5 radio sources of the Zenith survey at RATAN-600: VLA \(^1\) maps, radio spectra and optical identification

Yu.N. Parijskii\(^a\), W.M. Goss\(^b\), O.V. Verkhodanov\(^a\), A.I. Kopylov\(^a\), N.S. Soboleva\(^c\), A.V. Temirova\(^c\)

\(^a\) Special Astrophysical Observatory of the Russian AS, Nizhnij Arkhyz 357147, Russia
\(^b\) National Radio Astronomical observatory, P.O. Box 0, Socorro, New Mexico 87801, USA
\(^c\) St.Petersburg branch of the Special Astrophysical Observatory, Pulkovo, St.Petersburg, Russia

Received March 19, 1999; accepted September 1, 1999.

Abstract. VLA maps obtained at 1.4 GHz with a resolution of \(2.5'' \times 2''\) for three sources and \(6.5'' \times 2.3''\) for two sources detected in the RATAN–600 Zenith survey of 1988 have been analyzed. All five objects have an extended structure. Continuous radio spectra of these objects prepared by using the CATS database and RATAN-600 observations are given. All five objects have linear steep spectra (\(\alpha < -0.65\)). Using APM database and DSS we have found three candidates for identification. Two radio sources have been observed with the 6 m telescope. The nature of the studied objects, one of which is classified as QSO (BSO) and two others as galaxies, is discussed. One of the radio sources, \(RZ_5\), being a merging group of one large and several small galaxies, may have appeared in this process.

Key words: radio continuum: galaxies - radio continuum - quasars - survey catalogs

1. Introduction

In 1988 a survey was carried out at the RATAN–600 in the right ascension range between \(8^h\) and \(14^h\) at declination \(47^\circ 7'\) of 1' width with the use of the entire ring surface of the radio telescope (Mingaliev et al., 1991). A catalog of 70 objects (\(RZ\) sources) has been compiled at the wavelength of 8.0 cm. All the detected sources belong to a population of radio sources with flux densities from 14 to 70 mJy. General statistical investigation, estimation of spectral indices and luminosity calculation (in the assumption of \(z \sim 1\)) of \(RZ\) sources have been reported by Verkhodanov (1994). Several sources of this survey were studied using new RATAN–600 observational data obtained by Verkhodanov and Verkhodanova (1997–1999) in 1995 at four wavelengths.

To reveal morphology and select candidates for study with optical telescopes, one has to investigate the radio structure of the objects. By using morphological properties and selecting FRII objects (Fanaroff and Riley, 1974), one could extend the lists of the objects being candidates for distant radio galaxies studied in the programme “Big Trio” (Parijskij et al., 1996). Detection and investigation of this type objects play an important role in the understanding of the origin and evolution of galaxies at early epochs of the Universe. By studying faint radio sources that are close doubles (down to 2") we can also select gravitationally lensed candidates which belong to the most interesting objects in the present day astrophysics (Fletcher, 1998). These objects can be found among radio sources extended but unresolved with a beam of 2.5.

We studied the structure of 5 sources of the Zenith survey for the purpose of revealing morphology from the images obtained with VLA in intermediate configurations (BnA) in 1994. Besides, we have obtained continuous radio spectra of the objects using the new radio sky surveys NVSS (New VLA Sky Survey), FIRST (Faint Images of the Radio Sky at Twenty-cm) and WENSS (The Westerbork Northern Sky Survey), and the data of other surveys. We have made identification of the studied sources on the optical images of the Digital Sky Survey (DSS) and with the Automated Plate Measuring machine (APM) database via Internet. Two \(RZ\) objects have been observed at the 6 m telescope. Classification of all five objects has been carried out after the optical and radio investigation.
2. VLA maps

Maps of three Zenith survey radio sources, RZ5 (Fig.1), RZ9 (Fig.2) and RZ14 (Fig.3), with a resolution of 2″5 × 2″ at 1425 MHz and of two sources, RZ55 (Fig.4) and RZ70 (Fig.5), with a resolution of 6″5 × 2″3 at 1455 MHz were obtained with VLA in 1994. These objects were selected from the general RZ list as the brightest ones with steep spectra (α < −0.6, S∼ να) and proposed to the VLA observations in the unified list of the “Big Trio” objects. Isophotes shown on the maps of these sources (Figs. 1-5) are drawn by levels proportional to a factor of 2 starting with 1.2, 1.0, 0.6, 1.0, 1.2 mJy, respectively. Positive isophotes are shown by the solid lines, and negative by the dotted lines. Table 1 contains the data for these objects. In the columns are given the object name, coordinates at the epoch of 2000.0 and coordinate errors, flux densities and their errors in mJy, deconvolved major and minor axes of the radio sources in arcsec, positional angle in degrees. Coordinates of the integrated source (RZ5int) have been taken from the NVSS data. The major and minor axes and the positional angle for all sources have been borrowed from the FIRST catalog.

