Highlights

Uncovering Relativity's Mechanistic Counterpart: Discovering Time Dilation's Cause via Mill's Method

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- Mechanistic Counterpart to Relativity: Proposes a mechanistic model for time dilation and gravity, challenging the geometric perspective of general relativity.
- Specific Energy Model: Derives a specific energy model to explain kinetic and gravitational time dilation, showing gravity as a result of a specific internal energy gradient.
- Innovative Experimental Design: Describes a novel experiment using gravimeters to measure gravitational acceleration and infer the preferred frame.
- Simulation and Validation: Provides simulations to demonstrate the feasibility of detecting the preferred frame and discusses implications for future experiments.

Uncovering Relativity's Mechanistic Counterpart: Discovering Time Dilation's Cause via Mill's Method

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ABSTRACT

This paper introduces a mechanistic counterpart to Einstein's theory of relativity, derived using Mill's Method—the only valid method of induction rooted in the law of causality. Unlike geometric or mathematical models, which often lack causal explanations, this study provides a causal framework for understanding relativistic effects within a paradigm where the present is omnipresent, and only current entities exist.

The investigation begins by critically examining the foundational assumptions of relativity, including the isotropic nature of the speed of light. It then addresses limitations in the relativistic framework, particularly the reciprocity principle in special relativity, which hinders causal analysis. By re-evaluating time as a measure of change to things rather than as a dimension of the Universe, the study identifies a preferred frame for light speed, crucial for causal coherence.

The cause of kinetic time dilation is pinpointed as specific work done relative to this preferred frame, reducing the average effective speed of light relative to a moving object. This reduction slows the speed of causality, increasing the duration of changes to the object, resulting in time dilation. This framework unifies all forms of time dilation under a single cause.

From this causal understanding, a new relationship between specific energy and time dilation emerges. This model explains gravity as emerging from a gradient in specific internal energy, corresponding to time dilation gradients. The paper concludes with an experimental proposal to validate this new paradigm, suggesting a fundamental shift in our understanding of relativistic effects.

1. Introduction

In the history of scientific progress, many models have emerged that describe natural phenomena with remarkable precision. However, not all of these models provide a causal explanation for the mechanisms they describe. A distinction can be made between geometric or mathematical models, which predict outcomes without offering a causal narrative, and mechanistic models, which attempt to elucidate the underlying causes of observed phenomena. This paper explores this distinction within the context of Einstein's theory of relativity, proposing a mechanistic counterpart that challenges the conventional understanding of time, space, energy and gravity.

Historically, scientific advancements have often involved the transition from geometric models to mechanistic ones. For instance, Ptolemy's model of epicycles, while mathematically accurate in predicting the movements of celestial bodies, was eventually supplanted by Kepler's laws, which offered a causal explanation grounded in the influence of the sun on planetary motion. Similarly, Newton's law of gravitation provided a mechanistic account of gravitational forces, while later developments, such as the Newton-Cartan theory [ref], abstracted these forces into a purely geometric framework. Despite the predictive success of these geometric models, the absence of a causal mechanism has often been a point of contention (1)(2)(3).

Einstein's general relativity, a geometric model par excellence, describes the curvature of spacetime as the cause of gravitational effects. While mathematically elegant, this model leaves open questions about the underlying mechanisms governing relativistic phenomena. This paper seeks to address these gaps by proposing a causal framework that offers a mechanistic interpretation of time dilation and gravity, derived through Mill's Method of induction.

Mill's Method, grounded in the law of causality, provides a rigorous approach to identifying the causes of observed phenomena. Causality, rooted in the law of identity, asserts that a thing must act in accordance with its nature under

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the same conditions. However, the relativistic framework, particularly the reciprocity principle in special relativity, complicates the application of Mill's Method by making it difficult to determine specific causes of observed effects. This obstacle led to a critical reassessment of the assumptions underpinning relativity, culminating in a fundamental reevaluation of time and space.

