Theory of Time Frames: Variable Speed of Light

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Abstract

Within the framework of the Theory of Time Frames, we have revealed an intuitive explanation for the longstanding enigma surrounding the constancy of light speed in a vacuum. This was achieved through the astonishingly straightforward logic that acknowledges a photon's speed varies in proportion to the flow of time and the established fact that photons do not possess rest mass. Consequently, our research indicates that the speed of light is not constant but variable. However, this insight does not contradict the laws of physics or empirical evidence. Moreover, we propose a new dimensionless constant, $n_c = 299{,}792{,}458$, to replace the traditional constant of light speed, c. This novel constant is consistent with all observed measurements of light speed conducted within the observer's local time flow. Although this interpretation of light speed deviates from Einstein's theory, it is grounded in solid theoretical and empirical evidence.

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1 Introduction

This paper builds upon previous work [1] and [2] that established the foundation of the theory of time frames, outlining its core concepts and the relationships between different flows of time.

The primary objective of this paper is to challenge Einstein's postulate of the constant speed of light by proposing that the speed of light can be considered a variable.

Einstein's second postulate in the theory of special relativity asserts that the speed of light in a vacuum remains constant (c = 299,792,458 meters per second), regardless of the motion of the light source or observer.

This principle is valid whether light moves within inertial frames of reference or follows geodesic paths in curved spacetime under the influence of gravity. However, such a behavior of light is counterintuitive since it deviates from the laws of classical mechanics.

To justify the behavior of light, Einstein introduced new and unproven principles into his theory of relativity. These included the concepts of four-dimensional space-time, the bending of space-time, and length contraction [3][4]. This gives the impression that Einstein attempted to explain the unknown mechanism behind the constancy of the speed of light using the equally unknown mechanisms of the aforementioned new concepts.

Nevertheless, both the special and general theories of relativity have successfully predicted phenomena such as kinetic and gravitational time dilation, as illustrated in Figure 1. Experimental evidence has confirmed both kinetic and gravitational time dilation [5][6].

Figure 1

Conversely, the strategy and cognitive processes underpinning the theory of time frames are opposite (Figure 2). While acknowledging experimentally verified time dilation, the theory interprets it as a consequence of spatially varying time flows [1].

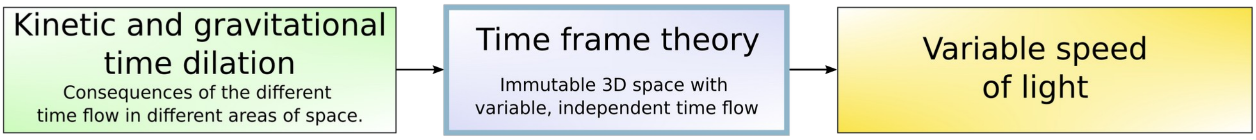

Figure 2

Unlike the four-dimensional spacetime model, the theory of time frames proposes a universe with three spatial dimensions and a separate time dimension, in which time can vary. The time dimension can exhibit different flow rates in distinct spatial regions.

The central concept of the theory of time frames is the variable flow of time, which slows down due to external factors such as mass, energy, and the relative motion of objects.

Variable time flows necessitate the introduction of variable time units. Consequently, this leads to the variability of all time-dependent quantities, including constants like the speed of light (c), Planck's constant (h), the gravitational constant (G), and others.

The variable speed of light not only contradicts Einstein's postulate regarding the constancy of the speed of light but also challenges Maxwell's equation for the speed of electromagnetic waves in a vacuum, as well as the results of empirical measurements.

Nevertheless, despite these compelling arguments, we aim to show how the concept of the flow of time allows for a reinterpretation of these arguments, thereby supporting the notion of a variable speed of light.

Furthermore, we propose a new dimensionless constant, $c_n = 299,792,458$, to supplant the traditional constant of light speed, $c = 299,792,458\frac{m}{s}$. This novel constant is consistent with all observed measurements of light speed conducted within the observer's local time frame.

2 Maxwell's equation for the speed of light

In the 19th century, James Clerk Maxwell's equations successfully described the behavior of electric and magnetic fields. These equations predict the existence of electromagnetic waves, such as light, and indicate that the speed of these waves should be a constant value [7]. However, the question arises under what conditions these formulas show the constancy of the speed of light.

The basic formula derived from Maxwell's equations directly relates the speed of the electromagnetic wave, 'c', to the basic vacuum constants:

$$c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} = 299,792,458\, m/s$$

Where:

- c is the speed of light in a vacuum.
- ε_0 is the electric constant (permittivity of free space).

- μ_0 is the magnetic constant (permeability of free space).

