UHF OBSERVATIONS OF THE TAIL-LIKE REGION OF THE HYDRA A RADIO GALAXY

BY

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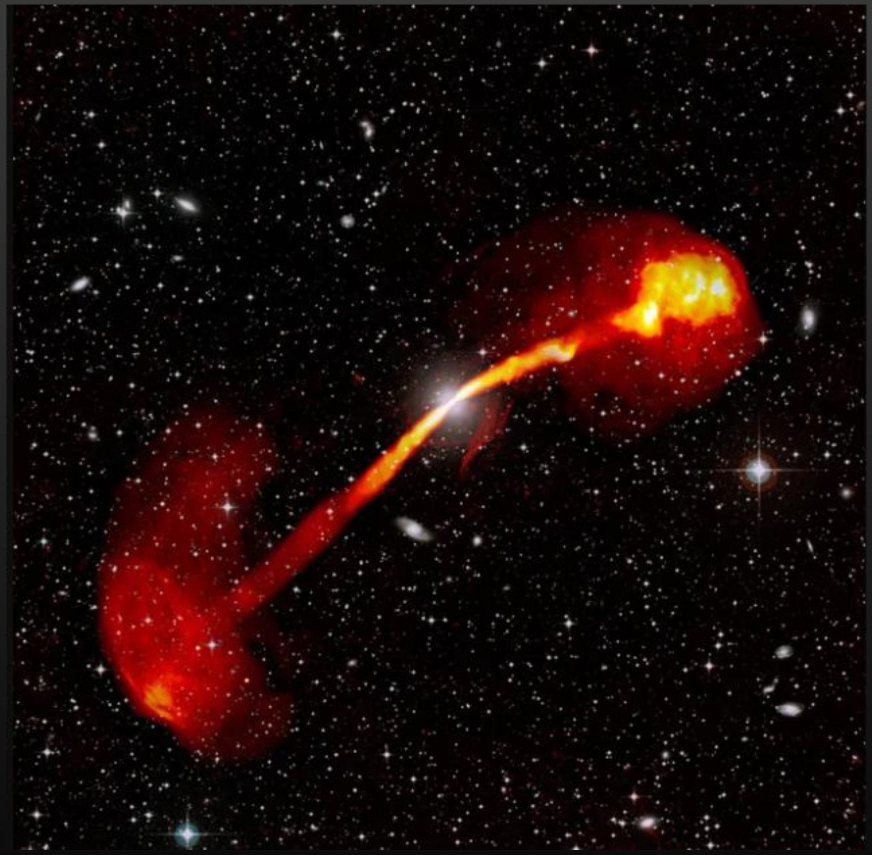
RADIO GALAXIES

- Subclass of Active Galactic Nuclei (AGN).
- High intensity radio emission in regions outside their visible extent.
- Exhibit a 'core-jet-lobe' morphology.
- Picture of radio galaxy IC 4296 captured by MeerKAT https://www.space.com/south-african-meerkat-telescope-galaxy-image



