Residual annual and diurnal periodicities of the Pioneer 10 acceleration term resolved in absolute CMB restframe

Roland Pabisch
roland.pabisch@liwest.at

Revised July 25, 2024

Abstract

Applying the general, classical Doppler formula (CMB-Doppler formula) of first order for two-way radio Doppler signals in the fundamental rest-frame of the isotropic cosmic microwave background radiation (CMB-space) between earthbound Deep Space Network stations (DSN), and the Pioneer 10 space probe (P 10) resolves the phenomenon of the residual, so far unexplained annual and diurnal signal variations on top of the constant acceleration term. The anomalous annual and diurnal oscillations vanish, if instead of the relativistic Standard-Doppler formula (SRT-Doppler formula) of first and second order the CMB-Doppler formula is used. That formula contains in distinction the absolute velocities $\mathbf{u}_{\mathrm{e}}$ of Earth, and $\mathbf{u}_{\mathrm{pio}}$ of P 10, derived from the absolute velocity $\mathbf{u}_{\mathrm{sun}}$ of the solar system barycenter in the CMB, with $u_{sun} = 369.0 \pm 0.9$ km/s, and the relative revolution velocity $\mathbf{v}_{\mathrm{e}}$ of Earth, and the relative velocity $\mathbf{v}_{\mathrm{pio}}$ of P 10 in the heliocentric frame from January 1987 until December 1996. The flyby radio Doppler and ranging data anomalies can be resolved as well by using the CMB-Doppler formula with the absolute, asymptotic velocities of the inbound and outbound maneuver flights, which have usually slightly different magnitudes, inducing the so far unexplained frequency shifts, and the unexplained difference in the independently obtained ranging data.

Keywords— Cosmology: cosmic microwave background - Astronomy: Pioneer 10 signal residuals - flyby anomalies - Theory: CMB-Doppler formula of first order in CMB rest-frame - time dilatation formula in CMB rest-frame

1 Introduction

For more than twenty years the conundrum of the Pioneer 10 (P 10), and Pioneer 11 (P 11) acceleration anomalies induced quite many publications. In two papers, (Rievers & Lämmerzahl, 2011) and (Francesco, Bertolami, & Gil, 2011), it is shown that thermal radiation pressure is most likely the final solution to that acceleration anomaly.

Only in a few papers, the residual annual and diurnal periodic oscillations (sinusoid) of the Pioneer 10 Doppler signals, on top of the constant acceleration term, are reported as an unexplained phenomenon (Anderson et al., 2002).

Despite the popularity of the acceleration anomaly of P 10 and P 11, few authors made attempts to resolve the residual annual and diurnal signal variations of the constant (former anomalous) acceleration term. The annual Doppler residuals are distributed about zero Doppler velocity with a systematic variation of about 3.0 mm/s on a scale of about 3 months (Anderson et al., 2008) (Ghosh, 2007) (Olsen, 2007).

In one of the attempts to understand this residual annual periodic term with an amplitude of $1.6 \cdot 10^{-8}\mathrm{cms}^{-2}$ (average between 1987 and 1996, if approximated by a simple sine wave), Anderson et al. suggest that the cause is most likely an error in the navigation programs determination of the direction of the space probes orbital inclination to the ecliptic plane. An additionally reported, significant residual diurnal term in the Doppler residuals, probably due to the sidereal rotation of Earth, is explained similarly, as a misalignment of the orbits of P 10 to the equatorial plane (Anderson et al., 2002).

