RADIO EMISSION OF SHAKHBAZIAN COMPACT GALAXY GROUPS

H. M. TOVMASSIAN AND V. H. CHAVUSHYAN
Instituto Nacional de Astrofísica Óptica y Electrónica, Apartado Postal 51 y 216, Puebla, Pue, CP 72000, México; hrant@inaoep.mx, vahram@inaoep.mx
O. V. VERKHODANOV
Special Astrophysical Observatory RAS, Nizhniy Arkhyz, Karachai-Cherkessia, 351147, Russia; vo@sao.ru
AND
H. TIERSCHE
Sternwarte Königstuhl, München, Germany; sternwarte.kgl@aon.at

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ABSTRACT

We detect 353 radio sources from the NRAO VLA Sky Survey (NVSS) and the FIRST Survey within the areas of 179 Shakhbazian compact groups (ShCGs) of galaxies. Ninety-three of them are identified with galaxies in 74 ShCGs. Six radio sources have complex structure. The radio spectra of 22 sources are determined. Radio luminosities of galaxies in ShCGs are in general higher than those of galaxies in Hickson compact groups (HCGs). A comparison of radio (at 1.4 GHz) and FIR (at 60 μm) fluxes of ShCG galaxies with those of HCG galaxies shows that galaxies in ShCGs are relatively stronger emitters at radio wavelengths, while galaxies in HCGs have relatively stronger FIR emission. The reasons for such differences are discussed.

Subject headings: galaxies: clusters: general — radio continuum: galaxies — submillimeter — surveys

1. INTRODUCTION

A couple of decades ago it was discovered that radio emission is observed about 3 times more often from double galaxies and members of groups of galaxies than from single, isolated galaxies (Tovmassian 1969; Sulentic 1976). It is widely accepted that galactic nuclear activity, one of the manifestations of which is a radio emission, is a result of interaction between galaxies. Interaction events should take place much more often in the dense environments of compact groups (CGs) of galaxies. Therefore, it was expected that some member galaxies in CGs should be relatively strong radio emitters. The first systematic search for radio emission from Hickson compact groups (HCGs) revealed radio emission at 18 cm above a flux limit of 1.5 mJy from 41 out of 88 observed member galaxies (Menon & Hickson 1985). It was found (Tovmassian & Shakhbazian 1981) that in groups of galaxies the radio emission is most often observed from the optically first-ranked galaxies. Menon (1992) showed that the radio emission in HCGs is almost always associated with the first-ranked elliptical galaxies, while the radio-detected spirals are uniformly distributed among the three brightest members of a group.

Prior to the HCGs, lists of so-called Shakhbazian compact groups of compact galaxies (SCCGs) were published (Shakhbazian 1973; Baier & Tiersch 1979 and references therein). This is the largest sample of galaxy groups known up to now and is relatively homogeneous. Shakhbazian’s CGs were found on the Palomar Observatory Sky Survey (POSS) prints by an eye search. They were identified according to the following criteria:

1. The groups consist of 5–15 members.
2. The apparent magnitude of the individual galaxies is between 14 and 19 mag.
3. The groups are compact, i.e., the distances between galaxies are only 3–5 times the diameters of galaxies.
4. Nearly all member galaxies are extremely red, with at most 1–2 blue galaxies in a group.
5. Members of groups are compact (relatively high surface brightness, borders not diffuse).
6. The groups are isolated.

ShCGs were originally called compact groups of compact galaxies because the images of most of the constituent galaxies in these groups seemed very compact. Later observations of these groups with high angular resolution revealed that member galaxies are mostly of E and S0 types. The fraction of early-type galaxies is 77% in SCGs, compared to 51% in HCGs and 40% in field galaxies (Tiersch et al. 1996b). Member galaxies in these groups are significantly redder than field galaxies of the same morphological type. The difference in B − V and V − R is ~0.2 mag redder than galaxies of the RC3. Emission-line and even Seyfert galaxies were found among Shakhbazian groups members.

Since, as it was later discovered, individual members of Shakhbazian groups turned out not to be compact, in recent papers these groups have been called Shakhbazian compact groups of galaxies (SCCGs) (Tovmassian et al. 1998c, hereafter TMTST; Tovmassian, Cardona, & Tiersch 1998a), or in analogy with HCGs, Shakhbazian compact groups (ShCGs) (Tovmassian et al. 1998b). Galaxies in ShCGs are relatively weak, because they are at least 3 times farther than HCGs (TMTST). Mainly for this reason, and probably also because of their very unusual supposed composition, the ShCGs attracted little attention until recently. Redshifts for only about 70 relatively bright and nearby ShCGs have been measured so far (Robinson & Wampler 1973; Arp, Burbidge, & Jones 1973; Mirzoyan, Miller, & Osterbrock 1975; Amirkhanian & Egikian 1987; Amirkhanian 1989; Kodaira et al. 1988, 1990; Kodaira & Sekiguchi 1991; Lynds, Khachikian, & Amirkhanian 1990; del Olmo & Moles 1991; Tiersch et al. 1997).

The densities of galaxies in ShCGs approaches 10³–10⁴ Mpc⁻³. Hence, interaction and merging processes should be frequent in them. As a consequence, some ShCGs could be radio and FIR emitters. However, because of larger dis-
tances and different morphological content (Tiersch et al. 1996a), we can expect a smaller rate of radio and FIR detections from ShCGs in comparison with HCGs. Results of the search for FIR emission from ShCGs were published recently by TMTST. In this paper we present the results of a search for radio emission from ShCGs.

2. OBSERVATIONAL DATA

The original lists of ShCGs included 377 groups. The positions of the group centers were given with accuracies of about 1'. For identification of radio sources with ShCGs, we used accurate coordinates of member galaxies measured afterward from the Digitized Sky Survey (DSS) by Stoll et al. (1997, and references therein). Positions of four groups, ShCG 206, 241, 301 and 353, were largely incorrect in original lists, and they were not found during accurate position measurements. It was also revealed that the group ShCG 214 coincides with ShCG 252, and that the group ShCG 340 consists of two groups, ShCG 340a and ShCG 340b. Spectral observations showed that five groups, ShCG 12, 13, 78, 146, and 180, consist mainly of stars. Thus, we searched for a radio emission at the positions of 367 ShCGs.

In looking for radio emission from ShCGs we first examined the NRAO VLA Sky Survey (NVSS; Condon et al. 1998) at 1.4 GHz at the positions of all 367 ShCGs. Generally, an area of ±3' centered on each group was investigated. The FIRST Survey (White et al. 1997), made at the same frequency, was used in addition for those 175 ShCGs that are located in the area of the sky covered by FIRST until 1998 November 1.

The errors of the radio-position measurements in these surveys are small enough. For the NVSS sources, they vary from ≤1" for sources stronger than 15 mJy to 7" at the survey flux limit at $F \sim 2.5$ mJy (Condon et al. 1998). For the FIRST radio sources the errors are smaller: ≤0.5" for sources with flux densities greater than 3 mJy, and 1" at the survey threshold of 1 mJy (White et al. 1997).

