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INTERSTELLAR EXTINCTION IN THE DIRECTION OF THE OPEN CLUSTER IC 348 AND THE PER OB2 ASSOCIATION

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Abstract. The relationship between interstellar extinction and distance in the direction of dark clouds in the areas around the open cluster IC 348 and the association Per OB2 is determined using the results of photoelectric photometry of 189 stars in the Vilnius photometric system. Two absorbing layers are found. The nearest layer, covering the whole area around IC 348, shows the mean extinction A_V of ~0.7 mag. It begins at the distance of 160 pc and probably is an extension of the Taurus dark clouds to the north-west. The second absorbing layer has the form of a chain of dark condensations, named L1468, L1470 and L1471 and is at 260 pc distance. This layer has a higher density, its mean extinction being ~2.0 mag. The cluster IC 348 is at about the same distance and is physically related with the dark cloud L1470. Distance of the Per OB2 association is found to be 340 pc, the mean extinction of its members is 0.95 mag. A model of spatial distribution of the Perseus and Taurus dark clouds based on photometric distance determinations in this and previous papers is proposed. Six stars in the IC 348 area are suspected to have an emission in the Hα line.

Key words: open cluster – OB associations – dark clouds – interstellar extinction – photometric classification – Vilnius photometric system

1. Introduction

This paper extends the interstellar extinction studies in the Perseus dark clouds. In earlier papers (Černis 1990a,b) the western part of the Perseus dark cloud complex around the reflection nebula NGC 1333 has been studied. The present paper deals with distribution of interstellar dust in two areas of the eastern part of the dark clouds. The first of them is of $2 \times 2°$ size around a young open cluster IC 348 (Dreyer 1895) and embraces the L1468 (or B3) and L1470 (or B4) dark clouds (Lynds 1962 and Barnard 1927). Its center is at $\alpha(1950) = 3^h40^m\!.0$ and $\delta(1950) = +31°40'$. All stars down to $V = 13$ mag are measured here. The second area is of $5 \times 7°$ size and includes the Per OB2 association. Its center is about 3 deg northeast from IC 348. In this area almost all stars of Per OB2 association down to 10 mag are measured.

The aim of this work was to determine the distance and extinction of the dark clouds in the eastern part of the Perseus complex (Fig. 1), the distances of the open cluster IC 348 and of the association Per OB2, as well as to find the physical relationship between these stellar groups and the dark clouds. The next goal of the study was to construct the spatial model of all complex of the Perseus and Taurus dark clouds using the new results together with the results obtained earlier.

2. Description of the studied areas

The open cluster IC 348 lies in the eastern part of the Perseus complex of dark clouds which forms a chain of dust condensations 2° wide and 6° long consisting of dark clouds L1448 (B203), L1450, L1451 (B202), L1452 (B206), L1455 (B204), B1, L1468 (B3), L1470 (B4) and L1471 (B5), see Fig. 1. Eastwards from the cluster, the Per OB2 association is situated (Ruprecht et al. 1981).

In the area of IC 348, studied in this paper, there are two dark clouds: L1468 and L1470. Khavtassi (1960) atlas shows here the cloud No. 255. In the association area the dust clouds Khavtassi 258 and 260 are shown. The last one is also B5 according to Barnard or L1471 according to Lynds.

Space distribution of the dark clouds in Perseus was investigated by Heeschen (1951), Lynds (1969) and Cernicharo et al. (1985) using star and galaxy counts. All authors agree that there are several

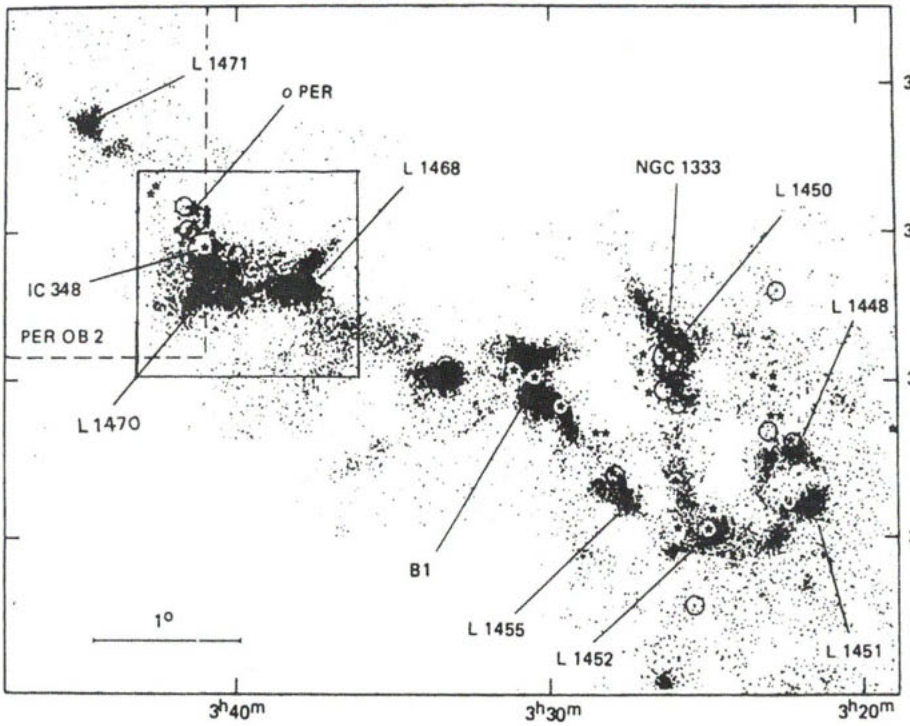

Fig. 1. The schematic chart of the Perseus complex of dark clouds.

clouds at different distances from the Sun. However, the estimated distances of the clouds show disagreement.

The brightest stars of IC 348 illuminate the surrounding dust, forming a group of reflection nebulae. A number of Hα emission stars have been detected in IC 348 (Herbig 1954). Blaauw (1952) suspects that the cluster is a part of the association. Dense areas of the clouds were studied in radio frequencies by Sancisi et al. (1974), Bachiller and Cernicharo (1986) and Bachiller et al. (1987). CO, OH, CH, NH_3 and H_2CO molecules were detected. The IRAS sources in the area were studied by Ladd et al. (1993).

The cluster IC 348 was first investigated by Gingrich (1922) who made an attempt to determine proper motions of its stars and the cluster distance. One-dimensional spectral classes of the brightest cluster stars were obtained by Hubble (1922), Vyssotsky and Williams (1948) and Greenstein (1948) and for faint stars by Strom et al. (1974). Two-dimensional spectral classes and *UBV* photometry are given by Harris et al. (1954). Strom et al. (1974) give more *UBV* and infrared photometry. Pfau and Lehmann (1982) present photographic *UBV* photometry of the field stars near IC 348. The age of the cluster is evaluated to be from 5 to 20 mln years (Strom et al. 1974). Many authors draw attention to a considerable variation of extinction throughout the cluster. From inspection of the Palomar Atlas plates, Lynds (1969) finds dust condensations of about 3′ sizes.

Blaauw (1952) was the first to study 17 members of the Per OB2 association. From their proper motions, he has found evidence of an expansion gradient corresponding to 1.3–1.5 mln year age. This result was later confirmed by Lesh (1969) and Sancisi et al. (1974). Further age estimate (2–3 mln years) has been made by Klochkova and Kopylov (1985) from the $[V_0, (B-V)_0]$ diagram. *UBV* photometry of the association was published by Harris (1956), Seyfert et al. (1960), Blanco et al. (1968) and Jaschek et al. (1972). Photometry in the Strömgren system was obtained by Rydgren (1971). MK spectral classes are given by Hiltner (1956) and Guetter (1977). Klochkova and Kopylov (1985) investigated the chemically peculiar stars of the association.

Most of the mentioned investigations are concerned with the brightest stars of the cluster and association. Stars fainter than 11 or 12 mag remain without photometric and spectral data.

3. Photometric observations and two-dimensional quantification of stars

Photometric observations of stars were accomplished on the 1-meter telescope of our institute at the Maidanak Observatory in Uzbekistan during four autumn observing runs (1985, 1987, 1989 and 1991). Techniques of observation, reduction outside the atmosphere and data processing are the same as described by Černis (1987, 1990). The mean square errors of the catalogue are ±0.012 mag for V magnitude and ±0.010–0.012 mag for colour indices (for some red stars, the ultraviolet and violet colour indices are of ±0.015 mag accuracy). The results of the photometry of 189 stars are presented in Table 1 which contains: the numbers of stars identified in Figs. 2, 3, 4 and 5, BD and HD numbers, coordinates, photometric two-dimensional classification obtained in the present work, V magnitudes, colour indices $U-P$, $P-X$, $X-Y$, $Y-Z$, $Z-V$ and $V-S$ and the number of independent observations n.

Table 1. The results of photometry.

