АСТРОФИЗИКА

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NEW OB-ASSOCIATION IN PUP - CMA.

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A new method of determination of distances to the stellar associations is proposed. This method is based on the measurements of mean thicknesses of globules of the systems of dark globules, connected with that association. It is shown that the method is in good agreement with other known so far methods. A new grouping of OB stars in Pup-CMa is found. It is shown that this grouping has properties characteristic for OB-associations: the stars of that grouping have similar distances, similar radial velocities, the grouping is connected with molecular clouds, with Herbig-Haro objects, cometary nebulae. All these results are in favour of this grouping to be a new OB-association. We named that association OB-association Pup-CMa. The preliminary results of ^{12}CO observations of molecular clouds, connected with that association are also given. The radial velocities of these clouds are in good agreement with the mean radial velocity of stars in the association in Pup-CMa.

1. *Introduction.* In [1] the connection of radial systems of dark globules with OB-associations was investigated. It was shown that all known so far 23 radial systems are connected with OB-associations. Recently a new radial system was found in Pup with the central star 30τCMa (O9III). We could not find any association connected with this system in the catalogues. As was mentioned above all the systems are connected with OB-associations, so we decided to search for one connected with the radial system in Pup. As will be shown further we succeeded and found a new grouping of OB-stars, having all characteristics of an OB-association: similarity of radial velocities of stars in the grouping, connection with the molecular clouds (which have radial velocities very similar with mean radial velocity of the stars of grouping), presence of an HII region, connection with unstable young objects: Herbig-Haro objects, cometary nebulae, Herbig A_e/B_e star et cet. So it is possible that this grouping is not a pure OB-association, but OB+T-association. This grouping of OB-stars is situated partly in Pup, partly in CMa.

A new method of determination of distances to the stellar associations is also suggested, based on the mean thickness of dark globules.

2. *The determination of distances by means of the mean thichnesses of dark globules of radial systems.* Since the pioneer works of Ambartsumian (see e.g. [2]) the distances to the stellar associations were

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revisioned several times. Even now in the catalogues of associations [3,4] there are distances to the same OB-association, which differ one and a half, even two times. Hence it is clear that every new method of determination of distances to the OB-associations is valuable without any doubt.

We suggest a new method based on the mean thickness of dark globules, situated in the radial systems of dark globules. These radial systems are connected with the OB-association, for which we would like to obtain the distance. We presume, that the mean thicknesses of dark globules are constant for each radial system (further it will be shown that such a presumption is not far of being correct). Recently it was shown that there are regions of high density inside the molecular clouds, and in average these regions have similar dimensions in different clouds [5,6]. The main mass of the clouds is in these regions. When the ionizing front from the bright stars comes to these regions, they are evaporating, if they are situated close to the ionizing stars, and are evaporating partly if they are situated farther. When the distances are larger, they remain in the ionizing flow, and in their backside the tails are formed. These objects are dark globules, and from the preceding we can conclude that the mean widths of these globules are similar in different radial systems.

As a standart we took the radial system in Rosette Nebula, with a distance 1.55 kpc [3,4]. The mean thickness for this system is 16" ($\sigma = 4$"). Having these data we can determine the distance to every radial system, for which we know the mean thickness of dark globules. Let us try to determine the distances for the radial systems from Table 1 in [1].

The results are summarized in Table 1, where in the successive columns are given: 1. the number of radial system from Table 1 in [1], 2. the number of globules, for which the mean thickness is determined, 3. the mean thickness of dark globules in arcsec (and errors), 4. the distance to the radial system, determined by the method suggested above, 5. OB-association, connected with radial system, 6.the distance to the OB-association from [3,4], 7.the difference between the distances in columns 4 and 6 (in percents).

As we can see from Table 1, these differences are small (in average ~ 10%).

Let us now consider the previously mentioned radial system in Pup. For three globules we obtained the coordinates of centres and the thicknesses in arcsec: N1. $\alpha_{1950} = 7^h21^m45^s$, $\delta_{1950} = -25°21'03''$, thick.= 46", N2. $\alpha_{1950} = 7^h22^m10^s$, $\delta_{1950} = -25°32'01''$, thick.= 46", N3. $\alpha_{1950} = 7^h22^m16^s$, $\delta_{1950} = -25°30'14''$, thick.= 53". The mean thickness of globules is 48" ($\sigma = 6$"). Hence the distance to this radial system by the method suggested above is 520 pc. In Table 1 the distance to that gpouping, calculated by us later in point 3 (540 pc), is given.

