АСТРОФИЗИКА

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RELATIONSHIP OF GALAXIES FROM THE SECOND BYURAKAN SURVEY TO ZWICKY CLUSTERS. II. DISCUSSION

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We analyze the data presented in a previous paper by Gyulzadyan and Petrosian, and discuss the results of a statistical investigation of the relationship between SBS galaxies and Zwicky clusters. The main results are that SBS galaxies follow the overall galaxy distribution in clusters and they do not avoid any type of Zwicky cluster. There is significantly higher probability of finding SBS galaxies occurring in medium compact clusters than in open clusters. They also follow the well established morphology-density relation. Earlier morphological type, higher luminosity, larger linear size and redder SBS galaxies tend to found in clusters with higher compactness, or in more compact regions of the clusters. The number distribution of SBS galaxies in Zwicky open clusters probably follows the distribution of normal galaxies. The number distribution of SBS galaxies in medium compact and compact clusters shows two-maxima structure.

Key words: *galaxies:SBS - Zwicky clusters*

1. *Introduction.* Galaxy evolution in different systems depends of its environment. In particular, galaxy-galaxy interactions can induce nuclear activity and/or enhanced star formation in the central region of a galaxy. Despite some contradictory results, observations in general support this idea. A higher rate of nuclear activity or enhanced star formation have been detected in interacting galaxies and in close pairs of galaxies (e.g. [1,2]), and an enhanced number of active galaxies has been found in extreme environments of compact groups (e.g. [3-5]). Studies of the number of components around active and non-active galaxies have reported contradictory results. Some studies [6-8], have found that active galaxies have a higher number of companions than those with non-active galactic nuclei, whilst others [9-11] do not find this excess. Miller et al. [12] find that the fraction of active galaxies is independent of the environment even in clusters. In recent years, a growing number of studies have reported an over-density of X-Ray point sources in the vicinity of clusters relative to field observations (e.g. [13-15]), while other studies (e.g. [16,17]) find no significant difference. Many studies (e.g. [18]) which have reported an over-abundance of X-Ray active galaxies in clusters find evidence that the excess sources are mostly distributed in outer structures of the clusters. There is also evidence that the amplitude of the over-density of these active galaxies increases within the

$0.2 < z < 1.2$ redshift interval [13,15] compared to local galaxies. The findings that active galaxies avoid the densest central regions [19] and prefer outer structures of the clusters is consistent with studies that suggest the large-scale structure surrounding clusters plays a pivotal role in driving galaxy evolution. Several studies at low redshift have found that outer, modest density substructures of clusters, such as groups and filaments, show a reduced number of active galaxies in comparison with high-redshift counterparts [20].

As a result of the high scientific interest in such a fundamental topic as galaxy evolution, there have been many studies trying to understand the effect of the environment on the evolution of the galaxies. The results obtained, even contradictory, add new details in understanding of the problem. Given the complex nature of these interactions, many more are needed to disentangle the effects and achieve a clear understanding of the processes involved. One method to study this problem is to look at the spatial distribution of active and star forming galaxies collected in specific catalogues of these objects. A recent example of this was used by Lee et al [11] who studied the spatial distribution of University of Michigan (UM) emission line galaxies (ELGs). They concluded that UM ELGs are reliable tracers of large-scale structure and they tend to be more isolated when compared to their normal galaxy counterparts. In the past, a similar study was published for the relationship of Markarian galaxies to Zwicky clusters [21,22]. It was shown that Markarian galaxies take part in the tendency of galaxies to cluster and follow the distribution of normal galaxies in the clusters. In order to extend this analysis to a larger sample of fainter and more distant active galaxies, we presented data for all Second Byurakan Survey (SBS) galaxies located within the contours of Zwicky clusters in our first paper [23] (hereafter Paper 1). This paper discusses the data presented in that first paper and reports the results of a statistical investigation on the relationship between SBS galaxies and Zwicky clusters.

