Section A: Overview of the Research Project

1. Title of the research project:
Multiband MeerKAT study of JWST SMACS0723

2. Broad area of research:
Science

3. Academic level of research project:
Masters

4. Abstract of research project:
The James Webb Space Telescope (JWST) is probing new frontiers in infrared astronomy through its unprecedented sensitivity and resolution. This project aims to study the radio environment of one of the JWST science verification targets, galaxy cluster JWST SMAC0723, using multiband MeerKAT data obtained at both UHF and L bands. The spectral information provided by the > 1 GHz bandwidth, coupled with the high quality JWST information, we can separate the cluster and field radio galaxies and study their spectral curvature and star formation properties.

5. Primary supervisor's details: Dr Kenda Knowles, k.knowles@ru.ac.za, Rhodes University

Section B: Details of Research Project

1. Scientific merit:

The James Webb Space Telescope (JWST) has recently released its first science images, enthralling to the astronomical community and public alike. Its first galaxy cluster observation is of SMACSJ0723.3−7327 (hereafter SMACSJ0723), a massive cluster at z=0.388. Gravitational lensing analyses of the JWST observation (Mahler et al. 2022, Pascale et al. 2022, Caminha et al. 2022) indicate the presence of significant past dynamical activity, with the intracluster light revealing extended features West and South-west of the brightest cluster galaxy (BCG). MUSE spectroscopy analysed by Mahler et al. shows no significant substructure along the line of sight, however there is a clear offset between the radial velocity of the BCG and that of the cluster centroid. Combined with Chandra imaging, the multiwavelength view of this system indicates traces of past/recent merger activity.

The newly obtained UHF and L band MeerKAT data for this system shows the presence of diffuse cluster emission, expected based on the past merger history, but a lot brighter than predicted by existing scaling relations, as well as a high density of radio galaxies. Coupled with high quality multiwavelength data from JWST, we will use the radio data to study the SMACJ0723 cluster environment, its non-thermal component, and its constituent galaxies in order to obtain a holistic understanding of the system. The almost contiguous frequency coverage between 550 MHz and 1.67 GHz provided by a joint L and UHF study will allow for a determination of the spectral index for even the faintest sources, as well as the spectral shape of the radio galaxies detected with a signal-to-noise > 10.

2. Feasibility:

The MeerKAT data is in-hand and has been processed, with images at a variety of resolutions available. Depending on the incoming student, the data can be reprocessed to ensure skills development in terms of radio data reduction. The JWST data is public and collaborators have produced lensing models for the system which may be used in conjunction with the radio to study the galaxies and merger dynamics.

The student will have access to RATT/RARG high-performance computing facilities which are more than sufficient for the data processing and storage requirements of the project.

An estimate of the project timeline is as follows:

Months 1 – 6: Literature review, familiarizing the student with radio data processing.

Months 7 – 12: Reprocess the radio data using existing pipelines. Create spectral index maps.

Months 13 – 18: Analysis – radio and multiwavelength

Months 19 – 24: Thesis write up and submission

3. SARAO research priority area:

This project exploits data projected to be available by 2024 from key existing radio astronomy instruments located in South Africa, specifically MeerKAT.

4. Specific qualifications/abilities/skills/experience required:

Familiarity with Python is required. Familiarity with radio data processing is advantageous but not required.

Interested students to email the supervisor well in advance of application deadlines. Interviews will be undertaken.