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Shakhbazian compact groups: Poor clusters of galaxies

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Abstract. The environment of 105 elongated ($b/a < 0.5$) ShCGs is investigated for galaxies probably associated with them. Counts of galaxies are made in two reciprocally orthogonal stripes of $5'$ width and $20'$ length passing through the center of each elongated group. The orientation of the first stripe is determined by the orientation of elongation of the distribution of the principal members of groups. It is found that there is an excess of galaxies in the narrow stripes oriented along the elongation of the group. Such peculiar distribution of the loose group members allows us to conclude that they are gravitationally bound with the compact group, and rotate around the common gravitational center. It is shown that the new-found distant members compose, together with the principal members of the compact group, a gravitationally bound, and, most probably, virialized system. All members of the system rotate around the common gravitational center. It is concluded that ShCGs are the cores of poor clusters of galaxies. They must be not young, and are relatively stable configurations. The number of such groups could be very high in the Universe.

Key words. galaxies: general, abundances, clusters: general

1. Introduction

The problem of formation, existence and evolution of compact groups (CGs) of galaxies is a very intriguing one. N-body simulations showed that due to the proximity of member galaxies of CGs to each other they start to merge after a small number of crossing times (Barnes 1985, 1989; Mamon 1986). Each group should finally merge to one elliptical galaxy on a time scale of $\sim 10^9$ years. On the other hand, it has been shown that CGs are located in a dense environment of galaxies (Rose 1977; Sulentic 1987). The presence of loose groups (LGs) around Hickson compact groups (HCGs) has been stated by many others (e.g. Rood & Williams 1989; Ramella et al. 1994; Ribeiro et al. 1998; Barton et al. 1998; Coziol et al. 1998; Vennik et al. 1993). Mamon (1986) and Walke & Mamon (1989) suggested that CGs are not real physical entities, but are chance alignments of galaxies in LGs. According to Hernquist et al. (1995) and Ostriker et al. (1995) HCGs are filaments seen end-on. Much evidence has been presented, however, for the reality of HCGs (Hickson & Rood 1988; Mendes de Oliveira & Giraud 1994; Mendes de Oliveira 1995; Ponman et al. 1996; Hickson 1997; Tovmassian et al. 1998). Diaferio et al. (1994, 1995), Governato et al. (1996) suggested that field galaxies from relatively denser

environments fall from time to time onto HCGs, and thus maintain their existence.

Tovmassian et al. (2001) showed that galaxies of LGs have been found by Rood & Williams (1989) and Ramella et al. (1994) mostly in the neighborhood of those HCGs the direction of elongation of which is oriented at about 45° to the line of sight. Moreover, Tovmassian (2001) showed that LGs in the environment of HCGs may be found more efficiently, if one looks for LG members in areas located along the elongation of the corresponding HCG. It means that members of LGs are distributed along the same direction as the principal members of HCGs. Tovmassian & Chavushyan (2000) found that the radial velocity dispersion (RVD) of the LG members depends on the elongation of the group. Such peculiar distribution of the LG members in narrow stripes oriented along the direction in which principal members of the CG are distributed, and the dependence of the RVD on the elongation of the group shows that the LG members are, apparently, physically associated with the CG, and possibly rotate around the common gravitational center (Tovmassian & Chavushyan 2000). Tovmassian & Chavushyan (2000) concluded that HCGs are, thus, more stable configurations than it has been assumed before. Governato et al. (1991) and Zepf & Whitmore (1991) showed earlier that if to assume that most massive galaxies of CGs are even in quasi stationary orbits, the actual merging time of the

group can be considerably delayed. If to take into account that these orbits have also regular orientation along the group (Tovmassian et al. 1998; Tovmassian 2001), the life time of groups may apparently be higher.

In this paper we searched the environments of Shakhbazian compact groups (ShCGs) for faint companions. Ten lists of ShCGs have been compiled during 1973–1979 by Shakhbazian, Petrosian, Baier and Tiersch (Shakhbazian 1973; Shakhbazian et al. 1974; Petrosian 1974, 1978; Baier et al. 1974; Baier & Tiersch 1975, 1976a, 1976b, 1978, 1979). The total ShCG survey contains 377 groups. It is the largest known sample of CGs. ShCGs are more member-rich than HCGs. Each group contains 5–15 members with apparent magnitudes of individual galaxies in the range of $14^{\mathrm{m}}-19^{\mathrm{m}}$. The distances between galaxies are typically only 3–5 times the diameter of galaxies. ShCGs are, on average, at least three times further than HCGs (Tovmassian et al. 1998). Therefore, only relatively bright members of LGs, if they exist, could be detected, and, hence, the number of found galaxies may be small.