No.	BD	HD	α(1950)	δ(1950)	Sp.	V	U–P	P–X	X–Y	Y–Z	Z–V	V–S	n
1.	37°779		$3^h28^m15^s$	$37°33'.1$	F3V	9.29	0.51	0.60	0.61	0.31	0.17	0.44	1
2.	37°794	22114	3 31 56	37 51.0	B7III	7.57	0.43	0.51	0.27	0.17	0.12	0.24	1
3.	37°796		3 32 57	37 55.6	A1V	9.83	0.62	0.85	0.45	0.26	0.14	0.30	1
4.	30°556	22307	3 33 30	30 54.6	F2V	8.57	0.57	0.67	0.57	0.26	0.13	0.38	2
5.	31°622		3 33 35	31 21.2	K5III	9.83	0.83	1.58	2.28	0.75	0.58	1.19	2
6*.	36°730		3 33 55	37 00.0	A0V	10.50	0.75	0.83	0.47	0.30	0.14	0.35	2
7.	30°557	22360	3 34 01	30 57.6	G9III	7.75	0.61	0.95	1.29	0.50	0.31	0.76	2
8.	31°624		3 34 05	31 25.7	F0V	10.86	0.53	0.67	0.62	0.34	0.20	0.43	2
9.	36°731		3 34 08	37 04.5	B8.5V	9.58	0.67	0.73	0.43	0.30	0.15	0.36	2
10.	30°558	22418	3 34 22	30 57.4	F5V	6.88	0.52	0.56	0.62	0.30	0.15	0.42	2
11.	31°625		3 34 28	31 27.3	A6V	9.36	0.57	0.75	0.56	0.27	0.18	0.34	2
12.			3 34 42	31 21.6	F5V	11.13	0.54	0.56	0.68	0.37	0.23	0.50	2
13.	30°557		3 35 07	30 42.2	F7V	10.57	0.50	0.58	0.72	0.38	0.21	0.55	2
14.	32°649		3 35 33	32 42.6	F0V	10.21	0.62	0.72	0.66	0.32	0.19	0.45	2
15.	31°627		3 35 46	32 05.1	G2V	10.47	0.45	0.58	0.84	0.37	0.25	0.50	2
16.	30°560		3 35 47	31 14.2	A8V	10.08	0.61	0.72	0.60	0.24	0.17	0.38	2
17.			3 35 49	32 04.4	G2V	11.49	0.50	0.59	0.86	0.37	0.29	0.51	2
18.			3 35 55	32 03.8	F8V	11.24	0.53	0.59	0.77	0.38	0.27	0.49	2
19.	32°651		3 36 15	32 23.7	F0V	9.50	0.62	0.77	0.61	0.27	0.15	0.39	1
20.	37°808		3 36 34	37 37.5	A4:IV	9.70	0.84	0.97	0.68	0.37	0.20	0.46	2
21.			3 36 37	31 26.7	G2V	11.99	0.45	0.67	0.84	0.40	0.27	0.55	2
22*.	31°629		3 36 48	31 45.9	B3:III:	9.10	0.66	0.62	1.03	0.76	0.39	1.07	4
23.	30°561		3 36 58	31 09.3	F1V	9.88	0.60	0.70	0.66	0.29	0.20	0.45	2
24.	30°562		3 37 25	31 09.3	F7V	10.12	0.55	0.62	0.77	0.37	0.23	0.55	2
25.	31°630	22781	3 37 42	31 40.0	K2V	8.79	0.45	0.82	1.16	0.30	0.36	0.71	1
26.			3 37 51	31 08.5	G1V	11.14	0.58	0.69	1.03	0.45	0.32	0.76	2
27.			3 37 54	31 58.4	F8III	12.33	0.81	0.78	1.08	0.60	0.34	0.91	1
28.	31°632		3 37 54	31 57.5	A9V	9.49	0.60	0.76	0.58	0.27	0.17	0.38	2
29.	31°633		3 37 58	31 26.3	G7V	10.21	0.43	0.64	0.91	0.35	0.25	0.61	2
30.	30°563		3 38 05	31 17.4	F4IV-V	9.92	0.55	0.61	0.72	0.33	0.21	0.50	2
31.	34°712	22848	3 38 11	34 14.2	K1III	7.81	0.56	0.98	1.47	0.50	0.37	0.68	1
32.	37°814	22859	3 38 28	37 25.7	A0V	7.74	0.54	0.83	0.34	0.17	0.07	0.15	2
33.	31°634		3 38 32	31 26.6	A8V	10.14	0.59	0.76	0.54	0.27	0.17	0.34	2
34.	31°635		3 38 44	31 35.2	F7V	10.59	0.54	0.58	0.73	0.36	0.22	0.54	2
35.	31°636		3 38 50	32 13.7	G2V	9.98	0.46	0.58	0.80	0.34	0.21	0.52	2
36*.	36°735		3 39 03	37 06.5	B8.5IV	9.89	0.67	0.71	0.45	0.30	0.16	0.38	2
37*.	36°735		3 39 03	37 06.6	G8III-IV	10.12	0.66	1.00	1.53	0.63	0.35	0.90	2
38.			3 39 04	32 48.1	A4V	10.52	0.76	1.00	0.66	0.37	0.18	0.51	2
39.	31°637		3 39 08	31 31.1	F9V	9.00	0.48	0.56	0.72	0.32	0.22	0.50	2
40.			3 39 08	31 16.5	G1V	12.10	0.56	0.65	0.94	0.48	0.29	0.66	2
41.	30°564		3 39 11	31 00.6	F2V	9.72	0.64	0.70	0.71	0.36	0.20	0.52	2
42*.	33°698	22951	3 39 12	33 48.4	B1V	4.97	0.15	0.17	0.19	0.17	0.06	0.17	3
43.			3 39 14	31 45.9	K3.5V	12.67	0.45	1.10	1.49	0.32	0.47	0.90	2
44.	31°638		3 39 14	32 15.1	G1V	9.66	0.48	0.65	0.81	0.34	0.23	0.54	3
45.			3 39 15	31 14.9	K3III	12.64	0.87	1.25	2.12	0.81	0.56	1.28	2
46.			3 39 16	31 48.3	A6IV	12.40	0.93	1.10	0.96	0.55	0.30	0.79	1
47.	32°659	22963	3 39 18	32 46.9	F4V	6.73	0.50	0.63	0.64	0.32	0.16	0.45	2
48.			3 39 24	32 13.8	K2V	11.05	0.49	0.90	1.30	0.30	0.40	0.75	2

Table 1 (continued)

No.	BD	HD	α(1950)	δ(1950)	Sp.	V	U–P	P–X	X–Y	Y–Z	Z–V	V–S	n
49.			3 39 35	32 13.7	G1V	12.46	0.50	0.53	0.86	0.40	0.26	0.62	1
50.	32°660	23027	3 39 52	33 10.0	A5V	9.25	0.70	0.86	0.62	0.32	0.17	0.43	2
51.	31°639	23040	3 39 52	31 29.6	K4V	9.10	0.48	0.99	1.42	0.27	0.47	0.82	2
52.	31°640		3 39 53	31 49.0	A3V	11.40	0.89	1.02	0.92	0.58	0.34	0.80	2
53.	33°703		3 40 05	33 25.8	A1V	10.82	0.75	0.97	0.61	0.43	0.16	0.44	1
54.			3 40 08	31 27.2	G0V	11.97	0.55	0.69	0.95	0.51	0.30	0.74	2
55.	33°704	23060	3 40 13	33 57.5	B3V	7.44	0.26	0.34	0.28	0.19	0.09	0.23	2
56.			3 40 16	32 08.1	K0III	12.76	0.84	1.00	1.72	0.73	0.47	1.11	2
57.	32°661		3 40 32	32 28.1	G0V	9.07	0.46	0.55	0.74	0.31	0.19	0.51	2
58.			3 40 43	32 03.7	G2IV	12.75	0.63	0.78	1.21	0.57	0.38	0.96	2
59.	32°662		3 40 46	32 28.4	F0V	9.27	0.60	0.70	0.66	0.31	0.18	0.44	2
60.	33°706		3 40 48	34 01.9	B8V	10.16	0.54	0.64	0.39	0.24	0.12	0.32	2
61.	36°741	23130	3 40 48	36 43.2	A2V	8.85	0.56	0.85	0.44	0.20	0.10	0.20	2
62.			3 40 50	32 00.3	F9.5V	11.34	0.52	0.66	0.85	0.40	0.26	0.64	2
63.*	31°641		3 41 00	31 57.9	A3V	9.89	0.71	0.92	0.60	0.32	0.18	0.40	5
64.			3 41 01	31 57.8	A3V	10.00	0.71	0.92	0.63	0.34	0.18	0.42	5
65.			3 41 01	31 29.5	K1IV-V	13.10	0.50	1.00	1.33	0.60	0.40	0.89	2
66.			3 41 11	32 00.1	F2V	1191	0.66	0.71	0.82	0.47	0.26	0.68	2
67.*	31°642	23180	3 41 11	32 07.8	B1III	3.83	0.20	0.23	0.24	0.17	0.08	0.20	2
68.			3 41 13	31 58.2	G0V	11.62	0.51	0.61	0.88	0.43	0.25	0.66	2
69.*			3 41 16	32 01.6	F9Ve?	13.47	0.78	0.79	1.17	0.61	0.39	0.99	3
70.			3 41 16	32 00.8	F1:IV	11.55	0.80	0.87	0.91	0.55	0.35	0.80	4
71.*	35°744	23204	3 41 22	35 41.9	A1V	8.32	0.59	0.86	0.43	0.22	0.12	0.20	2
72.			3 41 22	32 17.2	A1V	11.68	0.88	1.05	0.80	0.52	0.31	0.67	2
73.			3 41 23	32 00.5	A4V	11.75	0.83	1.04	0.81	0.49	0.27	0.65	4
74.			3 41 23	31 57.0	A8III-IV	10.60	0.95	1.03	0.90	0.52	0.33	0.72	4
75.			3 41 23	31 59.4	G3:Ve?	13.92	0.48	0.88	1.15	0.56	0.51	1.10	2
76.			3 41 24	31 59.2	F8:Ve?	13.34	0.88	0.84	1.19	0.66	0.48	1.14	2
77.*	31°643		3 41 26	32 00.4	B4.5V	8.52	0.56	0.58	0.64	0.44	0.26	0.64	7
78.			3 41 27	32 00.7	A3IV	10.22	0.99	1.04	0.80	0.52	0.28	0.73	5
79.			3 41 29	31 57.4	G7IVe?	12.94	0.74	1.02	1.47	0.81	0.53	1.22	3
80.			3 41 39	32 10.0	B8V	14.02	0.98	1.06	1.08	0.85	0.47	1.05	2
81.			3 41 40	32 16.8	G1V	13.77	0.68	0.69	1.15	0.64	0.36	0.94	2
82.			3 41 40	32 22.1	K5III	12.74	1.20	1.27	2.74	0.96	0.81	1.64	3
83.			3 41 40	32 06.2	K5:Ve?	13.95	0.75	1.34	1.83	0.34	0.61	1.03	2
84.			3 41 41	32 07.5	K3V	13.25	0.40	1.08	1.54	0.48	0.39	0.86	2
85.			3 41 42	32 09.9	B5V	11.23	0.57	0.65	0.89	0.61	0.37	0.94	1
86.			3 41 48	32 18.0	K2III	12.81	1.07	1.68	2.10	0.93	0.67	1.45	2
87.			3 41 53	31 55.5	A7V	13.32	0.95	1.00	1.09	0.70	0.40	0.91	2
88.	30°567		3 41 57	30 45.1	A0IV	9.88	0.82	0.87	0.56	0.37	0.20	0.45	2
89.			3 41 59	32 01.1	G0IVe?	12.65	0.67	0.85	1.05	0.62	0.39	0.93	2
90.	30°568		3 41 59	30 56.3	A7IV	9.51	0.76	0.88	0.62	0.31	0.16	0.41	1
91.			3 42 00	32 24.5	K3III	13.34	1.10	1.47	2.21	0.96	0.61	1.47	2
92.			3 42 00	31 50.8	K0V:	13.09	0.61	0.90	1.48	0.62	0.35	1.01	2
93.			3 42 00	30 44.6	G5III	10.77	0.73	0.94	1.36	0.72	0.38	1.03	2
94.			3 42 11	32 19.4	F6V	11.63	0.56	0.64	0.74	0.42	0.22	0.59	2
95.			3 42 15	32 28.4	A7m:	11.72	0.84	1.01	1.04	0.63	0.35	0.85	2
96.	31°644	23322	3 42 18	32 07.9	G9III-IV	7.87	0.67	0.97	1.37	0.56	0.37	0.88	2

Table 1 (continued)

