

Cover Page

1. Title of the research project:

Spectropolarimetric studies of Extended Sources in the MMDCS fields

2. Broad area of research:

Science

3. Academic level of research project:

Doctoral

4. Primary supervisor's details:

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- b. sikhosanas@ukzn.ac.za
- c. University of KwaZulu-Natal

5. Abstract of the project:

The MeerKAT Massive Distant Cluster Survey (MMDCS) is a focused MeerKAT survey at 1.28 GHz targeting a comprehensive sample of thirty of the most massive galaxy clusters at $z > 1$. The clusters are selected from the ACT DR5 catalogue, restricted to the portion of the sky overlapping with the DECaLS Data Release 9 optical and infrared footprint. The prime focus of the survey is to characterise cluster-scale diffuse emission and probe star formation rates in extreme environments. However, the observed fields are densely populated with intricate extended sources that are not necessarily cluster-bound. The aim of this project is to catalogue and characterise extended radio sources in the MMDCS fields. The main focus will be on the morphology, spectra, and polarisation properties of these sources. The project's findings will yield new results; hence, publications are anticipated.

Details of Research Project

1. Scientific merit:

Extended radio galaxies have been traditionally classified using the Fanaroff–Riley (FR; Fanaroff & Riley 1974) scheme as FRI and FRII sources. There also exist extended radio galaxies with far more complex jet morphologies in comparison to the traditional classes; these are labelled as wide-angled tails, narrow-angled tails, and bent tails. Studying the morphologies of radio lobes can give insights into the interaction between the beamed plasma emanating from active galactic nuclei and the surrounding ambient medium (Subrahmanyan, Saripalli & Hunstead 1996). The interaction between the jets and the intracluster medium (ICM) surrounding their host galaxy determines the subsequent evolution.

A study by Rudnick et al. (2022) showed a direct interaction between a magnetic filament, a radio jet, and a dense ICM clump in a galaxy cluster. Improved sensitivities of radio interferometers are continuously revealing extended emission that is not obviously linked to radio galaxies (Rubeis et al. 2026). These filamentary structures have sparked interest in theories of their formation mechanisms. Overall, they are characterised by projected lengths of 10s to 100s kpc, widths ranging from hundreds of pc to a few kpc, and steep spectral indices ($\alpha > 1.3$). In some cases, significant spectral variations were observed along the filaments' length (Rudnick et al. 2022; Velovi'c et al. 2023), although this is not ubiquitous (e.g., Giacintucci et al. 2022; Brienza et al. 2025; Bushi et al. 2025). These phenomena provide new opportunities to study the physical processes occurring in the ICM, such as magnetic field amplification and cosmic ray acceleration and propagation (Bell et al. 2019).

The MeerKAT Massive Distant Cluster Survey (MMDCS) is a MeerKAT *L/UHF*-band survey specifically designed to study a selection of 30 massive galaxy clusters at $z > 1$. The survey aims to study various aspects of these high-redshift clusters, including radio emission, star formation, active galactic nucleus (AGN) activity, and environmental effects within the cluster environments. The MMDCS sample comprises 30 of the most massive clusters selected from the Atacama Cosmology Telescope (ACT; Swetz et al. 2011) Data Release 5 catalogue (Hilton et al. 2021). This catalogue contains over 4000 clusters, of which 222 are located at $z > 1$. The MMDCS cluster sample covers redshift range $1.00 < z < 1.31$ and mass range $4.5 < M_{500c}/10^{14} M_{\odot} < 9.7$. These observed fields have rich environments comprising extended radio sources with complex morphologies.

2. Feasibility:

The student will be given access to the Ilifu platform for all the data processing and will have access to Hippo (the UKZN supercomputer) for storage purposes. The MMDCS fields already fall within the DECaLS field; hence, students will have access to photometric redshifts for the study.

3. Availability of required data:

All the 30 MMDCS fields have been observed and processed to at least 2GC. The survey has a project under Ilifu enabling the swift sharing of raw data and calibrated data products. Auxiliary X-ray (XMM) and DECaLS images available on the relative archival platforms.

