Astronomy Letters, Vol. 25, No. 6, 1999, pp. 380–388. Translated from Pis'ma v Astronomicheskii Zhurnal, Vol. 25, No. 6, 1999, pp. 447–456.
Original Russian Text Copyright © 1999 by Gubanov, Reshetnikov.

Identification of Radio Sources in Clusters of Galaxies

A. G. Gubanov and V. P. Reshetnikov
Astronomical Institute, St. Petersburg State University, Bibliotechnaya pl. 2, Petrodvorets, 198904 Russia
Received July 14, 1998; in final form, November 5, 1998

Abstract—We have carried out a detailed identification of radio sources from the FIRST catalog lying within the Abell radii of 26 rich galactic clusters with optical objects in the APM and DSS surveys. Of the 326 radio sources in the cluster fields, 99 are identified, 40 have probable identifications, and 187 are unidentified. Among these last sources, 20 are definitely located in the clusters and 34 are cluster members with high probability. Thus, ≈30–40% of the FIRST radio sources could be identified using APM and DSS data, and, on the average, there were two sources in each cluster.

INTRODUCTION

Investigation of the cosmological evolution of radio galaxies, the influence of the surrounding environment on the development of extragalactic radio sources, the relationship between the activity of galactic nuclei and interactions between galaxies, and a whole series of other issues require representative, complete, and uniform sets of radio sources in galactic clusters.

Existing samples of identified cluster radio sources include ~300 objects and are very nonuniform in their composition and in the reliability of their identifications, because cluster radio sources are relatively weak and often have a complex, extended structure, which hinders certain identification and requires large amounts of observing time, even on the most sensitive astronomical instruments.

PROGRAM FOR THE IDENTIFICATION OF CLUSTER RADIO SOURCES

Goals

The program for the identification of radio sources in galactic clusters being carried out at the Astronomical Institute of St. Petersburg State University and the Special Astrophysical Observatory (Gubanov *et al.* 1997) has two main goals:

(1) to identify radio sources in all 4076 rich galactic clusters in the ACO catalog (Abell *et al.* 1989) on the basis of new, high-sensitivity surveys, first and foremost the FIRST (White *et al.* 1997) and NVSS (Condon *et al.* 1998) radio surveys (with sensitivity ≈1–3 mJy at 1400 MHz) and the APM (Lewis and Irwin 1996), DSS[1], and USNO (Monet *et al.* 1996) optical data (with limiting magnitudes to $\approx 20^m$ in the R filter and $\approx 22^m$ in the B filter) and

(2) to include information about cluster radio sources in a freely accessible database supported by the Astronomical Institute of SPSU (URL http://www.astro.spbu.ru/Clusters.html).

This will provide astrophysicists with the basic parameters of ~7000–8000 identified radio sources in rich galactic clusters and makes it possible to construct groups of cluster radio sources for multi-faceted studies.

We envision a step-by-step execution of the program, in which each stage is determined by specific astrophysical problems that require sufficiently complete information about identified cluster radio sources. For example, one of the first problems posed was a search for the effects of gravitational lensing of radio sources by clusters of galaxies (Andernach *et al.* 1997). We are currently conducting a search for radio sources in a sample of rich (richness class $R \geq 2$) clusters in the area of the FIRST survey and a study of the brightest cluster galaxies in this region.

In accordance with these main studies, work is also being carried out on searches for distant clusters based on peculiarities in the radio structures of members, identification of candidates for BL Lacertae objects and unidentified FRII radio sources (as part of a search for the most distant objects in the Universe), and a number of other areas.

Methods and Means

In order to efficiently reduce the large volume of analyzed data, we used the galactic-cluster database developed at the Astronomical Institute of SPSU (Gubanov and Andernach 1997), which uses Web technology to provide a simple interaction with various series of data. This environment includes convenient means for visualization, which is very important for the process of identifying sources. In addition, it is possible to work with the program from remote computer terminals.

[1] The Digitized Sky Surveys were produced at the Space Telescope Science Institute under U.S. Government grant NAG W-2166.

1063-7737/99/2506-0380$15.00 © 1999 МАИК “Наука/Interperiodica”

The parameters for the FIRST, NVSS, and APM objects that fell within the Abell radii of clusters (three Mpc for a Hubble constant of 50 km s^{-1} Mpc^{-1}) were already entered in the database (for the area of sky that was analyzed in these surveys). The optical (DSS) and radio (FIRST) images were requested over the Internet using a special interface from the corresponding astronomical data centers during the process of identifying radio sources in specific clusters. Tabular and graphical data were ordered and examined using the auxiliary service programs developed for the cluster database (Gubanov and Titov 1997).

It is comparatively often necessary to refine the parameters for objects from the APM survey (coordinates and stellar magnitudes) and sometimes necessary to refine the FIRST survey. In this case, we reduced the DSS (FIRST) images using the European Southern Obervatory MIDAS package. The same package was used to superimpose the optical and radio images, when this was necessary to refine an identification or to construct maps of objects in the clusters included in the database.

In the first stage of our program, we intended to carry out detailed identifications for all radio sources that fall within the Abell radii for a sample of ~100 clusters. We applied a computer reduction and representation of the data using the corresponding digital and informational material available. This enabled us to develop simple identification procedures that could operate in an automated regime, with minimal intervention from the researcher, for implementation also in subsequent stages of the program. As a series to be reduced in this way, we chose rich clusters (richness class $R \geq 2$) and clusters containing cD galaxies that fell in the region of the FIRST survey ($\alpha, \delta_J = [7^h_{\cdot}5\ldots17^h_{\cdot}5$; $+22°\ldots+42°]$). Here, we present the results of such identifications for 26 clusters in this series.

