Section A: Overview of the Research Project

1. Title of the research project

RFI direction finder for radio astronomy sites

2. Broad area of research

Engineering

3. Academic level of research project

Masters

4. Abstract of research project

Radio-frequency interference (RFI) from man-made sources is a major challenge in radio astronomy systems. Man-made RFI can be due to human negligence on a radio astronomy site, such as the use of portable electronics, or from nearby radio, television, or satellite transmissions. The aim of this research project is to develop an RFI direction-finding system that can determine the direction of arrival (DoA) of mainly narrowband RFI sources (e.g. telecommunications transmissions) using a dedicated wideband receiver or by making use of existing telescope data.

5. Primary supervisor's details

a. Heinrich Edgar Arnold Laue

b. heinrich.laue@up.ac.za

c. University of Pretoria

Section B: Details of Research Project

1. Scientific/Engineering merit

Techniques for mitigating the effect of RFI after digitisation exist, but requires knowledge of the RFI sources. Being able to determine the DoA of RFI sources, either using an independent system or using the telescope data itself, can aid in this process. Such DoA information can also be used to locate transmissions as a result of human negligence, e.g. cellular transmissions or the use of petrol vehicles on site.

An RFI radio direction finder would aid in the mitigation of RFI at radio astronomy installations such as MeerKAT.

2. Feasibility

Radio direction-finding is a well-proven technology. The focus of this project will be identifying the types of RFI sources that are likely to be found on a radio astronomy site (for example, MeerKAT) and develop an appropriate RFI direction finder.

Should this project require a custom wideband antenna to be developed, the labs at the University of Pretoria (UP) are equipped with the software and infrastructure required for the in-house design, manufacturing, and characterisation of antennas and RF components based on conventional printed circuit board (PCB) manufacturing techniques. The newly-installed PCB manufacturing facility at CEFIM allows high-precision, multi-layer RF PCBs to be manufactured in-house. The Compact Antenna Test Range at UP is able to characterise antennas, and the RF labs at CEFIM are equipped with measurement equipment suitable for developmental testing. Electromagnetic simulation software is also available.

Proposed objectives for this project include:

Year 1: Coursework, literature review, high-level design, detailed design, and design validation in numerical simulation.

Year 2: Hardware implementation/on-site deployment, testing, and evaluation, leading to the publication of a conference article.

3. Contribution to SARAO research priority areas

Area 3: Hardware and data analysis systems for detecting, monitoring and locating sources of Radio Frequency Interference (RFI).

This project will contribute to the ability to detect and localise man-made RFI sources on radio astronomy sites including local sites such as MeerKAT.

4. Required qualifications, academic abilities, skills and/or experience

A bachelor's degree in electronic engineering is required, including basic knowledge of electromagnetic theory and signal processing.

Section C: CV of the Primary Supervisor

Heinrich Edgar Arnold Laue

Ph.D. Pr. Eng. (ECN) Pr. Eng. (ECSA) MIEEE
Senior Lecturer
Department of Electrical, Electronic and Computer Engineering, University of Pretoria
heinrich.laue@up.ac.za | +27 12 420 2177

Education

Doctor of Philosophy (Engineering) 2020
Design of compressive antenna arrays *University of Pretoria, South Africa*
Bachelor of Engineer Honours (Electronic Engineering) 2016
With distinction (89.8%) *University of Pretoria, South Africa*
Bachelor of Engineering (Electronic Engineering) 2015
With distinction (79.5%) *University of Pretoria, South Africa*

Work Experience

University of Pretoria, South Africa
Senior Lecturer May 2023-present
Contract Lecturer (remote) Feb.-Jun. 2022; Feb.-Apr. 2023
Research, supervision, teaching, lab management, general administration

PCB manufacturing facility manager, CEFIM *2023-present*
EJJ 210 Professional and Technical Communication *2022-present*
ELO/EWE/ERD 320 210 Electronic/Electrical/Computer Engineering Design *2023-present*

