29th International Cosmic Ray Conference Pune (2005) **4**, 61–64

Cosmic Ray Contributions to the Cosmic Microwave Background

T. Wibig[a] and A. W. Wolfendale[b]

(a) Department of Experimental Physics, University of Lodz, Poland;
The Andrzej Soltan Institute for Nuclear Studies, Cosmic Ray Lab., Lodz
(b) Department of Physics, University of Durham, Durham, UK
Presenter: A.W. Wolfendale (a.w.wolfendale@durham.ac.uk), uki-wolfendale-AW-abs3-og21-poster

Virtually all searches for astrophysical quantities have a cosmic ray (CR) background – or foreground – and we argue that the cosmic microwave background (CMB) radiation is no exception. An analysis has been made of searches for signatures in the CMB fluctuation map (WMAP(1)) which relate to Galactic phenomena in general and cosmic ray phenomena in particular.

It is argued that the conventional values of the cosmological parameters derived from WMAP are in need of revision.

1. Introduction

The famous WMAP [1] of the fluctuations in the CMB temperature is generally regarded as the most important map in contemporary astronomy. Certainly, important consequences for cosmology have been gleaned from its analysis [eg 2] and these have been both comprehensive and profound.

Recently [3] we have examined the map ([2] cleaned by the authors for their estimated CR contribution) in a variety of ways that will be described here. New results will also be included.

2. General Remarks

It is inevitable that there will be a finite contribution to the CMB map from CR effects, by way of synchrotron radiation, free – free emission and dust, the latter being warmed, in part, by CR. Early work was done by us [4] and this showed that the (correlated) sum of synchrotron and dust emission had a near – CMB temperature profile in the important frequency range 30–100 GHz and thus could not easily be removed. These early predictions have been confirmed by very recent analysis [eg 5]. The problem arises in that subtraction of this contribution from the measured map is not a trivial procedure and in our view the corrections so far have not been complete.

3. Geometrical Properties

Irrespective of the mechanism, the observation of effects correlated with Galactic parameters (eg symmetry about the Galactic Plane, differences between the Galactic Quadrants...) would show that there are residual deleterious components. We have identified the following:

(a) A Galactic North – South asymmetry

(b) Galactic quadrant effects

(c) A variety of symmetries

The above relate to mean temperatures and to the mean power of various l–values (the harmonics of an expansion of the map data).

Related effects have been recorded by others [eg 6, 7]. The conclusion is that there are residual foregrounds near the Galactic Plane ($|b| < 10°$) and that the important latitude region $|b| <= 10° - 20°$has been over-corrected. At higher latitudes there are correlations with phenomena seen in radio–maps (e.g. at 408 MHz [8])

At the highest latitudes, $|b| > 45°$, axes of symmetry have been determined for both the WMAP and other radiations, not least CRs (as evinced for electrons and protons in [9] and [10])

Some, and perhaps all, of the symmetries and asymmetries, etc., can be related to CR–effects, and this aspect will now be examined.

4. Cosmic Ray Effects

A tentative explanation of CR–contributions to the CMB temperature is that they come from CR–heating of cold dust grains away from the Galactic Plane. We have identified regions of the sky where such CR–effects should be low or high, as can be seen in Figure 1. The 'low' regions comprise parts of the sky where the column density of gas is low ('Galactic Chimneys', etc. or the CR spectra are steep, and the relevant CR intensities will be low. The 'high' regions are SNR shells where the CR intensity is higher than average as evinced by gamma ray studies [11, 12 and 13].

Figure 1 shows the situation; it is seen that 'low' CR regions have mainly negative temperatures and the opposite for 'high' CR regions.

There is little doubt that there is a strong effect; formally it is at the 10^-4 level for the negative excursions and 10^-3 for the positive ones.

Further analysis have included a search for a correlation between the mean CMB temperature and the gamma ray intensity [13]. The situation here is not clear cut. There are strong positive correlations in the Outer Galaxy but negative ones in the Inner Galaxy. The influence of gamma rays produced by Inverse-Compton interactions with starlight (a different mechanism from that postulated for our CR–induced foreground) may provide an explanation, but there is no certainty.

A restricted analysis of 30 GeV gamma ray data near the Galactic Plane (for $|b| < 10°$, has shown rather strong correlations for the range $|b| = 6° - 10°$, where we would have expected the biggest effect; at smaller latitudes, overlapping effects are very large and at larger latitudes statistical errors become large.