There are difficulties involved in choosing criteria for identifying radio sources in clusters. These difficulties are associated with the complex morphology of the sources, with the large density of optical objects in cluster fields and with the necessity of measuring redshifts. Therefore, in the first stage of our program, we chose the following procedure for identifying the radio sources.

On the computer display, we carefully examined the cluster fields for the APM, FIRST, and NVSS radio sources overlaid with schematic images of optical objects, which were prepared by specialized modules in the database in the form of Tc1 programs that can be called up by the user. These programs allow the screen to display of the coordinates and stellar magnitude of a galaxy (or of the flux density of a radio source), as well as the characteristic dimensions of any field object. It is possible to exclude either the optical or radio images and also to display the images many times, which is often useful when comparing the optical and radio data. The programs can expand the scale of part of a field near a selected object (which is especially important for cluster fields with a high surface density of galaxies), remove individual objects that are interfering with the examination, and provide a number of other functions (Gubanov and Titov 1997).

For each radio source that fell onto a cluster, we accessed the optical (DSS) and radio (FIRST) images for fields in its immediate vicinity. These images, together with tabulated data from the FIRST and NVSS radio catalogs and the APM survey (coordinates, flux densities, stellar magnitudes, types, and sizes), were compared with each other to evaluate the reliability of possible identifications and the probability that a particular object was a cluster member.

Traditionally, work on the identification of radio sources in clusters involves some qualitative classification of the objects that reflects the reliability of the proposed identification and the probability of cluster membership; this information is, of course, only tentative in the absence of redshift measurements for the identified objects but is nonetheless helpful for researchers using the data. Here, we consider a compact radio source to be identified (Id) if its coordinates coincide with the coordinates of an optical object within the errors (~3–5″ for weak objects). If the offset of the radio position from the optical position is comparable to the square root of the sum of the squares of the rms errors in the coordinates, the identification is considered to be probable (pId). Otherwise, the source is taken to be unidentified (NI).

For extended objects, the main criterion for certain identification was a correspondance between the radio structure and the optical image. We considered the identification to be reliable if the corresponding optical object was located at a position that had some significance in terms of the radio structure [between the components of a double source, at the location of a compact feature in the center of a complex structure, at the "head" of a head–tail (HT) source, at the bending point of a wide-angle-tail (WAT) structure, or at the base of a jet].

To reflect the probability of cluster membership for an object, we have introduced the following categories: in the cluster (C), probably in the cluster (pC), probably not in the cluster (pnC), and not in the cluster (nC). Usually, even in the absence of a redshift, we can be certain about the membership of a radio source in a cluster if it is identified with one of the brightest cluster galaxies, if it is located close to the center (no further than 1 Mpc from the center), and if it has a structure that is characteristic of the cluster (for example, HT or WAT for extended sources). It is also important that the optical magnitude of the object is in the range expected for the distance to the cluster (in absolute magnitude, from -20^m to -24^m in the V filter). When classifying the objects, we took into account precisely these considerations together with some others (for example, similar-

Table 1. List of clusters

ACO	RA(J2000)	DEC(J2000)	z	ACO	RA(J2000)	DEC(J2000)	z
A0586	$07^h32^m17^s.8$	+31°37′34″	0.1710	A1033	$10^h31^m33^s.8$	+35°04′34″	0.1258
A0642	08 19 05.7	+30 02 34	0.2063e	A1035	10 32 07.3	+40 12 33	0.0785
A0690	08 39 14.3	+28 51 24	0.0788	A1068	10 40 47.2	+39 58 20	0.1375
A0705	08 47 38.7	+30 00 56	0.1138e	A1073	10 42 26.6	+36 38 17	0.1390
A0715	08 54 44.4	+35 24 33	0.1685e	A1081	10 44 49.5	+35 34 14	0.1585
A0727	08 59 13.1	+39 26 19	0.0992e	A1094	10 47 32.8	+27 31 10	0.2004
A0781	09 20 23.2	+30 26 16	0.1763e	A1120	10 53 15.5	+30 48 02	0.2218e
A0800	09 28 30.0	+37 47 53	0.2223e	A1175	11 09 13.7	+33 10 44	0.2487
A0812	09 32 35.4	+37 53 42	0.1452e	A1178	11 09 50.1	+34 35 43	0.2596
A0908	09 59 35.8	+22 25 36	0.2026e	A1182	11 10 19.0	+31 46 43	0.1660e
A0943	10 12 12.2	+33 37 10	0.1485e	A1190	11 11 46.2	+40 50 42	0.0763
A0961	10 16 29.5	+33 37 01	0.1241	A1198	11 12 48.0	+30 22 40	0.1660e
A0963	10 17 09.7	+39 01 00	0.2060	A1258	11 26 08.7	+25 26 30	0.1469e

Table 2. Data on the identified radio sources

RS	r/Ra	RA-radio	DEC-radio	f/n	Nc	Sfst		Snvs
		RA-opt	DEC-opt	a/d	C	m	ID	Cl
A0586.1	0.07	07 32 20.45	31 37 57.6	fst	1	6.0		
		07 32 20.50	31 37 58.0	dss	B	15.4	Id	C
A0586.2	0.29	07 32 19.52	31 40 24.8	fst	1	5.7		
							NI	pC
A0586.3	0.38	07 32 20.33	31 41 19.7	fst	1	8.4		
		07 32 20.31	31 41 19.4	dss	B	17.8	Id	pC
A0642.1	0.14	08 19 08.59	30 03 35.7	fst	1	16.6		55.4
		08 19 08.51	30 03 35.6	apm	R	16.25	Id	C
A0642.2	0.20	08 19 01.10	30 03 56.7	nvs	1			4.8
		08 19 00.23	30 03 51.3	apm	R	17.05	pId	pC
A0690.1	0.05	08 39 15.83	28 50 38.9	fst	16	335.5		978.0
		08 39 15.85	28 50 40.5	apm	R	12.34	Id	C
A0690.2	0.28	08 38 49.02	28 48 51.7	fst	1	7.5		7.3
							NI	pnC

