Simulating the Sky as Seen by the Square Kilometer Array using the MIT Array Performance Simulator (MAPS)

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I. Background

The Square Kilometer Array (SKA) is a next-generation radio telescope array being planned by the international radio astronomy community. The SKA will operate over a wide range of frequencies (1.0 to 30 GHz) and once fully operational, will be 50-100 times more sensitive than existing radio arrays. At 1.4 GHz, the sensitivity is limited to a limiting flux density of ~10 nJy (from a 3-hour integration). Construction (in Australia or South Africa) is expected to begin some time around 2012 and the full operation is expected by 2024.

SKA'sitters is to remain within the observatories, particularly at beam frequencies, where confusion will be limited. Moreover, currently favored SKA sites require large areas of land dedicated to the array. New hardware developments (e.g., correlator FOV shaping, Lonsdale et al. 2004), and new software (e.g., Cornwell 2007) will be required to overcome these limitations. Testing and optimizing these tools, as well as optimizing the overall design of the SKA, demands the ability to model the sky background and its impact on radio SKA observations.

II. An Overview of MAPS

Development of the MIT Array Performance Simulator (MAPS) began at MIT Haystack Observatory in 2001 with the goal of providing a flexible tool for the generation of simulated low-frequency radio array observations and for testing new/revised calibration and analysis techniques. Initially, MAPS was created as a virtual radio telescope, but over time, a number of enhancements to MAPS have been incorporated by Randall Wayth and collaborators (Wayth et al., in prep.).

MAPS was designed to accommodate detailed descriptions of heterogeneous interferometric arrays and a variety of other highly flexible user inputs. Features include:

- Ability to input an arbitrary sky brightness distribution
- Option to include out-of-beam sources
- User-specified array geometries (including placement and orientation of individual receivers)
- Station-based beam forming
- Variable station beams
- beamforming through an input template (VLA and GCC; field-of-view, time and frequency resolution, bandwidth, channel width, correlation integration times, observation start and stop times)
- Option to include thermal noise
- Time- and location-dependent ionospheric effects; modeling of large- and small-scale ionospheric structure
- Fully polarized instrument response
- Ability to do all-sky simulations
- Ability to export simulated data into FITS format

A schematic illustrating how MAPS can be used for an arbitrary sky simulation is shown in Fig. 1. MAPS has a command-line-driven interface, with user inputs specified via command-line switches and text files.

MAPS remains under active development. The current version is maintained by R. Wayth and collaborators (Wayth et al., in prep.).

References


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