The persistent axis of evil anomaly has to be resolved in the CMB rest-frame

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Abstract

The anomalous alignment between the CMB quadrupole and octopole, that they are jointly perpendicular to the ecliptic plane, and also aligned with the direction of the solar dipole near to the equinoxes are up to now unsolved conundrums. The preferred axis in the cosmic radiation anisotropy and the alignments were dubbed "axis of evil" (Land & Magueijo, 2005), and are the most prominent of the CMB anomalies. It is standard that the 1^{st} order term of the dipole formula essentially represents a motion induced Doppler temperature pattern against the isotropic Planckian radiation field. We argue that the Doppler term is entirely a function of the peculiar velocity of the Planck space telescope in the CMB rest-frame (CMB-space). In two recent publications of us we have found solutions to the flyby anomalies and to the residual annual and diurnal P 10 signal variations on top of the resolved P 10 acceleration anomaly, using the peculiar velocity of Earth and the peculiar velocities of the involved space probes in the CMB-space. That two independent solutions are corroborating our assertion that the quadrupolar and octopolar terms, following from the 2^{nd} order term in $\beta = v/c$ expanding of the dipole formula, are not "relativistic corrections to the solar dipole, producing second order anisotropies at multipoles $\ell \geq 1$, with amplitudes proportional to β^{ℓ}, and more importantly couple the two dipole components" (Planck Collaboration, 2015). Instead, the 2^{nd} order term of the dipole formula, the inverse γ - factor, represents solely the annual eigen-frequency oscillations of the Planck HFI, proportional to the annual eigen-time variations in the fundamental CMB-space, as a function of the peculiar velocity of the Planck space telescope, leading to a solution of the only seemingly anomalous alignments.

Keywords: CMB anomalies, CMB rest-frame, flyby anomalies, annual and diurnal P 10 signal residuals, axis of evil, physical regularities in CMB restframe, cosmology

1 Introduction

By far the largest signal in the CMB anisotropy is the temperature dipole (i.e., the $\ell = 1$ anisotropy pattern), caused by the motion of the Sun with respect to the rest-frame defined by the CMB, which absolute inertial frame (Mansouri & Sexl (1976) and Mittelstaedt (1976)), we term the absolute CMB-space.

A current determination of the dipole is that of the Planck HFI (Planck Collaboration, 2019), and indicates a peculiar velocity of the solar system barycenter of $u_{sun} = 369.82 \pm 0.11 km \cdot s^{-1}$ in direction of constellation Crater near Leo. We consider this peculiar velocity as an absolute one in the CMB-space, and denote it with u, and use v only for relative velocities between objects moving in the absolute CMB-space. The direction of the vector $\vec{u}_{sun}$ corresponds to RA $= 167^{\circ}\!.942 \pm 0^{\circ}\!.007$, Dec $= -6^{\circ}\!.944 \pm 0^{\circ}\!.007$ (J2000), (Planck Collaboration, 2019). We view the immediate vicinity of the vector to the equinoxes to be a coincidence.

Importantly, it is to observe that the absolute velocity vector $\vec{u}_{sun}$, derived from the solar dipole inclines the ecliptic also coincidentally with a rather acute angle of $\beta \approx -11^{\circ}$, leading to a pronounced variation of the Earth´s absolute velocity. Due to the relative, mean orbital velocity of Earth $v_e = 29.78\ km \cdot s^{-1}$ and the absolute velocity $u_{sun} = 369.82 \pm 0.11 km \cdot s^{-1}$ of the solar system, the absolute velocity of Earth varies between $u_e \approx 343\ km \cdot s^{-1}$ around mid June and $u_e \approx 398\ km \cdot s^{-1}$ around mid December, while the velocity at mid March or mid September is $u_e \approx 371\ km \cdot s^{-1}$.

2 Solution to the axis of evil problem

In several publications it is shown that the quadrupole plane and the three octopole planes are aligned at the 99.9% C.L. Three of these planes are orthogonal to the ecliptic at 99.1% C.L., and the normals to these planes are aligned at 99.6% C.L. with the direction of the solar dipole near to the equinoxes (Schwarz et al., 2015). Essentially the same was already reported in (Schwarz et al., 2004) and (Lämmerzahl et al., 2006). Originally, this anomaly has led to the assumption that the solar system is in some way cosmically aligned (Huterer, 2007), as one of several attempts to explain it.

First, we quote the standard situation (Planck Collaboration, 2015):

> *The CMB dipole is induced by the effect of the relative motion of the satellite with respect to the CMB frame*
>
> $$T(\theta) = T_0 \left(\sqrt{1 - \left(\frac{v}{c}\right)^2} \frac{1}{1 - \frac{v}{c}\cos\theta} \right). \qquad (1)$$
>
> *The solar system motion with respect to the CMB frame, giving rise to what is referred to as the "solar dipole", is the dominant component of the satellite velocity. A residual contribution (called the orbital dipole) is induced by the yearly motion of the satellite with respect to the solar system barycenter. The solar dipole can be considered as stationary during the observations and*

is thus projected onto the sky as an $\ell = 1$ component with amplitude previously measured by COBE and WMAP 3355, $\pm 8\mu K$ (Hinshaw et al., 2009). Relativistic corrections to the solar dipole produce second order anisotropies at multilpoles $\ell \geq 1$, with amplitudes proportional to β^ℓ, and more importantly couple the two dipole components, as will be discussed below. Finally, to calibrate in temperature, we only rely on an external measurement of the CMB absolute temperature. We use $T_{CMB} = 2.7255K$ (Fixsen, 2009). The expansion of Eq. (1) in $\beta = v/c$ gives

$$T(\theta) \approx \; T_0 \left(1 + \frac{v}{c} \cos\theta + \frac{v^2}{2c^2} \cos 2\theta + O(v^3/c^3) \right). \qquad (2)$$

Hint: Eq. (1) and Eq. (2) are quoted in the equivalent form as in (Scott & Smoot, 2019).