2. Counts of galaxies

The study of HCGs showed that faint galaxies in their environments are distributed along the direction of the elongation determined by the principal members of the corresponding CG (Tovmassian & Chavushyan 2000; Tovmassian et al. 2001; Tovmassian 2001). Therefore, sufficiently elongated ShCGs with $b/a < 0.5$[1] were selected to look for galaxies in their environment.

Among the total list of 377 ShCGs there are 179 groups with $b/a < 0.5$. ShCGs have been selected as compact groups of *compact* galaxies, as the latter appeared on the Palomar Prints. Spectral observations showed later that some groups, e.g. ShCG 12, 78, 146, etc. (Tovmassian et al. 1998) consist mainly of stars. Such false groups would mask the searched peculiar distribution of the LG galaxies around CGs. For this reason we inspected on the DSS the images of galaxies in those groups in which almost no galaxies were identified in the APS catalog[2]. Revision of images of members of ShCGs with the use of the APS and DSS showed that many members of the groups ShCG 12, 25, 28, 99, 106, 107, 108, 115, 116, 119, 124, 140, 146, 148, 232, 239, 249, 250, 274, 287, 290, 293, 305, 316, and 319 are most likely stars. These groups were considered as, probably, false ones, and were excluded from further study. The b/a ratio for some groups (ShCG 52, 83, 104, 248) became higher than 0.5 after exclusion of starlike members which turned out to be stars. These groups were also excluded

from the study. Nine groups (ShCG 6, 38, 54, 120, 165, 190, 233, 361, and 362) located within the known Abell or Zwicky clusters of galaxies, were excluded as well. After exclusion of the mentioned ShCGs 142 groups were left. The APS catalog was used for counts. The counts were made in 105 of those ShCGs for which the APS data were available as of 1 December 2000.

We counted galaxies in two orthogonal narrow stripes passing through the center of each group (Fig. 1). The first stripe was set to be oriented in the direction of the elongation outlined by principal members of the corresponding ShCG. The position angle of this direction is determined with an accuracy of a few degrees. Since the largest dimension of the majority of ShCGs is about $2'-3'$, a value of $5'$ was chosen as the width of the searched stripes. The length of stripes is $20'$. At a mean redshift $z \sim 0.1$ of ShCGs (Tovmassian et al. 1998) the width and length of stripes correspond, on average, to ~ 600 kpc and ~ 2.3 Mpc, respectively[3].
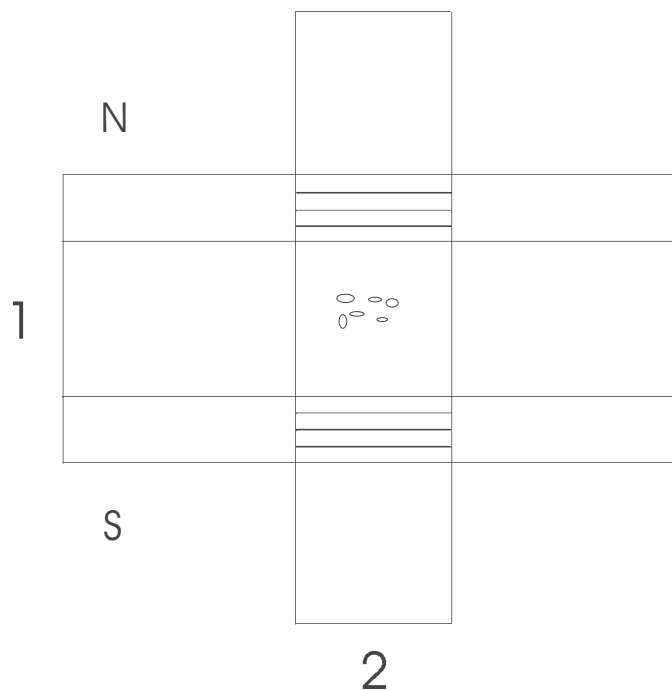

Fig. 1. The scheme of stripes where counts were made.