3. Radio source spectra

To prepare the radio spectra of the sources, we have used the catalogs of the database CATS (astrophysical CATalogs Support system) (Verkhodanov et al., 1997) and the data of the survey carried out at the North sector of RATAN–600 in 1995 (Verkhodanov and Verkhodanova, 1998, 1999).

Table 1: VLA data for RZ sources

| Name   | α + δ(J2000)       | α + δ(B1950)       | σα  | σδ  | S   | σS  | Major | Minor | PA  |
|--------|--------------------|--------------------|-----|-----|-----|-----|-------|-------|-----|
| RZ5N   | 082346.18+465200.3 | 082014.22+470142.0 | .02 | .1  | 34  | 4   | 5.37  | 4.28  | 134.3|
| RZ5S   | 082347.37+465148.6 | 082015.42+470130.4 | .01 | .1  | 110 | 15  | 8.85  | 4.46  | 158.6|
| RZ5int | 082347.13+465150.4 | 082015.18+470132.2 | .04 | .6  | 180 | 15  | 23    | 141   |
| RZ9    | 084141.23+465234.5 | 083812.66+470318.2 | .01 | .1  | 70  | 7   | 3.97  | 1.64  | 120.2|
| RZ14   | 084818.21+465153.1 | 084515.01+470258.7 | .02 | .1  | 53  | 4   | 5.58  | 0.74  | 24.6 |
| RZ55   | 131217.54+465106.0 | 131005.66+470659.8 | .01 | .1  | 150 | 20  | 9.24  | 1.33  | 164.7|
| RZ70   | 135751.31+465130.5 | 135552.48+470604.7 | .01 | .1  | 180 | 40  | 5.50  | 0.66  | 146.5|

Figure 1: Radio source RZ5 (J 082347+465150).
Figure 2: Radio source RZ9 (J 084141+465234).

Figure 3: Radio source RZ14 (J 084818+465153).
Figure 4: *Radio source RZ55 (J 131217+465106).*

Figure 5: *Radio source RZ70 (J 135751+465130).*
Table 2: Multifrequency data for 5 RZ radio sources. Fitting curves are derived with $y = \log S$ and $x = \log \nu$, where $S$ is the flux density in Jy, $\nu$ is the frequency in MHz.

| $\alpha$ | $\sigma_\alpha$ | $\delta$ | $\sigma_\delta$ | $\nu$ | $S$ | $\sigma_S$ | Catalog |
|----------|-----------------|---------|-----------------|------|-----|-----------|---------|
|          | $h$ $m$ $s$ $^\circ$ $'$$''$ MHz | Jy | Jy |
| RZ 5     | $y = 1.478 - 0.736x$ |
| 08 23 46.2 | 0.5 | +46 51 40 | 5 | 151 | 0.72 | 0.04 | 6CVI |
| 08 23 45  | 1.8 | +46 51 56.5 | 24.7 | 232 | 0.28 | 0.05 | MIYUN |
| 08 23 47.0 3 | | +46 51 52.7 | | 325 | 0.465 | 0.0055 | WENSS |
| 08 23 46.79 | 0.121 | +46 51 50.48 | 0.62 | 365 | 0.445 | 0.042 | TXS |
| 08 23 46.8  | | +46 51 54 | | 408 | 0.38 | 0.05 | B3 |
| 08 23 47.13 | 0.04 | +46 51 50.4 | 0.6 | 1400 | 0.1522 | 0.0054 | NVSS |
| 08 23 46.84 | | +46 51 53.05 | | 1400 | 0.128 | 0.0054 | WB92 |
| 08 23 46.18 | 0.02 | +46 52 00.3 | 0.2 | 1400 | 0.03357 | 0.00014 | FIRST |
| 08 23 47.37 | 0.01 | +46 51 48.6 | 0.1 | 1400 | 0.11003 | 0.00014 | FIRST |
| 08 23 50  | | +46 51 18 | | 1400 | 0.17 | 0.0054 | GB |
| 08 23 47.9  | 0.2 | +46 52 09 | 15 | 2308 | 0.123 | 0.033 | RATAN |
| 08 23 47.1  | 0.1 | +46 51 55 | 2 | 3750 | 0.055 | 0.006 | RZ |
| 08 23 47.9  | 0.1 | +46 52 09 | 15 | 3950 | 0.052 | 0.008 | RATAN |
| 08 23 46.0  | 0.8 | +46 51 51 | 9 | 4850 | 0.075 | 0.007 | GB6 |
| 08 23 46.7  | 1.1 | +46 51 56 | 12 | 4850 | 0.069 | 0.009 | 87GB |
| 08 23 47.9  | 0.2 | +46 52 09 | 15 | 7700 | 0.05 | 0.010 | RATAN |
| 08 23 47.9  | 0.2 | +46 52 09 | 15 | 11111 | 0.035 | 0.010 | RATAN |

