Towards more realistic MWA simulations using OSKAR

Research Field
Radio Astronomy/Computer Engineering

Project Suitability
Masters
PhD

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The Murchison Widefield Array (MWA) is a low frequency radio (think FM radio waves) interferometer consisting of 2048 dipole antennas, spread over 5km out in the WA outback. The MWA is indirectly capable of imaging the radio sky by correlating and processing the signals captured by each antenna, rather than immediately making an image like a traditional optical telescope. The data collected by the telescope is affected by a slew of instrumental effects such as receiver noise, reflections within cables connecting antennas, and frequency related effects imparted by the analogue signal processing known as the 'bandpass'. All these effects must be understood and mitigated to enable science.

Real data contains unknown astrophysical and atmospheric effects as well as these instrumental effects, making it hard to isolate and understand each effect. Realistically simulating observations gives us a path to individually investigate each effect and test our calibration and imaging software. Simulating interferometric data is computationally expensive, and as such requires efficient code. OSKAR is such a simulation package and utilises GPU acceleration to simulate up to millions of radio sources. In the images below, a real observation is shown on the left, and an OSKAR simulation shown on the right, showing excellent agreement.

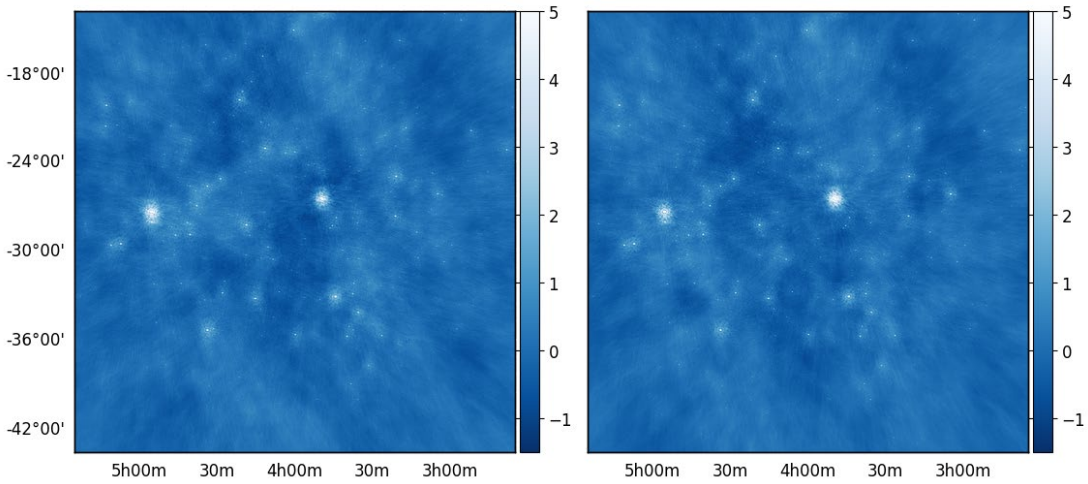

Figure – Left: 2 minutes of real MWA data imaged. Each bright spot is an image of a radio-emitting galaxy. Right: 2 minutes of MWA data simulated using OSKAR and 300,000 radio sources

OSKAR is a generic package and as such does not include the instrumental quirks of the MWA. The aims of this project then would be:

- Add instrumental effects, such as the bandpass and cable reflections into the OSKAR simulation pipeline. This could either be done internally to the OSKAR code or added to the data after the fact, depending on the computational experience of the student
- Test how well our current calibration software, the RTS, deals with these instrumental effects, and investigate how this might affect the scientific quality of processed MWA data
- Compare to real data from the MWA
- Depending on the scope of the project, think about adding atmospheric effects from the ionosphere into the OSKAR simulation package