2 Why to investigate solar system anomalies in the CMB restframe

The data from the COBE, WMAP and recently Planck satellites show the CMB anisotropy is dominated by the solar dipole term, attributed to the motion of the solar system with respect to the CMB rest-frame. The dipole is a frame dependent quantity, and we can therefor determine the absolute rest frame as that in which the dipole would be zero. We consider the solar and the orbital dipoles of entirely kinematic origin. The validity of that essential assumption will be discussed in the conclusions. Hence we view the velocity of the solar system barycenter $u_{sun} = 369.0 \pm 0.9$ km s^{-1} (Hinshaw et al., 2008) as an absolute velocity, in direction of constellation Becher, right ascension $\alpha = 11h\ 12m$ and declination $\delta = -7^{\circ}.06$ epoch J2000. Thus, the absolute velocity of Earth varies approximately between $u_{\mathrm{e}} = 341$ km s^{-1} (around mid June) and $u_{\mathrm{e}} = 399$ km s^{-1} (around mid December). The revolution of Earth causes a sizeable variation of the magnitude of $\mathbf{u}_e$, since the absolute velocity vector $\mathbf{u}_{\mathrm{sun}}$ inclines the ecliptic plane near the equinoxes by chance with an acute angle of approximately $\beta = -11^{\circ}$.

The latest dipole data from the Planck mission deviate only marginally from the WMAP data, hence we refer to the above invoked data of 2008, which we used in our paper of 2010 (Pabisch & Kern, 2010), and we use them for our calculations in Section 4 again.

Assuming the solar and orbital dipole effects are of kinematic origin, we have a perfect tool to determine very precisely the absolute velocities and directions of objects within the solar system. To us, it seemed to be the obvious thing to investigate possible velocity dependent anomalies of i.e. Earth flyby space probes, or the P 10 residual signal periodicities with the CMB-space Doppler formula of 1st order, instead of the relativistic Doppler formula. The solutions we have found lead to further important assumptions and assertions, discussed in Sections 5.2 to 5.4.

3 General, classical Doppler effect and time dilatation effect in the rest-frame of the CMB, the CMB-space

We argue that between any two bodies, moving in the frame of the solar system, or anywhere in the rest frame of the isotropic cosmic microwave background radiation (CMB-space), the classical, general Doppler formula of first order (CMB-space Doppler

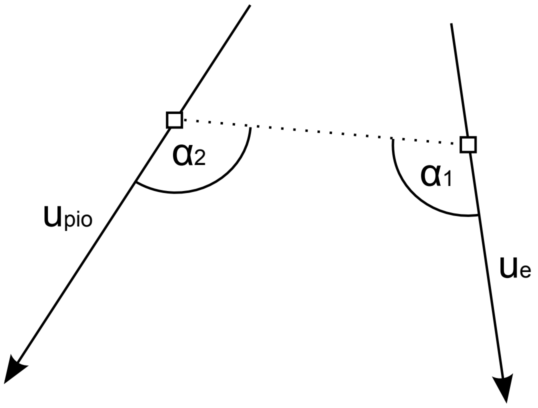

Figure 1: Schematic visualization of the absolute velocity vectors of Earth and P 10, and the up link radio signal trajectory with the emission angle α_1 and the absorption angle α_2 relative to their absolute velocity vectors in the ecliptic plane as seen from the ecliptic north pole. The dotted signal trajectory is in direction of the relative, heliocentric motion of P 10 towards Aldebaran.

formula) has to be applied in case of two-way signals, while for one-way signals the general Doppler formula of first order and second order (time dilatation) has to be used. The time dilatation effect is considered to be a function of absolute velocities u in the CMB-space, due to two fundamental properties of photons (Pabisch, 1999).

Especially between Earth and P 10, moving at absolute velocities $\mathbf{u}_{\rm e}$, and $\mathbf{u}_{\rm pio}$, the absolute CMB-space Doppler formulas of first order for two way signals have to be applied, instead of the relativistic Doppler formula of first and second order, using symmetric relative velocities.

The absolute velocity $\mathbf{u}_{\rm pio}$ of P 10 in the CMB-space is obtained by addition of the vectors of its relative velocity $\mathbf{v}_{\rm pio}$ in the solar system, and the absolute velocity $\mathbf{u}_{\rm s}$ of the solar system barycenter in the CMB-space. The absolute velocity $\mathbf{u}_{\rm e}$ of Earth we derive from its relative velocity $\mathbf{v}_{\rm e}$ in the heliocentric frame, and the absolute velocity $\mathbf{u}_{\rm s}$ of the solar system barycenter in the CMB-space, see Fig. 1.