2. *Expected and observed frequency of SBS galaxies in Zwicky clusters.* The overlap in sky coverage of the SBS [24] and Zwicky [25] (CGCG) surveys is approximately 990 sq. degrees. In this common area, excluding already studied Markarian galaxies [21,22], there are 1677 SBS galaxies and 1392 of them have redshifts. If we restrict the volume of space to consider only objects with $z < 0.050$ (near-distance class of Zwicky), this reduces the number of galaxies with known redshifts to 900 (65% of 1392). In this volume there is no any compact cluster and there are 21 open and 16 medium compact clusters with the area coverage shown in Table 1. This table also shows the number of observed SBS galaxies compared to the expected random number of SBS galaxies in the field of these clusters assuming a Poisson distribution. In the last column of Table 1 the numbers of real and probable members of clusters to the numbers of the SBS galaxies which are projected on the clusters are presented. One galaxy SBS1713+524 with radial velocity equal to 7140 km/s is

in near open cluster Zw1718.6+5229 which velocity is not determined (see Table 7 of Paper 1).

Table 1

PREDICTED AND OBSERVED NUMBERS OF SBS GALAXIES IN ZWICKY CLUSTERS

System type	Area, Square degrees	Number of SBS galaxies		
		Expected	Observed	Cluster members /Nonmembers
Open	207	188±14	218	142/75
Medium-compact	154	140±12	240	221/19
All near clusters	361	328±18	458	363/94
Field	629	572±24	442	*n/a*

As seen in Table 1, the observed numbers of SBS galaxies associated with open Zwicky clusters about 16%, and associated with medium compact clusters about 72% higher than expected from a random distribution. This means that in studied volume SBS galaxies do not avoid open and medium compact Zwicky clusters and about 4.5 times often prefer medium compact systems.

The observed numbers of galaxies are derived using data collected in the different Tables of Paper 1 which includes any association of the SBS galaxies with a Zwicky cluster. For example, Table 1 of Paper 1 presents cases when SBS galaxy is a member of a Zwicky cluster for which a radial velocity has been determined with more than one galaxy. Of 218 SBS galaxies coinciding with "near open" Zwicky clusters 47 (22%) are included in Table 1 of Paper 1 and are members of 12 clusters. Of 240 SBS galaxies, 47 (20%) are included in the same Table and are observed in 6 near medium compact clusters.

SBS galaxies are sometimes members of foreground or background groups of galaxies instead of being associated with the main cluster. Paper 1, Table 3 lists 44 SBS galaxies (20% of 218) which coincide with 9 foreground or background groups of 7 open clusters, and 28 galaxies (12% of 240) coinciding with 6 foreground or background groups of 4 medium-compact clusters. Tables 4 and 5 in Paper 1 lists 39 SBS galaxies (about 4% of total 900) which are probable members of 14 Zwicky clusters but cannot be confirmed because there is either no independent measurement of the cluster redshift using another galaxy, or the difference in velocities between the cluster and SBS galaxy is in the 2000-4000 km/s range. Finally, there are real projection cases for SBS galaxies on the Zwicky clusters. Paper 1, Table 6 lists 75 galaxies (34% of 218) which are projected on 11 open clusters, 19 galaxies (8% of 240) on 5 medium compact clusters.

It is clear from these and below numbers from Table 2 of Paper 1 that SBS galaxies participate in the clustering of galaxies with an over-density in cluster fields and an under-density in the field when compared to a random distribution. It is interesting to note that SBS galaxies coincide with medium compact clusters with greater probability (92%) than with open ones (65%), which is similar to that found for Markarian [21,22] and Seyfert [6] galaxies.

3. *SBS galaxies associated with substructure in clusters.* A large number of studies of the structure of galaxy clusters has shown that substructure in them is common (e.g. [26,27]) and the fraction of clusters with sub-clusters can exceed 70% [28]. Sub-clusters mostly form bound physical systems (e.g. [29,30]), but cases have also been observed [31] where they form unbound collections of groups or smaller clusters. Usually in such cases, the sub-clusters have velocity differences which are more than 2000 km/s. In Table 2 of Paper 1, the cases in which the SBS galaxies are associated with a sub-cluster in clusters which have two or more values of mean velocity and their differences are more than 2000 km/s. In this sample we have 38 SBS galaxies (17% of 218) in 3 open clusters and 120 (50% of 240) in 3 medium-compact clusters are observed.

