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Large Scale Density Inhomogeneities in the Universe

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LETTERS TO THE EDITOR

ASTRONOMY

Large Scale Density Inhomogeneities in the Universe

Sachs and Wolfe have recently considered the possibility of large scale density inhomogeneities in the universe with characteristic dimensions of the order of 10^9 parsecs.[1]. The suggestion[2] that quasi-stellar sources with highly red-shifted spectra are not isotropically distributed has aroused interest in large inhomogeneities. Rees and Sciama[3] have suggested that the tendency to cluster of quasi-stellar sources with large z implies that the mass of the universe may not be homogeneously distributed on a scale of $z \sim 1$. Although the observational status of the anisotropy of the distribution of these sources is in some doubt[4], we have recently obtained results which appear to set rather stringent limits on the magnitude of possible density inhomogeneities in the universe.

The recently discovered cosmic microwave background[5–8] originates at an epoch corresponding to a very large red-shift, and thus provides a powerful tool for investigating the isotropy and homogeneity of the universe on the largest scale. We have already pointed out[9] that our early results set limits of the order of 10 per cent to the large scale density inhomogeneities of the type considered in ref. 1. Conklin and Bracewell[10] have shown that inhomogeneities greater than 0·2 per cent in the background radiation do not appear to be present on a scale of angular resolution of the order of 1°, at least in the restricted area of the sky they surveyed.

For the past fifteen months, we have measured the isotropy and homogeneity of the cosmic microwave background. A Dicke radiometer operating at 3·2 cm wavelength was specially designed for this experiment[9]. Our measurements were made by comparing the temperature of the background microwave radiation along a full circle running 8° south of the celestial equator with the temperature measured at the north celestial pole, a fixed point in the sky. The temperature difference is displayed as a function of right ascension in Fig. 1, in which each point represents an average of the data obtained from about eighty runs, each of which lasted about 24 h. Before the results were averaged, a constant instrumental offset, C_{24}, was subtracted from the data of each run (see ref. 9). The temperature difference was averaged over an hour in sidereal time because this is approximately the angular resolution of our horn antenna. It can be seen from Fig. 1 that the largest departure from zero is of the order of 0·016° K, which should be compared with 3° K, the assumed value for the mean temperature of the microwave background[6–8]. Most of the random error in the data arises from fluctuations in the radiation temperature of the atmosphere; we estimate that this random error is about $\pm 0{\cdot}003°$ K.

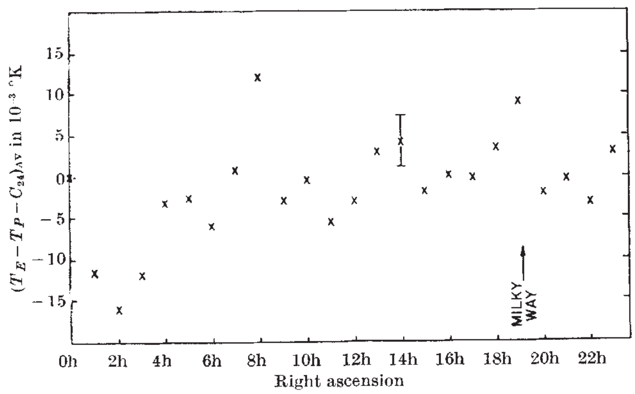

Fig. 1. Changes in the temperature of the background radiation along a circle parallel to the celestial equator at −8° dec. are displayed. The measurements were made with a 3·2 cm radiometer having an angular resolution of about 1 h in right ascension.

The passage of the central region of the Milky Way through our beam may be indicated by the slight increase in T_E at 19 h R.A. At ~ 2 h R.A. and near the celestial equator, there appears to be a more extended region of lower temperature. This feature closely corresponds in position and extent to one of the clusters of quasi-stellar sources suggested by Rees and Sciama[3]. Because the depth of this feature is only a few times the estimated error for a single point, however, its existence cannot yet be regarded as well established.

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[1] Sachs, R. K., and Wolfe, A. M., *Astrophys. J.*, **147**, 73 (1967).
[2] Strittmater, P., Faulkner, J., and Walmesley, M., *Nature*, **212**, 1441 (1966).
[3] Rees, M. J., and Sciama, D. W., *Nature*, **213**, 374 (1967).
[4] Penston, M. V., and Rowan-Robinson, G. M., *Nature*, **213**, 375 (1967).
[5] Dicke, R. H., Peebles, P. J. E., Roll, P. G., and Wilkinson, D. T., *Astrophys. J.*, **142**, 414 (1965).
[6] Penzias, A. A., and Wilson, R. W., *Astrophys. J.*, **142**, 419 (1965).
[7] Roll, P. G., and Wilkinson, D. T., *Phys. Rev. Lett.*, **16**, 405 (1966).
[8] Howell, T., and Shakeshaft, J. R., *Nature*, **210**, 1318 (1966).
[9] Partridge, R. B., and Wilkinson, D. T., *Phys. Rev. Lett.*, **18**, 557 (1967).
[10] Conklin, E. K., and Bracewell, R. N., *Phys. Rev. Lett.*, **18**, 614 (1967).

PLANETARY SCIENCE

Luni–Solar Daily Variations of the Geomagnetic Field at Tananarive during the International Geophysical Year

A PROGRAMME for the analysis of IGY data from magnetic observatories for luni-solar variations has recently been extended to the observatory at Tananarive, Madagascar (18° 55′ S., 47° 33′ E.). This site is of particular interest because it lies at dip latitude $\varphi = -34{\cdot}8°$ ($\tan\varphi = \frac{1}{2}\tan I$, where I is the magnetic dip). No data between $\varphi = -24°$ (St. Helena, D only) and $\varphi = -47°$ (Cape Town, Hermanus) have previously been analysed. In addition Tananarive is an inland observatory, so it is unlikely to have an anomalous luni-solar variation in Z, as is the case for coastal observatories[1].

The data consisted of instantaneous values of D, H and Z measured every 2 h at odd hours of Universal Time from July 1, 1957–December 30, 1958. Because of breaks in the records, August 22 and 23, 1958, were omitted for all elements and August 13 and 14, 1958, for D. Also, for reasons considered earlier[1], the five International Disturbed Days of each month were omitted.

The method of analysis and derivation of vector probable errors followed that described by Leaton, Malin and Finch[2], which is closely similar to that of Chapman and Miller[3]. The object of the analysis was the calculation of l_n and λ_n, the amplitude and phase of L_n, the luni-solar daily harmonic

$$L_n = l_n \sin(nt - 2\nu + \lambda_n)$$

where n is a small integer, t is the mean solar time measured from local midnight and ν is a measure of the epoch in a lunation which increases from 0 at one new moon to 2π at the next.