Giant radio galaxies in the Bootes deep field

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LOFAR

GOALS:

1. Understand the physics that allows some radio galaxies to reach gigantic size.
2. BH accretion mechanism in GRG hosts.
3. Lobes properties via equipartition analysis and their interaction with the environment.

P-D DIAGRAM

The aim of this analysis is to study the evolution of radio galaxies.
Main findings:

- Despite the high sensitivity of lofar, no GRGs are detected in the upper right corner. This result suggests that the luminosity of radio sources decrease as they evolve.
- The deficit of GRGs in the lower right corner might be due to the sensitivity limitation of radio facilities.

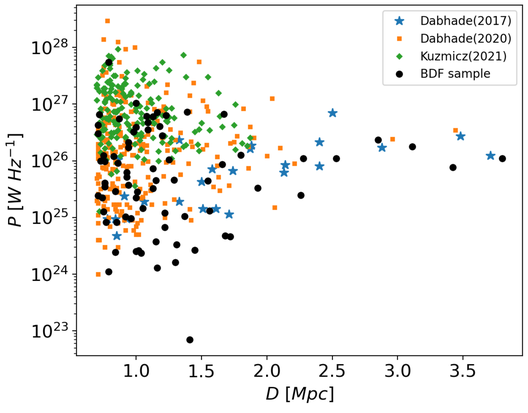

Fig.2: P-D diagram. The new GRGs reported in this work are denoted with black points. The other colours refer to previous GRGs sample.

ABSTRACT

The LOFAR Two-metre Sky Survey (LoTTS) is a unique opportunity to study large samples of radio galaxies at low frequencies. In this work, we focus on giant radio galaxies (GRGs) which can span Mpc scale. We report 47 GRGs with a projected size larger than 1 Mpc in the Bootes field that cover a 26.5 square degrees region, 40 of which have not been reported before. We also found 27 RGs with a linear size in the range 0.7-1 Mpc. This implies an area density of almost 3 GRGs per square degree. This estimate drops to less than 2 sources with Mpc size per square degree, if we restrict to objects with a linear size larger than 1 Mpc. The result is in agreement with Delhaize, J., et al. (2021), whose authors claimed that GRGs are not as rare as previous work suggested (e.g. Dabhade P., et al., 2017,2020). The GRGs in our sample have linear sizes ranging from 1 to 3.8 Mpc, with six sources larger than 2 Mpc, and redshifts up to 2.8. We classified the optical counterpart of the GRGs into high-excitation (HERG) and low-excitation (LERG) radio galaxies through an analysis involving WISE data which suggests that the host galaxies are mainly LERG type in our sample. We investigated the radio spectra of our sources using a combination of LBA, HBA and NVSS data. Overall, the implemented linear fit shows that the spectral indexes range between -0.7 and -0.9 in the hot spots, while flatter spectra are observed in the core region.

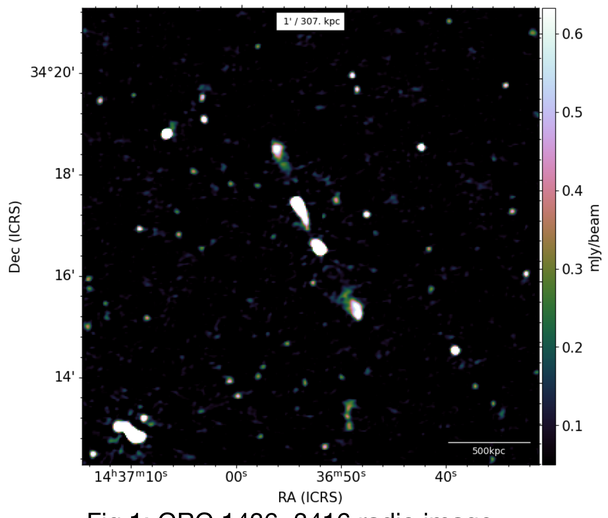

Fig.1: GRG 1436+3416 radio image from the Bootes deep field. It is a double-double radio galaxy at z = 0.37 and its linear size is 1.13, spanning 3.69' in the sky.

