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Article

Measuring Velocity Using Moving Clocks—The Surprising Test of Tangherlini's Theory

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Abstract

Motivated by Matsas et al. (2024), who demonstrated that time can serve as the sole fundamental dimension in place of traditional LMT dimensions, this study expands those results within the Minkowski and Tangherlini frameworks. Using a Lorentz transformation (LT) matrix approach, we validate the three-clock protocol, confirming that distance and newly discovered velocity expressions are derivable exclusively from proper times. The investigation is extended to Tangherlini's 4D spacetime to test whether absolute velocity is identifiable. While this resulted in velocity cancellation, a breakthrough was achieved by analysing the wave 4-vector geometric structure. By defining electromagnetic waves in transit as 'anonymous' — hosted by the ARF and unrelated to their original source frequency due to Doppler ambiguity at emission — we propose the Postulate of Anonymity, justified by the wave 4-vector structure in the Tangherlini framework. Using this concept, we successfully circumvented the "cancellation gap". We demonstrate that the ratio of spatial wave-vector components *ky/kx* (the tangent of the aberration angle) provides a direct, non-ambiguous measure of absolute velocity relative to the vacuum, reconciling with aberration methodologies utilized in the Planck 2013 mission. We prove that while the temporal component ω/c acts as a coordinate-dependent variable subject to sensor interaction, the spatial components tell the 'full truth' of the ARF. Consequently, we formally associate "peculiar velocity" with absolute velocity. The Andromeda Paradox is partially resolved as a coordinate artefact. We conclude that the wave 4-vector is a universal witness to an invariant, causal timeline anchored to the ARF.

Keywords: absolute rest; absolute velocity; Tangherlini transformation; postulate of relativity; physical units; relativistic transverse Doppler effect; cosmic microwave background; wave vector geometry; Andromeda paradox

1. Introduction

In a 2024 study, Matsas et al. [1] introduced a compelling conceptual framework in which time serves as the sole fundamental unit for all physical quantities, thereby superseding the traditional length–mass–time (LMT) dimensional system. A particularly significant implication of this framework is the ability to measure spatial distance using only three inertial clocks. This is made possible by employing the Unruh protocol[1] this unusual measurement can be achieved via a round-trip configuration involving one stationary clock C3 and two relatively moving clocks C1 and C2, as illustrated in Figure **1**. Although such a result is unattainable within a Galilean coordinate system, it becomes viable in Minkowski spacetime. This is because the reduction in degrees of freedom is caused by the implementation of Einstein's light-speed isotropy postulate. The

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[1] Undisclosed private communication, according to reference [1].

distance-measurement formula derived in [1] is based on the worldlines of three inertial clocks forming a triangle in a Minkowski diagram and is expressed as follows:

$$D = \frac{\sqrt{[(\tau_3{}^2 - \tau_1{}^2 - \tau_2{}^2)^2 - 4\tau_1{}^2\tau_2{}^2]},}{2\tau_3} \tag{1}$$

where τ_3 is the C3 clock time at the stationary system origin, and τ_1 and τ_2 are the respective trip durations of moving clocks (C1 and C2) at unspecified velocities. This formula can be expanded to the following equivalent expression:

$$D = \frac{\sqrt{\tau_1{}^4 - 2\tau_1{}^2\tau_2{}^2 - 2\tau_1{}^2\tau_3{}^2 + \tau_2{}^4 - 2\tau_2{}^2\tau_3{}^2 + \tau_3{}^4}}{2\tau_3} \tag{2}$$

1.1. Experimental Protocol

In this study, we employed a motion protocol that differs slightly from the original arrangement in [1]; however it remains physically equivalent.

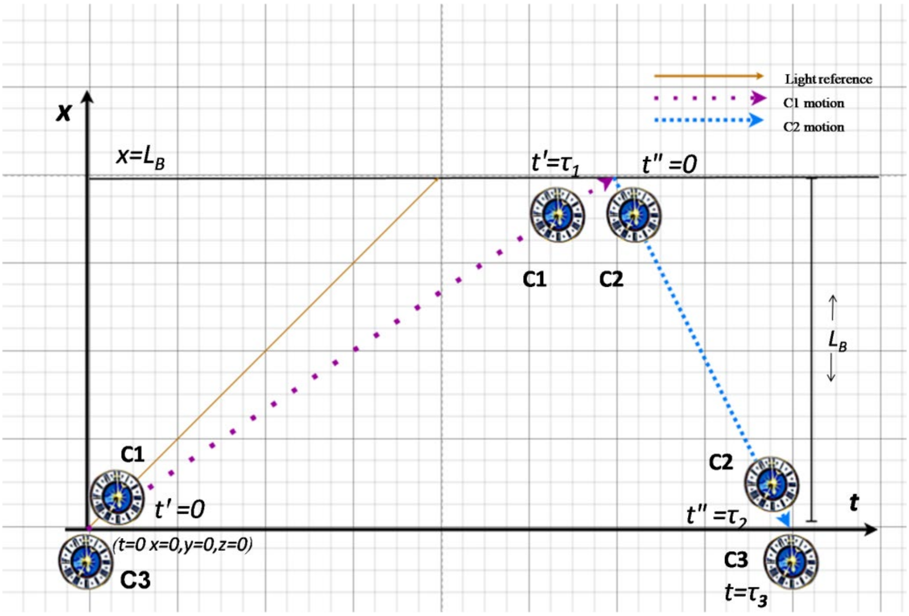

Figure 1 The three-clock scenario (angles not to scale).

1. **Reference Frame:** The stationary laboratory frame is designated as system **B** (base platform).
2. **Clock C1 Initiation:** Clock C1 approaches from the negative x-axis side at a constant, unknown velocity v_1. When passing the origin, it is synchronised to $t' = 0$.
3. **Base Synchronisation:** The stationary clock C3 is simultaneously reset to $t = 0$ at the moment of C1's departure from the origin.
4. **Clock C2 Worldline:** Clock C2 is launched from a distant point on the positive x-axis at velocity v_2 on a reciprocal heading towards the origin. To ensure a continuous trajectory, a negligible y-axis offset is assumed. Upon encountering C1 at an unknown position $x = L_B$, C2 is synchronised to $t'' = 0$.

5. **Procedural Independence**: Although this round-trip arrangement aligns with the triangular geometry in Minkowski spacetime used in [1], the individual legs of the trip can be executed sequentially in practice, because the recorded durations are independent of the specific epoch of initiation. The delay δ between the C1 and C2 arrivals could be measured by an additional unsynchronised clock, similar to C3, located at a fixed, unmeasured position $x = L_B$. This would increase the accumulated total duration on clock C3. For derivation clarity, we assume that δ=0 to maintain consistency with the reference [1].
6. **Data TransmissionC1**: At the point of encounter with C2, clock C1 transmits its elapsed proper time τ_1 to the origin of **B** to support future calculations, whereas C2 resets the time t'' to 0.
7. **Data Transmission C2:** Upon reaching the origin, clock C2 communicates the recorded duration τ_2 to the base to support future calculations.
8. **Final Measurement:** The stationary clock C3 records the total round-trip time τ_3, which represents the sum of the consecutive durations for clock C1 (τ_1) to reach the unknown distance L_B and for clock C2 (τ_2) to reach the origin from L_B.

Using this protocol, we confirm that the acquired data τ_1, τ_2, and τ_3 appear sufficient to resolve not only the unknown distance L_B but also the previously undetermined velocities v_1 and v_2. Additionally, an analysis of this scenario was performed in the 4D Tangherlini framework.

2. Methods

2.1. Background

Section 3 presents a validation of the distance formula in Equation (1) using the widely accepted LT matrix approach for relativistic kinematics. Although the validation of the distance was expected, the emergence of new velocity formulae in Equation (12) presented a distinct challenge. Additionally Tangherlini framework appears to be a controversial subject. We recognise that the research methodology must be adequate to the specific context in which the Tangherlini transformation (TT) is perceived. TT remains outside the mainstream; indeed, rejection is often declared *a priori*. Will [2] (pp 325,326), referencing the Mansouri-Sexl [3] generalisation of coordinates transformation, remarked that adopting the infinite signal speed required for absolute clock synchronisation a "perverse choice." However, this was understandable given the signal was not only unproven, but also intuitively self-contradictory. Torr and Smiley [4] (1986) referring to Pauli [5], explained the attitude towards absolute transformations lacking a group structure that it would seriously disturb the STR formalism by inherent anisotropies. Irrespective of conceptual difficulties infinite speed might cause, such strong rejections can stifle objective scientific discussion, which should not avoid controversial subjects. However, Tangherlini methodically derived the transformation from Einstein field equations and was fully aware of the instantaneous signal problem, yet expressing hope for absolute velocity detection via subluminal signals or rotational motion. Our objective was to check whether the unusual three-clock scenario can indeed prove the reality of absolute velocity. In some early derivations there were heuristic attempts, such as by Eagle [6], requiring electrically controlled vibrating quartz rods, or by Mansouri-Sexl where the absolute transformation appears to stem from a misinterpretation of the LT time coordinate transformation $t = (1 - v^2)^{(1/2)} T - vx$. The $(1 - v^2)^{(1/2)}$ factor should be positioned in the denominator as in the spatial coordinate (p 301 eq. 3.4). We presented a complete fundamental set of postulates in Appendix A, to derive the TT matrix independent of Einstein field equations, sufficient and free from other external constraints seeking to ground the discussion in objective, theoretical, and potentially experimental context in the domain and spirit of the STR.

2.2. The Adopted Approach

The following rules characterise our approach:

1. We adopt the standard idealisations of imposed by the STR [7], including Einstein's description of inertial systems where the equations of mechanics "hold good", and the use of ideal rigid measuring rods abstraction within a Euclidean geometric framework.

2. We assume that the TT applied to 4-vectors results in physically valid transformed physical quantities, thereby granting the TT the same confidence as for the LT, unless a contradiction is proved.

3. Confidence in the TT is further bolstered by the fact that, beyond Tangherlini's general relativity (GR) approach, these transformations can be derived from the fundamental postulates presented in Appendix A.

4. To maintain a clear focus on the correspondence (or lack thereof) between these theories, we intentionally exclude quantum theory or complex GR metrics. Following Descartes' Rule of Analysis in *Discourse on Method* [8] p.35): we aim to "divide each difficulty into as many parts as required" to achieve clarity by not introducing associated important, but separate concerns. In commenting on light propagation we usually stay within the classical view proven useful in the original STR.

5. Following Point 2, transformed physical quantities are deemed potentially measurable. The failure to determine absolute velocity excludes experimental confirmation; otherwise the theory must still be deemed theoretically sound and worthy of experimental effort.

6. Similarly to the STR approach, in the Tangherlini framework we implicitly assume the same idealisations and simplifications of physical reality as presented in Point 1.

7. Non linear systems of equations frequently appear and they are solved using Maple™2019 algebra package, which is also used to validate the intended transformations to reduce the chance of algebraic errors.

8. This publication presents our research which was exploratory by nature, follows sequential stages, emerging while the problem was evolving and changing direction, resulting from intermediate findings. It is therefore not formulated as a new conclusive theory or an updated theory, but aims to produce input to further research or generalisation.

2.3. Notation Convention

In the following sections we introduce up to four coordinate systems: **A** representing the ARF, **B** for the base system and **B1**, **B2** for clocks C1 and C2 respectively, which we recognise from the LT-based scenario. The notation used in this paper designates the last one or two symbols in the relevant variable's suffix to determine in which frame the quantity is observed/measured, while one or two preceding characters may define the frame to which the quantity belongs or identify a specific feature; hence, v_{BA} denotes the velocity of system **B** as measured in **A**. Similarly, for the C2 clock's system **B2**, we have v_{B2A}, which is the velocity of system **B2** in **A**. The symbol X_{LB1} refers to a vector aligned with the x-axis measured in system **B1** and representing the length L. This allows for a unique distinction between similar quantities in different frames. The transformed vector symbols change the suffix sequence accordingly. Some symbols have additional superscript to relate them to time axes. The convention is that time in the reference rest system, is represented by simple t variable and for relatively moving systems by t', t'', t''' as needed. In the transformation context, the same transformed quantity may be expressed as a function of the rest system time or that of the moving system time, therefore for example X'_{LB1} is the length vector in the moving system tt' time coordinate, while the same in the rest frame coordinates is un-primed X_{LB1}, both representing the same quantity.