No.	BD	HD	α(1950)	δ(1950)	Sp.	V	U–P	P–X	X–Y	Y–Z	Z–V	V–S	n
97*			3 42 28	32 16.6	K5IV-Ve	14.63	0.41	0.99	1.95	0.75	0.68	1.48	2
98.			3 42 29	32 17.7	G2IV-V	11.97	0.55	0.67	0.97	0.46	0.29	0.69	2
99.	31°645		3 42 30	32 17.1	B3V	9.13	0.49	0.52	0.65	0.50	0.23	0.64	3
100.	33°712		3 42 38	33 28.2	A4V	10.30	0.75	0.93	0.68	0.37	0.22	0.47	2
101.	31°646		3 42 40	31 51.7	A6V	9.71	0.73	0.86	0.61	0.32	0.16	0.45	4
102*			3 42 40	32 14.9	F9IVe	12.10	0.83	0.84	1.17	0.70	0.39	1.13	3
103.			3 42 43	32 04.1	A2V	11.88	0.83	1.04	0.78	0.50	0.30	0.60	2
104.			3 42 48	32 03.5	G2V	12.01	0.52	0.67	0.92	0.47	0.30	0.62	2
105.			3 43 05	32 03.5	G5IV-V	11.37	0.48	0.83	1.09	0.49	0.34	0.71	2
106*	31°647		3 43 15	32 06.0	A2V	9.64	0.64	0.86	0.47	0.23	0.12	0.27	3
107.	33°714		3 43 21	33 43.1	A4V	10.38	0.65	0.87	0.58	0.28	0.17	0.33	2
108.	37°827		3 43 25	37 47.1	A1V	11.32	0.59	0.96	0.59	0.28	0.20	0.35	1
109.	31°649	23478	3 43 32	32 08.1	B3V	6.62	0.26	0.34	0.27	0.17	0.08	0.23	3
110.	32°665		3 43 38	32 27.0	F2V	9.28	0.70	0.78	0.73	0.38	0.22	0.57	2
111.	37°828		3 43 43	37 56.8	A5IV:	9.37	0.82	0.90	0.74	0.43	0.25	0.64	1
112.	34°730		3 44 15	35 09.5	F2V	10.30	0.55	0.65	0.65	0.32	0.20	0.45	1
113.	34°730		3 44 16	35 09.6	K5III:	10.31	0.39	1.10	1.79	0.58	0.48	0.93	1
114.	32°666		3 44 17	33 10.2	B9.5III	9.72	0.73	0.76	0.44	0.28	0.16	0.37	2
115.			3 44 18	33 08.3	F8V	11.00	0.56	0.67	0.89	0.43	0.29	0.67	2
116.			3 44 29	33 03.5	F5V	11.11	0.60	0.65	0.72	0.36	0.20	0.56	2
117*	34°732	23606	3 44 35	34 51.8	B8.5V	9.53	0.55	0.71	0.31	0.20	0.13	0.20	2
118*	33°717		3 44 41	33 26.8	B2V	6.53	0.24	0.30	0.25	0.19	0.10	0.22	2
119.	31°652	23699	3 45 15	31 48.6	A8V	8.15	0.68	0.79	0.62	0.30	0.16	0.40	1
120.	31°653		3 45 21	31 09.0	A2.5IV	10.39	0.85	0.95	0.58	0.33	0.19	0.44	2
121*	31°655	23802	3 45 58	32 06.7	B6V	7.40	0.42	0.50	0.35	0.22	0.09	0.29	2
122.	34°739	23840	3 46 16	34 46.0	B7V	8.47	0.47	0.60	0.27	0.17	0.11	0.15	2
123*	32°667	23848	3 46 23	32 56.3	A2V	5.14	0.68	0.85	0.34	0.16	0.07	0.17	2
124.	31°657	23963	3 47 20	32 16.8	B9V	9.48	0.61	0.71	0.37	0.21	0.10	0.24	2
125.	31°658	23974	3 47 20	31 24.2	B6V	8.52	0.44	0.58	0.40	0.28	0.12	0.34	1
126.	31°659	24039	3 47 50	32 01.2	A4.5IV	9.23	0.74	0.95	0.59	0.32	0.16	0.37	3
127*	32°669	24038	3 47 52	32 24.5	A6V	9.04	0.70	0.91	0.61	0.31	0.15	0.38	2
128.	36°763		3 48 02	37 03.3	A8V	9.07	0.57	0.70	0.56	0.26	0.15	0.35	2
129.	34°748		3 48 22	34 59.8	B9.5V	9.73	0.61	0.80	0.36	0.21	0.12	0.18	2
130.	34°753		3 48 39	34 19.9	B8V	9.20	0.57	0.70	0.34	0.22	0.12	0.25	2
131.	33°727		3 48 40	33 50.6	K1III	9.67	0.49	0.96	1.39	0.50	0.32	0.77	2
132.	33°728	24131	3 48 42	34 12.6	B1V	5.75	0.16	0.19	0.19	0.16	0.09	0.18	2
133.	30°581		3 48 44	31 06.0	A0V	10.89	0.64	0.94	0.51	0.32	0.14	0.37	2
134.	30°582	24167	3 48 57	31 01.2	A5V	6.18	0.64	0.80	0.46	0.20	0.10	0.25	2
135.	32°674		3 49 05	33 15.4	A5I-II	8.92	1.25	0.84	0.52	0.38	0.20	0.55	2
136.	33°730	24190	3 49 06	34 04.4	B2V	7.41	0.24	0.31	0.23	0.18	0.09	0.21	2
137.	34°755		3 49 12	34 18.9	B9.5V	9.58	0.49	0.62	0.32	0.18	0.11	0.22	2
138.	30°584		3 49 13	30 59.4	A6V	9.64	0.78	0.91	0.65	0.39	0.17	0.47	2
139.	32°676		3 49 26	32 58.7	A0V	9.71	0.75	0.85	0.40	0.23	0.14	0.28	2
140.	35°757		3 49 27	35 37.5	A4V	10.09	0.71	0.85	0.55	0.27	0.17	0.36	2
141.	31°662	24222	3 49 30	32 15.6	G7III	6.70	0.57	0.83	1.11	0.44	0.28	0.65	1
142.	34°758	24242	3 49 37	34 19.6	A1V	9.48	0.57	0.87	0.42	0.21	0.10	0.20	2
143.	36°769		3 49 38	36 42.4	B9.5V	9.75	0.76	0.85	0.44	0.28	0.16	0.34	2
144.	34°759		3 50 05	34 45.7	A7IV	10.18	0.61	0.73	0.56	0.29	0.17	0.38	2

Table 1 (continued)

No.	BD	HD	α(1950)	δ(1950)	Sp.	*V*	*U–P*	*P–X*	*X–Y*	*Y–Z*	*Z–V*	*V–S*	*n*
145.	35°763	24300	3 50 08	35 24.3	B5.5V	8.65	0.37	0.51	0.25	0.17	0.10	0.18	2
146.	35°764		3 50 11	35 39.1	B7V	9.42	0.46	0.60	0.31	0.20	0.11	0.23	2
147.*	34°761	24321	3 50 19	34 54.7	B7V	8.80	0.42	0.57	0.30	0.19	0.10	0.21	2
148.	32°679	24322	3 50 19	32 57.8	A3V	8.26	0.65	0.88	0.52	0.25	0.13	0.29	2
149.*	31°666	24398	3 50 59	31 44.2	B1Ib	2.85	0.22	0.21	0.25	0.22	0.10	0.24	2
150.	32°683	24411	3 51 09	32 47.8	A2V	8.96	0.64	0.86	0.53	0.27	0.15	0.32	2
151.	30°589		3 51 13	30 51.1	A2V	9.49	0.75	0.91	0.62	0.40	0.19	0.47	2
152.*	34°766		3 52 06	34 08.1	A1V	9.52	0.57	0.81	0.47	0.24	0.15	0.31	2
153.*	30°591	24534	3 52 15	30 54.0	O9.5ep	6.10	0.15	0.13	0.27	0.25	0.10	0.39	3
154.	34°767	24583	3 52 40	34 23.9	B7V	8.96	0.46	0.60	0.28	0.18	0.10	0.20	2
155.*	31°669	24601	3 52 45	32 00.6	B8V	8.60	0.54	0.66	0.36	0.23	0.11	0.28	2
156.	33°741		3 52 45	34 08.7	A0V	9.98	0.54	0.81	0.38	0.21	0.10	0.21	2
157.	31°670	24600	3 52 49	32 01.1	B9.5V	8.87	0.56	0.69	0.43	0.26	0.12	0.29	2
158.	33°743		3 52 57	34 15.1	A7IV:	9.53	0.59	0.76	0.60	0.32	0.17	0.41	2
159.*	34°768	24640	3 53 15	34 56.1	B1V	5.46	0.18	0.24	0.18	0.15	0.08	0.16	2
160.	35°771	24664	3 53 29	35 51.5	F8V	8.29	0.45	0.55	0.68	0.33	0.19	0.48	2
161.	32°691	24736	3 54 09	32 44.6	B9V	8.55	0.58	0.73	0.34	0.21	0.12	0.22	2
162.	35°772		3 54 23	35 49.9	K3III	9.09	0.62	1.22	1.83	0.64	0.44	0.96	1
163.*	35°775		3 55 43	35 38.9	O8III	4.02	0.11	0.08	0.19	0.17	0.09	0.24	2
164.	32°697	24913	3 55 45	32 36.9	A1V	8.36	0.64	0.83	0.41	0.22	0.11	0.24	2
165.	32°698		3 55 58	32 34.8	A7:IV	9.85	0.75	0.85	0.69	0.31	0.18	0.44	1
166.	31°680		3 56 43	31 55.4	B6V	9.31	0.44	0.54	0.31	0.20	0.10	0.23	2
167.	35°781		3 56 49	35 39.1	A1V	9.90	0.64	0.88	0.47	0.25	0.15	0.30	2
168.	32°703	25143	3 57 46	32 16.9	B8.5V	8.53	0.49	0.64	0.34	0.20	0.08	0.22	2
169.	34°788		3 58 00	35 13.6	F5V	10.28	0.50	0.66	0.71	0.36	0.22	0.56	1
170.	31°686	25185	3 58 15	32 07.8	A3V	8.86	0.71	0.90	0.51	0.27	0.13	0.31	2
171.	34°790		3 58 30	35 10.5	A3V	10.20	0.61	0.86	0.56	0.28	0.17	0.34	2
172.	31°687	25239	3 58 36	32 04.6	B9V	9.21	0.62	0.70	0.38	0.24	0.11	0.29	3
173.	34°791		3 58 42	35 14.3	K3III	9.33	0.65	1.21	1.81	0.58	0.44	0.93	1
174.	31°689		3 58 50	31 52.3	A4:V	9.81	0.73	0.84	0.60	0.35	0.16	0.43	2
175.	32°708	25309	3 59 25	32 46.3	B7V	8.46	0.49	0.53	0.31	0.20	0.09	0.26	2
176.	34°794	25308	3 59 27	35 15.7	A0III	8.52	0.82	0.83	0.40	0.27	0.15	0.34	2
177.	32°709		3 59 28	32 418	A3IV	9.81	0.80	0.91	0.51	0.24	0.15	0.33	2
178.	31°694		3 59 49	31 491	A1V	9.80	0.63	0.83	0.41	0.23	0.10	0.23	2
179.	34°801		4 00 25	34 416	B9V	9.70	0.61	0.77	0.36	0.22	0.11	0.26	2
180.	32°711		4 01 13	32 289	A8:V	9.66	0.64	0.80	0.62	0.30	0.16	0.39	3
181.	33°772		4 01 20	33 52.6	A1V	10.49	0.71	0.89	0.46	0.24	0.15	0.30	2
182.	33°772		4 01 29	33 51.4	K3III-IV	9.37	0.65	1.17	1.72	0.54	0.38	0.85	1
183.	32°714	25539	4 01 32	32 26.1	B3V	6.81	0.26	0.33	0.23	0.17	0.07	0.19	2
184.	32°717		4 02 17	32 44.9	B9V	9.86	0.56	0.67	0.37	0.22	0.09	0.27	1
185.			4 02 33	32 52.7	F9IV-V	10.61	0.53	0.62	0.81	0.39	0.22	0.58	2
186.*	34°809		4 02 42	34 29.7	A3V	10.24	0.60	0.84	0.52	0.25	0.13	0.32	2
187.	33°778		4 02 50	34 02.6	A1V	10.19	0.70	0.88	0.41	0.21	0.11	0.27	1
188.*	31°703	25799	4 03 28	32 15.1	B3V	6.97	0.27	0.35	0.25	0.18	0.08	0.21	2
189.*	33°785	25833	4 03 43	33 18.7	B3.5V	6.92	0.28	0.39	0.23	0.16	0.08	0.18	2