This equation makes it possible to calculate the speed of light directly from the electric and magnetic properties of free space (ε_0 and μ_0). Thus, the speed of light is considered a fundamental natural constant.

However, derived purely from electromagnetic theory, *the equation lacks gravitational components and does not consider light's behavior within gravitational fields*. Consequently, it can be assumed that its validity is limited to conditions of vacuum in the case of negligible gravitational fields.

2.1 ε_0 and μ_0 and the speed of light in a variable flow of time

Nevertheless, regardless of the stated assumption, it is proposed that the presented Maxwell's equation can extend to encompass the speed of light in strong gravitational fields.

Changes in the gravitational field affect the flow of time, leading to alterations in the duration of time units. Consequently, these changes in time units influence all physical quantities and constants that include time units in their dimensions.

Since the dimensions of constants ε_0 and μ_0 include time units, variations in these constants occur in response to changes in the flow of time. According to Maxwell's equation, these variations in ε_0 and μ_0 result in alterations to the speed of light.

Consequently, observing the presented Maxwell's equation in the framework of variable time flows, we can conclude that *this equation is not in opposition to the concept of a variable speed of light*.

3 Deductions about the behavior of light

The theory of time frames involves different flows of time in different spatial regions. We take into account that changes in the flow of time affect the movement of all bodies and particles. Therefore, there's no reason why light particles (photons) shouldn't also be subject to this influence.

Based on these insights, we derive critical deductions about the behavior of light:

1. **Instantaneous change in speed of light**: Given that photons possess no rest mass and thus are unaffected by inertia, *we deduce that their speed changes instantaneously in response to alterations in the flow of time*. This deduction is rooted in a logical analysis of the properties of photons and the nature of inertia.
2. **Proportionality of time flow to the speed of light:** Recognizing that all motion is inherently subject to the flow of time, it follows logically that the motion of photons, too, is governed by the temporal dynamics of the space through which they travel. Consequently, w*e infer that the speed of light is directly proportional to the flow of time in the traversed space*.

These deductions are supported by the underlying principles of time frames theory, specifically the impact of time flow on the duration of time units and the invariant nature of length units across different time flows. This leads to the understanding that the speed of light, while consistent within a given (homogeneous) time flow, is fundamentally dependent on the flow of time within the space through which its movement takes place.

In the subsequent sections, the phenomena and broader implications of these deductions will be described in detail, providing a deeper insight into the interplay between light speed and time flow.

4 Rational explanation for the speed of light

The constancy of the speed of light, as described by the special theory of relativity, represents a fundamental divergence from the principle of classical mechanics. In classical mechanics, speeds are relative and add or subtract based on the relative motion of the observer and objects.

However, this is not the case with light, as we always measure the same speed of light regardless of the observer's movement, the movement of the source of light, or both at the same time.

Although the phenomenon of the constancy of the speed of light is often mentioned as strange and counterintuitive, we will demonstrate that within the framework of the theory of time frames, it can be explained simply and intuitively.

In this context, the following questions can be posed:

1. **Why is the speed of light not affected by the motion of the light source?**

   Based on the logical deduction (Chapter 4, 2. The proportionality of time flow to the speed of light), it is understood that the speed of light varies with the flow of time in the space it traverses. *No matter the movement of the light source, as the light enters the observer's local time flow, it adopts a speed proportional to that local time flow.* Therefore, the movement of the light source itself does not affect the speed of light that the observer will measure in his local time flow.

2. **Why does the speed of light remain unchanged by the movement of the observer?**

   The explanation mirrors the one provided for the preceding question. The speed of light, as measured by an observer, is solely determined by the observer's local time flow. Regardless of the observer's movement, when light enters the observer's local time domain, its speed adjusts to match that specific time flow.

This implies that all light beams passing through the observer's local time domain consistently exhibit the same speed, which depends solely on the observer's local time flow.

This also suggests that *the speed of light, as measured by the observer, remains independent of any previous conditions, i.e., its history*.

4.1 Example: The passage of light through multiple time frames

Notes regarding time frames: In our introductory paper on the theory of time frames [2], we introduced a novel concept named time frames. Time frames encompass inertial reference frames within a confined space characterized by a defined, homogeneous flow of time.

When light passes through the spatial area of a time frame (T_f), it is influenced by the flow of time (q_t) defined within that area. The speed of light depends solely on the flow of time within the time frame it passes through. This is true regardless of the light's speed before entering that time frame.

Let's explore the relationships concerning the influence of the flow of time on the speed of light, as illustrated in Figure 3.