The absolute velocity $\mathbf{u}_{\rm dsn}$ of the Deep Space Network (DSN) station, obtained by adding its relative, rotational velocity in the geocentric frame to the absolute velocity $\mathbf{u}_e$ of Earth, has to be applied calculating the residual diurnal term.

The CMB-space Doppler formula of first and second order for an one-way up link tracking signal from an earthbound DSN station to P 10 reads

$$f'_{\rm up} = \frac{f_{\rm e}}{f_{pio}} \cdot \frac{c + u_{\rm pio} \cdot \cos\alpha_2}{c - u_{\rm e} \cdot \cos\alpha_1}, \tag{1}$$

where $f_{\rm e}$ denotes the variant eigenfrequency of the DSN station in the CMB-space, with $f_{\rm e} = f_0 \cdot \sqrt{1 - (u_{\rm e}/c)^2}$, f_0 being the eigenfrequency of a system at rest in the CMB-space, and $f_{\rm pio} = f_0 \cdot \sqrt{1 - (u_{\rm pio}/c)^2}$.

$f'_{\rm up}$ is the frequency of the up link signal, as measured by P 10,
c the constant velocity of light in the CMB-space,
α_1 the angle between the vector $\mathbf{u}_{\rm e}$ and the emitted up link signal,
α_2 the angle between the vector $\mathbf{u}_{\rm pio}$ and the received up link signal, as can be seen

in Fig.1, while
$\sqrt{1-(u_{\mathrm{e}}/c)^2}$ and $\sqrt{1-(u_{\mathrm{pio}}/c)^2}$
are functions of $u = [\mathit{0}, c[$ in the CMB-space. Hence, eigen-time (proper time) or eigen-frequency are seen as not universally invariant, but variant as a function of absolute velocities u in the CMB-space, derived from two fundamental properties of photons (Pabisch, 1999) (Pabisch & Kern, 2010).

The CMB-space Doppler formula of first and second order for an one-way Doppler downlink signal from P 10 to a DSN station is given by

$$f'_{\mathrm{down}} = \frac{f_{\mathrm{pio}}}{f_{\mathrm{e}}} \cdot \frac{c + u_{\mathrm{e}} \cdot \cos\alpha_1}{c - u_{\mathrm{pio}} \cdot \cos\alpha_2}, \tag{2}$$

where f_{pio} denotes the eigen-frequency of P 10,
f'_{down} the frequency of the down link signal as measured by a DSN station,
c the constant velocity of light in the CMB-space,
α_2 the angle between the vector $\mathbf{u}_{\mathrm{pio}}$ and the emitted down link signal,
α_1 the angle between the vector $\mathbf{u}_{\mathrm{e}}$ and the received down link signal. We also use α_2 and α_1 as down link emission- and absorption angles in formula (2), for the sake of simplicity, despite the fact that they differ very slightly from the up link angles, due to the motion of Earth during the signal propagation time.

Thus, the CMB-space Doppler formula of first order for a two-way Doppler signal from a DSN station to P 10 and back reads

$$f''_{\mathrm{CMB}} = f_{\mathrm{e}} \cdot \frac{c + u_{\mathrm{pio}} \cdot \cos\alpha_2}{c - u_{\mathrm{e}} \cdot \cos\alpha_1} \frac{c + u_{\mathrm{e}} \cdot \cos\alpha_1}{c - u_{\mathrm{pio}} \cdot \cos\alpha_2}, \tag{3}$$

where f''_{CMB} denotes the frequency of the two-way signal, as sent and received by the DSN station, while the standard relativistic formula (SRT-formula),
(Lämmerzahl, Preuss, & Dittus, 2006) is

$$f''_{\mathrm{SRT}} = f_{\mathrm{e}} \cdot \left(1 - \frac{v}{c}\cos\eta\right)^2 \left(\frac{1}{\sqrt{1-(v/c)^2}}\right)^2, \tag{4}$$

or more common

$$f''_{\mathrm{SRT}} = f_{\mathrm{e}} \cdot \frac{c + v\cos\eta}{c - v\cos\eta}. \tag{5}$$

Different to standard theory, the time dilatation effect in the CMB-space is canceled, if two-way signals are used, since the effect is asymmetric. Only with one way signals and a special experimental set up it would become measurable.