Notes

6. IDS 90-59 AB, $\Delta m = 1.6$, $D = 2''.4$. Measured together.
22. Photometric classification is uncertain. Possible photometric binary star as B3III+F5I.
36. ADS 2696A, $\Delta m = 0.2$, $D = 6''$, measured separately.
37. ADS 2696B.
42. V magnitude from Hoffleit (1982).
63. ADS 2723, $\Delta m = 0.0$, $D = 11''.4$, measured separately.
67. o Per. V magnitude from Hoffleit (1982).
69. The star has considerably lower Q_{XZS} values due to possible emission in the Hα line.
71. ADS 2729 AB, $\Delta m = 0.2$, $D = 1''$. Measured together.
77. ADS 2730, $\Delta m = 0.2$, $D = 0''.45$. Measured together.
97. LkHα 329 (Herbig and Rao 1972). The star has considerably lower Q_{XZS} values.
102. LKHα 330 (Herbig and Rao 1972).
106. ADS 2723, $\Delta m = 0.0$, $D = 11''$. Measured together.
117. ADS 2771A.
118. ADS 2772AB, $\Delta m = 2.5$, $D = 3''$.
121. ADS 2784 AB, $\Delta m = 2.0$, $D = 2''$.
123. SB, Var V467 Per, eclipsing binary system.
127. ADS 2804 AB, $\Delta m = 4.7$, $D = 1''$. Measured together.
147. ADS 2834 A, $\Delta m = 5.7$, $D = 7''$. Measured together.
149. V magnitude from Hoffleit (1982).
152. ADS 2857, $\Delta m = 2.3$, $D = 3''$. Measured together.
153. ADS 2859, $\Delta m = 5.8$, $D = 22''$. Var X Per, (γ Cas type). Spectrum from Hoffleit (1982).
155. ADS 2866 AB, $\Delta m = 3.4$, $D = 1''$. Measured together.
159. Var, NSV 1418, β Cep- type.
163. V magnitude and spectrum from Hoffleit (1982).
186. ADS 2975 AB, $\Delta m = 0.2$, $D = 2''$. Measured together.
188. Var, NSV 1459, $V = 6.98 - 7.27$ (Hoffleit, 1982).
189. Var, AG Per, Eclipsing binary system. $\Delta m = 0.8$, $D = 0''.8$. Measured together.

To obtain two-dimensional quantification of stars, reddenning-free diagrams Q_{UPY}, Q_{PYV}; Q_{UPY}, Q_{XYV}; Q_{UXY}, Q_{UPYV}; Q_{UPY}, Q_{XZS}; Q_{XZS}, Q_{XYZ} calibrated in spectral MK classes and absolute magnitudes M_V (Straižys et al. 1982) were used. Spectral class is determined with the accuracy ± 1 spectral subclass, M_V has the mean accuracy ± 0.5 mag. Absolute magnitudes cor-

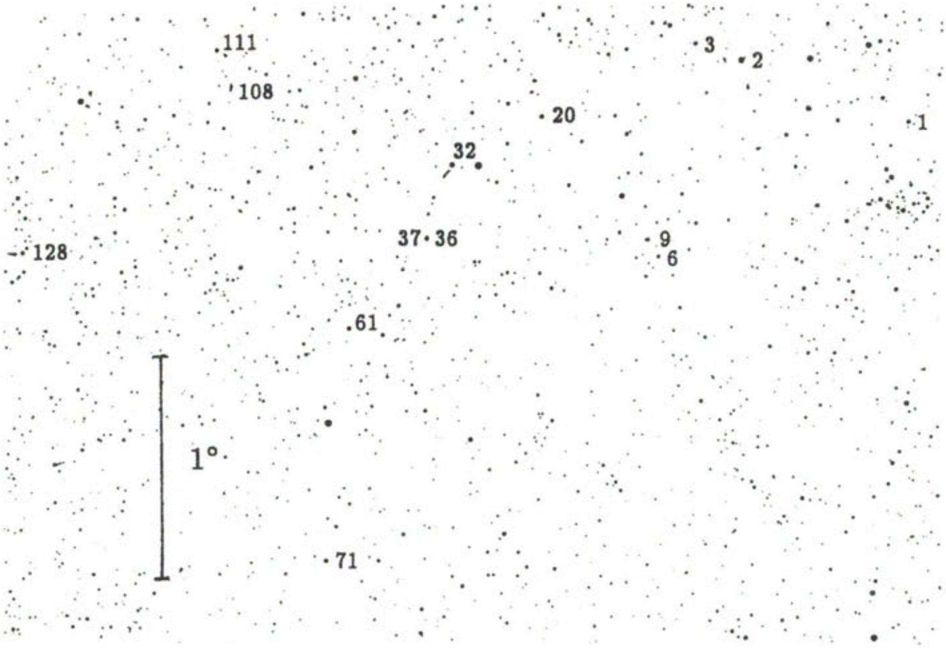

Fig. 2. Identification chart of stars in the northern part of the association Per OB2.

respond to the distance scale based on the Hyades distance modulus $V - M_V = 3.2$.

Colour excesses E_{Y-V} were calculated as differences between the observed $Y - V$ and the intrinsic colour indices $(Y - V)_0$ taken from Straižys et al. (1982) with corrections from Straižys (1992). E_{Y-V} were transformed into E_{B-V} using the ratios E_{B-V}/E_{Y-V} calculated by Straižys and Jodinskienė (1981), slightly dependent on spectral type and absolute magnitude. Distances of stars were derived as usual:

$$5 \log r = V - M_V + 5 - RE_{B-V},$$

where the values of $R = A_V/E_{B-V}$ were taken different in different parts of the area due to variations of the interstellar extinction law (see Section 4). The probable errors of A_V are expected to be approximately ± 0.1 mag and the distance errors must be within $\pm 25\%$. At 200 pc distance this corresponds to approximately ± 50 pc.

Quantification results, distances and extinctions in different areas are presented in the following tables: Table 2 contains 40 stars

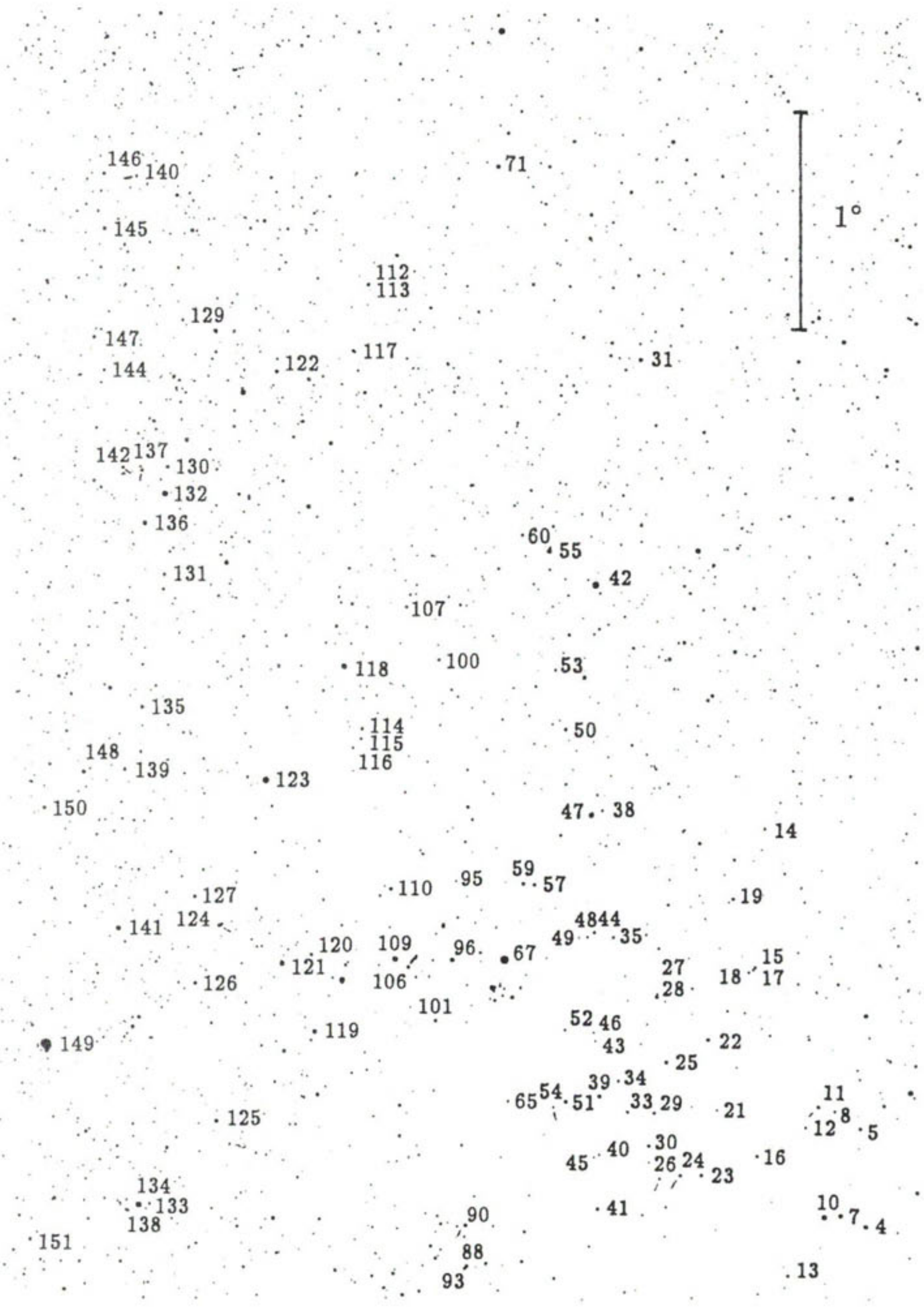

Fig. 3. Identification chart of stars in the area of the open cluster IC 348 and the western part of the association Per OB2.

