DEEP 10 AND 15 GHZ SEARCHES FOR CMB ANISOTROPIES

R. D. Davies
University of Manchester
Nuffield Radio Astronomy Laboratories
Jodrell Bank, Macclesfield
Cheshire, UK

A. N. Lasenby
University of Cambridge
Mullard Radio Astronomy Observatory
Madingley Road
Cambridge

The search for anisotropies in the Cosmic Microwave Background (CMB) is fundamental to observational cosmology: it requires observations on a range of angular scales and at a range of frequencies to distinguish CMB structure from foreground galactic structure. We have made significant progress in setting new limits to CMB anisotropies on angular scales of 3°-12° using scaled observing systems at 10 and 15 GHz. This regime of angular scales is particularly matched to the predictions of Cold Dark Matter (CDM) and isocurvature scenarios of galaxy formation in the early Universe.

Our first deep search for anisotropies was made at 10 GHz using a beam switching technique employing an 8° beam with an 8° throw (Davies *et al.* 1987). Anisotropies were detected at an rms level of $\Delta T/T = 3.7\times10^{-5}$ as seen in the system output; this level corresponded to an intrinsic rms in the sky (before convolution with the beam) of $\Delta T/T = 5.7\times10^{-5}$. It was not clear whether this detection referred to structure in the CMB or in the Galaxy. An entirely independent experiment at 10 GHz also with an 8° throw but employing a 5° beamwidth showed the same features, confirming that the structure was astronomical in origin and not any artifact of the observing system. These results required higher frequency observations. 15 GHz was chosen as a suitable frequency where cryogenically cooled HEMT technology was well established for reliable long-term operation on the high and dry site at Teide Observatory, Tenerife. Galactic emission is expected to be a factor of ~3 less than at 10 GHz.

The first results are now available from the 15 GHz experiment which is a scaled version of the 10 GHz, 5° beamwidth system. A 24 hr RA scan at Dec = +40° is now available for analysis and comparison with 10 GHz data. The rms noise per beamwidth in the added data in the system output is 20 μK. A likelihood analysis was performed on

J. Bergeron (ed.), Highlights of Astronomy, Vol. 9, 323–325.
© 1992 *IAU. Printed in the Netherlands.*

https://doi.org/10.1017/S1539299600009138 Published online by Cambridge University Press

the high galactic latitude part of the RA scan to make a firm statistical assessment of the astronomical signal in the data at both 10 and 15 GHz.

At 10 GHz there is a clear detection with an intrinsic $\Delta T/T = 5.5\times10^{-5}$ consistent with 8° beamwidth 10 GHz data of Davies *et al.* (1987). The likelihood ratio maximizes at an angular scale of 6°-8° (FWHP). Smoothed in our observing beam, $\Delta T/T$ (5°) = 3.9×10^{-5}. By contrast, the 15 GHz data shows no detection, with the likelihood rising smoothly towards zero fluctuation amplitude. An upper limit on the intrinsic fluctuation amplitude at 95 percent confidence is $\Delta T/T$ (intrinsic) < 1.84×10^{-5}. It might be expected that galactic synchrotron emission with a brightness temperature spectral index of ~3 would make a significant contribution to this value of the upper limit. Indeed the structure in the 10 GHz scan is weakly seen in the 15 GHz data, suggesting a spectral index of 3.1, a value suggested for the limiting spectral index by Banday and Wolfendale (1991). However if the 10 GHz scan scaled by this spectral index is subtracted from the 15 GHz data, the upper limit to the rms fluctuations is not significantly reduced because of the weakness of the galactic contribution relative to the 15 GHz noise. We prefer at this stage to set a conservative upper limit of 1.8×10^{-5} to the intrinsic fluctuations from the direct observations.

These results on degree scales, when taken with those of Readhead *et al.* (1989), leave very little parameter space for open adiabatic fluctuation models (Vittorio *et al.* 1991). Similarly Hot Dark Matter adiabatic models as well as isocurvature models appear to be ruled by these results. The relaxation of the constraints on the various scenarios produced in cosmological models with a cosmical repulsion term (e.g. Sugiyama, Gouda and Sasaki 1990) does not save most scenarios in face the new upper limits presented here.

The current 15 GHz experiment is capable of pushing a factor of two lower where the galactic contribution will become measurable. A 30 GHz scaled experiment is currently in operation at Teide Observatory; this will be unaffected by galactic emission at a level of $\Delta T/T \leq 2\times10^{-6}$.

We acknowledge the contributions of our collaborators, Robert Watson and John Hopkins at Jodrell Bank, Stephen Hancock at MRAO, Raphael Rebolo, Carlos Gutierrez and John Beckman at the Instituto de Astrofisica de Canarias, Tenerife, Spain.

References

Banday, A. J. and Wolfendale, A. W., 1991. *Mon. Not. R. Astr. Soc.*, 248, 705.

Davies, R. D., Lasenby, A. N., Watson, R. A., Daintree, E. J., Hopkins, J., Beckman, J. E., Sanchez-Almeida, J. and Rebolo, R., 1987. *Nature*, 326, 462.

https://doi.org/10.1017/S1539299600009138 Published online by Cambridge University Press

Readhead, A. C. S., Lawrence, C. R., Myers, S. T., Sargent, W. L. W., Hardebeck, H. E. and Moffett, A. T., 1989. *Astrophys. J.*, 346, 566.

Sugiyama, N., Gouda, N. and Sasaki, M., 1990. *Astrophys. J.*, 365, 432.

Vittorio, N., Meinhold, P., Muciaccia, P. F., Lubin, P. and Silk, J., 1991. *Astrophys. J.*, 372, L1.

https://doi.org/10.1017/S1539299600009138 Published online by Cambridge University Press