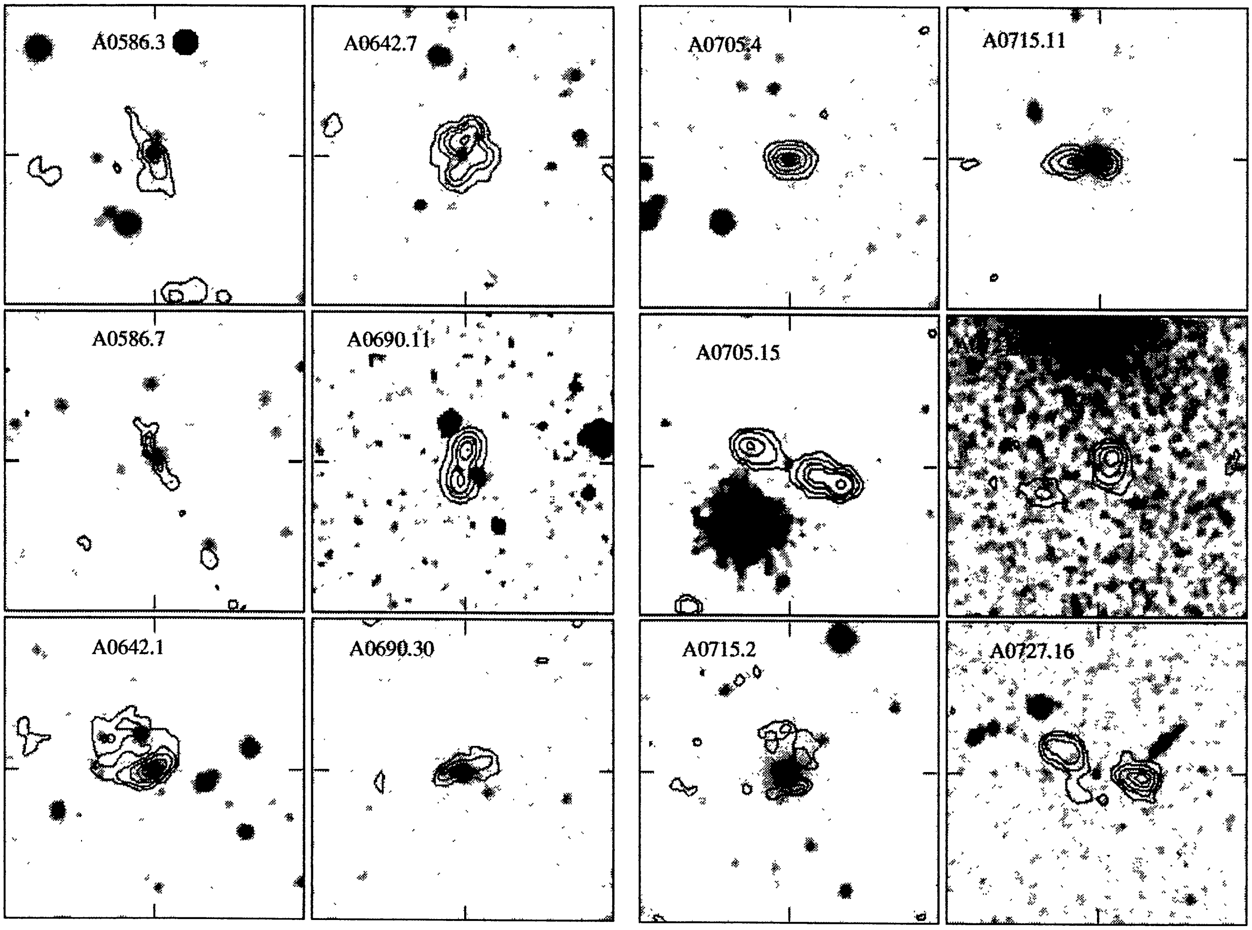
ity of the optical object to an elliptical rather than a spiral galaxy).

Thus, class C contains predominantly bright, elliptical galaxies near the cluster centers which are identified with radio sources that have characteristic structures. Class pC contains galaxies which are located closer to the cluster boundary or which have optical magnitudes that are close to the lower boundary of the expected range. The remaining objects were assigned to one of the two other categories; class nC contains only a few objects for which redshift measurements allowed us to determine with certainty that they are outside the cluster.

RESULTS

Table 1 lists the 26 Abell clusters for which we carried out identifications together with the coordinates of their centers at epoch J2000 and their redshifts (or estimates of their redshifts, denoted by a letter "e").

Table 2 contains information about the identified radio sources located within the Abell radii (three Mpc)



Radio contours based on the FIRST survey superimposed on optical images for DSS fields for a number of extended radio sources.

of the clusters from Table 1. We present here only part of this table; it is presented in its entirety, together with comments, in electronic form in the format for the astronomical data center in Strasbourg (CDS) and is accessible via Internet at the URL http://cdsweb.u-strasbg.fr/cats/J.html.