4. Expected milestones and timelines:

Below is an overview of the estimated timelines for the duration of the PhD

- ☐ Months 1 - 3: Project onboarding, literature review, and setting up user environments on Ilifu.
- ☐ Months 4 - 12: Data processing for fields that need 3GC and ensuring coherent data reduction methods for all the fields.
- ☐ Months 13 - 20: Producing spectral index maps and polarisation products for all the observed fields.
- ☐ Months 21 - 31: Analysis of the spectropolarimetric results and preparation of manuscript for pilot catalogue results.
- ☐ Months 32 - 36: Completing analysing and compiling thesis for submission.

5. Specific requirements:

The candidate should have sufficient background of radio interferometry. They should have experience using Linux based operating systems and be comfortable with coding in Python. Experience with MeerKAT data reduction will be advantageous.



Compose

University of KwaZulu-Natal
Westville Campus

More

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Education and Qualifications

- PhD in Applied Mathematics [2021], University of KwaZulu-Natal, Dissertation Title: Diffuse Radio Emission In ACTPol Clusters, Supervisor: Prof. K. Moodley
- MSc in Applied Mathematics [2017], University of KwaZulu-Natal, Dissertation Title: Giant radio halos and relics in ACTPol clusters, Supervisor: Prof. K. Moodley
- BSc (Hon) in Applied Mathematics, *Cum Laude* [2015], University of KwaZulu-Natal
- BSc in Applied Mathematics and Physics, *Cum Laude* [2014], University of KwaZulu-Natal

Research Interests

- Diffuse radio emission in galaxy clusters.
- Cluster-scale magnetic fields.
- Extended radio galaxies
- Radio interferometry data analysis techniques.

Employment History

- Astronomy lecturer [November 2023 – current], University of KwaZulu-Natal
- Ad hoc temporary tutor [February 2022 – December 2023], University of KwaZulu-Natal
- Teacher's assistant [October 2021], University of KwaZulu-Natal
- Lab assistant [February – June 2021], University of KwaZulu-Natal
- Innovation Officer [October 2016 – September 2017], UKZN InQubate
- Tutor [February 2013 – May 2016], University of KwaZulu-Natal

Research Positions

- South African Radio Astronomy Observatory Postdoctoral Fellow, University of KwaZulu-Natal [April 2021 – October 2023]

Teaching

- Lecturer, ASTR304: Observational Project [2023, 2024, 2025, 2026]
- Lecturer, ASTR204: Galaxies and Cosmology [2022, 2023, 2024, 2025]
- Lab assistant, ASTR301: Astronomy Beyond the Visible [2021]
- Teacher's assistant, ASTR204: Galaxies and Cosmology [October 2021]

Student Supervision

- MSc, BScHons: Supervisor, UKZN National Astrophysics and Space Science Programme, student: Neliswa Bhengu [May 2025 – current]
- MSc: Supervisor, UKZN, Surprise Moleele [February 2025 - current]
- PhD: Co-supervisor, University of the Witwatersrand, Dakalo Phuravhathu [2024 – current]
- MSc: Co-supervisor, UKZN National Astrophysics and Space Science Programme, student: Asabele Sabelo [2023 – current]
- MSc: Co-supervisor, UKZN National Astrophysics and Space Science Programme, student: Banele Mthembu [2023 – 2025]
- BScHons: Supervisor, UKZN National Astrophysics and Space Science Programme, student: Khethiwe Cele [2022]
- BScHons: Supervisor, UKZN, student: Adhveer Domanlall [2021]

Thesis Examination

- University of Zululand, MSc [2026]
- University of KwaZulu Natal, PhD [2026]
- Rhodes University, MSc [2025]
- University of KwaZulu Natal, MSc [2025]

