Innovation Placement Project: Imaging Simulations for SKA-LOW

Summary

Industry partner: Square Kilometre Array Organisation

Location: Jodrell Bank Observatory, Lower Withington, Macclesfield SK11 9DL

Contact: Dr Robert Laing, SKA System Scientist, r.laing@skatelescope.org

Project overview: The aim of this project is to develop novel computational techniques to quantify the effects of errors in station calibration on the performance of SKA-LOW and to evaluate the effects of other potential limiting factors affecting its performance for imaging of the Epoch of Reionization.

Activity to be undertaken

The Square Kilometre Array (SKA) project is an international effort to build the world’s largest radio telescope. Two arrays are currently being designed: SKA1-MID (for frequencies between 350 MHz and 20 GHz) and SKA1-LOW (50 - 350 MHz). This project concerns SKA1-LOW, which will use 512 stations each of 256 antennas located in Western Australia. The highest priority science case for this array is to image neutral hydrogen at redshifts of around 10, where the Universe becomes partially ionized by the first stars and active galaxies - the Epoch of Reionization (EoR). Detecting the EoR is extremely challenging, and requires careful control of systematic errors. One aspect of this is the calibration of the individual aperture-array stations. Signals from the 256 antennas in a station must be combined with the correct time delays and weights to form a beam in the direction of observations. Any errors in this process limit the imaging performance of the array and therefore its ability to detect faint spectral and spatial signatures of the EoR. The present project will evaluate the effects of different levels of error on the derived images. The detailed work programme is as follows:

- Using embedded-element patterns calculated from electromagnetic simulations, use the OSKAR software to evaluate station beams with and without calibration errors included
- Simulate interferometric visibilities for the SKA-LOW configuration using a detailed sky model over a range of frequencies, apply simulated ionospheric delay errors and add in the effects of station-beam errors
- Apply state-of-the-art direction-dependent calibration methods
- Evaluate the effects of residual errors on the resulting image cubes

The project is at the cutting edge of radio-astronomy data processing and is also an important test of the final design of the SKA.

The position will be based at SKAO Headquarters and the successful candidate will work as part of the established SKA SIM team. This includes members from the Universities of Cambridge and Oxford as well as SKAO staff and external collaborators. The position is available from September 2019 or as soon as possible thereafter.
Skills / Knowledge / Expertise

The award holder will require a background in data processing for radio interferometry. Experience in coding (ideally in python) is also important. (S)he will gain knowledge of high-performance computing techniques which will be widely applicable in industry and would be ideally placed to contribute to the SKA project in the future. The benefit to the SKA project is a cost-effective test of a novel data-reduction strategy and a more rigorous prediction of operational availability.

Deliverables

1. Report and associated data for a simulation of the effects of dish pointing errors

2. Report on an assessment of pointing self-calibration for SKA1-MID and derived requirements for dish pointing accuracy

Both of these reports could form the basis for refereed publications as well as informing the SKA design process.