4. *SBS galaxies as members of a cluster.* The global properties of clusters of galaxies are correlated with the properties of their individual members which also depend on the location of the galaxies within the clusters. This is illustrated by the well established Dressler [32] morphology-density relation, with a very high fraction of early-type massive galaxies found in compact clusters and in cluster cores. This has been extended to a large range of galaxy density from SDSS [33] and to higher redshift [34]. To consider the properties of SBS galaxies which are members of clusters, we use the sample of Zwicky clusters containing SBS galaxies as real members and with no measured substructure (see Paper 1, Table 1). This sample contains 13 open clusters with 47 SBS galaxies, 11 medium-compact clusters with 54 SBS galaxies and 7 compact clusters with 11 SBS galaxies. In all there are 31 clusters with 112 SBS galaxies. To look at the correlation between properties of 31 Zwicky clusters and their member 112 SBS galaxies the following set of parameters are selected and are presented in Table 2:

- The compactness of the cluster (Cl Type). The coding is: open cluster - 1; medium-compact cluster - 2; compact cluster - 3.
- Absolute value of the difference between radial velocity of cluster and its member SBS galaxy ($|V_{cl} - V_{SBS}|$).
- Distance (r) of SBS galaxy from the center of the cluster, determined by coordinates given in CGCG and calibrated to the effective radius (R) (according to CGCG) of the cluster (r/R).
- Morphological type of the SBS galaxy. The coding is: S0 = -2; S0/a = 0;

Sa = 1; Sab = 2; Sb = 3; Sbc = 4; Sc = 5; Scd = 6; Sd = 7; Sdm = 8; Sm = 9; Im = 10; Compact = 14; merger = 15.

- Absolute blue luminosity of the SBS galaxy (M_B) computed from apparent B magnitude and redshift (z) according to the relation: $M_B = B - 5\times\log z - 43.01 - 0.24\times\csc(b^{\prime\prime})$,
- Linear major diameter of the SBS galaxy (D) in kpc.
- $B - R$ integral color ($B - R$) of the SBS galaxy.
- Neighbor count (Nn) within a 50 kpc radius circle around SBS galaxy.

In Table 2, these parameters for SBS galaxies are presented or calculated according to the SBS galaxies database [35]. The Table also includes the Zwicky clusters and their member SBS galaxies names.

Table 2

PROPERTIES OF SBS GALAXIES IN ZWICKY CLUSTERS

Zw cluster	Cl type	SBS	$\lvert V_{Cl} - V_{SBS}\rvert$	r/R	Morph	$M(B)$	D(Kpc)	$B - R$	Nn
1	2	3	4	5	6	7	8	9	10
0739.8+4949	2	0744+502	260	0.59	7	-18.67	9.14	0.6	0
		0746+501	340	0.78	0	-19.96	19.52	0.6	0
		0748+499	670	0.94	1	-19.76	19.95	0.8	0
0745.1+5220	2	0748+520	1020	1.54	4	-21.13	41.54	0.9	0
0810.1+5813	2	0805+577	185	1.00	14	-17.97	5.90	0.4	0
		0806+573	145	1.19	5	-18.98	19.03	0.5	0
		0806+579A	85	0.73	5	-20.00	22.80	0.5	1
		0806+579B	205	0.71	3	-18.16	13.78	0.7	1
		0807+581	425	0.40	0	-19.63	19.32	0.6	0
		0808+580A	25	0.39	5	-18.71	22.98	0.6	2
		0808+580B	245	0.28	0	-20.09	24.30	0.7	0
		0808+581A	85	0.33	0	-17.60	9.85	0.7	0
		0808+581B	65	0.29	0	-18.44	11.62	0.7	0
		0808+587	215	0.69	-2	-19.68	18.83	0.7	0
		0809+577	325	0.62	4	-18.73	21.60	0.8	0
		0809+582	425	0.07	4	-19.53	17.66	0.7	0
		0810+581	95	0.10	3	-19.95	33.40	0.5	0
		0810+583A	235	0.17	14	-18.36	11.18	0.7	0
		0810+583B	515	0.12	0	-17.26	8.92	0.4	0
		0810+585	655	0.40	3	-19.93	16.82	0.2	0
		0811+574	55	0.93	3	-18.61	12.49	0.4	0
		0811+583	575	0.29	0	-18.07	10.67	0.4	0
		0811+584	595	0.45	4	-19.65	22.78	0.5	1
		0811+585A	505	0.39	0	-17.78	12.26	0.4	0
		0811+585B	85	0.46	0	-17.70	7.26	0.5	1
		0812+576	595	0.75	3	-19.25	13.57	0.7	0
		0812+577	85	0.74	3	-18.70	12.96	0.6	0
		0812+582	145	0.31	0	-17.88	8.23	0.3	0
		0812+586	235	0.71	0	-17.06	8.13	0.5	0
		0813+578	295	0.74	14	-17.34	5.04	0.7	0
		0814+579A	125	0.77	5	-19.55	27.14	0.4	2
		0814+579B	245	0.74	1	-18.69	9.18	0.4	0
		0814+579C	155	0.76	3	-17.76	16.02	0.5	2