Conference Participation

- Poster presentation, African Astronomical Society conference, Pretoria, South Africa [March 2025]
- Poster presentation, IAU General Assembly, Cape Town, South Africa [August 2024]
- Oral presentation, Cosmology in the Alps Conference, Les Diablerets, Switzerland [March 2024]
- Oral presentation, MeerKAT@5 conference, Stellenbosch, South Africa [February 2024]
- Oral presentation, South Africa Gravity Society conference, Hluhluwe, South Africa [March 2023]
- Oral presentation, African Astronomical Society conference, Johannesburg, South Africa [March 2023]
- Oral presentation, Cosmology on Safari, Hluhluwe, South Africa [March 2023]
- Oral presentation, University of Geneva Observatory, Geneva [October 2022]
- Oral presentation, Mathematics Workshop for Emerging Researchers, Drakensberg, South Africa [January 2022]
- Lightning talk, Science at Low Frequencies VIII conference, Zoom [December 2021]
- Oral presentation, A new window on the radio emission from galaxies, galaxy clusters and cosmic web: current status and perspectives (RGCW) conference, Zoom [March 2021]
- Oral presentation, MetreSkyII Conference, Pune, India [March 2019]
- Oral presentation, SuperMIGHTEE India-SA Busy Week, Pune, India [April 2018]

- Poster presentation, SnowCluster - The Physics of Galaxy Clusters conference, Snow Lake City, USA [March 2018]

Invited Talk

- Magnetic Fields and Cosmic Rays across Diverse Scales: What's Next?, Harvard and Smithsonian's Centre for Astrophysics, USA [September 2025]

Seminars

- University of the Witwatersrand [July 2025]
- University of South Africa [October 2025]
- Harvard and Smithsonian's Center for Astrophysics group meeting, online [June 2024]

Grants

- Swiss National Science Foundation Travel Grant [2026]
- NRF Thuthuka Research Grant [2025 – 2027]
- SARAO Faculty Research Grant [2024 – 2026]
- SARAO Undergraduate Scholarship Grant PI [2024 – 2027]
- College of Agriculture, Engineering and Science Travel Grant [2024]
- Swiss National Science Foundation Travel Grant [2024]

Consortium Membership

- Large Synoptic Survey Telescope – member of the galaxies science collaboration [2022 – current]
- Meerkat Absorption Line Survey (MALS) - member of continuum imaging and cluster science team [2019 – current]
- Meerkat Extended Relics, Giant Halos, and Extragalactic Radio Sources - member of the data reduction and analysis team [2017 – current]
- Atacama Cosmology Telescope – member of the cluster science team [2015 – current]

Society Membership

- South African Gravity Society [March 2023 – current]
- African Astronomical Society [March 2022 – current]
- International Astronomical Union [October 2021 – current]

Academic Service

- SARAO Postgraduate and Postdoctoral Research Conference [April 2025 – current]
- Organiser of the Cosmology on Safari conference [2023, 2025]

- SARAO users committee member [January 2024 – current]
- Organiser of the Cosmology in the Alps conference [2023 – current]
- SARAO Free-standing Honours Scholarships Review Panel [2023]
- Executive committee and board member of the African Astronomical Society [2022 – current]
- SOC member of the African Astronomical Society conference [2022]
- Organiser of the Astrophysics Research Centre seminars [2021 – 2022]
- Member of the Astrophysics Research Centre’s diversity and inclusion committee [2021 – current]
- SARAO Free-standing Undergraduate Scholarships Review Panel [2020 – 2022]

Academic Achievements

- SKA SA (SARAO) Scholarship [2011 – 2020]
- L’Oreal-UNESCO For Women in Science South African Young Talents research grant [2019]
- Selected to attend the 69th Lindau Nobel Laureate Meeting [2019]
- Department of Science and Technology African Women in Science Doctoral Scholarship [2018]
- SAWISE Hope Scholarship (research visit at Princeton University) [2014]
- Scholarship top 10 African females in the faculty [2011 – 2013]

Outreach and Public Engagement

- UKZN Career Exhibitions [2025]
- UKZN & Mthethwamatics Teach the Nation Programme [June 2025]
- UKZN Be A Scientist for a Week Programme [June 2024]
- UKZN & Mthethwamatics Teach the Nation Programme [June 2024]
- UKZN CAES Meet & Greet for First Year Students [March 2024]
- UKZN Women in Science Event [February 2024]
- The Space Odyssey with Ritu and Precious [June 2022 – current]
- Umhlathuzana Education Fund Chief Operating Officer [September 2022 – current]
- Public Talk, Uncovering the Unknowns with the JWST, Astronomical Society of Southern Africa [January 2022]
- Public Talk, My PhD Journey, SARAO National Science Week [August 2021]
- YouTube recording, Diffuse Emission in Galaxy Clusters, South African Astronomical Observatory [June 2021]
- Public Talk, My PhD Journey, SADC-UNESCO International Day of Women and Girls in Science Webinar [February 2021]
- Invited panelist, ‘Ensuring we are building a future-ready generation’, The Standard Bank Top Women Conference [October 2020]
- Public Talks, Careers in Astronomy, Astrophysics Research Centre [2018 – 2023]

