

Optical morphology of distant RATAN-600 radio galaxies

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Introduction

We present direct imaging data of 22 ultra steep spectrum (USS) radio sources obtained at (or near) a subarcsecond seeing. The basic sample of 40 double radio sources was selected from the RATAN-600 catalogue (Parijskij et al., 1991). The FR II-structure has been confirmed with VLA (Kopylov et al., 1995a) and preliminary optical identifications which come from the 6 m-telescope (Kopylov et al., 1995b). As the RATAN-600 flux limit at 3.9 GHz (≈ 10 mJy) is fainter than that of major surveys, the sample may have high- z contents. Based on the Hubble diagram (Fig. 1) it is expected that most of the RC/USS sources have $z > 0.7$.

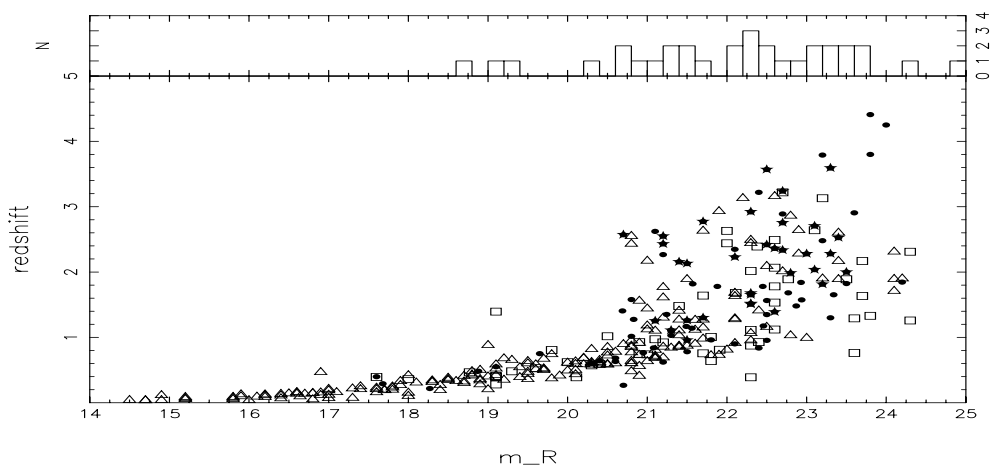


Figure 1: Hubble diagram in R-band for various galaxies from the literature. The histogram of RC/USS sources is shown above.

Observations

Optical images were obtained using the 2.56 m Nordic Optical Telescope (NOT) at La Palma during three observing runs in March, May and December 1994. Typical exposure

times were from 1200 to 2000 seconds depending on the brightness of the object. On photometric nights, calibration stars from Landolt (1992) were observed several times each night at a range of air masses. The seeing varied from $0.5''$ to $2.0''$. For the analysis we have adopted cosmology with $H_0=50 \text{ km s}^{-1} \text{ Mpc}^{-1}$ and $q_0=0.0$.

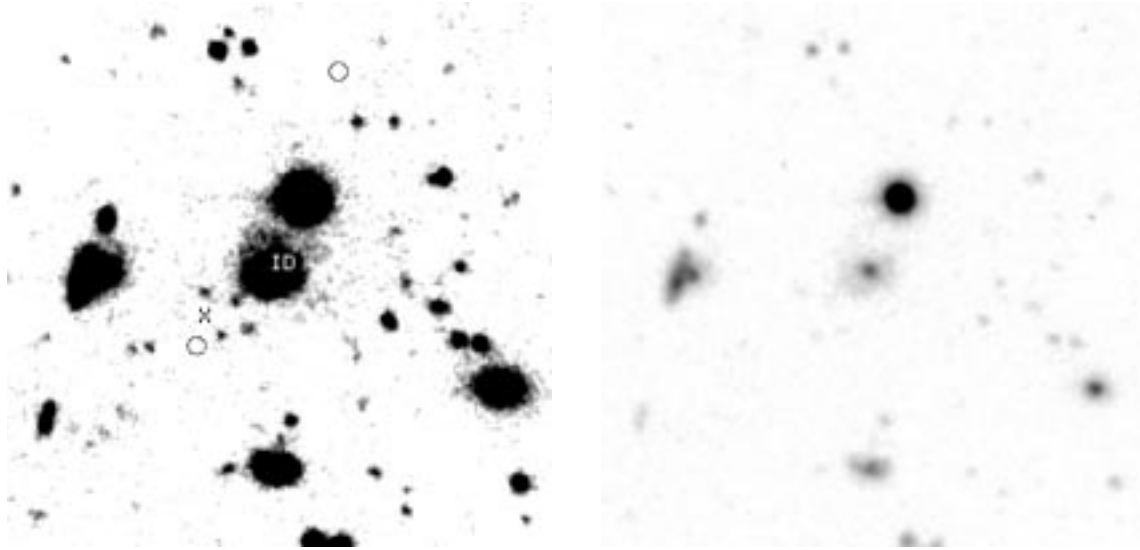


Figure 2: The central portion ($60'' \times 60''$ or $252 \times 252 \text{ kpc}$) of RC0457+0452. North is up and East is to the left. Left, Gaussian smoothed R-band image (3600s, FWHM= $0.8''$). The position of the hotspots and centre of gravity of the radio source are marked with circles and a cross, respectively. On the right is V-band image (1800s, FWHM= $0.7''$). The contrasts are different in the images, the R-band image is for faint features and V-band for morphology of relatively bright emission. Note the double nucleus in the companions to the east and south.

