Simulating all-sky MWA observations using WODEN

Research Field
Radio Astronomy

Project Suitability
PhD
Masters

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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 and reflections within cables connecting antennas. 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. Furthermore, the MWA has an extremely large field-of-view, being able to see essentially all the way down to the horizon.

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 however and is further compounded by the field-of-view of the MWA, as one must simulate essentially the entire sky. One solution is to implement parallel code on GPUs, to which end we have begun developing a software package dubbed WODEN.

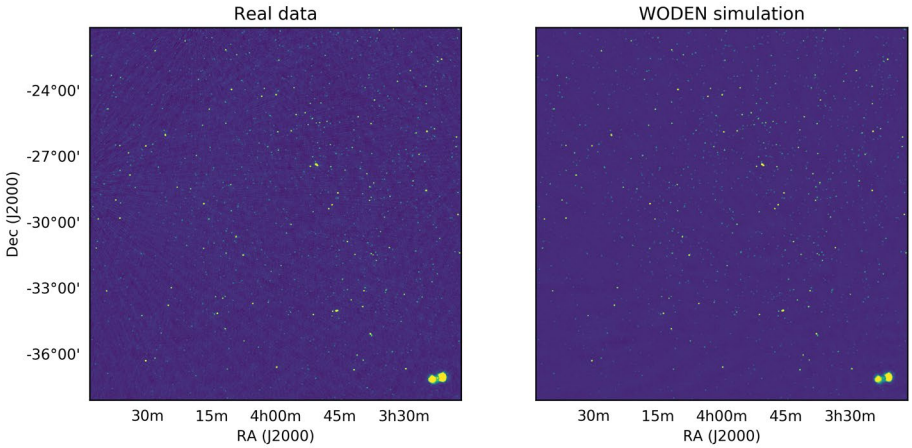

Figure 1: A comparison of an image made from real MWA data (left) containing the large and bright galaxy Fornax A seen bottom right, and an image made with the WODEN simulation package (right).

The goal of this project would be to develop a fast but accurate way of simulating all-sky emission through WODEN. One could simply split the sky into pixels, but at the required resolutions, this will require > 100 million pixels. As an interferometer records data in the Fourier transform space of an image, an alternative is to take an all-sky image, Fourier transform, and sample using a suitable kernel, to generate simulated interferometric data. This process is known as 'degridding'. The aims of this project would then be:

- Implement GPU-based degridding in WODEN and compare to pixel-based methods
- 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, or other instrumental effects

This project would suit computationally minded physics majors, or comp-sci students with a strong interest in astrophysics.