3. RESULTS AND DISCUSSION

3.1. Identifications

Three hundred and fifty-three NVSS radio sources were found within the boundaries of 179 ShCGs. Fifty-three of these sources were also registered in the FIRST survey. Seven more sources were found only in FIRST. The more correct positions and fluxes of the radio sources from FIRST are used in the subsequent discussion.

The high positional accuracies of the radio surveys used allowed us to identify with high confidence some of the radio sources with certain galaxies in dense environments of ShCGs. The positions of these radio sources coincide appreciably well, generally within 2"–3", with corresponding objects in ShCGs.

The probability of the reality of radio identifications was estimated by the "likelihood ratio" (LR) (de Ruiter, Willis, & Arp 1977). It was assumed that the density of background radio sources is $\rho = 5.16 \times 10^{-4}$ arcsec$^{-2}$ for high Galactic latitudes (Cohen et al. 1977).

The identification was considered to be reliable if $LR > 2$. This may not be very correct in this case, since we identify radio sources in dense groups of galaxies. For this reason we inspected each identification on the DSS images.

Ninety-three of the 353 discovered radio sources were identified with certain objects in 74 ShCGs. The list of identifications is presented in Table 1. The first column lists the Shakhbazian designation of the group and the number of the galaxy (as labeled in the original ShCG finding charts) considered to be the radio emitter, with below it the designation of the identified radio source. Columns (2) and (3) list the R.A. and decl. (J2000.0) of the galaxy and source, and column (4) gives the flux density of the source.

In five cases (ShCG 054, 163, 298, 347, and 352), the NVSS radio source is located between two nearby galaxies, and it was not possible to determine which of them is the radio emitter. The possibility that both galaxies are radio emitters could also not be excluded.

Two or more radio-emitting galaxies were found in 13 ShCGs.

Radio sources that were found within the boundaries of nine ShCGs (051, 057, 120, 248, 250, 330, 346, and 352) coincide appreciably well with the positions of relatively weak objects not considered to be member galaxies of corresponding groups in the original ShCG lists. These identifications should be considered as tentative, although these objects could be members of corresponding groups. Future spectral observations of these weak objects may be able to clarify whether they are really members of the corresponding groups.

Two hundred and sixty radio sources detected within the boundaries of 99 ShCGs were not identified with any visible object. They may be just background radio sources.

3.2. Remarks on Identifications

ShCG 001.01.—The central brightest galaxy of S0 type. There is an emission line at 3727 Å in the spectra of this galaxy (Robinson & Wampler 1973).

ShCG 003.01.—The central brightest galaxy. This group is also known as VV 153.

ShCG 007.01.—The central brightest galaxy.

ShCG 009.07.—This galaxy is located at the edge of the group.

ShCG 010.01.—The central brightest spiral galaxy.

ShCG 011.04.—One of the brightest galaxies.

ShCG 016.01.—The brightest galaxy, a spiral. As a typical radio galaxy it has two radio-emitting lobes on two sides of the galaxy, and a weaker component coinciding with the galaxy itself (Fig. 1a). Radio lobes are at a projected distance of about 10 kpc from the galaxy. The redshift of the group, known also as I Zw 167 and Arp 330, is 0.02913 (Amirkhanian 1989).

The FIR source in TMTST was tentatively identified with galaxy 3, which according to Stoll et al. (1996) is an H II region. A consideration of Figure 2 of TMTST shows that both galaxies with radio emission, 3 and 1, may be FIR emitters. FIR observations with better angular resolution may clarify the situation.

ShCG 018.02.—One of the bright galaxies.

ShCG 021.01.—The dominant galaxy of the group, with 16.76 mag. Two other radio sources, FIRST J234646.6-014417 and FIRST J234647.6-014414, seem to be ejected from the brightest galaxy (Fig. 1b).

ShCG 023.02.—One of the bright galaxies.

ShCG 024.02.—The brightest galaxy, 19.36 mag.

ShCG 029.03.—The brightest galaxy.

ShCG 033.03.—The second brightest (18.35 mag) galaxy in the group. It is a spiral.

ShCG 040.01.—The dominant cD galaxy (Struble & Rood 1987). The group is known also Abell cluster A0193, $z = 0.0498$ (Struble & Rood 1991).
TABLE 1