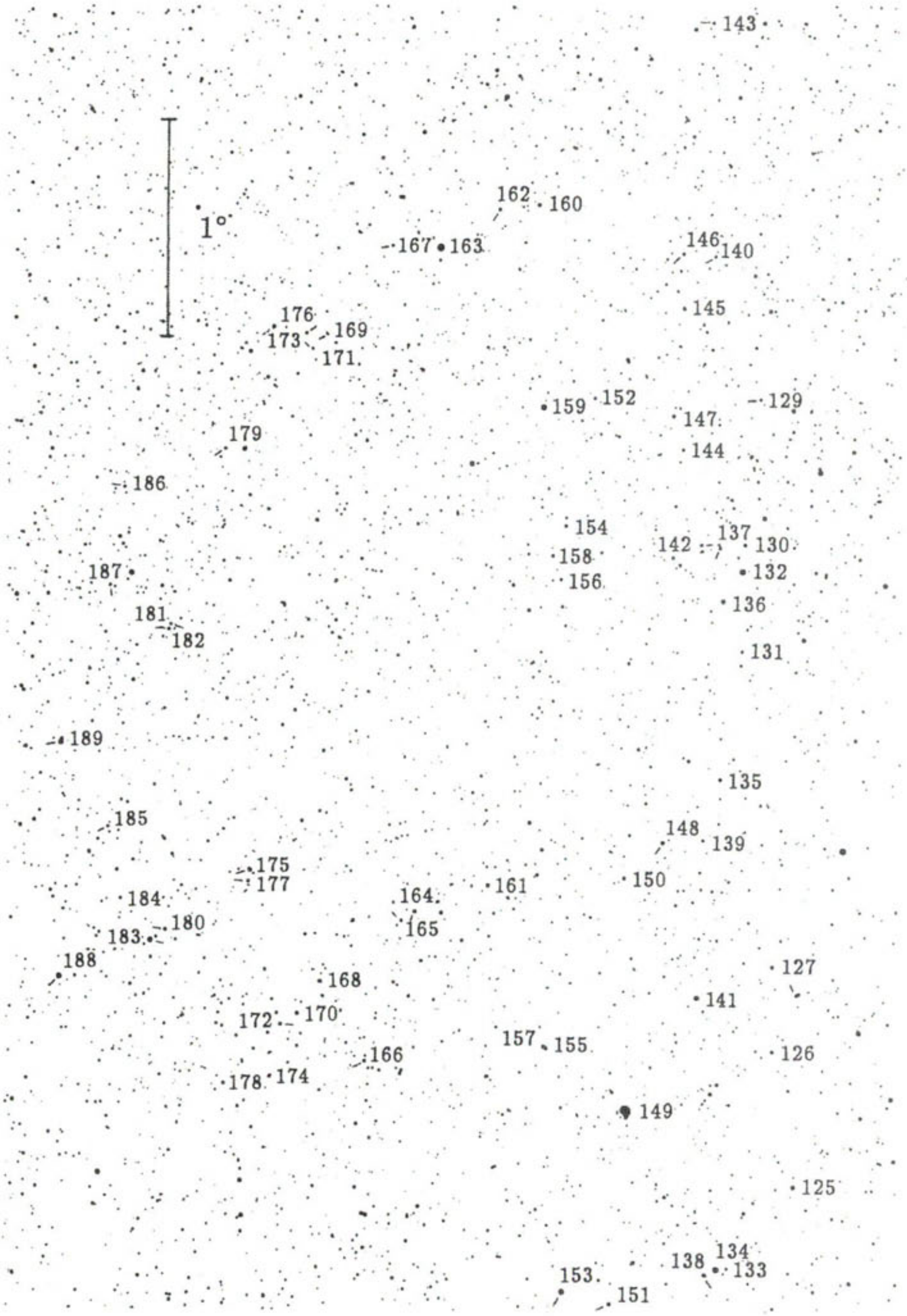

Fig. 4. Identification chart of stars in the eastern part of the association Per OB2.

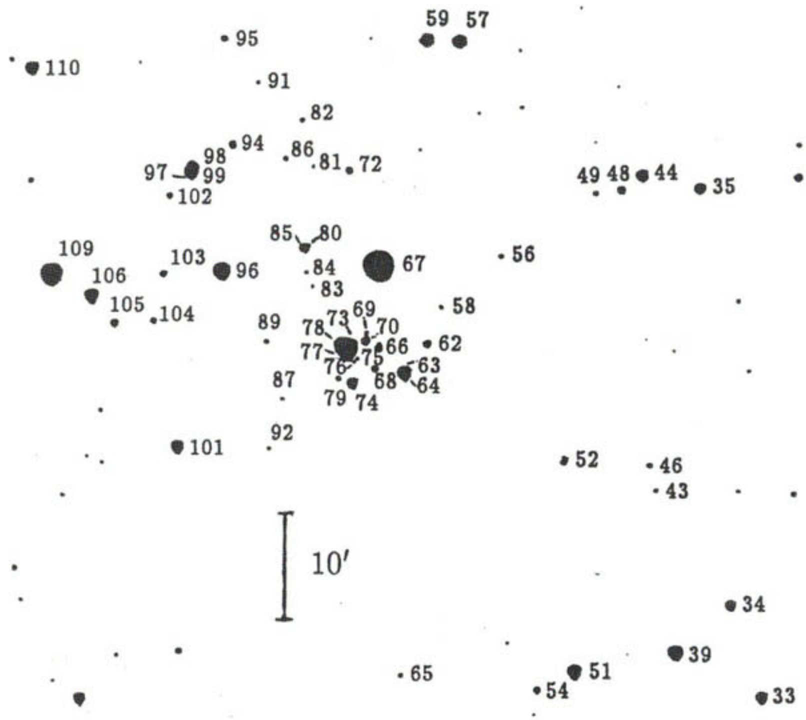

Fig. 5. Identification chart of stars in the region of the open cluster IC 348.

in the direction of L1468 and L1470 clouds which are not on the IC 348 list; Table 4 contains 46 stars in the area of 1° diameter around IC 348; Table 6 presents data for 103 stars in the Per OB2 area.

4. Determination of the ratio R

Černis (1990a) has obtained $R = 3.7$ for the vicinity of the reflection nebula NGC 1333, while the highest density areas of the nebula show R values as high as 5.0. To derive R in the area of the open cluster IC 348, polarization observations by Strom et al. (1974) in the *UBVR* and 7500 Å bandpasses of 13 heavily reddened cluster stars were used. Using their λ(max), i.e. wavelengths of maximum polarization and the Whittet and van Breda (1978) ratio $R = 5.5\lambda_{\mathbf{max}}$ (μm), we derive the value $R = 3.5 \pm 0.2$ for the

Table 2. The results of photometric quantification of stars in the vicinity of the dark cloud L1470

No.	BD	Sp*	Sp (Viln)	V	M_V	E	A	r
4.	30°556		F2V	8.57	+3.0	0.00	0.00	140
5.	31°622		K5III	9.83	+0.6	0.39	1.47	356
7.	30°557		G9III	7.75	+0.9	0.06	0.22	212
8.	31°624		F0V	10.86	+3.0	0.23	0.80	258
10.	30°558		F5V	6.88	+3.5	0.00	0.00	43
11.	31°625		A6V	9.36	+2.4	0.23	0.78	172
12.			F5V	11.13	+3.6	0.19	0.65	238
13.	30°559		F7V	10.57	+4.0	0.15	0.51	163
14.	32°649		F0V	10.21	+2.8	0.19	0.65	225
15.	31°627		G2V	10.47	+4.7	0.08	0.26	126
16.	30°560	A5[2]	A8V	10.08	+2.8	0.14	0.49	228
17.			G2V	11.49	+4.5	0.13	0.43	205
18.			F8V	11.24	+4.1	0.17	0.56	207
19.	32°561		F0V	9.50	+3.0	0.08	0.26	177
21.			G2V	11.99	+4.7	0.14	0.48	230
22.	31°629	B5[2]	B3:III:	9.10	−2.5:	1.43	4.75	(294)
23.	30°561	F0[2]	F1V	9.88	+3.1	0.13	0.43	186
24.	30°562	F5[2]	F7V	10.12	+4.0	0.15	0.52	132
25.	31°630		K2V	8.79	+7.0	0.00	0.00	23
26.			G1V	11.14	+4.5	0.27	0.95	137
27.			F8III	12.33	+1.0	0.56	1.93	758
28.	31°632	A3[1]	A9V	9.49	+2.8	0.12	0.39	182
29.	31°633		G7V	10.21	+5.5	0.00	0.00	87
30.	30°563	F2[2]	F7IV−V	9.92	+3.5	0.08	0.26	170
33.	31°634		A8V	10.14	+2.8	0.13	0.44	240
34.	31°635		F7V	10.59	+4.0	0.13	0.44	170
38.		A5[1]	A4V	10.52	+2.3	0.42	1.40	231
39.	31°637		F9V	9.00	+4.0	0.02	0.05	96
40.			G1V	12.10	+4.5	0.28	0.96	213
41.	30°564	F2[1]	F2V	9.72	+3.0	0.18	0.63	165
45.			K3III	12.64	+0.6	0.56	2.11	968
47.	32°659	F8[1]	F4V	6.73	+3.2	0.05	0.17	47
51.	31°639		K4V	9.10	+7.0	0.00	0.00	26
54.			G0V	11.97	+4.4	0.34	1.15	192
57.	32°661		G0V	9.07	+4.1	0.00	0.00	103
59.	32°662		F0V	9.27	+2.9	0.16	0.54	140
65.			K1IV−V	13.10	+5.0:	0.38	1.37	(222)
90.	30°568	A3[1]	A7IV	9.51	+1.8	0.25	0.85	235
93.			G5III	10.77	+0.2	0.52	1.84	655
110.	32°665		F2V	9.28	+2.9	0.23	0.77	1132

* References for the spectra: [1] Cannon and Mayall (1949), [2] AGK 3 catalog.

area. Other estimate of R was obtained by using the mentioned Strom et al. (1974) *UBVHKL* photometry of the cluster stars. We have selected 11 B1–F2 stars from the list to use them for extrapolation of interstellar extinction law obtaining $R = 3.45 \pm 0.1$. The average value $R = 3.5$ was used to calculate the distances and extinctions A_V of the stars in the direction of IC 348 and the dark clouds L1468 and L1470 in its vicinity (Tables 2 and 4). This value of R is the same as that derived earlier by Straižys et al. (1985) and Černis (1987) for the Taurus dark clouds. The maximum value $R = 4.1$ is found for the star Gingrich 12 ($A_V = 2.6$, A3IV). For the association Per OB2 area the value $R = 3.2$ was accepted as justified by Guetter (1977). A similar value, $R = 3.21$, was obtained by Turner (1976). Thus, the value $R = 3.2$ was applied to all 103 stars in the area of the Per OB2 association (Table 6).