Examples of individual objects

We could confirm 16 optical identifications down to $m_R=24$, which were obtained with the 6-m telescope. We show some examples of different galaxy morphologies and galaxy environments of RC/USS objects.

RC0457+0452:

The redshift of this objects is 0.186 (Dononov et al., 1999). The apparent magnitude is $m_R=19.7$ which is consistent with the Hubble diagram (Figure 1). The absolute magnitude is $M_R=-20.7$, which suggests that the object is slightly fainter than a typical FRI radio galaxy (e.g. Colina & De Juan, 1995). The galaxy shows signs of interaction (isophote twists, distorted morphology) which is quite common for FRI host galaxies (Colina & De Juan).

This object is possibly located in a cluster of galaxies. There are two apparently interacting companion galaxies, $20''$ to the east and $22''$ to the south. The projected distances between these objects are 84 and 92 kpc, respectively. Both of these objects appear to be interacting systems (Fig 1).

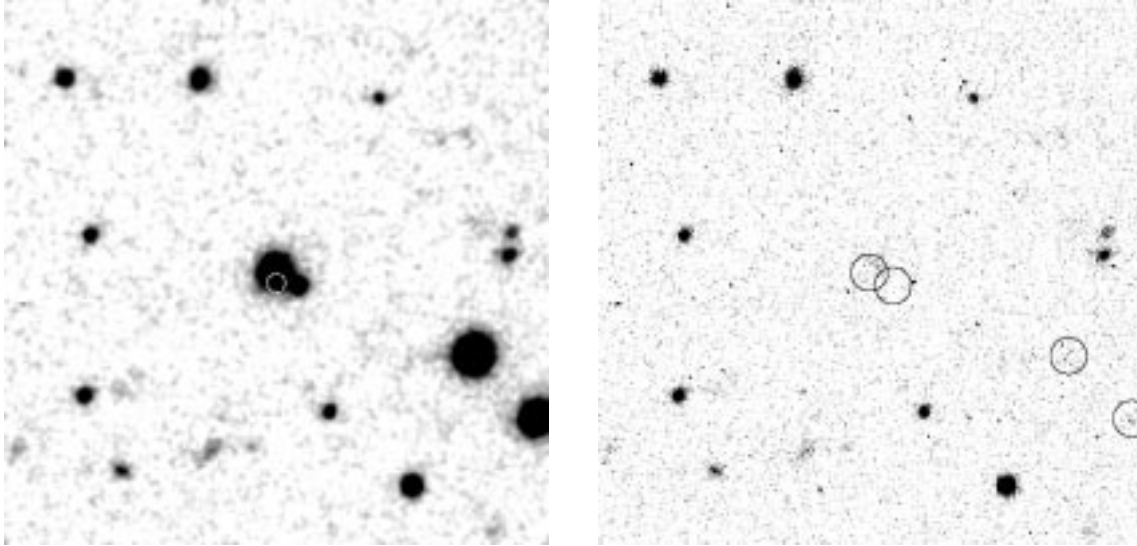


Figure 3: The central portion ($60'' \times 60''$ or 656×656 kpc) of RC2144+0513. The left hand image (R-band 1800s, FWHM=1.0'') is slightly smoothed with a Gaussian function. East is to the left and North is up. Right, the same frame (non smoothed) after subtracting the scaled PSF. The circles (radius of 2'', projected distance of 2 kpc at $z=1.01$) show the position of the subtracted source. There are no (or only weak) signs of the host galaxy.

RC2144+0513:

Recently Dononov et al. (1999) measured the the redshift of the object ($z=1.01$). Astrometry suggests that the brighter, unresolved object coincides with the radio source (Fig. 3). This object has $m_R=18.9$, which corresponds with $M_R=-25.9$ and is a typical value for a $z=1$ quasar (e.g. Goldschmidt et al. 1999) There is a nearby companion 2.9'' to the south west, which corresponds with the projected distance of 32 kpc. This object has $m_R=20.9$ and is unresolved, however the signal is rather weak and it could also be a compact companion galaxy. However this is unlikely, because in this case the absolute magnitude would be uncomfortable high ($M_R=-23.9$), unless this is the actual radio galaxy.

Summary

We obtained subarcsecond seeing images of 22 objects of which we could study the morphology of 16 objects. Five of these remained unresolved. Typically the resolved objects have a multicomponent structure with extended emission. The brightness of these objects varies from $m_R=18.8$ to 24.0. Of the remaining objects three were very faint and optical identification remained uncertain for the other three objects. Ellipticities of the objects agree well with other studies of high- z radio galaxies (Pursimo et al., 1999). They also found that many RC/USS objects have close companions.

The results of the imaging study and the first redshifts make it imperative to measure spectroscopic redshifts for the RC/USS galaxies.

References

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