MSc AND PhD BURSARIES FOR 2023

CENTRE FOR RADIO COSMOLOGY

UNIVERSITY OF THE WESTERN CAPE

DEADLINE: 6 June 2022

The Centre for Radio Cosmology (CRC) at UWC is internationally recognised for its research in cosmology and galaxy evolution with MeerKAT, the Square Kilometre Array (SKA) and other telescopes (see astro.uwc.ac.za for further details). In 2022, the CRC research team includes 21 PhD/ MSc students and 11 postdoctoral fellows. Postgraduate students at the CRC work in a friendly and highly active research environment, with support from postdoctoral researchers.

The CRC is offering MSc and PhD bursaries for 2023. Successful applicants will be supervised by the team of CRC staff – Dr Ed Elson, Prof Lerothodi Leeuw, Dr Michelle Lochner, Prof Roy Maartens, Prof Mario Santos, Prof Russ Taylor – on cutting-edge projects described briefly below. The available topics cover the Key Science goals of the SKA in cosmology and galaxy evolution – which are closely linked to the science goals of the major upcoming optical/ infrared surveys, such as DESI, LSST and *Euclid*.

Students also have the possibility to be co-supervised by visiting professors Romeel Davé and Alkistis Pourtsidou (University of Edinburgh), Andrew Baker (Rutgers University), Matt Jarvis (Oxford University), Chris Clarkson (Queen Mary University of London), Stefano Camera (University of Turin), and Phil Bull (University of Manchester).

CRC students have opportunities to spend time in institutions abroad (depending on travel restrictions), in particular the ones just mentioned. Our research depends critically on data science and CRC students have access to the resources of our partner IDIA (Inter-University Institute for Data Intensive Astronomy) at UWC (www.idia.ac.za).

APPLICATIONS

Applicants should email a single PDF document containing the following:

- Your CV.
- Transcripts of all university-level results.
- A brief statement of research interests, related to the topics below (1 page). Please include any previous research experience, however minor, with details of the research project and supervisor.

Applicants should also arrange for 2 reference letters to be sent directly to us by the same closing date.

Email: ntnqakala@uwc.ac.za (Ms Nqakala)
Deadline: **6 June 2022**

Preference will be given to students who fit into the demographic guidelines provided by the NRF and SARAO (SA Radio Astronomy Observatory).

BURSARY VALUES

CRC bursaries are at the same level as bursaries from SARAO. The 2022 SARAO levels for *Full Cost of Study* are:

MSc: 2 years at R172,900 per year
+ travel grant (up to R29k/year) + equipment grant (up to R27k for 2 years)
PhD: 3 years at R180,430 per year
+ travel grant (up to R36k/year) + equipment grant (up to R40k for 3 years)

These may be increased for 2023. Please check NRF/SARAO rules for eligibility requirements.

BURSARY CONDITIONS

Bursaries are granted on a year by year basis - i.e. continuing into the next year depends on satisfactory progress.

RESEARCH TOPICS

We offer a range of topics that tackle some of the big questions at the forefront of international cosmology and galaxy evolution. Research students in South Africa have a historic opportunity provided by MeerKAT (sarao.ac.za/science/meerkat/) and the future SKA (skatelescope.org/). In each topic below, there is a focus on the South African-based radio arrays MeerKAT, SKA, HERA (reionization.org) and HIRAX (hirax.ukzn.ac.za/). Some topics also look at the synergy of radio surveys with optical/ infrared galaxy surveys such as LSST, DESI and *Euclid*.

Training in cutting-edge theory, computation, simulations and data science will be provided.

1. Measuring neutral hydrogen (HI) across cosmic time with MeerKAT

We will use MeerKAT observations to make statistical detections of neutral hydrogen intensity on cosmological scales. There are several projects, from more technical data analysis to simulations of the signal. These include the measurement of the power spectrum and detection of the elusive Baryon Acoustic Oscillations (BAO) that can constrain Dark Matter and Dark Energy. The data analysis techniques use state of the art statistical methods including machine learning algorithms.

2. Unveiling the properties of HI galaxies

Using existing multi-wavelength observations and upcoming MeerKAT data, we will investigate the properties of HI in galaxies, giving new information on the HI and Dark Matter content of the Universe. There are 2 possible projects. (a) Statistical techniques like ‘stacking’ will allow us to probe the mass function of HI galaxies down to low flux limits. (b) Using HI spectral line observations from current data, in particular MeerKAT, to study nearby HI galaxies and quantify their dynamics, mass distribution and star formation properties.

3. Probing the first galaxies in the Universe
We will investigate the Epoch of Reionization and use HERA data to probe the HI 21cm signal from the early Universe. There are several projects, including simulations of the signal, the observation pipeline and data analysis techniques (such techniques can include machine learning methods).

4. The radio continuum sky below the detection threshold
We will develop and apply statistical techniques (e.g. stacking) to radio continuum data from current surveys, in particular MeerKAT, to study the properties of radio galaxies below the detection threshold. This will allow us to constrain their source counts, luminosity functions and even 2-point correlation function at very low flux limits.

5. Machine learning in Astronomy
Telescopes such as the SKA in South Africa and the Vera C. Rubin Observatory in Chile will produce enormous quantities of data that will require novel techniques to analyse. This research topic aims to develop machine learning techniques for astronomical datasets, including those from MeerKAT. Of particular interest is the development of anomaly detection algorithms capable of discovering rare, or even completely new, objects in large data-sets.

6. Probing Dark Energy
Dark Energy is thought to be the source of the accelerating expansion of the Universe, and its properties can be accurately measured by using the probes extracted from HI and other surveys – such as the power spectrum, bispectrum, BAO scale, redshift-space distortions (RSD) and weak lensing. There are several possible projects, associated with different probes.

7. Testing Einstein's theory of General Relativity
We will explore whether the acceleration of the Universe is possibly not from Dark Energy, but instead from a modification of General Relativity – using the probes from HI and other surveys (especially RSD). There are several possible projects, associated with different probes and different tests.

8. Extracting ‘fossil’ information from the very early Universe
The primordial fluctuations generated in the first instants of the Universe provide the seeds for the formation of the large-scale structure. Imprints of the primordial Universe are ‘frozen’ in the large-scale distribution of matter. Using HI and other surveys, we can extract this ‘fossil’ information via some of the probes listed in Topic 6. There are several possible projects, associated with different probes and different properties.

We can also consider **other topics** on a case by case basis.