3. Distance and Velocity Calculations in Minkowski Spacetime

The following derivations implicitly assume the idealisations and simplifications of the physical reality typical of the STR [7]. The preferred method for these derivations is linear algebra, utilising the Lorentz transformation (LT) matrix which is defined as follows:

$$\Lambda_v = \begin{bmatrix} \gamma_v & -v\frac{\gamma_v}{c} & 0 & 0 \\ -v\frac{\gamma_v}{c} & \gamma_v & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \tag{3}$$

$$\gamma_v = 1/\sqrt{1 - v^2/c^2}$$

We assume that a stationary inertial base system **B**, is represented by a 4D Cartesian coordinate system. Within this frame, we analyse the motion of two inertial point masses represented by clocks C1 and C2, moving along the x-axis. The 4-vector X_{LB} represents an unknown, reference distance:

$$X_{LB} = \begin{bmatrix} ct \\ L_B \\ 0 \\ 0 \end{bmatrix}. \tag{4}$$

The transformation of the fixed X_{LB}in **B** to the local C1 coordinates using the LT matrix Λ_{v1}multiplied by X_{LB} yields the moving point X_{LB1} approaching C1, which is at the origin of the inertial system designated as **B1**:

$$\Lambda_{v1} \begin{bmatrix} ct \\ L_B \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} \frac{c^2 t - L_B v_1}{\sqrt{c^2 - {v_1}^2}} \\ \frac{c(L_B - v_1 t)}{\sqrt{c^2 - {v_1}^2}} \\ 0 \\ 0 \end{bmatrix} \equiv X_{LB1}. \tag{5}$$

The transformed vector $X_{LB1}$is initially expressed in terms of the base system time t and must be converted to the local proper time t' of C1:

$$(X_{LB1})_1/c = t' \Rightarrow t = \frac{\sqrt{c^2 - {v_1}^2}ct' + L_B v_1}{c^2}. \quad (6)$$

The converted vector in the local primed coordinates is obtained by substituting the expression for t from Equation (6) and subsequent simplifications:

$$X'_{LB1}= \begin{bmatrix} ct' \\ \dfrac{-c\sqrt{c^2 - {v_1}^2}v_1 t' + L_B c^2 - L_B {v_1}^2}{c\sqrt{c^2 - {v_1}^2}} \\ 0 \\ 0 \end{bmatrix}. \quad (7)$$

The time required for L_B to come into contact with the C1 origin can be determined when $\left(X'_{LB1}\right)_2 = 0$, which is calculated from the following equation:

$$-c\sqrt{c^2 - {v_1}^2}v_1 t' + L_B c^2 - L_B {v_1}^2 = 0 \Rightarrow t' = \frac{L_B\sqrt{c^2 - {v_1}^2}}{v_1 c} \equiv \tau_1, \quad (8)$$

where τ_1 is the proper time of clock C1.

The simplest way without presenting the similar derivation again from as from Equations (5) to (8) is to think of the equivalent scenario for C2 using the translated C2's worldline which has a negative velocity v_2, hence sloping down from the C3's origin $(x = 0, t = 0)$ to $x = -LB$, because the duration over the same distance is independent of the specific epoch and position of initiation. The vector X''_{LB2} for C2 would differ from the C1's X'_{LB1} only in terms of the velocity symbol and coordinate $x = L_B$ replaced by $x = -L_B$, as it can be deduced from Figure 1.Then, by analogy,

$$-c\sqrt{c^2 - {v_2}^2}v_2 t'' - L_B c^2 + L_B {v_2}^2 = 0 \Rightarrow t'' = \frac{L_B\sqrt{c^2 - {v_2}^2}}{-v_2 c} \equiv \tau_2. \quad (9)$$

In clock C3, the duration of the roundtrip is the sum of the successive durations on each segment as given by the following expression:

$$\tau_3 \equiv \frac{L_B}{v_1} + \frac{L_B}{-v_2}. \quad (10)$$

The minus sign in the denominator makes the C2 clock trip duration positive.

Given that the clock times were measured, there three unknowns: L_B, v_1,and v_2, and three equations:

$$\begin{cases} \tau_1 = \dfrac{L_B\sqrt{c^2 - {v_1}^2}}{v_1 c} \\ \tau_2 = \dfrac{L_B\sqrt{c^2 - {v_2}^2}}{-v_2 c} \\ \tau_3 = \dfrac{L_B}{v_1} + \dfrac{L_B}{-v_2}. \end{cases} \tag{11}$$

The solution of the nonlinear system of equations (11) obtained by the Maple™ package with respect to L_B, v_1,and v_2 is as follows:

$$\begin{cases} L_B = \dfrac{\pm c\sqrt{{\tau_1}^4 - 2{\tau_1}^2{\tau_2}^2 - 2{\tau_1}^2{\tau_3}^2 + {\tau_2}^4 - 2{\tau_2}^2{\tau_3}^2 + {\tau_3}^4}}{2\tau_3} \\ v_1 = \dfrac{\pm c\sqrt{{\tau_1}^4 - 2{\tau_1}^2{\tau_2}^2 - 2{\tau_1}^2{\tau_3}^2 + {\tau_2}^4 - 2{\tau_2}^2{\tau_3}^2 + {\tau_3}^4}}{{\tau_1}^2 - {\tau_2}^2 + {\tau_3}^2} \\ v_2 = \dfrac{\pm c\sqrt{{\tau_1}^4 - 2{\tau_1}^2{\tau_2}^2 - 2{\tau_1}^2{\tau_3}^2 + {\tau_2}^4 - 2{\tau_2}^2{\tau_3}^2 + {\tau_3}^4}}{{\tau_1}^2 - {\tau_2}^2 - {\tau_3}^2}. \end{cases} \tag{12}$$

The expression for L_B in (12) is valid only for the positive value. Although it appears algebraically distinct from the original Equation (1), it is equivalent to the expanded original form in Equation (2). The constant speed of light $c$is is absent in (2), because it was set to the dimensionless value of one in [1], in accordance with the Minkowski diagram convention.

Although we reject negative L_B (unless it represents a coordinate on the negative side of x),we must decide which velocity variant to choose. In the scenario illustrated in Figure 1, it was found that, all the roots preceded by the plus sign represent the consistent solution of the system. Another feature of this system should be noted: The travel times of clocks C1 and C2 in **B** to x= L_B and $x = 0$, respectively can be calculated.

$$\tau_{C1} = \frac{L_B}{v_1} = \frac{\tau_1^2 - \tau_2^2 + \tau_3^2}{2\tau_3}$$
$$\tau_{C2} = \frac{L_B}{v_2} = \frac{\tau_3^2 + \tau_2^2 - \tau_1^2}{2\tau_3} \tag{13}$$

Conceptual Implications

The ability to measure L_B using clocks alone is a noteworthy discovery by Unruh and Matsas et al. [1]; however, the capacity to obtain velocities without using presynchronised clocks is arguably more significant. Conventionally, velocity measurement requires two distant, synchronised clocks by definition: $v = dx/dt$ (with some exceptions, such as Doppler effect measurements or dual light-pulse round-trip measurements for uniform motion). Surprisingly, no explicit distance is necessary for the velocity expressions in Equation (12), because it is entirely factored into the temporal parameter arrangement. The three clocks, moving relative to one another, indicate their proper times without regard for any specific coordinate system; clocks possess no inherent knowledge of sensors or reference frames. Once we derived Equation (12), the result in Equation (13) is not unexpected. However, this simple and beautiful formula leads to the remarkable conclusion that three convention-independent invariant clock proper times can practically determine L_B, v_1, v_2, τ_{C1}, and τ_{C2} without any physical implementation of a coordinate system or pairwise synchronised clocks, only at most, it requires designating a distant point on the x-axis, labelled as L_B without actually measuring it. The main thesis of one fundamental unit sufficient in physics postulated by Matsas et al. [1] is convincingly demonstrated. It may be premature to conclude that Equation (13) shows nature's preference for a particular one-way velocity of light isotropy convention. Although τ_{C1} duration was captured at $x = L_B$ locally in **B1,** all the equations leading to Equation (13) were derived using the STR framework. There are additional interesting consequences of Equation (13), which is discussed in Section 4.4.

These findings suggest that the three-clock-based measurement result is a natural consequence of the spacetime geometry. This prompted an investigation into possible implications of the three-clock scenario within Tangherlini spacetime, which was introduced in the 1958 doctoral thesis at Stanford University [9]. Although the mathematical difference between the LT and the corresponding Tangherlini transformation (TT) matrices is subtle, the physical ramifications are vast. A scenario similar to that shown in Figure 1 can be applied by employing a hypothetical absolute ARF concept and three moving clock frames in relative motion.

4. Three Clocks in Tangherlini Spacetime

4.1. Tangherlini framework and the Thought Experiment Rationale

The extended solution of Matsas et al. [1] in Equations (12) raised the following questions:

1. Can the length be calculated?
2. Can relative clock velocities be calculated?
3. Can absolute velocity be calculated with three distant clocks bypassing the standard distant STR synchronisation?
4. Can predictions in Tangherlini framework differ from those made in the STR framework?

The predictions in Equations (12) are functions of clocks proper times which make them invariant, therefore the intuitive answer is that they should be equivalent in Tangherlini framework. However, such general and likely true answer, requires a demonstration of the mechanism in that framework that abandoned the STR synchronisation.

The transformation derived by Tangherlini provides an analytical relativistic framework similar to that in STR [7]. Originally named the "absolute Lorentz transformation" (ALT), the TT was derived from the Einstein field equations in the absence of gravitational sources. We found that the same transformation can be derived from first principles based on fundamental postulates, including:

1. The assumption of an ARF,
2. The experimentally established isotropy of the round-trip average speed of light and
3. Potentially controversial invariance of the instantaneous signal hypothesis (see Appendix A for the exact formulation of the postulates).

No relativistic effects were assumed *a priori*; time dilation and length contraction emerged naturally. Unlike the STR convention, where absolute velocity is outside the scope of measurement, we treat the ARF as a reference inertial system where t is the absolute time variable; however, it is immeasurable without knowing which inertial system is the ARF. Thus far, according to the present consensus, absolute velocity suggestions appear fallacious, as once asserted by Eddington [10] (p.59). In contrast, Tangherlini attempted to reason about the possibility of detecting absolute motion based on the presented theory, but this was inconclusive at that time. First, he noted that if two distant clocks are not absolutely synchronised, it is not possible to calculate the one-way relative velocity of anything, because there is no way of correlating the time of arrival in terms of the time of departure [9] (p48). In Chapter 6 of [9] (p73–74), a suggestion is made that using subluminal signals, it would be possible to detect the absolute motion of the Earth. However, despite the focused, detailed analysis, no closed-form explicit solution or sufficient details of the measurement method demonstrating this possibility could be found. Additionally, in the final chapter of [9] (p101), Tangherlini concluded that in the examples presented in the doctoral thesis, absolute velocity always cancels out when measurements are performed *"in the usual manner"*. We assume that these methods do not depend on the prior absolute synchronisation of separated clocks, which seems to be impossible without instantaneous signals.

After determining that velocities can be measured with only three clocks, as shown in Equation (12), the question emerged as to whether this method was sufficiently unusual to prove absolute velocity. The Unruh three-clock protocol [1] requires only three measurable proper times, and no two distant clocks appear to be synchronised, only by the coincidence of their positions in a predefined location to reset them to 0.

4.2. Three-Clock Thought Experiment in Tangherlini 4D Spacetime

The scenario analysis performed in Section 3 can now be followed in Tangherlini framework. We attempted to follow similar process with the TT matrix, which is represented as follows:

$$\Omega_{\infty}^{v} = \begin{bmatrix} 1/\gamma_v & 0 & 0 & 0 \\ -v\dfrac{\gamma_v}{c} & \gamma_v & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad (14)$$

where$\gamma_v = 1/\sqrt{1 - v/c^2}$.

The infinity subscript in the TT matrix symbol emphasises the role of the instantaneous signal postulate. Matrix differs from the LT matrix (3) because of the absence of the space-dependent time coordinate, which is now zero. Although the impossibility of absolute synchronisation with

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infinitely fast signals appears to be a fundamental obstacle, the significance of the TT framework would be profound if such obstacles could be circumvented.