Table 2 (continued)

1	2	3	4	5	6	7	8	9	10
0822.4+5453	1	0809+549	1090	1.35	14	-18.52	6.92	0.5	0
		0823+550	730	0.17	15	-19.13	14.53	0.4	1
0855.0+5248	1	0853+520	680	0.49	5	-18.30	24.98	0.5	0
		0855+520	880	0.43	0	-18.42	13.16	0.8	0
0941.9+5653	3	0940+569A	660	0.72	14	-21.19	46.07	0.9	0
		0940+569B	240	0.67	5	-21.11	43.80	0.6	0
		0941+565	60	0.90	1	-20.33	36.20	0.8	0
0943.7+5454	2	0941+559	858	1.40	6	-20.03	39.19	0.4	0
		0943+561	492	1.56	15	-16.88	7.69	0.6	0
		0943+563B	858	1.75	-1	-17.93	8.04	0.2	1
		0946+547A	1062	0.56	0	-19.32	27.68	0.8	0
		0946+547B	1212	0.61	0	-18.55	10.22	0.5	1
1012.8+5337	1	0954+515	1243	1.31	0	-18.10	9.44	0.5	1
		0956+524A	827	1.04	1	-21.06	30.67	0.6	0
		0956+524B	1217	1.02	0	-17.89	11.72	0.4	1
		0959+521	1123	0.95	3	-20.78	37.42	0.6	0
		0959+544	883	0.79	0	-19.24	19.32	0.5	0
		0959+549	1273	0.91	1	-19.40	20.80	0.5	0
		1000+535	493	0.68	0	-20.28	31.29	0.7	0
		1001+540	1183	0.65	15	-19.29	21.61	0.5	0
		1002+518	1003	0.91	3	-20.76	29.00	0.6	0
		1002+524	617	0.72	0	-20.90	43.51	0.5	0
		1015+539	433	0.20	3	-19.77	26.70	0.5	0
		1033+541	973	1.19	-1	-20.06	15.74	1.5	0
1029.3+5736	2	1022+573	370	0.86	3	-20.04	19.01	0.6	0
		1028+566	380	0.88	0	-18.72	13.40	0.3	1
1114.3+5457	2	1110+556	300	0.85	-1	-19.34	12.41	0.5	4
		1113+560	480	1.09	15	-19.38	21.71	0.3	1
		1115+554	1140	0.52	3	-20.44	19.05	0.6	0
		1116+538	420	1.10	0	-18.59	27.30	0.3	1
		1117+547	1470	0.43	5	-21.06	46.81	0.8	1
1128.4+5618	3	1129+563	911	0.31	-2	-20.53	28.65	0.7	1
1144.0+5555	3	1145+558	190	0.60	4	-21.34	34.30	0.5	6
1144.6+5452	3	1145+549	72	0.38	-2	-21.69	61.61	0.5	2
1152.4+5805	3	1154+583B	1530	1.21	14	-21.04	39.60	0.7	0
1158.3+5816	3	1156+581	771	0.69	-2	-21.43	50.32	1	0
1158.7+5153	2	1201+520	120	0.82	0	-20.91	31.20	0.4	2
1209.8+5920	2	1210+593	1470	0.09	14	-20.98	35.25	0.6	0
1211.4+6013	2	1212+601A	13	0.13	-2	-21.71	25.09	0.5	1
		1212+601B	253	0.13	-2	-21.14	20.58	0.6	1
1301.9+5001	1	1305+502	1270	0.60	14	-18.81	10.51	0.3	0
		1308+501A	1250	1.03	4	-19.28	17.17	0.5	0
		1310+502	100	1.27	0	-18.54	13.33	0.4	1
1333.8+5931	3	1332+592	720	0.54	-2	-21.36	75.10	0.8	0
		1334+597	1230	0.38	0	-19.91	28.76	0.6	1
		1337+596	270	0.70	0	-20.86	42.19	0.9	0
1341.0+5930	1	1314+605	90	1.04	13	-15.54	3.81	0.4	2
		1319+579A	180	0.97	16	-13.65	1.46	0.6	0
		1319+579B	60	0.97	16	-17.37	7.79	0.3	0
		1341+594	840	0.04	14	-15.97	4.27	0.3	3