Competitively Allocated Telescope Time

MeerKAT – 139.3 hours

- *Mapping Extended Diffuse Radio Emission at $z = 1.23$: ACT-CL J0329.2-233* [7.3 hours]
– **Sikhosana, S. (PI)**, Hilton, M., Baker, A., Bernardi, G., J., Hughes, J., Klutse, D.,

- Kesebonye, K., Knowles, K., van Marrewijk, J., Moodley, K., Mroczkowski T., Partridge, B., Wollack, E., Vargas, C.
- *The MeerKAT Massive Distant Clusters Survey* [22 hours] – Hilton, M.(PI), **Sikhosana, S. (Technical lead)**, Baker, A., Bernardi, G., Devlin, M. Dicker, S., Dunkley, J., Hughes, J., Klutse, D., Kesebonye, K., Knowles, K., van Marrewijk, J., Moodley, K., Mroczkowski T., Oozeer, N., Orłowski-Scherer, J., Partridge, B., Wollack, E., Perrott, Y., Basu, K., Sifon, C., Vargas, C.
 - *MERGHERS: evolution of cluster scale radio sources through cosmic time* [50 hours] – Knowles, K. (PI), **Sikhosana, S. (Technical lead)** and the MERGHERS collaboration
 - *The MeerKAT view of the Shapely Concentration* [16 hours] – Smirnov, O., Bernardi, G., Di Gennaro, Knowles, K., **Sikhosana, S.**, Venturi, T., Vir Lal, D.
 - *The MeerKAT view of the Shapely Concentration* [16 hours] – Smirnov, O., Bernardi, G., Di Gennaro, Knowles, K., **Sikhosana, S.**, Venturi, T., Vir Lal, D.
 - *Tracing star formation in groups and filaments around a young active galaxy cluster at $z = 1.46$* [16 hours] – M. Hilton, Knowles, K., Makhathini, S., Moodley, K., **Sikhosana, S.**, Smail, I., Stach, S., Swinbank, M.
 - *L-band diffuse emission study of ACT-CL J2023.3-5535* [12 hours – early science] – Knowles, K., Hilton, M., Hughes, J.P., Makhathini, S., Moodley, K., Ramaila, A., **Sikhosana, S.**

(Upgraded) Giant Meterwave Radio Telescope (u)GMRT – 201 hours

- PID: 43_026 – *G-MERGHERS: Spectral studies of MERGHERS sources with the GMRT* [32 hours] – Knowles, K. and the MERGHERS collaboration
- PID: 36_050 – *Low frequency radio study of a complete mass-selected sample of SZ clusters from ACTPol* [72 hours] – K. Knowles, **S. Sikhosana**, A. Baker, N. Gupta, M. Hilton, J. Hughes, H. Intema, K. Moodley, E. Reese, C. Sifon, J. Sievers
- PID: 33_010 – *Low frequency radio study of a complete mass-selected sample of SZ clusters from ACTPol* [20 hours] – K. Knowles, **S. Sikhosana**, A. Baker, N. Gupta, M. Hilton, J. Hughes, H. Intema, K. Moodley, E. Reese, C. Sifon, J. Sievers
- PID: 32_016 – *Low frequency radio study of a complete mass-selected sample of SZ clusters from ACTPol* [45 hours] – K. Knowles, H. Intema, N. Gupta, M. Hilton, K. Moodley, **S. Sikhosana**, A. Baker, V. Bharadwaj, J. Hughes, E. Reese, C. Sifon, J. Sievers, R. Bond, N. Battaglia
- PID: 30_012 – *Diffuse Radio Emission in an SZ mass-selected sample of ACTPol galaxy clusters* [32 hours] – K. Knowles, A. Baker, V. Bharadwaj, N. Gupta, M. Hilton, J. Hughes, H. Intema, K. Moodley, E. Reese, J. Sievers, C. Sifon, **S. Sikhosana**, V. Singh, R. Srianand, E. Wollack