The limiting magnitude of the counted galaxies is 22^{m} in R. The photometric accuracy of the APS may be worse than the claimed value of about $0^{\mathrm{m}}25$. This may introduce an uncertainty at the limit of the APS detection. One has also to take into account that there could be some selection effects related to misclassification of galaxies and stars in the APS. Indeed, two nearby stars on the sky or a fuzzy image of a star could be recognized as a galaxy. On the other hand, a galaxy with a bright core may be misclassified as a star. Such misidentification may have some influence on the counts made. However, as is seen

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[1] The parameter b/a, where a is the angular distance between the most widely separated galaxies in the group, and b is the sum of the angular distances b_1 and b_2 of the most distant galaxies, on either side of the line a joining the most separated galaxies (Rood 1979), characterizes the elongation of the group.

[2] The APS databases are supported by the National Aeronautics and Space Administration and the University of Minnesota, and are available at `http://aps.umn.edu/`

[3] $H = 75$ km s^{-1} Mpc^{-1} throughout this paper.

below, such selection effects do not have any significant influence in the case of the counts made.

The numbers, N_c, of galaxies in the first stripe, oriented along the elongation of the corresponding group, and the numbers, N_o, in the orthogonal stripe were counted. Since the aim of the counts made was to see if there is a systematic difference in the numbers of galaxies in two reciprocally orthogonal stripes, the counts do not include galaxies in the central square with a $5'$ side. Hence, counts were made in stripes with areas $5' \times 15' = 75 \ \square'$. The identified members of ShCGs which were out of the common central square, were not included in the counts. Then the difference, Δ_c between N_c and N_o was calculated for each group.

For comparison, additional counts were made also in two half as narrow stripes on both sides (to the north, and to the south) of the first stripe (the area of each of these narrow stripes is $2.5' \times 20' = 50 \ \square'$). Then the differences $\Delta_{n-s} = N_n - N_s$ between the numbers of galaxies in the northern and southern stripes were calculated. The differences Δ_s between the numbers of galaxies $N_{n+s} = N_n + N_s$ in two side stripes and N_o in the orthogonal stripe were calculated as well. In the latter case, to make equal the sum area of two side stripes to that of the central stripe ($(2.5' + 2.5') \times 15'$), the counts were not made in those parts of the side stripes (shaded in Fig. 1) which overlap with the orthogonal stripe.

The results of counts are presented in Table 1. In the first column the designation of the group is given. The right ascension and declination of the center of the searched stripe are presented in Cols. 2 and 3. The center of the searched area mostly coincides with that given in the original ShCG lists (Shakhbazian 1973; Shakhbazian et al. 1974; Petrosian 1974; Petrosian 1978; Baier et al. 1974; Baier & Tiersch 1975, 1976a, 1976b, 1978, 1979). The position angle of the first stripe is given in Col. 4. The numbers N_c and N_o of galaxies in the central and orthogonal stripes are given in Cols. 5 and 6 respectively. The difference Δ_c is presented in Col. 7. The differences Δ_{n-s} and Δ_s are presented in Cols. 8 and 9, respectively.

3. Discussion

If the distribution of galaxies in the environment of ShCGs does not depend on the orientation of the elongation of the latter, then all three considered differences Δ_c, Δ_{n-s}, and Δ_s would apparently be determined by noise, and would have a normal distribution around zero. The histogram of the distribution of differences Δ_c between numbers of galaxies in the central stripe oriented along the elongation of the group and in the orthogonal one, is presented on the upper frame of Fig. 2. On the same figure the differences Δ_{n-s} between numbers of galaxies in two side stripes (middle frame), and differences Δ_s between the sum of the numbers of galaxies in two side stripes and in the central orthogonal stripe (lower frame) are presented. The results of counts are summarized in Table 2. The Kolmogorov-Smirnov test showed that with a probability $P = 99\%$ the

