10 to 60 ARCMIN FLUCTUATIONS IN THE COSMIC MICROWAVE BACKGROUND

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Considerable astronomical interest attaches to sensitive measurements of temperature fluctuations of the microwave background on scales of a few arcmins to a few degrees. We describe here the first in a series of experiments being carried out at Jodrell Bank which are aimed at providing reliable and repeatable information on these angular scales. The first experiment used the MK II 25m dish at λ6 cm and covered scales from 10 arcmin (the beamwidth) to 60 arcmin (twice the beamthrow). At this relatively long wavelength, the atmosphere has negligible effect on the observations and day to day repeatability consistent with receiver noise alone was obtained. The observations were made in wagging mode near the North Celestial Pole (NCP) so that the two beams alternately traced out a reference circle on the sky, radius 30 arcmin, over the course of 24 hours. The NCP field was chosen since a high sensitivity discrete source survey (Pauliny-Toth et al. 1978) was already available covering the area. This meant that antenna temperatures around the reference circle could be corrected for any source induced effects $\gtrsim$0.4 mK. In addition control observations were made at positions 30 arcmin East and West of the central field, so that systematic effects due to interaction of telescope sidelobes with objects in the immediate telescope environment, could be monitored and removed. Because of the high degree of repeatability of the data we were able to carry out this process in detail, and derive three tracks, each 188 arcmin long, fully corrected for known sources and systematic effects. The main statistical analysis was carried out on the track for the central region (which had the fullest coverage) after deletion of points observed during daylight hours, which were affected by the Sun. On the 10 arcmin scale this left 11 independent points around the reference circle. An explicit estimator for the amount of intrinsic sky variance compatible with the observed residual variations was constructed and an upper limit (at 95% confidence) of 0.86 mK (in brightness temperature) was found, corresponding to a limit to $\delta T/T$ of 3.0×10^{-4}. The upper limits for the 30 and 60 arcmin scales, found by combining points in groups, were 4.6×10^{-4} and 2.3×10^{-3} respectively. In addition the temperatures of the three observing centres relative to the mean temperature around their reference circles could be found.

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These showed significant displacements away from zero and after allowing for possible effects of weak sources below the limit of the Pauliny-Toth et al. survey, a tentative indication of intrinsic anisotropy at a level of 9 x 10^{-5} between these points (30 arcmin apart) was found. Further observations both at Bonn (to detect weaker sources) and at Jodrell Bank (to include more observing centres) have been made to shed light on this possible detection and to refine further our upper limits on variations around the reference circles.

Our present limits on the 10 to 60 arcmin scales rule out existing theories of galaxy formation through adiabatic perturbations in the early universe, but are not yet sufficiently sensitive to rule out theories based on isothermal perturbations. We are examining ways of analysing the data via an angular autocovariance function, which as stressed by Davis & Boynton (1980) is the natural way of expressing the predictions of such theories.

As part of this overall study we have used the same observing methods to investigate the possible microwave decrement in the clusters A576 and A2218. We find clear evidence for emission at λ6 cm at the centres of both clusters.

REFERENCES

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DISCUSSION

Jones: Rosie Wyse and I recalculated the damping of adiabatic perturbations through recombination and the resultant temperature fluctuations in the microwave background. Generally speaking, we find that previous estimates of $\delta T/T$ are too large and our numbers are easily consistent with your observations.

Bonometto: I have recently recomputed small scale fluctuations due to adiabatic fluctuations. What we find is a dependence on the spectral index if it is sufficiently large. Just choosing $|\delta(k)|^2 \propto k^u$ with u = 0 before recombination, adiabatic fluctuations give results that are not in contradiction with the microwave background limits.

Kaiser: I have calculated the small angle fluctuations of the CBR in the adiabatic scenario and I have found it possible to construct models in which nonlinear structure forms by z = 3 and the temperature fluctuations do not exceed 10^{-4} even with Ω as low as 0.1. These fluctuations occur predominantly on an angular scale ≃ 3 × $\Omega^{1/2}$ arcmin

It seems plausible that in the isothermal picture reioniza- may occur, in which case the last scattering shell is broad and small-scale fluctuations would be "washed out."

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Lasenby: I have recomputed the predictions for RMS($\delta T/T$) in the minimal isothermal case (that is, just Doppler scattering), and I have found results that are more optimistic from an observational point of view than those given by Davis and Boynton. Even so, the current upper limits will have to be reduced by factors of at least 3 to 4 before they come into conflict with the revised predictions, so invoking secondary ionization as a way out is not necessary yet.

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