Namibia Water Corporation Ltd Feb. 2019-Apr. 2023
Electronic Engineer in Training *Communications sub-division*
Telemetry and communications-network design, assembly, installation, commissioning, and maintenance; procurement; SCADA design, server maintenance and support to operational staff

University of Pretoria, South Africa 2015-2018
Assistant Lecturer (part-time)

Mentorship

Supervision of final-year project students *University of Pretoria, South Africa*

Keegan O'Reilly	Visual coffee roast development analyser	2023
Joshua Travern	Acoustic camera	2023
Tinosimuka Ndava	Multi-beam antenna array	2023
Mu'Azzam Omar	Reconfigurable intelligent radio-frequency surface	2023

Informal workplace mentorship
Candidate engineers and technicians at NamWater 2021-2022

Volunteer Experience

IEEE AFRICON 2023 2023
Chair, Track 3—Wireless Communication Systems, Antennas, Microwave Systems and Propagation Models

IEEE South Africa Antennas & Propagation/Microwave Theory & Technology/Electromagnetic Compatibility (AP/MTT/EMC) Joint Chapter Jul. 2022-present
Chapter officer: Students & Young Professionals

IEEE Antennas & Propagation Society Young Professional Ambassador 2022
Presented multiple talks at various international chapters/sections

Professional Memberships

Engineering Council of Namibia
Professional Engineer PE2107006

Engineering Council of South Africa
Professional Engineer 202101846

Institute of Electrical and Electronics Engineers (IEEE)
Member 2021-; student member 2016-2020 93936730

Personal Information

Date of birth
4 November 1991

Citizenship
Namibian

Languages
Afrikaans (native), English (proficient)

Publications

webofscience.com/wos/author/record/2183563 Scopus h-index: 5
orcid.org/0000-0002-5706-1539

Peer-reviewed journal publications

[1] H. E. A. Laue and W. P. du Plessis, "Design and analysis of a proof-of-concept chequered-network compressive array," in *IEEE Transactions on Antennas and Propagation*, vol. 70, no. 9, pp. 7546-7555, Sep. 2022.

[2] H. E. A. Laue and W. P. du Plessis, "A checkered network for implementing arbitrary overlapped feed networks," in *IEEE Transactions on Microwave Theory and Techniques*, vol. 67, no. 11, pp. 4632-4640, Nov. 2019 (with code).

[3] H. E. A. Laue and W. P. du Plessis, "Numerical optimization of compressive array feed networks," in *IEEE Transactions on Antennas and Propagation*, vol. 66, no. 7, pp. 3432-3440, Jul. 2018 (with code).

[4] H. E. A. Laue, "Demystifying compressive sensing [Lecture notes]," in *IEEE Signal Processing Magazine*, vol. 34, no. 4, pp. 171-176, Jul. 2017.

[5] H. E. A. Laue and W. P. du Plessis, "A coherence-based algorithm for optimizing rank-1 Grassmannian codebooks," in *IEEE Signal Processing Letters*, vol. 24, no. 6, pp. 823-827, Jun. 2017 (with code).

Peer-reviewed conference publications

[6] H. E. A. Laue and W. P. du Plessis, "Compressive direction-finding antenna array," in *IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications (APWC)*, Cairns, QLD, Australia, 19–23 Sep. 2016, pp. 158-161.

Other conference publications/presentations

[7] H. E. A. Laue and W. P. du Plessis, "Chequered-network compressive arrays: overview and future directions," in *International Conference on Electromagnetics in Advanced Applications (ICEAA)*, Cape Town, South Africa, 5–9 Sep. 2022, p. 64.

Popular articles

[8] H. E. A. Laue, "Innovation, a skewed balance between old and new—lessons from my journey to compressive antenna arrays" in *IEEE Antennas and Propagation Magazine*, vol. 65, no. 3, pp. 102-106, June 2023.

[9] "A new direction," in *Science Today* insert in Mail & Guardian, 2016. Available: https://sciencetoday.co.za/2016/11/14/a-new-direction/