Southern African Large Telescope (SALT) – 120 hours

- PID: 2022 – *SMERGHERS: Constraining galaxy cluster merger geometry and timescales* [120 hours] – Hilton, M., Baker, A., Hughes, J., Knowles, K., Loubser, I., Moodley, K., **Sikhosana, S.**

Publications [ORCID ID: 0000-0003-3199-1161]

- Kolokythas K., Venturi T., Knowles K., **S. P. Sikhosana**, et al., The MeerKAT Galaxy Cluster Legacy Survey -- II. Catalogue of the diffuse radio emission in MeerKAT-GCLS clusters, Monthly Notices of the Royal Astronomical Society, 2025
- Dakalo G. Phuravhathu, M. Hilton, **S. P. Sikhosana**, et al., The MeerKAT Massive Distant Clusters Survey: Detection of Diffuse Radio Emission in Galaxy Clusters at $z > 1$, Monthly Notices of the Royal Astronomical Society, 2025
- K. S. Trehaeven, T. Venturi, O. Smirnov, G. Di Gennaro, M. Rossetti, S. Giacintucci, S. Bardelli, P. Merluzzi, **S. P. Sikhosana**, D. Dallaca, R. Kale, Minor Mergers in the Shapley Supercluster: The Mini-Halo in A 3558, Monthly Notices of the Royal Astronomical Society, 2025
- Brenda Namumba, Roger Ianjamasimanana, Bärbel Koribalski, Albert Bosma, Evangelia Athanassoula, Claude Carignan, Gyula IG Józsa, Peter Kamphuis, Roger P Deane, **Sinenhlanhla P Sikhosana**, et al., Investigating the HI distribution and kinematics of ESO444-G084 and [KKS2000] 23: New insights from the MHONGOOSE survey, Astrophysics & Astronomy, 2025
- K Rajpurohit, A Botteon, E O'Sullivan, W Forman, M Balboni, L Bruno, RJ van Weeren, M Hoeft, G Brunetti, C Jones, AS Rajpurohit, **SP Sikhosana**, Radial Profiles of Radio Halos in Massive Galaxy Clusters: Diffuse Giants Over 2 Mpc, The Astrophysical Journal, 2025
- Swarna Chatterjee, Denisha Pillay, Abhirup Datta, Ramij Raja, Kenda Knowles, Majidul Rahaman, **SP Sikhosana**, Exploring The Dynamical Nature and Radio Halo Emission of Abell 384: A Combined Radio, X-ray and Optical Study, Monthly Notices of the Royal Astronomical Society, 2025
- **SP Sikhosana** et al., The MeerKAT massive distant clusters survey: A radio halo in a massive galaxy cluster at $z = 1.23$, Astrophysics & Astronomy, 2025
- JD Wagnveld, H-R Klöckner, N Gupta, PP Deka, P Jagannathan, S Sekhar,..., **S. Sikhosana**, et al., The MeerKAT Absorption Line Survey Data Release 2: Wideband continuum catalogues and a measurement of the cosmic radio dipole, Astrophysics & Astronomy, 2024
- DY Klutse, M Hilton, I Heywood, I Smail, AM Swinbank, K Knowles, **SP Sikhosana**, MeerKAT observations of starburst galaxies and AGNs within the core of XMMXCS J2215.9 – 1738 at $z = 1.46$, Monthly Notices of the Royal Astronomical Society, 2024
- Peter Doze, Matt Hilton, John P Hughes, ..., **Sinenhlanhla Sikhosana**, et al., A Multiwavelength Approach to Constraining the Merger Properties of ACT-CL J0034.4+0225, The Astrophysical Journal, 2024
- PP Deka, N Gupta, P Jagannathan, S Sekhar,..., **S. Sikhosana**, et al., The MeerKAT Absorption Line Survey (MALS) data release I: Stokes I image catalogs at 1-1.4 GHz, The Astrophysical Journal, 2024
- JD Wagnveld, H-R Klöckner, N Gupta, PP Deka, P Jagannathan, S Sekhar,..., **S. Sikhosana**, et al., The MeerKAT Absorption Line Survey: Homogeneous continuum catalogues towards a measurement of the cosmic radio dipole, Astrophysics & Astronomy, 2023