distributions of all three considered differences Δ_c, Δ_{n-s} and Δ_s are normal. Mean values of the last two differences are, as it was expected, close to zero: 1.0 ± 6.6 and -0.2 ± 7.5 respectively. Meanwhile, the mean value of differences Δ_c is 3.7 ± 6.9.
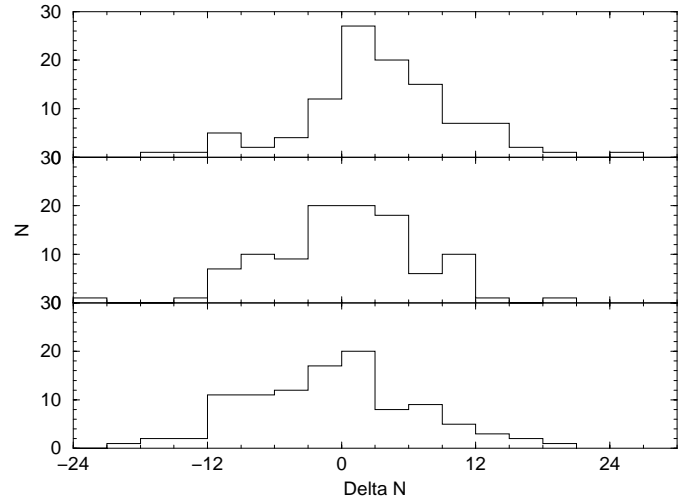
Fig. 2. The hystograms of distribution of differences Δ_c (up), Δ_{n-s} (middle), and Δ_s (lower).

Considering the differences Δ_{n-s} and Δ_s as a control samples, we may assume that a LG is, probably, detected, if Δ_c exceeds the dispersion ~ 8 of both these distributions. It is prominent that $\Delta_c \geq 8$ in the case of 26 ShCGs, while the number of groups with $\Delta_c \leq -8$ is only 8. In the samples of differences Δ_{n-s} and Δ_s the numbers of groups with large positive values (≥ 8) of Δ_{n-s} and Δ_s are smaller: 15 and 19 respectively. These numbers differ very little from the numbers of groups with large negative (≤ -8) values of Δ_{n-s}'s and Δ_s's: 10 and 18 respectively. Hence, it is very probable that most of the 26 ShCGs with $\Delta_c \geq 8$ are associated with LGs. There are, on average, 12 ± 4 galaxies in the environment of each of these 26 ShCGs.

The two-sample Mann-Whitney rank sum test showed that the hypothesis that the distribution of Δ_c is of the same parent distribution as that of Δ_{n-s} and that of Δ_s, is rejected with probabilities $P > 99.8\%$ and $P > 99.99\%$, respectively. Hence, an excess of, on average, four galaxies is found in the environment of the studied elongated ShCGs. And, as in the case of HCGs (Tovmassian 2001), these galaxies are located along the direction in which the principal members of CGs are distributed.

The two-sample Mann-Whitney rank sum test showed that the distribution of differences Δ_s between the sum of the numbers of galaxies in two side stripes and in the central orthogonal stripe does not differ from the distribution of Δ_{n-s} with a significance level $P = 10^{-8}$. It means that members of LG galaxies are found merely in the narrow central stripe with $5'$ width. It is not excluded that some amount of LG members may be located in the central square in the immediate vicinities of bright members of groups.

Table 1. The results of counts.