4 The residual annual and diurnal sinusoids of the constant acceleration term of P 10 vanish in CMB-space

The annual and diurnal residuals vanish, if instead of the SRT-Doppler formula of first and second order the CMB-space Doppler formula of first order (3) is used. The residual annual effect is approximated as follows. Between 1987 January 1 and 1996 December 31, the relative, heliocentric velocity of P 10, and the absolute velocity of P 10 in the CMB-space are considered as constant, and the revolution trajectory of Earth as circular.

With $\cos\eta = \frac{\vec{v}_{\mathrm{rel}}\cdot\vec{r}}{|\vec{v}_{\mathrm{rel}}||\vec{r}|}$ we obtain

$$\frac{c|\vec{r}| + \vec{u}_{\mathrm{pio}}\cdot\vec{r}}{c|\vec{r}| - \vec{u}_{\mathrm{e}}\cdot\vec{r}}\,\frac{c|\vec{r}| + \vec{u}_{\mathrm{e}}\cdot\vec{r}}{c|\vec{r}| - \vec{u}_{\mathrm{pio}}\cdot\vec{r}} = \frac{c|\vec{v}_{\mathrm{rel}}||\vec{r}| + v_{\mathrm{app}}\vec{v}_{\mathrm{rel}}\cdot\vec{r}}{c|\vec{v}_{\mathrm{rel}}||\vec{r}| - v_{\mathrm{app}}\vec{v}_{\mathrm{rel}}\cdot\vec{r}}, \tag{6}$$

with v_{app} as apparent velocity, and

$$\vec{r} = \vec{r}_{\mathrm{pio}} + \vec{v}_{\mathrm{pio}}\ t - r_{\mathrm{e}}\begin{pmatrix}\cos(\omega t+\varphi)\\ \sin(\omega t+\varphi)\\ 0\end{pmatrix}, \tag{7}$$

$$\vec{v}_{\mathrm{e}} = \omega\ r_{\mathrm{e}}\begin{pmatrix}-\sin(\omega t+\varphi)\\ \cos(\omega t+\varphi)\\ 0\end{pmatrix}, \tag{8}$$

with $\vec{u}_{\mathrm{pio}} = \vec{u}_{\mathrm{sun}} + \vec{v}_{\mathrm{pio}}$, and $\vec{u}_{\mathrm{e}} = \vec{u}_{\mathrm{sun}} + \vec{v}_{\mathrm{e}}$. The used parameters are listed in Table 1.

Table 1: Parameters as of 1987 January 1

$\vec{v}_{\mathrm{pio}}$	$(1.557, 13.022, 0.672)$	km s^{-1}
$\vec{r}_{\mathrm{pio}}$	$\left(1.946\cdot 10^9, 5.651\cdot 10^9, 3.24\cdot 10^8\right)$	km
r_{e}	$1.5\cdot 10^8$	km
φ	1.752	rad
ω	$2\cdot 10^{-7}$	rad s^{-1}

Considering the first derivative v_{app} as the apparent velocity

$$\frac{d}{dt}\left(v_{\mathrm{app}} - |\vec{v}_{\mathrm{pio}} - \vec{v}_{\mathrm{e}}|\right), \tag{9}$$

we obtain a sinusoid as plotted in Fig. 2.

