FIRST RESULT FROM THE VERY SMALL ARRAY: COSMOLOGICAL PARAMETER ESTIMATION, AND FUTURE WORK

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The Very Small Array (VSA) is a 14 element Interferometer, operating at between 26-36 GHz, which has been constructed expressly to measure the anisotropies in the CMB. Here we present the constraints on the basic set of cosmological parameters in the standard ΛCDM inflationary model that are obtained using data taken using the VSA's 'compact' configuration, which probes the CMB power spectrum in the range $150 < l < 900$. We will also describe future work, including the testing of this dataset for Non-Gaussianity.

1 Independent analyses

In order to demonstrate the robust nature of our parameter estimates, model-fitting to the VSA compact array dataset was performed using three independent analyses.

The first and second of these both used the straightforward method of calculating likelihood values over a hypercube grid of the parameters. They were performed using two independently written sets of code, to guard against software errors. In both cases, the grids used were sufficently large that the likelihood function tends to zero at their edge so that, in effect, we only apply a very weak top-hat prior to the results by using a finite grid.

A third analysis was also employed, using a Markov Chain Monte-Carlo (MCMC) method to probe the parameter space. The full details of this method can be found in [4].

We found that the results from the three analyses were all consistent. This gives us confidence that our analysis software is correct.

2 Simulating the data pipeline

In addition to the three independent analyses performed, we also simulated the entire data pipeline to ensure that it did not introduce any bias into the data.

Table 1: Cosmological parameters estimated from VSA and COBE data, using several priors. All the confidence regions correspond to the 68 per cent level.

Prior	$\Omega_b h^2$	n_s	Ω_{tot}	$\Omega_{cdm} h^2$	Ω_m	Ω_Λ
$\{0.4 < h < 0.9\}$	$0.029^{+0.009}_{-0.009}$	$1.04^{+0.11}_{-0.08}$	$1.03^{+0.12}_{-0.12}$	$0.13^{+0.08}_{-0.05}$	-	-
$\{0.4 < h < 0.9\} + \{\tau = 0\}$	$0.026^{+0.008}_{-0.008}$	$0.99^{+0.06}_{-0.07}$	$1.01^{+0.12}_{-0.13}$	$0.13^{+0.08}_{-0.05}$	-	-
$\{10\,\text{Gyr} < \text{age} < 20\,\text{Gyr}\}$	$0.028^{+0.009}_{-0.008}$	$1.02^{+0.11}_{-0.08}$	$1.05^{+0.14}_{-0.12}$	$0.12^{+0.05}_{-0.04}$	-	-
$\{10\,\text{Gyr} < \text{age} < 20\,\text{Gyr}\} + \{\tau = 0\}$	$0.025^{+0.008}_{-0.008}$	$0.97^{+0.06}_{-0.07}$	$1.03^{+0.15}_{-0.12}$	$0.12^{+0.06}_{-0.04}$	-	-
$\{h = 0.72 \pm 0.08\} + \{10\,\text{Gyr} < \text{age} < 20\,\text{Gyr}\}$	$0.028^{+0.007}_{-0.008}$	$1.00^{+0.08}_{-0.05}$	$0.96^{+0.06}_{-0.12}$	$0.19^{+0.08}_{-0.07}$	$0.48^{+0.08}_{-0.21}$	$0.47^{+0.33}_{-0.16}$
$\{\text{SNIa}\} + \{0.4 < h < 0.9\}$	$0.029^{+0.009}_{-0.009}$	$1.02^{+0.12}_{-0.08}$	$1.02^{+0.08}_{-0.06}$	$0.09^{+0.05}_{-0.04}$	$0.32^{+0.09}_{-0.06}$	$0.71^{+0.07}_{-0.07}$

Starting with simulated realisations of the Fourier modes of a ΛCDM CMB sky with known input cosmological parameters, we produced simulated observations of the CMB by the VSA and then used our data reduction procedures and the MADCOW software package [5] to recover estimates of the power spectrum. Having done this, we were able to successfully recover the original input cosmological parameters of the simulation using the above analysis pipelines. Thus, we can be confident that our data pipeline is unbiased.

3 Results: Cosmological parameter estimates

The Cosmological parameter estimates were principally made using the VSA and COBE data points. The analyses were performed using a variety of priors (see table 1).

We have also combined our data with the SN1a dataset, and separately with a prior on the Hubble parameter consistent with the Hubble key project (or, equivalently, constraints from combined X-ray/S-Z observations). In all cases ,we found our data to be consistent (within the 68% confidence region) with a flat universe with a scalar spectral index of one. Our peak value for $\Omega_b h^2$ is a little higher than is found in Big Bang Nucleosynthesis (BBN), however the BBN result does overlap with the 68% confidence limits of our results, implying no significant discrepency between these results.

4 Further work

4.1 Testing for non-Gaussianity

We are currently testing our data for non-Gaussianty (NG) [6]. NG is interesting for several reasons. Firstly, any NG which is primordial in origin would be a good tracer of some of the alternative (to inflation) mechanisms for CMB isotropy, such as cosmic strings. Various foregrounds to the CMB, such as the galaxy, radio point sources and the S-Z effect, also possess NG signatures, and so NG testing can tell us if we are subject to significant contamination from these. Additionally, instrumental systematic effects are often NG in nature, so NG testing provides us with a good way of searching out these effects as well. And finally, our analysis to find the CMB power spectrum contains the assumption that the data is Gaussian distributed, so we need to check to make sure that this is really true!

4.2 Shallow survey and the extended array

Due to the relatively small area of the sky observed by the VSA, the errors on our estimates of the first acoustic peak in the CMB power spectrum are dominated by sample variance. To improve on this situation, we have performed a shallow, wide area survey using the compact array. We will be analysing this data in order to improve our results in this region.

Beyond the compact array, we have now switched over to the extended array configuration, which features longer baselines and larger antenna horns, enabling us to probe the CMB power spectrum out to beyond l=1800 with a factor of 5 improvement in flux sensitivity over the compact array. The extended array is fully operational, and has been observing primordial fields since September 2001.

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