CLASSIFICATION OF RADIO GALAXIES

FR-I RADIO GALAXIES

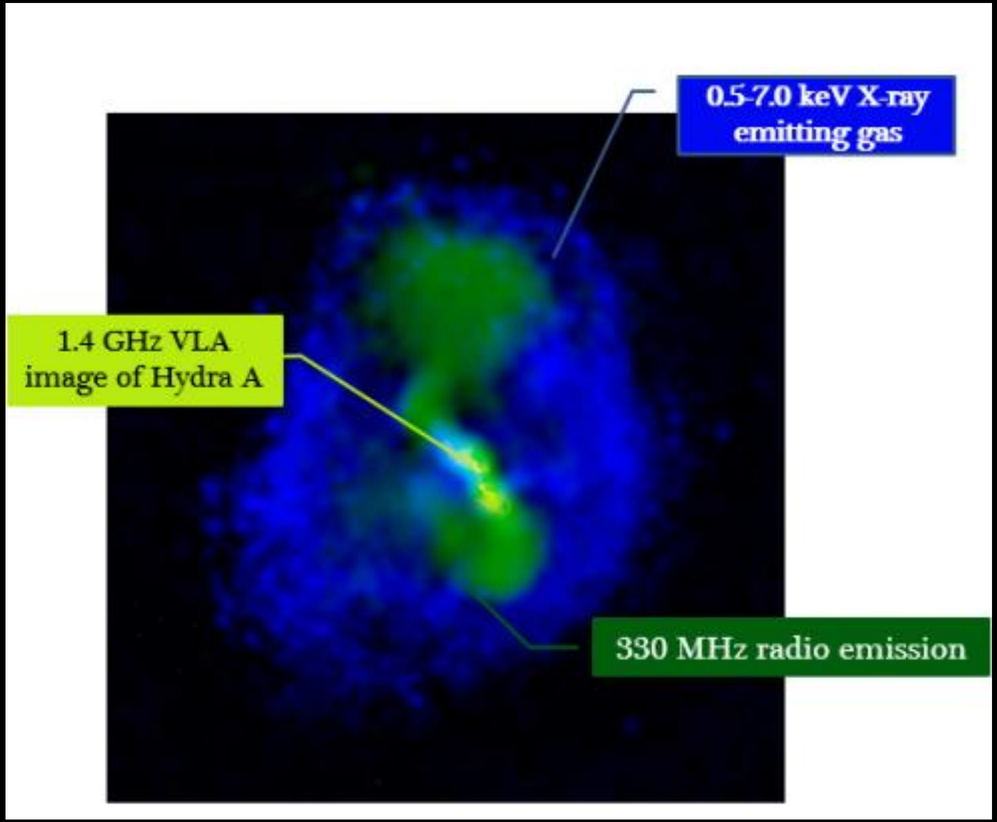
- Low radio luminosity
- Mostly found in cluster environments.
- Jets display decreasing surface brightness away from core.

FR-II RADIO GALAXIES

- High radio luminosity
- Mostly found in isolated environments
- Lobe dominated

HYDRA A

- FR-I type radio galaxy found at the centre of the Abell 780 cluster.
- Low frequency and X-ray observations show that it is comprised of
  - Bright central core
  - Pair of relativistic jets
  - Pair of inner radio lobes
  - Pair of outer radio lobes with the south facing lobe having a tail-like extension.
  - Three pairs of X-ray cavities surrounding the lobes.



Optical image of Hydra A by Canada-France-Hawaii-Telescope/DSS.

SPECTRAL AGEING

- The radio spectrum of Hydra A displays a spectral break which has been ascribed to spectral ageing.
- Spectral ageing is the time it takes for an electron in the lobe region to radiate all of its energy through synchrotron and inverse-Compton emission.
- Two most commonly used models to determine the spectral age are the Kardashev-Pacholczyk (KP) and Jaffe-Perola (JP) models.

SPECTRAL AGEING

- The formulae below shows the emissivity and electron energy distribution associated with a spectral age model (Harwood et al., 2013)

$$S_{model}(\nu) = \frac{\sqrt{3}e^3 B}{8\pi\varepsilon_o c m_e} \int_0^{\pi/2} \int_{E_{min}}^{E_{max}} F(x) \frac{1}{2} \sin^2 \alpha N(E) dE d\alpha$$