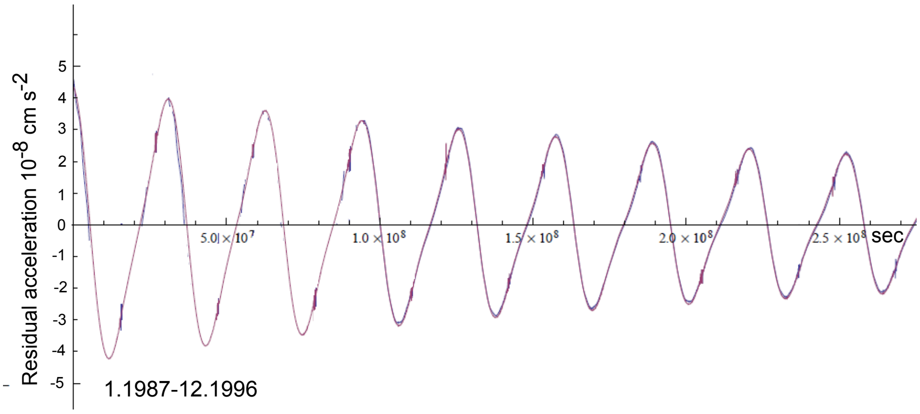

Figure 2: The theoretically derived residual annual sinusoid of P 10

The first maximum of the amplitude with a magnitude of $4 \cdot 10^{-8}$cm s^{-2} we find on 1987 December 24, and the last maximum with a magnitude of $2 \cdot 10^{-8}$cm s^{-2} we find on 1996 Dec 26, see Table 2. Compared to that theoretically derived values, the measured residual annual periodic term has on average an amplitude of magnitude $1.6 \cdot 10^{-8}$cms^{-2} (average between 1987 and 1996, if approximated by a simple sine wave) (Anderson et al., 2002).

Table 2: Theoretically derived values of extremata

	Date	Magnitude
first maximum	1987 Dec 24	$4 \cdot 10^{-8}$cm s^{-2}
first minimum	1987 Jun 27	$4.23 \cdot 10^{-8}$cm s^{-2}
last maximum	1996 Dec 26	$2 \cdot 10^{-8}$cm s^{-2}
last minimum	1996 Jun 28	$2 \cdot 10^{-8}$cm s^{-2}

Our further maxima follow yearly at the same date, and a significant decrease of the maxima and minima of the amplitudes until 1996 can be seen. The differences in the magnitudes of the amplitudes are considerably, but probably due to the approximations of us (between 1987 January 1 and 1996 December 31, the relative, heliocentric velocity of P 10, and the absolute velocity of P 10 in the CMB-space are considered as constant, and the revolution trajectory of Earth as circular), and of Anderson et al. (2002), who report a magnitude of $1.6 \cdot 10^{-8}$cms^{-2} (average between 1987 and 1996, if approximated by a simple sine wave). Despite the approximation of the authors and the approximation of us, the impact of the absolute velocity of Earth and P 10 is obvious.

The observed magnitude of the diurnal residual term is $2.8 \cdot 10^{-10}$cm s^{-2}, and has an annual maximum on 1996 December 17 (Anderson et al., 2002). Our calculations for 1996 show a yearly maximum on December 26, and a magnitude of $2 \cdot 10^{-10}$cm s^{-2}. That rather close result we consider as a further potential confirmation of our CMB approach.

5 Conclusions

5.1 Flyby Anomalies

The CMB-space Doppler formula (3) of first order for two-way signals not only offers a possibility to resolve the residual annual and diurnal variations on top of the constant acceleration term of P 10, but is capable to explain the unresolved flyby anomalies as well (Pabisch & Kern, 2010). An additional analysis in the article of Rievers & Lämmerzahl (2011) shows that thermal recoil pressure is not the cause of the Rosetta flyby anomaly. The flyby anomalies, which in most cases show an apparent acceleration, some null results, and one significant deceleration are still unexplained in standard physics (Anderson et al., 2008) (Acedo, 2017). The total geocentric orbital energy of the spacecrafts per unit mass should be the same before and after the flyby. The data indicate this is not always true.