We can estimate the distance to the radial system by another method. The radial system is formed by the star 30τCMa (O9III), which is sur-

Table 1

THE DISTANCES TO THE RADIAL SYSTEMS

NN	Number of glob.	Mean thick. of globules	Distance to the rad.syst.	OB-associat. connect. with radial syst.	Distance to the associa-tion	Difference between col.4 and 6
1	8	35" (10")	0.72kpc	Cep OB 4	0.88kpc	18%
2	8	18 (4)	1.35	Anon	----	---
3	7	30 (6)	0.85	Cam OB 1	0.80	6
4	4	67 (10)	0.38	Ori OB 1	0.45	16
5	4	63 (10)	0.40	"---"--"	0.45	11
6	9	16 (4)	1.55	Mon OB 2	1.55	0
7	6	53 (7)	0.47	Mon OB 1	0.55	15
8	6	31 (6)	0.81	CMa OB 1	0.95	15
9	5	17 (4)	1.45	Sgr OB 2	1.52	5
10	4	18 (4)	1.40	"---"--"	1.52	8
11	6	33 (7)	0.76	Sct OB 2	0.73	4
12	5	34 (7)	0.73	"---"--"	0.73	0
13	9	21 (4)	1.22	Vul OB 4	1.02	20
13.1	7	39 (4)	0.67	Cyg OB 9	0.74	9
13.2	3	40 (4)	0.62	Cyg OB 7	0.74	16
14+15	6	30 (7)	0.84	"---"--"	0.74	14
16	8	35 (7)	0.73	"---"--"	0.74	1
17	9	35 (10)	0.73	Cep OB 2	0.75	3
18	3	48 (6)	0.52	Pup+CMa	0.54	4

rounded by an HII region LBN1059, 1061. From Table 1 in [1] we can see, that a similar star is present in the system N4. In that system the HII region with a radius ~ 3° is illuminated by the star λOri (O8III). The distance to λOri is ~ 450 pc. The radius of HII region, illuminated by the star 30τCMa is ~ 2°, hence the distance to 30τCMa will be less than 670 pc (we must presume that the physical conditions in both HII regions are identical).

3. *The grouping of OB-stars in PUP-CMA.* As we can see from Table 1 in [1], all radial systems from this Table are connected with OB-associations. We tried to look for a new OB-association which is connected with the system in Pup, mentioned above.

For that purpose we consider the distribution of OB-stars in the region $\alpha_{1950} = \left(6^h20^m - 8^h10^m\right)$, $\delta_{1950} = \left(-15° - -35°\right)$, which contains also the radial system in Pup. The dimensions of this region we accepted ~ 200 pc, which correcponds to maximum dimensions of known OB-associations (if the