The data in Table 2 (published in its entirety in electronic form) are organized as follows. The first column (RS) gives the number of the radio source, which consists of the cluster name and (after the point) the source number. The sources for a particular cluster are presented in the order of their distances from the cluster center. Further, the distance from the cluster center (r/Ra) in units of the Abell radius (here, three Mpc) is given. We then present the radio-source coordinates at epoch J2000 [hours, minutes, and seconds of right ascension (RA-radio) and degrees, minutes, and seconds of declination (DEC-radio)]. The next column (f/n) indicates the survey from which the radio coordinates were taken (fst = FIRST, nvs = NVSS). For single-component sources, the coordinates are simply those from the corresponding catalog (FIRST, NVSS). For multi-component sources, we present the coordinates for the central source, or the mean coordinates for all components. Further, we give the number (Nc) of components from the FIRST (NVSS) catalog that were attributed to the given source. The next two columns present the integrated flux densities (in mJy) from the FIRST and NVSS catalogs (Sfst and Snvs). Note that in several cases, the value for Snvs represents the sum of the flux densities for two different radio sources.

Next, we find data for the optical objects. After the optical coordinates (RA-opt and DEC-opt), the column (a/d) indicates the survey from which the coordinates were taken (apm = APM, dss = DSS). The next columns (C and m) show the filter used (R for E-plate measurements, B for Palomar-atlas O-plate measurements) and corresponding stellar magnitude. When it was necessary to measure the coordinates or magnitude for an object using the DSS survey (because they were absent from the APM or distorted there), we used the corresponding ties to the coordinates and magnitude scale for objects from the APM catalog in the given field.

As indicated above, the abbreviations in the second-to-last column (ID) indicate identified (Id), probably identified (pId), and unidentified (NI) sources.

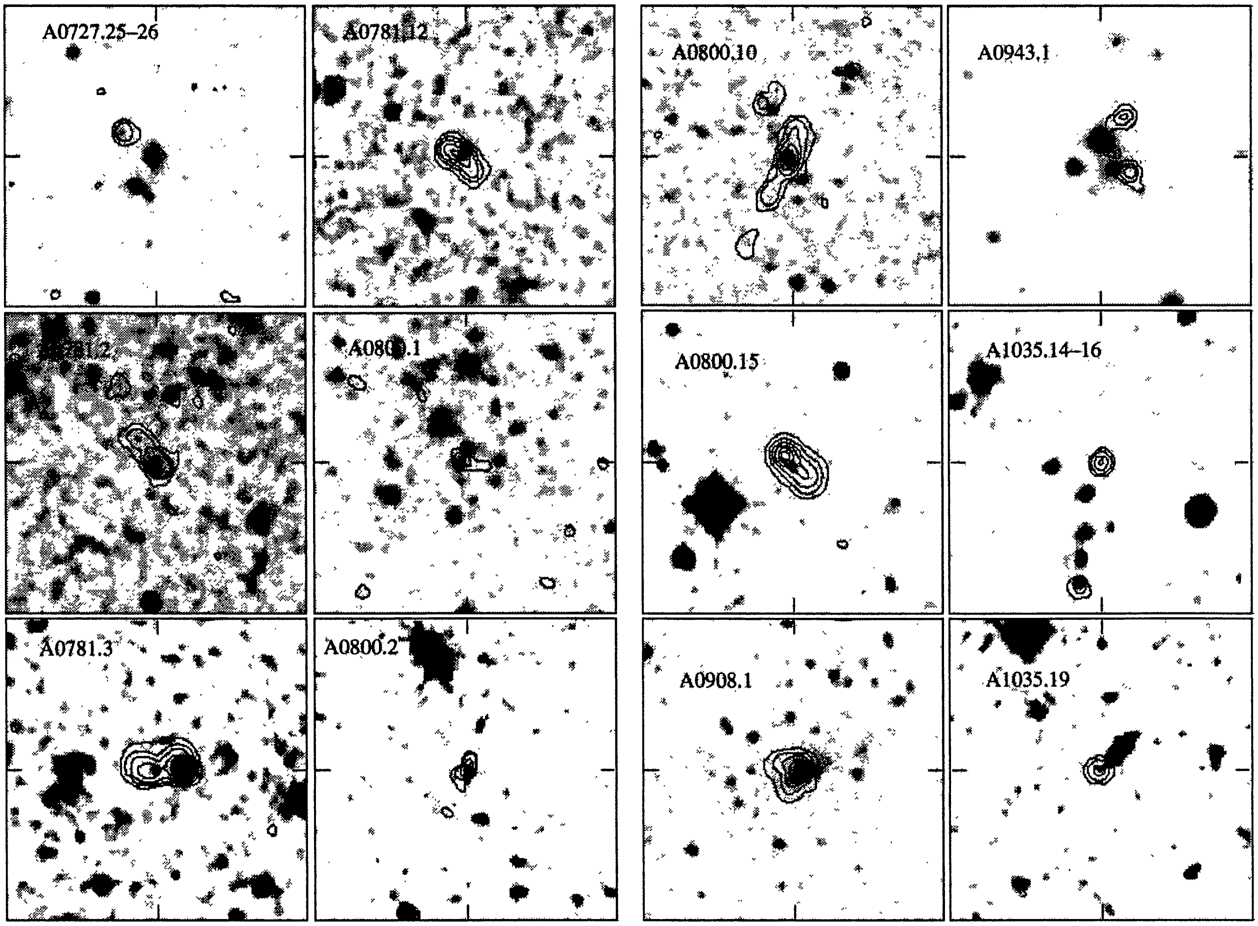


Figure. (Contd.)