The graphical representation of the scenario differs slightly from that of the previous case in terms of axes symbols, as shown in Figure 2. This shows the perspective of the base system denoted by **B** with the system clock C3, which is an inertial moving system with respect to the hypothetical ARF denoted by **A**, which thus far, according to the present consensus, cannot be identified. However, it is treated here as a special purpose inertial system with a time variable t, wherein no measurement can be made because no reference points are known in empty space. The scenario is shown as if C2 starts instantaneously when C1 arrives, making it truly unrealistic but as explained on page 3. It can be programmed to arrive later and have a delay δ measured and factored in the equations accordingly. Therefore we proceed with the simplest case and assume fixed L_B and zero delay δ.

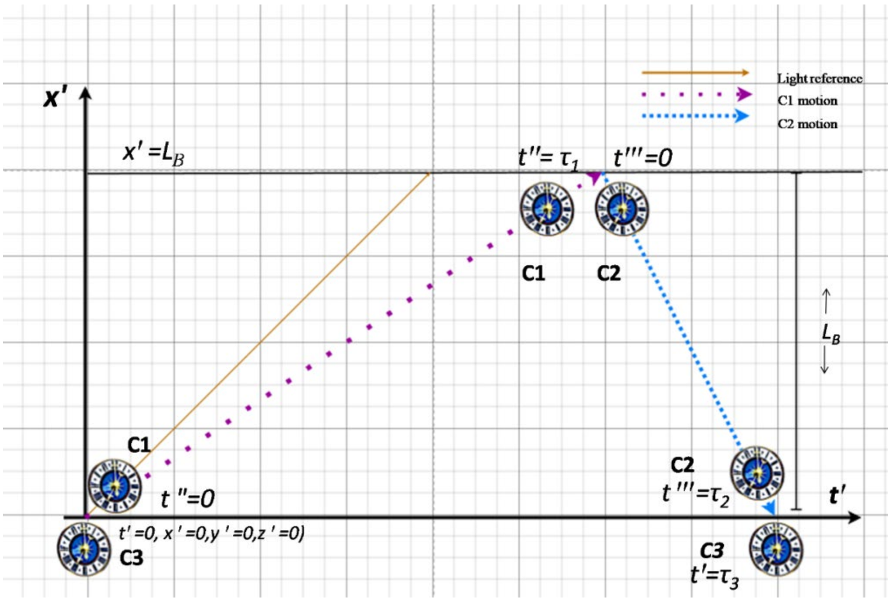

Figure 2 The three-clocks scenario in system B (angles not to scale).

In partial agreement with Poincaré's [11] objections[2] regarding the absolute space coordinate axes we instead consider the absolute rest state to be a unique property of the subclass of inertial systems out of the class of all inertial systems rather than the state of the 'void'.

Our position disagrees with Newton's concept of absolute space, which "remains always similar and immovable." [12], but aligns with Einstein's remark on the ether: "the idea of motion may not be applied to it" [13]. The inaccessibility of the featureless absolute space to measurement and the same with respect to any inertial absolute system **A,** can be overcome by using the inverse transformation (TT^{-1}) from any inertial system where times and lengths are measurable and can be formally related to **A,**

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[2] This idea came from Poincaré, claiming that "absolute space is nonsense, and it is necessary for us to begin by referring space to a system of axes invariably bound to our body (which we must always suppose put back in the initial attitude)." With no features in space, the only way to bootstrap the derivation is to assume that at time t=0, some abstract coordinate system in A is momentarily aligned with the moving one and stays where it was as the distance increases. Absolute space then has no role other than being a passive container for inertial systems as far as this simple linear algebra model is concerned.

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based on the presented model. Currently, absolute velocity remains hypothetical until its measurability is proved.

4.3. Derivation and Mathematical Reconciliation

In system **B**, we designate a fixed distant point X_{LB}as a 4-vector at which the worldline of C1 ends and that of C2 begins:

$$X_{LB} = \begin{bmatrix} ct' \\ L_B \\ 0 \\ 0 \end{bmatrix}. \tag{15}$$

Instead of relative velocities as in the LT-based three-clock scenario, we look for absolute velocities with respect to the initially undefined absolute frame **A**. There is no obvious way to measure the relative velocity in Tangherlini spacetime; therefore, we need to introduce the base system's absolute velocity vector $\overrightarrow{\boldsymbol{v_{BA}}}$in **A** with an unknown magnitude v_{BA}. For simplicity, as in the STR standard configuration, this vector is aligned with the virtual x-axis of **A** and with the collinear x'-axis of **B**, as prescribed by the Tangherlini standard coordinate configuration (x- boost).

We can determine the vector equation of motion (EOM) of X_{LB} in **A** as X_{LBA} by applying the inverse TT matrix $(\Omega_{\infty}^{v_{BA}})^{-1}$.

$$\left(\Omega_{\infty}^{v_{BA}}\right)^{-1} \begin{bmatrix} ct' \\ L_B \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} \dfrac{c^2 t'}{\sqrt{c^2 - {v_{BA}}^2}} \\ \dfrac{(v_{BA} t' + L_B)c^2 - L_B {v_{BA}}^2}{c\sqrt{c^2 - {v_{BA}}^2}} \\ 0 \\ 0 \end{bmatrix} \equiv X_{LBA}. \tag{16}$$

The variable t' in **B** must be eliminated from the transformed vector so that the absolute time $t$is consistently expressed in absolute coordinates.

$$\frac{(X_{LBA})_1}{c} = t \Rightarrow t' = \frac{t\sqrt{c^2 - {v_{BA}}^2}}{c}. \tag{17}$$

X_{LBA} can now be expressed in absolute time coordinates as follows:

$$X'_{LBA} = \begin{bmatrix} ct \\ \dfrac{c\sqrt{c^2 - {v_{BA}}^2} v_{BA} t + L_B c^2 - L_B {v_{BA}}^2}{c\sqrt{c^2 - {v_{BA}}^2}} \\ 0 \\ 0 \end{bmatrix}. \tag{18}$$

The moving clock C1 is associated with the symbol **B1**, which represents its local coordinate system, and X_{LBA} must be converted to this system, in which a fixed L_B is considered to be a moving point towards the origin of **B1**. The absolute velocity of **B1** in **A** is designated as v_{B1A}. Therefore, it must be transformed using the transformation matrix $\Omega_{\infty}^{v_{B1A}}$.

$$\Omega_{\infty}^{v_{B1A}} X_{LBA} = X_{LBB1} = \begin{bmatrix} \sqrt{c^2 - {v_{B1A}}^2}\, t \\ \dfrac{ct(v_{BA} - v_{B1A})\sqrt{c^2 - {v_{BA}}^2} + L_B c^2 - L_B {v_{BA}}^2}{\sqrt{c^2 - {v_{BA}}^2}\sqrt{c^2 - {v_{B1A}}^2}} \\ 0 \\ 0 \end{bmatrix}. \tag{19}$$

The variable t must be eliminated from the transformed vector so that can be consistently expressed in thet'', x'' coordinates.

$$\frac{(X_{LBB1})_1}{c} = t'' \Rightarrow t = \frac{ct''}{\sqrt{c^2 - {v_{B1A}}^2}}. \tag{20}$$

After the substitution, X_{LBB1} can be expressed in **B1** terms of the coordinate t''as follows:

$$X''_{LBB1} = \begin{bmatrix} ct'' \\ \dfrac{L_B(c^2 - {v_{BA}}^2)\sqrt{c^2 - {v_{B1A}}^2} + c^2 t'' \sqrt{c^2 - {v_{BA}}^2}(v_{BA} - v_{B1A})}{\sqrt{c^2 - {v_{BA}}^2}(c^2 - {v_{B1A}}^2)} \\ 0 \\ 0 \end{bmatrix}. \tag{21}$$

The X''_{LBB1} marker in the **B1** frame appears to move towards the **B1** origin. The time at which clock C1 coincides with the marker is when its x'' coordinate is 0:

$$(X''_{LBB1})_2 = 0 \Rightarrow t'' = \frac{L_B\sqrt{c^2 - {v_{BA}}^2}\sqrt{c^2 - {v_{B1A}}^2}}{c^2(-v_{BA} + v_{B1A})} \equiv \tau_1. \tag{22}$$

The trip duration τ_1 of clock C1 is now determined. Because of the downwards worldline orientation, the duration τ_2 of clock C2 follows the same formula (22), but with a different velocity symbol and with the sign inverted so that τ_2 remains positive. This is by the same rationale as the one leading to Equation (9) by shifting the start point to the origin of **B** and heading onto the point $(x' = 0, t' = 0)$.

$$(X'''_{LBB2})_2 = 0 \Rightarrow t''' = \frac{-L_B\sqrt{c^2 - {v_{BA}}^2}\sqrt{c^2 - {v_{B2A}}^2}}{c^2(-v_{BA} + v_{B2A})} \equiv \tau_2. \tag{23}$$

We have determined the durations on paths from the perspective of moving clocks C1 and C2; now, we need to find the relative velocities v_1 and v_2 of these clocks in **B** and the time of the round trip τ_3 measured by clock C3. The vector EOM of C1 in **A** is given by the 4-vector X_{B1A}:

$$X_{B1A} = \begin{bmatrix} ct \\ v_{B1A}t \\ 0 \\ 0 \end{bmatrix}. \tag{24}$$

Applying TT to X_{B1A} yields the following:

$$\Omega_{\infty}^{v_{BA}} X_{B1A} = X_{B1B} = \begin{bmatrix} \sqrt{c^2 - {v_{BA}}^2}t \\ \dfrac{ct(-v_{BA}+v_{B1A})}{\sqrt{(c^2 - {v_{BA}}^2)}} \\ 0 \\ 0 \end{bmatrix}. \tag{25}$$

After Equation (25) is converted to local time t' of **B**, the relative EOM of C1 is expressed as follows:

$$X'_{B1B} = \begin{bmatrix} ct' \\ \dfrac{c^2t'(-v_{BA}+v_{B1A})}{(c^2 - {v_{BA}}^2)} \\ 0 \\ 0 \end{bmatrix}. \tag{26}$$

Similarly, for **B2**:

$$X'_{B2B} = \begin{bmatrix} ct' \\ \dfrac{c^2t'(-v_{BA}+v_{B2A})}{(c^2 - {v_{BA}}^2)} \\ 0 \\ 0 \end{bmatrix}. \tag{27}$$

The relative velocities v_{T1} and v_{T2} in Tangherlini spacetime are then obtained using the same formula except that v_{B2A} has replaced v_{B1A}:

$$\begin{aligned} v_{T1} &= \frac{c^2(-v_{BA}+v_{B1A})}{(c^2 - {v_{BA}}^2)} \\ v_{T2} &= \frac{c^2(-v_{BA}+v_{B2A})}{(c^2 - {v_{BA}}^2)}, \end{aligned} \tag{28}$$

The round-trip time registered by clock C3 is as follows:

$$\tau_3 = \frac{L_B}{v_{T1}} - \frac{L_B}{v_{T2}} = \\ = \frac{L_B(c^2 - {v_{BA}}^2)}{c^2(-v_{BA}+v_{B1A})} - \frac{L_B(c^2 - {v_{BA}}^2)}{c^2(-v_{BA}+v_{B2A})}. \qquad (29)$$

We obtain the system of the following three nonlinear equations from Equations (22), (23) and (29):

$$\begin{cases} \tau_1 = \dfrac{L_B\sqrt{c^2 - {v_{BA}}^2}\sqrt{c^2 - {v_{B1A}}^2}}{c^2(-v_{BA} + v_{B1A})} \\ \tau_2 = -\dfrac{L_B\sqrt{c^2 - {v_{BA}}^2}\sqrt{c^2 - {v_{B2A}}^2}}{c^2(-v_{BA} + v_{B2A})} \\ \tau_3 = \dfrac{L_B(c^2 - {v_{BA}}^2)}{c^2(-v_{BA}+v_{B1A})} - \dfrac{L_B(c^2 - {v_{BA}}^2)}{c^2(-v_{BA}+v_{B2A})}. \end{cases} \qquad (30)$$

From this system, we cannot calculate L_B because we have three unknown velocities and therefore four unknowns, with only three equations. We cannot rely on the method described in Section 3 because it is not yet practically feasible. However, this is not an obstacle because L_B is a free parameter that can be measured by traditional methods, particularly using the return time of the light signal on the roundtrip: $L_B = c\Delta t_{ret}/2$.

