DEEP RADIO SOURCE COUNTS AND SMALL SCALE FLUCTUATIONS OF THE MICROWAVE BACKGROUND RADIATION.

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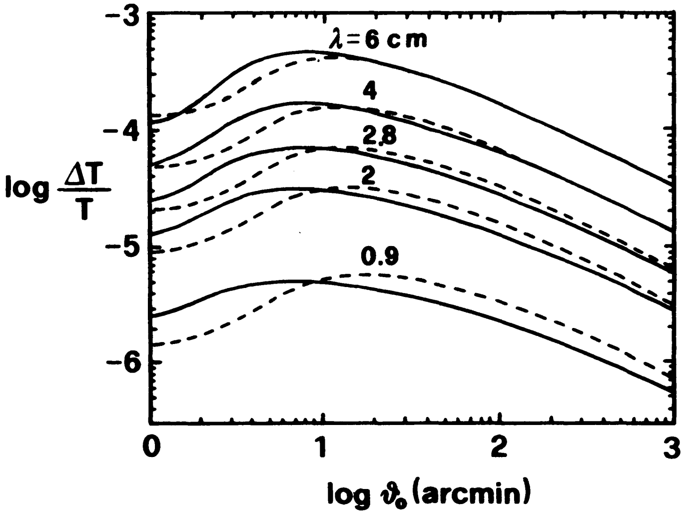
Source counts which now extend to surface densities of $\sim 10^5$ sources/sr make possible a direct evaluation of the radio source contribution to the small-scale fluctuations in the microwave background on scales larger than $\sim$10', at wavelengths $\gtrsim$6 cm. Comprehensive radio spectral data permit a straightforward and largely model-independent extrapolation of the N(S) relation to shorter wavelengths. On the other hand, Peacock and Gull (1981, hereafter PG) have constructed a set of models which incorporate a wealth of additional data, such as local luminosity functions, luminosity/redshift distributions, luminosity-spectral index correlations; they can therefore be exploited to optimize the extrapolations both to higher frequencies and to fainter flux densities. Only one of these models, however, namely No. 4, is consistent with the recent P(D) results (Wall et al. 1982; Ledden et al. 1980) which provide information on the areal density of sources at s$\sim$1mJy; therefore, in the following we shall focus on it. (It is interesting to note, in passing, that P(D) counts do not reflect the faint end of counts at 408 MHz as it



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would be expected in view of the rapid convergence of the flat spectrum source counts below 500 mJy. In fact, PG model 4 predicts that 5 GHz counts at S<lmJy are dominated by flat spectrum sources. The figure shows the temperature fluctuations as a function of the angular scale as predicted, at several wavelengths, by PG model 4 (continuous lines) and by Kulkarni's (1978) model A (dashed lines). The latter is used to illustrate the fact the results are essentially independent of the adopted radio luminosity function. The small discrepancies between the two models at angular scales <10' simply reflect the uncertainties in the counts at mJy levels; the widening of differences with increasing frequency is the effect of different assumptions about the spectral index distributions. The largest uncertainty in our calculations is associated with the assumption that all sources have a simple power law spectrum with constant spectral index up to very high frequencies; in fact, it is known that the spectra of many compact sources steepen above some frequency $\nu_s \simeq 20 - 30$ GHz. At $\nu > \nu_s$ an increase $\Delta\alpha$ of the mean spectral index results, for a given flux density, in a decrease of the counts by a factor $(\nu(1+z_e)/\nu_s)^{\Delta\alpha(1-\beta)}$, where z_e is the effective redshift of countec sources and β is the slope of differential counts. For $\nu < \nu_s$, the effect of steepening is restricted to those flux densities where counts are dominated by sources at $z > (\nu_s/\nu-1)$. It is easly seen that, for reasonable values of ν_s, z_e and $\Delta\alpha$, the effect is small, at least for $\lambda > 3$ cm, and even at $\lambda = 0.9$ cm the amplitude of expected fluctuations can hardly decrease by more than a factor of 3 to 5.

The amplitude of fluctuations $\Delta T/T$ peaks at angular scales $\theta_o \sim 10'$ where it reaches values $> 10^{-4}$ for $\lambda > 3$ cm. This means that the most sensitive searches for primordial anisotropies at cm wavelengths have already come close to the source confusion limit. Primordial anisotropies of amplitude $\Delta T/T \sim 10^{-5}$ on angular scales in the range from a few arcminutes to $\sim 1°$ can possibly be detected only if observations are made at $\lambda \lesssim 1.5$ cm. However, inhomogeneous atmospheric emission may be a problem at such wavelengths.

References

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DISCUSSION

Ekers: It is possible to correct for the effect of discrete sources by obtaining higher angular resolution observations to determine the contribution from discrete sources and subtracting these from the lower resolution observation.

de Zotti: The results I presented were obtained by assuming that sources are subtracted when they provide a deflection larger than the r.m.s. value by a factor ≥ 3. The technique you mention may certainly decrease the discrete source contribution to fluctuations; I suspect, however, that the uncertainties inherent in such subtraction will not allow a decrease by a large factor.

Wilkinson: I would like to make two points which contradict statements made by several speakers: 1) for small-scale anisotropy measurements at wavelengths of 1 cm or less, radio sources are not a problem. System noise will provide a higher limit; 2) on angular scales of a few arcminutes, atmospheric fluctuations do not limit accuracy at $\lambda = 1.5$ cm.

These comments are based on a recent small-scale measurement done by Juan Uson and me, using the NRAO maser and 140-foot telescope. From a beam size of $1\overset{'}{.}5$ and a beam throw of $4\overset{'}{.}5$, the result is $\delta T/T < 1.1 \times 10^{-4}$ with 95% confidence; 24 spots along $\delta = 87°$ were observed. The result is only two times larger than the ideal limit for a 50 K system noise. About one-third of the total observing time was useful.

de Zotti: 1) The figure clearly shows that at $\lambda \simeq 1.5$ cm, fluctuations due to discrete sources are at least one order of magnitude below your upper limit to $\Delta T/T$; therefore, I can only agree with your comment.

2) It is also not a surprise that atmospheric fluctuations at that wavelength and on an arcminute angular scale are well below $\delta T/T \sim 10^{-4}$; on the other hand, we expect that they may become a problem for substantially more sensitive future experiments ($\delta T/T \sim 10^{-5}$), especially on larger angular scales and for still shorter wavelengths.

Kaiser: The CBR fluctuations in the adiabatic picture are predicted to display 20% linear polarization, so sensitive polarimetry may enable us to detect or constrain cosmological fluctuations at a level below the amplitude of the discrete source fluctuations.

Windhorst: Do the latest 21 and 6 cm VLA deep source counts below 1 mJy enable you to make a more definite choice between the various models?

de Zotti: For our purpose, the VLA counts do more than allow a better choice between models. They permit us to extend the direct, model-independent estimates of fluctuations at $\lambda \geq 6$ cm to essentially the full range of angular scales we have considered. Preliminary checks show that the models we have adopted are in reasonable agreement with the VLA data and lead to the estimate that our extrapolations below 10', at $\lambda \geq 6$ cm, cannot be in error by more than a factor of 1.5.