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Radio Continuum Observations at 5 GHz of Shakhbazyan's Compact Groups of Galaxies

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Abstract

Radio continuum observations at 5 GHz were made of four Shakhbazyan's (1973) compact groups of galaxies with the 100-m telescope in Bonn. Upper limits of 0.5–0.8 mJy were given as their radio flux densities, which suggest that they are not particularly radio active. A radio galaxy of $\sim$8.7 mJy was found at $\sim$3′ southwest of Shakhbazyan 1. The physical relation of this radio galaxy to the object is still not clear.

Key words: Clusters of galaxies; Compact groups of galaxies; Radio sources.

1. Introduction

A wealth of compact groups of galaxies have been found by Shakhbazyan (1973), Shakhbazyan and Petrosyan (1974), and Baier et al. (1974). One of the most typical objects, Shakhbazyan 1 (hereafter referred to as Shk 1), has been optically investigated by some authors (Robinson and Wampler 1973; Arp et al. 1973; Börngen and Kalloglyan 1974; Massey 1977; Kirshner and Malumuth 1980). The Shakhbazyan objects are quite a different type of galaxy associations from the known clusters and compact clusters of galaxies because of their uniqueness (see section 4).

Recently Sanamyan and Arutyunyan (1977) reported that there is a physical connection between Shakhbazyan objects and radio sources through a correlation analysis using radio source catalogs. On the contrary, Tovmasyan et al. (1979) pointed out that there is no statistically significant excess in the number of radio sources around Shakhbazyan objects over the value expected from a random distribution of the radio sources on the sky. We report here resutls of radio continuum observations of four typical Shakhbazyan objects to clarify whether they are radio active or not.

2. Observations

Radio continuum observations of four Shakhbazyan objects, Shk 1, 2, 5 and 19, were made at a frequency of 5 GHz with the 100-m telescope of the Max-

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Planck-Institut für Radioastronomie in Bonn. The four objects were chosen either because of their relatively rich appearance or high compactness compared with the others, as well as because of their positions on the sky which made it convenient to observe them within the allocated observing time. We used a Dicke-switched-mode receiver combined with a cooled parametric amplifier. The system noise temperature at the cold sky was approximately 100 K. The bandwidth was 500 MHz and the half-power beam width of the antenna was 2.′5. The calibration of the flux density and pointing of the antenna were made by using 3C 295, whose flux density at 5 GHz was assumed to be 6.36 Jy.

Each object was scanned in the right ascension (R. A.) centered at the position of the object given in the table of Shakhbazyan (1973). The scans were made at a speed of 30′ per minute over a distance of 10–12′ on the sky and were repeated to give an integration time of 120–200 s per data point at every 1′. The rms detection limit was approximately 0.5–0.8 mJy.

3. Results

The observations have shown no significant enhancements of radio signals at the given positions of the four Shakhbazyan objects. Table 1 summarizes the upper limits on their radio flux densities at 5 GHz and spectral powers. The spectral power, P, is estimated through $P=4\pi d^2 S$, where d is the distance to the object and S is the flux density. Here the distance to Shk 1 is obtained from its redshift, $z=0.1168$, combined with the Hubble parameter of $H=75\,\mathrm{km\,s^{-1}Mpc^{-1}}$. The distances of the other objects are estimated from the mean visual magni-

Table 1. Parameters for four Shakhbazyan's (1973) compact groups of galaxies and upper limits on their radio flux densities and spectral powers at 5 GHz.

Shk No. (1)	R.A. (1950) (2)	Decl. (1950) (3)	N (4)	Size (5)	p (6)	m_v (mag) (7)	z (8)	d (Mpc) (9)	S (mJy) (10)	P (10^{22}W Hz^{-1}) (11)
1......	$10^h52^m03^s$*	40°44′*	17	1.′4	1.1	17	0.1168	470	<0.5	<1.3
2......	11 41 06	51 42	9	1.0	0.8	17	—	470	<0.8	<2
5......	11 14 24	55 11	5	0.7	1.0	17	—	470	<0.8	<2
19......	13 26 00	16 06	5	0.35	2.1	16.5	—	370	<0.5	<2