ShCG	RA 2000.0	Dec 2000.0	θ °	N_c	N_o	Δ_c	Δ_{n-s}	Δ_s
3	11 15 16.0	53 40 40	117	38	25	+13	+10	+8
4	16 19 45.0	61 42 30	95	20	11	+9	+6	−3
9	13 24 05.3	19 01 48	28	33	25	+8	+3	+3
10	14 10 48.0	46 15 40	89	33	24	+9	+3	+2
14	14 25 20.0	47 15 01	33	25	17	+8	+4	+9
24	23 46 56.6	−00 53 02	89	38	35	+3	+3	−10
27	23 32 42.3	01 33 00	151	18	27	−9	+1	−8
31	00 58 17.4	13 54 45	109	24	24	0	−4	−4
32	01 01 47.1	−01 34 50	172	23	13	+10	−1	−2
33	01 03 42.6	−01 09 00	18	13	13	0	+4	−2
41	01 29 01.5	07 40 27	37	24	22	+2	+6	−10
43	01 38 27.1	08 31 08	54	39	39	0	+5	−15
44	01 40 52.9	02 51 13	166	22	24	−2	+1	−2
46	02 05 12.4	03 20 58	25	23	11	+12	−3	+8
47	02 06 00.6	02 52 45	124	20	9	+11	+2	+10
48	09 48 07.5	46 52 32	99	27	21	+6	−2	+1
49	10 15 19.0	38 55 35	30	40	29	+11	+1	+1
51	10 30 32.9	39 12 57	94	28	26	+2	−4	−6
55	10 43 34.5	48 21 54	105	22	21	+1	+4	+2
56	10 43 30.0	42 01 18	54	26	25	+1	−9	−1
57	10 45 20.4	49 32 00	30	27	38	−11	+3	−12
68	11 47 38.8	39 16 16	10	10	7	+3	+5	+2
69	11 52 14.4	39 06 47	5	23	17	+6	+4	0
74	14 21 08.4	42 03 55	105	29	23	+6	−2	+2
75	14 27 36.1	38 46 00	135	23	15	+8	+3	0
79	15 32 39.8	43 04 00	40	22	15	+7	+5	+3
81	21 57 58.0	−01 45 34	48	41	35	+6	+11	+13
84	23 34 37.5	07 59 25	157	8	9	−1	−5	0
95	08 28 37.9	50 17 43	97	14	10	+4	−6	+12
121	11 30 52.4	37 53 12	72	11	8	+3	+6	+8
122	11 43 13.6	57 18 20	93	23	19	+4	−2	−3
131	14 38 05.6	62 44 03	77	8	4	+4	0	0
141	01 04 15.7	−01 33 12	104	15	8	+7	−2	−4
142	01 47 11.1	03 25 23	101	32	19	+13	+6	−5
145	02 16 36.7	−02 08 30	34	31	29	+2	−3	−8
182	08 38 19.1	29 44 54	110	26	21	+5	−5	+1
183	08 44 34.0	27 17 10	26	23	19	+4	+6	−11
184	09 08 07.9	30 36 28	55	16	12	+4	0	+8
185	09 22 26.0	31 32 41	44	23	10	+13	+7	+8
186	09 22 52.5	28 55 24	26	28	24	+4	+10	−2
187	09 40 27.0	30 59 03	49	13	12	+1	+4	+4
189	10 27 55.3	32 15 43	12	30	26	+4	−7	−9
195	11 04 33.2	28 42 25	139	14	18	−4	+9	+2
196	11 05 46.4	28 24 30	48	23	18	+5	−4	−5
200	11 41 13.8	27 26 10	10	16	14	+2	+10	+2
204	12 30 07.6	27 35 06	43	32	33	−1	−10	−1
209	13 10 39.2	31 44 16	100	36	23	+13	+12	+16
211	13 36 30.0	28 34 34	174	20	26	−6	−7	−8
213	13 45 11.6	26 53 31	177	43	26	+17	+7	+3
214	13 45 23.7	32 06 36	53	36	15	+21	+5	+15
220	15 59 30.0	29 42 16	82	21	22	−1	+11	+4
221	15 36 55.0	30 41 24	98	44	18	+26	+7	+11
222	15 43 38.7	31 33 12	95	38	37	+1	−1	−11

Table 1. continued.

