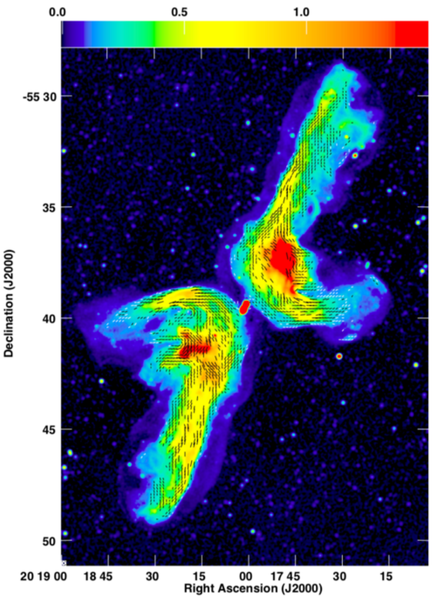
1. **Level of the project:** Masters (MSc)
2. **Institution for registration:** University of Cape Town

3. **Name of the Primary Supervisor:** Dr Sarah White
4. **Institution of the Primary Supervisor:** South African Astronomical Observatory
5. **Contact details of the Primary Supervisor:** sarahwhite.astro@gmail.com

6. **Name of the Co-supervisor:** Dr Moses Mogotsi
7. **Institution of the Co-supervisor:** University of Cape Town / SAAO
8. **Contact details of the Co-supervisor:** moses@saao.ac.za

9. **Project title:** The most-powerful radio-galaxies in the Universe
10. **Description of the project:**



Radio telescopes, such as MeerKAT, give us an unparalleled view of the Universe, thanks to being able to detect star formation (i.e. the growth of galaxies), black-hole accretion (i.e. the growth of supermassive black-holes), and diffuse radio-emission (e.g. how radio-jets interact with the surrounding medium). It is also unaffected by dust along the line-of-sight, allowing us to build the most-complete picture of physical processes in powerful radio-galaxies. Furthermore, by observing galaxies at multiple radio-frequencies, we can construct spectral-index maps (Figure 1) and infer the age of the radio emission by measuring the degree of 'spectral curvature' in the radio part of the spectrum (Figure 2).

Figure 1: Radio spectral-index map of G4Jy 1613 (Cotton et al., 2020)

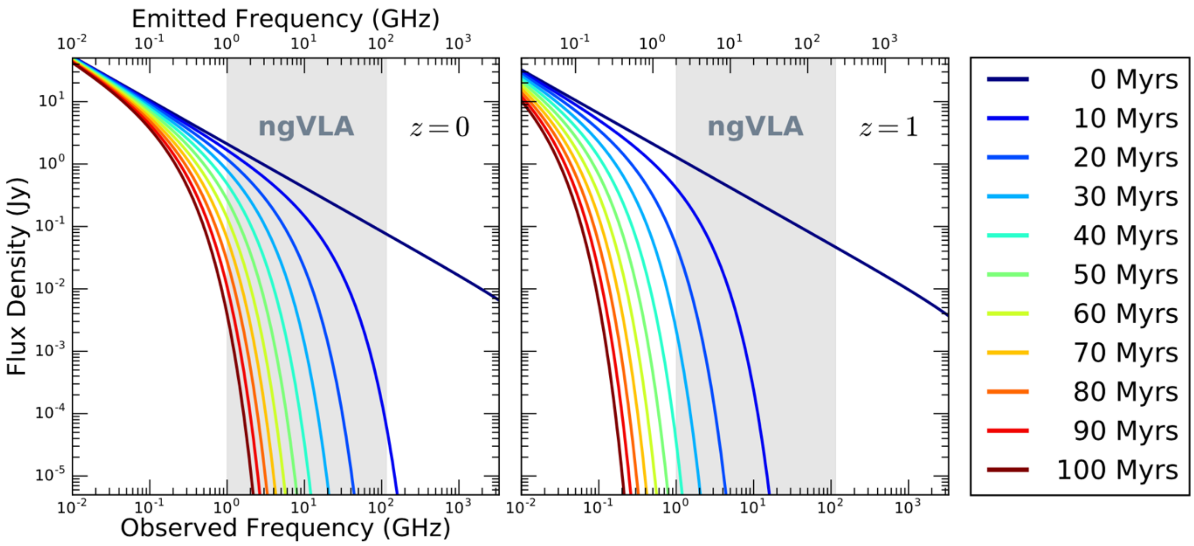


Figure 2: Estimating the age of radio emission via spectral curvature (Harwood et al., 2013; Nyland et al., 2018)

Knowing the redshift, *z* (i.e. a measure of distance), allows us to break the degeneracy between different spectral-age models within a specific observing band. (For illustration, Figure 2 shows the observing band of the next-generation Very Large Array [ngVLA] shaded in grey.) For this we have optical spectroscopy from the Southern African Large Telescope (SALT), where spectral features in the optical part of the electromagnetic spectrum (e.g. García-Pérez et al., 2024) allow us to calculate the redshift of these radio galaxies for the first time. These redshifts are also crucial for calculating *any* intrinsic property of the radio galaxy, such as its radio power (typically in units of W Hz^{-1}) and its linear size (in units of kiloparsec, kpc). The latter is important for identifying which sources are *giant* radio-galaxies.

This project will provide the student with a valuable *multiwavelength* appreciation of powerful radio-galaxies by: reducing SALT spectra (White et al. 2025), collating radio images, and constructing radio spectra from radio flux-density (W m^{-2} Hz^{-1}) measurements. They will also develop an understanding of the (now-famous!) G4Jy Sample (White et al., 2020a, 2020b), which is a compilation of ~1,860 of the brightest radio-galaxies in the southern sky – an excellent, legacy dataset, in preparation for the multi-radio-frequency capabilities of the Square Kilometre Array (SKA).

References for further reading:

- Harwood et al. (2013) – https://arxiv.org/pdf/1308.4137
- Nyland et al. (2018) – https://arxiv.org/pdf/1803.02357
- Cotton et al. (2020) – https://arxiv.org/pdf/2005.02723
- White et al. (2020b) – https://arxiv.org/pdf/2004.13125
- White et al. (2020a) – https://arxiv.org/pdf/2004.13025
- García-Pérez et al. (2024) – https://iopscience.iop.org/article/10.3847/1538-4365/ad159e/pdf
- White et al. (2025) – https://arxiv.org/pdf/2505.13619

11. Skills required:

The student is expected to demonstrate good programming skills in Python, and excellent organisation aided by diligent book-keeping skills. Their ability to problem-solve when working with new software (such as TOPCAT) is also highly desirable. If interested in this project, the student should contact *both* supervisors as soon as possible (and preferably **before 15th June**).

12. Data availability and resources:

The G4Jy catalogue is available here: https://github.com/svw26/G4Jy/tree/master/catalogue and SALT spectroscopy is provided via the multi-semester campaign, 2020-1-MLT-008 (PI: White). These spectra will be reduced using the updated RSS Science Data Pipeline: https://astronomers.salt.ac.za/software/rss-pipeline/ . Also readily available are radio images from the Rapid ASKAP Continuum Survey (https://research.csiro.au/racs/), and radio flux-density measurements from the Australia Telescope Compact Array (ATCA).