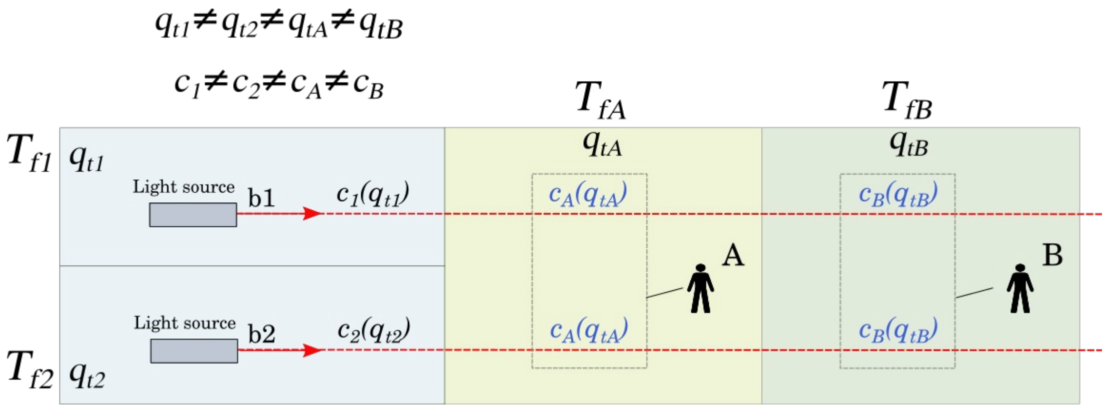

Figure 3

Light sources located within time frames T_{f1} and T_{f2} emit light beams (b_1 and b_2), respectively. The light beam b_1 traverses the time flow region q_{t1}, dictating the speed of light c_1.

Similarly, the light beam b_2 moves through a region characterized by time flow q_{t2}, which dictates the speed of light c_2. Since the time flows (q_{t1} and q_{t2}) differ, the speeds of the light beams (c_1 and c_2) also differ.

When the light beams enter the local time frame T_{fA} of observer A, they arrive at the time flow area q_{tA}. Observer A will now measure the same speed of light (c_A) for both light beams (b_1 and b_2) since they pass through the same time flow q_{tA}.

Similarly, observer B, measuring in their local time frame, T_{fB}, where the valid time flow is q_{tB}, will also observe that the speeds of both light beams are identical (c_B).

However, because of different time flows ($q_{tA} \neq q_{tB}$), the measured speeds will differ ($c_A \neq c_B$).

This example demonstrates the consistency of light speed within a specific time frame. However, across various time frames, the speed of light can differ, influenced by the distinct flows of time that characterize each time frame.

5 Local measurement of the speed of light

Note: The observer always conducts all their measurements in local time units determined by the observer's local flow of time. This is true regardless of whether the observer is measuring physical events locally within their local time frame or in a distant time frame.

Figure 4 provides an example illustrating local measurements of the speed of light by observers A and B.

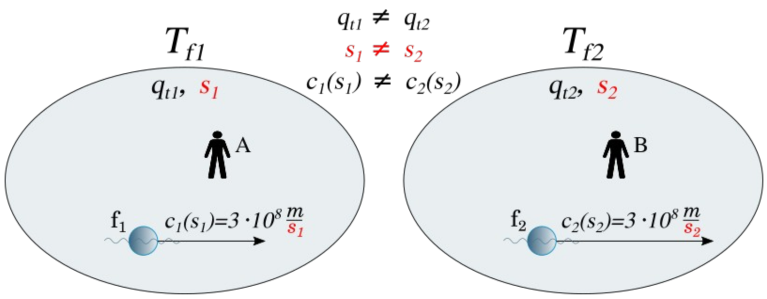

Figure 4

Observer A measures the speed of light locally within his local time frame, T_{f1}, which incorporates the flow of time, q_{t1}. Time flow q_{t1} determines the unit of time, denoted as s_1, which observer A uses to measure the speed of light. The measured speed of light is expressed as:

$$c_1(s_1) \approx 3 \cdot 10^8 \ \frac{m}{s_1} \qquad (1)$$

Observer B, within his local time frame T_{f2}, characterized by the flow of time q_{t2}, measures the speed of light in units of time s_2:

$$c_2(s_2) \approx 3 \cdot 10^8 \ \frac{m}{s_2} \qquad (2)$$

The unit of length (m) remains invariant across all time frames. However, since the units of time s_1 and s_2 differ, it must be acknowledged that the speeds of light c_1 and c_2 also differ from each other.

