The Relativistic Effect of the Deviation between the CMB Temperatures Obtained by the COBE Satellite

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The Far-Infrared Absolute Spectrophotometer (FIRAS) on the COBE satellite, gives different temperatures of the Cosmic Microwave Background. This deviation has a theoretical explanation in the Doppler effect on the dipole (weak) component of the radiation, the true microwave background of the Universe that moves at 365 km/sec, if the monopole (strong) component of the radiation is due to the Earth. Owing to the Doppler effect, the dipole radiation temperature (determined by the 1st derivative of the monopole) is lower than the monopole radiation temperature, with a value equal to the observed deviation. By this theory, the WMAP and PLANCK satellites, targeting the L2 point in the Sun-Earth-Moon system, should be insensitive to the monopole radiation. In contrast to the launched WMAP satellite, the PLANCK satellite will have on board absolute instruments which will not be able to detect the measured temperature of the Cosmic Microwave Background. That the monopole (strong) component of the observed Cosmic Microwave Background is generated by the Earth is given a complete theoretical proof herein.

The COBE satellite, launched in 1989, has on board two instruments targeting the temperature of the Cosmic Microwave Background (CMB), namely the Far-Infrared Absolute Spectrophotometer (FIRAS) and the Differential Microwave Radiometer (DMR). FIRAS, having just a single channel for a signal, is sensitive to both the strong (monopole) and weak (dipole) components of the Background Radiation, and measures the general temperature in the Background without distinction between the monopole and dipole components of the field. The DMR has another construction: having a few channels for a signal, the DMR recognizes only the difference between the signals in the channels, and so gives just a difference between the temperature of the Background in the different directions. In other words, the DMR is sensitive to only the weak (dipole) component of the field that provides a possibility of direct search for its anisotropy [1].

The WMAP satellite launched in 2001 has on board only differential instruments working similarly to the DMR on COBE, so its data accounts only for the weak (dipole) component of the Background [2].

The anisotropy in the Background measured by the differential instruments is actually the same: DMR at COBE registered the anisotropy 3.353±0.024 mK, while WMAP gave 3.346±0.017 mK. The main direction of the anisotropy, by COBE, is $l=264.26^\circ\pm0.33^\circ$, $b=48.22^\circ\pm0.13^\circ$ (l is the Galactic longitude, b is the Galactic latitude). WMAP gives $l=263.85^\circ\pm0.1^\circ$, $b=48.25^\circ\pm0.04^\circ$ [3].

The absolute temperature of the Background initially obtained from the direct measurement by FIRAS

$$T_{FIRAS} = T_0 = 2.730 \pm 0.001\,\text{K},$$

is the undifferentiated temperature of the monopole and dipole components of the field. However, the COBE team also extracted the absolute temperature from the 1st derivative of the monopole, which was interpreted as the actual temperature of the dipole component of the field. They obtained another numerical value [4]

$$T = 2.717 \pm 0.003\,\text{K},$$

so the average deviation $\Delta T = 0.013$ K between these two results is a dozen times bigger than the measurement precision. So we have a minimal relative deviation between the CMB temperature by FIRAS from the monopole and from the 1st derivative of the monopole

$$\Delta T/T_0 = 0.33\% \ \text{ at } 1\sigma,$$

$$\Delta T/T_0 = 0.18\% \ \text{ at } 2\sigma,$$

which is small number, but is significantly not zero. So the CMB temperature measured by FIRAS from the monopole and its 1st derivative aren't the same. This is a systematic deviation with many years of the COBE observations. The COBE team attempted to explain the deviation as systematic errors in the calibration of the instruments. However, as pointed out by Robitaille [5], so large an increase of σ supposed by the COBE team is unlikely for the FIRAS instrument, which has excellent signal to noise ratio. The systematic deviation shouldn't be removed from the consideration.

As pointed out by Robitaille [5], this systematic deviation has no chance of being explained by anything other than the fact that the monopole and dipole components of the Background have *different origins*. He has elucidated the similarity of the Cosmic Microwave Background Radiation with radiation of Earth origin. He supposed that the monopole field has a different origin to that of the dipole, and is due to the Earth, not the whole Universe. According to

Robitaille [5, 6], the monopole (strong) field, is nothing but that generated by Earth objects (mostly oceans) and moves, in common with the Earth, with respect to the dipole (weak) field which is the real microwave background of the Universe.

Robitaille's claim, obtained from purely experimental analysis, can be easily checked by the relativistic effects which should appear in the COBE measurements, if the monopole field moves, in common with the Earth, with respect to the dipole field related to the whole Universe.

It follows from the measurement that the COBE satellite, in unison with the Earth, moves relative to the Cosmic Microwave Background with a velocity of 365 ± 18 km/sec [7]. DMR is sensitive to only the dipole field, so we are sure of the velocity with respect to the dipole field.