The system solution was attempted using Maple™ 2019. Unfortunately, despite the unusual nature of the three-clock method, which does not explicitly rely on distant clock synchronisation, *no solution was found because of the usual absolute velocity cancellation*.

In confirming and analysing the disappointing but widely expected null result, an important connection was found between the Minkowski and Tangherlini frameworks.

1. Using proper times $\tau_1, \tau_2,$ and τ_3 represented by Equations (30);
2. Substituting them into the positive root of the equation for L_B and to all velocity roots denoted as v_{11}, v_{12}, v_{21}, and v_{22}, using Equations (12); and
3. Assuming that $\{v_{BA} >, 0\ v_{B1A} > v_{BA}, v_{B2A} < v_{BA}, v_{BA} < c, v_{B1A} < c,$ and $c > 0\}$ and L_B is a real positive number, the result of algebraic simplification is as follows:

$$
\begin{aligned}
&D \equiv L_B = L_B\\
&v_{11} = \frac{c^2(-v_{BA} + v_{B1A})}{c^2 - v_{BA}v_{B1A}}\\
&v_{12} = \frac{c^2(v_{BA} - v_{B1A})}{c^2 - v_{BA}v_{B1A}}\\
&v_{21} = \frac{c^2(-v_{BA} + v_{B2A})}{c^2 - v_{BA}v_{B2A}}\\
&v_{22} = \frac{c^2(v_{BA} - v_{B2A})}{c^2 - v_{BA}v_{B2A}}.
\end{aligned}
\tag{31}
$$

This was as expected for L_B. The absolute velocities did cancel each other; thus, L_B remained invariant yet unknown unless explicitly assumed. However, no cancellation was observed for the STR relative velocities. One instance of the STR velocity can be the result of an unlimited number of combinations of v_{BA}andv_{B1A}. Measuring any of the velocities from v_{11} to v_{22} is insufficient to solve for v_{BA} because of one extra degree of freedom. At this point, all the classic predictions seem to confirm the postulate of relativity as formulated by Poincaré [14] (first presented on June 5, 1905), placing the inability to detect the absolute movement of the Earth as the foundation (see the discussion on page 28). Poincaré reported that his principle, which is consistent with the Lorentz transformation, was thoroughly reviewed and rederived with full mathematical rigour [14]. This finding made it pointless for him and most of his successors to look elsewhere. However, the peculiar relationships in Equations (31) and their potential significance have triggered further investigations.

4.4. Relationship between the STR and Tangherlini frameworks.

The variable light velocities in the standard coordinate configuration in the Tangherlini framework are given by:

$$
c_{x+} = \frac{c^2}{c + v_{BA}}, c_{x-} = \frac{c^2}{c - v_{BA}}. \tag{32}
$$

where c_{x+} and c_{x-} are the positive variable magnitudes of the velocity of light on the x'-axis in the positive and negative directions, respectively; therefore, all relative velocities are also functions of absolute velocities. First, we analyse the results in Equation (13). Using the proper times τ_1, τ_2 ,and τ_3 given in Equation (30) and substituting them into the <u>first</u> Equation (13), we obtain the following:

$$
\begin{aligned}
\tau_{C1} = \frac{\tau_1^2 - \tau_2^2 + \tau_3^2}{2\tau_3} = \frac{L_B(c^2 - v_{BA}v_{B1A})}{c^2(-v_{BA} + v_{B1A})} \Rightarrow\\
t_L = \frac{x_L(c^2 - v_{BA}v_{B1A})}{c^2(-v_{BA} + v_{B1A})},
\end{aligned}
\tag{33}
$$

where t_L is the current time coordinate at the instant of x=x_L in the propagation of C1 in **B** *in the LT-based scenario.* One proper time corresponds to an unlimited number of pairs v_{BA}, v_{B1A}. The Lorentz coordinates with Tangherlini coordinates can be related knowing that their x-axes are perfectly aligned thus x in Lorentz coordinates of **B** are the same as x′ in Tangherlini coordinates: $x = x'$. The common axes can serve as a bridge between the two theories.

In the Tangherlini framework perspective v_{T1} is the relative velocity of **B1** in **B** given by the first Equation (28); therefore the variable distance travelled x is:

$$v_{T1}t_T = \frac{c^2(-v_{BA}+v_{B1A})}{(c^2 - {v_{BA}}^2)}t_T = x_T = x_L, \tag{34}$$

where t_T is the time coordinate in the Tangherlini framework at the instance of the distance $x_T = x_L$. Both models have different coordinate labels because non-primed variables belong to the reference rest frames, which differ in both cases. For the motion from the STR perspective, the same motion is described as $v_{11}t_L$ which according to Equation (31) expands to

$$v_{11}t_L = \frac{c^2(-v_{BA} + v_{B1A})}{c^2 - v_{BA}v_{B1A}}t_L = x_L = x_T, \tag{35}$$

where $t_L$is the time coordinate in the STR framework. This leads to the following system which can be solved for v_{BA} and v_{B1A}:

$$\begin{cases} \dfrac{c^2(-v_{BA} + v_{B1A})}{c^2 - v_{BA}v_{B1A}}t_L = x_L \\ \dfrac{c^2(-v_{BA}+v_{B1A})}{(c^2 - {v_{BA}}^2)}t_T = x_T, \end{cases} \tag{36}$$

One of the two solutions including v_{BA} is of interest, from which the relationship between t_L and t_T can be found:

$$t_L = t_T - \frac{x_L v_{BA}}{c^2}. \tag{37}$$

This relation allows bidirectional conversions between the Tangherlini and STR frameworks, because the x, x'-axes are identical when they statically coincide in ***B***. In four dimensions the conversion scheme between the Tangherlni and STR systems is:

$$\{t_L = t_T - x_L v_{BA}/c^2, x_L = x_T, y_L = y_T, z_L = z_T\} \tag{38}$$

This equation also indicates the irreducible degree of freedom because v_{B1A} elimination from the scope. This degree of freedom is the main reason for all the cancellations. It was previously believed that removing this freedom could occur only by implementing the nonexistent instantaneous signal synchronisation. Fortunately, this is not the only option. An attempt to demonstrate this follows in the next section.

4.5. Radiation in Space and Doppler Effect

The irreducible degree of freedom can either mean the failure of the initial hypothesis about the three-clocks scenario and abandoning the research, or attempting a search for possibly missing equation. We then looked at other possibilities before doing so.

Thus far, our derivation of the TT has assumed an empty, featureless, and passive space, focusing on the relative kinematics between a hypothetical privileged inertial system and any other selected inertial systems. The relativistic TT can be derived from the empirical law of isotropy of the average round-trip speed of light without assuming a specific physical cause for this behaviour. However, it is logical to conclude that this property of light cannot be attributed to inertial systems themselves but to the environment during propagation between the source and a detector. This raises a critical question: is there an overlooked property of light that could provide an additional equation and resolve the absolute velocity?

A trivial observation in wave mechanics is that while light is emitted and absorbed by atoms—events which facilitate our measurements—its orderly, causal propagation between points in space is determined by the inherent properties of the vacuum and the nature of the electromagnetic (EM) field itself. Once emitted, a beam of light exists independently of any inertial source; it propagates as a coherent, standalone entity, behaving in many respects like a 'rigid rod' of electromagnetic energy. This perspective aligns with the classical realism of Maxwell, who argued that "there is an aethereal medium filling space and permeating bodies, capable of being set in motion and of transmitting that motion from one part to another" [15]

While we do not seek to resurrect the 19th-century mechanical ether, it is essential to define the 'ownership' or 'belonging' of an EM wave while in transit. To deny light a medium of existence is to leave energy 'nowhere' during its travel. This conceptual 'belonging' is supported by Einstein himself; despite his 1905 dismissal of the ether [7], he clarified in 1920 [13] that "the special theory of relativity does not compel us to deny ether. We may assume the existence of ether; only we must take from it the last mechanical characteristic which Lorentz had still left it." Einstein subsequently concluded, that this relativistic ether was "justified by the results of the general theory of relativity." By recognizing the vacuum-as-a-medium, we provide a physical anchor for the wave that exists independently of the observer’s relative coordinate system while in transit.

Considering light from a distant star that may no longer exist, it travels through the void and interacts with any inertial system it encounters. At the moment of interaction, the original source is irrelevant; only the freely propagating beam matters. While a stationary observer in the ARF would measure an intrinsic frequency, a moving observer the system **B** would measure a changed frequency.

Combining the information presented above we may establish the 'Postulate of Anonymity' suggesting that all EM radiation in transit propagates in vacuum with no original frequency information related to emitters from which it originates. This is left for further discussion to confirm whether this explains the observed phenomenon of the CMB.

This approach invites us to look beyond the average round-trip speed of light and examine the Doppler effect as an additional fundamental property of EM waves. We consider a monochromatic EM wave, also referred to as radiation, propagating along the x'-axis of **B** from the positive side towards a detector and clock C3 at the origin.

Let $\boldsymbol{K_A}$ be the wave 4-vector of the outgoing wave from **A** in free space towards an observer described in the ARF as

$$\boldsymbol{K_A} = \begin{bmatrix} \dfrac{\omega_A}{c} \\ -\dfrac{\omega_A}{c} \\ 0 \\ 0 \end{bmatrix}. \tag{39}$$

The outgoing wave becomes an incoming wave in base system **B**. TT is applied to convert this vector to **B** as follows:

$$\boldsymbol{K_{AB}} \equiv \begin{bmatrix} \dfrac{\omega_{AB}}{c} \\ k_{xB} \\ k_{yB} \\ k_{zB} \end{bmatrix} = \Omega_{\infty}^{v_{BA}} \begin{bmatrix} \dfrac{\omega_A}{c} \\ -\dfrac{\omega_A}{c} \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} \dfrac{\omega_A\sqrt{c^2 - v_{BA}^2}}{c \cdot c} \\ -\dfrac{\omega_A(c + v_{BA})}{c\sqrt{c^2 - v_{BA}^2}} \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} \dfrac{\omega_A}{c}\sqrt{1-\beta^2} \\ -\dfrac{\omega_A}{c}\sqrt{\dfrac{(1+\beta)}{(1-\beta)}} \\ 0 \\ 0 \end{bmatrix}, \tag{40}$$

where $\beta = v_{BA}/c$.

The explicit presence of v_{BA} in the two components of the wave vector in Equation (40) suggests a potential mechanism for determining the absolute velocity, provided that the angular frequency and wave number can be accurately measured. However, a critical interpretive challenge arises: the temporal component of the transformed wave 4-vector in frame **B** cannot be regarded as the valid longitudinal Doppler frequency in this frame.

Although Equation (40) shows the absolute frequency scaled by $\sqrt{(1-\beta^2)}$—a result that initially appears to be the 'preferred frame' asymmetry sought in this study—this derived frequency contradicts established analyses of absolute transformations. For instance, Sfarti [16] utilised the algebraic form of the TT to demonstrate that the resulting Doppler shift is identical to that of the STR. Other authors, such as Drągowski and Włodarczyk [17], confirmed this equivalence using an absolute transformation (following the Rembieliński framework).

This convergence should be expected, given that TT is consistent with Einstein field equations; consequently, the choice of synchronisation convention should not alter the predicted physical observables. It is therefore necessary to clarify the mathematical discrepancy in the wave 4-vector transformation that suggests otherwise, specifically by examining how the induced longitudinal projection affects the temporal component with the expected relativistic shift.

To explain the mechanism underlying the LT result, a generic format of the $\boldsymbol{K_g}$ wave 4-vector in the source **S**pace is utilised.

$$\boldsymbol{K_g} = \begin{bmatrix} \frac{\omega_S}{c} \\ k_x \\ 0 \\ 0 \end{bmatrix}. \tag{41}$$

LT is applied from a moving source **S** perspective to make predictions in **B**:

$$\Lambda_{v_{SB}} \boldsymbol{K_g} = \Lambda_{v_{BS}} \begin{bmatrix} \frac{\omega_S}{c} \\ k_x \\ 0 \\ 0 \end{bmatrix} = \begin{bmatrix} \frac{-k_x v_{BS} + \omega_S}{\sqrt{c^2 - v_{BS}^2}} \\ \frac{c^2 k_x - \omega_S v_{BS}}{c\sqrt{c^2 - v_{BS}^2}} \\ 0 \\ 0 \end{bmatrix}, \tag{42}$$

where $\Lambda_{v_{BS}}$ is the LT matrix, v_{BS} is the velocity of base system **B** receding from the initial coincidence point with the radiation source system **S** and ω_S is the angular frequency in the source.