5. Distances of the dust clouds

In Fig. 6, the interstellar extinction A_V is plotted against the distance r for 86 stars projected on the dark clouds L1468, L1470 and partially on L1471 using the data from Tables 2 and 4. Up to 120 pc distance only the unreddened foreground stars are seen. After that it is a jump of extinction at 140–180 pc distance to the average value of $A_V = 0.71 \pm 0.27$ mag. At $r > 200$ pc the second jump of extinction takes place. The first jump can be attributed to the extinction of the dust layer which might be an extension of the Taurus dark clouds, overlapping the Perseus dark cloud complex. Earlier investigations by Straižys and Meištas (1980), Meištas and Straižys (1981) and Černis (1987) show that the Taurus dark clouds are at about the same distance as the first cloud layer in Perseus. Additional confirmation of this may be found in Černis (1990a,b).

The second jump of extinction may be related with the dense clouds L1468 and L1470 which further will be called the Perseus clouds in contrast to the Taurus clouds which form the first layer. This second cloud layer of higher density than the first one: the mean extinction of stars behind it is 2.7 ± 0.6 mag. After subtraction of 0.7 mag, given by the first layer, we obtain 2.0 mag as the mean extinction of the second layer.

Existence of the second dust layer (the Perseus clouds) is also supported by the lack of moderately absorbed stars ($A_V < 1.5$ mag) at $r > 250$ pc, since all distant stars are affected by heavy extinction of the Perseus clouds. Although the nearest stars with heavy extinction are at about 220 pc, estimation of the distance errors indicates that the most probable distance of the Perseus clouds should be 250–270 pc.

The dark cloud L1470 contains some reflection nebulae which are illuminated by the immersed stars of IC 348. This immersion is

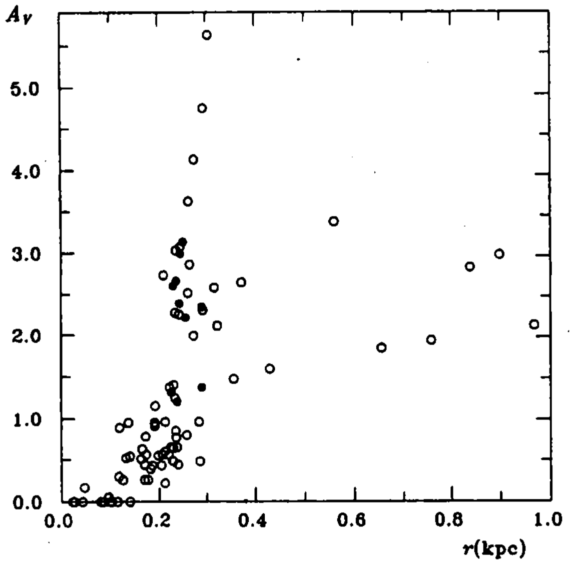

Fig. 6. Interstellar extinction A_V versus distance r in the direction of the open cluster IC 348 and the dark clouds L1468 and L1470 (up to 1 kpc). Dots are members of the cluster IC 348 according to Fredrick (1956).

different for different cluster stars, since they exhibit variable extinction. Thus, it is expected that distances both of the cluster and of the dark cloud must coincide. This will be discussed in the following section.

Fig. 7 exhibits the plot of interstellar extinction versus distance for 103 stars in the association Per OB2 area (Table 6). The majority of stars here are affected only by moderate extinction (A_V < 1.5 mag) which appears at about 160 pc, i.e. at the distance of the Taurus clouds. Probably, only one dust layer exists in this direction, its average extinction being $A_V = 0.95 \pm 0.08$ mag, similar to that given by the first cloud in the direction of open cluster IC 348. This may mean that the association is outside the Perseus clouds edge or it is in a vast and comparatively transparent window.

Table 3 summarizes distance determinations of dark clouds in the area investigated here. Although we confirm the distance of the first absorbing cloud, found by Heeschen (1951) from star counts, there are no signs of the second cloud at 800 pc. The same conclusion is obtained by Lynds (1969) and Cernicharo et al. (1985).

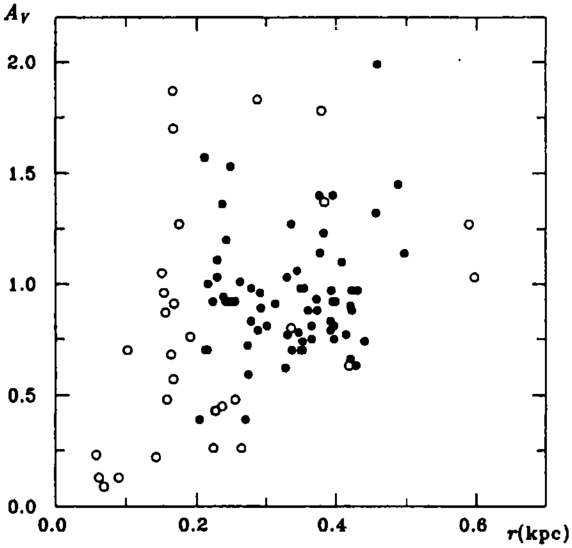

Fig. 7. Interstellar extinction A_V versus distance r in the direction of the Per OB2 association. Dots are members of the association, circles are foreground and background stars.

Table 3. Distances of the Perseus dark clouds

Source	Distance (pc)	Method
Heeschen (1951)	200-300, 800	star counts
Lynds (1969)	200-300	galaxy counts
Cernicharo et al. (1985)	200, 300	star counts
Černis (1990)	160 and 220	photometric distance
This work	160 and 260	photometric distance

6. Distance of the cluster IC 348

Table 4 contains the results of photometric quantification of 46 stars in the area of 0.5 deg radius around the cluster IC 348. It gives the numbers of stars from Table 1, BD numbers and numbers in the Gingrich (1922) and Fredrick (1956) lists. Other columns are self-explanatory. The last column gives the cluster membership probability. Ten stars marked by asterisks are considered as the most reliable cluster members, estimated by Fredrick (1956) from relative proper motions of 31 stars in the same area. Mean distance of these ten Fredrick stars is 251±15 pc.

Eight more stars, not included in the Fredrick's list of proper motion investigation (Nos. 72, 75, 80, 81, 83, 85, 87, 95), can be added as the probable cluster members, since their distances are in the same range, as of the true cluster members.

Six stars of the cluster (Nos. 69, 75, 76, 79, 83 and 89) exhibit very low values of the reddening-free parameter Q_{XZS} of the Vilnius system, which is indication of emission in the Hα line (Paupers et al. 1989). The same anomaly of Q_{XZS} is found for two stars (Nos. 97 and 102) which are Hα emission stars, discovered spectroscopically (Herbig 1954). Probably, all these emission-line stars are the cluster members in the pre-main-sequence stage.

Fig. 8 shows the $V_0, (B-V)_0$ diagram for the probable members of the cluster. Filled circles denote cluster members according to Fredrick (1956). The scatter of stars near the main sequence is large enough, what happens also for other young open clusters. The zero-age main sequence is drawn according to Straižys (1982) taking $V_0 - M_V = 6.49$ from this work. The star *o* Per (B1 III) probably is not a cluster member (Fredrick 1956), however, some other authors tend to consider it as a member (Strom et al. 1974).

To derive the cluster distance, 13 probable its members (designated by *m* in Table 4), having reliable spectral classes and M_V were selected. Taking these stars together with the ten true cluster members, we obtain the mean distance 260±16 pc which is not very different from the previous value. Thus, the distance of the cluster IC 348 almost coincides with the distance of the Perseus dark clouds determined earlier. Distances of the cluster determined by other authors are summarized in Table 5. The mean value of extinction of 31 probable cluster members (denoted with signs m and m?) is $A_V = 2.5 \pm 0.6$ mag. The star No. 80 (B8 V) is immersed into the dense dark cloud, having $E_{B-V} = 1.68$. It is a convenient object for investigation of the interstellar reddening law.

7. Distance of the Per OB2 association

Table 6 gives the results of photometric quantification of stars, their colour excesses, extinctions and distances in the area of the Per OB2 association. Distances are calculated with the normal value of the ratio $R = 3.2$. In the Table there are 78 stars, marked by

