0.037	0.154	435	12.945
113	F6 V	3.60	0.547	0.067	0.279	1057	13.998
114	G0 V	4.30	0.622	0.092	0.383	413	12.764
115	K0 III	0.70	0.895	0.125	0.520	2087	12.818
116	F8 V	4.00	0.519	0.009	0.037	258	11.096
118	G5 IV	3.00	0.733	0.123	0.512	572	12.299
119	G8 III-IV	1.95	0.864	0.179	0.745	2380	14.578
120	G8 III-IV	1.95	0.807	0.122	0.507	1360	13.118
122	F5 IV-V	3.00	0.464	0.004	0.017	666	12.137
124	G8 IV-V	4.30	0.773	0.138	0.574	540	13.538
126	K0.5 IV	3.10	0.857	0.127	0.528	1275	14.157
127	K1 IV	3.10	0.822	0.062	0.258	1998	14.861

Table 3. (continued)

ID	Ph.sp	M_V	$Y–V$	E_{Y-V}	A_V	r (pc)	V
128	K2 V	6.40	0.723	0.043	0.179	529	15.197
129	F5 V	3.50	0.508	0.048	0.200	1506	14.588
131	K4.5 V	7.05	0.764	0.000	0.000	409	15.109
132	G1 V	4.40	0.550	0.000	0.000	367	12.226
133	K1.5 III	0.65	0.974	0.139	0.578	1253	11.719
135	G5 III	0.90	0.641	–0.020	0.000	9368	15.758
137	F8 IV-V	3.67	0.476	–0.030	0.000	452	11.948
138	F2 III	1.70	0.379	–0.021	0.000	1011	11.724
139	K1 V	6.10	0.725	0.075	0.312	737	15.749
142	G0 V	4.30	0.553	0.023	0.096	516	12.959
148	F5 V	3.50	0.478	0.018	0.075	2127	15.214
149	G1 V	4.40	0.600	0.050	0.208	1242	15.079
150	F7 V	3.80	0.555	0.055	0.229	840	13.650
151	F5 V	3.50	0.532	0.072	0.300	1752	15.017
152	F5 V	3.50	0.532	0.072	0.300	1130	14.065
153	F5 IV-V	3.00	0.490	0.030	0.125	2950	15.475
155	K7 V-M0 V	8.40	0.870	–0.050	0.000	155	14.349
158	G2 IV-V	3.75	0.667	0.107	0.445	716	13.470
160	F8 V	4.00	0.547	0.037	0.154	368	11.981
161	G2 V	4.60	0.624	0.064	0.266	733	14.191
162	F8 V	4.00	0.522	0.012	0.050	705	13.291
163	G1.5 V	4.50	0.601	0.046	0.191	1205	15.096
164	K0 III	0.70	0.832	0.062	0.258	5919	14.819
165	G7 III	0.80	0.821	0.131	0.545	1607	12.375

Table 4. Probable members of NGC 2395.

ID	Sp. type	V	E_{Y-V}	r, pc
41	F8 V	11.96	–0.03	390
53	F9 V	11.98	–0.01	380
73	F7 V	12.22	0.03	440
75	F9 V	11.84	–0.01	350
104	G0 V	12.39	0.01	410
112	G2 V	12.45	0.04	430
114	G0 V	12.76	0.09	410
132	G0 V	12.23	0.02	370
137	F5 V	11.95	0.02	470
142	G0 V	12.96	0.02	520

5. ON THE CLUSTER MEMBERS

For the estimation of the membership of the cluster and for the determination of its physical properties we have plotted the color-magnitude diagram for the area stars (Figure 3). Already Chincarini

(1963) has shown that in the V, $B–V$ diagram the main sequence of the cluster is not well defined. Figure 3 shows that there are now signs of the cluster sequences. We have selected 10 stars which according to their distances and spectral types might be members of a physical group. These stars are listed in Table 4.