List of Radio Identifications

| ShCG.G-xy and | R.A.  | Decl.  | Flux  |
|---------------|-------|--------|-------|
| Radio Source  | (J2000.0) | (J2000.0) | (mJy) |
| (1)           | (2)   | (3)    | (4)   |
| 001.01        | 10 55 05.7 | +40 27 30 | 3.9   |
| NVSS J015506+402726 | 10 55 06.18 | +40 27 26.7 |
| 003.01        | 11 15 23.4 | +53 41 23 | 1.32  |
| FIRST J1115 +534122 | 11 15 23.504 | +53 41 22.8 |
| 007.01        | 11 05 53.8 | +39 46 58 | 39.93 |
| FIRST J110553.7+394654 | 11 05 53.766 | +39 46 54.1 |
| 009.07        | 13 24 01.5 | +19 03 21 | 4.2   |
| NVSS J132401+190320 | 13 24 01.74 | +19 03 20.2 |
| 010.01        | 14 10 48.1 | +46 15 58 | 11.78 |
| FIRST J141448.1+461557 | 14 10 48.176 | +46 15 57.45 |
| 011.04        | 14 11 01.7 | +44 42 15 | 1.72  |
| FIRST J111411+444214 | 14 11 01.826 | +44 42 14.34 |
| 016.01        | 16 49 11.3 | +53 25 12 | 23.43 |
| FIRST J164911.4+532510 | 16 49 11.496 | +53 25 10.91 |
| FIRST J164910.5+532507 | 16 49 10.398 | +53 25 07.31 |
| FIRST J164912.5+532514 | 16 49 12.582 | +53 25 14.56 |
| 018.02        | 08 53 37.2 | +79 09 17 | 3.8   |
| NVSS J085339+790915 | 08 53 39.73 | +79 09 15.4 |
| 021.01        | 23 46 48.6 | −01 44 16 | 64.19 |
| FIRST J234648.6−014416 | 23 46 48.633 | −01 44 16.75 |
| FIRST J234646.6−014417 | 23 46 46.680 | −01 44 17.41 |
| FIRST J234647.6−014414 | 23 46 47.641 | −01 44 14.56 |
| 023.02        | 16 10 03.2 | +52 14 52 | 1.15  |
| FIRST J161003+521450 | 16 10 03.560 | +52 14 50.33 |
| 024.01        | 23 46 56.2 | −00 52 27 | 2.19  |
| FIRST J234656.3−005227 | 23 46 56.352 | −00 52 27.21 |
| 029.03        | 16 08 45.1 | +52 26 17 | 2.48  |
| FIRST J160845.1+522616 | 16 08 45.191 | +52 26 13.1 |
| 033.03        | 01 03 42.7 | −01 08 13 | 3.80  |
| FIRST J010342.5−010813 | 01 03 42.521 | −01 08 13.10 |
| 040.01        | 01 25 07.6 | +08 41 59 | 33.4  |
| NVSS J012510+084224 | 01 25 07.87 | +08 41 59.2 |
| 041.01        | 01 29 00.6 | +07 40 40 | 36.8  |
| NVSS J012900+074042 | 01 29 00.61 | +07 40 42.1 |
| 042.11        | 01 30 44.6 | +07 50 09 | 3.3   |
| NVSS J013044+075004 | 01 30 44.65 | +07 50 04.4 |
| 051.01        | 10 30 44.6 | +39 12 45 | 14.2  |
| FIRST J103044.5+391245 | 10 30 44.619 | +39 12 44.28 |
| 051.02        | 10 30 44.1 | +39 10 29 | 5.64  |
| FIRST J103044.0+391029 | 10 30 44.196 | +39 10 29.73 |
| 053.01        | 10 36 46.7 | +44 49 48 | 2.74  |
| FIRST J103646.4+444946 | 10 36 46.496 | +44 49 46.39 |
| 053.04        | 10 36 52.8 | +44 48 21 | 35.82 |
| FIRST J103653.0+444818 | 10 36 53.027 | +44 48 18.19 |
| 053.14        | 10 36 45.7 | +44 49 54 | 3.86  |
| FIRST J103645.9+444955 | 10 36 45.988 | +44 49 55.16 |
| 054.06        | 10 40 37.2 | +40 12 58 | 1.16  |
| FIRST J104037.3+401257 | 10 40 37.320 | +40 12 57.92 |
| 054.09        | 10 40 27.1 | +40 13 41 | 11.2  |
| 054.10        | 10 40 27.0 | +40 13 48 | 11.2  |
| NVSS J104026+401345 | 10 40 26.92 | +40 13 45.9 |
| 057.01        | 10 45 26.7 | +49 31 08 | 20.01 |
| FIRST J104527.2+493106 | 10 45 27.266 | +49 31 06.27 |
| 057.02        | 10 45 26.1 | +49 31 25 | 29.92 |
| FIRST J104526.4+493116 | 10 45 26.492 | +49 31 16.98 |
| 062.01        | 11 25 53.2 | +38 22 04 | 30.32 |
| FIRST J112553.3+382201 | 11 25 53.305 | +38 22 01.38 |
| FIRST J112552.1+382153 | 11 25 52.121 | +38 21 53.30 |
| 065.07        | 11 30 50.6 | +35 04 15 | 4.79  |
| FIRST J113050.5+350415 | 11 30 50.578 | +35 04 15.03 |
| 074.08        | 14 20 57.3 | +43 02 54 | 2.39  |
| FIRST J142057.5+430250 | 14 20 57.562 | +43 02 50.45 |
| 083.01        | 23 26 08.8 | −01 43 30 | 5.849 |
| FIRST J232608.8−014329 | 23 26 08.867 | −01 43 29.83 |
| Radio Source | R.A. (J2000.0) | Decl. (J2000.0) | Flux (mJy) |
|--------------|----------------|----------------|------------|
| FIRST J092713 + 525832 | 09 27 13.5 | +52 58 33 | 2.08 |
| FIRST J110431.2 + 355157 | 11 04 31.27 | +35 51 57.7 | 3.72 |
| FIRST J110432.6 + 355212 | 11 04 32.6 | +35 52 12.5 | 71.46 |
| FIRST J110433.1 + 355222 | 11 04 33.137 | +35 52 22.14 | 9.01 |
| FIRST J010422.2 – 013326 | 01 04 22.2 | –01 33 26.54 | 12.67 |
| NVSS J152105 + 750421 | 15 21 05.13 | +75 04 21.5 | 7.1 |
| NVSS J182806 + 830605 | 18 28 06.27 | +83 06 05.8 | 169.5 |
| NVSS J015736 + 293853 | 01 57 36.3 | +29 38 56 | 43.4 |
| NVSS J082800 + 285134 | 08 28 00.28 | +28 15 34.1 | 10.0 |
| FIRST J083823.2 + 294521 | 08 38 23 | +29 45 22 | 3.92 |
| FIRST J022511.1 + 285552 | 02 25 11.148 | +28 55 52.89 | 5.17 |
| FIRST J110306 + 274823 | 11 03 06.80 | +27 48 23.19 | 1.13 |
| FIRST J113522.8 + 304343 | 11 35 22.7 | +30 43 43 | 1.45 |
| FIRST J113521.4 + 304257 | 11 35 21.3 | +30 42 58 | 0.77 |
| FIRST J121951.6 + 282521 | 12 19 51.68 | +28 25 21.51 | 8.00 |
| FIRST J122902.3 + 272702 | 12 29 02.37 | +27 27 02.36 | 179.56 |
| FIRST J122902.7 + 272731 | 12 29 02.77 | +27 27 31.58 | 234.00 |
| NVSS J123519 + 273438 | 12 35 19.0 | +27 34 41 | 3.84 |
| FIRST J130139.0 + 314417 | 13 01 39.04 | +31 44 17.01 | 1.88 |
| FIRST J143335 + 264153 | 14 33 35.463 | +26 41 53.91 | 1.65 |
| FIRST J145233.5 + 275751 | 14 52 33.543 | +27 57 51.72 | 31.38 |
| FIRST J145231.6 + 275807 | 14 52 31.680 | +27 58 07.84 | 48.27 |
| FIRST J145234.2 + 275751 | 14 52 34.297 | +27 57 51.86 | 40.66 |
| FIRST J048250.5 + 361547 | 10 48 25.0 | +36 15 46 | 9.09 |
| FIRST J131216.0 + 361108 | 13 12 16.040 | +36 11 08.36 | 2.47 |
| FIRST J131210.1 + 361112 | 13 12 10.191 | +36 11 12.45 | 0.91 |
| FIRST J133447.0 + 330857 | 13 34 47.004 | +33 08 57.16 | 7.78 |
| FIRST J135619 + 351119 | 13 56 19.184 | +35 11 19.85 | 1.35 |
| FIRST J001354 – 083850 | 00 13 54.6 | –08 38 49 | 1.08 |
| NVSS J025235 – 130617 | 02 52 35.5 | –13 06 15 | 9.7 |
| NVSS J052525 – 110020 | 10 52 52.89 | –11 00 20.7 | 75.8 |
| NVSS J135810 – 125306 | 13 58 10.67 | –12 53 07.0 | 5.8 |
| NVSS J221244 – 134026 | 22 12 44.8 | –13 40 33 | 15.4 |
| FIRST J231733.2 – 090532 | 23 17 33.1 | –09 05 32 | 5.04 |
| FIRST J001354 – 083850 | 00 13 54.6 | –08 38 49 | 1.08 |
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TABLE 1—Continued

