



# Application

## Postgraduate Bursary Programme

### Square Kilometre Array Project

- i. **Supervisor's Title and Full Name:** Professor Michaël Antonie van Wyk (email: mavanwyk@gmail.com).
- ii. **Supervisor's University:** University of the Witwatersrand, School of Electrical and Information Engineering
- iii. **Title of Research Project:** Direction of Arrival Estimation Techniques for Wideband Radio Frequency Sources
- iv. **Level of Research Project:** MSc Electrical Engineering
- v. **Overview and Aims of the Research Project (300 to 400 words max.)**

#### Overview:

To avoid the contaminated spectral bands of interest to Radio-Astronomical observatories and their sensitive data acquisition systems, desolate regions are selected for deploying such observatories. Digital broadcasting and multiple-access communication systems, whether satellite- or ground-based, produce wideband interference that affects even the remotest of locations due to sidelobe leakage. Radio-frequency interference (RFI) mitigation necessitates accurate localisation and tracking of these sources of RFI, for which direction of arrival (DOA) methods have become indispensable tools.

Historically, DOA methods have mostly been developed and studied in the context of narrowband signals, with some attempts to deal with the reality of modern wideband signal scenarios only appearing recently and then for very idealised situations only. Proposed methods build on the well-known methods such as MUSIC, ESPRIT, TOPS and variations on these themes [1].

Herewith we propose a *skills development* project that aims to expose an MSc-level student to modern wideband DOA methods [2], specifically setting out to analyse spectral properties of modern digital broadcast / communication signals, modelling such signals and then advancing to the application of wideband DOA methods as part of the RFI mitigation process [3]. The focus will be on the fundamental understanding of these methods, which would



prepare the student for subsequent research for further studies towards a PhD degree. The opportunity also exists for such an MSc student to implement selected algorithms on SDR and FPGA/DSP hardware and perform experiments in an anechoic chamber in the School of Electrical and Information Engineering here at the University of the Witwatersrand.

### **References:**

- [1] Yeo-Sun Yoon, "Direction-of-Arrival Estimation of Wideband Sources using Sensor Arrays," PhD Thesis, Georgia Institute of Technology, 2004.
- [2] Rui Guo, Yue Zang, Qianqiang Lin, Zengping Chen, "A Channelization-Based DOA Estimation Method for Wideband Signals," *Sensors*, 16, pp. 1–18, 2016,
- [3] International Telecommunication Union, "Techniques for mitigation of radio frequency interference in radio astronomy", Rep. ITU-R RA. 2126-1, 2013.

### **Aims of research project:**

1. Analysis and modelling of the spectral properties of specific wideband digital broadcast and multiple access communications radio-frequency signals.
2. Implement and simulate different wideband DOA algorithms; conduct a performance comparison study.
3. Incorporate the best performing wideband DOA algorithm in some RFI mitigation strategies in simulation; conduct a performance comparison study.
4. Preliminary experimentation and evaluation on available SDR / FPGA / DSP systems.

### **Relation to Priority Areas:**

The projects address the following priority areas:



- Hardware and data analysis systems for detecting, monitoring and identifying Radio Frequency Interference (RFI), including the use of telescope data (e.g. using MeerKAT visibilities to locate RFI sources).
- Real-time digital signal processing instrumentation for radio astronomy, specifically using FPGA and GPU platforms.

#### **vi. Work Breakdown Structure**

- Year 1 (100 to 200 words max.)

During the first year, the student is expected to conduct a literature survey on wideband DOA and RFI mitigation techniques, implement the relevant algorithms and simulate an interference scenario using a mathematical software package such as Matlab.

- Year 2 (100 to 200 words max.)

The student is expected to perform a numerical evaluation of the algorithms implemented in the first year. Preliminary hardware implementations will be undertaken as a skills development exercise. Finally, the thesis write-up is to be completed.

#### **vii. Access to Equipment**

WITS University is to provide access to SDR platform, as well as the FPGA and DSP hardware as required. WITS will provide office space on the campus for the candidate, as well as a PC and software required for the project.

#### **viii. Supervisor experience**

- Successfully supervised/co-supervised 36 MSc students.
- Successfully supervised/co-supervised 6 PhD students.
- Successfully supervised/co-supervised 4 Postdoctoral fellows.