Table 2 (the end)

1	2	3	4	5	6	7	8	9	10
		1344+600	420	0.23	5	-16.00	9.22	0.6	0
		1354+597	840	0.50	14	-16.57	5.77	0.5	2
		1405+550	510	0.29	10	-15.60	5.23	0.7	1
		1405+597	570	0.96	0	-15.13	3.02	0.4	5
1341.9+5550	2	1342+562A	570	1.57	14	-19.46	11.22	0.4	2
		1342+562B	660	1.57	0	-19.17	15.49	0.4	2
1406.4+5513	1	1409+557	390	0.92	1	-16.32	6.90	0.8	1
		1411+546A	150	1.21	10	-15.60	4.83	0.4	0
		1413+573	1170	3.07	10	-16.71	13.65	0.5	0
		1415+578	930	3.89	0	-18.35	18.36	0.6	0
1429.9+5256	1	1423+517	320	1.07	10	-15.94	4.57	0.3	2
		1430+526	640	0.24	15	-16.89	7.33	0.2	2
		1435+516	260	1.07	15	-16.79	7.50	0.4	0
		1436+529A	940	0.67	15	-17.28	9.18	0.2	0
		1436+529B	220	0.76	7	-17.29	7.52	0.4	0
		1437+515	470	1.28	10	-16.79	4.56	0.4	0
1431.9+6020	1	1430+596	180	0.61	10	-16.03	6.09	0.4	1
		1441+610	390	1.07	0	-16.44	5.79	0.5	0
1456.2+4901	1	1445+491	1940	1.48	0	-17.09	5.13	0.4	0
1457.5+5415	1	1452+540	300	0.44	-2	-16.15	8.64	0.4	4
		1507+524	600	1.22	5	-18.47	9.73	0.4	1
		1509+527	660	1.26	0	-17.57.	7.36	0.5	0
		1509+555	390	1.15	0	-18.21	32.76	0.5	0
1613.8+5632	1	1616+545	600	1.12	5	-18.68	16.73	0.7	0
		1620+577	1140	0.81	10	-16.99	13.71	0.4	0
1647.6+5337	2	1646+523	370	1.40	-2	-19.63	13.00	0.6	1
		1646+536	350	0.24	0	-19.56	25.10	0.7	0
		1650+535	200	0.49	-2	-19.40	10.22	0.7	1
1730.4+5829	1	1715+579	190	0.83	0	-19.33	23.65	0.6	0

5. ***Multivariate Analysis of SBS galaxies as members of a cluster.*** We have performed a statistical comparison between Zwicky clusters and their member SBS galaxies using a Multivariate Factor Analysis (MFA) to identify correlations between the observed parameters listed in Table 1. The MFA gives a description or explanation of the interdependence of a set of variables in terms of the factors without regard to the observed variability. A detailed description of the MFA method can be found in [36,37]. This method has been used in astronomy by several authors (e.g. [38]). For a comparison of clusters and galaxies properties we choose as initial variables all parameters collected in Table 1. In order to simplify the interpretation of the results, we only present the Varimax orthogonal rotation values for the two most significant factors which contain correlation thresholds higher than 0.4. Table 3 shows the factor loadings, i.e. the correlation coefficients between the initial variables and the factors.

