Development in Africa with Radio Astronomy

UK Masters by Research Prospectus
2025 Call

Introduction

We are pleased to announce advanced training opportunities in the form of Masters by Research places at UK universities as part of the Development in Africa with Radio Astronomy (DARA) project. DARA is funded by the UK's International Science Partnerships Fund via a grant from the Science and Technologies Facilities Council. The opportunities are open to nationals of the SKA African Partner Countries (APCs): **Botswana, Ghana, Kenya, Madagascar, Mozambique, Namibia, Mauritius and Zambia**. These places are fully funded such that the DARA project will cover all tuition fees and maintenance allowance at the UKRI recommended level of £20,780 per year. The cost of your return flight, visa, health surcharge and TB test costs will also be covered by the DARA project as well as funds for conference attendance. Projects are offered at some of the UK DARA partner universities: Leeds, Manchester, Edinburgh and Highlands & Islands. Where possible each project will have collaborators at a partner institution in South Africa or Africa to build a strong network.

The 2025 Call

This round of funding can provide for eight one-year Masters (MSc) by research places. The projects on offer are described on the following pages. Candidates will be required to apply for the funding from DARA first and a decision on who to fund will be made by a DARA sub-committee. The selected candidate(s) will then apply as a fully funded applicant to their chosen university to obtain an actual place on the course. The timetable for the process is set out below:

Opportunity Announced	6th May 2025
Deadline for applications for funding	1st June 2025
Selection of applicants to be funded	20th June 2025
Deadline for selected applicants to apply to nominated university for a place	4th July 2025
Start of MSc study in the UK	January 2026 *(dependent on university and visa application times)*

We expect that all candidates selected for full funding will obtain a place, but in the unlikely event that this is not the case we will offer funding to the next candidate on the priority list drawn up by the selection committee.

Eligibility

Applicants for funding must:

- Be nationals of one of the SKA African Partner Countries listed above or resident in one of these countries for at least the last three years.
- Have a good first degree in Physics or a relevant related subject.
- Satisfy any other entry conditions of the universities they are proposing to study at including the English language requirements.
- Have preferably undergone the basic training programme of the DARA project or have similar relevant experience.

Application Procedure

1. Complete the Advanced Programme Application Form, at the link below.

   https://www.dara-project.org/advancedprogramme

   Please have the following documents ready to upload:
   - Higher education degree certificate and transcripts
   - CV
   - Passport ID page
   - Statement of motivation
   - Ranked list of (at least) 4 projects from the list below

2. You will also need **two letters of recommendation** – which can be uploaded during the application process, or sent by email to the DARA Project Manager, Emma Smith, e.c.smith1@leeds.ac.uk.

If you have any problems or questions about the application, or need a paper application form, please contact the DARA Project Manager (e.c.smith1@leeds.ac.uk).

List of Projects

LEEDS-1

Title: Searching for radio stars in deep MeerKAT extragalactic surveys

Partners: University of Leeds, UK

Supervisors: Mark Thompson (Leeds)

MeerKAT is leading the way in deep radio surveys of the sky, probing the radio galaxy populations to micro-Jansky levels with surveys such as MIGHTEE and DEEP2. However, while the primary aim of these surveys is to understand distant radio galaxies and their active nuclei, they can also be used to identify radio counterparts to foreground objects such as stars. In this MSc project you will search for radio stars within the MIGHTEE survey, using Bayesian

Likelihood Ratio techniques to identify radio counterparts to stars within the survey fields. Stellar radio emission is a great diagnostic indicator of high energy processes in stellar atmospheres across the HR diagram. You will learn techniques for matching multiwavelength catalogues with each other and radio analysis techniques to study the spectrum and polarisation of candidate radio stars.

LEEDS-2

Title: Unveiling planet-forming discs with the Square Kilometre Array

Partners: University of Leeds, UK

Supervisors: John Ilee (Leeds)

Planets are born in discs of dust and gas that surround young stars, but the specific mechanisms that form them remain elusive. These discs are shrouded in dense clouds of dust and gas, making it extremely difficult to observe planet formation in the act. The upcoming Square Kilometre Array (SKA) is a project to build the world's largest radio telescope(s) in South Africa and Australia, with headquarters here in the UK at Jodrell Bank. The SKA will be many times more powerful than current instruments, and will have the power to 'unveil' planet forming discs with great clarity for the first time. It will observe emission from large dust grains in the most dense and coldest regions of planet-forming discs - precisely the locations at which planets are thought to form.

In this project, the successful candidate will help lay the ground for the first SKA observations of these protoplanetary discs. Combining hydrodynamic models of discs and growing planets, you will characterise the growth and evolution of the raw material for planet formation. You will analyse how the distribution of cm-sized 'pebbles' in the disc changes at different evolutionary stages and as planets grow. Using radiative transfer models, you will predict the appearance of the discs at cm wavelengths, including contributions to the emission from jets and winds. Your results will lay the groundwork for the first SKA observations and help determine the best observing strategies for this next-generation instrument.

The project is suitable for a candidate with interests in i) simulations and modelling, or ii) astronomical observational data analysis. Experience with programming languages such as Python and FORTRAN would be advantageous, but is not essential.

LEEDS-3

Title: Simulations of the radio emission from colliding wind binary systems

Partners: University of Leeds, UK and North West University, South Africa

Supervisors: Julian Pittard (Leeds) and Fanie van den Heever (NWU)

Colliding wind binaries (CWBs) are a class of massive star system where each star has a strong stellar wind that collides with the other. They are great systems for investigating the physics of particle acceleration by high Mach number shocks. You will simulate the thermal and non-thermal emission from specific CWB systems using a sophisticated numerical code and compare your results against observations and work in the literature. The focus will be on matching the observed radio spectrum (spectral slope and low frequency turndown) and making predictions for the non-thermal X-ray and gamma-ray emission. The predictions will be useful for future SKA and CTA studies of these objects. You should be comfortable with running/modifying a computational code that is written in C.