5. Applications to Cosmology

We have identified CR–concerned anomalies which affect the position of the 'one–degree–peak'(i.e. the ℓ–value) and its height and the amplitude of the power spectrum at small l–values, all of which have an effect on the derived cosmological 'constraints'. The last mentioned is particularly interesting. The original analysis showed reduced power at low ℓ (below $\ell \simeq 10$), and this led to the speculation of 'new physics' [14]. It is possible that 'cosmic variance' is responsible but not too likely. The cosmic ray analysis is important in that it favours a more normal amplitude of the power spectrum in this region.

The situation with respect to the one–degree peak is interesting in that our 'best peak' in the power spectrum is lower in intensity and at a lower ℓ-value than in the standard form.

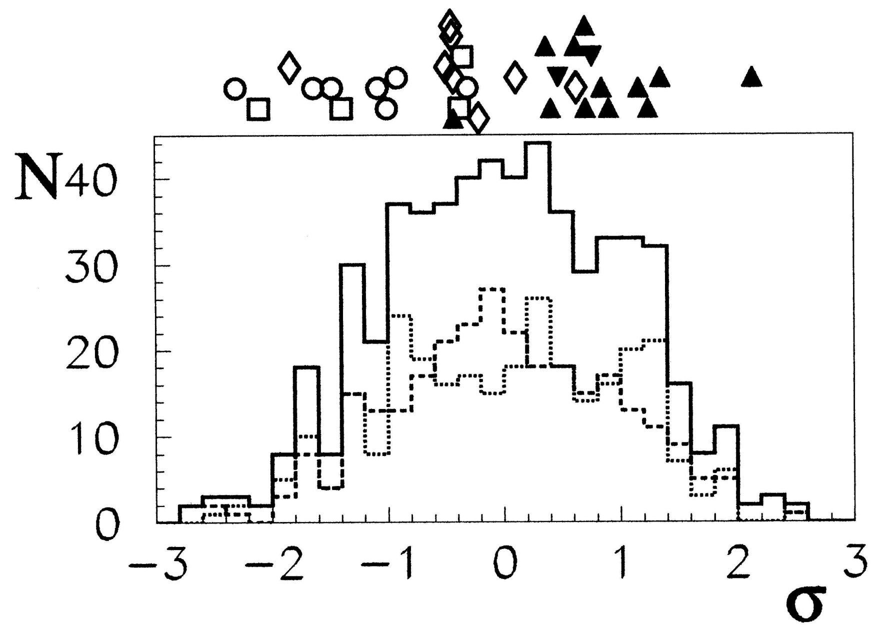

Figure 1. Excesses and Deficits. Values for the C–R associated excesses and deficits of CMB temperature in comparison with the frequency distribution of mean temperatures for similar spatial regions are shown by the solid histogram (dashed and dotted histograms are for the Northern and Southern hemispheres, respectively). The filled–in symbols relate to the SNR shell excesses and the open symbols are for hydrogen poor regions and regions having steep electron or proton spectra where we expect deficits. The histogram is for similar areas distributed at random all over the sky. 'N' is the number of 'areas'

Briefly, the conclusions are as follows:

1. The presently – derived cosmological constants are in need of revision.
2. If only one parameter – the universal mass fraction, $\Omega_m h^{2-}$ can be adjusted it should be increased from 0.15 to 0.22 ± 0.05; such an increase has important consequences.
3. A low ℓ, we can see a reason why the previous low power should be ruled out, and the more conventional view accepted.

References

[1] Tegmark M. et al., 2003, Phys. Rev **D65**, 123523.
[2] Bennett C.L. et al., 2003a, Ap.J., 583, 1; 2003b, Ap.J.Suppl, 148.
[3]Wibig T. and Wolfendale A.W., 2005, M. N. R. A. S. (in press).

[4] Banday A.J. and Wolfendale A.W., 1990, Mon. Not. R. Astr. Soc. 245 182.
[5] De Oliveira-Costa A et al., 2004, Ap. J. Lett., 606 L89.
[6] Ericksen, H.K. et el., 2004, Ap.J. 605, 14.
[7] Hansen F.K. et al., 2004, Ap. J. Lett., 607 667.
[8] C.G.T. Haslam et al., 1981, 'Origin of Cosmic Rays', Ed. G. Setti, G. Spada and A.W. Wolfendale, IAU symp. No. 94, 217.
[9] Fathoohi L.J. et al., 1985, J Phys. G21, 679; 1985, J. Phys. G 21, 1547.
[10] Erlykin A.D. and Wolfendale A.W., 2001, J. Phys. G 27, 941.
[11] Wolfendale A.W. and Zhang L., 1994, J. Phys G 20, 935.
[12] Osborne J.L. et al., 1995, J. Phys. G., 21, 429.
[13] Hunter S.D. et al., 1997, Ap.J. 481, 205.
[14] Efstathiou, G., 2003, Mon.Not.R.Astr.Soc., 343, L95.