Development in Africa with Radio Astronomy

Advanced Training Programme UK Prospectus

2019 Call

Introduction

We are pleased to announce advanced training opportunities in the form of Masters places at UK universities as part of the Development in Africa with Radio Astronomy (DARA) project funded by the UK's Newton Fund. The opportunities are open to nationals of all AVN partner countries, namely: Botswana, Ghana, Kenya, Madagascar, Mozambique, Namibia, Mauritius and Zambia. These places are fully funded such that the Newton Fund will cover all tuition fees, bench fees and maintenance allowance at the RCUK recommended level of £15,009 per year. Projects are offered at the four UK DARA partner universities: the University of Leeds, the University of Manchester, the University of Hertfordshire and the University of Bristol. For each project, time may also be spent at a partner institution in South Africa or Africa to gain additional skills and build collaborations. The cost of your return flights, initial visa and health surcharge costs will be covered by the Newton Fund.

The 2019 Call

This round of funding can provide for seven 1-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 the DARA Project Steering 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.

Call Timetable

Opportunity Announced	19 November 2019
Deadline for applications for funding	8 December 2019
Selection of applicants to be funded	20 December 2019
Deadline for selected applicants to apply to nominated university for a place	15 January 2020
Start of advanced study in the UK	No later than 31 March 2020

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 DARA Project Steering Committee. Completed Masters students may well wish to continue their studies and apply for PhD places, although there is no further funding currently awarded for these via DARA.

Eligibility

Applicants for funding must:

- Be nationals of one of the AVN 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 in particular.
- 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 to apply and remember to attach a transcript of your higher education certificates, passport copy and CV.
2. Your statement of interest and motivation (section 13 of the application form) must include a ranked list of at least four projects from the list below to indicate which projects you are interested in pursuing.
3. Completed applications should be sent to the DARA Project Manager, Patricia Grant, either via email at P.Grant@leeds.ac.uk or via post to: Patricia Grant, School of Physics and Astronomy, University of Leeds, Leeds, LS2 9JT.
4. Arrange for two letters of recommendation to be sent to the same address prior to the application deadline.

Inquiries can also be made to the UK Principal Investigator
Prof Melvin Hoare at M.G.Hoare@leeds.ac.uk.

List of Projects

BRISTOL-1

Title: X-ray reflection and variability from radio jets

Partners: University of Bristol, UK and SA Institute TBA

Supervisors: Dr Andrew Young (Bristol), SA co-supervisor TBA

Relativistic jets emit radiation spanning the entire electromagnetic spectrum from radio to X-rays and beyond. The goal of this project is to use theoretical models of jets to predict the broad-band spectrum of a jet as a function of distance from the central black hole, paying particular attention to the radio and X-ray wavebands. Jets may produce significant X-ray synchrotron radiation at distances of hundreds to thousands of gravitational radii along the jet, or via inverse Compton processes closer to the base

of the jet. Some of these X-ray will illuminate the accretion disk producing a back-scattered spectrum containing characteristic spectral features such as fluorescence lines that can be measured using X-ray observatories. Furthermore, these jets may be variable (perhaps due to a variable mass injection rate at the base of the jet) with fluctuations propagating outwards along the jet. Modelling these fluctuations will allow time delays between different radio and X-ray energy bands to be calculated which can then be compared with the time delays seen in radio and X-ray observations. The ultimate goal of this project is to provide a suite of models that describe the radio to X-ray spectrum and variability of jet models that can be compared with data.

HERTS-1

Title: The nature of compact sources selected by LOFAR

Partners: University of Hertfordshire, UK and SA Institute TBA

Supervisors: Martin Hardcastle (Hertfordshire), SA co-supervisor TBA

Description Radio-loud AGN, the subset of the AGN population in which a significant fraction of the AGN's output takes the form of synchrotron-emitting jets, are key to modern models of galaxy formation and evolution, as they are thought to provide the energy input required to prevent the cooling of the hot phase of baryonic matter and hence to slow or halt the growth of the most massive galaxies. We are using the new LOFAR northern-sky radio survey LoTSS to study radio-loud AGN in the local universe at low frequencies; LOFAR's next-generation capabilities give us a view of AGN structures that is much less biased than any preceding survey. However, new capabilities lead to new puzzles. One of these is the nature of an emerging population of low-luminosity, compact active nuclei in galaxies. To understand these we have proposed for and been awarded high-frequency Jansky VLA observations of a sample of compact sources selected from the LOFAR AGN population which will reveal their structure on small (sub-kpc) scales. The VLA data will be taken in late 2019. The student will join the LOFAR Surveys collaboration, analyse the VLA data and interpret the results, and plan follow-up science using the much larger LOFAR datasets that will be available in 2020.

