

Proposed MSc Project 2025

Atypical radio galaxies from the ROGUE I catalogue: probing their physical nature, nuclear activity and the interplay with their large-scale environments

Supervisor: Dr Zara Randriamanakoto (zara@sao.ac.za)

Affiliation: South African Astronomical Observatory

Student will be expected to register at UCT or UWC

Background: Radio galaxies (RGs) have long been widely split into Fanaroff-Riley type I (FR I) and type II (FR II) based on their morphology and the distribution of the radio surface brightness in the lobes. However, follow-up studies have revealed a significant population showing unusual and distinct morphologies such as Hybrid Morphology Radio Sources (HyMoRS) and bent-tail RGs. HyMoRS present a mixed FR morphology with FR I structures on one side and FR II's on the other side of the core (see Figure 1 left panel). On the other hand, bent RGs are found to show different and complex morphologies other than the typical FR dichotomy with their jets distorted, resembling a tail, on either side of the central galaxy (see Figure 1 middle panel). Another interesting class of RGs arises from the activity of the core given that radio AGN are known to be subject to recurrent phases of jet activity cycling through periods of activity and dormancy. The most striking evidence of the episodic nature of RGs is observed in Double-Double Radio Galaxies (DDRGs) where a new pair of radio lobes grows inside an old pair of diffuse remnant lobes with a common center (see Figure 1 right panel). What conditions cause some galaxies to have uncommon morphology? What triggers the jet activity to go through multiple cycles? These are some key questions that are not yet fully addressed in the field of galaxy evolution.

Project description: This project uses multi-frequency radio surveys (LOFAR/LoTSS DR2, FIRST, NVSS, and VLASS) to conduct a comprehensive study of radio galaxies with peculiar morphologies (including HyMoRS, bent-tail radio galaxies, and DDRGs) from the Radio sources associated with Optical Galaxies and Having Unresolved or Extended morphologies (ROGUE, Koziel-Wierzbowska et al. 2020) catalogue. The student will perform radio spectral analyses as well as a visual inspection of recently published LOFAR radio images of these sources of interest to shed more light on the above key questions and ultimately help our understanding of the relationship between radio galaxies and their large-scale environments.

Special requirements: Basic Python or any other programming language. Familiarity with radio astronomy software such as CARTA would be highly useful but is not necessary.

References: Baoqiang et al. 2025, ApJS, 276, 46 • Golden-Marx et al. 2023, ApJ, 956, 87 • Gopal-Krishna & Wiita 2000, A&A, 360, 507 • Koziel-Wierzbowska et al. 2020, ApJS, 247, 53 • Mahatma et al. 2019, A&A, 622, 13 • Mingo et al. 2019, MNRAS, 488, 2701 • Randriamanakoto et al. 2020, MNRAS, 496, 3381 • Schoenmakers et al. 2000, MNRAS, 315, 371

If you are interested, you should get in touch for further details and to discuss the project.

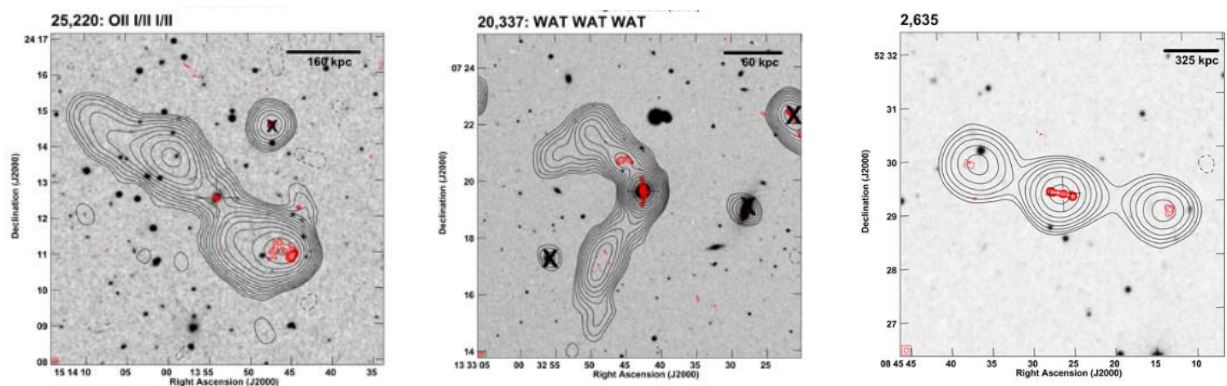


Figure 1: An example of a hybrid RG (*left*), a bent-tail RG (*middle*), and a giant DDRG (*right*). These sources are taken from the ROGUE I catalogue. The radio contours are from FIRST (in red) and NVSS (in black) overlaid on top of the SDSS DR7 *i*-band images.