ShCG	RA 2000.0	Dec 2000.0	θ °	N_c	N_o	Δ_c	Δ_{n-s}	Δ_s
230	09 51 36.0	32 08 51	53	25	11	+14	+10	+1
231	10 01 41.4	38 18 45	23	24	35	−11	+10	−14
235	10 56 20.0	32 18 00	89	31	24	+7	−1	+2
237	11 05 28.6	38 00 54	74	24	16	+8	+5	+5
240	11 33 40.0	36 03 52	127	18	27	−9	+15	+5
244	12 17 05.9	35 18 00	131	18	16	+2	+12	−4
246	12 38 22.7	32 13 06	65	37	31	+6	+1	−4
251	13 36 53.6	36 49 33	41	22	16	+6	0	−2
255	14 10 42.0	32 15 42	125	37	35	+2	−1	0
257	14 46 56.8	37 34 04	150	28	27	+1	−9	+4
259	15 39 30.7	37 50 44	45	18	26	−8	−10	−6
260	15 42 24.2	34 54 00	92	28	27	+1	+8	+17
272	02 32 10.5	−13 12 46	6	15	13	+2	+10	+7
273	02 52 36.0	−13 06 00	144	9	11	−2	+1	−4
276	03 17 14.0	−13 51 25	32	25	22	+3	−1	−4
279	04 12 54.3	−08 29 04	131	32	25	+7	+6	+10
289	13 58 09.3	−12 53 00	95	36	35	+1	+2	−7
291	14 06 18.2	−10 28 57	113	35	34	+1	+19	−3
295	15 05 59.4	−12 24 51	11	46	39	+7	−4	+1
297	21 42 17.5	−11 53 28	138	42	34	+8	−8	−6
299	22 18 15.2	−13 39 33	60	31	35	−4	+2	−2
300	22 24 31.2	−11 20 58	88	23	19	+4	−9	+11
304	23 43 40.0	−12 28 35	91	19	20	−1	+2	+1
308	00 37 11.7	−07 41 54	161	23	16	+7	−1	+20
309	00 51 16.8	−07 24 33	2	12	24	−12	−3	−3
314	01 25 45.7	−03 29 44	107	28	12	+16	+6	+6
317	02 10 41.8	−06 35 12	130	31	19	+12	+1	+1
318	11 09 36.9	−04 20 20	92	11	12	−1	+5	−1
320	11 14 46.7	−06 21 40	22	11	10	+1	0	−1
321	11 15 59.1	−03 56 02	145	20	14	+6	+11	−2
322	11 23 41.7	−04 13 02	93	24	21	+3	+2	−1
323	12 19 17.3	−07 24 14	123	41	39	+2	−6	−9
324	12 25 44.7	−08 31 38	90	20	14	+6	+1	−5
325	12 43 48.7	−06 47 34	50	25	23	+2	−3	−10
331	22 25 27.1	−02 47 00	13	14	31	−17	0	−15
332	22 52 12.8	−05 00 07	124	29	31	−2	−2	−11
333	22 02 03.4	−05 43 00	152	25	23	+2	−1	+6
334	23 06 52.2	−04 33 32	159	24	33	−11	+4	−19
338	00 04 23.3	03 49 18	27	20	25	−5	+3	−3
343	08 41 13.1	07 32 01	42	26	24	+2	−10	+14
344	08 47 32.3	03 41 53	155	37	27	+10	−9	−6
347	09 17 32.9	07 42 30	41	31	27	+4	+1	+8
349	10 06 35.5	06 55 48	120	31	34	−3	−14	−2
350	11 00 01.2	08 24 22	131	21	19	+2	−7	−10
355	13 12 11.6	07 18 29	95	22	17	+5	0	+3
356	13 30 39.3	11 24 09	41	46	36	+10	+1	+8
367	09 01 44.0	21 42 07	86	22	23	−1	−1	−11
370	09 50 20.9	23 16 38	11	34	19	+15	−4	+5
371	11 43 33.1	21 53 48	37	40	33	+7	−2	+2
374	13 15 59.1	21 25 01	37	38	37	+1	−23	−9
376	13 56 34.9	23 21 50	89	42	29	+13	−7	−6
377	14 30 17.1	22 25 55	127	30	22	+8	−7	+1

Hence, many ShCGs are associated with LGs, members of which, as in the case of brighter galaxies in the environments of some HCGs and poor galaxy groups with measured redshifts (Tovmassian & Chavushyan 2000) or galaxies in the environment of HCGs with higher limiting magnitude (20$^{\mathrm{m}}$) (Tovmassian 2001), are distributed along the elongation of the corresponding ShCGs. There are, on average, four galaxies in each LG. This shows that unavoidable selection effects in misclassification of the images of stars and galaxies in the APS do not have any significant influence on the statistical results, obtained by comparing the numbers of galaxies in orthogonal stripes, and do not mask the expected correlation.

Table 2. The mean values of differences Δ_{c}, $\Delta_{\mathrm{n-s}}$, and Δ_{s}.

Δ_{c}	$\Delta_{\mathrm{n-s}}$	Δ_{s}
3.7 ± 6.9	1.0 ± 6.6	-0.2 ± 7.5

Redshifts of only 24 ShCGs out of 105 are known (Tiersch et al. 1996, 2001). Only one of these groups, ShCG 333, is at a redshift 0.011. Redshifts of other groups are in the range of 0.0517–0.185. At a mean redshift of ShCGs, $z \sim 0.1$ (Tovmassian et al. 1998) the absolute magnitude of the faintest detected galaxy of the associated LG is, on average, equal to -16^{m}. It means, that the members of the LGs associated with ShCGs are of moderate luminosities. The number of fainter galaxies could apparently be larger (Schechter 1976; Valotto et al. 1997).