Table 2

THE STARS OF THE OB-ASSOCIATION IN PUP-CMA

N	SAO	HIPP.	V	$B-V$	M_v	Sp	V_R(km/s	$m(r)$
1	2	3	4	5	6	7	8	9
1	172196	32112	7.4	0.0	-1.0	B5.5 V	-----	8.0
2	172297	32408	7.64	-0.11	-1.0	B5.5 V	-----	8.52
3	172334	32547	7.7	-0.3	-1.6	B3.5 V	-----	9.3
4	172356	32642	8.0	-0.3	-1.0	B5.5 V	-----	9.0
5	172403	32782	7.04	-0.18	-2.3	B3 IV	-----	9.34
6	172420	32827	6.33	-0.18	-1.7	B3 V	-----	7.91
7	172425	32856	7.1	-0.30	-1.6	B3.5 V	+18	8.55
8	172461	32952	8.0	0.0	-1.0	B5.5 V	-----	8.55
9	172499	33035	8.03	0.18	-1.6	B3.5 V	+25	8.73
10	172520	33092	4.82	-0.22	-3.9	B1 IV	+31	8.5
11	172542	33152	3.86	1.73	-6.0	K3 Iab	+36	8.6
12	172578	33294	6.81	-0.2	-2.3	B3 IV	+10	9.11
13	172588	33316	5.28	-0.19	-3.4	B3 II-III	+38	9.4
14	152126	33347	4.38	-0.06	-3.9	B3 II	+41	9.0
15	172617	33412	7.81	-0.15	-1.0	B5.5 V	+17	8.81
16	172656	33532	6.37	-0.19	-1.7	B3 V	-----	7.97
17	172706	33673	6.99	-0.17	-1.0	B5.5 V	-----	8.0
18	172725	33721	6.53	-0.17	-1.4	B4 Vne	+9	7.93
19	172750	33770	7.36	-0.13	-1.6	B3.5 V	-----	8.96
20	172839	33977	3.03	-0.09	-6.8	B3 Ia	+48	9.5
21	172872	34041	6.87	-0.16	-2.3	B3 IV	-----	8.7
22	172876	34048	7.97	-0.17	-1.0	B5.5 V	-----	8.97
23	197566	34248	6.34	-0.16	-2.3	B3 IV	+14	8.64
24	172989	34331	6.62	-0.17	-3.5	B1 V	-----	9.5
25	173002	34360	5.71	-0.10	-3.5	B1 Ve	-----	8.3
26	152480	34566	8.0	-0.09	0.0	B8.5 V	-----	8.0
27	173189	34786	6.91	-0.14	-1.6	B3.5 V	-----	8.3
28	173244	34924	6.11	-0.26	-2.3	B3 IV	-----	8.4
29	197719	34937	6.57	-0.17	-2.7	B2 IV	+28	9.2
30	152608	35004	7.36	-0.16	-1.6	B3.5 V	+20	8.96
31	173280	35026	7.7	-0.7	-1.6	B3.5 V	-----	9.3
32	197770	35168	7.15	-0.17	-1.4	B4 V	-----	8.55
33	173350	35208	7.2	0.1	-1.0	B5.5 V	-----	8.2
34	197827	35391	7.7	0.0	-1.6	B3.5 V	-----	8.9
35	173446	35415	4.39	-0.16	-6.0	O9 III	+40	8.8

1	2	3	4	5	6	7	8	9
36	173462	35453	7.47	-0.16	-1.0	B5.5 V	-----	8.47
37	173464	35461	7.30	0.0	-1.6	B3.5 V	+26	8.3
38	173520	35604	7.88	-0.15	-1.1	B5 Vne	-----	8.98
39	173517	35609	6.61	-0.15	-1.7	B3 V	+10	8.3
40	197925	35795	5.40	-0.16	-2.4	B5 IIIne	+24	8.3
41	197944	35887	6.59	-0.2	-1.6	B3.5 V	+7	8.14
42	173651	35904	2.44	-0.07	7.0	B5 Ia	+41	9.3
43	173752	36168	5.4	0.1	-4.6	B0 IVpe	+48	8.9
44	173793	36246	7.1	-0.12	-1.0	B5.5 V	-----	8.1
45	198042	36362	5.77	-0.19	-2.3	B3 IV	+8	8.07
46	173980	36707	7.71	-0.17	-1.0	B5.5 V	-----	8.7
47	198121	36741	7.36	-0.13	-1.6	B3.5 V	-----	8.96
48	198168	36955	7.22	-0.12	-2.6	B2.5 IV	-----	9.7
49	198312	37524	6.96	-0.15	-1.1	B5 V	-----	8.06
50	174433	37751	5.62	-0.19	-3.5	B1 V	-----	8.8
51	174475	37880	6.74	-0.14	-2.3	B3 IV	-----	9.0
52	174522	37957	8.0	-0.12	0.0	B8.5 V	-----	8.0
53	198463	38110	7.21	-0.15	-0.9	B6 V	-----	8.11
54	174730	246760	7.75	0.0	-1.2	B8 III	-----	8.95

distance is 520 pc, as was found above). We have taken the stars out of [7]. We used the data from [8] and its former publications, but mainly from [9]. The absorption was calculated by the formula $R = 3.1 \times E(B-V)$.