The reason for this difference is now clear. The temporal component is intertwined with the spatial k_x component, unlike when using TT. Absolute time scaling by TT cannot reflect the frequency change because of the interaction with sensors, which are tied to the spatial coordinates of ***B***. In practical terms, the TT effect yields an ideal local frequency that would change because of time dilation. This one cannot be physically measured without the moving **B**-attached sensor direct interaction, which would change the frequency to the default value as predicted by the STR. In both cases this is the physical frequency being measured by a sensor, not the abstract temporal component of the wave 4-vector. Why we can explain the mechanism behind true description of measured the Doppler-shifted frequency in relative reference frame as in Equation (42), more explanation will follow in Section 4.6.

However, this is not the end of the problem. A more interesting result can be obtained by analysing the transverse Doppler effect.

Initially, we assume that 'transverse' is relative to the observer in the moving **B**, relatively to **S**, in which the wave is moving along the observer's y' axis. Therefore, the wave 4-vector must be appropriately 'tilted' to propagate along the y'- moving axis which is moving. Starting with the LT we obtain:

$$\Lambda_{v_{BS}}\boldsymbol{K_{TS}} \equiv \Lambda_{v_{BS}}\begin{bmatrix} \frac{\omega_S}{c} \\ \frac{\omega_S}{c}\frac{v_{BS}}{c} \\ -\frac{\omega_S}{\gamma c} \\ 0 \end{bmatrix} = \begin{bmatrix} \frac{\sqrt{c^2 - v_{BS}^2}\omega_S}{c^2} \\ 0 \\ -\frac{\sqrt{c^2 - v_{BS}^2}\omega_S}{c^2} \\ 0 \end{bmatrix} = \begin{bmatrix} \frac{\omega_S}{\gamma c} \\ 0 \\ -\frac{\omega_S}{\gamma c} \\ 0 \end{bmatrix} = \begin{bmatrix} \frac{\omega_B}{c} \\ k_{xB} \\ k_{yB} \\ 0 \end{bmatrix}, \tag{43}$$

where γ is a function of velocity v_{BS}.

In the Planck 2013 space mission report [18], the referenced article by Challinor and van Leeuwen [19] explain the theoretical foundation of the transformation of the received radiation from the CMB, and provides a formula for the frequency in the CMB which was adapted to our notation as follows:

$$\omega_S = \omega_B\gamma(1 + \hat{\boldsymbol{n}} \cdot \boldsymbol{v}), \tag{44}$$

where $-\hat{\boldsymbol{n}}$ is the photon propagation direction unit vector and $\boldsymbol{v}$ is a spatial vector of magnitude β. In the $\hat{\boldsymbol{n}}$ direction aligned with y'-axis in **B**, the formula changes to $\omega_S = \omega_B\,\gamma(1+0)$, and is the same as in the Equation (43) $\omega_S = \omega_B\,\gamma$ obtained by comparing temporal elements. Our approach transforms motion from the CMB as the stationary frame to **B** frame**,** whereas in [19] the CMB motion in the observer-centric system is preferred. Both approaches are equivalent as demonstrated in Equation (43).

Next, we consider the case in which the source emits radiation that is perpendicularly to the x and x' axes in **B**.

$$\Lambda_{v_{BS}}\boldsymbol{K_{TA}} \equiv \Lambda_{v_{BS}}\begin{bmatrix} \frac{\omega_S}{c} \\ 0 \\ -\frac{\omega_S}{\gamma c} \\ 0 \end{bmatrix} = \begin{bmatrix} \frac{\omega_S}{c\sqrt{c^2 - v_{BS}^2}} \\ -\frac{v_B\omega_S}{c\sqrt{c^2 - v_{BS}^2}} \\ -\omega_S/c \\ 0 \end{bmatrix} = \begin{bmatrix} \frac{\gamma\omega_S}{c} \\ -\frac{\gamma\beta\omega_S}{c} \\ -\omega_S/c \\ 0 \end{bmatrix} = \begin{bmatrix} \frac{\omega_B}{c} \\ k_{xB} \\ k_{yB} \\ 0 \end{bmatrix}. \tag{45}$$

A nonzero longitudinal wave number component k_{xB} emerges, which is absent in the source system emitting radiation, perpendicular to the x and x' axes. Additionally, the transverse component k_{yB} exposes an unchanged stationary frequency ω_S in k_{yB} (if measurable). These are well-known facts.

4.6. Transverse Doppler Effect Relative to Observer Identifies Absolute Velocity

We realised that vacuum itself as the host-carrier of waves may correspond to the stationary system **S,** unknown *a priori*.

In the usual Doppler effect measurement scenario, the velocity v_{BS} of the system **B** can be measured using two consecutive round-trip experiments, and then, ω_S can be calculated after measuring ω_B.Subsequently substituting the experimental velocity value into the temporal element expression in Equation (45) we obtain $\omega_S = \sqrt{c^2 - v_{BS}^2}\omega_B$. Now, the theory can be tested by receiving information from the source to determine what the frequency ω_S was, then verifying whether it matches. However, what can possibly be done if the source relative velocity is unknown because it is no longer present, and ω_s is also unknown because there is no one to measure it? The solution is in the ratio of R=k_{yB}/k_{xB}.

$$R = \frac{k_{yB}}{k_{xB}} = \frac{-\frac{\omega_S}{c}}{-\frac{v_{BS}\omega_S}{c\sqrt{c^2 - v_{BS}^2}}} = \frac{c^2\sqrt{c^2 - v_{BS}^2}}{v_{BS}} \tag{46}$$

We can now find the unknown velocity v_{BS}.

$$\boxed{\begin{gathered} v_{BS} = c\sqrt{\frac{1}{R^2 + 1}}, \\ \mathrm{R} = \tan(\varphi) \Rightarrow \\ \cos(\,\varphi) = -\frac{v_{BS}}{c} \Rightarrow \\ v_{BS} = -\cos(\,\varphi)c, \end{gathered}} \tag{47}$$

where φ is the aberration angle in the moving system **B**.

Using trigonometric identities we obtained $\cos(\,\varphi) = -v_{BS}/\mathrm{c}$, which is the same as the Einstein's aberration formula in [7] (p56). These are *frequency-independent expressions* and the aberration angle can be measurable, as for example in the Planck 2013 mission [18].

The critical question remains: among infinitely many possible inertial systems, which one is responsible for this random wave? The source may no longer exist or it could be scattered by obstacles. We conclude that to maintain the propagation and frequency the only possible system remaining must be consistent with the ARF (or vacuum), wherein radiation always propagates even in the absence of particles.

Relative spaces of inertial systems are abstractions and can only be involved through interactions of matter such as measurements or by the presence of media affecting the speed of light. We acknowledge that radiation originates from moving bodies; however, in transit, we assume that EM waves become *anonymous* and 'owned' by the ARF or alternatively by vacuum, which is not the empty geometric space because it has properties such as permittivity ε_0 and permeability μ_0. Travelling radiation carries tangible energy not 'owned' by any relative space, until an object in this space interacts with it. The original radiation sources are no longer significant because any unique observed frequency can result from an unlimited number of combinations of source speeds and local frequencies which appears to be an unsolvable ambiguity. However, Equations (47) are not ambiguous in **B**.

In order to clarify the status of the CMB as an inertial frame, Stewart and Sciama [20] maintain that the rest frame of the microwave radiation may be defined as the rest frame of the matter which last scattered it. This reflects the situation predicted by Eddington [10] (p.30) in 1927, allowing a universally significant frame to be called absolute. Although this appears to conflict with standard early STR narratives that once dismissed absolute velocity, it is supported by empirical evidence: the speeds of the solar system and Earth have already been measured against the CMB using aberration angles within this 'sea of anonymous waves.'

This can also be verified in the Tangherlini framework:

$$\Omega_{\infty}^{v_{BA}}\boldsymbol{K_{TA}} \equiv \Omega_{\infty}^{v_{BA}}\begin{bmatrix}\dfrac{\omega}{c}\\ 0\\ -\dfrac{\omega}{c}\\ 0\end{bmatrix} = \begin{bmatrix}\sqrt{c^2-v_{BA}^2}\\ -\dfrac{v_{BA}\omega}{c\sqrt{c^2-v_{BA}^2}}\\ -\omega/c\\ 0\end{bmatrix} = \begin{bmatrix}\gamma_{v_{BA}}\omega\\ -\dfrac{\gamma_{v_{BA}}\beta\omega}{c}\\ -\omega/c\\ 0\end{bmatrix} \equiv \begin{bmatrix}\dfrac{\omega_B}{c}\\ k_{xB}\\ k_{yB}\\ 0\end{bmatrix}. \tag{48}$$

$$\boxed{\begin{gathered}\mathrm{R} = \frac{-\frac{\omega}{c}}{-\frac{\gamma_{v_{BA}}\beta\omega}{c}} = \frac{1}{\gamma_{v_{BA}}\beta} = \tan(\varphi)\\[2ex] \cos(\varphi) = -\frac{v_{BA}}{c} \Rightarrow\\[2ex] v_{BA} = -\cos(\varphi)c.\end{gathered}} \tag{49}$$

We conclude that k_{xB} andk_{yB} have the same form of expressions as for the LT case; therefore, v_{BS} and v_{BA} are the same velocities of **B** relative to the ARF or the source frame **S** as long as **S** and the ARF are physically identical and because we allow both **S** and **A** to perform transformations predicting physical effects in **B.** They both generally agree, with at least one exception. While the relative velocity of **S** in **B** for the LT case is by definition, $v_{BS} = -v_{BS}$, this is different in the TT case. To obtain of the ARF velocity in **B** (v_{AB}) we need to transform the origin vector $O_A = [ct, 0,0,0]^T$ into **B** resulting in:

$$v_{AB} = -v_{BA}\frac{c}{\sqrt{c^2 - v_{BA}^2}} = -v_{BA}\gamma_{vBA}. \tag{50}$$

The asymmetry of reciprocal velocities in this case is due to different clock synchronisation convention; therefore, velocities acceleration, and other derivatives like momentum will never agree in numerical values. However, the predicted physical effects will all be the same, as we have demonstrated. Because we did not need to synchronise distant clocks anywhere in the universe

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with instantaneous signals and still identified the absolute velocity as a consequence of postulates in Appendix A, Tangherlini theory is a correct, convention-free variation of the special relativity theory. Although being conventional, the STR is an equally correct theory, as demonstrated. However, it is superior for practical use because it is not feasible to absolutely synchronise distant clocks accurately based on the known velocity of the Earth, which fluctuates constantly, including the solar-centric and polar axis relative rotations.

We should now return to the problem of discrepancy in the temporal component of the wave 4-vector discussion starting on page 18. The temporal component in Equation (48) remains the same. This cannot be a discrepancy. The wave 4-vector is an immediate consequence of energy-momentum vector for a photon in vacuum which correctly represents the photon without consideration of any particular relative space of a specific inertial system, that is, it has a universal significance. This confirms the validity of our interpretation of an anonymous wave no longer related to a particular emitter. A particular spectral frequency emitted from an excited hydrogen atom emitted may be matched by another emitted photon modified by a different source velocity.

In Section 2.2 paragraph 2, we adopted a rule of reasoning that TT applied to 4-vectors results in physically valid transformed quantities, thereby granting the TT the same confidence as the LT to represent the reality. Convinced about the equivalence of the Tangherlini and STR frameworks we conclude that the transformed wave 4-vector represents an EM wave or a photon in vacuum or in terms of kinematics in the ARF, which is the common independent frame where the electromagnetic field physically exists as opposed to intersecting unlimited number of abstract non-interfering geometric relative spaces. The wave 4-vector properties in Equation (48) appear to validate our provisional 'Postulate of Anonymity' introduced on page 17. Therefore we no longer hesitate to declare the velocity v_{BA} in Equation (49) to be the long-sought absolute velocity relative to the absolute rest frame (or vacuum).

While we have presented a limited derivation in the standard configuration of coordinates with an x-axis-aligned absolute velocity vector, three-dimensional generalisations exist within both, the STR and TT frameworks; notably, Chang [21] presented such a generalisation for the Tangherlini transformation.