If the monopole field is due to the Earth, the COBE satellite is at rest with respect to the monopole field, but moves, in common with the Earth, at 365 ± 18 km/sec relative to the dipole field which is the true microwave background of the Universe. In such a case, two kinds of relativistic effects should appear for COBE: (1) the effects caused by the relative motion with respect to the dipole field (the Doppler effect and the effect of Special Relativity); (2) the effects caused by the physical properties of the local space of the COBE-bound observer, such as the presence of the Earth's gravitational field, and also the space rotation due to the daily rotation of the Earth (the effects of General Relativity).

By the Doppler effect, the temperature T of a radiation, the source of which moves with a velocity v at an angle θ relative to the direction from the observer to the source, differs from the same radiation's temperature T_0 measured when its source is at rest: $T = \frac{T_0}{1+\frac{\mathrm{v}}{c}\cos\theta}$. Assuming that the source of the dipole radiation moves with $\mathrm{v} = 365\pm18$ km/sec away from the observer and the Earth (the monopole radiation source), we obtain

$$\frac{\Delta T}{T_0} = \frac{T_0 - T}{T_0} = \frac{\mathrm{v}}{c} = 0.12\% \pm 0.006\%$$

i.e., due to the Doppler effect, the dipole radiation temperature T (measured by the 1st derivative of the monopole) should be 0.12% smaller than the monopole radiation temperature T_0 (measured by FIRAS).

This theoretical result is very close to the 0.18% registered at 2σ. In the real situation, this coincidence can be accounted for if one takes into account that fact that the COBE team provided different data for the dipole-measured temperature [5]. So the relativistic lowering of the Cosmic Microwave Background temperature due to the Doppler effect on its dipole component, the source of which moves away from the Earth (the source of the monopole), is in good agreement with that observed by COBE.

Now consider the effect of Special Relativity. It is well known [8], that the temperature T of radiation, the source of which moves relative to the observer with a velocity v, is: $T = T_0\sqrt{1-\frac{\mathrm{v}^2}{c^2}}$. With $\mathrm{v} = 365$ km/sec we obtain the relativistic lowering of the observed temperature of the dipole radiation due to the Special Relativity effect

$$\frac{\Delta T}{T_0} = \frac{T_0 - T}{T_0} = 7.4\times10^{-7} = 0.000074\%\,,$$

that is inconsequentially small for $\frac{\Delta T}{T_0} = 0.12\%$ produced by the Doppler effect, and really registered by COBE. So there is no essential rôle played by Special Relativity in the relativistic lowering of the dipole radiation temperature.

The effects of General Relativity can also be examined. By General Relativity, if the monopole radiation is due to the Earth, it is affected by the gravitation and rotation of the Earth's space so that the temperature of the monopole radiation is as well higher than the dipole radiation far away from the Earth. It has been obtained that the temperature deviation between the monopole and dipole radiations expects to be $\sim10^{-8}$%.

The effects caused by the COBE satellite itself (its own mass and spin), were a few orders smaller than the above effects caused by the Earth. The values are also inconsequentially small for 0.12% produced by the Doppler effect, and observed by COBE. So General Relativity's rôle in the relativistic lowering of the dipole radiation temperature is infinitesimal.

The General Relativity effects are bulky for deduction and calculation. For this reason the calculations for these effects are no presented in this paper.

We therefore conclude that:

> The different temperature of the Cosmic Microwave Background measured by the FIRAS instrument of COBE has a theoretical explanation in the Doppler effect on the dipole (weak) component of the radiation, the true microwave background of the Universe that moves away at 365 km/sec from the monopole (strong) component of the radiation due to the Earth. Owing to the Doppler effect, the CMB radiation temperature, measured by the 1st derivative of its monopole component, is lower than the monopole radiation temperature directly measured by FIRAS. This important finding can be referred to as ***a relativistic effect of the deviation between the temperature of the monopole and dipole components of the Cosmic Microwave Background.***

The calculation herein provides the theoretical proof of the assertion that the monopole component of the Cosmic Microwave Background is due to the Earth. If so, the WMAP satellite, located far away from the Earth, at the Lagrange 2 (L2) point in the Earth-Moon system, should be insensitive to the monopole radiation. Its instruments should register only the dipole radiation from the Universe. Therefore, the absolute and differential instruments located at the L2 point should manifest no difference in the measured temperature of the radiation.

The WMAP satellite, unfortunately, has on board only the differential instruments (working like the DMR on COBE). However the PLANCK satellite, which will soon be launched, has on board absolute instruments. PLANCK will also be located at the L2 point, so its absolute instruments should be unable to register any signal from the monopole origination (from the Earth). This is in contrast to COBE, located near the Earth.

The above theoretical calculation and the measurement by COBE are the complete theoretical and experimental proofs of the assertion that the monopole (strong) component of the Cosmic Microwave Background is derived from the Earth, while the dipole (weak) component is the true microwave background of the Universe relative to which the Earth moves with a velocity of 365 km/sec. Due to the theoretical and experimental proofs, we expect to have a profoundly altered understanding of the Cosmic Microwave Background.

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