The last column (C1) presents our classification for the probability of cluster membership: in cluster (C), probably in cluster (pC), probably not in cluster (pnC), and not in cluster (nC).

For a number of extended radio sources, we constructed superpositions of the radio (FIRST) and optical (DSS) images, shown in the figure. Each field is 2′ × 2′, and the coordinates of their centers are presented below in the comments for each cluster. The optical images with superimposed radio contours for cluster radio galaxies have been entered into our database and are accessible via the Internet.

Below, we present comments about our identifications of radio sources in each cluster.

A0586. The weaker of the two nuclei in the common envelope of the brightest galaxy at the cluster center (resembling a cD galaxy) is identified with the radio source A0586.1. The unidentified diffuse source A0586.2 and the radio galaxy A0586.3 may also belong to the cluster. The radio galaxy A0586.7 is probably located in a different cluster or in a subcluster. The coordinates of the field centers in the figure are $07^h32^m20^s.327$, $+31°41'19''.73$ for A0586.3 and $07^h32^m42^s.53$, $+31°34'22''.2$ for A0586.7.

A0642. The radio source A0642.1 is a head-tail cluster radio galaxy. The small peak in the "tail" of this radio source coincides with the position of another galaxy; i.e., this second galaxy (with coordinates $08^h19^m10^s.31$, $+30°03'37''.5$ and mR = 18.96) may also be a radio galaxy. The NVSS radio source A0642.2 may also be located in the cluster (a higher-resolution radio image is needed for more certain identification). The unusual radio source A0642.7 (which resembles 3C315) is probably located in a different cluster. The coordinates of the field centers in the figure are $08^h19^m08^s.51$, $+30°03'35''.6$ for A0642.1 and $08^h18^m51^s.18$, $+29°55'47''$ for A0642.7.

A0690. The cD galaxy (A0690.1) is a known powerful, extended (≈6′) WAT radio source (see, for example, O'Donoghue *et al.* 1990). The radio source A0690.9 is identified with a cD galaxy, which may be located in a subcluster of A0690 or in a different cluster. To the southeast of A0690, there is another (poor) clus-

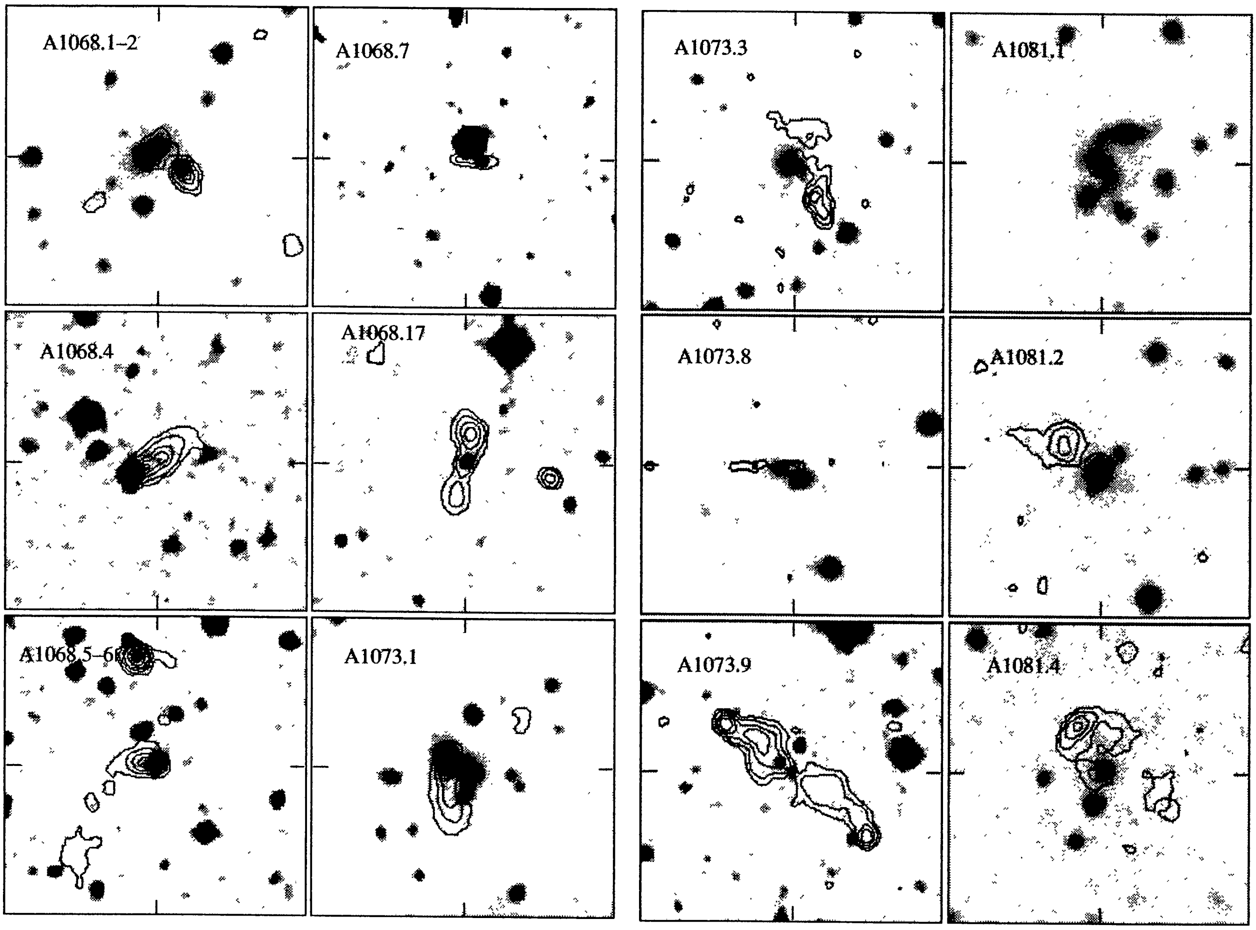


Figure. (Contd.)