The relative, asymptotic inbound and outbound velocities in the geocentric frame are actually equal, but the absolute, osculating asymptotic inbound and outbound velocities $\mathbf{u}_{\mathrm{in}}$ and $\mathbf{u}_{\mathrm{out}}$ in the CMB rest-frame have in general slightly different magnitudes. The different directions of $\mathbf{u}_{\mathrm{in}}$ and $\mathbf{u}_{\mathrm{out}}$ relative to $\mathbf{u}_{\mathrm{e}}$, and the different emission and reception angles contribute to the difference of the frequencies too. Thus, the CMB-space Doppler effect is inducing the difference as measured, which in standard theory is considered as an anomalous difference of the relative velocities (Anderson et al., 2008).

$$\frac{\Delta V_\infty}{V_\infty} = K(\cos\delta_{\mathrm{in}} - \cos\delta_{\mathrm{out}}). \tag{10}$$

The empirically derived formula (10) contains the declinations δ_{in} and δ_{out} of a spacecrafts incoming and outgoing asymptotic relative velocities in the geocentric frame. Anderson et al. found for K the constant value $3.099 \cdot 10^{-6}$ (Anderson et al., 2008).

Using the CMB-space approach for two-way tracking signals, we obtained $3.009 \cdot 10^{-6}$ for K (Pabisch & Kern, 2010) (Pabisch, 2022). Obviously, the ranging data anomaly, proportional to the apparent flyby Doppler anomaly, is also caused by the different absolute velocities of the inbound and outbound flights. The CMB-space approach explains accelerations, decelerations and null results as well.

Our solutions to the flyby anomalies and to the annual and diurnal P10 residuals in CMB-space are inconsistent with the relativistic Doppler formula of 1st order.

5.2 Variance of Earth eigen-time

Already the COBE, and the first WMAP data have been precisely enough to inspire a broad discussion about several unexpeted CMB anomalies (Lämmerzahl et al., 2006) (Huterer, 2007). The further WMAP, and finally the Planck data and allowed an even more exact determination of the solar dipole, and confirmed these anomalies (Schwarz, Starkman, Huterer, & Copi, 2014) (Schwarz, Copi, Huterer, & Starkman, 2015).

The current best determination of the dipole amplitude is reported to correspond to an absolute velocity of the solar system barycenter of $u_{sun} = 369.82 \pm 0.11$ km s^{-1}, in direction of constellation Becher, $RA = 167.^\circ942 \pm 0.^\circ942$ $Dec = -6^\circ.944 \pm 0.^\circ007$ $(J2000)$ (Aghanim & Planck Collaboration, 2018).

Using that magnitude and direction of the absolute velocity of the solar system barycenter, the difference of the approximate, absolute velocities of Earth between mid December, $u_{\mathrm{e}} = 399$ km s^{-1}, and mid June, $u_{\mathrm{e}} = 341$ km s^{-1}, is big enough to lead to a significant annual time dilatation modulation of ±115 ns s^{-1} versus a clock at rest in the absolute CMB-space, as can be seen in the 2nd order term of the dipole formula, see formula (13), and that effect we consider also of kinematic origin. Due to a velocity of $u_{\mathrm{e}} = 371$ km s^{-1} in mid March/mid September, Earth bound clocks run then slower by 760 Nanoseconds/s as clocks at rest in the CMB-space. Hence, we consider eigentime as universally not invariant.

5.3 CMB anomalies

The absolute velocity vector $\mathbf{u}_{\mathrm{sun}}$ inclines the ecliptic plane with an acute angle of approximately $\beta = -11^\circ$, near the equinoxes. That fortunate coincidence sheds unraveling light on a prominent CMB anomaly. The, as anomalous considered alignments of the CMB multipoles (quadrupole, octopole and even higher multipoles) among each other, and to the dipole and the ecliptic plane are not caused by unknown physical effects or systematic errors as supposed in literature (Schwarz et al., 2014). To us, that alignments are caused by the orbital motion of Earth in the CMB-space, and thanks to the fact that the absolute vector of the sun runs nearly parallel to the ecliptic. In the publication of Schwarz et al. (2015) it is concluded, that currently the physics behind the other most prominent CMB anomalies (north-south hemispheric asymmetry, preference of odd parity, and cold spot) is still unknown, and the anomalies are not consistent with the inflationary Lambda-CDM standard model of cosmology.