Table 4. The results of photometric quantification of IC 348 stars

No.	BD	G	F	Sp*	Sp (Viln)	V	M_V	E_{B-V}	A_V	r	Mem
35.	31°636		1M	G0[5]	G2V	9.98	+4.7	0.00	0.00	115	nm
43.					K3.5V	12.67	+6.9	0.08	0.30	118	nm
44.	31°638		1		G1V	9.66	+4.7	0.00	0.00	100	nm
46.					A6IV	12.40	+1.9	0.78	2.64	372	m?
48.			2		K2V	11.05	+6.5	0.00	0.00	81	nm
49.			3		G1V	12.46	+4.7	0.14	0.48	286	nm?
52.	31°640		4		A3V	11.40	+1.5	0.90	3.03	236	m
56.		1	5	G8–K0[4]	K0III	12.76	+0.8	0.46	1.66	1159	nm
58.		2	6	F8–G0[4]	G2IV	12.75	+3.0	0.46	1.59	(429)	m?
62.		3	7	F8[5]	F9.5V	11.34	+4.3	0.16	0.55	198	nm
63.*	31°641	4	8	A0V[3]	A3V	9.89	+1.9	0.36	1.20	238	m
64.*		5	9	A2V[3]	A3V	10.00	+1.9	0.39	1.31	226	m
66.*		6	10	F0III,V[3]	F2V	11.91	+3.2	0.40	1.37	290	m
67.	31°642			B1III[3]	B1III	3.83	−4.4	0.29	0.96	284	m
68.		7	11	F8[5]	G0V	11.62	+4.4	0.17	0.60	212	nm
69.		8	12	F8[4]	F9Ve?	13.47	+4.3	0.65	2.25	242	m
70.*		9	13	F2IV,V[3]	F1:IV	11.55	+2.3	0.65	2.21	256	m
72.					A1V	11.68	+1.7	0.85	2.86	265	m
73.*		10	14	A2V[3]	A4V	11.75	+2.1	0.69	2.34	290	m
74.*		11	15	F0m:[3]	A8III–IV	10.60	+1.3	0.70	2.38	243	m
75.					G3:Ve?	13.92	+4.8	0.65	2.27	234	m
76.			16		F8:Ve?	13.34	+4.0:	0.80	2.73	(210)	m
77.*	31°643		17	B5V[3]	B4.5V	8.52	−0.3	0.80	2.66	236	m
78.*		12	18	A2III[3]	A3IV	10.21	+0.8	0.77	2.60	230	m
79.*		13	19	F8[4]	G7IVe?	12.94	+3.0	0.84	2.99	245	m
80.					B8V	14.02	+1.0	1.68	5.63	305	m
81.					G1V	13.77	+4.6	0.57	1.99	273	m
82.					K5III	12.74	+0.3	0.77	2.82	839	nm
83.		14			K5:Ve?	13.95	+6.5:	0.17	0.64	(230)	m
84.		15			K3V	13.25	+6.5:	0.16	0.56	(173)	m?
85.		16		A0[4]	B5V	11.23	+0.1	1.17	4.13	275	m
86.					K2III	12.81	+0.7	0.91	3.37	560	nm
87.					A7V	13.32	+2.6	1.06	3.62	263	m
89.		17	20	G1III[4]	G0IVe?	12.65	+3.0	0.61	2.11	322	m
91.					K3III	13.34	+0.6	0.79	2.97	899	nm
92.		18		K2[4]	K0V:	13.09	+5.0:	0.37	1.24	(234)	m?
94.			21	G0[5]	F6V	11.63	+4.0	0.23	0.77	236	m
95.					A7m:	11.72	+1.7	0.90	3.07	245	m
96.	31°644	19	22	K0[3]	G9III–IV	7.87	+1.6	0.25	0.89	119	nm
97.				..e[6]	K5IV–Ve	14.63	+5.0:	0.64	2.30	292	m
98.			23		G2IV–V	11.97	+4.7	0.16	0.56	220	nm
99.*	31°645		24	B5[5]	B3V	9.13	+1.0	0.89	3.13	251	m
102.			25	G2e[6]	F9IVe	12.10	+2.5	0.73	2.51	261	m
103.			26	A[5]	A2V	11.88	+1.8	0.77	2.58	316	m?
104.			27		G2V	12.01	+4.7	0.26	0.91	191	nm
105.			28		G5IV–V	11.37	+4.0	0.27	0.95	191	nm

* **Remarks:** Numbers of the most reliable cluster members, estimated by Fredrick (1956), are marked by asterisks. References for spectra: [3] Harris et al. (1954), [4] Strom et al. (1974), [5] Vyssotsky and Williams (1948), [6] Herbig and Rao (1972).

Table 5. Distance of the open cluster IC 348

Source	Distance (pc)	Method
Gingrich (1922)	107	proper motion study
Greenstein (1948)	160	spectroscopic parallaxes
Harris et al. (1954)	380	spectroscopic parallaxes
Fredrick (1956)	480	proper motion study
Strom et al. (1974)	330	spectroscopic parallaxes
This work	260	photometric distance

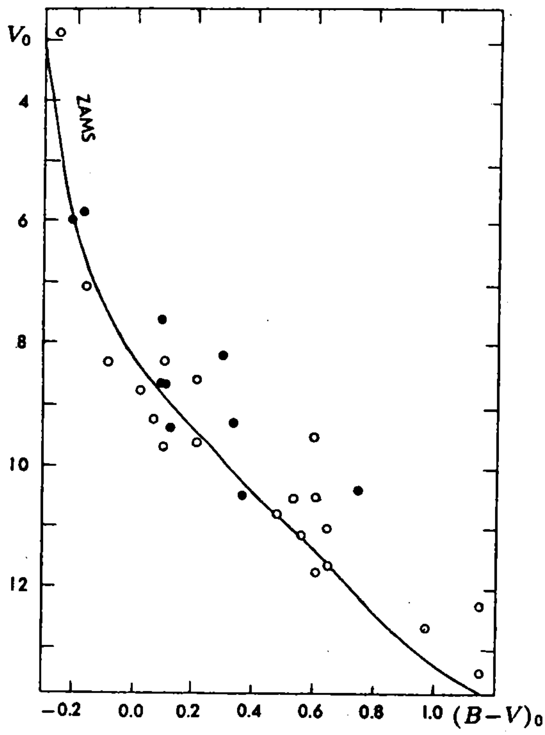

Fig. 8. The $V_0, (B-V)_0$ diagram for the stars of IC 348.

Table 6. The results of photometric quantification of stars in the region of the association Per OB2.

No.	BD	Sp*	Sp (Viln)	V	M_V	E_{B-V}	A_V	r	Mem
1.	37°779		F3V	9.29	+3.3	0.06	0.22	143	
2.	37°794	B9III[7]	B7III	7.57	−1.0	0.22	0.75	366	OB
3.	37°796	A1V[7]	A1V	9.83	+1.1	0.29	0.98	355	OB
6.	36°730	A1V[7]	A0V	10.50	+1.6	0.38	1.27	336	OB
9.	36°731	B9V[7]	B8.5V	9.58	+0.3	0.42	1.40	377	OB
20.	37°808	A4IV[7]	A4:IV	9.70	+1.2	0.46	1.53	248	OB
31.	34°712		K1III	7.81	+0.8	0.07	0.26	224	
32.	37°814	A1V[7]	A0V	7.74	+0.8	0.11	0.39	204	OB
36.	36°735	B9.5II[7]	B8.5IV	9.89	+0.0	0.43	1.45	488	OB
37.	36°735	G8V:[7]	G8III−IV	10.12	+2.0	0.34	1.20	242	OB
42.	33°698	B1IV[8]	B1V	4.97	+3.3	0.27	0.89	292	OB
50.	32°660		A5V	9.25	+2.3	0.31	1.05	151	
53.	33°703		A1V	10.82	+1.7	0.55	1.83	287	
55.	33°704	B2IV−V[7]	B3V	7.44	+1.7	0.29	0.97	431	OB
60.	33°706	B7V[7]	B8V	10.16	+1.0	0.33	1.10	409	OB
61.	36°741	A5V[7]	A2V	8.85	+1.3	0.12	0.39	270	OB
71.	35°744	A2IV[7]	A1V	8.32	+1.1	0.21	0.72	273	OB
88.	30°567		A0IV	9.88	+0.2	0.53	1.78	380	
100.	33°712	A7III[7]	A4V	10.30	+2.1	0.46	1.57	211	OB
107.	33°714	A4V[7]	A4V	10.38	+2.1	0.29	0.96	291	OB
108.	37°827	A0[8]	A1V	11.32	+1.7	0.40	1.32	457	OB
111.	37°828	Am[7]	A5IV:	9.37	+1.4	0.55	1.87	(166)	OB?
112.	34°730		F2V	10.30	+3.1	0.13	0.43	226	
113.	34°730		K5III:	10.31	+3.0:	0.12	0.45	(236)	
114.	32°666	A0III[7]	B9.5III	9.72	−0.4	0.38	1.27	589	(OB)
115.			F8V	11.00	+4.1	0.28	0.96	154	
116.			F5V	11.11	+3.6	0.14	0.48	255	
117.	34°732	A0V[7]	B8.5V	9.53	+0.6	0.28	0.92	400	OB
118.	33°717	B2.5V[8]	B2V	6.53	−2.5	0.35	1.14	378	OB
119.	31°652		A8V	8.15	+2.4	0.21	0.70	102	OB?
120.	31°653	A3V[7]	A2.5IV	10.39	+1.0	0.41	1.40	396	OB
121.	31°655	B5Vn[7]	B6V	7.40	+0.5	0.28	0.92	248	OB
122.	34°739	B8V[7]	B7V	8.47	+0.1	0.23	0.77	331	OB
123.	32°667	A3[9]	A2V	5.14	+1.8	0.07	0.23	(58)	OB?
124.	31°657	A0V[7]	B9V	9.48	+1.0	0.22	0.74	353	OB
125.	31°658		B6V	8.52	+0.3	0.41	1.36	236	OB
126.	31°659	A3IV[7]	A4.5IV	9.23	+1.4	0.31	1.03	229	OB
127.	32°669	A7V[7]	A6V	9.04	+2.2	0.26	0.87	156	(OB)
128.	36°763	A9V[7]	A8V	9.07	+2.6	0.14	0.48	158	(OB)
129.	34°748	A0V[7]	B9.5V	9.73	+1.1	0.24	0.81	366	OB
130.	34°753	B9V[7]	B8V	9.20	+0.1	0.29	0.97	423	OB
131.	33°727		K1III	9.67	−0.5	0.00	0.00	1081	
132.	33°728	B0.5V[8]	B1V	5.75	−3.2	0.29	0.97	394	OB
133.	30°581		A0V	10.89	+1.6	0.41	1.37	384	
134.	30°582		A5V	6.18	+2.1	0.04	0.13	62	
135.	32°674	A0II[7]	A5I−II	8.92	−4.1	0.42	1.43	2080	
136.	33°730	B2Vn[8]	B2V	7.41	−2.5	0.31	1.03	597	(OB)
137.	34°755	A0p(Si)[7]	B9.5V	9.58	+0.8	0.20	0.66	421	OB
138.	30°584		A6V	9.64	+2.2	0.38	1.27	175	
139.	32°676	A0V[7]	A0V	9.71	+0.8	0.28	0.92	396	OB

Table 6 (continued)