This paper argues that time is not a dimension of the Universe independent of things within it, but rather time is a measure of the interval over which change occurs to things within the Universe, aligning with an absolute framework of time and space. By reinterpreting time in this way and considering a preferred frame for the speed of light, a new causal understanding of time dilation emerges. Specifically, kinetic time dilation is posited to result from specific work done relative to the preferred frame, leading to a reduction in the average effective speed of light relative to the moving object. This reduction slows the speed of causality, thereby increasing the duration of changes—an effect known as time dilation.

Building on this causal insight, this paper develops a new specific energy model, which integrates time dilation as a reduction in an object's specific internal energy. This model not only unifies different forms of time dilation under a common cause but also provides a mechanistic explanation for gravity as an emergent force arising from a gradient in specific internal energy of objects.

The implications of this new framework are profound, suggesting that the phenomena traditionally explained by relativity can be reinterpreted through a mechanistic lens. Furthermore, this paper outlines a simple experiment designed to test this new paradigm against the predictions of relativity, potentially paving the way for a significant shift in our understanding of the physical Universe.

2. Background

2.1. What is Mill's Method and Why it Works

Mill's Method works because it operates on an intimate understanding of the law of causality, which is a derivative of the law of identity. Both laws make statements about existence as such. The law of identity asserts that each thing is identical to itself, meaning an object or concept has a specific nature and set of characteristics that define what it is. In other words, something is what it is and cannot be something else at the same time and in the same respect. The law of causality asserts that each thing must act in accordance with its identity or nature. The nature of an action is caused and determined by the nature of the entities involved; a thing cannot act in contradiction to its nature. In this sense, the law of causality is the law of identity applied to action (4).

The validity of the law of identity rests on the fact that it is an axiomatic concept. Axiomatic concepts are the starting points of cognition, upon which all proofs depend, and all axiomatic concepts are validated by the fact that any attempt to disprove them requires their acceptance. This means any argument against the law of identity must possess an identity, thereby nullifying the argument. We observe directly that things are what they are. Even if we cannot determine what things are, we can at least know *that* they are (5).

Mill's Method exploits these laws by recognizing that, given the same essential conditions, a thing must act the same way every time. Any deviation from a past action suggests that at least one essential condition has changed. This studied action is often called the *effect*. The antecedent factors that comprise the essential conditions that determine the effect are termed the *cause*. To summarize, every effect has a cause, and no effect occurs without one, meaning no entity acts against its nature.

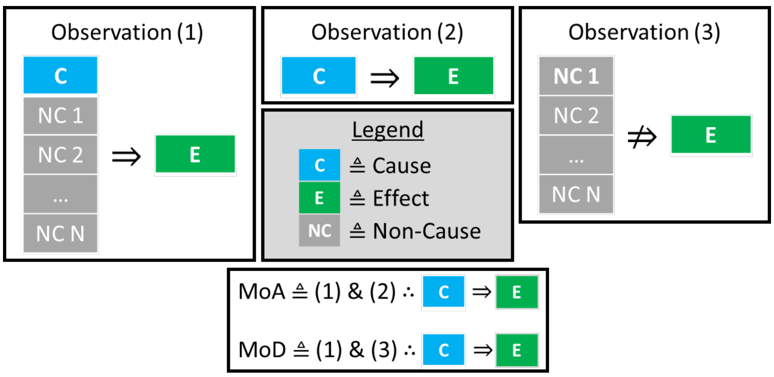

Figure 1: **Mill's method of agreement and method of difference.**

Mill's Method establishes a means of controlling conditions—known as the *controlled experiment*—to isolate cause-effect relationships. Mill's two basic methods used to discover these relationships are illustrated in Figure 1 and can be summarized as follows (6):

- **Method of Agreement (MoA)**: A controlled experiment in which plausible causes are removed, yet the effect remains. This proves that the cause is contained in the remaining set of plausible causes.
- **Method of Difference (MoD)**: A controlled experiment in which plausible causes are removed, and the effect disappears. This proves that the cause is contained in the removed set of plausible causes.

