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Commissioning the Very Small Array

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Abstract. The Very Small Array (VSA) is a fourteen-element interferometer for sensitive measurement of the CMB anisotropies on scales of three degrees to ten arcminutes. The telescope is now observing on site in Tenerife after a period of commissioning, including the first map of the Sunyaev–Zel'dovich effect in the Coma cluster.

A distinguishing feature of the instrument is that each antenna in the array tracks quasi-independently, providing a characteristic fringe rate per baseline which can be used to reject many systematics. This effect has been optimised in the antenna array design.

1. Introduction

The VSA (see Paul Scott, these Proceedings) is an interferometric experiment for mapping anisotropies in the the CMB. An interferometer is well-suited to measuring such a signal as antenna baselines directly sample the Fourier modes of the sky which can be readily converted to a power spectrum. In addition interferometers can provide excellent rejection of systematic noise due to filtering of signals which do not move with the celestial sky, and by switching and correlating of the signal from each antenna which removes instrumental drifts.

The telescope was assembled and tested at the Mullard Radio Astronomy Observatory, Lord's Bridge, near Cambridge, between February 1998 and November 1999, prior to being shipped to the Observatorio del Teide, Tenerife at 2400m altitude.

2. Commissioning Observations

Commissioning data from the new site show that the design sensitivity has been achieved, that atmospheric contamination is negligible (correlated emission is undetectable for $> 80\%$ of the time and contribution to the noise temperature is ~ 5K) and that the telescope is remarkably stable over long periods. The calibration of a baseline varies in phase by an average of only 8° in 15 days.

As part of the commissioning the first ever map of the Sunyaev–Zel'dovich effect in the Coma cluster was produced (Fig. 1). This 5σ result was produced in 12x4hrs using $< 40\lambda$ data from 6 baselines. As well as primordial CMB work the VSA will produce SZ maps of many low-z clusters.

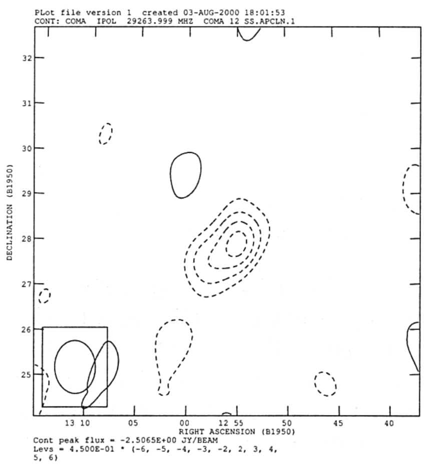

Figure 1. CLEANed map of the SZ effect in the Coma cluster. Contour levels are 450mJy beam^{-1}, beam size 1.17°x0.91°.

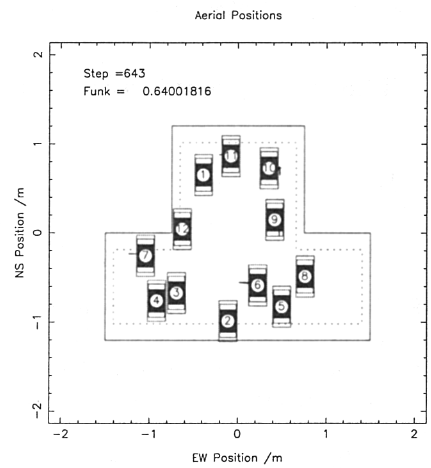

Figure 2. Twelve antenna VSA array design, optimised for Fourier-plane coverage and fringe rate, on a restricted table area.

3. Array Design

The VSA is unique amongst current CMB interferometers in that its antennas track the sky independently in one dimension. This results in a variable path from each antenna to the source and thus a characteristic fringe rate on each baseline. Non-astronomical contaminants, such as cross-talk, ground-spill and the atmosphere, have differing paths to the antennas and can thus be identified and filtered from the data.

The fringe rate however drops to zero where a baseline lies perpendicular to the source motion. These samples must be flagged from the data, reducing the sensitivity and distorting the Fourier-plane coverage.

The VSA array has been designed to minimise the low fringe samples (typically to $\sim 6\%$ under 3 cycles hr^{-1}), whilst also optimising the Fourier-plane coverage for power spectrum recovery (Fig. 2).

4. Conclusions

The VSA has finished commissioning and is now observing CMB fields. Its design has been optimised for maximum rejection of many non-astronomical contaminants. For the removal of astronomical source contamination see Angela Taylor and EM Waldram, these Proceedings.

Acknowledgments. The VSA is a collaboration between Cavendish Astrophysics (University of Cambridge, UK), Jodrell Bank Observatory (University of Manchester, UK) and Instituto de Astrofísica de Canarias (Tenerife, Spain).