Now the situation in the CMB-space as we view it:
The motion of an observer with the absolute velocity u to the isotropic CMB radiation rest-frame, the CMB-space, produces a temperature pattern of

$$T(\theta) = T_0 \left(\sqrt{1 - \left(\frac{u}{c}\right)^2} \frac{1}{1 - \frac{u}{c} \cos\theta} \right). \qquad (3)$$

As quoted above, both effects are considered so far to be anisotropies in the background radiation, hence Eq. (1) is Taylor expanded in $\beta = v/c$, to investigate the purportedly different anisotropies as multipoles.

However, we consider the 2^{nd} order effect not as a "relativistic correction" to the solar dipole anisotropy. The inverse γ - factor term of Eq. (3) exclusively represents the annual eigen-frequency oscillations of the Planck HFI, proportional to the eigen-time variability in the CMB rest-frame as a function of its variable absolute velocity over the course of one year. Thus, it represents the proportional time dilatation effect in the CMB-space. The fact that the quadratic term of the CMB dipol equation produces precisely the values of the inverse γ - factor confirms the purely kinematic origin of the first order effect.

The flyby anomalies are a long pending problem too (Anderson et al., 2008; Acedo, 2017). In previous publications of us, we have found a general solution to all flyby anomalies in the CMB-space, using the absolute velocities of the space probes and of Earth in the classical Doppler formula of 1^{st} order (Pabisch & Kern, 2010; Pabisch, 2024). The same CMB-space approach applies to our resolution of the residual annual and diurnal P 10 signals (Pabisch, 2024), found on top of the meanwhile resolved P 10 acceleration anomaly (Anderson et al., 2005; Rievers & Lämmerzahl, 2011). In concordance with this solution of two different anomalies, using the CMB-space approach, our interpretation of the quadratic term of Eq. (3) seems to be mandatory.

Hence, we treat all constituent elements of the axis of evil problem within the CMB-space.

(i) Since the vector $\vec{u}_{sun}$ intersects the ecliptic plane at an acute angle of $\beta \approx -11^\circ$ ($\cos 11^\circ = 98{,}16$), the alignment with the ecliptic is obvious.

(ii) The annual oscillations of the Planck HFI eigen-frequencies are caused by the annual variations of the absolute velocities of the space telescope on its L2 position, hence the alignment of the 2^{nd} order effect to the ecliptic is obvious too.

(iii) The absolute velocity of Earth varies between $u_e \approx 343\ km \cdot s^{-1}$ around June 20 and $u_e \approx 398\ km \cdot s^{-1}$ around December 20, while the velocity at mid March or mid September is $u_e \approx 371\ km \cdot s^{-1}$, which velocities result from the relative mean orbital velocity $v_e = 29.78\ km \cdot s^{-1}$, and the absolute velocity of the solar system barycenter $u_{sun} = 369.82 \pm 0.11\ km \cdot s^{-1}$.

iv) On Earth, eigen-frequency and the proportional eigen-time variations result from a time delay effect against clocks at rest in the CMB-space of 880 $ns \cdot s^{-1}$ at velocity $u_e = 398\ km{\cdot}s^{-1}$, versus a delay of 765 $ns{\cdot}s^{-1}$ at velocity $u_e = 371\ km{\cdot}s^{-1}$, and a time delay of 654 $ns \cdot s^{-1}$ at velocity $u_e = 371\ km \cdot s^{-1}$.

Thus, atomic clocks on Earth vary annually $\approx \pm 110\ ns \cdot s^{-1}$ around a time dilatation value of 765 $ns \cdot s^{-1}$ at mid March/September. They are delayed less than one microsecond per second versus clocks at rest in the CMB-space. Earth eigen-time is obviously not invariant, due to a time dilatation effect as a function of absolute velocities u (Pabisch, 1999). Time is not relative but variable as a function of $u \in [0, c[$.

The claimed annual eigen-time variations of $\approx \pm 110\ ns \cdot s^{-1}$ of atomic clocks may be confirmed applying highly stable millisecond pulsar signals, comparing two, only seemingly exact equal time periods on Earth, if showing a different number of signals.

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Appendix

Quote from Mansouri & Sexl (1976):

> *"Global ist ein Inertialsystem durch die isotrope kosmische 3 K Strahlung ausgezeichnet, welches man daher als absoluten Raum ansehen könne. Diese durchaus richtige Feststellung steht aber nicht im Widerspruch zum Relativitätsprinzip, da dieses Inertialsystgem nicht durch physikalische Gesetzmäßigkeiten, sondern nur durch die kontingente Anwesenheit eines Strahlungshintergrundes ausgezeichnet ist".*

Translated from the original: Globally, an inertial system is characterized by the isotropic cosmic 3 K radiation, which can therefore be regarded as absolute space. However, this quite correct statement does not contradict the principle of relativity, since this inertial system is not characterized by physical laws, but only by the contingent presence of a radiation background.

Quote from Mittelstaedt (1976):

> *"Durch die Möglichkeit die absolute Geschwindigkeit der Erde im Ruhesystem der Hintergrundstrahlung zu messen, haftet der Relativitätstheorie ein Schönheitsfehler an, der aber keine negativen Folgen für die Richtigkeit der Theorie hat, denn die absolute Geschwindigkeit lässt die Eigenmessgrößen Zeit, Länge und Masse invariant".*

Translated from the original: The possibility of measuring the absolute velocity of the earth in the rest system of the background radiation is a minor flaw in the theory of relativity, as it has no negative consequences for the correctness of the theory, because the absolute velocity leaves the proper values of time, length and mass invariant.