$$N(E) = N_0 E^{-2\alpha+1} (1-\beta)^{(2\alpha+1)-2}$$

SPECTRAL AGEING

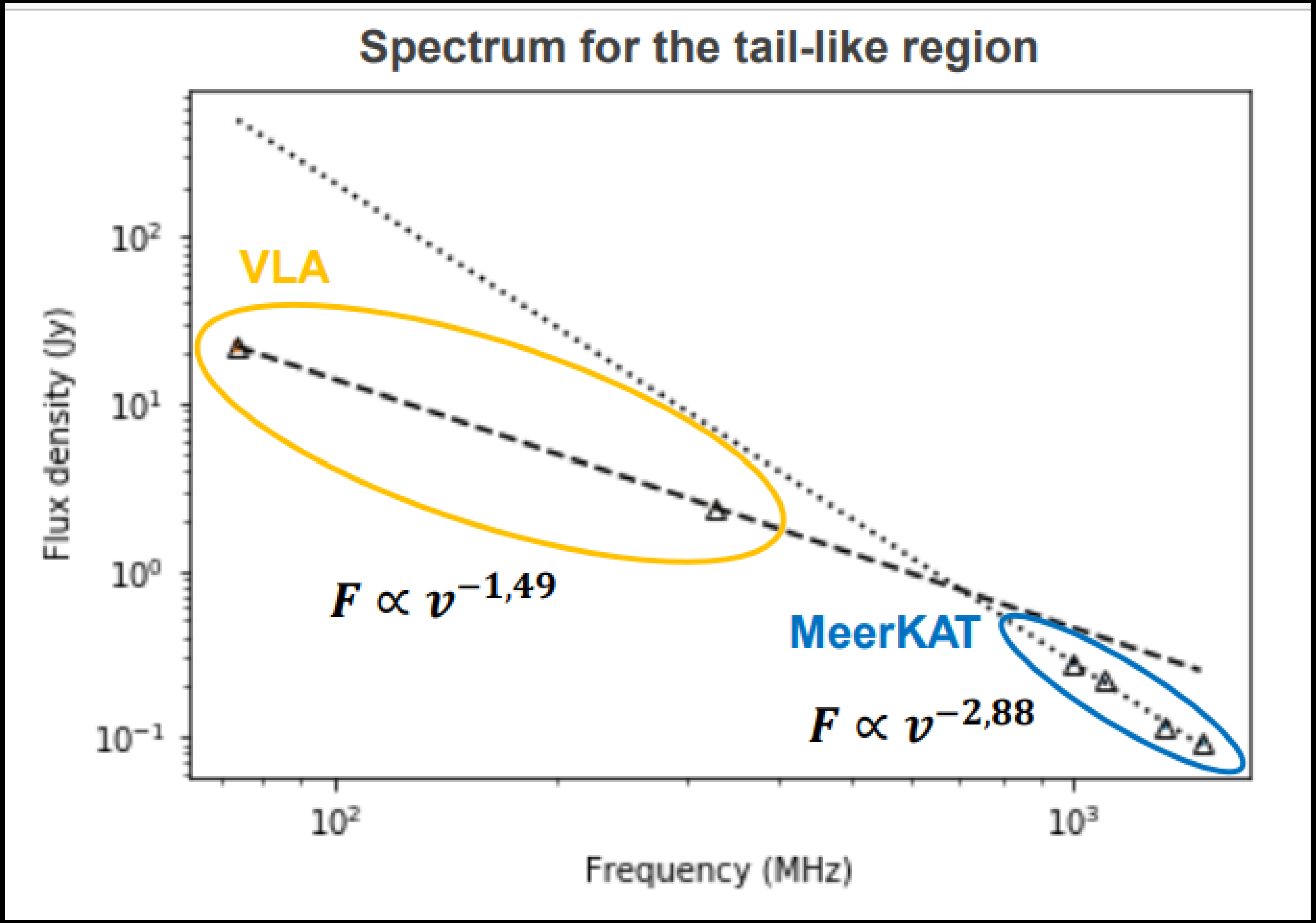
- The KP model assumes that the electron pitch angle is isotropic and constant over electron radiative lifetimes. This means that we have $\beta \propto \mathrm{EB}^2\ (\sin\alpha)^2\ t$
- The JP model assumes that the electron pitch angle is isotropic on short time-scales relative to the electron radiative lifetimes. This means that we have $\beta\ \propto\ \mathrm{EB}^2\ \langle\sin\alpha\rangle^2\ t$

PREVIOUS OBSERVATIONS OF HYDRA A

- Limited research has been conducted looking at the tail-like region of the Hydra A galaxy.
- As part of her thesis, my colleague Mika Naidoo analysed the region using the L-band of MeerKAT.
- For the spectral age, the KP model was the best fit and the region had undergone significant spectral ageing making it the oldest in Hydra A.
- The predicament with L-band observations is that the spectral break in the radio spectrum can not be calculated directly and this can influence the spectral age calculated.