| R.A. (J2000.0) | Decl. (J2000.0) | Flux (mJy) |
|----------------|----------------|------------|
| ShCG G-xy and Radio Source (1) |                |            |
| NVSS J003119—072440 ...............   | 00 51 19.63 | -07 24 40.1 | 6.3 |
| 312.10 ................. | 01 03 30.0 | -03 32 30 |
| NVSS J010330—033239 ............... | 01 03 30.97 | -03 32 39.3 | 3.7 |
| 317.01 ................. | 02 10 53.3 | -06 33 33 |
| FIRST J021052.5—063343 ............. | 02 10 52.327 | -06 33 43.22 | 97.0 |
| FIRST J021053.6—063333 ............. | 02 10 53.615 | -06 33 33.9 | 176.52 |
| FIRST J021054.2—063344 ............. | 02 10 54.215 | -06 33 44.21 | 96.57 |
| FIRST J021050.1—063336 ............. | 02 10 50.189 | -06 33 36.38 | 132.83 |
| 320.09 ................. | 11 14 46.8 | -06 21 36 |
| NVSS J111446—062137 ............... | 11 14 46.59 | -06 21 37.3 | 4.1 |
| 329.03 ................. | 14 37 12.0 | -03 45 51 |
| NVSS J143712—034547 ............... | 14 37 12.02 | -03 45 47.2 | 8.1 |
| 330.06 ................. | 15 14 22.9 | -09 36 07 |
| NVSS J151423—093603 ............... | 15 14 23.36 | -09 36 03.6 | 6.7 |
| 331.07 ................. | 22 25 26.8 | -02 47 02 |
| NVSS J222526—024702 ............... | 22 25 26.76 | -02 47 02.4 | 42.6 |
| 335.02 ................. | 23 23 37.4 | -07 24 00 |
| NVSS J232337—072357 ............... | 23 23 37.04 | -07 23 57.3 | 4.6 |
| 340.05 ................. | 00 42 24.6 | +20 22 05 |
| NVSS J004224+202204 ............... | 00 42 24.38 | +20 22 04.5 | 3.3 |
| 344.07 ................. | 08 47 35.8 | +03 42 01 |
| NVSS J084736+034159 ............... | 08 47 36.07 | +03 41 59.9 | 4.5 |
| 346.01 ................. | 09 15 12.4 | +05 14 23 |
| NVSS J091512+051426 ............... | 09 15 12.20 | +05 14 26.4 | 9.3 |
| 347.01 ................. | 09 17 28.6 | +07 42 31 |
| NVSS J091729+074233 ............... | 09 17 29.10 | +07 42 33.2 | 8.0 |
| 347.03 ................. | 09 17 34.0 | +07 41 10 |
| 347.04 ................. | 09 17 34.3 | +07 41 22 |
| NVSS J091729+074233 ............... | 09 17 34.15 | +07 41 16.0 | 18.3 |
| 348.02 ................. | 09 26 29.3 | +03 26 17 |
| NVSS J092629+032617 ............... | 09 26 29.41 | +03 26 17.7 | 10.8 |
| 351.06 ................. | 11 10 24.7 | +04 49 47 |
| NVSS J111024+044945 ............... | 11 10 24.63 | +04 49 45.3 | 11.93 |
| 352.01 ................. | 11 21 31.5 | +02 53 02 |
| NVSS J112131+025303 ............... | 11 21 31.61 | +02 53 03.5 | 5.2 |
| 359.01 ................. | 14 29 54.4 | +18 50 07 |
| NVSS J142954+185008 ............... | 14 29 54.19 | +18 50 08.6 | 2.6 |
| 360.01 ................. | 15 41 26.5 | +04 43 56 |
| NVSS J154126+044355 ............... | 15 41 26.54 | +04 43 55.8 | 27.2 |
| 362.04 ................. | 23 32 36.4 | +19 22 27 |
| 362.01 ................. | 23 32 37.1 | +19 22 33 |
| NVSS J233236+192215 ............... | 23 32 36.82 | +19 22 15.4 | 3.6 |
| 370.03 ................. | 09 50 20.5 | +23 16 54 |
| NVSS J095029+231655 ............... | 09 50 20.47 | +23 16 55.4 | 1.26 |
| 371.02 ................. | 11 43 33.1 | +21 53 50 |
| NVSS J114333+215406 ............... | 11 43 33.28 | +21 54 06.1 | 4.7 |
| 372.03 ................. | 11 46 49.5 | +24 08 22 |
| FIRST J114649.5+240821 ............. | 11 46 49.539 | +24 08 21.43 | 2.7 |
| 376.04 ................. | 13 56 35.7 | +23 21 37 |
| FIRST J135635.7+232135 ............. | 13 56 35.734 | +23 21 35.95 | 4.59 |

ShCG 041.01.—The brightest galaxy of the group.
ShCG 042.11.—A weak galaxy; membership in the group should be proved spectroscopically. The brightest galaxy, 2, of possibly S0 type, is located nearby.
ShCG 051.01.—The brightest galaxy, located at the periphery of the group.
ShCG 051.01.—A weak object that could possibly be a member of the group. The possibility cannot be excluded, however, that the radio source may be only a projected one.
ShCG 053.01.—The brightest galaxy of the group, which is also known as Abell cluster A1050.
ShCG 053.04.—One of the bright galaxies.
ShCG 054.06.—One of galaxies of the group. Its membership in the group should be proved by spectral observations. The group is also known as Abell cluster A1067.
ShCG 054.09.10.—A weak pair of galaxies.
ShCG 057.01.—The brightest galaxy.
ShCG 057.02.—Probable identification.
ShCG 062.01.—The brightest galaxy, located at the periphery of the group. The stronger radio source FIRST J112552.1+382153 is located very close to the first one. It may be an ejection from the galaxy ShCG 062.01, or a projected source.
ShCG 065.07.—A galaxy located at the periphery of the
ShCG 016.01

ShCG 021.01

ShCG 021.01

ShCG 021.01

ShCG 021.01

ShCG 021.01

Fig. 1.—Radio sources with complex structure. Below each radio image from FIRST is the optical image from the DSS of the corresponding field in the same scale. The sizes of images of ShCG 016.01, 021.01, 120.Anon, and 203.Anon are equal to 1' × 1'. The size of the field of ShCG 219.01 is 1.5 × 1.5, and that of ShCG 317.01 is 2.5 × 2.5.

The group, also known as Abell 1284. The FIR source found here is the galaxy 27 in the southern part of the group (TMTST).

ShCG 074.08.—Relatively weak galaxy, which is very close to the brighter galaxy 3.

The FIR source was identified with galaxy 9 (TMTST).

ShCG 083.01.—The brightest galaxy, 18.02 mag.

ShCG 104.03.—This galaxy is located at about 10' to the south of the brightest galaxy, 2. The latter was identified as the FIR source (TMTST). The possibility cannot be excluded, however, that only galaxy 3 is really a FIR emitter.