We left the stars which have distance moduli in the interval $(7^m.91 - 9^m.7)$. The mean distance module for these stars is $m(r) = 8^m.66\ (\sigma = 0^m.48)$, which corresponds to the distance $d = 540$ pc. The distribution of OB-stars is presented in Fig.1. The boundary of grouping is outlined by solid line. There are 54 stars in the grouping, 36 of them are of MS, the others are subgiants, giants, supergiants. There is also one late type supergiant - HIP 33152, K3Iab. It was mentioned by Ambartsumian in [10], that there are also late type supergiants among the stars occurring in the OB-associations. The data concerning this grouping are summarized in Table 1 (N18), and the data concerning separate stars, in Table 2. In Table 2 in column 1 the number of star is given, in column 2 - the number of star from SAO catalogue, in column 3 - the number of star from HIPPARCOS catalogue [9], in columns 4-7 the corresponding data for these stars are given from [7,8,9], in column 8 - the radial velocities of stars from [7], in column 9 - the distance moduli, calculated by using the data in other columns.

We can calculate the distance of this grouping, using the values of parallaxes of the stars, given in [9]. We have a mean value of parallax for

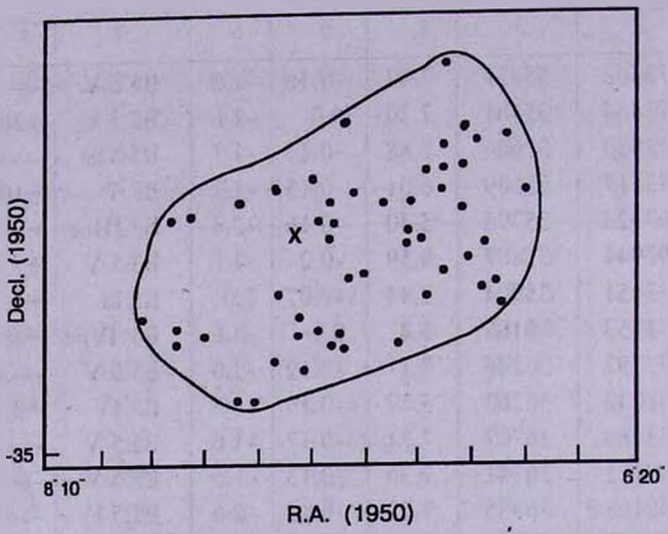

Fig. 1. The distribution of OB stars in the Pup-CMa. The position of radial system of dark globules is marked by ×.

these stars equal to 1.99 mas, which corresponds to the distance of 500 pc ($\sigma = 150$ pc). This value is in good agreement with the previous results obtained in this paper.

We tried to compare the grouping in Pup-CMa with the known so far OB-associations. We compared the mean distance moduli and their dispersions. In Table 3 the mean distance moduli and their dispersions for grouping in Pup-CMa and for some known OB-associations are given (the values are calculated using the data from [11]). As we can see from Table 3, the dispersion of mean distance module for Pup-CMa does not differ significantly from the ones for other OB-associations.

Table 3

MEAN DISTANCE MODULI FOR THE STARS OF OB-ASSOCIATIONS

Assoc.	CamOB1	AurOB1	PerOB1	AurOB2	CasOB2	CasOB6	CasOB8	Pup-CMa
m (r)	$9^h.6$	10.4	11.4	12.1	11.9	10.5	12.5	8.7
s	$0^h.45$	0.56	0.58	0.53	0.54	0.57	0.47	0.48

Now we can determine the mean radial velocity of the stars of grouping in Pup-CMa. We used data from [7]. There are data for 22 stars. The mean radial velocity for these stars is $V_R = 26$ km/s, dispersion $\sigma = 13$ km/s. Now we must compare these values with the corresponding values for some known so far OB-associations. In Table 4 there are values for some OB-associations (the values were calculated using data from [11]).

As we can see from Table 4, the dispersion of mean radial velocity for association in Pup-CMa does not differ significantly from the values for

known OB-associations.