2.2. Peikoff's Refinement to Induction

Peikoff refines the inductive approach outlined by Mill. This refinement becomes obvious when we observe that a controlled experiment is not chosen at random, and interpreting the results does not originate from a blank slate of understanding. A solid conceptual framework is necessary to intelligently select useful controlled experiments and to interpret what is observed during those experiments (7)(8).

For example, without the concept of velocity, which includes both speed and direction, Newton would be left with the old generalization that a change in speed is caused by an acceleration, instead of the wider generalization that that a change in velocity is caused by an acceleration. Without the concept of vectors, Newton would have been lost when studying the circular motion of planets, since a constant speed would suggest zero acceleration. Newton would not have been able to discover that planets are accelerating towards the sun, and he would not have realized that a force acts upon them in accordance with $\vec{F} = m\vec{a}$, and that $\vec{a} = -\hat{r}GM/\vec{r}^2$. Integrating the concept of velocity into one's conceptual framework is necessary to understand what one is observing with circular motion.

Thus, a valid method of induction requires a valid theory of concepts, and Objectivism provides such a theory. Given a valid conceptual framework, the refined causal discovery method is to observe the causal action via Mill's method, identify the causal relationship at play, quantize the action in precise mathematical terms, and integrate the new generalization with the rest of one's conceptual framework (7)(9).

2.3. Contrast With Hypothetico-Deductive Method

Throughout history, philosophers have attempted to validate[2] induction by attempting to reduce it to deduction (7). The Hypothetico-Deductive Method is one such approach (10).

The challenge of induction is finding a valid method for generalizing from specific instances. This is crucial because deductions rely on premises, at least one of which must be a generalization. There is a relationship between induction and deduction: induction arrives at general principles from specific instances, while deduction applies general principles to specific instances (as shown in Figure 2).

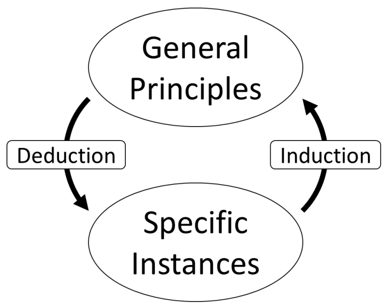

Figure 2: **Induction versus deduction.**

Logic—whether inductive or deductive—serves as the primary means of validating concepts and knowledge, implying that all knowledge depends on a valid method of induction. Without valid generalizations, deductions lack sound premises (7)(9)(11).

The Hypothetico-Deductive Method tries to short-circuit induction by replacing it with guessing. It involves making observations, hypothesizing a general principle, deducing unobserved but verifiable consequences, and testing them. If enough previously unobserved consequences are confirmed, the hypothesis is accepted as true (10). However, certainty is impossible with this method because it amounts to simple enumeration, a form of induction that was considered childish by Francis Bacon (12), and rightly so, as he puts it:

> For the induction which proceeds by simple enumeration is childish; its conclusions are precarious and exposed to peril from a contradictory instance; and it generally decides on too small a number of facts, and on those only which are at hand. (12)

The major flaw with the Hypothetico-Deductive Method is that a single counterexample can invalidate the generalization, and, in principle, generalizations can never be validated with this method. Many proponents of this method acknowledge its limitations, leading to the belief that knowledge can never be fully validated (10).

Perhaps unsurprisingly, the Hypothetico-Deductive method is based on itself. That is, the method rests on the following guessed generalization: the only way to achieve a generalization is to guess. Of course, by their own method,

[2] Validate means to demonstrate something is true.

they can never be certain of their self-induced skepticism because a single counterexample, such as Peikoff's theory of induction (7), would demonstrate that a valid method of discovering generalizations is possible.

This Hypothetico-Deductive method is particularly relevant to this paper because relativity was derived through this method. Relativity is based on postulates (generalized assumptions), and while relativity's verifiable predictions align with observations, its unverifiable predictions often conflict with fundamental principles like the law of identity and causality.