ShCG 120. Anon.—The central brightest radio source FIRST J110431.2+355157 coincides with a weak object between galaxies 4 and 6, located at the periphery of the group. Two weaker radio sources, FIRST J110432.6+355212 and FIRST J110433.1+355222, seem to be radio lobes ejected from the central object (Fig. 1c). The group is also known as cluster A1151.

The membership of the object in the group should be checked by spectral observations. The FIR emitter located just here was considered to be an uncertain identification in MTST. Apparently, the same object may really be a FIR emitter.

ShCG 141.01.—The brightest galaxy, 18.93 mag.

ShCG 149.01.—One of the brightest galaxies in the central region of the group.

ShCG 163.01/03.—Brightest galaxies (probably interacting) in the center of the group.

ShCG 166.02.—One of the bright galaxies of the group, also known as cluster A2247.

ShCG 168.06.—One of the bright galaxies of the group. The FIR source was identified with the brightest galaxy, 1 (TMTST).

ShCG 177.01.—The brightest galaxy.

ShCG 181.04.—Galaxy 4 is located near to the brightest galaxy, 1.

ShCG 182.01.—The brightest galaxy, located at the end of the elongated group.

ShCG 186.01.—One of three, probably interacting brightest galaxies.

ShCG 194.01.—The dominant galaxy.

ShCG 199.01.—The dominant galaxy.

ShCG 199.03.—The second-brightest galaxy.

ShCG 202.03.—The brightest galaxy.

ShCG 203. Anon.—A pair of relatively strong radio sources is identified with a very weak object in the north part of the group (Fig. 1d). The pair was not considered to belong to the group in the original ShCG lists. Spectral observations are needed to clarify this case.

ShCG 205.03.—One of the brightest galaxies.

ShCG 209.01.—The brightest galaxy, located in the center of the group.

ShCG 219.01.—Radio source FIRST J145233.5+275751 is identified with the brightest galaxy. It seems to be interacting with galaxy 2. Galaxy 1 has a halo or spiral arms. The group is also known as cluster A1984.

Two other radio sources, FIRST J145231.6+275807 and FIRST J145234.2+275751, seem to be ejected from galaxy 1 (Fig. 1e). This galaxy and galaxy 1 are interacting.

ShCG 234.04.—Relatively weak galaxy, located in the
central part of the group. Its membership in the group should be proved by spectral observations.

**ShCG 248.04.**—The brightest galaxy of the group. In TMTST the FIR source was identified with the same galaxy.

**ShCG 248.**—Relatively bright galaxy, located at about 1° to the west of the group. It may be a member of the same group. A consideration of the isophotes of the FIR source (TMTST) shows that both this galaxy and galaxy 4 of the group may be FIR emitters.

**ShCG 250.**—Weak object that could possibly be a member of the group. However, the possibility that the radio source may be only projected onto this group cannot be excluded.

**ShCG 273.06.**—A relatively bright galaxy that is probably interacting with galaxy 3. The FIR source was identified with galaxy 3 (TMTST). The discovery of radio emission from this galaxy suggests that it may just be the FIR source. The errors for the IRAS positional measurements in this case are 18′′ × 6′′.

**ShCG 279.04.**—Relatively weak galaxy, 17.75 mag. Probable identification.

**ShCG 282.04.**—Galaxy of S0 type, which is apparently interacting with the brightest galaxy 1, of Sbc type.

**ShCG 289.03.**—E-type galaxy, which apparently interacts with galaxies 1 (of E/S0 type) and 4. Galaxy 1 is the brightest galaxy, 17.55 mag, and galaxy 3 is the third brightest, being a little bit weaker, 17.97 mag.

**ShCG 298.02.06.**—A pair of apparently interacting bright galaxies. The stellar magnitudes are equal to 18.71 mag and 19.55 mag, respectively.

**ShCG 303.03.**—Bright galaxy in the center of the group, apparently interacting with another bright galaxy, 4.

**ShCG 309.07.**—The brightest galaxy, 17.49 mag. It seems to be interacting with galaxy 8.

**ShCG 312.10.**—The dominant galaxy. It seems to be interacting with galaxy 9, and has a couple of dwarf satellites.

**ShCG 317.01.**—The FIRST Survey shows very complex structure (Fig. 1f) of the radio source identified with the brightest galaxy of the group (15.72). It has several components connected with bridges. The overall size of the radio complex is about 100 kpc. The redshift of the group is 0.0434 (Tiersch et al. 1999).

**ShCG 320.09.**—One the bright galaxies, 17.88 mag.

**ShCG 329.03.**—The brightest galaxy of the group, 17.96 mag.

**ShCG 330.**—A weak object that could possibly be a member of the group. The possibility cannot be excluded, however, that the radio source may only be a projected one.

**ShCG 331.07.**—The brightest galaxy, 16.06 mag. The FIR source was identified with the same galaxy (TMTST).

**ShCG 335.02.**—The second-brightest galaxy, 18.27 mag.

**ShCG 339.01.**—One of the three brightest galaxies.

**ShCG 340.05.**—One of the brightest galaxies.

**ShCG 344.07.**—Galaxy of Sab type. Seems to be interacting with another, relatively weak galaxy.

The FIR source was identified in TMTST with the brightest galaxy, 1, of S0 type. The reconsideration of the FIR isophotes, taking into account the errors of the IRAS positional measurements in this case (40′′ × 23′′), allows us to suggest that galaxy 7 may also be an FIR emitter.

**ShCG 346.**—A weak object, which could possibly be a member of the group. The possibility cannot be excluded, however, that the radio source may only be a projected one.

**ShCG 347.01.**—The brightest galaxy, located at the end of the elongated group.

**ShCG 347.03.04.**—The radio source is located between galaxies 3 and 4, and could be identified with one of them.

**ShCG 348.02.**—One of two brightest galaxies in the group.

**ShCG 351.06.**—The dominant spiral galaxy (UGC 06212). It is located at the periphery of the group. In TMTST, the FIR source was identified with the same galaxy.

**ShCG 352.**—The position of the radio source coincides well with the weak object at about 17″ to the southwest from the brightest galaxy, 1.

**ShCG 359.01.**—The brightest galaxy.

**ShCG 360.01.**—The brightest galaxy of S0 type. This very compact group is also known as cluster A2113.

**ShCG 362.01.04.**—The radio source is located at about 12″ south of galaxy 4, and could be identified with it or with the brightest galaxy, 1, located nearby. These two galaxies seems to be interacting. The group is also known as III ZW 108.

**ShCG 371.02.**—The group is very dense. The radio source is identified with one of the three central bright galaxies of the group, 2, 3, or 4. The latter is the brightest in the group. In TMTST the FIR source was tentatively identified with galaxy 2. However, the optical spectrum of these galaxy is a normal one with absorption lines, while the spectrum of galaxy 4 has emission lines. (The results of the spectral observations of this group will be published elsewhere.) On the basis of spectral data, we assume that galaxy 4 may also be a FIR emitter.

