The CBR frequency spectrum below 1 GHz recent results and new observations

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Abstract. We are carrying on measurements of the absolute temperature of the CBR at various frequencies near and below 1 GHz, looking for so far undetected deviations from a planckian spectrum. The amplitude and frequency of those distortions can give precious information about the history of the Universe.

Deviations from a planckian distribution in the frequency spectrum of the Cosmic Background Radiation (CBR) may have been produced by the energy releases associated to various processes (matter - antimatter annihilation, dissipation of shok waves and turbulences, birth of matter condensations etc.) and still be visible if the nergy release occurred at $Z_i \leq 10^6$. A search for deviations $\Delta T/T$ from a flat (planckian) distribution of measured values of T_{CBR}, the thermodynamic temperature of the CBR, versus ν can tell us about the past history of the Universe up to $Z_i \simeq 10^6$.

In spite of the efforts of many authors (for a review see for instance Sironi and Celora 1990), no evidence of distortions has been so far obtained. Between 30 and 900 GHz stringent limits ($\Delta T/T < 1\%$) have been set by Mather et al. (1990) and Gush et al. (1990).Between 30 GHz and 2.5 GHz the 5% upper limit set in 1984 by the White Mt. collaboration (Smoot et al. 1985) is still valid. Below 2.5 GHz the limits go up and reach $\sim 30\%$ or more below 1 GHz. High and low frequency distortions are related to diferent periods of the Universe history, therefore we cannot conclude from the high frequency limits that also at low frequency distortions, if present, are small. Recent numerical analyses (Burigana et al. 1991) have shown for instance that we can expect large distortions near and below 1 GHz without any appreciable distortion at higher frequencies. The frequency and amplitude of those distortions are affected by the density and temperature of the intergalactic medium. The maximum deviation from the equilibrium distribution is expected at a wavelength:

$$\lambda_m \simeq 5.64 \hat{\Omega}_b^{2/3} cm \qquad (1)$$

which is directly related to the barion density $\hat{\Omega}_b = \Omega_b (H_0/50)^2$ of the Universe.

In view of that in 1985 our group in Milano and the group of G.Smoot in Berkeley began a program of new measurements of T_{CBR} at $\nu < 2$ GHz, a frequency region which had been practically abandoned after a few observations made immediately after the discovery of the CBR. In particular the Milano group concentrated on observations at $\nu <$ 1 GHz and repetitions of the measurement at 2.5 GHz, to have a link with the results obtained between 2.5 and 90 GHz by the White Mt. collaboration (Smoot et al. 1985). Table 1 gives a list of the data in literature at $\nu < 3$ GHz, including our recent results. The error bars at low frequency are very large because: i)the values of temperature one can find in literature for T_{gal}, the galactic diffuse radiation, and T_{ex}, the blend of the unresolved extragalactic sources, have large uncertainties. They have to be subtracted from T_{sky}, the temperature of the sky, to get T_{CBR}, and their importance increases as the frequency decreases. Moreover T_{gal} must be known if one uses zenith scans to measure the

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atmospheric contribution to the antenna temperature; ii)the wavelenghts are such that the waveguides are too large and the coaxial cables too lossy therefore large correcting factors are required to work out the absolute value of the antenna temperature. iii)the level of radio interferences is extremely high below 1 GHz and continues to increase.

To obtain substantial improvements over the results listed above new instrumental and observational procedures are necessary. With the aim of reaching a final uncertainty on T_{CBR} of 300 mK at 0.6 GHz and 100 mK at 2.5 GHz we set up at Campo Imperatore, (lat.=42^0 26' N, long.=13^0 33' E, elev.=2000 m a.s.l.), a radioquiet site on the Italian Appennines, a completely new experiment. It is based on i)three radiometers at 0.6, 0.82 and 2.5 GHz. They use geometrically scaled corrugated horns with beams shaped for minimum sensitivity to signals from undesired directions. ii)the collected signals pass through a spectrum analyzer whose output is continously monitored for rejection of the interferences. iii)a new reference sources which uses waveguides down to 0.6 GHz is under construction. The expected accuracy of its temperature is 50 mK. iv)simultaneous observations at the three frequencies for about two years will give multifrequency maps of T_{sky} from which T_{CBR}, T_{gal} and T_{ex} will be obtained by modelling their the frequency and spatial distribution. Regular observations at the three requencies will begin in spring 1992.

We are also involved with other peoples in the feasability study of LOBO (LOw frequency Background Observatory), a space experiment intended to cover the frequency spectrum of the diffuse radiation from $\sim$ 30 GHz down to $\sim$ 0.5 GHz.

Table 1 - A list of data at $\nu < 3$ GHz

ν (GHz)	λ (cm)	T_{CBR} (K)	Reference
0.408-0.610	73-49	3.7 ± 1.2	Howell and Shakeshaft 1967 : Nature **216**, 753
0.600	50	3.0 ± 1.2	Sironi et al. 1990 : Ap.J. **357**, 301
0.635	47.2	3.0 ± 0.5	Stankevich et al. 1970 : Aust. J. Phys. **23**, 529
0.820	36.6	2.7 ± 1.6	Sironi et al. 1991 : Ap.J. **378** (in press)
1.4	20.7	2.8 ± 0.6	Howell and Shakeshaft 1966 : Nature **210**, 1318
–	21.2	3.2 ± 1.0	Penzias and Wilson 1967 : A.J. **72**, 315
1.5	21.3	2.11 ± 0.38	Levin et al. 1988 : Ap.J. **344**, 14
2.5	12	2.62 ± 0.25	Sironi et al. 1984 : Phys.Rev.D **29**, 2686
–	–	2.79 ± 0.15	Sironi and Bonelli 1986 : Ap.J. 311, 418
–	–	2.50 ± 0.34	Sironi et al. 1991 : Ap.J. **378** (in press)

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