Table 4

MEAN RADIAL VELOCITIES FOR STARS OF OB-ASSOCIATIONS

Assoc.	Stars	Mean Vel.	Dispersion
Per OB 1	31	-42 km/s	10 km/s
Cas OB 6	11	-22	20
Cep OB 3	7	-22	7
Aur OB 2	9	-9	13
Pup-CMa	22	26	13

All these results give us an opportunity to conclude that the grouping in Pup-CMa is really a new OB-association.

It is interesting to note, that there are some unstable young objects, connected with this association. In the dark cloud LDN1664 there are some stars, connected with the cometary nebulae CLN112-116 and Herbig-Haro objects HHL50-53 [12]. The dark nebula LDN1660 is connected with a Herbig A_e/B_e star vdB 66 N096.

4. *The connection of new association with molecular clouds.* Now is well known, that almost all OB-associations are connected with dark clouds, that is with molecular clouds. The molecular clouds are situated not far from the stars of associations, composing a whole complex with them (see e.g. [13]). There are some such clouds in the investigated region - LDN1659-1667. The observations of molecular clouds in ^{12}CO (1-0) were obtained with the Columbia University millimetre-wave telescope at Cerro-Tololo, Chile. This 1.2 m diametre instrument has a full beamwidth at half maximum (FWHM) of 8'.8 at 115 GHz and a main beam efficiency of 0.82. Rather detail observations were done of 7 molecular clouds, situated in the area of grouping. More complete results will be published in [14]. Here we give as an illustration the contour maps of two clouds only. These clouds are connected with dark globules and unstable objects (Herbig-Haro objects, cometary nebulae, IRAS point sources). In Fig.2 are presented the contour maps for two molecular clouds. The radial velocities of gas in LDN1664 is in the interval 15-24 km/s, and in LDN1667 - in the interval 13-29 km/s. With the cloud LDN1664 the following unstable objects are connected: Herbig-Haro objects HHL50 (which is connected with IRAS point source IRAS07225-2428), HHL51 (with IRAS07225-2422), HHL52 (with IRAS 07227-2423), HHL53 (with IRAS07232-2422); cometary nebulae: CLN110, CLN111 (is connected with IRAS07225-2422), CLN112 (with IRAS07227-2423). With the cloud LDN1667 the following unstable objects are connected: cometary nebulae CLN108, CLN109 (is connected with IRAS07222-2610), and also the mentioned above radial system of dark globules.

