NEW LIMITS TO THE SMALL SCALE FLUCTUATIONS IN THE COSMIC BACKGROUND RADIATION

K. I. Kellermann and E. B. Fomalont
National Radio Astronomy Observatory*

J. V. Wall
Royal Greenwich Observatory

The VLA has been used at 4.9 GHz to observe a small region of sky in order to extend the radio source count to low flux density (Fomalont et al., these proceedings) and to look for small scale fluctuations in the 2.7 K cosmic microwave background radiation.

The new VLA observations were made in September 1981 in the D-configuration which synthesized a 700-m diameter aperture to give a resolution of 18 arcsec (FWHP) at 4.9 GHz. Forty hours, spaced over four different nights, were spent integrating on a field centered at $\alpha = 00^h15^m24^s$, $\delta = 15°33'00''$ (epoch 1950.0). The field of view was limited by the primary beam of the 25-m antennas with a diameter of 8.9 arcmin (FWHP). The system noise temperature was 60 K and we observed in both left and right circular polarizations (LCP and RCP) using a 50 MHz bandwidth for each polarization.

The instrumental and atmospheric gain and phase fluctuations were monitored by observing the nearby calibrator source 0007+171 for two minutes at 30 minute intervals. The flux density scale was obtained from an observation of 3C48 which we assumed has a flux density of 5.36 Jy at 4.9 GHz. Radio maps were made in the usual manner and the CLEAN algorithm was used to deconvolve the effects of the sidelobes in the synthesized beam pattern. The map size contains 512 x 512 pixels each with a separation of six arcsec. This corresponds to a field of view of 51.2 arcmin and thus the map extends well beyond the primary beam response pattern of the 25-m antennas. The fluctuations across the radio maps were analyzed by examining distribution of the observed deflections. Only the negative portion of the distribution was used in calculating the fluctuation characteristics since the faint discrete radio sources produce a positive tail in the histograms.

Fluctuations in the radio maps may arise from receiver noise,

* *Operated by Associated Universities, Inc., under contract with the National Science Foundation.*

G. O. Abell and G. Chincarini (eds.), Early Evolution of the Universe and Its Present Structure, 125–126.

https://doi.org/10.1017/S0074180900038791 Published online by Cambridge University Press

instrumental instabilities, tropospheric path-length changes during the observations, and real sky brightness fluctuations. The difference map between the LCP and RCP observations is a good indication of the actual observational sensitivity since many instrumental effects and all tropospheric emission which is not circularly polarized are canceled. This distribution for the entire 512 x 512 map of the quantity (LCP-RCP)/$\sqrt{2}$ gives an rms of 10.3 μJy which is in reasonable agreement with the value of 8.5 estimated from the relevant system parameters. For the inner 6.4 arc minutes of this map alone (64 x 64 pixels), the distribution of noise fluctuations is essentially identical to that of the entire 512 x 512 map.

The analysis of the distribution of the average of the two polarizations (LCP + RCP)/2 gives a value of 11.2 mJy over the entire 512 x 512. The rms fluctuations in the inner part of the averaged map covering 6.4 arcmin (well within the FWHP primary beam) are 15.4 μJy, corresponding to an additional fluctuation of 10.3 μJy (the quadrature difference between 15.4 and 11.2).

We also have examined radio maps with 60 arcsec resolution by heavily weighting the data associated with the shorter spacings. A similar analysis of this data to that of the 18 arcsec resolution data gives the following results. The rms of the averaged map is 42 μJy over the 512 x 512 map; the rms of the averaged map in the inner 6.4 arcmin area is 54 μJy. This corresponds to an excess of 34 μJy in the center of the map with a resolution of 60 arcsec. This excess may be caused by real sky brightness fluctuations or by subtle instrumental effects, and we have taken the observed excess as the maximum possible true value. We thus place the following upper limits to possible small scale fluctuations in the cosmic background radiation, including a correction for the average primary beam attenuation of 20%.

TABLE 1. Limits to Background Fluctuations at 4.9 GHz

Angular scale	rms fluctuations	$\Delta T/T$
18 arcsec	13 μJy	7.8×10^{-4}
60 arcsec	40 μJy	2.1×10^{-4}

The present results appear to be limited by receiver noise and instrumental effects at about the same level. It will be difficult to improve them significantly using the VLA without a large increase in observing time and bandwidth and a better understanding of the magnitude and effect of small correlator offsets and very low cross talk between the antennas.

The detection of measurable fluctuations in the microwave background on scales of the order of tens of arcsec would be of particular interest since this corresponds to the scale associated with mass fluctuations which might be associated with the formation of galaxies in the early universe.

https://doi.org/10.1017/S0074180900038791 Published online by Cambridge University Press