ter, whose two brightest galaxies are identified with the radio sources A0690.34 and A0690.35. Two other radio sources in the field of this cluster (A0690.33 and A0690.36) are also identified, but they are probably not cluster members. The coordinates for the field centers for the extended radio sources in the figure are $08^h38^m13.^s497$, $+28°51'01.''56$ for A0690.11 and $08^h40^m51.^s961$, $+28°50'55.''24$ for A0690.30.

A0705. There are no certain identifications of radio sources with cluster galaxies. The radio sources A0705.1, A0705.2, and A0705.3 all require more detailed study. The radio galaxy A0705.4 may be located in the cluster; however, measurement of its redshift is required before we can be absolutely certain. The coordinates of the field centers for the extended radio sources in the figure are $08^h48^m02.^s260$, $+30°04'22.''12$ for A0705.4 and $08^h47^m41.^s47$, $+30°14'01.''5$ for A0705.15.

A0715. The cD galaxy at the cluster center is identified with the extended radio source A0715.2. The FIRST radio image provides evidence that this object may be gravitationally lensed, which would be interesting to verify. The radio source A0715.1 is probably also in the cluster. At the edge of the cluster lies the radio galaxy A0715.13, which may belong to a subcluster of A0715 or a background group of galaxies. All remaining radio sources are probably not in the cluster. The coordinates for the field centers for the extended radio sources in the figure are $08^h54^m57.^s52$, $+35°24'51.''4$ for A0715.2 and $08^h54^m44.^s27$, $+35°33'55.''7$ for A0715.11.

A0727. The optical field of this cluster is complex, and it is difficult to distinguish cluster galaxies. None of the radio sources can clearly be identified with bright cluster galaxies; it is possible that only the radio source A0727.7, which is identified with a fairly bright galaxy, is located in the cluster. It is unlikely that radio sources identified with weak optical galaxies are cluster members. The coordinates of the field centers for the extended radio sources in the figure are $08^h58^m45.^s25$, $+39°29'23.''5$ for A0727.4; $08^h58^m16.^s15$, $+39°30'50.''8$

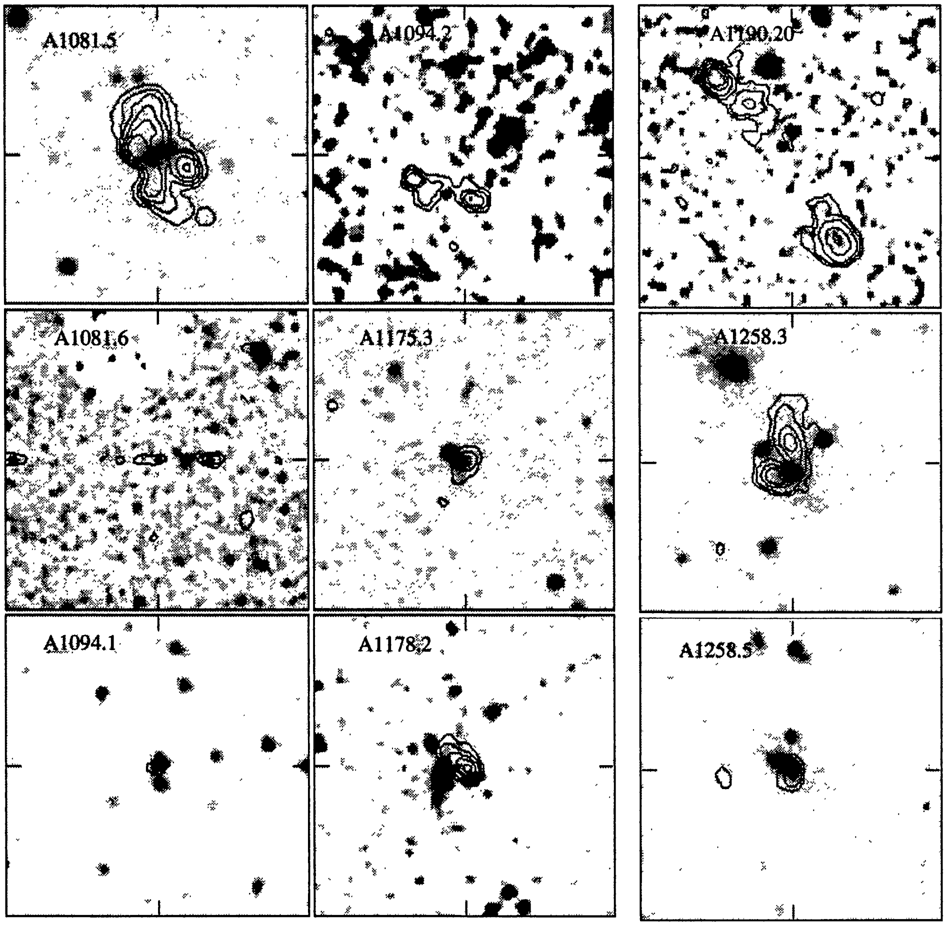


Figure. (Contd.)

for A0727.16; and $08^h57^m51^s.477$, $+39°18'46''.28$ for A0727.25–26.