**ShCG 372.03.**—One of the bright galaxies.

**ShCG 376.04.**—The dominant galaxy. The FIR source was identified with the same galaxy (TMTST). Spectral observations of this group (the results of which will be published elsewhere) show that this galaxy, and also some others in the group, have emission lines.

**3.3. The Optical Rank of the Radio-emitting Galaxy**

Radio emission, as we already mentioned, is most often observed from the optically first-ranked galaxies or other brightest members of groups of galaxies (Tovmassian & Shakhbazian 1981; Menon 1992). We identified most radio sources detected in ShCGs (64) with the brightest or one of the bright galaxies in corresponding groups. Only in 19 cases are the identified objects not the brightest members. If the discovered regularity (Tovmassian & Shakhbazian 1981; Menon 1992) holds in the case of ShCGs as well, then some of these 19 identifications with weaker members of groups may not be correct. The membership of these objects in the corresponding groups should be checked by spectral observations.

**3.4. The Structure of Radio Sources**

Because of the large distances of ShCGs from us, the angular sizes of member galaxies are generally small enough. For this reason, the angular resolution of the FIRST (5″) and, especially, of the NVSS (45″) in most cases does not allow us to distinguish whether the observed radio radiation is emitted from the nuclear region of the galaxy or from its disk. Hence, we assumed that the measured flux refers to the disc.
However, in some cases the high angular resolution of the FIRST survey allowed us to resolve detected radio sources. Radio sources identified with ShCG 016.01, 021.01, 219.02, and 317.01 have composite structure (Fig. 1). Some of them consist of two lobes located diametrically on two sides of the parent galaxy, which is characteristic of classical radio galaxies. In the case of ShCGs 016.01 and 219.01, the radio sources are of FR II type. Radio sources identified with ShCG 120.Anon and 203.Anon also seem to consist of two components. In ShCGs 016.01, 120.Anon, and 317.01, the radio emission of the central galaxy itself is also observed. The radio source in ShCG 317 is a very complex one (Fig. 1).

3.5. Radio Spectra

Radio sources detected within ShCG areas were cross-identified with sources of the CATS (astrophysical CATalog Support system) database (Verkhodanov et al. 1997), which unifies 200 radio astronomical catalogs, including the Texas catalog at 365 MHz (Douglas et al. 1996), the 6C at 151 MHz (Baldwin et al. 1985), the high-sensitivity WENS at 327 MHz (Rengelink et al. 1997), and others. We used the task *match* in the identification circle of a 90” radius. We found that 22 of the detected radio sources have been observed at at least two frequencies. The spectra of these radio sources are presented in Figure 2. The spectral indices of these sources were determined. To determine the spectral indices, we used a least-squares method to fit the obtained data sample used to construct the spectra.

The spectral indices are presented in Table 2. Most of the spectra have normal slopes. The radio source identified with ShCG 248.04 has a very unusual, too steep spectrum. It is possible that the flux density of this source at 365 MHz is overestimated. The spectra of three sources, ShCG 041.01, 051.04, and 163.01/03, are inverted.

3.6. Radio Luminosities

Redshifts for only a handful ShCGs had been measured until recently (Robinson & Wampler 1973; Arp et al. 1973; Mirzoyan et al. 1975; Amirkhanian & Egikian 1987; Amirkhanian 1989; Kodaira et al. 1988, 1990; Kodaira & Sekiguchi 1991; Lynds et al. 1990; del Olmo & Moles 1991). The redshifts of only 37 ShCGs with detected radio sources are known. Most of these redshifts are as yet unpublished (Tiersch et al. 1999). We derived the radio luminosities of these sources at 1.4 GHz by assuming $H = 50$ km s$^{-1}$
The mean redshift of the group members, if available, was used in calculations. The derived radio luminosities are presented in Table 3.

We compared radio luminosities of galaxies in ShCGs with that of galaxies in HCGs (Fig. 3). To create Figure 3 we used total fluxes of 56 HCG spiral galaxies (Menon 1995) at 1415 MHz, and 34 more HCG galaxies identified with the NVSS and FIRST radio sources by us. The list of the latter galaxies is presented in Table 4.

A consideration of Figure 3 shows that radio sources in ShCGs are more powerful. Indeed, the radio luminosities of more than half of HCGs located at redshifts greater than 0.05 are less than 22.0 W Hz$^{-1}$, while only one out of 11 ShCGs at the same distances has such low radio luminosity. It can also be seen that most of the powerful ShCG radio sources are located at larger distances, where no HCGs were found.

3.7. Comparison of the Radio- and FIR-emitting Properties of ShCGs and HCGs

Since redshifts are known for only a limited sample of ShCGs, it is not yet possible to study the radio luminosity function of ShCG galaxies. Such a study may be undertaken.

![Figure 2](image2.png)

**Fig. 2.—Continued**

![Figure 3](image3.png)

**Fig. 3.—Dependence of radio luminosity on redshift for HCGs (open circles) and ShCGs (filled circles).**
upon completion of the program initiated by Tiersch et al. (1999) for the spectral study of ShCGs. However, the available data do allow us to compare the radio and FIR emission of HCGs and ShCGs.

For comparison of the radio and FIR emission abilities of ShCGs and HCGs, we draw the graph $\log F_{60} - \log F_{1.4}$ (Fig. 4). The $60 \mu m$ IRAS band was by far the most sensitive for the detection of extragalactic objects (see, for example, Hickson et al. 1989, Surace et al. 1993).

For star-forming galaxies, a very close connection was found between two apparently unrelated physical mechanisms, the thermal emission from dust and the synchrotron radio emission from relativistic electrons (Dickey & Salpeter 1984; Helou, Soifer, & Rowan-Robinson 1985; Hickson et al. 1989; Helou & Bicay 1993). It has been shown that the ratio of the FIR and radio fluxes of starburst galaxies is almost constant.

If the ratio of the FIR and radio fluxes of galaxies in the CGs under consideration is also constant, as it is in the star-forming galaxies, then because of different distances from us, and also because of differences in the emitted fluxes, the CG galaxies should be distributed on Figure 4 along a diagonal line.

To construct Figure 4 we used:

1. Thirty-four spiral HCG galaxies from the list of Menon (1995), and 12 HCG galaxies from Table 4 (this paper), whose FIR emission at 60 $\mu m$ was measured by Allam et al. (1996). Nine galaxies from Table 4 also are spirals.
2. Eleven ShCG galaxies with detected radio and FIR emission (TMTST). These are galaxies in groups ShCG 016, 074, 104, 120, 168, 248, 273, 331, 344, 371, and 376.
3. Markarian starburst (SB) and Markarian Seyfert (Sy) galaxies. The FIR (at 60 $\mu m$) and radio fluxes of Markarian galaxies are taken from Bicay et al. (1995).