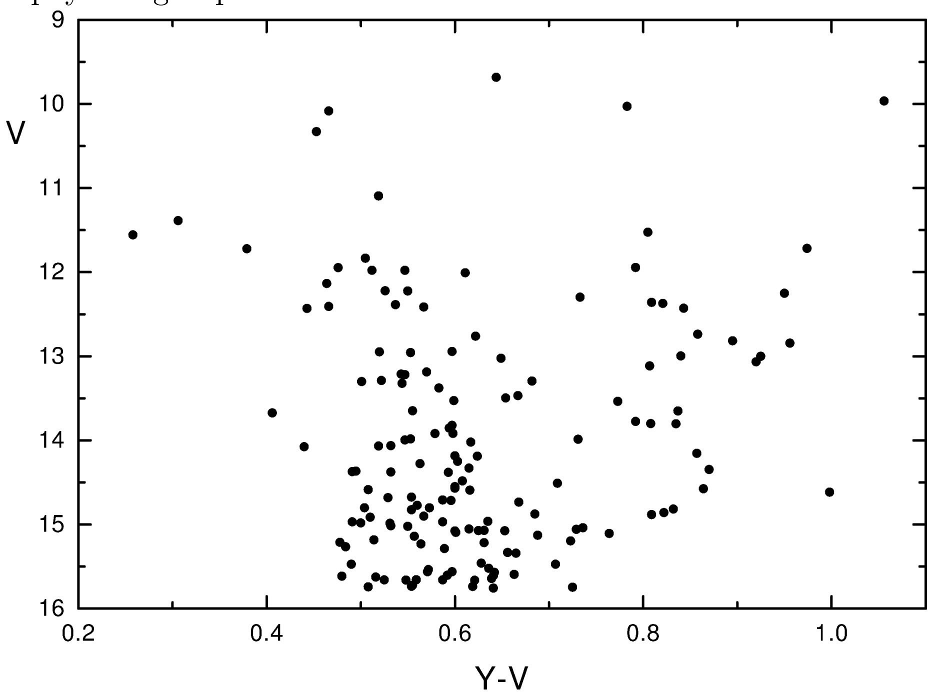

Fig. 3. Color-magnitude diagram in the NGC 2395 area.

The average distance of these stars is 420 pc. In the V vs. $Y–V$ diagram they form a relatively compact group which, however, has no extension to fainter stars. It is possible that these main-sequence stars of spectral classes F5–G2 have gathered accidentally in the same volume of space with a radius of about 70–100 pc.

10 stars of Table 4 include all 9 stars used by Chincarini (1963) to determine color excess and distance of the cluster. Chincarini has considered that these stars belong to B-type main sequence, while in reality they are F and G main-sequence stars. Therefore, the parameters of the cluster determined by Chincarini were completely unreal.

6. MORPHOLOGY OF THE CLUSTER

The distribution of member stars within a cluster should change during its evolution. The structure of the parent molecular cloud

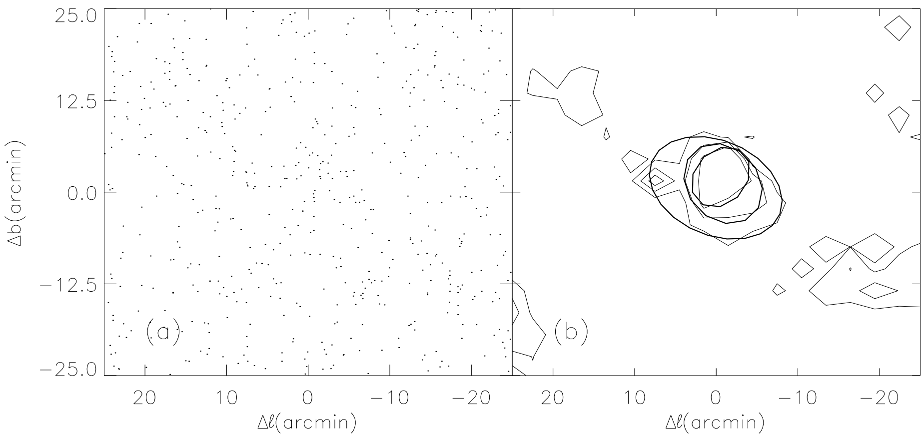

Fig. 4. 2MASS field for morphology determination of NGC 2395; (b) contour plot of NGC 2395, see the text for more explanations.

from which the star cluster formed plays an important role on the initial stellar distribution. Mutual gravitational interaction then modifies the distribution of member stars of the cluster. As the cluster ages, external disturbances such as the Galactic tidal force or encounters with giant molecular clouds would eventually desintegrate the star cluster.

Chen et al. (2004) have studied the morphology of Galactic open clusters with the help of the 2MASS point-source catalog. They concluded that all open clusters are elongated. This phenomenon is evident even among the young clusters (a few million years old): these clusters had no sufficient time to fully relax dynamically, and their morphology must bear direct imprint of the structure of the parent molecular clouds. Furthermore, the cluster ellipticity is found to be correlated with its height above the Galactic plane, suggesting the influence of the Galactic tidal force.