A0781. The probable cluster center is located roughly 5′ to the northwest of the position indicated in the ACO catalog. Therefore, the radio source A0781.2 is very likely located in the cluster. It is possible that the extended source A0781.1 is also in the cluster. The lack of detailed structural information makes it impossible to identify the extended NVSS radio sources A0781.1, A0781.5, and A0781.6. The coordinates of the field centers for the extended radio sources in the figure are $09^h20^m13^s.90$, $+30°28'58''.7$ for A0781.2; $09^h20^m23^s.15$, $+30°29'42''.6$ for A0781.3; and $09^h20^m01^s.20$, $+30°34'05''.1$ for A0781.12.

A0800. The radio source A0800.1 (and possibly A0800.2) is located in the cluster. The coordinates of the field centers for the extended radio sources in the figure are $09^h28^m36^s.018$, $+37°47'07''.29$ for A0800.1; $09^h28^m23^s.199$, $+37°49'54''.75$ for A0800.2; $09^h28^m09^s.75$, $+37°54'49''.3$ for A0800.10; and $09^h28^m58^s.98$, $+37°40'50''.6$ for A0800.15.

A0812. All radio sources are located outside this compact cluster with a central cD galaxy, and none are identified with cluster galaxies.

A0908. This cluster has a well-defined core that coincides with a cD galaxy with an asymmetric envelope, which is identified with the radio source A0908.1. The coordinates of the field center for the map of A0908.1 in the figure are $09^h59^m47^s.062$, $+22°24'09''.69$.

A0943. The close companion of the cD galaxy is probably a WAT radio source (A0943.1). The radio source A0943.2 may also be in the cluster. The coordinates of the field center for the map of A0943.1 in the figure are $10^h12^m01^s.26$, $+33°34'57''.9$.

A0961. The probable cluster center is $10^h16^m22^s.9$, $+33°38'17''$—the position of the dominant cD galaxy in the cluster core. There are no FIRST radio sources near this center.

A0963. This cluster is known to be a gravitational lens. The radio sources A0963.2 and A0963.3 may be located in the cluster.

A1033. The radio sources A1033.1, A1033.3 (HT), and A1033.8 (WAT) are in the cluster (Law-Green *et al.* 1995; Andernach *et al.* 1997). The sources A1033.4 and A1033.6 may also be located in the cluster.

A1035. The magnitude scale for this field in the APM survey is incorrect. The radio sources A1035.3 and A1035.6 and possibly A1035.1, A1035.2, and A1035.8 are located in the cluster. The coordinates of the field centers for the radio sources in the figure are $10^h31^m16^s.686$, $+40^{\circ}00'51''.09$ for A1035.14–16 and $10^h32^m23^s.236$, $+40^{\circ}29'14''.51$ for A1035.19.

A1068. The radio source A1068.1, which identified with a cD galaxy, and the radio source A1068.2, which is identified with its companion, are cluster members. The radio sources A1068.4 and A1068.5, which resemble HT radio galaxies, are probably also in the cluster. The radio source A1068.6, which was identified with a weak object, may lie in the cluster. The coordinates of the field centers for the extended radio sources in the figure are $10^h40^m44^s.30$, $+39^{\circ}57'10''.4$ for A1068.1–2; $10^h40^m44^s.54$, $+39^{\circ}54'54''.2$ for A1068.4; $10^h40^m28^s.86$, $+40^{\circ}00'03''.3$ for A1068.5–6; $10^h40^m19^s.444$, $+39^{\circ}55'29''.67$ for A1068.7; and $10^h41^m40^s.29$, $+39^{\circ}40'18''.8$ for A1068.17.

A1073. It is not clear how the cluster galaxies group. The HT radio source A1073.1 is identified with the brightest galaxy at the center. The source A1073.3 may also be identified with a bright cluster galaxy. The coordinates of the field centers for the extended radio sources in the figure are $10^h42^m32^s.85$, $+36^{\circ}39'42''.2$ for A1073.1; $10^h42^m35^s.80$, $+36^{\circ}41'32''.3$ for A1073.3; $10^h43^m13^s.387$, $+36^{\circ}41'11''.13$ for A1073.8; and $10^h42^m02^s.46$, $+36^{\circ}47'07''.5$ for A1073.9.

A1081. This cluster is probably comprised of a number of subclusters. The radio source A1081.2 may be associated with a bright galaxy in a subcluster to the south of the cluster center, and the sources A1081.4 and A1081.5 may be associated with galaxies in a northern subcluster (or in another cluster). It is possible that the bright central galaxy of the three interacting galaxies located at the center, which is identified with the radio source A1081.1, is also a cluster member. The structure of the radio source A1081.6 resembles a sidelobe pattern; if it is a real source, it is most likely identified with a bright galaxy that may be a cluster member. The coordinates of the field centers for the radio sources in the figure are $10^h44^m50^s.991$, $+35^{\circ}36'05''.73$ for A1081.1; $10^h44^m51^s.509$, $+35^{\circ}31'38''.34$ for A1081.2; $10^h44^m41^s.969$, $+35^{\circ}40'16''.22$ for A1081.4; $10^h44^m55^s.13$, $+35^{\circ}40'53''.9$ for A1081.5; and $10^h45^m05^s.32$, $+35^{\circ}28'52''.1$ for A1081.6.

A1094. The radio source A1094.1 may be associated with this cluster. The coordinates of the field centers for the radio sources in the figure are $10^h47^m36^s.322$, $+27^{\circ}30'15''.41$ for A1094.1 and $10^h47^m47^s.73$, $+27^{\circ}31'04''.5$ for A1094.2.