| RZ 9     | $y = -1.663 + 0.001x + 11.190e^{x(-x)}$ |
| 08 41 43.0 | 0.5 | +46 52 08 | 5 | 151 | 0.37 | 0.02 | 6CVI |
| 08 41 44.9 | 0.5 | +46 52 19 | 5 | 151 | 0.41 | 0.02 | 6CH |
| 08 41 41.15 | | +46 52 33.9 | | 325 | 0.182 | 0.0036 | WENSS |
| 08 41 41.1 | 0.2 | +46 52 52 | 1.7 | 327 | 0.19531 | 0.00834 | WSRTW |
| 08 41 40.3 | | +46 52 52 | | 408 | 0.12 | 0.05 | B3 |
| 08 41 41.24 | 0.01 | +46 52 34.7 | 0.1 | 1400 | 0.07445 | 0.00014 | FIRST |
| 08 41 41.28 | 0.05 | +46 52 34.9 | 0.6 | 1400 | 0.0737 | 0.0016 | NVSS |
| 08 41 41.8 | 0.1 | +46 52 50 | 2 | 3750 | 0.044 | 0.006 | RZ |
| 08 41 42.1 | 0.2 | +46 53 04 | 15 | 3950 | 0.043 | 0.008 | RATAN |
| 08 41 41.9 | 1.1 | +46 52 56 | 12 | 4850 | 0.035 | 0.005 | GB6 |
| 08 41 42.4 | 1.5 | +46 53 43 | 17 | 4850 | 0.057 | 0.006 | 87GB |
| 08 41 42.1 | 0.2 | +46 53 04 | 15 | 7700 | 0.039 | 0.010 | RATAN |

| RZ 14    | $y = 1.512 - 0.914x$ |
| 08 48 19.6 | 0.5 | +46 52 34 | 5 | 151 | 0.3 | 0.02 | 6CVI |
| 08 48 22.5 | 0.5 | +46 51 54 | 5 | 151 | 0.37 | 0.02 | 6CH |
| 08 48 18.18 | | +46 51 53.9 | | 325 | 0.17 | 0.0036 | WENSS |
| 08 48 18.6 | | +46 51 42 | | 408 | 0.12 | 0.05 | B3 |
| 08 48 18.21 | 0.01 | +46 51 53.1 | 0.1 | 1400 | 0.05126 | 0.00014 | FIRST |
| 08 48 18.24 | 0.05 | +46 51 53.2 | 0.6 | 1400 | 0.0503 | 0.0008 | NVSS |
| 08 48 22.5 | 0.3 | +46 52 21 | 4 | 3750 | 0.016 | 0.006 | RZ |
| 08 48 17.6 | 0.2 | +46 52 01 | 15 | 3950 | 0.03 | 0.008 | RATAN |

| RZ 55    | $y = 1.470 - 0.775x$ |
| 13 12 18.8 | 0.5 | +46 51 22 | 5 | 151 | 0.6 | 0.03 | 6CH |
Table 2: Multifrequency data for 5 RZ radio sources. Fitting curves are derived with $y = \log S$ and $x = \log \nu$, where $S$ is the flux density in Jy, $\nu$ is the frequency in MHz (continued)