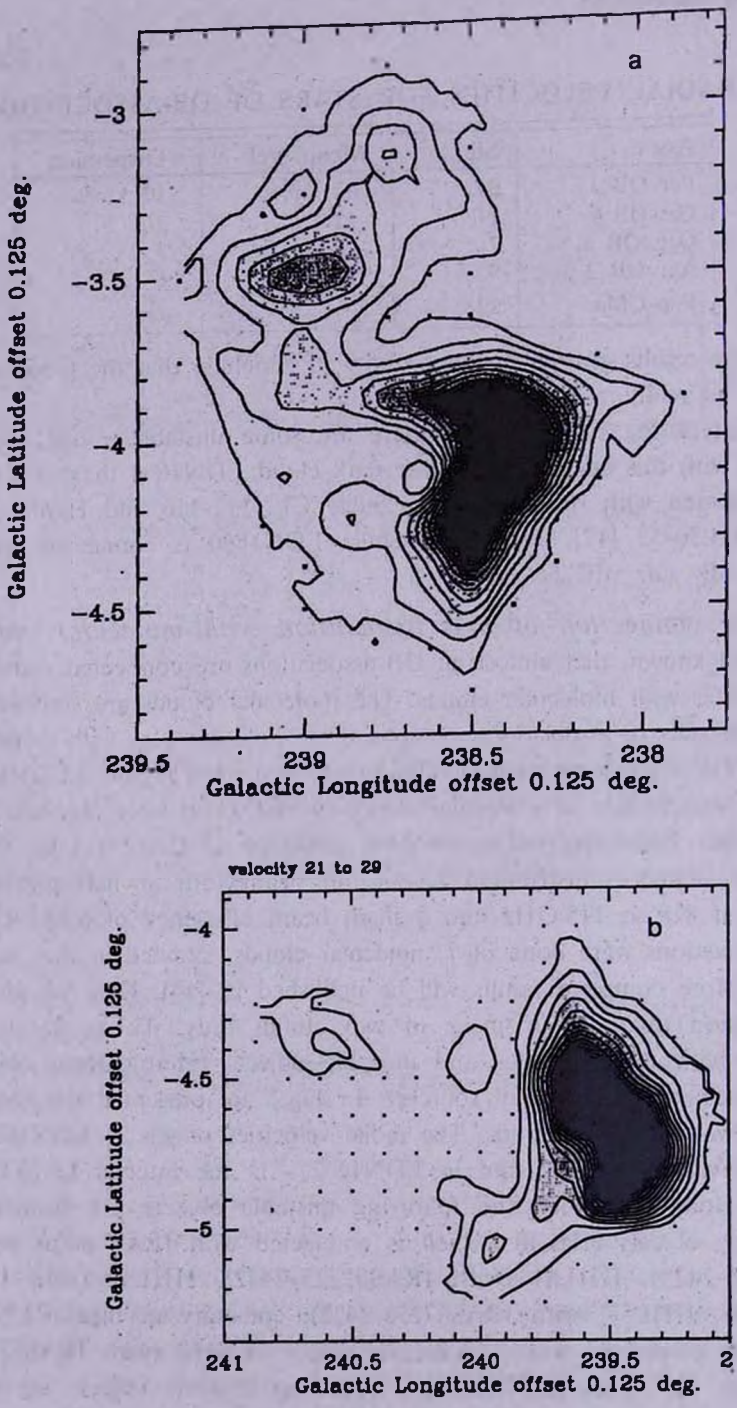

Fig.2. The distribution of $^{12}CO(1-0)$ in the dark clouds: a) LDN1664, b) LDN1667.

The distribution of molecular gas in these two clouds is presented in Fig.2. The mean radial velocity of gas in these clouds is 21 km/s, which is in good agreement with the main radial velocity of stars in the grouping ($V_R = 26$ km/s). The results of characteristic values fot these and other clouds (dimensions, masses, densities) will be presented in [14].

5. *Summary*. In [1] it was shown that all known so far radial systems of dark globules are connected with OB-associations. The purpose of this work was to show that the recently found by us radial system of dark globules in Puppis is also connected with an OB-association. We have found a group of OB stars in the vicinity of that radial system, which has all properties of OB-associations: it is rather isolated, is connected with molecular clouds, with unstable young objects (Herbig-Haro objects, cometary nebulae et cet.). The number of stars, members of that grouping, is 54, the dispersions of distance moduli and mean radial velocities of these stars are very similar to the values of corresponding dispersions for known so far OB-associations. The distance to the grouping is 540 pc, the mean radial velocity of the stars is 26 km/s. The preliminary results of ^{12}CO observations of molecular clouds show that they have velocities very close to the mean radial velocity of the stars, that is these clouds belong to the association.

It is also suggested a method of determination of distances to the radial systems, by mean values of thicknesses of dark globules included in these systems. The distances of several OB-associations (which have such radial systems) were calculated by that method. They differ from the corresponding values, given in the catalogues, by ~ 10%.

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НОВАЯ ОВ-АССОЦИАЦИЯ В КОРМЕ - Б.ПСЕ

А.Л.ГЮЛЬБУДАГЯН, Х.МАЙ

Предложен новый метод определения расстояний до звездных ассоциаций. Этот метод основан на измерении средней толщины глобул радиальных систем темных глобул, связанных с ассоциацией. Показано, что этот метод находится в хорошем согласии с ранее известными методами.

Найдена новая группировка ОВ-звезд в Корме - Б.Псе. Показано, что эта группировка имеет свойства ОВ-ассоциаций: звезды группировки имеют сходные радиальные скорости, сама группировка связана с молекулярными облаками, объектами Хербига-Аро, кометарными туманностями. Все эти результаты свидетельствуют в пользу того, что эта группировка является ОВ-ассоциацией. Мы назвали ее ОВ-ассоциацией Pup-CMa. Приводятся также предварительные результаты ^{12}CO наблюдений молекулярных облаков, связанных с этой ассоциацией. Радиальные скорости облаков находятся в хорошем согласии со средней радиальной скоростью звезд ассоциации.

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