From equations (1) and (2), we can derive the relationships between the speed of light and the duration of time units:

$$\frac{c_1(s_1)}{c_2(s_2)} = \frac{s_2}{s_1} \qquad (3)$$

Since the ratio of the flow of time is denoted as $r_t = \frac{s_2}{s_1} = \frac{p_1}{p_2}$ [2], as per equation (3), we can express the ratio of the speed of light as follows:

$$r_t = \frac{c_1(s_1)}{c_2(s_2)} = \frac{s_2}{s_1} = \frac{p_1}{p_2} \qquad (4)$$

These relations hold true only when measuring the speed of light in the local time frames of the observer.

5.1 The local light constant (n_c) and the reinterpretation of light speed measurement

Based on the measurement results (1) and (2), we derive the following relationships:

$$\frac{c_1(s_1) \cdot s_1}{m} \approx 3 \cdot 10^8 = n_c \qquad (5)$$

$$\frac{c_2(s_2) \cdot s_2}{m} \approx 3 \cdot 10^8 = n_c \qquad (6)$$

It is apparent from these equations that the result of local measurements of the speed of light consistently includes a **dimensionless constant**, denoted as n_c = 299,792,458, or approximately $3 \cdot 10^8$. This constant shall be referred to as the **local light constant,** where n indicates that it is a numeric value.

The local light constant remains invariant across all time frames.

Relations (3) show that the speed of light and the duration of a unit of time exhibit an inversely proportional relationship. In a slower flow of time, the speed of light is lower, but the duration of time units is longer. Conversely, in a faster flow of time, the speed of light is higher, while the units of time are shorter.

Inversely proportional balancing: As a consequence of this inversely proportional relationship between the speed of light and the duration of a unit of time, mutual compensation (or inversely proportional balancing) occurs. This leads to the outcome that all observers, when measuring the speed of light locally, consistently obtain the same numerical value (the local light constant $n_c \approx 3 \cdot 10^8$), in their measurement results. This applies regardless of differences in the flow of time to which the observers are subjected, meaning it is also independent of differences in the duration of time units used by observers to measure the speed of light.

6 Remote measurements of the speed of light

Observer A is in the time frame T_{f1}, while observer B is in the time frame T_{f2}. For observer A, T_{f2} is a distant time frame, whereas for observer B, T_{f1} is a distant time frame. We will examine how observers, from their perspectives, perceive the speed of light in distant time frames.

6.1 Observer A: Remote measurements of the speed of light

Observer A (Figure 5), located in time frame T_{f1}, where the flow of time is q_{t1} and the unit of time is s_1, measures the speed of light in the distant time frame T_{f2}, where the flow of time is q_{t2} and the time unit is s_2.

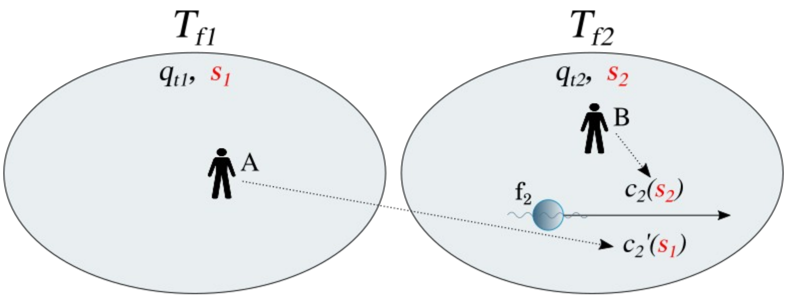

Figure 5

From the previous consideration, we understand that observer B, who makes local measurements of the speed of light within the time frame T_{f2}, will record the following:

$$c_2(s_2) = n_c \cdot \frac{m}{s_2} \approx 3 \cdot 10^8 \, \frac{m}{s_2} \qquad (7)$$

From relation (4), it follows:

$$r_t = \frac{s_2}{s_1}$$

$$s_2 = r_t \cdot s_1 \qquad (8)$$

The time diagram in Figure 6 shows the relationship between time units.

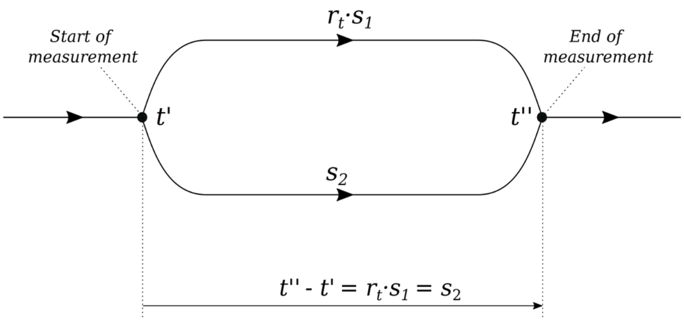

Figure 6

By substituting s_2 in equation (7) with the expression (8), we obtain the following result:

$$c_2(s_1)' \approx \frac{1}{r_t} \, 3 \cdot 10^8 \, \frac{m}{s_1} \qquad (9)$$

The value $c2(s1)'$ represents the speed of light within the time frame T_{f1}, as determined by the remote measurement conducted by observer A. Observer A carried out the measurements using his local time unit, s_1.