The first factor *F1* which accounts for about 35% of the common dispersion is the combination of Zwicky cluster type, morphology, absolute luminosity, linear size of the galaxies and their $B-R$ color. More compact clusters are populated with earlier morphological type, higher luminosity, larger linear size and redder galaxies. Since earlier morphological type galaxies have higher luminosity, larger linear diameter and redder optical color (e.g. [39]), this correlation between galaxy parameters and cluster compactness is just a reflection of well determined morphology-density relation [32,33].

Table 3

VARIMAX NORMALIZED FACTOR LOADINGS

Variable	*F1*	*F2*
Cl type	0.740	-0.337
$\|V_{cl} - V_{SBS}\|$	0.030	0.756
r/R	-0.246	0.554
Morph	-0.486	0.176
$M(B)$	-0.888	-0.093
D	0.860	0.112
$B-R$	0.610	0.259
Nn	-0.168	-0.596
Accumulated variance	35	53

Factor *F2*, which accounts for about 18% of the common dispersion, combines the absolute value of the difference between radial velocity of cluster and its member SBS galaxy ($|V_{cl} - V_{SBS}|$), the relative distance (r/R) of the SBS galaxy from the center of the cluster and neighbor count (Nn) within a 50 kpc radius circle around the SBS object. Galaxies located closer to the center of the cluster have more neighbors and a lower velocity difference from the mean velocity of the cluster. This correlation also depends on the compactness of the system (correlation coefficient is -0.337) and is more significant in higher compactness clusters. From an observational point of view such a correlation can be expected. A galaxy which is projected closer to the highly populated center of the cluster is more likely to be a physical member, so the galaxy velocity may differ less from the average velocity of the cluster. This tendency may be stronger in more compact clusters.

We compare the distribution of SBS galaxies in different type Zwicky clusters in Fig.1. This shows the distributions of r/R values normalized to the total numbers of galaxies in different type of clusters, with step $\Delta(r/R) = 0.2$. Fig.2 presents cumulative distributions for the same r/R values. As seen from these Figures (and also by $K-S$ test) the distribution of SBS galaxies in open Zwicky clusters is significantly different from that in medium-compact and compact clusters whilst there is not a significant difference between the distribution in medium compact and compact clusters. The SBS galaxies in open Zwicky clusters do not show any concentration in central regions of these clusters and their distribution probably follows the distribution of normal galaxies [22]. In medium-compact and compact Zwicky clusters SBS galaxies

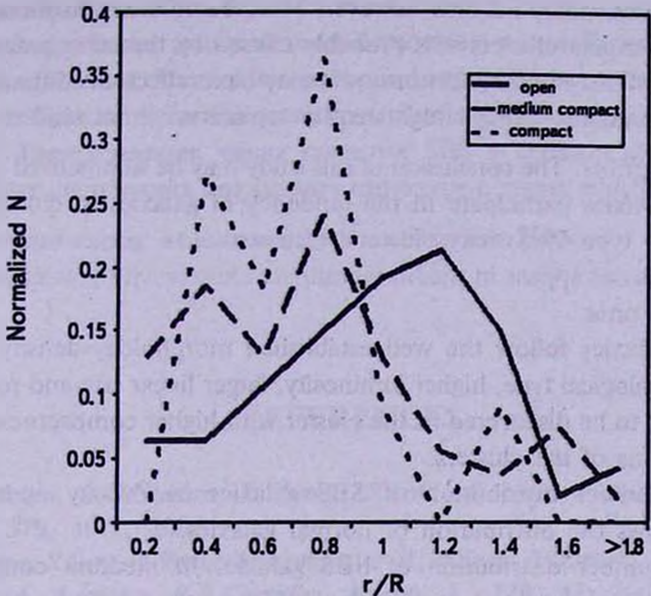

Fig.1. Normalized distribution of SBS galaxies, members of all Zwicky clusters, according to their distance from cluster center.