| $h$  | $m$  | $s$  | $\circ$ | $'$ | $''$ | MHz | Jy  | Jy  |
|------|------|------|---------|-----|------|-----|-----|-----|
| 13   | 12   | 18   | 1.4     | +46 | 51   | 04.7| 18.8| 232 | 0.51| 0.05 | MIYUN|
| 13   | 12   | 17.22| +46    | 51   | 09.5| 0.0036| WENSS|
| 13   | 12   | 17.297| 0.153 | +46 | 51   | 07.77| 0.67| 365 | 0.28| 0.018| TXS   |
| 13   | 12   | 16.9 | +46    | 51   | 08   | 0.005| B3   |
| 13   | 12   | 17.40| 0.01   | +46 | 51   | 07.4 | 0.1  | 1400| 0.11988| FIRST |
| 13   | 12   | 17.43| 0.05   | +46 | 51   | 07.9 | 0.6  | 1400| 0.1146 | 0.0005| NVSS  |

| $h$  | $m$  | $s$  | $\circ$ | $'$ | $''$ | MHz | Jy  | Jy  |
|------|------|------|---------|-----|------|-----|-----|-----|
| 13   | 12   | 22   | +46    | 51   | 42   | 0.009| GB   |
| 13   | 12   | 20.1 | 0.1    | +46 | 51   | 06   | 2    | 3750| 0.035| 0.006| RZ    |
| 13   | 12   | 18.9 | 0.2    | +46 | 52   | 20   | 15   | 3950| 0.04 | 0.008| RZAN  |
| 13   | 12   | 17.0 | 1      | +46 | 51   | 18   | 11   | 4850| 0.05 | 0.005| GB6   |
| 13   | 12   | 17.3 | 1.6    | +46 | 51   | 19   | 22   | 4850| 0.053| 0.007| 87GB  |
| 13   | 12   | 18.9 | 0.2    | +46 | 52   | 20   | 15   | 11111| 0.046| 0.010| RZAN  |

**RZ 70**

$y = 2.113 - 0.936x$

| $h$  | $m$  | $s$  | $\circ$ | $'$ | $''$ | MHz  | Jy  | Jy  |
|------|------|------|---------|-----|------|------|-----|-----|
| 13   | 57   | 51.1 | 0.5     | +46 | 51   | 24   | 5   | 151 | 1.23 | 0.06 | 6CII  |
| 13   | 57   | 50.6 | 0.8     | +46 | 52   | 02   | 10.8| 232 | 0.67 | 0.05 | MIYUN |
| 13   | 57   | 53.1 | 0.9     | +46 | 51   | 39.6 | 12  | 232 | 0.6  | 0.05 | MIYUN |
| 13   | 57   | 51.04| +46    | 51   | 32.8 | 0.007| WENSS|
| 13   | 57   | 51.164| 0.089 | +46 | 51   | 31.86| 0.36| 365 | 0.471| 0.016| TXS    |
| 13   | 57   | 51.4 | +46    | 51   | 36   | 0.067| WENSS|
| 13   | 57   | 51.13| 0.1    | +46 | 51   | 31.45| 0.01| 1400| 0.16628| 0.00014| FIRST |
| 13   | 57   | 51.2 | +46    | 51   | 30.3 | 0.005| B3   |
| 13   | 57   | 51   | +46    | 52   | 20   | 1400 | 0.15| GB   |
| 13   | 57   | 49.34| +46    | 51   | 51.45| 1400 | 0.161| WB92|
| 13   | 57   | 51.11| 0.04   | +46 | 51   | 31.87| 0.6 | 1400| 0.1674| 0.0004| NVSS   |
| 13   | 57   | 54.0 | 0.2    | +46 | 52   | 34   | 15  | 2398| 0.075| 0.033| RZAN   |
| 13   | 57   | 54.6 | 0.1    | +46 | 51   | 29   | 2   | 3750| 0.024| 0.006| RZ    |
| 13   | 57   | 54.0 | 0.2    | +46 | 52   | 34   | 15  | 3950| 0.068| 0.008| RZAN   |
| 13   | 57   | 51.3 | 1.1    | +46 | 51   | 37   | 13  | 4850| 0.039| 0.005| GB6    |
| 13   | 57   | 49.9 | 1.9    | +46 | 51   | 47   | 25  | 4850| 0.035| 0.006| 87GB   |
| 13   | 57   | 54.0 | 0.2    | +46 | 52   | 34   | 15  | 7700| 0.054| 0.010| RZAN   |
| 13   | 57   | 54.0 | 0.2    | +46 | 52   | 34   | 15  | 11111| 0.037| 0.010| RZAN   |

Among the basic catalogs stored in the CATS database several largest ones (NVSS, FIRST, WENSS, Texas) cover entirely the area of the Zenith survey.