To differentiate remote measurement from local measurement, a prime symbol (') has been added.

6.2 Observer B: Remote measurements of the speed of light

In this scenario (Figure 7), observer B, whose local time frame is T_{f2}, measures the speed of light in the distant time frame T_{f1}. Observer B is situated within the flow of time q_{t2}, which defines the time unit s_2.

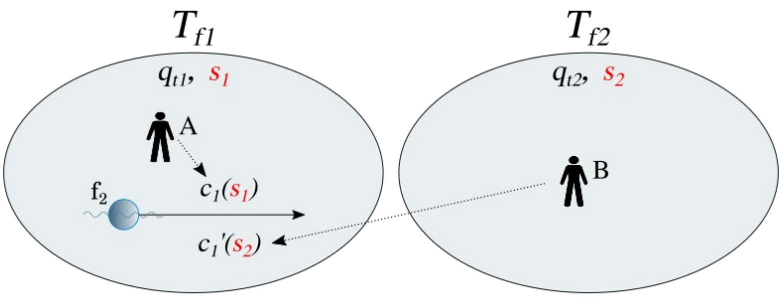

Figure 7

The time unit s_2 is the local time unit of Observer B, with which he measures the speed of light in the time frame T_{f1}.

Since observer A measures the speed of light locally, within his local time frame T_{f1}, his measurement result will be:

$$c_1(s_1) = n_c \cdot \frac{m}{s_1} \approx 3 \cdot 10^8 \ \frac{m}{s_1} \qquad (10)$$

It follows from relation (8):

$$s_1 = \frac{s_2}{r_t} \qquad (11)$$

The time diagram in Figure 8 illustrates the relationship between time units.

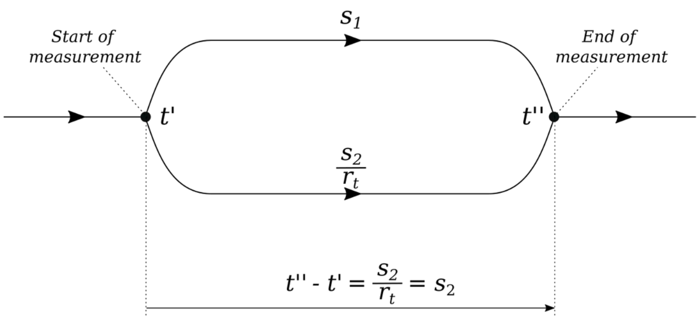

Figure 8

If we replace the time unit s_1 in relation (10) with relation (11), we get:

$$c_1(s_2)' \approx r_t \cdot 3 \cdot 10^8 \ \frac{m}{s_2} \qquad (12)$$

The value $c_1(s_2)'$ represents the speed of light within the time frame T_{f1}, as determined by the remote measurement conducted by observer B. Observer B carried out the measurements using his local time unit, s_2.

7 Transition of light through different flows of time

Figure 9a illustrates an example where light passes through three time frames T_{f1}, T_{f2}, and T_{f3}, with their respective time flows q_{t1}, q_{t2}, and q_{t3} differing from each other. We will assume that observers A, B, C, D, and the light source are in a state of rest relative to each other.