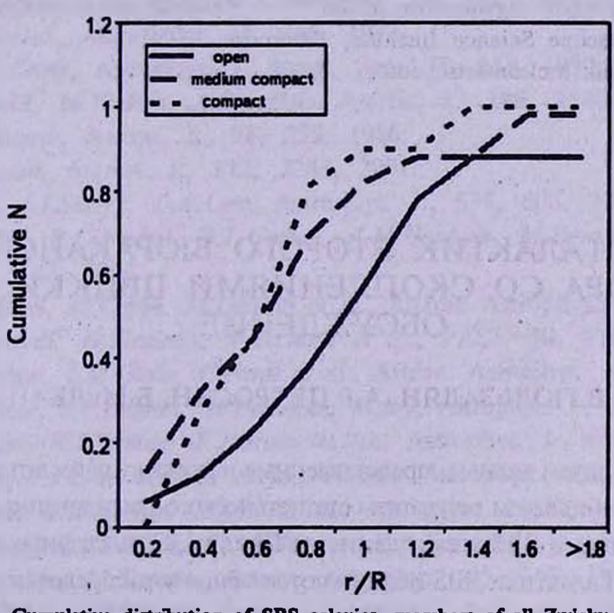

Fig.2. Cumulative distribution of SBS galaxies, members of all Zwicky clusters, according to their distance from cluster center.

distribution shows two maxima structure. The inner maxima are due to significant concentration of SBS galaxies in the central regions of these clusters. The nature of secondary maxima however, could be different for these systems. In medium-compact clusters it is probably caused by the sub-clustering phenomena [40], whilst in compact clusters it may be a reflection of the formation of a shell around the central high-density regions of these clusters [41,42].

6. *Conclusions*. The conclusion of this study may be summarized as follows:

1. SBS galaxies participate in the tendency of galaxies to cluster and do not avoid any type of Zwicky clusters.

2. SBS galaxies appear in medium compact clusters with greater probability than in open ones.

3. SBS galaxies follow the well established morphology-density relation. Earlier morphological type, higher luminosity, larger linear size and redder SBS galaxies prefer to be discovered in the cluster with higher compactness or more compact regions of the clusters.

4. The number distribution of SBS galaxies in Zwicky open clusters probably follows the distribution of normal galaxies.

5. The number distribution of SBS galaxies in medium compact and compact clusters shows two-maxima structure.

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СВЯЗЬ ГАЛАКТИК ВТОРОГО БЮРАКАНСКОГО ОБЗОРА СО СКОПЛЕНИЯМИ ЦВИККИ. II. ОБСУЖДЕНИЕ

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Мы анализируем данные, представленные в предыдущей статье Гюльзадян и Петросян, и обсуждаем результаты статистического исследования отношений между галактиками SBS и скоплениями Цвикки. Суть главных результатов в следующем: Галактики SBS подчиняются общему распределению галактик в скоплениях, и они не избегают типов скопления Цвикки. Вероятность обнаружения галактик SBS в средних компактных скоплениях значительно выше, чем в открытых скоплениях. Они также хорошо подчиняются установленному для этих скоплений отношению морфология - плотность. SBS галактики раннего морфологического типа, с более высокой яркостью, с большими линейными размерами и более красным цветом, чаще находятся в скоплениях с более высокой компактностью, или в более компактных областях скоплений. Численное распределение SBS галактик в открытых скоплениях Цвикки вероятнее всего подчиняется распределению нормальных галактик. Распределение числа галактик SBS в средних компактных и компактных скоплениях показывает структуру с двумя максимумами.

Ключевые слова: *галактики:SBS - скопления Цвикки*

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