Using these catalogs we have detected the five objects to have counterparts in the NVSS (Condon et al., 1998), which has a sensitivity as high as 2.5 mJy, and a resolution of 45" at 1400 MHz.

In the FIRST survey (White et al., 1997) which is carried out at VLA in the B-configuration at 1400 MHz with a resolution of 54" and a sensitivity limit of 1 mJy at 5σ level, we have detected all five RZ sources. The coordinates of the objects coincide with those of 1994 VLA observations within 0.05'. All the basic components of the complex sources (except the tail of the object RZ9 (Fig.2)) are confirmed by the FIRST data. Images of the FIRST sources are shown in Figs. 6–10.

The WENSS survey (Rengelink et al., 1997) carried out at 325 MHz with a sensitivity of about 18 mJy at 5σ level and a resolution of 54"×54"·cosecδ has counterparts for all five sources. The Texas survey carried out at 365 MHz on the Texas radio interferometer (Douglas et al., 1996) with a sensitivity as high as 150 mJy, but complete to 250 mJy, contains counterparts of only three sources: RZ5, RZ55 and RZ70.

Table 2 contains a list of identifications with the catalogs of the CATS database (Verkhodanov et al., 1997). The data of the RZ catalog have been taken from Mingaliev et al. (1991) and the ones marked as RATAN are from the paper by Verkhodanov and Verkhodanova (1999).

The radio spectra have been fitted with the package SPG under OS Linux (Verkhodanov, 1997). As the main fitting function of the radio spectra the
Figure 6: The FIRST map of the radio source RZ5 (J 082347+465150) overlaid on the 2×2 DSS image.

Figure 7: The FIRST image of the radio source RZ9 (J 084141+465234) overlaid on the 2×2 DSS image.
Figure 8: The FIRST image of the radio source RZ14 (J084818+465153) overlaid on the 2′×2′ DSS image.

Figure 9: The FIRST image of the radio source RZ55 (J131217+465106) overlaid on the 2′×2′ DSS image.
The authors have used the curve $y = A + Bx$, where $x = \log \nu$, $y = \log S$, $\nu$ is the frequency in MHz, $S$ is a flux density in Jy.

The fitting procedure took into account weights of each point in proportion to the value $1/\epsilon^2$, where $\epsilon$ is the ratio of the flux density error $\sigma_S$ and the flux density $S$. If a point of the spectrum is appreciably away from the spectrum line, its weight is decreased ten times.

Automatic selection using the least square criterion from the fitted curve taken from the set

$y = A + Bx,$
$y = A + Bx + Cx^2,$
$y = A + Bx + C \times \exp(x),$ 
$y = A + Bx + C \times \exp(-x),$ shows the linear fitting for four sources, and for RZ9 with the curve $y = -1.663 + 0.001x + 11.190\exp(-x)$.

In the case of linear approximation, the best fit for RZ9 radio spectrum is done with the line $y = 1.024 - 0.678x$. When we fitted the RZ9 spectrum, we took into account that a corresponding point of the 87GB survey is likely to be wrong and the RATAN point at 2.7 cm may be too high because of the noise.

The steep linear spectrum due to synchrotron radiation is typical of radio galaxies and some quasars. If the object RZ9 has a concave spectrum, it could be explained in the frames of a model of superposition of two spectra: a flat spectrum of a core, and a steep spectrum of component(s).

The spectra of the radio sources are shown in Fig.11.

4. The search for optical candidates

Electronic versions of the Palomar Observatory Sky Survey have been used to search for candidates for optical identification. We used the APM catalog (see, e.g. Irwin, 1998), to be exact, the modified client program of T. McGlynn `apmcatalog`, for the stream identification of the sources via Internet and estimation of magnitudes in the R and B filters, and the DSS2 (Digitized Sky Survey), accessible via the Web-page of the Space Telescope Science Institute [http://stddata.stsci.edu/dss/](http://stddata.stsci.edu/dss/) for the identification of the Zenith survey sources.

DSS frames of $2' \times 2'$ in size with the overlaid FIRST maps are shown in Figs. 6–10 for all five sources. The candidates for optical identification of the first three sources are situated inside the central isophote. There are no optical candidates brighter than $21'$ in E-band for RZ55 and RZ70 on DSS.