- Brenda Namumba, Javier Román, Jesus Falcón-Barroso, Johan H Knapen, R Ianjamasimanana, Elizabeth Naluminsa, Gyula IG Jozsa, Marie Korsaga, Natasha Maddox, Brad Frank, **S. Sikhosana**, et al., MIGHTEE-H I: possible interactions with the galaxy NGC 895, Monthly Notices of the Royal Astronomical Society, 2023
- **SP Sikhosana**, K Knowles, M Hilton, K Moodley, M Murgia, MeerKAT's view of the bullet cluster 1E 0657-55.8, Monthly Notices of the Royal Astronomical Society, 2023
- R. Kale, V. Parekh, M. Rahaman, D. C. Joshi, T. Venturi, K. Kolokythas, J. O. Chibueze, **S. Sikhosana**, D. Pillay, K. Knowles, SoUthern Clusters Cale Extended Source Survey (SUCCESS): A GMRT and Meerkat study of nine massive galaxy clusters, Monthly Notices of the Royal Astronomical Society, 2022
- S. Giacintucci, T. Venturi, M. Markevitch, H. Bourdin,...,**S.P. Sikhosana**, et al., A candle in the wind: a radio filament in the core of the A3562 galaxy cluster, The Astrophysical Journal, 2022
- T. Venturi, S. Giacintucci, P. Merluzzi, G. Bussarello,..., **S.P. Sikhosana**, et al., Radio footprints of a minor merger in the Shapley Supercluster: From supercluster down to galactic scales, Astrophysics & Astronomy, 2022
- **S.P. Sikhosana**, K. Knowles, M. Hilton, K. Moodley, et al., A GMRT Narrowband vs. Wideband Analysis of the ACT-CL J0034.4+0225 Field Selected from the ACTPol Cluster Sample, Galaxies, 2021
- K. Knowles, W.D. Cotton, L. Rudnick, ..., **S.P. Sikhosana**, et al., The MeerKAT Galaxy Cluster Legacy Survey: I. Survey Overview and Highlights, Astrophysics & Astronomy, 2021
- D.S Pillay, D. Turner, M. Hilton, ..., **S.P. Sikhosana**, et al., A Multiwavelength Dynamical State Analysis of ACT-CL J0019.6+0336, Galaxies, 2021
- K. Knowles, D.S. Pillay, S. Amodeo, ..., **S.P. Sikhosana**, et. al, MERGHERS Pilot: MeerKAT discovery of diffuse emission in nine massive Sunyaev-Zel'dovich-selected galaxy clusters from ACT, MNRAS, 2021
- N. Gupta, P. Jagannathan, R. Srianand, ..., **S. Sikhosana** et. al, Blind HI and OH Absorption Line Search: First Results with MALS and uGMRT Processed Using ARTIP, The Astrophysical Journal, 2021
- Steve K. Choi, Matthew Hasselfield, Shuay-Pwu Patty Ho,... , **S. Sikhosana** et al., The Atacama Cosmology Telescope: a measurement of the Cosmic Microwave Background power spectra at 98 and 150 GHz, JCAP, 2020
- Simone Aiola, Erminia Calabrese, Loïc Maurin, Sigurd Naess, Benjamin L. Schmitt, Graeme E. Addison,..., **S. Sikhosana** et al., The Atacama Cosmology Telescope: DR4 maps and cosmological parameters, JCAP, 2020
- P. Ade, J. Aguirre, Z. Ahmed, **P. Sikhosana** et. al., The Simons Observatory: Science Goals and Forecasts, JCAP, 2019
- K. Knowles, K. Moodley, J. Sievers, **S. Sikhosana** et. al, MERGHERS: An SZ-selected cluster survey with MeerKAT, Proceedings of Science, 2017

Publications Review

- Monthly Notices of the Royal Astronomy Society [2025]
- Astronomy & Astrophysics [2024]

- Nature [2023]

Impact Score: Google Scholar

citations	1860
h-index	12
i10-index	15