A1120. No identifications with cluster galaxies were found.

A1175. The radio sources A1175.2 and A1175.3 are probably in the cluster, although they are appreciably displaced from the center indicated in the ACO catalog. The coordinates of the field center for the map of A1175.3 in the figure are $11^h09^m19^s.116$, $+33^{\circ}14'40''.70$.

A1178. There were no identifications for galaxies in the cluster. The head–tail radio source A1178.2 is probably located in a different cluster. The coordinates of the field center for the map of A1178.2 in the figure are $11^h10^m03^s.021$, $+34^{\circ}32'43''.87$.

A1182. It is possible that A1182.1 is a member of the cluster.

A1190. The radio sources A1190.2, A1190.3, A1190.5 (see, for example, Owen and Ledlow 1997), and probably A1190.10 are in the cluster near the center. In the southern part A1190, there is either another cluster or a subcluster rich in E galaxies, where an additional two radio sources are located: A1190.38 and A1190.41 (A1190.36 is also located in a galaxy group or separate cluster to the southeast of A1190). The coordinates of the field center for the map of A1190.20 in the figure are $11^h12^m34^s.37$, $+41^{\circ}00'14''.2$.

A1198. There were no identifications of radio sources in the cluster, although the sources A1198.1, A1198.2, A1198.3, and A1198.5 require more detailed study.

A1258. The HT radio source A1258.3 is definitely in the cluster, and A1258.2 and A1258.6 radio sources are also very likely located in the cluster. The source A1258.5 is identified with a bright peculiar galaxy in the southern part of the cluster and may also be a cluster member. The coordinates of the field centers for the radio sources in the figure are $11^h26^m00^s.04$, $+25^{\circ}28'38''.9$ for A1258.3 and $11^h26^m09^s.520$, $+25^{\circ}20'35''.17$ for A1258.5.

Of all the radio sources that we found to be in the fields of the 26 clusters, 326 fell within the cluster Abell radii. Of these, 99 were identified with APM and DSS objects with certainty, 40 have probable identifications (i.e., they are in the category pId), and 187 were unidentified. Among the unidentified sources, 20 are definitely located in clusters (class C) and 34 are cluster members with high probability (class pC).

Thus, as we expected, we were able to identify ≈30–40% of the FIRST radio sources solely by using the APM and DSS data and to find, on the average, two sources in each cluster.

We note, however, that correct identification of radio sources in the clusters requires further visual analysis of the radio and optical images, since the centers of radio sources are often substantially shifted from the positions of the host galaxies. Indeed, among the 20 radio sources found with certainty to lie in the clusters, only 11 have a single component (at the FIRST angular resolution of about 5″), and only five are compact (i.e., with sizes comparable to or smaller than the available resolution). Of the 15 others, five have wide-angle-tail structure; five are head–tail radio sources; and for five other extended FRI sources, it is difficult to determine their morphological types. Under these circumstances, the graphical cluster database interface developed at the Astronomical Institute of SPSU (Gubanov and Titov 1997) proved an excellent instrument for the identification of radio sources.

ACKNOWLEDGMENTS

This work was carried out as part of the "Integration" program (project no.578) and was supported by the Russian Foundation for Basic Research (project code 97-02-18212).

REFERENCES

Abell, G.O., Corwin, H.G., Jr., and Olowin, R.P., *Astrophys. J., Suppl. Ser.*, 1989, vol. 70, p. 1.

Andernach, H., Gubanov, A.G., and Slee, O.B., *Observational Cosmology with the New Radio Surveys*, Bremer, M., Jackson, N., Perez-Fournon, I., Eds., Dordrecht: Kluwer Acad. Press, 1997, vol. 226, p. 107.

Condon, J.J., Cotton, W.D., Greisen, E.W., *et al.*, *Astron. J.*, 1998, vol. 115, p. 1693.

Gubanov, A.G. and Andernach, H., *Balt. Astron.*, 1997, vol. 6, p. 263.

Gubanov, A.G., Kopylov, A.I., Reshetnikov, V.P., and Titov, V.B., *Problemy sovremennoi radioastronomii. XXVII Radioastronomicheskaya konferentsiya, S.-Peterburg* (Problems in Modern Radio Astronomy. XXVII Radio Astronomy Conference, St. Petersburg), 1997, vol. 1, p. 168.

Gubanov, A.G. and Titov, V.B., *Problemy sovremennoi radioastronomii. XXVII Radioastronomicheskaya konferentsiya, S.-Peterburg* (Problems in Modern Radio Astronomy. XXVII Radio Astronomy Conference, St. Petersburg), 1997, vol. 1, p. 320.

Law-Green, J.D.B., Leahy, J.P., Alexander, P., *et al.*, *Mon. Not. R. Astron. Soc.*, 1995, vol. 274, p. 939.

Lewis, G. and Irwin, M., *Spectrum, RGO Newsletter*, 1996, vol. 12, p. 22.

Monet, D., Bird, A., Canzian, B., *et al.*, *USNO-SA1.0*, Washington: U.S. Naval Observatory, 1996.

O'Donoghue, A.A., Owen, F.N., and Eilek, J.A., *Astrophys. J., Suppl. Ser.*, 1990, vol. 72, p. 75.

Owen, F.N. and Ledlow, M.J., *Astrophys. J., Suppl. Ser.*, 1997, vol. 108, p. 41.

White, R.L., Becker, R.H., Helfand, D.J., and Gregg, M.D., *Astrophys. J.*, 1997, vol. 475, p. 479.

Translated by D. Gabuzda