5.4 CMB-space Dipole formula versus SRT-Dipole formula

The motion of an observer with velocity u to the isotropic CMB radiation rest-frame, the CMB-space, produces a temperature pattern of

$$T(\theta) = T_0 \left(\sqrt{1 - \left(\frac{u}{c}\right)^2} \frac{1}{1 - \frac{u}{c}\cos\theta} \right). \tag{10}$$

Formula (11) is written in most publications

$$T\left(\theta\right)_{SRT} \approx T_0 \left(1 + \frac{v}{c}\cos\theta + \frac{v^2}{2c^2}\cos 2\theta + O(v^3/c^3) \right). \tag{11}$$

Our CMB-space dipole formula, derived from the theory behind formulas (1) and (2), has just as well two terms, whereof the linear term is the CMB-space Doppler formula of first order for absolute velocities, and the second, quadratic term represents the time dilatation effect in CMB-space, as a function of absolute velocities, due to two fundamental properties of photons (Pabisch, 1999) (Pabisch & Kern, 2010),

$$T\left(\alpha\right)_{CMB} = T_0 \sqrt{1 - \left(\frac{u_\mathrm{e}}{c}\right)^2} \frac{c + u_e \cos\alpha}{c}. \tag{12}$$

Because of (11) and due to $v_\mathrm{e} = u_\mathrm{e}, \theta = \alpha$, we obtain finally

$$\frac{T_{CMB} - T_{SRT}}{T_0} = \frac{u_\mathrm{e}^2 \sin^2\alpha \sqrt{1 - \left(\frac{u_\mathrm{e}}{c}\right)^2}}{c^2 - c\; u_\mathrm{e}\cos\alpha}. \tag{13}$$

Because of the low absolute velocity of Earth, the difference between the two formulas is miniscule.

5.5 Anisotropic and inhomogeneous structure of Cosmos and some consequences

i) Signal data from a millisecond pulsar with a very stable rotational period, as i.e. from PSR J0437-4715 on the southern hemisphere, might probably confirm the annual variance of Earth eigentime in addition. A challenging experiment, but with all the extremely efficient instruments on Earth and in space it should be possible.

ii) Using the CMB-space Doppler formulas of first and/or second order between objects in the Universe, we will have the possibility to determine the absolute velocities and positions of nearby galaxies. A model of an universe with an absolute, anisotropic and inhomogeneous structure should enhance the resolution of many pending cosmological inconsistencies or unexplained phenomena which puzzles astronomers, like the observation of one of the earliest spiral galaxies, i. e. BX422.

iii) The P 10 acceleration anomaly should be analyzed again in the CMB-space, by applying the CMB-Doppler formula for two-way tracking signals, despite the proposed solution due to thermal recoil (Rievers & Lämmerzahl, 2011) (Francesco et al., 2011). In their paper “Is the physics within the Solar system really understood”, Lämmerzahl et al. (2006) discuss a collection of then unexplained phenomena within the solar system and the universe, like the CMB anomalies, the Flyby anomaly, the conundrum of Dark Matter and Dark Energy, to mention the most prominent and still unexplained phenomena. They finally refer to a seldom mentioned anomaly in the summary of that article. Comets usually come back a few days earlier before being expected when the standard equations of motion are applied. Treating that problem with the absolute CMB-space approach, a solution to that deviation might be possible too.

iv) The necessity to apply the CMB-space Doppler formula instead of the standard Doppler formula, and the firm experimental evidence of the variant eigen-frequency or eigen-time of any laboratory system as a function of its absolute velocity according to the quadratic term of the dipole formula (the first term of Eq. 13), derived from the CMB dipole data of the COBE, WMAP and Planck instruments (Adam & Planck Collaboration, 2015), are inconsistent with the relativity principle and the equivalence principle. The effect of time dilatation is not dependent on symmetric relative velocities between observers, but depends exclusively on absolute velocities in CMB-space, due to absolute properties of photons (Pabisch, 1999). As one of the consequences, the time arrow has a positive direction only, resolving an old conundrum.