NGC 2395 may be an old open whose dynamical evolution has been affected by the the Galactic perturbation forces. We analyzed the morphology of NGC 2395 with the Two-Micron All-Sky Survey (2MASS) point-source catalog in the K_s band. The Palomar DSS images show clearly dozens of bright stars distributed sparsely in an elongated way. The 2MASS data also show a concentration of relatively bright stars. Stars fainter than $K_s \sim 13$ mag display no obvious density enhancement against field stars. It is likely that low-mass member stars have been "evaporated" over the age of NGC 2395.

We applied to NGC 2395 the same probabilistic star-counting technique as described in Chen et al. (2004). Essentially the local stellar number density, or the degree of clustering, around a given star is a measure of the likelihood of that star being in a cluster environment. Once a star is assigned a “membership probability”, a spatial grid is used to compute the number density of *member stars*, to which the boundary (3σ above background) and the core (one-third of the maximum density) of a star cluster are fitted by ellipses. Figure 4 shows the distribution of stars of NGC 2395. It is seen that the star group is elongated, with an outer boundary of an eccentricity $\sim$0.7 and a core of an eccentricity $\sim$0.6. However, as it was shown in Section 5, most of stars in this group are located at very different distances and cannot be the cluster members. Only a small part of these stars are probable members of the cluster. NGC 2395 is located in the thick disk, about 100 pc above the Galactic plane (Chen et al. 2003). Probably it has suffered a significant tidal distortion on its shape and lost most of its former members.

6. CONCLUSIONS

1. Our investigation shows that many stars in NGC 2395 are at very different distances. Only 10 stars of spectral types F5 V – G2 V with V magnitudes between 11.8 and 13.0 may be suspected to belong to a physical group. However, there is no evidence of extension of the main sequence to fainter stars.

2. The distances of the mentioned 10 stars are between 350 pc and 520 pc, the average value is 420 pc. Color excesses of these stars are close to zero, only the star No. 114 has $E_{Y-V} = 0.09$ mag. Metallicity of these stars probably is close to solar, since all stars which are most similar to the cluster stars have normal chemical composition.

3. According to probabilistic star-counting analysis, NGC 2395 may be the cluster which suffered significantly from the Galaxtic tidal distortion on its shape and population.

4. For a better understanding of the cluster, proper motions and radial velocities of stars would be helpful.

ACKNOWLEDGMENTS. This work was supported by the National Science Council of Taiwan, the Ministry of Education and Science of Lithuania, and by the American Astronomical Society Chretien Grant of 2000.

REFERENCES

Battinelli P., Capuzzo-Dolcetta R. 1991, MNRAS, 249, 76

Chen W., Chen C. W., Shu C. G. 2004, AJ, submitted

Chen L., Hou J. L., Wang J. J. 2003, AJ, 125, 1397

Chincarini G. 1963, Mem. Soc. Astron. Italiana, 34, 23

Collinder P. 1931, Annals Leiden Obs., 2

Dias W. S., Alessi B. S., Moitinho A., Lepine J. R. D. 2002, A&A, 389, 871

Dutra C. M., Bica E. 2000, A&A, 359, 347

Kazlauskas A., Černis K. 2003, unpublished

Laugalys V., Straižys V. 2002, Baltic Astronomy, 11, 205

Loktin A. V., Beshenov G. V. 2001, Astr. Letters, Moscow, 27, 386

Lynga G. 1987, Open Cluster Data, 5th Edition, Lund Observatory, CDS VII-92A

Mermilliod J.-C. 2004, A Site Devoted to Stellar Clusters WEBDA, http://obswww.unige.ch/webda

Parenago P. P. 1945, AZh, 22, 129

Perryman M. A. C., Brown A. G. A., Lebreton Y. et al. 1998, A&A, 331, 81

Schlegel D. J., Finkelbeiner D. P., Davis M. 1998, ApJ, 500, 525

Sharov A. S. 1963, AZh, 40, 900 = Soviet Astron., 7, No. 5

Straižys V. 1992, *Multicolor Stellar Photometry*, Pachart Publishing House, Tucson, Arizona

Straižys V., Černis K., Kazlauskas A., Laugalys V. 2002, Baltic Astronomy, 11, 231

Straižys V., Sviderskienė Z. 1972, Bull. Vilnius Obs., No. 35, 3

Trumpler R. J. 1930, Bull. Lowell Obs., 14, 171

Zdanavičius J., Zdanavičius K. 2003, Baltic Astronomy, 12, 642