The absolute velocity derivation presented above does not immediately necessitate novel experimental methods, as this aspect has already been addressed in CMB research [18] However, other methods cannot be ruled out.

Reflecting on Equations (49) and in the spirit of the great scientist and philosopher Henri Poincaré who added a potential falsification clause to his interpretation of the Postulate of Relativity (page 28) that could be accepted as certainty at the time of its conception, we propose the following conjecture:

Conjecture 1: *The frequency-independent aberration angle φ of any electromagnetic signal in transit defined as an Anonymous Wave yields a unique, non-ambiguous velocity value. This velocity is physically identical to the receiver's motion relative to the Absolute Rest Frame and is consistent with the peculiar velocities measured against the Cosmic Microwave Background. Because the wave-vector* $\mathbf{k}$ *represents the wave in vacuum, this absolute velocity is invariant regardless of the source's historical identity, original frequency or kinematic state.*

4.7. Closing the Cancellation Gap

The term 'cancellation gap' refers to the historical period—beginning with Einstein's 1905 postulate—during which absolute velocity was categorically denied due to its systematic cancellation in various attempts to find it. Eddington [10] (p.30) describing the cancellation obstacles remarked that: "just as we have got rid of the other unknowns, behold! V disappears as well, and we are left with the indisputable but irritating conclusion—0=0." However, he also conceded that "In physics we should not be quite so scrupulous as to the use of the word absolute. Motion with respect to aether or *to any universally significant frame* would be called absolute." [10] (p.30). This opportunity emerged in 1967-1968 through the works of Stewart and Sciama [20] then Peebles and Wilkinson [22] on the CMB measurement methodology, identifying what was termed "peculiar velocity." While this velocity bears the functional hallmarks of absolute motion, the gap remained partially open because the absolute association lacks a formal mathematical and theoretical bridge and consensus. However, this association became intuitively admissible since 1967-68 when relativistic Doppler based methodology [22] was ready for implementation. It is worth mentioning, that relativistic approach to temperture of the black body radiation was determined as early as in 1906 by Kurd von Mosengeil [23]. He used special relativity approach to thermodynamics, having known relative velocity between the cavity and the observer, which is not known a priori with the CMB.

By identifying the wave vector geometric information within Einstein's framework, specifically regarding radiation from an anonymous source and propagating in the ARF and the proposed Conjecture 1 (page 23) , this gap may now be considered closed. By substituting the measured peculiar velocity into v_{BA} in Equation (22) and knowing the proper time τ_1 communicated in the thee-clocks scenario, one can calculate the absolute velocity v_{B1A}, in accordance with Edington's remarks above. With v_{B1A} calculated, we realise that Tangherlini's claim [9] (p73–74) about the impossibility to determine relative velocities no longer applies, because by substituting both v_{BA} and v_{B1A} to the first equation (28) we obtain relative velocity v_{T1}. This leads to a surprising conclusion that after all, any two clocks at a distance L, can be absolutely synchronised in x' direction without instantaneous signals by setting the system origin time to 0 and programming the signal receiving clock to set its time to L/v_{T1}. This is highly impractical, but theoretically significant.

In conclusion, the ARF revealed its real meaning not by the fundamental assumption in Appendix A naming it 'absolute', but by being the only possible host of anonymous radiation, reflected by the properties of the wave 4-vector, because no inertial system in subluminal motion can 'own' it. This results from the fact that an unlimited number of competing systems have equal rights due to emitter frequency and velocity ambiguity. Giving the credit to the peculiar approach as the only rational choice at the time of CMB discovery, we acknowledge that the reality is more complex that linear algebra of special relativity and more research has to continue to achieve a consensual resolution.

4.8. Physical Simultaneity and Mathematical Consistency

Relative simultaneity has always been the most controversial conclusion of the STR conflicting with the natural sense of the absolute, universal 'Now' in most people. In the STR framework it is a consistent concept which can be verified experimentally using a set of synchronised clocks. The absolute nature of the Tangherlini framework appears to be not reconcilable with the STR 'by definition' that in terms of already demonstrated equivalence and the relation of both theories to GR, it becomes paradoxical. Therefore for full reconciliation of the Tangherlini and STR frameworks and justification of our claims we need to demonstrate the consistency in this unsettled aspect.

We define Physical Simultaneity as the objective temporal relation between discrete events as they arise in their respective rest frames and their proper times registered by collocated clocks. This is contrasted with the perception of the events and their temporal order by distant observers in relative motion or at relative rest. A verification method must be possible, or at least plausible, to determine or deny the simultaneity of events. We maintain that the Tangherlini and STR frameworks are consistent; while simultaneity is inherently relative in STR; however, regarded as absolute in the Tangherlini framework. How can this be consistent? Can we allow for 'some' inconsistency?

We now attempt to solve this problem by formulating it first. The following two cases are considered.

1. When two or more events can be successive or simultaneous and registered by collocated clock in the same location, then perceived by observers at a distance while possibly moving relatively to the event location and/or to each other.

2. When two or more events can be successive or simultaneous in two distant locations and registered by collocated, synchronised clocks, then perceived by observers at a distance while possibly moving relatively to the event location and/or to each other

Any theoretical treatment of simultaneity requires two or more aligned and synchronised coordinate systems, for simplicity in a standard configuration as first introduced by Einstein [7]. When the origins of two relatively moving systems coincide, the proper time of the origin clocks is reset to zero. From this moment onwards, the ideal clocks are correlated and independently increment their proper time, a process and rate independent of any coordinate convention. Their proper time is a physical invariant. Both stationary and moving clocks allow for the determination of the state of their distant counterparts at the origin despite separation. Lorentz Transformation or its inverse allows two-way mapping of the proper times of separating clocks precisely. In theory, specific synchronised origin clocks in inertial motion have constant rates and their states increment simultaneously. The relation between them is

$$\boldsymbol{E_{0B1}} = \Lambda_{v_{B1B}} \boldsymbol{E_{0B}} = \Lambda_{v_{B1B}} \begin{bmatrix} t \\ 0 \\ 0 \\ 0 \end{bmatrix} \Rightarrow \boldsymbol{E'_{0B1}} = \begin{bmatrix} ct' \\ -v_{B1B}t' \\ 0 \\ 0 \end{bmatrix} \qquad (51)$$

where vectors $\boldsymbol{E_{0B}}$ $\boldsymbol{E_{0B1}}$ represent the origin events in systems **B** and **B1** and respectively and $\Lambda_{v_{B1B}}$ is the Lorentz transformation matrix from **B** to **B1.**

In the simplest possible manifestation representing **Case 1**, let us assume the stationary frame **B** as the base. The prerequisite is that at least two inertial frames must have coordinate systems aligned and synchronised at the origin and beyond**.** Two arbitrary events $\boldsymbol{E_{1B}}$ and $\boldsymbol{E_{2B}}$ in the spatial origin of **B** can be defined as:

$$\boldsymbol{E_{1B}} = \begin{bmatrix} t+\Delta t_1 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \boldsymbol{E_{2B}} = \begin{bmatrix} t+\Delta t_2 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \tag{52}$$

where Δt_1 and Δt_2 are arbitrary time intervals and $\Delta t_1 < \Delta t_2$. The events can be transformed to the moving system **B1** using the LT matrix thus they are the same events in **B1** coordinates. Skipping multiple steps of algebraic manipulations similar to what was done before; we can show how the events change.

$$\begin{gathered} \boldsymbol{E_{1B1}} = \Lambda_{v_{B1B}} \begin{bmatrix} t+\Delta t_1 \\ 0 \\ 0 \\ 0 \end{bmatrix} \Rightarrow \boldsymbol{E'_{1B1}} = \begin{bmatrix} c(t'+\Delta t_1)c/\sqrt{c^2 - {v_{B1B}}^2} \\ -v_{B1B}t' - v_{B1B}\Delta t_1 c/\sqrt{c^2 - {v_{B1B}}^2} \\ 0 \\ 0 \end{bmatrix} \\ \boldsymbol{E_{2B1}} = \Lambda_{v_{B1B}} \begin{bmatrix} t+\Delta t_2 \\ 0 \\ 0 \\ 0 \end{bmatrix} \Rightarrow \boldsymbol{E'_{2B1}} = \begin{bmatrix} c(t'+\Delta t_2)c/\sqrt{c^2 - {v_{B1B}}^2} \\ -v_{B1B}t' - v_{B1B}\Delta t_2 c/\sqrt{c^2 - {v_{B1B}}^2} \\ 0 \\ 0 \end{bmatrix}. \end{gathered} \tag{53}$$

The time interval between events varies by the gamma factor only, comparing to that in **B** frame, which is $(\boldsymbol{E_{2B}})_1/c - (\boldsymbol{E_{1B}})_1/c = \Delta t_2 - \Delta t_1$ applicable to both, Andromeda galaxy and the distant, stationary observer in its frame, nearby the moving observer B1.

$$\frac{(\boldsymbol{E_{2B1}})_1}{c} - \frac{(\boldsymbol{E_{1B1}})_1}{c} = \frac{c}{\sqrt{c^2 - {v_{B1B}}^2}}(\Delta t_2 - \Delta t_1). \tag{54}$$

The conclusion is that neither the order of events in **B1** can change, nor they can become simultaneous unless they become simultaneous in **B.** Repeating the same process with the TT matrix yields the same result for the order of events $\boldsymbol{E_{1B}}$ and $\boldsymbol{E_{2B}}$ between the system **A** and **B**, only the intervals differ. The order invariance is maintained because of the invariance of proper times of the clocks involved rather than coordinates convention.

$$\frac{(\boldsymbol{E_{2B1}})_1}{c} - \frac{(\boldsymbol{E_{2B1}})_1}{c} = \frac{\sqrt{c^2 - {v_{B1B}}^2}}{c}(\Delta t_2 - \Delta t_1). \tag{55}$$

We are satisfied that yet another controversial aspect of consistency between the two complementary theories has been demonstrated. The experimental verification of predictions appears plausible at high cost at significant distances and high speeds with a carefully crafted scenario in deep space and instrumentation; however there is no benefit to do so in this theoretically obvious STR warranted context.

The presented instance of relative simultaneity is significant because it challenges the general idea of a relative 'Now' for every moving observer as proposed by Eddington [10] (p.49). We discovered yet another consistency between the two theories which retain the instantaneous invariant relation of the clocks synchronised as above with the absence of instantaneous signals.

This is because 'Now' is determined by correlated proper times of the clocks involved, no matter what distance between them.

This serves as a resolution to a special case of the Andromeda Paradox, a name popularised by Roger Penrose [24] (p 260), based on a problem originally posed as a part of an ongoing philosophical debate by Rietdijk [25]. Rietdijk attempted to prove a predetermined block universe using arguments derived from the STR interpretation of relative simultaneity.

In the standard scenario, two people passing each other have different ideas of what is happening 'now' in the Andromeda galaxy. At the moment they are together, their opinions should differ as to whether an attacking alien fleet has departed or the decision to attack has not yet been made, because STR assigns each observer a different plane of simultaneity.

However, this ignores the fact that observers may have perfect knowledge of Andromeda time as given by equations (53). If they know the schedule of the decision and departure, they can precisely determine how their 'now' relates to that schedule even before they meet. In such a context, drawing simultaneity planes in conventional coordinates to illustrate the paradox has no physical impact. Because the causal order of the time of events is invariant (Equation (54)), the suspected discontinuity in Andromeda's relative histories is revealed as a mathematical artefact of coordinates convention rather than a physical variation of reality.

The simplified scenario differs from the standard Andromeda paradox in that one participant is stationary relative to Andromeda, while the other is passing by. That does not change the fact that they are in relative motion and relative simultaneity as above still should apply. We have only shown a blueprint of the proof, yet results with no surprise converged from the standpoint of two complementary theories (Equations (54) and (55)), unlikely to arise from potential algebraic or conceptual errors.

The substantial difference in the standard is also the fact that two observers determine what happens in Andromeda from their own perspective as stationary synchronised instantaneously to Andromeda at time 0, because only then we have two matching systems consistent with the standard configuration, as it is clearly seen in [24] (Fig 5.22 p 260). There is no doubt relative simultaneity applies. This is an interesting aspect worth further investigation. Additionally **Case 2** (distant events simultaneity) is worth pursuing in its own merit, yet not immediately relevant to the solved problem in **Case 1,** which shows an interesting valid alternative.