3. Relativity's Tenuous Foundation

We learn from history that geometric models can predict observations with great accuracy and still be false. The fact that a model is false does not mean it is useless, as accurate predictions can be valuable in deriving a correct causal model.

For example, before discovering the elliptical nature of planetary motion, Kepler sought the quantitative causal relationship between the sun and planets. Even though he knew his initial model was causally lacking and therefore false, he needed a more accurate model. He famously said (2):

> Who would have thought it possible? This hypothesis, so closely in agreement with the acronychal [opposition] observations, is nonetheless false. (2)

Many regard relativity as above reproach, refusing to consider that it too might be an interim step toward a causal model. However, a brief survey of its foundation reveals its tenuous state of affairs.

3.1. Light Postulate

The special theory of relativity (SR) rests on two postulates[3] (13):

SR1) Principle of Relativity: The laws of physics take the same form in every frame in uniform motion.

SR2) Light Model: The speed of light is constant in a vacuum and is independent of the relative motion of the source.

From these postulates, the entire body of special relativity is deduced.

A universal specificity theory (US) resting on different postulates can predict the same verifiable observations as relativity (13). Such a model resembles Lorentz Ether Theory, but reduces its foundation to these postulates:

US1) Principle of Specificity: The laws of physics take a specific form in a preferred frame.

US2) Light Model: The speed of light is constant only in a preferred frame in a vacuum and is independent of the relative motion of the source.

Both theories agree the laws of physics *appear* to take the same form and that the speed of light *appears* to be constant in every frame in uniform motion but disagree on why. Relativity claims they are the same, while specificity argues they only appear the same due to the miscalibration of instruments and experience, as time and space measurements depart from absolute values.

An intuitive way to understand specificity is to imagine that, among the infinitely many inertial frames with the "right" to claim they are stationary, only one frame is truly stationary. In this preferred frame, the speed of light is isotropic. In specificity, an observer in any inertial frame who assumes they are stationary will experience miscalibration of instrumentation, making it impossible to prove otherwise.

Though both theories make the same verifiable predictions, the difference lies in which postulates align with reality. Despite evidence levied in favor of relativity's light postulate, alternative postulates should not be dismissed lightly.

One piece of evidence often cited in favor of relativity is that the speed of light has been measured as constant, regardless of the Earth's motion around the sun. The Earth's velocity changes by up to 60×10^3 $[m/s]$ throughout its orbit, so if the speed of light were not constant, this difference should have been detected (14). However, when investigating how the speed of light is measured, it becomes clear that either (1) the average two-way speed of light was measured or (2) the one-way speed used a clock synchronization scheme that assumes **SR2** is true (15).

[3]Postulates are used in the Hypothetico-Deductive Method to reason the following: if these postulates are true, then the rest follows.

Of course a measured average two-way speed might result from averaging the same speed in both direction, or from averaging a faster speed in one direction with a slower speed in the other. Less obviously, a one-way measure using a clock synchronization scheme that holds **US2** to be true would find the speed of light to be anisotropic. Therefore, no current measure of the speed of light proves one postulate over the other.

Another piece of evidence cited in favor of relativity is that Maxwell's equations suggest the speed of light equals the square root of the inverse product of the permeability (ε_0) and permittivity (μ_0) of free space, as shown in Equation (1).

$$c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}} \tag{1}$$

The argument is that since Maxwell did not specify which frame his equations apply to, they must apply to all inertial frames. However, this falls short because Maxwell's original work is built on the assumption that a preferred frame exists (16). Therefore, his equations work equally well in a preferred frame.

Since both theories (relativity and specificity) make the same verifiable predictions, any confirmed prediction of relativity is also a confirmed prediction of specificity (13).