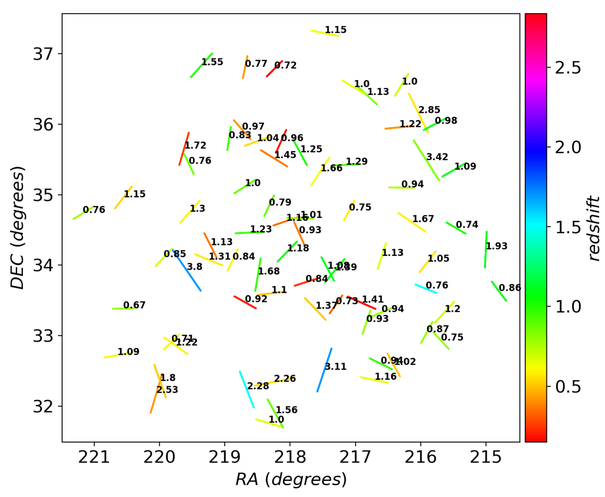

Fig.3: Distribution of the GRGs in the Bootes field. The colorbar highlights the redshift range of our sample, while the length of the bars reflects the linear size of the source, which is also made explicit by the number attached.

INFRARED ANALYSIS WITH WISE

We carried out an analysis on the infrared properties of the GRG hosts to distinguish them into high excitation radio galaxies (HERGs) and low-excitation radio galaxies (LERGs). The former have an accretion rate onto the black hole and lower mass black hole compared to LERGs. Fig.3 shows how GRGs in this sample exhibit a preference towards low-excitation mode.

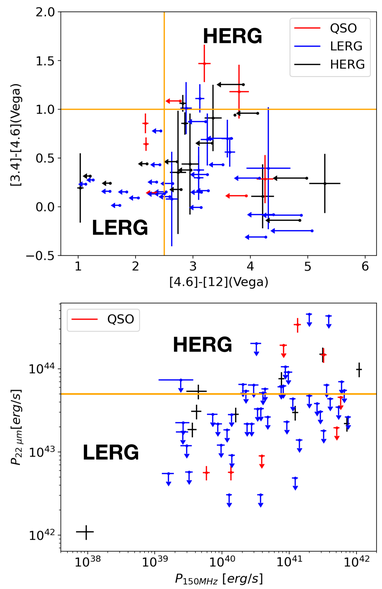

Fig.4: Upper panel: $P_{22\mu m} - P_{150MHz}$. relation. Galaxies with infrared power lower than $\sim 5 \cdot 10^{43}$ are considered LERGs. Lower panel: WISE colour-colour diagram. The LERG region is delimited by W1-W2 < 1 and W2-W3 < 2.5.

MULTI-FREQUENCY STUDY

We used the LOFAR (150 MHz and 50 MHz) and NVSS (1.4 GHz) data to implement a multi-frequency analysis for some of the largest and brightest GRGs. We fitted the spectra with a power law, $S \propto \nu^{-\alpha}$, finding α in the range 0.7-0.9 in the hot spots and flatter spectra in the core.

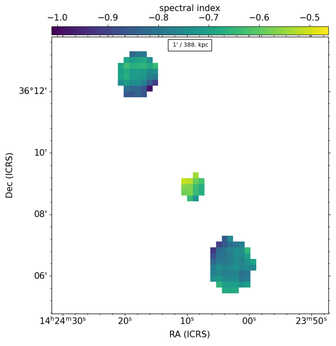

Fig.5: Spectral index map of the GRG 1424+3609. The redshift of the source is 0.54 and its linear size is 2.85 Mpc.

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FOLLOW-UP:

1. Visual inspection of other fields in the LoTSS survey (e.g., Lockman Hole, ELAIS N-1)
2. Analysis of the environment with multi band observations.
3. Sunyaev-Zeldovich radio images of GRGs to investigate the energetics of particles in the lobes.