The **Case 2** analysis of spatially separated simultaneous events and the Standard Andromeda paradox resolution are deferred to future work. However we propose a conjecture, based on the established equivalence of the STR and Tangherlini frameworks

Conjecture 2: *Given the established equivalence of the STR and Tangherlini frameworks, the Tangherlini and STR framework will yield consistent physical resolution of the relative simultaneity for spatially separated events and the standard Andromeda Paradox.*

If confirmed, this would demonstrate that absolute simultaneity is the coordinate artefact rather than a true temporal relation. This would conclude the final and deeper demonstration of the equivalence of the two frameworks and the integrity of nature.

Conjecture 2 is not presented as an open speculation. First, the established equivalence of the STR and Tangherlini frameworks as sub-theories of GR provides a guarantee: two internally

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consistent sub-theories of the same parent theory cannot yield physically divergent outcomes for identical initial conditions. However, this argument, while conclusive, does not illuminate the mechanism. Second, and more concretely, the conjecture has been verified in draft form using symbolic algebraic computation for the remaining cases, including spatially separated simultaneous events and the standard Andromeda scenario. A rigorous treatment of all cases, leaving no aspect unresolved, requires a dedicated paper and is reserved for future work. The **Case1** analysis presented here is intended to expose the underlying mechanism rather than to fully resolve the conjecture.

5. Discussion and Conclusions

5.1. Historical Perspective of the Absolute Velocity Problem

Given the contentious nature of the concept of absolute velocity, it is beneficial to consider its historical context to comprehend why it remained largely unexamined for an extended period.

The investigation of relative motion began to gain significant momentum around 1887 after the Michelson–Morley 'null' experiments [26], which demonstrated the constancy of the round-trip average speed of light, indicating in their opinion the lack of motion of the Earth in the supposed ether, contrary to well-known orbital and rotational motions. After their experiments, Michelson and Morley [26] stated that any relative motion between the Earth and the ether must be very small; however, we know that this is not the case.

Assuming one way velocity isotropy and the invariance of physical laws in all inertial frames, Einstein [27] rederived Lorentz transformation published in 1905, translated in [7] and special relativity was born.

Shortly before that, Poincaré [14] formulated one of the earlier versions (June 5, 1905) of the postulate of relativity which can be translated as follows:

> *It seems that this impossibility of experimentally demonstrating the absolute movement of the Earth is a general law of Nature; we are naturally inclined to admit this law, which we will call the Postulate of Relativity, and to admit it without restriction. Whether this postulate, which has so far been in agreement with experience, should be confirmed or refuted later by more precise experiments, it is in any case interesting to see what the consequences may be*[3].

Unlike in Einstein's systematic derivation approach, this postulate formulation seems to assume the absence of "absolute movement of the Earth" *a priori*, without mentioning the problems related to one-way velocity measurement. The uncertainty expressed in the last sentence of the quote may explain the long-standing desire to detect the ether and the absolute motion relative to it. It also supports the idea of potential falsification. Poincaré referred to the electromagnetic radiation as vibrations of the ether until the end of his life; for example, in *Last Essays* [28]. The falsification attempt is presented in this study by deriving the velocity of an arbitrary system relative to an anonymous radiation source system **S** in Equation (47). The "impossibility of experimentally

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[3] *Translation from French [14] by Google Translate.*

demonstrating the absolute movement of the Earth" as a law of nature was logical at the time of conception. However, it was not strictly correct. This does not invalidate the principle of relativity in the vast majority of physical scenarios within the scope of the STR.

The concept of absolute velocity and the variable one-way velocity of light have been rendered obsolete in contemporary physics for many years. Nevertheless, certain researchers have persisted in exploring methodologies to circumvent the challenges associated with instantaneous synchronisation. Notable examples of such efforts are documented, for example in the works of Mansouri and Sexl [3], Selleri [29], Tangherlini [30], Greaves [31], Spavieri, Gillies and Haug [32]. The emphasis is frequently on rotating frames and the empirically validated Sagnac effect.

5.2. The Significance of the Instantaneous Signal

The detectability of absolute motion is intricately linked to the concept of instantaneous signals, which have consistently been subjects of debate. An instantaneous signal is something that our intuitive understanding of time demands; however, this notion is generally deemed unscientific. There appears to be a consensus that simultaneity is inherently relative, and intuitive instantaneous perception is a mistaken generalisation, as noted by Canales [33]. Einstein [34] described this mistake as stemming from the failure to differentiate between what is simultaneously observed and what is simultaneously occurring. Nonetheless, he made a noteworthy observation during a discussion in 1911 [35] regarding the concept of a signal propagating infinitely fast, which would allow us to define time. This stands somewhat in contrast to the notion of time defined in his 1905 paper [27] and [7] (in English).

The instantaneous temporal relation between distant events is typically understood as ‘now.’ This concept was officially dismissed by Eddington [10] (p 49), who asserted that there was no absolute "Now", but rather a multitude of relative ‘Nows’ unique to every observer. However, this concept proved difficult to relinquish for some physicists. According to Jammer [36] quoting Rudolf Carnap, the problem of ‘now’ was a significant concern for Einstein. Without delving into the full complexity of this issue, it is noted that the instantaneous temporal relation was a source of uncertainty for other physicists, such as Bell [37]. He posited the existence of a mechanism by which the setting of a measuring device influences the reading on another instrument at any distance, necessitating an instantaneous signal, thereby implying that the underlying theory cannot be Lorentz invariant. Without making any judgment on whether Bell’s signal can indeed be instantaneous or merely superfast, we acknowledge that Lorentz invariance exists within the STR convention and does not exclude superluminal signals contrary to popular belief. This is because they are not excluded in the Tangherlni framework which has proven to be consistent with STR. Apparent backward-in-time-travelling signals are merely convention-related synchronisation artefacts, akin to the case of crossing conventional time zones in fast jets travelling in the East-West direction, when one may arrive to the destination earlier than departed.

The nature of an instantaneous signal is such that it appears as a limit of a set of superluminal signals with ever-increasing velocity, none of which has a maximum value. This peculiar ‘signal’ can also be intuitively dismissed. Even the intuition of a creative mind, allowing for the instantaneous perception of the entire universe at once, may struggle to conceptualise a signal moving from here to a distant galaxy or beyond instantaneously, let alone finding the immediately reflected signal returning to the source at the exact moment of emission (but not earlier). Such an instantaneous signal appears to contravene causality based on simple local common-sense reasoning. At the time of emission, one might expect the signal to be delivered where it was not present and return when emitted. In considering the concept of transmission, one must address the paradox of its existence returning from a state of non-existence. Typically, a signal can be characterised as a brief EM pulse or a minute particle, such as a photon or a tachyon. The notion of an infinite velocity implies that the signal does not traverse space; rather, it becomes omnipresent and absent at the moment of emission. However, mathematics offers a more accommodating framework than mere imagination. The concept of instantaneous signal velocity, represented by an unbounded numerical series without a definitive maximum, mitigates concerns regarding intuitive non-causality, because such a scenario appears physically impossible. The sequence of emission and return events remains intact, irrespective of the brevity of the interval between them. This unattainable limit demarcates the boundary of causality and coexistence, with the latter not necessarily being experimentally accessible by signals. This perspective on the instantaneous signal, however, is inherently open to scientific scrutiny. The absence of observable instantaneous signals in nature has historically hindered philosophers and scientists from synchronising time across distant locations. The primary obstacle is the issue of circularity, in which two clocks at separate locations must display the same time simultaneously, with ‘simultaneously’ defined as events occurring at the same time. Einstein addressed this dilemma by postulating a constant one-way velocity of light and synchronising distant clocks accordingly, thus cutting the Gordian knot.

We have successfully demonstrated that no instantaneous signal is necessary to determine the absolute velocity in the Tangherlini and STR frameworks, both theories consistently represent the same reality, comparable to two faces of the same coin or two maps of the Earth in different projections.

5.3. Peculiar Velocity vs. Absolute.

The peculiar velocity term is usually defined as the deviation of galaxies’ velocity from the Hubble flow [38], but it is also commonly used as the velocity relative to the CMB. For example Ellis and Baldwin [39] stated that "the standard interpretation of the dipole anisotropy in the microwave background radiation as being due to our peculiar velocity in a homogeneous isotropic universe." Other interpretations regard this velocity as relative to a locally defined common rest frame. It is uncommon to refer to the peculiar velocity as absolute velocity because the STR does not define such a category. Otherwise, it might as well be true the CMB in our local region may not be the same elsewhere, even though there is no evidence of that. In the presented approach, the rest frame emerged as an anonymous, unavoidable and unique reference frame representing an inertial system that justifies the Doppler effect when a radiation source and frequency cannot be identified. This emerged from purely kinematical considerations using the STR framework and the properties of the wave vector, resulting in Equation (49). This is in agreement with Einstein’s [7] (p56) derivation of the Doppler effect and the aberration angle. Subsequently, this result was also consistent with the Tangherlini framework where the ARF is a fundamental postulate. Linear algebra underlying our approach to the STR does not know the boundary of the universe; therefore the ARF theoretically extends to infinity and such ARF generalisation could be premature. It is more appropriate to say that the emergent ARF extends to the area wherever light propagates. We may call peculiar velocity absolute within these bounds as suggested by Eddington (see page 24). The STR apparently does not support absolute velocity and the ARF; however, if the latter is found, it will not differ from any other inertial system the STR can handle, as demonstrated by CMB methods [18] , [19] and our results. These findings were unexpected, despite the crucial role played by the LT in determining the solar system velocity with respect to the CMB. The nature of our findings is reflected by the long-standing view of late Jose G. Vargas [40]: "there is more to structure in special relativity than meets the eye."

5.4. Results

The initial goal of this research was to verify whether an unusual method based on the Unruh protocol presented by Matsas et al. [1] could provide an opportunity to detect the ubiquitous absolute velocity because this method appears independent of the three distant clocks synchronisation in the inertial frame of interest ***B***. This was an attempt to verify Tangherlini's suggestions that the absolute motion of the Earth could be detected using subluminal signals, as mentioned on page 9. In the process, several interesting results were obtained.

1. The three-clock scenario based on the Unruh protocol described by Matsas et al. [1] in Minkowski spacetime was implemented as an algebraic, STR-based model, leading to the system of equations (11). The system had solutions (12) consisting of eight roots, half of which were of the opposite sign to their counterparts. The original distance formula from [1] is fully reproduced by the first solution in Equations (12). Two previously unpublished relative velocity expressions for moving clocks not presented in [1] emerged.

2. Owing to established dependencies, an important connection between the Tangherlini and STR frameworks has been revealed, indicating the complementarity of the former rather than being antagonistic or irrelevant. We derived the coordinate conversion equations between the standard STR and Tangherlini coordinates as: $\{t_L = t_T - x_L v_{BA}/c^2, x_L = x_T, y_L = y_T, z_L = z_T\}$, resulting from Equations (36) and (37). This shows that the two theories are closely related and free of contradiction through a shared foundation, rather than juxtaposition without true correspondence. Only practical usefulness keeps them apart.

3. Our hypothesis of the possible detection of the absolute velocity using subluminal signals based on the '*unusual*' model represented by Equations (30) was not confirmed, as the absolute velocities still cancelled out "*in the usual manner*" [9] (p101), even though no explicit distant clock synchronisation was needed in the stationary system.

4. Our research continued despite the first null result and succeeded, although not outside uniformly translating systems as suggested by Tangherlini [9] (p105). The missing extra equation was found from the transverse Doppler effect, which is measurable in the moving system, as shown on Page 19. This was demonstrated using the STR approach. We presented possibility of determining the velocity of the base system **B** (v_{BS}) by deriving the aberration angle expression in Equation (47) and similar for the absolute v_{BA} velocity in Tangherlini framework, both indistinguishable.

$$\boxed{\begin{gathered} v_{BS} = -\cos(\varphi)c \\ v_{BA} = -\cos(\varphi)c, \end{gathered}}$$

where φ is the transverse Doppler effect-induced aberration angle and v_{BS} is the relative velocity of the moving base system **B** in an undisclosed radiating source system **S** and v_{BA} is the absolute velocity. Both **A** and **S** have the common feature of the isotropy of the round-trip average speed of light. The wave vector has two nonzero components sufficient to derive the expressions above, without knowing anything about the undisclosed system's emitter velocity or frequency. This approach has not been explored earlier because stationary and moving system examples in the literature always explored two or more known inertial systems, where physical quantities can be measured. The present example invokes an anonymous system from which only the incoming wave is measured. This is somewhat related to the CMB radiation, where no microwave can be linked to a known emitter initial state.