3.2. Equivalence Principle

General relativity (GR) builds upon SR by extending **SR1** into the equivalence principle (13):

GR1) Equivalence Principle: The laws of physics in free-falling frames are the same as in uniformly moving frames. Additionally, a frame undergoing uniform acceleration can be treated as stationary in a uniform gravitational field.

A universal specificity theory could also predict the same observations as GR, but it would reject the equivalence principle. Specificity attributes the appearance of equivalence to measurement errors rather than true physical equivalence.

The equivalence principle may seem intuitive—experiments in a free-falling lab resemble those in a lab moving uniformly through space—but it disregards a distinction between the two. "Equivalent" means identical in all essential respects, implying that their differences are inessential. However, one key difference is the change in relative motion between two frames—in free fall, it can changes, while it remains constant when floating in empty space. This distinction is why Newton was certain that gravity was a force: the relative motions between planets, moons, satellites, and free falling objects changed, and his laws of motion showed that a change in motion is caused by a force, $F = ma$.

Why is this distinction inessential, as the equivalence principle tacitly assumes? In my experience, no satisfactory answer has ever been given, and as we shall see later in Section 8 no answer can be given. We will see that the equivalence principle should be renamed the "similarity principle," as there are many similarities between the situations taken as equivalent, and a lot can be learned from this similarity, but they are in fact found to not be equivalent when examined closely.

3.3. Relativity versus More fundamental Principles

Relativity's assumptions face scrutiny not only due to plausible contrary assumptions but also because they hinder the discovery of causes for relativistic phenomena. Questions about what causes differences in time and length intervals between frames proves impossible to answer. More generally, integrating the most fundamental principles of human knowledge, such as the law of identity and the law of causality, with relativity's framework proves impossible due to the absurdities associated with unverifiable predictions.

Special relativity has a reciprocity principle, stemming from the fact that any frame in uniform motion has the "right" to claim it is at rest (13). It is simply a matter of translating measurements from one frame to another using the Lorentz Transformation, shown in Equation (2) as a specific case when relative velocity, v, lies solely on the x-axis (13).

$$\begin{aligned} t' &= \gamma_K (t - \frac{v}{c^2} x) \\ x' &= \gamma_K (x - vt) \\ y' &= y \end{aligned}$$

$$
\begin{aligned}
z' &= z
\end{aligned} \tag{2}
$$

Where :

$$
\gamma_K = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}
$$

$x, y, z, t \in \mathbb{R}$ are spatial and time measurements from frame taken to be at rest.
$x', y', z', t' \in \mathbb{R}$ are spatial and time measurements from frame taken to be in motion relative to rest frame.
v is the relative velocity between both frames.
c is the speed of light.

From this system of equations, the time dilation differential, dt'/dt, which is a ratio of infinitesimal time intervals between two frames, can be determined directly by evaluating an interval of time:

$$
\begin{aligned}
&\text{Let : } dt' = t'_2 - t'_1 \\
&\text{Let : } dt = t_2 - t_1 \\
&\quad t'_1 = \gamma_K\left(t_1 - \frac{v}{c^2}x_1\right) \\
&\quad t'_2 = \gamma_K\left(t_2 - \frac{v}{c^2}x_2\right) \\
&\quad dt' = \gamma_K\left(dt - \frac{v}{c^2}dx\right) \\
&\qquad = \gamma_K\left(dt - \frac{v}{c^2}v\,dt\right) \\
&\qquad = dt\gamma_K\gamma_K^{-2} \\
&\therefore \frac{dt'}{dt} = \gamma_K^{-1} \in \mathbb{R} \leq 1 \blacksquare
\end{aligned} \tag{3}
$$

In a similar manner, the length contraction differential, dx'/dx, which is a ratio of infinitesimal length intervals between two frames, can be determined directly by evaluating an interval of length at an instant of time:

$$
\begin{aligned}
&\text{Let : } dx' = x'_2 - x'_1 \text{ @ } t' \\
&\text{Let : } dx = x_2 - x_1 \text{ @ } t \\
&\quad x'_1 = \gamma_K(x_1 - vt) \\
&\quad x'_2 = \gamma_K(x_2 - vt) \\
&\quad dx' = \gamma_K(x_2 - vt) - \gamma_K(x_1 - vt) \\
&\quad dx' = \gamma_K(dx) \\
&\therefore \frac{dx'}{dx} = \gamma_K \in \mathbb{R} \geq 1 \blacksquare
\end{aligned} \tag{4}
$$