No.	BD	Sp*	Sp (Viln)	V	M_V	E_{B-V}	A_V	r	Mem
140.	35°757	Am[7]	A4V	10.09	+1.7	0.27	0.91	313	OB
141.	31°662		G7III	6.70	+1.8	0.04	0.13	90	
142.	34°758	A2V[7]	A1V	9.48	+1.7	0.18	0.59	274	OB
143.	36°769	A0V[7]	B9.5V	9.75	+0.6	0.37	1.23	383	OB
144.	34°759	A8III[7]	A7IV	10.18	+1.7	0.23	0.78	347	OB
145.	35°763	B6V[7]	B5.5V	8.65	−0.1	0.23	0.75	398	OB
146.	35°764	B9.5V[7]	B7V	9.42	+0.4	0.27	0.90	421	OB
147.	34°761	B8V[7]	B7V	8.80	+0.6	0.24	0.81	301	OB
148.	32°679	A5III[7]	A3V	8.26	+1.5	0.22	0.68	164	(OB)
149.	31°666	B1Ib[8]	B1Ib	2.85	+5.9	0.32	1.06	345	OB
150.	32°683	A5IV[7]	A2V	8.96	+1.3	0.27	0.92	223	OB
151.	30°589		A2V	9.49	+1.7	0.51	1.70	167	
152.	34°766	A1V[7]	A1V	9.52	+1.7	0.28	0.94	238	OB
153.	30°591	O9.5p[8]	O9.5ep	6.10	+4.2	0.60	1.99	459	OB
154.	34°767	B7V[7]	B7V	8.96	+0.1	0.23	0.77	415	OB
155.	31°669	B8V[7]	B8V	8.60	+0.5	0.30	1.01	262	OB
156.	33°741	A0V[7]	A0V	9.98	+1.5	0.21	0.70	353	OB
157.	31°670	B8V[7]	B9.5V	8.87	+1.2	0.30	1.00	216	OB
158.	33°743	A8IV[7]	A7IV:	9.53	+1.7	0.27	0.92	241	OB
159.	34°768	B1.5V[8]	B1V	5.46	−3.3	0.27	0.88	374	OB
160.	35°771		F8V	8.29	+4.0	0.03	0.09	69	
161.	32°691	A0IV[7]	B9V	8.55	+0.5	0.25	0.83	278	OB
162.	35°772		K3III	9.03	+0.6	0.21	0.80	336	
163.	35°775	O8III[8]	O8III	4.02	−5.6	0.35	1.14	497	OB
164.	32°697	A0V[7]	A1V	8.36	+1.5	0.27	0.91	168	(OB)
165.	32°698	A8(Sr)[7]	A7:IV	9.85	+1.9	0.27	0.92	255	OB
166.	31°680	B6V[7]	B6V	9.31	+0.3	0.26	0.88	423	OB
167.	35°781	A1V[7]	A1V	9.90	+1.7	0.29	0.98	278	OB
168.	32°703	B9V[7]	B8.5V	8.53	+1.2	0.21	0.70	212	OB
169.	34°788		F5V	10.28	+3.6	0.17	0.57	167	
170.	31°686	A1V[7]	A3V	8.86	+1.7	0.23	0.76	191	(OB)
171.	34°790	Am[7]	A3V	10.20	+1.5	0.29	0.98	350	OB
172.	31°687	B9.5V[7]	B9V	9.21	+0.3	0.28	0.92	396	OB
173.	34°791		K3III	9.33	+0.6	0.17	0.63	419	
174.	31°689	A0III[7]	A4:V	9.81	+1.9	0.33	1.11	229	OB
175.	32°708	B6V[7]	B7V	8.46	+0.3	0.24	0.79	393	OB
176.	34°794	A0IV[7]	A0III	8.52	−0.1	0.31	1.03	330	OB
177.	32°709	A3V[7]	A3IV	9.81	+1.0	0.24	0.81	398	OB
178.	31°694	A0V[7]	A1V	9.80	+1.6	0.19	0.62	328	OB
179.	34°801	A0V[7]	B9V	9.70	+0.9	0.25	0.83	393	OB
180.	32°711	Am[7]	A8:V	9.66	+2.3	0.21	0.70	215	OB
181.	33°772	A1[9]	A1V	10.49	+1.7	0.28	0.93	373	OB
182.	33°772		K3III−IV	9.37	+4.0:	0.07	0.26	(264)	
183.	32°714	B3V[8]	B3V	6.81	+1.3	0.24	0.79	288	OB
184.	32°717	B95II[7]	B9V	9.86	+0.9	0.22	0.74	441	OB
185.			F9IV−V	10.61	+3.4	0.13	0.43	227	
186.	34°809	A7V[7]	A3V	10.24	+1.9	0.21	0.70	337	OB
187.	33°778	A2V[7]	A1V	10.19	+1.4	0.19	0.63	429	OB
188.	31°703	B3V[8]	B3V	6.97	+1.7	0.27	0.88	361	OB
189.	33°785	B5pV[8]	B3.5V	6.92	−1.5	0.21	0.70	350	OB

Remark to Table 6

* References for the spectra: [7] Guetter (1977), [8] Klochkova and Kopylov (1985), [9] Seyfert et al. (1960).

Table 7. Distance of the Per OB2 association

Source	Distance (pc)	Method
Blaauw (1952)	300	spectroscopic parallaxes
Morgan et al. (1953)	360	spectroscopic parallaxes
Seyfert et al. (1960)	400	spectroscopic parallaxes
Borgman and Blaauw (1964)	334	photometric distance
Racine (1968)	330	spectroscopic parallaxes
Guetter (1977)	413	spectroscopic parallaxes
Klochkova and Kopylov (1985)	340	spectroscopic parallaxes
This work	338	photometric distance

OB, which are the association members according to Guetter (1977). The mean distance of these stars is 338±16 pc. Table 7 gives the distance evaluations of the association by other authors. Our result is closest to that obtained by Klochkova and Kopylov (1985). Let us remind that our distance is adjusted to the Hyades distance modulus $V - M_V = 3.2$. In the case of its value 3.3, the distance must be increased by a factor of 1.05.

Individual members of the association show distances between 220 and 550 pc. This spread of distances is a result of: (1) real distance differences of the association members and (2) distance determination errors which are of the order of 25%. Since the association angular diameter is $\sim 8°$, its radial extent can be about 50 pc, if it is round. Stars with $r < 250$ pc and > 480 pc can be either foreground or background field stars. Some of them, which are among the foreground stars, can be the unresolved association binaries.

It can be concluded that the center of Per OB2 association is by about 80 pc farther than the Perseus dark clouds. However, if the ratio R for the interstellar matter in front of the association is 3.5, instead of 3.2, the difference of distances between the association center and the dark cloud complex would be not so significant: 310 pc for the association against 260 pc for the dark clouds. Taking into account the radial extent of the association, its physical relationship with the dark clouds cannot be excluded.

8. General discussion and conclusions

The obtained results are in favour of the presence of two dust layers in the direction of the eastern part of the Perseus dark clouds. This is in accord with our earlier conclusion (Černis 1990a) for the western part of the complex, around the reflection nebula NGC 1333, where also two dust layers at 160 pc (0.4 mag) and 220 pc (1.8 mag) were detected. Inspection of the first layer shows that its density gradually increases when going eastward: in the vicinity of IC 348, the layer gives 0.7 mag extinction, while in front of Per OB2 it is already 0.95 mag. This tendency continues when we reach the Taurus dark clouds (Straižys and Meištas 1980; Meištas and Straižys 1981; Meištas 1983). The same dust layer extends also southward from the Perseus dark clouds, in the direction of the Pleiades (Černis 1987).

Consequently, the Taurus dark cloud complex, which usually is supposed to be of 15 deg diameter, probably has an extended periphery, adding at least 10 deg from all sides. This leads to a conclusion that the linear diameter of the Taurus cloud complex can be as large as 80 pc at 160 pc distance. If the far edge of the Taurus complex is at 200 pc, it can be connected with the front edge of the Perseus dark cloud complex.

The Perseus cloud complex distance is 220 pc in the western part (Černis 1990a) and 260 pc in the eastern part (this paper). If this distance difference is real, the Perseus complex clouds lie almost parallel to the galactic plane, being approximately 80–90 pc below it. The Per OB2 association center is at 340 pc, i.e. it extends the Perseus complex into depth. The Taurus dark cloud complex also seems to be parallel to the galactic plane (Straižys et al. 1992). Fig. 9 gives distribution of the Taurus and Perseus objects in the "distance versus galactic latitude" pattern.

The peculiar position of both these dark clouds and the star forming complexes is easily understandable in terms of the Gould Belt or Local superassociation, which contains dark clouds, young clusters and associations as well as many field stars in the solar vicinity. This Belt forms an angle 13° with the galactic plane. As a result, its objects in Ophiuchus, Scorpio and Serpens are above the galactic plane while the objects in Taurus, Perseus and Orion are below it. The Taurus dark cloud complex is at ~30 pc and the Perseus complex is at ~80 pc below the plane.

The most peculiar position shows the Per OB2 association which is even farther from the galactic plane (90 pc). The association

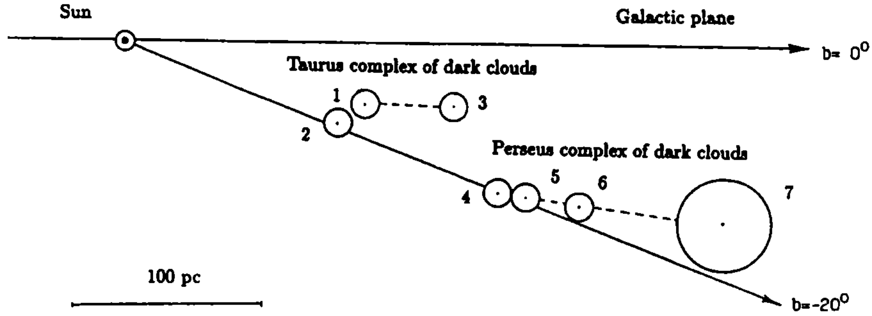

Fig. 9. The spatial distribution of dark clouds and young stellar groups in the galactic anticenter region. Numerical designations: 1. dark clouds around TMC-1; 2. the Merope dark cloud; 3. dark clouds surrounding the cluster NGC 1750/58; 4. the vicinity of the reflection nebula NGC 1333; 5. the dark cloud Barnard 1; 6. the vicinity of the open cluster IC 348; 7. the Per OB2 association. If the Sun is slightly above the galactic plane, the distances of these objects from the plane should be a little different.

almost does not contain the interstellar dust and is reddened only by the foreground Taurus clouds. Its age is much less than the age of the IC 348 cluster which still remains in its birthplace, the dust cloud L1470. It is difficult to understand this situation evolutionary. Probably, all the interstellar gas and dust in the Per OB2 volume have condensed into stars during the last star forming episode.

The following conclusions follow from the above investigation.

(1) Analysis of interstellar extinction in the direction of the open cluster IC 348 indicates the existence of two dust layers at 160 ± 20 pc and 260 ± 20 pc from the Sun. The first layer is of lower density with the mean $A_V = 0.71 \pm 0.27$ mag and is probably related with the Taurus dark clouds. Behind it is the second layer with the mean $A_V = 2.0 \pm 0.6$ mag. It is likely to belong to the Perseus dark cloud complex which is almost parallel to the equatorial plane, being about 80 pc below it.

(2) The distance of the cluster IC 348 is 260 ± 16 pc as derived from 23 probable cluster members. The mean extinction in the cluster area is $A_V = 2.50 \pm 0.6$ mag.

(3) The distance and the mean extinction of the Per OB2 association stars is 338 ± 16 pc and 0.95 ± 0.08 mag, respectively. Probably, it is reddened by an extension of the Taurus dark clouds.

(4) Results of the present study support the conclusions drawn in my previous paper (Černis 1990a) where interstellar extinction in the direction of the western part of the Perseus complex of dark clouds has been investigated.

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