The high accuracies of radio positional measurements allowed us to identify with high confidence the detected

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**TABLE 2**

| ShCG.G-xy | $z$ |
|-----------|----|
| 007.01    | -0.01 |
| 010.01    | -1.46 |
| 016.01    | -0.58 |
| 041.01    | 0.27  |
| 051.01    | 0.79  |
| 053.04    | -0.12 |
| 054.06    | -0.75 |
| 054.09/10 | -0.52 |
| 057.01    | -0.77 |
| 062.01    | -0.45 |
| 065.07    | -1.00 |
| 120.Anon  | -0.73 |
| 163.01/03 | 0.26  |
| 168.06    | -0.72 |
| 177.01    | -0.63 |
| 182.01    | -1.01 |
| 203.Anon  | -0.71 |
| 219.01    | -0.42 |
| 234.04    | -0.48 |
| 248.04    | -3.44 |
| 250.Anon  | -1.04 |
| 317.01    | -0.67 |

**TABLE 3**

| ShCG.G-xy | $z$ | $\log P_{1.4}$ (W Hz$^{-1}$) |
|-----------|----|-----------------------------|
| 001.01    | 0.1168 | 23.36 |
| 016.01    | 0.0301 | 23.74 |
| 021.01    | 0.0773 | 24.34 |
| 029.03    | 0.0346 | 22.11 |
| 033.03    | 0.0337 | 22.14 |
| 040.01    | 0.0486 | 23.53 |
| 041.01    | 0.0900 | 24.11 |
| 083.01    | 0.0970 | 23.38 |
| 166.02    | 0.0396 | 24.04 |
| 168.06    | 0.1262 | 25.07 |
| 181.01    | 0.0917 | 23.56 |
| 202.03    | 0.0262 | 22.38 |
| 205.03    | 0.0932 | 23.16 |
| 218.02    | 0.0947 | 22.81 |
| 248.04    | 0.2712 | 23.90 |
| 248.Anon  | 0.2712 | 24.46 |
| 254.03    | 0.0638 | 22.38 |
| 282.04    | 0.1428 | 24.83 |
| 289.03    | 0.0706 | 23.10 |
| 298.02/06 | 0.1692 | 24.29 |
| 309.07    | 0.0892 | 23.34 |
| 312.10    | 0.0733 | 22.94 |
| 317.01    | 0.0434 | 24.61 |
| 330.Anon  | 0.1078 | 23.53 |
| 331.07    | 0.0534 | 23.72 |
| 335.02    | 0.0875 | 23.18 |
| 340b.05   | 0.1045 | 23.19 |
| 344.07    | 0.0774 | 23.03 |
| 346.Anon  | 0.1349 | 23.87 |
| 348.02    | 0.0894 | 23.57 |
| 351.06    | 0.0290 | 22.64 |
| 352.Anon  | 0.0490 | 22.73 |
| 359.01    | 0.0328 | 22.08 |
| 360.01    | 0.1082 | 24.14 |
| 362.01/04 | 0.02291| 21.91 |
| 371.02    | 0.1301 | 23.55 |
| 376.04    | 0.0660 | 22.93 |

Fig. 4.—Comparison of the radio and 60 $\mu m$ fluxes of member galaxies in HCGs and ShCGs, as marked (the $\log F_{60} - \log F_{1.4}$ graph).
These galaxies thus obey the correlation between the thermal emission from dust and the synchrotron radio emission from relativistic electrons found for star-forming galaxies, and hence they are also SB galaxies. Galaxies that are below the dashed line appear to have relatively stronger FIR emission. Along the same dashed line are also distributed, as expected, most of the Markarian SB galaxies.

Seventeen HCG galaxies (~36%) are above the dashed line. This means that they have stronger radio emission than SB galaxies. It is remarkable that two of these galaxies, HCG 92c and HCG 96a, are Seyfert galaxies, and three others, HCG 56b, HCG 68a, and HCG 68b, are E and S0 type galaxies.

The situation is different for ShCG galaxies. Nine of them (82%) are located above the arbitrarily drawn diagonal line. Above this line are also located 12 out of 13 (~92%) Markarian Seyfert galaxies. Hence, most ShCG galaxies are not SB galaxies. If the identification of the FIR source with a radio-emitting galaxy is not correct, then the galaxy with detected radio emission and thus with smaller FIR emission would move to the left on Figure 4 and hence would be located even higher above the dashed line. The blending of a few probable FIR sources in dense groups would have the same effect.

It is worth noting that those HCG and ShCG galaxies for which either FIR or radio emission was detected would also have different locations on the log $F_{60}$–log $F_{1.4}$ graph.

There are 73 ShCG galaxies, fluxes of which at 1.4 GHz exceed 1 Jy, but only upper limits of fluxes at 60 μm were determined (TMTST). These galaxies appear to be located above the dashed line in Figure 4. At the same time, there are only 15 ShCG galaxies with determined FIR fluxes (TMTST) and radio fluxes lower than the 1 Jy detection limit (this paper). The latter would be located below the dashed line. In the case of HCG galaxies the situation is reversed. There are 34 HCG galaxies with 1.4 GHz fluxes exceeding the 1 mJy limit (Menon 1995, and present paper) and FIR fluxes lower than the limiting value (Allam et al. 1996). These galaxies would be located above the dashed line in Figure 4. Many more HCG galaxies (65) with measured FIR fluxes and upper limits of radio fluxes would be located below the dashed line, in the lower part of Figure 4. Thus, for galaxies with either of the fluxes measured (60 μm or 1.4 GHz), we see the same trend: most ShCG galaxies would be located above the dashed line in Figure 4, while HCG galaxies would be located mainly below this line.

Sulentic & De Mello Rabaca (1993) claimed that the FIR sources in HCGs are likely to represent the combined contribution of two or more members. If we assume that in all Hickson’s groups with detected FIR emission, the FIR emitters are in reality two galaxies with equal fluxes, then the corresponding points on Figure 4 should move to the left by 0.3, but they would still be located lower than ShCG galaxies. Moreover, if the same is also valid for the more dense ShCGs, then the corresponding positions of ShCG galaxies on Figure 4 should also move to the left, and the discovered trend would certainly not be altered.

Hence, one may conclude that galaxies in ShCGs are relatively stronger radio emitters, while HCG galaxies are stronger FIR emitters. This means that physical conditions in ShCGs are somehow favorable for triggering active galactic nuclei (AGNs) with relatively strong synchrotron emission of relativistic electrons, while in HCGs the conditions are favorable for forming SB galaxies with relatively