Two radio sources RZ5 and RZ70 were observed with the 6 m telescope in February, 1994. Three 400s CCD frames were acquired for RZ5 and six 400s...
Table 3: Results of optical identification

| Name | $\alpha + \delta$ (radio) | $\alpha + \delta$ (APM) | E | Cl | O | Cl | LR |
|------|---------------------------|--------------------------|----|----|----|----|----|
| RZ5C | 082347.13+465150.4         | 082347.14+465152.0       | 19.53 | -1 | >21.5 | 0 | 93.39 |
| RZ5N | 082346.18+465200.3         | -"-                      | -"- | -"- | -"- | -"- | 0.00 |
| RZ5S | 082347.37+465148.6         | -"-                      | -"- | -"- | -"- | -"- | 0.07 |
| RZ9  | 084141.23+465234.5         | 084141.46+465236.3       | >21$^1$ | 0 | 21.13 | 1 | 4.43 |
| RZ14 | 084818.21+465153.1         | 084818.33+465154.8       | 19.03 | -1 | 19.26 | -1 | 35.37 |
| RZ55 | 131217.54+465106.0         | >21$^1$                  |       |    | >21.5  |    |
| RZ70 | 135751.31+465130.5         | >24$^2$                  |       |    | >21.5  |    |

1 DSS2 magnitude values
2 6 m telescope data

Table 3 contains the results of optical identification of the objects with the APM data. In the columns are listed the object name (for RZ5 the northern and southern components, and a gravity center by NVSS), APM coordinates at 2000.0, the magnitude and object class on the E plate, the magnitude and object class on the O plate (the class is described in terms of APM, with −1 (stellar like), 0 (noise like) and 1 (extended)), likelihood ratio, calculated by the following formula (de Ruiter et al., 1977):

$$LR(r) = \frac{1}{2\lambda} \exp[0.5\lambda^{-2}(2\lambda - 1)],$$

where $\lambda = \pi\sigma_{RA}\sigma_{Dec}\rho$, $\rho$ is the density of background objects equal to $5.16 \times 10^{-4}$ sec$^{-2}$ (Cohen et al., 1977), $r = [(\Delta RA/\sigma_{RA})^2 + (\Delta Dec/\sigma_{Dec})^2]^{0.5}$.

5. Discussion

Figure 11: The spectra of the radio sources.
Figure 12: The map of the 6m telescope CCD image of radio source RZ5 (J 082347+465150).

$\Delta RA$, $\Delta Dec$ are differences of radio and optical positions, $\sigma RA$ and $\sigma Dec$ are root-mean-square errors of the radio and optical coordinates, respectively. The identification is considered reliable if $LR > 2$.

Analyzing the VLA maps (see Table 1) one can find that all five objects are not point-like. Two objects ($RZ5$ and $RZ55$) have distinguished radio components. Identification of the objects with DSS and APM shows only 3 radio sources identified with a high probability with the optical objects visible on DSS. Despite the fact that $RZ5$ is identified with a red star–like object of 19$^m$5, BTA observations of 1994 have shown that it is rather an elliptical galaxy. An averaged 6 m CCD image (Fig. 12) of $RZ5$ shows that merging of galaxies is probably observed in this object. Actually, it is not merging of equal galaxies, but we have a case of “cannibalism”, i.e. a giant galaxy “eats up” surrounding galaxies of lower mass. Radio emission of this merged group of at least 8 galaxies, with the largest one at the center, may be produced by active processes working during the merging, which may have an explosive character (Kontorovich et al., 1992).

The source $RZ9$, which is slightly extended at 1400 MHz, is identified with an extended one in optics (O-plate) and, may be, with a galaxy or a QSO, i.e. a radio core. If the 2'5-wide tail on the left side of $RZ5$ (Fig. 2) is not a false structure, then it may be a jet flying out from the core.

The source $RZ14$, having an extended but unresolved into components structure and a steep radio spectrum, coincides with a star-like object with a very blue O-E color index, which is most likely a QSO (blue star–like object, BSO). Taking into account that it has an extended structure (probably two close radio components) we can suppose it to be a candidate for a gravitationally lensed object (Fletcher, 1998).

The sources $RZ55$ and $RZ70$, showing an extended structure (although $RZ70$ is not resolved into components) and having steep spectra, are not visible on the Palomar Observatory Sky Survey plates. Therefore, they may be selected as candidates for distant radio galaxies and objects for further investigation.