LEEDS-1

Title: The southern ultra-compact H II region population

Partners: University of Leeds, UK and SKA-SA

Supervisors: Melvin Hoare and Stuart Lumsden (Leeds), Sharmila Goedhart (SARAO)

Description: In this project you will use data from the CORNISH-South survey taken with the Australia Telescope Compact Array to study the early stages of the formation of massive stars as they start to ionize their surroundings and form ultra-compact H II regions. This is the first high spatial resolution (2.5 arcsec) radio continuum survey of the southern Galactic plane. You will measure the radio fluxes, sizes, distances and infra-red colours to characterise and confirm the nature of the ultra-compact H II regions from the full CORNISH-South catalogue.

LEEDS-2

Title: The radio emission from young massive stars

Partners: Leeds, UK, & North West University, SA

Supervisors: Stuart Lumsden and Melvin Hoare (Leeds), James Chibueze (NWU)

Description: The CORE project is designed to study the fragmentation of molecular cores into protostars through observations with the NOEMA mm interferometer. As part of this project Leeds have taken the lead in obtaining radio maps of these sources with the JVLA. These maps can be used to search for thermal/non-thermal radio emission from the stars, as well as extended jets, to help us understand how feedback from the young stars affects their surroundings. You will reduce and analyse these JVLA data in order to achieve these goals.

LEEDS-3

Title: ALMA observations of complex organic molecules in protoplanetary disks: methyl cyanide as a gas temperature probe

Partners: Leeds, UK

Supervisors: Catherine Walsh (Leeds)

ALMA, the Atacama Large Millimeter/submillimeter Array, is a state-of-the-art telescope in Chile. It has the resolution and sensitivity to observe emission from dust and gas on size scales similar to that of the Solar System in nearby young exoplanet-forming systems. The research conducted during this project will involve the reduction and analysis of ALMA observations of gas-phase molecules in a nearby young exoplanet-forming sources obtained as part of the ALMA Large Programme, “Molecules with ALMA on Planet-forming Scales”. The project will involve determining the temperature structure of a protoplanetary disk using rotational transitions of methyl cyanide (CH3CN). The PGR will receive training in (sub)millimeter astronomy, interferometry, molecular astrophysics, radiative transfer techniques, numerical modelling, computer programming, and the treatment and manipulation of large datasets. This is great opportunity to gain vital skills needed for future large interferometric facilities such as SKA.

MAN-1

Title: Measuring magnetic fields in galaxy clusters using the eMERLIN telescope

Partners: University of Manchester, UK and SAAO, SA

Supervisors: Anna Scaife (JBCA) & Zara Randriamanakoto (SAAO)

Description: Clusters of galaxies are the largest gravitationally bound objects in the Universe. Containing tens to hundreds of galaxies each, clusters of galaxies are filled with hot thermal gas that emits in the X-ray band and which is permeated by large-

scale magnetic fields. Understanding the evolution of the magnetic field strength in galaxy clusters is a key science goal of the Square Kilometre Array (SKA). In this project the student will use new data from the eMERLIN telescope to study the polarised radio emission from galaxies embedded in galaxy clusters. The polarisation angle of this emission is rotated by the magnetised medium of the galaxy clusters through an effect known as Faraday rotation, which will enable us to measure the magnetic field strength in these galaxy clusters. One of the limitations of this method in previous studies has been the resolution of the radio observations. The eMERLIN telescope has comparable resolution to the forthcoming SKA1-MID telescope and this project will also help us to predict what SKA observations of similar cluster galaxies will look like. This project is primarily observational and the student will work with standard radio astronomy calibration and imaging packages such as CASA to make images from the eMERLIN data. With these images the student will then study the Faraday rotation across each galaxy and use those measurements to constrain the magnetic field strengths in ten galaxy clusters.