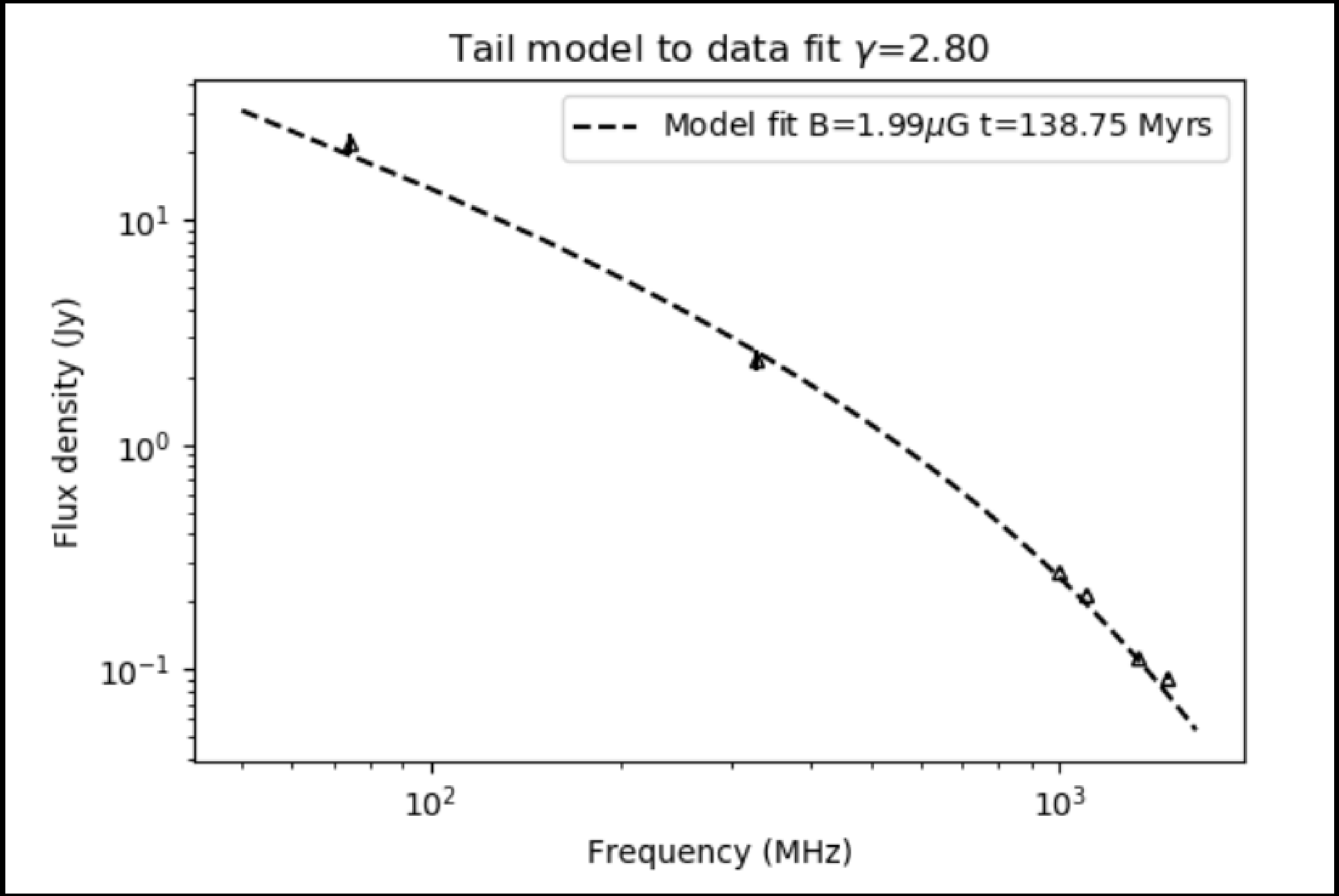
PREVIOUS OBSERVATIONS OF HYDRA A

RADIO SPECTRUM OF HYDRA A FOR LOW FREQUENCY VLA AND L-BAND FREQUENCY MeerKAT OBSERVATIONS PRODUCED BY MIKA NAIDOO.



PREVIOUS OBSERVATIONS OF HYDRA A

SPECTRAL AGE MODEL FITTING FOR THE TAIL-LIKE REGION OF HYDRA A BY MIKA NAIDOO.



PROJECT AIMS

- We aim to directly measure the spectral break frequency in the radio spectrum of the tail-like region of Hydra A using MeerKAT's UHF band observations.
- With these observations we hope to:

  - Further constrain the KP and JP models.

  - Obtain a more accurate view of the spectral age

  - Investigate the possible emission mechanisms and the history of electron injection in the region.

DATA COLLECTION

- MeerKAT's UHF observations of Hydra A took place on the nights of February the 13th and 16th 2024.
- Three 30-minutes scans of Hydra A were conducted.
- The field J0408-6545|0408-658 was used as a bandpass calibrator with two 5-minutes scans conducted.
- The field J1008+070 was used as a complex gain calibrator with three 150-seconds scans conducted.