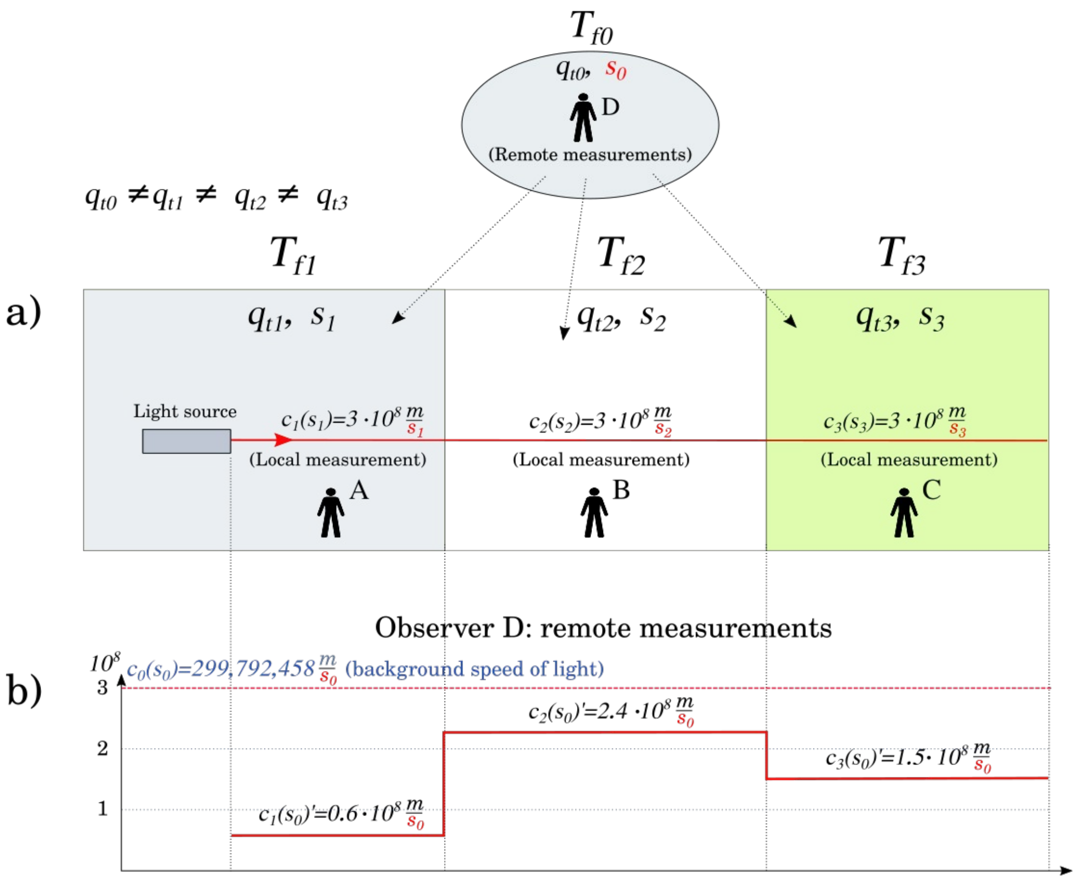

Figure 9

Observers A, B, and C measure the speed of light within their local time frames, using their local time units s_1, s_2, and s_3.

As we agreed in the previous example, since the observers measure the speed of light in their local time frames, their measured values will consistently contain the same numerical value, the local light constant n_c = 299,792,458. For simplicity, in this example, we will round off the local light constant to n_c = 3·10ˆ8.

Consequently, observers measuring the speed of light within their local time frames will record the following measurements:

Observer A: $c_1(s_1) = n_c\,\dfrac{m}{s_1} = 3\cdot 10^8\,\dfrac{m}{s_1}$

Observer B: $c_2(s_2) = n_c\,\dfrac{m}{s_2} = 3\cdot 10^8\,\dfrac{m}{s_2}$

Observer C: $c_3(s_3) = n_c\,\dfrac{m}{s_3} = 3\cdot 10^8\,\dfrac{m}{s_3}$

The flow of time q_t is a relationship that describes how much time $(p \cdot s)$ has passed in a given area of space in proportion to one background second (1 s_0) [1].

$$q_t = \frac{p \cdot s}{s_0}$$

p is the time flow coefficient.

From the definition of the time flow, it follows:

$$s_0 = p \cdot s$$

$$s = \frac{s_0}{p}$$

Let us consider the following values of time flow:

$$q_{t1} = 0.2 \cdot \frac{s_1}{s_0}$$

$$q_{t2} = 0.8 \cdot \frac{s_2}{s_0}$$

$$q_{t3} = 0.5 \cdot \frac{s_3}{s_0}$$

The time diagram (Figure 10) shows the relationship between p_0, $p_1 \cdot s_1$, $p_2 \cdot s_2$, and $p_3 \cdot s_3$.

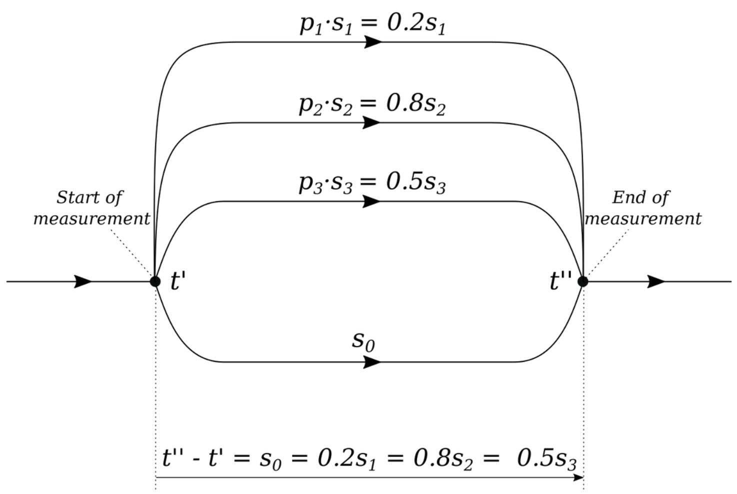

Figure 10

Based on the time flows q_{t1}, q_{t2}, and q_{t3}, it follows:

$$s_0 = p_1 \cdot s_1 = 0.2 \cdot s_1$$

$$s_0 = p_2 \cdot s_2 = 0.8 \cdot s_2$$

$$s_0 = p_3 \cdot s_3 = 0.5 \cdot s_3$$

Therefore, the time-flow coefficients have the following values:

$p_1 = 0.2$

$p_2 = 0.8$

$p_3 = 0.5$

Time units s_1, s_2, and s_3 depend on time-flow coefficients:

$$s_1 = \frac{s_0}{p_1} = \frac{s_0}{0.2} = 5\,s_0$$

$$s_2 = \frac{s_0}{p_2} = \frac{s_0}{0.8} = 1.25\,s_0$$

$$s_3 = \frac{s_0}{p_3} = \frac{s_0}{0.5} = 2\,s_0$$

Thus, we have expressed all three time units s_1, s_2, and s_3 in terms of the background time units, s_0. This enables us to observe the differences among the measured speeds of light.

The recalculated speeds of light are:

$$c_1(s_0)' = 3 \cdot 10^8\,\frac{m}{s_1} = 3 \cdot 10^8\,\frac{m}{5s_0} = 0.6 \cdot 10^8\,\frac{m}{s_0}$$

$$c_2(s_0)' = 3 \cdot 10^8\,\frac{m}{s_2} = 3 \cdot 10^8\,\frac{m}{1.25s_0} = 2.4 \cdot 10^8\,\frac{m}{s_0}$$

$$c_3(s_0)' = 3 \cdot 10^8\,\frac{m}{s_3} = 3 \cdot 10^8\,\frac{m}{2s_0} = 1.5 \cdot 10^8\,\frac{m}{s_0}$$

The speeds of light $c_1(s_0)'$, $c_2(s_0)'$, and $c_3(s_0)'$ correspond to the results of remote measurements by observer D.

Observer D is located in the time frame T_{f0}, within the background time flow q_{t0}. This implies that his measurements are performed in background time units (s_0).

The graph (Figure 9b) shows the relationship between these speeds. Also shown is the maximum possible speed of light, **the background speed of light** $c_0 = 299,792,458\,m/s_0$, or approximately $c_0 = 3 \cdot 10^8 m/s_0$. The background speed of light is achievable only in the region of the background time flow (q_{t0}). All other speeds of light are slower because of their slower time flows resulting from gravitational fields or the relative motion of objects.

The graph also illustrates that the speed of light changes abruptly when transitioning from one time frame to another, as a result of the change in the flow of time. Light instantly reacts to changes in time flow, as it does not possess rest mass and therefore lacks inertial properties.

8 Perception of the observer

Figure 11 depicts two time frames, T_{f1} and T_{f2}, characterized by differing flows of time ($q_{t1} \neq q_{t2}$). The consequence of different time flows is different units of time ($s_1 \neq s_2$). This discrepancy in time units indicates that clocks within these time frames will register different durations of elapsed time ($t_1 \neq t_2$).

