PROCEEDINGS OF SCIENCE

# SALT observations of the largest radio galaxies.

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Using the Southern African Large Telescope we have broadened the sample of Giant Radio Galaxies (GRG) in the southern sky. These radio galaxies are the largest physically connected objects in the Universe. Determination of physical conditions in their diffuse bridges gives an excellent tool of probing the pressure of the intergalactic medium (IGM). This, in turn, allows the study of the IGM pressure evolution with redshift. During the three semesters of SALT RSS observations we have measured redshifts of 10 GRGs, some of them as distant as $z \sim 0.75$. Here we present the results of these observations and radio data analysis which could not be performed without the knowledge of the GRGs distances.

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## 1. Introduction

Our work is focused on understanding the creation and evolution of radio lobes. In larger perspective, we attempt to deepen our knowledge of the IGM (Intergalactic Medium). We attempt to do this by measuring the extent of radio lobes of radio galaxies. We focus on objects larger than 700 kpc, known as Giant Radio Galaxies (abbreviated as GRG). These objects consist of a central galaxy, being the source of jets, and two, often symmetrical, lobes, visible in the radio part of the spectrum. Sources of these jets are the super-massive central galactic black holes. Knowing redshifts of these objects, it is possible to convert flux in to luminosities. It will allow us to model spectral ages of radio lobes. For the simplicity of our study, we use FR II galaxies, with the luminosity of the jets growing outwards (in FR I type, radio lobes luminosity grows inwards). This division was proposed by Fanaroff and Riley[1], hence the abbreviation of FR.

Most of the known GRGs are located on the northern sky (more than hundred GRG were known until 2007), and in the nearby universe. Because of that we attempt to enrich our sample with SALT data from the southern hemisphere. Our aim is also to search for these objects at high redshifts in order to build a sample spread over time. This is a continuation of project "Giant Radio Galaxies as a Probe of the Cosmological Evolution of the IGM"[3] started in 2007.

## 2. Data

For the sake of simplicity we focused on FR II type radio galaxies. These objects have a luminosity growing outwards and are easy to measure. We chose objects with declination in the range of $-14^{o} < \delta < +0.1^{o}$ because of SALT telescope's technical constraints. Additionally we wanted objects with large radio images ($\theta > 150''$). Also we were looking for objects with flux lower than 450 mJy at the frequency of 1.4 GHz and fainter than 19 mag in the R optical filter. These observational constraints strengthen the possibility of GRG identification. The base of this work consisted of 6 GRG candidates from the 2011-2 observational semester and 7 candidates from the year 2012. All of these objects were observed with RSS of the SALT telescope. These images were made with long exposure time and low resolution in two positions (in order to omit the SALT CCD camera gap). We used the CuAr lamp wavelength calibration.

## 3. Results

From these objects we created a sample of 10 GRG for which we managed to calculate their redshift. We measured angular sizes of these objects based on the FIRST and NVSS radio maps. Using the distances as derived from luminosities for them, we determined the size of the radio lobes. Results of this work are presented in Table 1 and a sample of spectra and radio maps are presented in Figure 1.

## 4. Future plans

Next step of this work will be to model the spectral age of radio lobes. We will use the DYNAGE algorithm [2] to ascertain their evolution and specifics of their creation. We also plan



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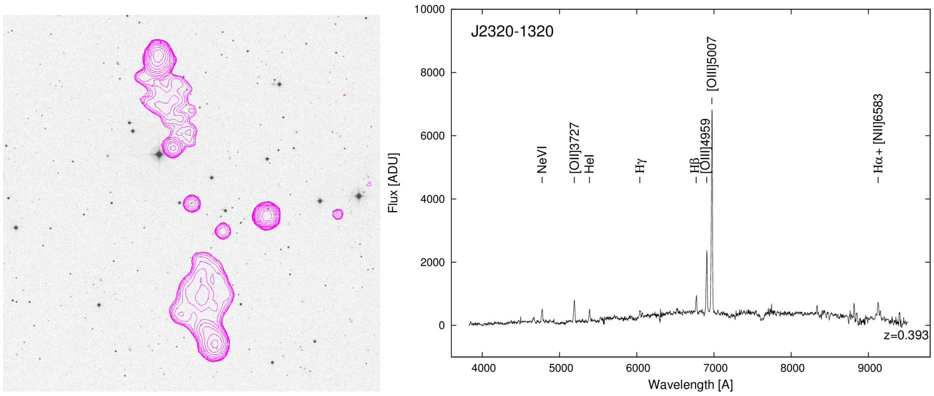