Finally we predict that further data from the James Webb Space Telescope (JWST) will find no traces of a very early universe in deep space. In deep space, or even more distant, we still will see high redshift galaxies with unexpectedly high stellar masses. Neither a significant number of protogalaxies nor a significant number of first stars will be found. Due to our approach of new physics in the CMB-space, we assume that no singularities exist in black holes, and there was no big bang out of a singularity with a subsequent cosmic inflation.

References

Acedo, L. (2017, Jan). The Flyby anomaly: A multivariate analysis approach. *arXiv preprint arXiv:1701.05735v1*.

Adam, R., & Planck Collaboration. (2015, Jul). Planck 2015 results. VIII. High Frequency Instrument data processing: Calibration and Maps. *arXiv preprint arXiv:1502.01587*. Retrieved from `https://arxiv.org/abs/1502.01587` (Formula (3) in section 3.1 CMB dipole conventions.)

Aghanim, N., & Planck Collaboration. (2018, Dec). Planck 2018 results. I. Overview and the cosmological legacy of Planck. *arXiv preprint arXiv:1807.06205*. Retrieved from `https://arxiv.org/abs/1807.06205`

Anderson, J., Campbell, J. K., Ekelund, J. E., Ellis, J., Jordan, J. F., Konopliv, A. S., ... Wang, Y. J. (2008). Anomalous Orbital-Energy Changes Observed during Spacecraft Flybys of Earth. *Physical Review Letters*, *100*(9).

Anderson, J., Laing, P., Lau, E., Liu, A., Nieto, M., & Turyshev, S. (2002). Study of the anomalous acceleration of Pioneer 10 and 11. *Physical Review D*, *65*(8). Retrieved from `https://journals.aps.org/prd/abstract/10.1103/PhysRevD.65.082004` doi: 10.1103/PhysRevD.65.082004

Francesco, F., Bertolami, O., & Gil, P. (2011). Modelling the reflective thermal contribution to the acceleration of the Pioneer spacecraft. *physics.space-ph*.

Ghosh, A. (2007). On the Annual and Diurnal Variations of the Anomalous Acceleration of the Pioneer 10. *Apeiron*, *14*(3).

Hinshaw, G., Weiland, J. L., Hill, R. S., Odegard, N., Larson, D., Bennett, C. L., ... et al. (2008). Five-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Data Processing, Sky Maps & Basic Results.

Huterer, D. (2007, December). Why is the solar system cosmically aligned? *Astronomy*.

Lämmerzahl, C., Preuss, O., & Dittus, H. (2006). Is the physics within the Solar system really understood?

Olsen, O. (2007). The constancy of the Pioneer anomalous acceleration. *Astronomy & Astrophysics*, *463*, 393–397.

Pabisch, R. (1999). *Derivation of the time dilatation effect from fundamental properties of photons*. Springer-Verlag Wien New York.

Pabisch, R. (2022). Flyby Doppler and Ranging Data Anomalies Are Due to Different Inbound and Outbound Velocities in the CMB Rest Frame. *viXra*.

Pabisch, R., & Kern, C. (2010). Verfahren zur Verbesserung der Steuerungsgenauigkeit einer Raumsonde im Sonnensystem. *Deutsches Patent- und Markenamt*(DE 10 2010 054 741 A1).

Rievers, B., & Lämmerzahl, C. (2011, May). High precision thermal modeling of complex systems with application to the flyby and Pioneer anomaly. *arXiv preprint arXiv:1104.39852*. Retrieved from `https://arxiv.org/abs/1104.39852`

Schwarz, D. J., Copi, C. J., Huterer, D., & Starkman, G. D. (2015, Oct). CMB anomalies after Planck. *Physical Review Letters*, *93*(22). doi: 10.1103/PhysRevD.93.221301

Schwarz, D. J., Starkman, G. D., Huterer, D., & Copi, C. J. (2014). Is the low-l Microwave Background Cosmic? *Physical review letters*, *93*(22), 221301. Retrieved from `https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.93.221301` doi: 10.1103/PhysRevLett.93.221301