Faculty of Science and Engineering

2021 Australian Government Research Training Program Scholarships
Strategic Project Profile

PROJECT TITLE: Suppression of Instrumental Noise Coupling in Closely-Spaced Antennas for Radio Cosmology

FIELD OF RESEARCH CODE: 0201; 0906; 1005

PROJECT SYNOPSIS:
Radio Cosmological observation involves reception of extremely faint signals from the early universe. These signals, which occupy the frequency range from tens of megahertz (MHz) to approximately 200 MHz, are received by radio instruments that consist of antenna(s), low-noise receiver(s), and a signal processor which may include a correlator. However, the instruments add their own noise which can be several orders of magnitudes above the desired signal. Therefore, the key to a successful detection is adequate suppression of such instrumental noise through prediction, modelling and/or cancellation schemes.
Despite these challenges, there has been a claim to detection using a single antenna system sited at the Murchison Radio-astronomy Observatory (MRO) in Western Australia. The interest now is to validate this claim using a different system and approach. A team of radio Cosmologists and engineers at the Curtin Institute of Radio Astronomy (CIRA) have been actively collaborating on these systems. One example of active research is the very-closely spaced antennas forming a radio interferometer. In this approach, the noise from each receiver connected to the antenna is independent such that the instrumental noise is thought to be uncorrelated. Despite the independent noise sources, however, it has been shown through advances in phased array antenna modelling and measurements that the output of the correlator contains significantly correlated noise from the low-noise amplifiers (LNAs). The reason for this is the LNA noise radiates through the antenna and enters a neighbouring antenna in the array. As a result, each receiver branch contains noise from all other branches, resulting in the correlated instrumental noise at the output. This process is called noise coupling.

Our calculations have shown that the residual correlated noise due to noise coupling can be one to two orders of magnitude above the desired Cosmological signal. The objective of the project is to reduce this to below the expected level of the Cosmological signal. A few leading approaches that have emerged include noise coupling decorrelation, noise modelling and subtraction, and a noise cancelling system. These techniques can be shown to work under the assumption that the parameters of the device in question are fully known and match the model; however, there is a practical limit to how well these parameters can be known under realistic MRO field conditions. An important component of the project, therefore, is to carefully evaluate the impact of variation in the device parameters under temperature, humidity, aging and slight mismatches between components on the residual correlation. These effects will be characterised, and based on analysis of the outcome the leading method will be selected. Methods to predict device behaviour under field conditions through inputs from simple environmental sensors will also be evaluated to enhance the robustness of the noise coupling suppression.

FEASIBILITY AND RESOURCING – DESCRIPTION OF THE SUPPORT THIS PROJECT WILL RECEIVE:

The student will be supported by a fully equipped engineering laboratory at CIRA as well as access to simulation software available through our engineering servers. CIRA is a part of The International Centre for Radio Astronomy Research (ICRAR) which is joint venture between Curtin and the University of Western Australia receiving support from the State Government of Western Australia in preparation for hosting the Square Kilometre Array (SKA) in Western Australia. For more information regarding engineering program at ICRAR, visit: https://www.icrar.org/our-research/technology-engineering-program/

THE SIGNIFICANCE OF THE PROJECT/ PROGRAM FOR THE ENROLLING SCHOOL OR INSTITUTION:

Successful outcome of this project will significantly increase the chance of successful detection of early-universe Cosmological signal by suppression of noise coupling. Overcoming this effect is key to successful detection. This is significant because Cosmology is a key science case of CIRA as an organization and that of the next-generation Low-Frequency SKA (SKA-Low) telescope.
Students must express interest in this scholarship opportunity by emailing the Project Lead listed below. Please provide a copy of your current curriculum vitae and detail your suitability to be involved in this strategic project.

**PROJECT LEAD CONTACT:**

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