MANCHESTER-1

Title: Commissioning and comparison of backends for the RHINO 21cm global signal experiment

Partners: University of Manchester

Supervisor: Phil Bull

RHINO is an experiment to observe the highly-redshifted 21cm line from neutral hydrogen gas around the very first stars and galaxies, using a large horn antenna currently under construction at Jodrell Bank Observatory. An absolutely-calibrated prototype receiver is currently being commissioned using a LimeSDR board for digitisation, but we also have access to a more powerful Zynq UltraScale+ RFSoC board that could be used instead. In this project, you will set up both boards and perform detailed comparisons of their performance characteristics, with a view to selecting the best option for deployment. This will involve significant work on the analogue signal chain, some DSP programming (mostly using python), and field tests with a prototype antenna.

MANCHESTER-2

Title: Extragalactic radio jets on sub-kpc scales

Partners: University of Manchester and University of South Africa

Supervisor: Robert Beswick and Emmanuel Bempong-Manful (Manchester) and Zolile Mguda (UNISA)

The jets and extended lobes of extragalactic radio sources are known to play a key role in AGN feedback processes and the co-evolution of supermassive black holes and their host galaxies. The e-MERLIN Legacy programme on radio jets has been mapping a number of powerful radio galaxies and quasars to obtain the best possible information about the inner structure of the jet outflows. One target of special interest is 3C273 – the first documented object to be identified as quasar – which lies at a distance of about 700 Mpc, where we have excellent radio and multiwavelength data. In this project the student will map

the structure of the inner jets of 3C273 using the new multifrequency e-MERLIN observations at radio wavelengths and attempt to measure the physical properties of the jets. The student will learn the techniques of radio data reduction (i.e., calibration and imaging) as well as the analysis and interpretation of the data to understand the jet flow. The project can be extended by building a model of the radio spectrum in 3C273, using ancillary data at other frequencies, and by looking at some other sources of similar type.

EDINBURGH-1

Title: A machine learning investigation of comet composition

Partners: University of Edinburgh

Supervisor: Cyrielle Opitom

Description: Comets are some of the most pristine bodies in the solar system. Their ices have remained preserved since the formation of the solar system, so that studying the composition of comets allows us to understand the conditions prevailing early in the solar system. Spectroscopy has been the technique of choice to study the composition of comets for the past 60 years, providing a wealth of data on the composition of dozens of comets. Over the years, multiple studies have attempted to link the composition of comets to their place of formation in the early solar system without success. The goal of this project will be to use a new database of comet composition assembled from multiple studies and apply machine-learning techniques on this database to find new classes of comets based on their composition and attempt to link them to their place of formation in the early solar system. The use of machine learning techniques will allow us to include much more data than usually considered in similar studies, including information coming from different wavelength ranges, to produce a comprehensive view of the composition of comets and its variation.

EDINBURGH-2

Title: Push and pull – Studying the interplay between AGN and star-forming gas

Partners: University of Edinburgh

Supervisors: Marcin Glowacki and Romeel Davé

Neutral hydrogen (HI) gas is a key component of galaxies. This gas will condense into molecular hydrogen and then form stars. Furthermore, a galaxy's HI content extends far beyond the stellar disk, and hence contains stronger signatures of the impact of the galaxy's environment and recent merger history. Another important feature of galaxy evolution history are the supermassive black holes at their centres. Some, termed as active galactic nuclei (AGN), create large outflows of material from the matter pulled into their accretion disks. What is the impact of feedback from AGN on the star-forming HI gas in

these galaxies? Hydrodynamical galaxy simulations such as Simba and Simba-C are one avenue for investigating this question, and comparing to current and upcoming surveys with brand new radio telescopes in the lead-up to the Square Kilometre Array.
In this project, the student will use the state-of-the-art Simba cosmological galaxy formation simulation suite to explore the gas content of simulated galaxies, with a focus on radio galaxies associated with AGN. Simba has already been found to match well with the MIGHTEE radio galaxy survey, but investigation into the HI content of Simba radio galaxies remains to be done. Mock spectral-line cubes will be created by the student for identified radio galaxies in Simba, and be analysed to investigate a range of galaxy properties. Further study into e.g. gas asymmetry, HI absorption, and gas accretion may also be carried out. Different galaxy feedback models and redshift snapshots will be investigated to determine the impact of AGN on the HI content at different stages of the Universe's history, and the newest simulation suite, Simba-C, will also be included. This work will in turn inform future observation studies of radio galaxies, namely the MIGHTEE and MIGHTEE-HI surveys, currently underway with the MeerKAT radio telescope. Strong Python and Unix skills are essential.

UHI-1

Title: Analyses of weather station data from mountain sites in Kenya and comparison with met model reanalyses.

Partners: University of Highlands and Islands (Glasgow)

Supervisors: Eddy Graham

Previous research indicates that some of the best sites for optical astronomy at equatorial latitudes may reside in northern Kenya. During 2025, three automatic weather stations are being sited on three candidate mountain site locations, at altitudes of 2000-3000m, in an effort to monitor conditions and to assess their quality for a possible future large Kenyan telescope. In this project you will analyse the weather datasets gathered by the automatic weather stations to determine their astronomical viewing quality. The student will also perform a preliminary statistical analysis to compare the observational weather data with climate model reanalyses and output from the very high resolution Weather Research and Forecasting model, which is also being run in real-time for all three sites. It may also be possible to use the datasets to determine basic atmospheric indices, to be used as proxies for astronomical viewing quality.