5. The Tagherlini framework and the corresponding STR allowed the detection of what is defined as the absolute velocity in the assumed ARF. In the context of the existing CMB it does not appear peculiar anymore. Whether referring to it as 'the absolute' in the context of the universe governed by theories other than special relativity, it requires further scrutiny. The presented approach calls for a public discussion because of the long-standing controversy. Finding a Lorentz transformation capable of reconciling this controversy was not anticipated. Tangherlini's hypothesis about the possibility of detecting absolute velocity using subluminal signals initially unconfirmed, materialised in a different way by using the relativistic transverse Doppler effect exactly matching that derived within the STR framework.
6. The apparent conflict between absolute simultaneity and relative simultaneity, where Tangherlini and STR theories deemed complementary appear to predict different judgment about the sequence of events has been partially resolved (Section 4.8). Causal invariance of events temporal order demonstrated in Equations (54) and (55) was consistently derived from the LT and TT involving a problem definition based on the proper time invariance in synchronised clocks in the origins of relatively moving systems, regardless of their relative motion. Once clocks are synchronised at a common origin, they become correlated, incrementing their proper time independently of coordinate conventions. A special case of the famous Andromeda paradox, described by Penrose [24] (p 260), based on the problem originally posed by Rietdijk [25], and non-existent In Tangherlini framework, ceased to exist in the STR framework from the perspective of the proper time invariance in presynchronised clocks continuing motion after the synchronisation at Andromeda launch site. The full resolution of the paradox and relative simultaneity in general is deferred to a future work pending the proof of the Conjecture 2 (page 27).

5.5. Conclusions

1. **Validation or the Matsas et al** [1] **three-clock protocol result**
    - **Finding:** The distance D formula is confirmed and unpublished moving clocks velocities were derived.
    - **Result**: Both, distance and velocities are derivable exclusively from the proper times of three clocks. This extends the protocol's validity in its own right for local kinematic measurements.
2. **Failure to circumvent absolute velocity cancellation**

    - **Finding:** The unusual clock protocol not using Einstein synchronisation is no exception to the known behaviour and the absolute velocity cancellation was unavoidable.

    - **Distance not computable**: The same three-clocks scenario treatment in the Tangherlini framework demonstrated inability to determine the distance formula unlike in the STR framework due to absolute velocities cancellation.

    - **Absolute velocities not fully eliminated**: In contrast, to the distance, clocks velocities remain irreducible functions of three absolute velocities. The solution for the absolute velocity is still impossible due to three degrees of freedom in two equations. However, the three-clock scenario developed in the STR framework maps to an unlimited number of absolute velocity combinations in the Tangherlini framework. This allows mapping Tangherlini to STR coordinates, demonstrating their close relationship is consistent not accidental.

- **Tangherlini to Lorentz coordinates conversion**: The conversion of coordinates between the two frameworks in the standard axes configuration can be performed by using transformation Equations (38).

3. The Identification of Absolute Velocity

- **The Breakthrough:** Tangherlini framework defined absolute velocity was derived with respect to the ARF from transverse Doppler effect—the only case in this framework where the cancellation did not occur—and it was found isomorphic to the peculiar velocity derived from the STR framework. Unlike in the standard CMB methodology, in both cases the stationary frame was assigned to the ARF or to the CMB frame in the STR solution.

- **Mechanism:** The absolute velocity solution is physically tied to the aberration angle (φ) This was accomplished by defining the wave 4 vector defined in the ARF or CMB frame which transformed to the moving observer framed predicted its structure in those frames. The form of the wave 4-vector transformed from the ARF to the observer in the Tangherlini framework differed from the one in the STR in the temporal first component only, with the angular frequency ω attributed to vacuum as opposed to the frequency affected by interaction with the detector. This aligned well with the introduced concept of 'anonymous wave' or EM radiation in vacuum, which seems to be represented by the ARF and contains no information about the emitter. The anonymity arises when its source cannot be identified in contrast with the case where both, the emitter and detector are well known. In the latter case the received frequency is ambiguous because there is unlimited number of frequencies and emitter velocities pairs yielding the same value. Therefore it was assumed that the ARF or vacuum is the only host of these waves. The context of vacuum applies to the STR because there is no ARF concept in this framework.

- **Equations:** The Tangherlini and STR approaches were found to be fully equivalent, and reconciliation with the STR framework is evident. The reconciling equations derived from the wave vector component ky/kx ratio are $v_{BS} = -cos(\varphi)c\,, v_{BA} = -cos(\varphi)c$ in the STR framework and Tangherlini framework respectively where v_{BS} is the velocity of the moving observer relative to the stationary local frame (CMB) and v_{BA} is the absolute velocity of the observer relative to the ARF. The equivalence of these expressions confirms that the peculiar velocity is the manifestation of absolute motion in the STR framework. The reason why these expressions are identical is that by definition, the isotropy of one-way velocity of lights holds in all STR inertial frames, whilst this is only true in the ARF in the Tangherlini framework. The transverse Doppler effect in EM waves constitutes a definitive exception in terms of absolute velocity cancellation, mathematically reconciling the Tangherlini and STR frameworks.

4. Challenge to Poincaré's Principle of Relativity

- **Historical Context**: Poincaré's Principle of Relativity declared the impossibility of detecting absolute motion, because a universal physical reference frame was not conceptually experimentally developed until 1967-68, when the CMB measurements

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methodology became fully developed as indicated by publications of Stewart and Sciama [20], Peebles and Wilkinson [22]. Physicists in the early 20th century deliberately embraced the STR framework that preserves the principle of relativity locally, regardless of the cosmological environment.

- **The progress**: The standard approach to relativistic Doppler effect based methodology emerging in 1968 involves two moving inertial frames, one stationary observer-centric and the other moving local rest CMB frame, without declaring it 'absolute' by naming it peculiar for there is no ARF in the STR. This partially closed the cancellation gap by opening opportunities for challenge. We believe it may be considered fully closed by introducing our concept of anonymous waves after proving the proposed Conjecture1 (page 23).

5. **Relative vs absolute simultaneity**

- **The conflict:** Absolute simultaneity and relative simultaneity, where Tangherlini and STR theories deemed equivalent are generally expected to differ about the sequence of distant events thus breaking the equivalence, is partially resolved (Section 4.8), surprisingly yielding the same result. The order invariance is maintained because of the invariance of proper times of the clocks involved rather than coordinates convention. The studied case applies to a special case of Andromeda paradox, originating from Rietdijk [25] presenting philosophical arguments, then paraphrased for wide audience by Penrose [24] (p 260).

- **Mechanism:** The analysis and derivation leading to this conclusion indicate that two sequential events in the same location are order invariant in moving frames when they are fully pre-synchronised in coinciding origins and axes in an Andromeda location nominated as the central stationary system, because of invariance of proper times in synchronised and uniformly moving clocks within the STR framework. Each observer then has a perfect knowledge of Andromeda coordinate time and their own as if there was no relative simultaneity, albeit all clock indications are different. Naturally this is exactly reproduced in Tangherlini framework confirming frameworks consistency. The original paradox scenario is different because observers synchronise clocks at coincidence point at a distance from Andromeda launch site without means to reach the launch site instantaneously. Although the standard case of the paradox demonstrates relative simultaneity as well as the generally known case of two distant events on x-axis were not elaborated, the proposed Conjecture 2 (page 27) claims that the Tangherlini and STR framework will produce physically consistent result which is an unusual conclusion yet expected based on GR origin of the two frameworks.

6. **Realignment of physics**

- **Reconciliation:** This study may allow realigning physics with the reality of absolute velocity. No experimental result confirmed within STR is invalidated; however, narratives dismissing absolute motion must be reviewed. We hope that the results will spur further research to expand and unify knowledge.

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Abbreviations:

The following abbreviations are used in this manuscript:

ALT	Absolute Lorentz Transformation
ARF	Absolute Rest Frame
CMB	Cosmic Microwave Background
EM	Electromagnetic
EOM	Equation of Motion
GR	General Relativity
LT	Lorentz Transformation
STR	Special Theory of Relativity
TT	Tangherlini Transformation

Appendix A. On Absolute Rest, Velocity and Tangherlini Transformation

Tangherlini's [9] derivation of the transformation referred to in this study was originally based on the Einstein field equations, resulting in transformation equations compatible in structure with the LT equations derived by Einstein, as presented in [7] (p48). The arrangement of the two relatively moving coordinate systems can be referred to as the standard configuration, where the relative velocity vector is aligned with the first spatial axis (usually x). The mathematical representations of the TT, the postulates leading to its derivation and resulting properties are collectively referred to as the TT framework.

With respect to the TT framework, the ARF must be postulated a priori to allow different derivation processes using a method other than that of Tangherlini. For example, Selleri [41] defines the ARF as the one in which the velocity of light is the same in any direction, without demanding that moving frames follow the same rule. The impossibility of absolute synchronisation with instantaneous signals—let alone without them— appears to be the fundamental obstacle to the use of TT on a larger scale. The TT framework appears to be the only sensible but impractical alternative to the STR framework. Both frameworks share the same foundation, namely, the empirical law of isotropy of the round-trip average speed of light discovered by Michelson and Morley [26].

The TT framework can be derived from the first principles of Newtonian kinematics without reference to inertial rotational motion or the forcing postulates of length contraction or time dilation, as in some previous approaches. However, the frequently analysed Sagnac effect appears to be a legitimate approach.

The necessary and sufficient set of postulates and constraints for completely defining the TT is as follows:

Postulate 1: *There exists an absolute rest frame represented by an inertial system* ***A****, with three Cartesian coordinate axes that can be bound (aligned) to preexisting axes of an inertial system* ***M*** *at time t=0 and t′=0. In that system, the one-way velocity of light is constant and equal to c in all directions, and there is only one system* ***A*** *(together with all its possible translations and rotations, all being at rest with it).*

Postulate 2: *The round-trip average speed of light in any inertial system is a constant, whose value c= 299792458 m/s, and is independent of the relative direction and velocity of those systems.*

Postulate 3: *An instantaneous signal being represented as the limit of all signals moving in the same direction with ever increasing velocity* $v_{\alpha A}$, *observed in the absolute inertial system* ***A*** *as* $S_{\infty A} \equiv t = x/\lim\limits_{v_{\alpha A}\to\infty} v_{\alpha A}$, *is invariant in all inertial frames such that when observed in an inertial moving system* ***M*** *of the absolute velocity* v_{MA}, *it is* $S'_{\infty M} \equiv t' = x'/\lim\limits_{v_{\alpha M}\to\infty} v_{\alpha M}$, *where* $v_{\alpha M} \neq v_{\alpha A}$.

Constraint 1: *The spatial origin of system* ***M*** *moving in the system* ***A*** *coordinates transforms to the origin point in* ***M*** *at rest with itself as* ***M****(0,0,0) at every instance of time t′.*

Constraint 2: *The determinant of the linear coordinate transformation matrix* Ω_{∞}^{v} *is equal to +1, as in the case of the LT and Galilean transformation matrices.*

Note: The formulation of the Postulate 3 was chosen to avoid mathematically cumbersome infinite speed signal's EOM. Any superluminal signal motion is allowed in inertial systems by the virtue of Einstein's description of inertial systems where the equations of mechanics "hold good" [7] (p.38). There is no inherent velocity limit in Newton's mechanics neither in the STR where superluminal signal can be transformed from one frame to another; however, exhibiting peculiar effects including one point of singularity above a certain superluminal velocity. In the ARF, we can take the transformable superluminal signal EOM as for any other signal. In the transformed EOM we can take the limit $\lim\limits_{v_{\alpha M}\to\infty} v_{\alpha M}$ which establishes the mathematical presence of the instantaneous signal with the consequence of clearing the spatial temporal component, present in the LT matrix.

The TT matrix Ω_{∞}^{v} meeting the postulates and constraints can be derived and is shown in Equation (14). Including the full derivation process in this paper would exceed a sensible publication word count limit.

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