Title of the research project*:* Polarisation Properties of Radio Sources in the MERGHERS Tier 1 Clusters

Abstract of research project:
Magnetic fields are ubiquitous in both small-scale and large-scale objects in the universe. However, their origin and evolution is still an open topic. At the scale of galaxy clusters, magnetic fields manifest through the presence of diffuse synchrotron emission in the intracluster medium (ICM). Probing magnetic fields in the ICM is notably challenging, especially in low-density regions such as the cluster peripheries. However, one can study the polarisation properties of cluster-embedded radio sources (such as radio galaxies and relics) and background radio sources to probe magnetic field characteristics in galaxy clusters. In this project, we will use observations from the MeerKAT Exploration of Relics, Giant Halos, and Extragalactic Radio Sources survey to explore the polarisation properties of diffuse radio sources in galaxy clusters and the Faraday effect on both cluster-embedded and background radio sources.

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(2) Full name: Kenda Knowles
University: Rhodes University

Scientific merit:
The origin of the seed magnetic fields that permeate the universe is currently debated between primordial mechanisms and seeding from Galactic Outflows (see Donnert et al. 2018 for review). Their evolution and amplification is displayed through the synchrotron radiation observed in the ICM. This synchrotron radiation can spread over Mpc-scales and have polarisation percentages up to 70% (Rajpurohit et al. 2022c). A detailed study of diffuse radio sources (e.g. radio relics) in galaxy clusters may give insight into the properties of magnetic fields in galaxy clusters. For example, one can probe if the weak seed fields are amplified by a dynamo process in the ICM and how the magnetic fields impact the physics of the ICM. The broadband continuum observations performed with MeerKAT can maximise their scientific outcome in this particular topic when performing the Rotation Measure (RM) synthesis technique (Brentjens & de Bruyn 2005). This technique can overcome depolarisation effects such as bandwidth depolarisation and help reconstruct the faint polarised signals in wide fields of view. As a result, we obtain a detailed reconstruction of the cluster magnetic fields through the polarisation properties of radio relics. Moreover, we can make the so-called RM grid (see, e.g. Anderson et al. 2021) considering cluster-embedded and background sources whose polarised signal witnesses the properties of the intervening cluster magnetic field. Polarised emission from diffuse cluster sources and RM values

can be used to track intra-cluster magnetic fields (e.g. Clarke et al. 2001, Murgia et al. 2004, Vacca et al. 2012. Govoni et al. 2017, Stuardi et al. 2019, Osinga et al. 2022).
We will use the MeerKAT Exploration of Relics, Giant Halos, and Extragalactic Radio Sources (MERGHERS; Knowles et al., 2016,2021) survey's tier 1 data to study the polarisation properties of cluster-embedded and background radio sources to characterise the magnetic fields in a sub-sample of galaxy clusters.

Timeline:

- Literature review (Months 1 - 2)
- Producing full stokes IQUV maps (Months 3 - 7)
- Apply RM tools to the images (Months 8 - 12)
- Extracting polarisation properties from RM images (Months 13 - 14)
- Writing thesis and submitting (Months 15 - 18)

Feasibility:

The MERGHERS data is already available and stored in the UKZN super-computer, Hippo, and Ilifu. The student will be given access to Hippo and Ilifu for data storage and processing. The supervisors have the necessary theoretical background and data reduction experience to guide the student. The student will have regular online meetings with the co-supervisors and physical meetings when the international co-supervisor visits South Africa.

Supervision Roles:

- *Dr S.P. Sikhosana is the administrative and research supervisor.*
- *Dr F. Loi is the research co-supervisor.*
- *Dr K. Knowles is a collaborator and support co-supervisor.*

Academic abilities:

Familiarity with Python programming, radio interferometry and observational radio astronomy is advantageous but not strictly required.