Calculation of the cosmic microwave background temperature

Hans Peter Good
Sargans, Switzerland
e-mail: hp.good at catv.rol.ch

January 26, 2022

Abstract

The cosmic microwave temperature is derived assuming empty space is a symmetric electron-positron plasma. The outcome is compared with the result obtained from FIRAS on the COBE satellite.

Keywords: Cosmic microwave background, fundamental constants, number constants, universality, empty space, electron-positron plasma.

Today the CMB radiation is supposed to be the left over of the “Big Bang”. The success of this paradigm is overwhelming, but the theory cannot explain why the initial spectrum had almost the shape of a Planckian blackbody, which is, on a laboratory scale, extremely difficult to approach by a physical setting. In addition, the theory cannot accurately predict, by first principles, the present-day temperature of the linearly redshifted Planck light of the recombination phase either. In mainstream cosmology, the exact CMB temperature at the present epoch is not a basic parameter for the understanding of the cosmos, because the CMB temperature always changes. Only minute fluctuations in the CMB spectrum are predictable.

The author speculated [1] that the vacuum is a symmetric electron-positron plasma and that space (vacuum) itself constitutes the source of the omnidirectional microwave glow measured today. The hypothesis is that the absolute CMB temperature is given [1a] by $T_{CMB} \equiv 2^{-9/2} c_1^3 \tau$, where c_1 is the radius of the nine dimensional hypersphere with the hyper volume $V_9(c_1) = 1890^{-1}$, and τ is a background temperature interconnected to universal gravity [1b]. The background temperature is defined [1c] by $k_B\tau \equiv 2^{-17/4} (hc)^{3/4}$ with h being Planck’s constant, c being the velocity of light in vacuum and k_B being Boltzmann’s constant that converts energy (J) into temperature (K). The radius c_1 can be evaluated analytically [1d] and reads $2^{-2/3}\pi^{-4/9}$.

To derive the formulas the author assumed [1e] that the kilogram is a redundant unit and that it can be replaced by ms^2, that is $kg = ms^2 \rightarrow m^3/c^2$. This allows units of the MKS system to be solely defined as powers of the meter. In this view, energy defined by $J \equiv kgm^2s^{-2}$ corresponds to m^3. The dimension of the product (hc) is kgm^3s^{-2} and transforms into m^4. The dimensioned term $(hc)^{3/4}$ has, according to $(m^4)^{3/4} = m^3$, the dimension energy (J) as it must be. The factor $(hc)^{3/4}/k_B$ depends on man made constants and allows to connect pure numbers with the dimensioned reality of the measurements. Thus with the help of the previous definitions, a value of **≈ 2.720 K** results for the background temperature T_{CMB}.

Absolute measurements of the cosmic background temperature T_{CMB} have a long history and are a major technical challenge due to galactic and extragalactic emissions, foreground emissions, noise from the instruments and absolute calibration issues. To this day, the COBE satellite provided the most precise measurement of the CMB temperature and reaffirmed the presence of a dipole signal [2] associated with the motion of the local group. Mather and co-workers [3] carried out the first evaluation of the data from FIRAS aboard the COBE satellite. To refine the analysis [4] and to improve the calibration [5], two additional publications followed. Table I summarizes the concluding results.

Table I: Three independent experimental estimates of the cosmic microwave background temperature (T_{CMB}) using the FIRAS data set.

		Monopole temperature [K]	**Dipole temperature [K]**	
Refined analysis	[4]	2.730(1)		Absolute thermometry with external calibration.
		2.7255(9)		Frequency calibration using the galactic CO emission. The frequency determination dominates the uncertainty.
			a) 2.717(3)	Indirect measurement, which relies on the spectrum of the dipole and its amplitude. Offsets and long-term drifts do not matter.
Improved calibration	[5]	2.725(1)		Readout correction of the thermometers due to self-heating of the excitation current. The absolute calibration of the thermometers dominates the uncertainty. The authors assume other systematic errors to be negligible.
			b) 2.722(3)	Indirect measurement with a frequency scale correction.

Notes:

All statistical uncertainties (in round brackets) derived directly from the data are at the 1 σ level.

a) The authors raised the statistical error to a 1 σ combined uncertainty of 7 mK to account for the systematic error arising from the Galactic cut.

b) The authors raised the statistical error to a 1 σ combined uncertainty of 12 mK to account for the systematic error arising from the DMR calibration.

The calculated value of ≈ **2.720 K** lies within the statistical 1 σ uncertainty of the dipole temperature, but significantly outside the combined 1 σ uncertainty of the monopole temperature. A better understanding of the systematic errors of the observations is necessary to judge with fair certainty, whether the calculated value can be considered as a theoretical value of the cosmic background temperature.

References

[1] Hans Peter Good, On the Origin of Natural Constants, De Gruyter 2018.
a) p. 108, b) p. 67, c) p. 111, d) p. 15, e) p. 4

[2] D. J. Fixsen et al., The Astrophysical Journal 420(1994), 445–449.

[3] J. C. Mather et al., The Astrophysical Journal 420(1994), 439–444.

[4] D. J. Fixsen et al., The Astrophysical Journal 473(1996), 576–587.

[5] J. C. Mather et al., The Astrophysical Journal 512(1999), 511–520.