6. Conclusions

VLA maps with a resolution of $2''5 \times 2''$ for three RATAN–600 Zenith radio sources, $RZ5$, $RZ9$ and $RZ14$, and with a resolution of $6''5 \times 2''3$ for two sources, $RZ55$, $RZ70$, have been analyzed.

All five objects are extended and two of them ($RZ5$ and $RZ55$) are clearly resolved. All the sources have linear steep spectra ($\alpha < -0.65$), and one of them ($RZ14$) has an ultrastEEP spectrum.
Confident optical counterparts have been found in the Palomar Digitized Sky Survey for 3 radio sources. The radio source $RZ5$, being a merging group of one large and several small galaxies (as 6 m telescope observations show), may have appeared in this process.

The radio source $RZ14$ is probably a BSO and could be a candidate to a gravitationally lensed object.

Two radio sources, $RZ55$ and $RZ70$, which have no optical counterparts up to 21$^m$5 ($RZ70$ up to 24$^m$), may be distant radio galaxies ($z > 0.5$).

Acknowledgements. The authors are grateful to S.A.Pustilnik for useful comments on this paper. This work has been supported partly by the Federal program “Astronomy” (grants 1.2.1.2 and 1.2.2.4), Federal program “Integration” (grant No 578), and the Russian Foundation of Basic Research (grant No 99-07-90334).

References

Cohen A.M., Porcas R.W., Browne I.W., Daintree E.J., Walsh D., 1977. Mem. of Roy. Astr. Soc., 84, 1
Condon J.J., Dickey J.M., Salpeter E.E., 1990, Astron. J., 99, 1071
Condon J.J., Cotton W.D., Greisen E.W., Yin Q.F., Perley R.A., Broderick J.J., 1998, Astron. J., 115, 1693
Douglas J. N., Bash F. N., Bozyn F. A., Torrence G.W., Wolfe C., 1996, Astron. J., 111, 1945
Fletcher A., 1998, Ph.D. thesis, Massachusetts Inst. of Tech. Boston, USA
Irwin Mike, 1998, http://www.ast.cam.ac.uk/~apmcat/
Kontorovich V.M., Kats A.V., Krivitskij D.S., 1992, Pisma v Zhurnal Eksperimentalnoj i Teoreticheskoj Fiziki. 55, No 1, 3
Mingaliev M.G., Verkhodanov O.V., Khabrakhmanov A.R., Temirova A.V., Gol’nev V.Ya., 1991, Soobshch. Spets. Astrofiz. Obs., 68, 47
Parijskij Yu. N., Goss W.M., Kopylov A.I., Soboleva N.S., Temirova A.V., Verkhodanov O.V., Zhelenkova O.P., Naugolnaya M.N., 1996, Bull. Spec. Astrophys. Obs., 40, 5
Rengelink R.B., Tang Y., de Bruyn A.G., Miley G.K., Bremer M.N., Rottgering H.J.A., Bremer M.A.R., 1997, Astron. Astrophys. Suppl. Ser., 124, 259 [http://www.strw.leidenuniv.nl/wensy/]
de Ruiter H.R., Willis A.G., Arp H.C., 1997, Astron. Astrophys. Suppl. Ser., 28, 211
Verkhodanov O.V., 1994, Astron. Zh., 71, 352
Verkhodanov O.V., Trushkin S.A., Andernach H., Chernenkov V.N., 1997, Astronomical Data Analysis Software and Systems VI. ASP Conference Series, eds.: G.Hunt and H.E.Payne. 125, 322 [http://cats.sao.ru]
Verkhodanov O.V., 1997, In: Problems of modern radio astronomy, XXVII Radio Astron. Conf. St.-Petersburg. Inst. of Applied Astronomy, 1, 322
Verkhodanov O.V., Verkhodanov N.V., 1997, In "Problems of modern radio astronomy". XXVII Radio astron. conf. St.-Petersburg. Inst. of Applied Astronomy, 1, 195
Verkhodanov O.V., Verkhodanov N.V., 1998, In: Current problems of extragalactic astronomy, Proc. XV Conf., May 25-29, Pushchino, Pushchino Sci.Center, 18
Verkhodanov O.V., Verkhodanov N.V., 1999, Astron. Zh., 76, No. 7 (in press)
White R.L., Becker R.H., Helfand D.J., Gregg M.D., 1997, Astrophys. J., 475, 479