It has been found that ShCGs have forms of prolate spheroids or "cigars" (Oleak et al. 1995, 1998). The distribution of the LG galaxies along the "cigar" shows that the whole CG+LG system has the same shape. The peculiar distribution of LG galaxies in narrow stripes in the environment of HCGs and of poor groups of galaxies, and the dependence of the RVD of LG members on the elongation of the whole system, allowed Tovmassian et al. (1998), Tovmassian & Chavushyan (2000), and Tovmassian (2001) to conclude that the principal members of HCGs and the LG members associated with them move predominantly along the direction of elongation of the whole system. The situation is analogous in the case of ShCGs. Such space configuration and movement of members of ShCGs may be explained by three options:

1. Principal members and faint distant members of ShCGs *depart from the center of group in opposite directions.*

a. It could be a result of ejection from central galaxy in accordance with Ambartsumian's (1961) or Arp's (1973, 1997 and references therein) ideas. However, no physical mechanisms of such processes are yet known.

b. According to Binggeli (1982), clusters of galaxies with separations less than 30 h^{-1} Mpc tend to "point towards each other". Splinter et al. (1997) showed by N-body simulations that alignments of cluster-cluster orientation drop off at distances >15 h^{-1}. Hence, a CG

located between two nearby large clusters would disintegrate, and members of the former would depart from each other in the direction of the large cluster-cluster alignment. However, the distribution of orientation of major axes of HCGs is isotropic in relation to distribution of clusters of galaxies (Palumbo et al. 1995). Hence, there is no outside force to stretch the groups. The same could apparently be applied to ShCGs as well. Therefore, the first option should be ruled out.

2. *Infall of environmental galaxies of filaments upon the group from opposite directions.* The widths of filaments (see Figs. 5 and 6 in Eisenstein et al. 1997) are generally larger than the widths of the searched stripes (~ 600 kpc). It means that the infall should generally be isotropic, while the contrary is observed. Moreover, the orientation of the elongation of groups is not correlated with the distribution of nearby clusters (Palumbo et al. 1995). Therefore, this option should be ruled out as well.

3. The most realistic option which does not contradict to observational data is the following: principal members of the ShCG and faint members in its environment, distributed along the elongation of the group compose *a gravitationally bound system, and, probably, rotate around the gravitational center of the whole group* in orbits preferentially oriented along the elongation of the group.

We may assume that a member of the CG makes one revolution around the gravitational center of the group during two crossing times, $2\tau_{\mathrm{cr}}$. The half length of the elongated group is the semiaxis of the supposed orbit. The mean τ_{cr} of ShCGs is about 2×10^8 years, and the mean radius is about 120 kpc (Tiersch et al. 2001). According to Kepler's third law, a LG galaxy at a mean distance of 0.5 Mpc from the center of the CG makes one revolution in $\sim 5 \times 10^9$ years, i.e. in less than the Hubble time. The orbits of the principal members of the "cigar"-like systems may, however, be larger than the observed ~ 100 kpc. For groups oriented close to the plane of the sky the observed length $r_{\mathrm{o}} = r_{\mathrm{t}} \cdot \cos \alpha$ would be near to the true value r_{t}, while the observed RVD, $\sigma_{\mathrm{o}} = \sigma_{\mathrm{t}} \cdot \sin \alpha$ (σ_{t} is the true value), would be smaller. For groups oriented near to the line of sight the observed length would be minimal, while the σ_{o} would be close to the real value. The revolution time of the LG member at a distance a determined by the observed semiaxis r_{o} of the CG and its measured crossing time, $\tau_{\mathrm{cr}} \sim r_{\mathrm{o}}/\sigma_{\mathrm{o}}$, can be estimated:

$$T \sim \sqrt{a^3/r_{\mathrm{o}}\sigma_{\mathrm{o}}^2} = \sqrt{a^3 \left(r_{\mathrm{t}} \cdot \cos \alpha \cdot \sigma_{\mathrm{t}}^2 \cdot (\sin \alpha)^2 \right)^{-1}}.$$