Notes to table 1 [quantities in columns 1-7 are from Shakhbazyan (1973)]:
(1) Shakhbazyan No.
(2), (3) Position of center of the group.
(4) Number of member galaxies.
(5) Optical extent of the group.
(6) Compactness of the group.
(7) Mean visual magnitude of individual member galaxies.
(8) Redshift (Robinson and Wampler 1973).
(9) Estimated distance.
(10) Upper limit to the radio flux density at 5 GHz.
(11) Spectral power at 5 GHz.
* A more accurate optical position of Shk 1 is R.A.$=10^h52^m15.^s64\pm0.^s02$ Decl.$=40°43'30.''4\pm0.''3$ (1950).

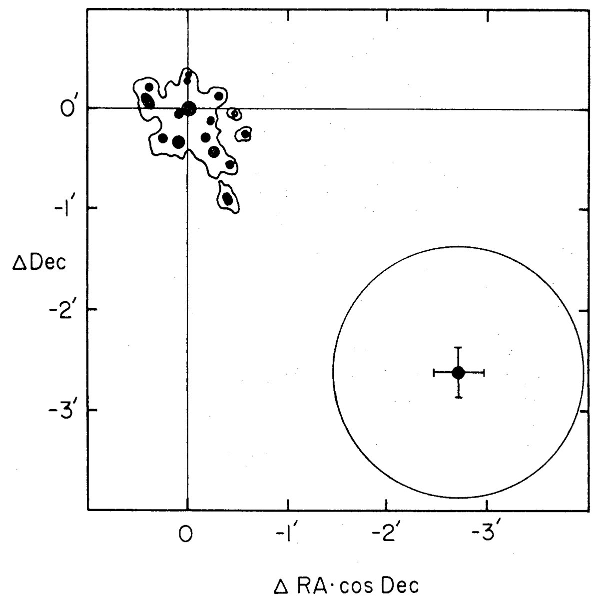

Fig. 1. Positions of Shk 1 and a nearby radio source detected at 5 GHz. Position of the radio source is shown with a cross whose length indicates the error in position determination. The circle indicates the HPBW of the 100-m telescope at 5 GHz. The radio source is identified with an elliptical galaxy marked with a filled circle. Member galaxies of Shk 1 are also marked with filled circles. The contours of the lowest surface brightness of the photometry by Massey (1977) are drawn. The coordinates are offsets in R. A.×cos Decl.$_0$ and Decl. centered at galaxy 1 of Shk 1 (R.A.$_0$=10 h 52 m 15.64s, Decl.$_0$=40°43′30″.4; epoch 1950.0).

tudes of the member galaxies by assuming that their intrinsic luminosities are the same as those of Shk 1. Table 1 includes also their positions, numbers of member galaxies, apparent sizes, compactness, mean magnitudes of the member galaxies (Shakhbazyan 1973) and distances.

In the course of confirming our results on Shk 1 by declination scans we found a radio source near Shk 1. The position of the radio source is at R. A.= 10h 52 m 01s±1s, Decl.=40°40′.8±0′.3 (epoch 1950) and its total flux density at 5 GHz is 8.7±1 mJy. To see the positional relation of this radio source with Shk 1, we determined more accurately the optical position of Shk 1 using the Palomar Sky Survey prints referring to the AGK3 star positions (Heckmann et al. 1975): The center position of the brightest member, or galaxy 1 (Robinson and Wampler 1973), is at R.A.=10h 52 m 15.64s±0.02s, Decl.= 40°43′ 30″.4±0″.3 (1950). The radio source found above is then located 3.′8 southwest to Shk 1's optical center and approximately 2′ away from its southern limb. At the position of this radio source there is an elliptical galaxy of ~16th magnitude. Figure 1 illustrates their positional relation. We note that this radio source, probably a radio galaxy, is located on the line of direction in which the distribution of member galaxies of Shk 1 is elongated. However, the physical connection of Shk 1 to the presently found radio galaxy still remains open to question; a chance detection of a background radio source of this flux density cannot be ignored on account of the radio source counts (Jauncey 1975). We must wait for a more accurate mapping around Shk 1 and the radio source to learn their physical connection.