MeerKAT telescope array from https://www.manchester.ac.uk/about/news/the-meerkat-radio-telescope-in-south-africa-receives-prestigious-award-of-the-royal-astronomical-society/

DATA REDUCTION

- Done using the CARACal software pipeline which is specifically designed to handle data reduction task from the MeerKAT telescope.
- Contains Python scripts called 'workers' which allow the user to complete various data reduction tasks.
- Main data reduction tasks are:

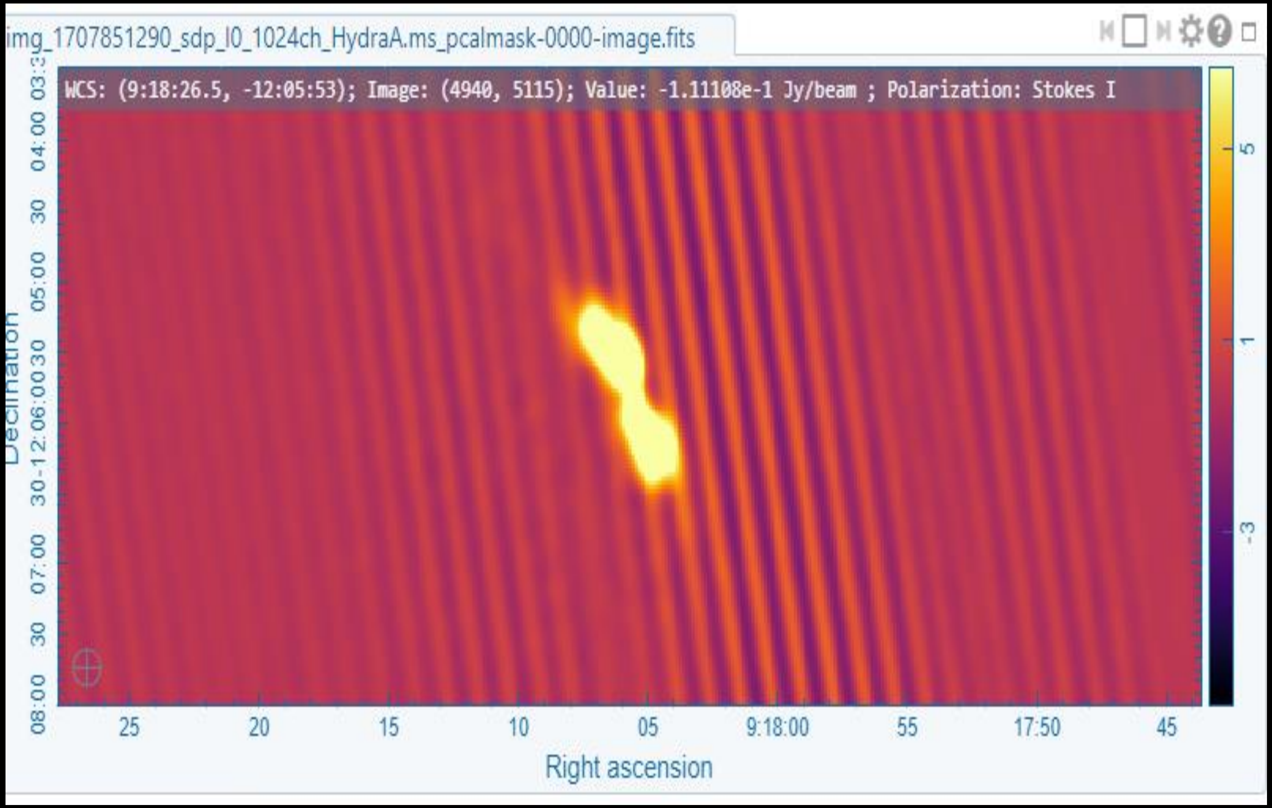
 - Flagging: Mark bad data from antennas, scans etc

 - Cross-calibration: Done using the default order by solving for delays, gains and bandpass on primary calibrator and applying those solutions to secondary calibrator.

 - Self-calibration: Use a model of Hydra A to calibrate for it thus obtaining an improved final image.

PRELIMINARY IMAGES

- Producing satisfactory images of Hydra A is still a working progress.
- We have encountered some some artefacts in our images and are investigating the origins of these artefacts. They could be caused by RFI but we still need to look into them.



THANK YOU FOR YOUR TIME !!!