**Figure 1:** Example of GRG radio map (J0003+0351) - left panel and spectra (J2320-1320) - right panel.

| ID | $z_{spec}$ | $z_{phot}$ | d[kpc] |
|---|---|---|---|
| J0003+0351 | $0.0948 \pm 0.0067$ | $0.129 \pm 0.021$ | $2029.21 \pm 128.46$ |
| J0022–0818 | $0.571 \pm 0.017$ | $0.510 \pm 0.022$ | $2352.02 \pm 34.76$ |
| J0117–0111 | $0.377 \pm 0.017$ | $0.335 \pm 0.059$ | $1352.492 \pm 39.037$ |
| J0117+0026 | $0.554 \pm 0.015$ | $0.121 \pm 0.049$ | $1420.49 \pm 19.96$ |
| J0202–0939 | $0.766 \pm 0.011$ | $0.693 \pm 0.079$ | $1122.14 \pm 6.31$ |
| J0241+0038 | $0.63400 \pm 0.00005^*$ | $0.82 \pm 0.16$ | $1564.09 \pm 52.24$ |
| J1130+0630 | $0.398 \pm 0.014$ | — | $1449.13 \pm 30.7$ |
| J1208+0259 | $0.241 \pm 0.016$ | $0.2140 \pm 0.0404$ | $733.59 \pm 36.54$ |
| J1232–1015 | $0.2531 \pm 0.0082$ | — | $1974.63 \pm 48.03$ |
| J1253–0139 | — | $0.191 \pm 0.012$ | — |
| J1434+0929 | — | $0.600.15 \pm 0.15$ | — |
| J2106–1012 | — | $0.414 \pm 0.025$ | — |
| J2320–1320 | $0.3927 \pm 0.0096$ | — | $1110.76 \pm 17.49$ |
| J2328–0825 | $0.3839 \pm 0.0073$ | $0.56 \pm 0.12$ | $1419.79 \pm 17.23$ |

**Table 1:** Presentation of spectroscopic and photometric redshifts along with derived sizes of GRGs. Spectroscopic redshifts were calculated in our work, while photometric ones were taken from the SDSS DR9 catalog. The star symbol denotes an object with spectroscopic redshift from SDSS.

to observe spectra of more GRG candidates in order to calculate their redshifts. These are needed to get GRG radio sizes. DYNAGE algorithm models these radio lobes using data points provided. In order to model the radio lobes correctly, and trustworthy, we need radio observations at least at four different wavelengths for our GRGs. Because of that, we also need to focus on finding more data for our objects.

## References


[1] Fanaroff, B. L. and Riley, J. M., *The morphology of extragalactic radio sources of high and low luminosity*, Monthly Notices of the Royal Astronomical Society vol.167 p.31p-36p [1974]

[2] Machalski J., Jamrozy M., Stawarz Ł., and Kozieł-Wierzbowska D., *Understanding Giant Radio Galaxy J1420-0545: Large-scale Morphology, Environment, and Energetics*, Astrophysical Journal vol.740 p.58 [2011]

[3] Machalski J., Koziel-Wierzbowska D., and Jamrozy M., *Giant Radio Galaxies as a Probe of the Cosmological Evolution of the IGM. I.Preliminary Deep Detections and Low-Resolution Spectroscopy with SALT*, Acta Astronomica vol.57 p.227-248 [2007]