MAN-2

Title: SETI using interferometric techniques.

Partners: University of Manchester, UK and University of Pretoria and Berkeley SETI Research Center & Breakthrough Listen

Supervisors: Mike Garrett (JBCA & Leiden), Jack Radcliffe (Pretoria) and Andrew Siemion (Berkeley SETI Research Center & Breakthrough Listen).

Description: The Search for Extraterrestrial Intelligence (SETI) is one of the key science programmes of the SKA. Until recently, SETI searches have been conducted almost exclusively by single dishes (e.g. Arecibo) or beam-formed compact arrays (e.g. ATA). With new telescopes like the SKA and ngVLA being composed of multiple dishes distributed across hundreds of km, it makes sense to consider how such instruments might best be employed by SETI in general. Interferometry offers some advantages over traditional approaches (see arXiv:1810.07235) and this project would advance our understanding of how this technique could best be developed and deployed. The project requires the student to reduce large interferometric data sets, devise new calibration techniques appropriate for SETI, and develop python based software modules appropriate to recognise and extract SETI signals from the data.

MAN-3

Title: Characterising Filamentary Structures in Molecular Clouds

Partners: University of Manchester, UK and SA Institute TBA

Supervisor: Prof Gary Fuller, SA co-supervisor TBA

Description: Filamentary structures are ubiquitous in the interstellar medium. They are found spanning more than a factor of 1000 in scale-size from filamentary giant molecular clouds down to sub-structure in individual star forming cores. How these filaments form and evolve is key to understanding the star formation process. One important issue is how filaments can be systematically identified and how the method

of identification impacts the derived physical properties of the structures. In this project a number of different techniques for filament identification will be explored and compared. The different methods will be used on both real data and the results of numerical simulations. The goal of the project is assess the reliability of methods to identify filaments and constraint their properties to improve.

MAN-4

Title: Magnetic Fields and Massive Star Formation

Partners: University of Manchester, UK and SA Institute TBA

Supervisor: Prof Gary Fuller, SA co-supervisor TBA

Description: Magnetic fields pervade the interstellar medium (ISM). However, it is unclear what role these magnetic fields play in the formation and evolution of the ubiquitous filamentary structure of the ISM and the massive dense clumps within which massive stars and their associated stellar clusters form. This project will use observations of the polarized emission from dust to study the magnetic fields in a massive infrared dark clouds. These regions are not yet dominated by star formation and therefore are the most promising candidates for studying the role of the magnetic field with minimal confusing influence of feedback from embedded stars. The polarization properties of the regions will be compared with measurements of the gas properties to assess the relative roles of magnetic fields and turbulence in the evolution of the regions. The polarization and gas observations will also be compared with state of the art numerical simulations being carried out at JBCA to help constrain the interaction of the gas and magnetic fields in these regions.

MAN-5

Title: A radio interferometry study of water in the water fountain nebulae

Partners: University of Manchester, UK and SA Institute TBA

Supervisors: Albert Zijlstra and Anita Richards (Manchester), SA co-supervisor TBA

Description: Every death is different. Low and intermediate mass stars end their lives with a phase of spectacular mass loss, where between 40% and 80% of the stellar mass is ejected into space within about 100,000 years. The ejecta form a bright planetary nebula while the remnant of the star quickly evolves towards the white dwarf phase. A binary companion can have a dramatic effect in this phase, and can cause the formation of disks and jets. The most extreme (and rare) of these are the so-called water fountain nebulae, where the jets have velocity in excess of 100 km/s and are seen in maser lines of water molecules in the jets. The current project involved the reduction and analysis of high resolution 22GHz MERLIN observations of water masers in such objects. The unique spatial resolution will be used to map the location of the water emission, trace the velocity fields and derive the acceleration. The observations will show where the acceleration of the jets and outflows occur, and will address the question how and why the water fountains differ from the common planetary nebulae.