We may note that the position accuracy of the original table by Shakhbazyan (1973) is not very good so that the R. A. scans in our observations might have missed the true positions of the objects other than Shk 1. For a more detailed survey we need more accurate position determinations as well as radio mapping of wider areas around individual objects.

4. Discussion

The uniqueness of Shakhbazyan objects has been stressed by some authors, particularly for Shk 1: (a) Shk 1 is a very compact group of 17 elliptical galaxies having an angular extent of $2\times1'$ or 270×140 kpc for $z=0.1168$ with $H=75\,\mathrm{km\,s^{-1}Mpc^{-1}}$ (Robinson and Wampler 1973); (b) the color of member galaxies of Shk 1 is as red as $B-V=1.5$ mag, redder by 0.7 mag than normal ellipticals (Börngen and Kalloglyan 1974); (c) the existence of ionized gas is known in the central galaxy (Robinson and Wampler 1973); and (d) the existence of luminous intergalactic matter is known (Massey 1977).

As to the mass of the group and the nature of member galaxies there is a controversy. Robinson and Wampler (1973) found a very small velocity dispersion of $62\,\mathrm{km\,s^{-1}}$ in Shk 1. Arp et al. (1973) claimed that the mass-to-light ratio is as small as unity in solar units, and stressed their high surface brightness. On the other hand, Kirshner and Malumuth (1980) have found a larger value for the velocity dispersion ($840\,\mathrm{km\,s^{-1}}$) and a large velocity dispersion in individual galaxies. They estimate the mass-to-light ratio as 111 ± 15 in solar units and conclude that the member galaxies are ordinary ellipticals, which is consistent with Massey's (1977) surface photometry. However, Kirshner and Malumuth (1980) stress that Shk 1 is extraordinary in the sense that it is about as dense as the center of Coma cluster.

Our negative detection of radio emission of the four Shakhbazyan objects confirms the conclusion of Tovmasyan et al. (1979). We stress that their spectral radio powers are far less than those of normal clusters of galaxies which are of the order of 10^{23}–$10^{24}\,\mathrm{W\,Hz^{-1}}$ (e.g., Andernach et al. 1980). The radio quietness could be related to the unique characteristics of the objects raised above, if the characteristics are common to any Shakhbazyan object. The radio quietness may add a new puzzling problem when discussing their origin and evolution.

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References

Andernach, H., Waldthausen, H., and Wielebinski, R. 1980, *Astron. Astrophys. Suppl.*, **41**, 439.

Arp, H. C., Burbidge, G. R., and Jones, T. W. 1973, *Publ. Astron. Soc. Pacific*, **85**, 423.

Baier, F. W., Petrosyan, M. B., Tiersch, H., and Shakhbazyan, R. K. 1974, *Astrofiz.*, **10**, 327.

Börngen, F., and Kalloglyan, A. T. 1974, *Astrofiz.*, **10**, 21.

Heckmann, O., Dieckvoss, W., Kox, H., Günther, A., and Brosterhus, W. 1975, *AGK3, Star Catalogue of Positions and Proper Motions North of* $-2^{\circ}.5$ *Declination Derived from Photographic Plates taken at Bergedorf and Bonn in the Years 1928–1932 and 1956–1963* (Hamburger Sterrewacht).

Jauncey, D. L. 1975, *Ann. Rev. Astron. Astrophys.*, **13**, 23.

Kirshner, R. P., and Malumuth, E. M. 1980, *Astrophys. J.*, **236**, 366.

Massey, P. 1977, *Publ. Astron. Soc. Pacific*, **89**, 13.

Robinson, L. B., and Wampler, E. J. 1973, *Astrophys. J. Letters*, **179**, L135.

Sanamyan, V. A., and Arutyunyan, Eh. A. 1977, *Astrofiz.*, **13**, 543.

Shakhbazyan, R. K. 1973, *Astrofiz.*, **9**, 495.

Shakhbazyan, R. K., and Petrosyan, M. B. 1974, *Astrofiz.*, **10**, 13.

Tovmasyan, G. M., Shakhbazyan, E. Ts., and Shirbakyan, M. S. 1979, *Astrofiz.*, **15**, 513.