| HCG.G-xy | Morphological Type | Radio Source | $F_{1.4}$ (mJy) |
|----------|-------------------|--------------|-----------------|
| 2b        | c1                | NVSS B002843+081155 | 13.4            |
| 4a        | Sc                | NVSS B003143−214248 | 43.5            |
| 5a        | Sab               | NVSS B003619+064718 | 5.7             |
| 8d        | S0                | NVSS B004656+231800 | 4.1             |
| 15d       | E2                | NVSS B020502+015639 | 5.1             |
| 21a       | Sc                | NVSS B024258−175503 | 4.7             |
| 21b       | Sab               | NVSS B024316−175400 | 2.9             |
| 25c       | Sb                | FIRST J033204.2−010008 | 5.41          |
| 28b       | E5                | NVSS B042457−102607 | 4.4             |
| 37a       | E7                | FIRST J091339.4−295934 | 25.58          |
| 46a       | E3                | NVSS B101924+180522 | 4.5             |
| 48b       | Sc                | NVSS B103527−265140 | 15.5            |
| 51c       | S0                | FIRST J112230.0+241646 | 7.44          |
| 53a       | SBc               | NVSS B112631+210419 | 21.7            |
| 56b       | SB0               | FIRST J113240.2+252701 | 25.81         |
| 56d       | S0                | FIRST J113235.2+252650 | 25.76         |
| 58c       | SBoa              | NVSS B113918+103451 | 3.3             |
| 60a       | E2                | FIRST J120307.2+514030 | 50.89         |
| 61a       | S0a               | FIRST J121218.8+291046 | 1.45          |
| 61c       | Sbc               | FIRST J121231.0+291006 | 37.01         |
| 62a       | E3                | NVSS B125029−085604 | 5.4             |
| 64d       | S0                | NVSS B132306−033526 | 2.3             |
| 65a       | E3                | NVSS B132703−291520 | 3.5             |
| 65e       | E2                | NVSS B132705−291357 | 3.8             |
| 68a       | S0                | FIRST J135326.6+401658 | 38.30         |
| 68b       | E2                | FIRST J135326.7+401808 | 7.99          |
| 71a       | SBc               | FIRST J141057.2+252949 | 3.21          |
| 71b       | Sb                | FIRST J141102.5+253110 | 8.40          |
| 78a       | E1                | NVSS B151710+210435 | 16.3            |
| 78a       | Sbb               | NVSS B154805+682219 | 7.0             |
| 79a       | E0                | NVSS B155659+205344 | 10.2            |
| 84a       | E2                | NVSS B164644+775541 | 21.2            |
| 86a       | E2                | NVSS B194859−305716 | 19.6            |
| 86b       | E2                | NVSS B194849−305644 | 8.1             |
| 94a       | E1                | NVSS B231444+182606 | 30.1            |

radio source with a certain galaxy in the corresponding CG. The situation is not the same in the case of the IRAS FIR observations. Absolute positions provided by IRAS are accurate up to 6” (within ± 3 σ) in the in-scan and ~25” in the cross-scan directions, respectively. In the case of HCGs, which are nearer to us and have relatively larger angular dimensions than ShCGs, in most cases (37 out of 47) it was possible to identify the detected FIR source with a certain galaxy in the corresponding group (Allam et al. 1996). The FIR sources detected in ShCGs (TMTST) are in general weaker than those in HCGs. As a result, their positional measurement accuracies usually reach values of about 10”–30” in the in-scan and cross-scan directions, respectively. For this reason, and also because of the relatively smaller angular sizes of ShCGs, it was not possible to determine with certainty which galaxy in a dense group is the FIR emitter (TMTST). The brightest member of the group is usually mentioned as a probable source. To construct Figure 4, we attributed the measured FIR flux either to a single galaxy or to two nearby galaxies (see §3.2). This uncertainty does not, however, influence the conclusions reached.

A consideration of Figure 4 shows that most HCG galaxies (30 out 47, i.e., ~64%) are located along and somewhat below the arbitrarily drawn diagonal dashed line.
strong thermal dust emission. What could be the reason for such difference?

CGs are generally very dense formations. According to N-body simulations (Carnevali, Cavaliere, & Santangelo 1981; Barnes 1985, 1989; Mamon 1990; Zheng, Valtonen, & Chernin 1993), the member galaxies in the high-density environments of CGs should interact and merge into one large galaxy in about $10^8$ yr. For this reason, the very existence of CGs has been questioned by some authors (Walke & Mamon 1989; Mamon 1986, 1995; Hernquist, Katz, & Weinberg 1995). Meanwhile, Hickson & Rood (1988), Mendes de Oliveira & Giraud (1994), Mendes de Oliveira (1995), Oleak et al. (1995) and recently Tohmassian et al. (1998b) have presented firm evidence for the reality of CGs. To explain the existence of CGs, Governato, Tozzi, & Cavaliere (1996) proposed a second-generation merger scenario, according to which CGs permanently aggregate new members from their surrounding areas. Such a scenario could be valid, since, according to Rood & Williams (1989), Vennik, Richter, & Longo (1993), and Ramella et al. (1994), most HCGs are associated with loose groups of galaxies.

ShCGs and HCGs differ from each other by the number of members and by morphological content. Where HCGs generally contain four or five members, ShCGs have up to 15 members. The relative number of E or S0 type galaxies in HCGs is only ~50% of its members (Hickson et al. 1989), while ShGGs are richer in early-type galaxies. About 77% of member galaxies in ShGGs are of E and S0 type (Tiersch et al. 1996b). For this reason, ShCGs are considered to be more evolved systems than HCGs.

Since almost half of HCG galaxies are spirals with a sufficient amount of gas and dust, the gravitational interaction between them and with a suggested newcomer galaxy may trigger starburst processes in interacting galaxies. The FIR emission is characteristic of such events. Meanwhile, in the more evolved ShCGs most galaxies are of E and S0 type, and the number of spirals is relatively small. The gas has been pushed out of them during previous interaction processes between galaxies, and fills the intergalactic space. The spirals here should also have shed their dust content. The presence of intergalactic gas in CGs was proved by the detection of diffuse X-ray emission (Ebeling, Weges, & Bohringer 1994; Pildis, Bregman, & Evrard 1995; Saracco & Ciliegi 1995; Tiersch et al. 1996a) from some of the groups. Through interaction with a newcomer galaxy to the group, this intergalactic gas may be falling in the form of cooling flows directly into the center of the preferentially dominant early-type galaxy in the group. As a result of this, an active nucleus in the galaxy with sufficiently strong radio emission may be formed. Because of the small amount or even absence of dust in such galaxies, their FIR emission would be very weak or even completely absent.

4. CONCLUSIONS

Three hundred and fifty-three NVSS (Condon et al. 1998) radio sources are found within the boundaries of 179 ShCGs. Sixty sources were also registered in the FIRST survey (White et al. 1997), of which seven sources were found only in the FIRST.

Ninety-three of the radio sources found have been identified with corresponding galaxies in 74 out of 366 ShCGs. We find a complex structure for radio sources in ShCG 016, 021, 120, 203, 219, and 317. We construct radio spectra of 22 radio sources. We show that in general, ShCG galaxies have higher radio luminosities than galaxies in HCGs. A comparison of the radio and FIR fluxes of galaxies in HCGs and ShCGs shows that the latter are stronger radio emitters, while HCG galaxies are generally stronger FIR emitters. It is suggested that the reason for this may be that ShCGs are more evolved than HCGs, and galaxies in them do not have enough dust to produce the FIR emission. On the other hand, conditions in ShCGs are more favorable for the formation of active galactic nuclei with relatively stronger radio emission.

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