One has to take into account that r_{o} would never be zero, since galaxies in the group are not aligned along one line, and are moving in orbits with high excentricity. Similarly, σ_{t} would not be zero, since velocities of member galaxies in a group are not obviously parallel to each other. It follows then, that the deduced revolution time T would be higher than the real value for groups oriented close to the line of sight, and also for those oriented nearly orthogonal

to the line of sight. The estimated time would be nearer to the real value for groups with elongations oriented at intermediate angles to the line of sight. Therefore, the real rotation time would be smaller than the value estimated above by using the average values of the semiaxis and the crossing time of ShCGs. Hence, the CG+LG systems may well be virialized.

Near the gravitational center of a "cigar"-like system galaxies move faster. In such conditions efficiency of merging should apparently be small. However, in a "cigar"-like configuration with relatively small cross-section the effect, that sweeps out the gas by tidal forces from member galaxies passing-by not far from each other, may be very effective. This may partly explain the small spiral content of ShCGs, which is only ∼20% (Tiersch et al. 1996, 2001), meanwhile in HCGs, for example, the spirals compose about half of the population (Hickson et al. 1989). One has to take into account, however, that ShCGs were selected as groups of red galaxies. Therefore, the large content of ellipticals in them may be considered as a result of a bias. However, it is a fact that there exist such groups consisting mainly of ellipticals. It means that processes of interaction have, indeed, occurred in these groups, and they are not young formations, i.e. the ShCGs are dynamically more evolved than HCGs. It is natural that the rate of powerful infrared and radio sources in ShCGs, containing mostly gas poor ellipticals, is small (Tovmassian et al. 1998, 2000).

Hence, the option that members of LGs in the environment of ShCGs rotate around the common gravitational center preferentially in the direction of elongation of the CG, as was concluded for HCGs (Tovmassian & Chavushyan 2000; Tovmassian 2001), seems to be acceptable in the case of ShCGs as well.

Thus, ShCGs seem to be more stable configurations than it has been supposed. The conclusion on very short life-times of CGs determined in N-body simulations, when only 5–10 galaxies have been considered, and when a probable regular rotational movement of member galaxies around the gravitational center of a group have been ignored (Barnes 1985, 1989; Bode et al. 1993; Mamon 1986), is hardly applicable to CGs generally. The ShCGs present an explicit observational evidence for it. The suggestion of Governato et al. (1991) and Zepf & Whitmore (1991) on the quasi stationary orbits of most massive galaxies of CGs is nearer to reality.

4. Conclusions

The vicinities of 105 elongated ShCGs are searched for fainter members. Counts of galaxies are made in two orthogonal narrow stripes of 5′ width and 20′ length centered on each ShCG. The first stripe is oriented in the direction determined by the principal members of the corresponding group. Counts are made also in two half-as-narrow stripes on both sides of the central stripe.

About four galaxies are, on average, detected in the environment of each of the investigated 105 ShCGs. In the case of 26 ShCGs with $\delta_c \geq 8$ about 12 galaxies on average are found. The faint galaxies found are distributed along the direction of the elongation of the group. It is concluded that faint members together with the brighter members compose a gravitationally bound, most probably virialized system. The orbits of the member galaxies are preferetially aligned with the elongation of the group. Hence, ShCGs are more stable formations than has been assumed. Their new-found members of moderate luminosities are located at relatively large distances (up to 1 Mpc) from the visual central concentration of brighter galaxies. Apparently, ShCGs may contain fainter members. Therefore, these groups may be regarded as, rather, poor clusters of galaxies.

Processes of interaction, e.g. tidal stripping and ram pressure, are more likely in "cigar"-like ShCGs with small cross-sections than in ordinary poor groups or clusters of galaxies. At the same time, the processes of merging should be rarer for regular movement of member galaxies.

If the orientation of the elongated group is close to the line of sight, its bright members seen nearby on the sky may be far from each other in space. When the orientation of the group is nearly orthogonal to the line of sight, it would be detected as a CG only in the case when its bright members happen to be close to each other on the sky in the course of regular rotation around the gravitational center of the group. The probability of the latter is apparently very small. The groups without dominant bright members would also be undetected. It follows that the number of such groups in the nearby Universe could be much higher.

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