Beamforming for the ASKAP Radio Telescope

A. P. Chippendale*[1], K. W. Bannister[1], S. Hegarty[2], I. Heywood[1,3], A. W. Hotan[1], J. Marvil[1], D. McConnell[1], R. J. Sault[1,4], and P. Serra[1]

[1] CSIRO Astronomy and Space Science, PO Box 76, Epping, NSW 1710, Australia, http://www.atnf.csiro.au/projects/askap
[2] Centre for Astrophysics and Computing, Swinburne University of Technology, PO Box 218, Hawthorn, Victoria 3122, Australia
[3] Department of Physics and Electronics, Rhodes University, PO Box 94, Grahamstown 6140, South Africa
[4] School of Physics, University of Melbourne, Victoria 3010, Australia

This presentation will discuss work underway to implement reliable beamforming algorithms for the Australian Square Kilometre Array Pathfinder (ASKAP) telescope and to understand how beamforming impacts astronomical measurements made with phased array feeds (PAFs).

We have commenced exploring links between beamforming and astronomical performance with PAFs via extensive experimentation with the Boolardy Engineering Test Array (BETA, Hotan et al., PASA, 2014). This array consists of six Mark I PAFs, each installed at the focus of a 12 m parabolic reflector ASKAP antenna, and a real-time digital back-end capable of forming and simultaneously processing nine dual-polarisation beams, each with 304 MHz bandwidth per polarisation.

Key measurements have included beam-equivalent sensitivity over the field-of-view, isolating system temperature and antenna efficiency via drift-scans of the galactic plane, measurement of port and beam patterns via holography, calibration of the gain and phase bandpass of beams, and detection of per-port gain variations and sampler delay jumps using the PAF array covariance matrix.

We have made wide-field images that demonstrate stability in time and good fidelity in both source flux and spectral index when compared to surveys made with other telescopes. We have also found the polarimetric response of PAF beams to be good and stable, but that the ability to make wide-field polarimetric images is critically dependent on the beamforming algorithm. The majority of our work has been performed with maximum signal-to-noise ratio beamformer weights, but we are now implementing and characterising beams generated by the linearly constrained minimum variance algorithm and by least-squares fitting to template beam patterns.

CSIRO are installing PAFs at the foci of 36 parabolic reflector antennas to form the ASKAP radio telescope. The ASKAP PAFs are a 94 port $\times$ 2 polarisation version of a planar connected "chequerboard" array (Hay and O'Sullivan, Radio Science, 43, no. 6, 2008). They operate over 0.7 GHz to 1.8 GHz and, together with digital beamformers, enable each 12 m diameter ASKAP antenna to observe a 30 deg^2 field of view and survey the sky extremely rapidly.

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