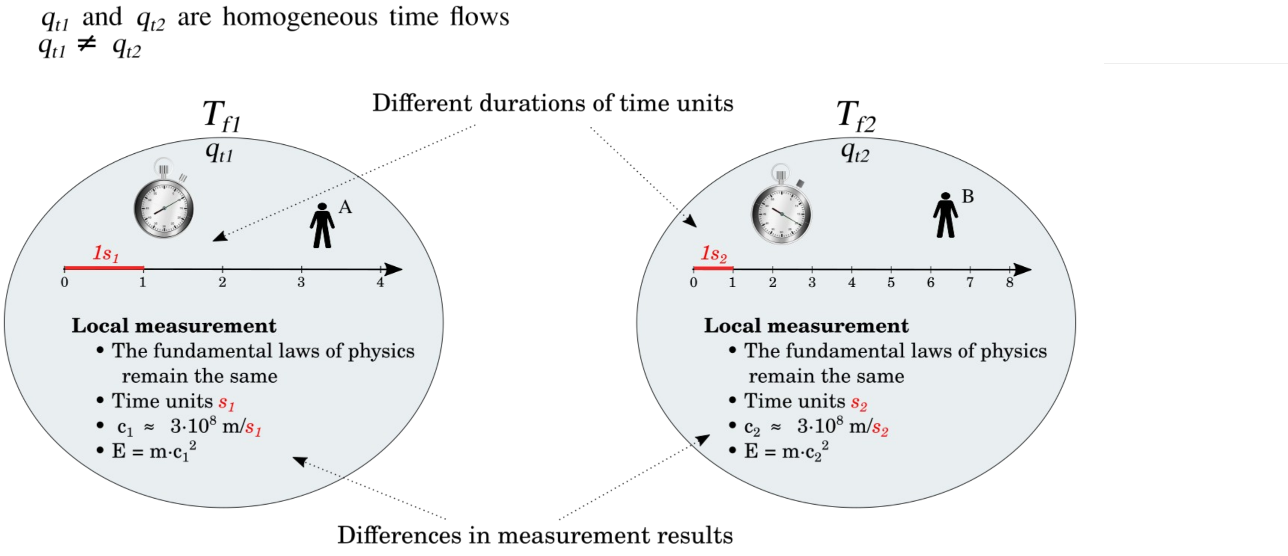

Figure 11

Drawing on the presentations thus far, we can make the following statements regarding the observer's measurement:

1. **Consistency of physical laws within time frames:** During local measurements, observers will find that the fundamental laws of physics remain unchanged across different time frames, regardless of differences in the flow of time. This indicates that the core principles governing physical systems do not vary in diverse temporal contexts.

   Example:
   Let's take the time frame T_{f1}, where the flow of time is represented by q_{t1}, and thus, the unit of time is denoted as s_1. In this context, the speed of light is measured as c_1, leading to the mass-energy equivalence formula $E_1 = mc_1^2$. Similarly, within a time frame T_{f2}, characterized by a flow of time q_{t2} and a time unit s_2, the speed of light adjusts to c_2, modifying the energy formula to $E_2 = mc_2^2$. This example illustrates the consistency of physical laws, even as the metrics of time undergo variations.

2. **Differences in Measurements:** When observers compare measurements taken at different time frames, they will notice deviations or differences in their results. These differences arise because of differences in the flow of time. In different flows of time, the dynamics of all motions are different. Likewise, the duration of time units is different, affecting the measurement process itself.
3. **Lack of awareness of differences in time units:** Let us assume an observer measures the same physical events across different time frames, implying variations in the flow of time. In such a scenario, because of the consistency of physical laws, an observer making local measurements of physical events cannot perceive differences in the flow of time or in the durations of the time units used for these measurements. This phenomenon highlights a perceptual limitation inherent to the local frame of observation.
4. **External observers notice differences:** External observers, situated beyond the confines of time frames T_{f1} and T_{f2}, and engaging in measurements from this detached perspective (remote measurements within T_{f1} and T_{f2}), can detect mutual variations in the velocity of events within these time frames. These observations are directly due to the differential flows of time, illustrating the relative nature of temporal dynamics as perceived from an external vantage point.

9 Conclusion

The constancy of the speed of light represents a fundamental paradigm in physics. However, observing the speed of light within the framework of the theory of time frames, we have challenged this established paradigm and recognized the necessity for its revision.

Our research has determined that the speed of light is not constant but variable. The speed of light is proportional to the flow of time in the space through which it passes. When light moves through a time frame, its speed will be constant and dependent on the flow of time within that time frame. However, as light moves from one time frame to another, its speed will vary depending on the flow of time within those time frames.

This understanding of the variability of the speed of light has led to the need to replace the light constant c with a dimensionless local light constant n_c. The local light constant n_c appears in all observed measurements of the speed of light, which are conducted within the local time frames of observers.

This adjustment implies that measurements of the speed of light, traditionally considered a universal constant across all reference frames, would now depend on the local flow of time within the observer's time frame.

The variability of the flow of time has necessitated the introduction of variable time units, significantly complicating the representation and analysis of physical quantities and constants. To mitigate these issues, it is possible to use background time units (s_0) as the primary unit against which all other time units are calibrated. This approach is detailed in Chapter 7 of this document.

Similarly, in the context of variable time units, it becomes imperative to reassess other constants involving time units, such as Planck's constant (h) and the gravitational constant (G). Subsequent research will undoubtedly explore these topics.

Within the framework of the theory of time frames, we have managed to explain the enigma of light's strange behavior simply and intuitively, offering a view that diverges from Einstein's theory of relativity. Despite this, we have remained consistent with the laws of physics and empirical results.

Our discovery that the speed of light is variable, rather than constant, deepens our understanding of light and time. This confirms the promising direction of the theory of time frames and provides a new perspective for research and further development of this theory.

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