From studying Equation (3), we can see the only adjustable parameter is the relative velocity, v, between the two frames. Applying Mill's MoD and MoA given this relationship yields logical havoc. For example, since either frame can "rightly" conclude it is at rest under the relativity framework, each evaluates the time dilation differential to be less than one. This means each evaluates the other frame as taking longer to complete experiments than their own. For example, if one frame measures two hours for a coffee to reach room temperature, then the predicted time it took for the other frame is longer than two hours. Logically speaking, it makes no sense for both frames to simultaneously predict that the other frame took longer for the same changes to complete.

This realization was likely the motivation behind the genesis of the twins paradox, in which one twin travels quickly to a distant star and back, aging less than the twin who stayed on Earth. Relativity addresses this by selecting one frame as stationary, but this arbitrary resolution fails to address the underlying contradiction.

A resolution to the twins paradox does not eliminate the absurdity of unverifiable prediction, such as both frames predicting that the other experiences time dilation. While relativity can make predictions at the end of the round trip accurately, it cannot be trusted to describe the reality of each leg of the round trip.

Depending on the reference frame used, the results can vary significantly. For instance, in one frame taken as stationary, the traveling twin might age more on the way to the star and less on the return trip, balancing the aging from the first leg. In contrast, another frame might predict the opposite sequence. Yet another frame could predict that the traveling twin ages less on both legs. Infinitely many frames exist predicting results in between. They all agree on the return trip's outcome but differ on what happens during the journey (13).

Relativity, by definition, is currently secure from evidence contradicting its verifiable predictions, as the only evidence produced is the conclusion at the end of the round trip. However, the unverifiable contradictory predictions, which are accepted within relativity's framework, remain absurd. This makes it impossible to integrate relativity with the law of identity and, therefore, impossible to evaluate the cause of time dilation using this framework.

Given that relativity accepts this chaos of contradictory unverifiable predictions as correct, how can one establish a controlled experiment to evaluate why a duration of change lengthens with relative velocity? If one uses the frame in motion, such as the traveling twin's frame during one leg, as at rest, then according to the MoD, a change in local motion causes all objects in other frames to experience length contraction[4] and time dilation, even for objects infinitely far away. This conclusion is clearly wrong as it violates local causality.

In addition to the logical havoc created when evaluating the causes of relativistic phenomena under the framework of relativity, the relativity of simultaneity also adds to the havoc and violates more fundamental principles. For example, we know that things are what they are. Some things have the potential to become something else; it is part of their nature. For instance, seeds have the potential to become flowers, and flowers have the potential to turn to ash. Causality dictates that a thing changes from what it is to its potential, but it is never simultaneously changed and not changed. A thing is never a seed, a flower, and ash simultaneously. Under the framework of relativity of simultaneity, a thing can be a seed, flower, and ash simultaneously.

If you are familiar with the Andromeda paradox (17), we can concretely evaluate a slight modification to it using the context of flowers. Suppose three scientists, A, B, and C, set up an experiment such that they will be seated in a conference room at the moment a seed grows into a mature flower on a ship far away, about 82.137×10^6 $[ly]$, and traveling at $v = 0$ relative to the conference room.

Once the conference meeting ends, at $t = 0$, Scientist A remains seated in the conference room, Scientist B begins walking away at 1 $[m/s]$ toward the flower, and Scientist C begins walking away at 1 $[m/s]$ away from the flower. Let's see what each scientist would predict for the state of the living organism so far away.

Assume it takes 100 days for the seed to turn into a flower after being planted, and another 100 days for the flower to turn to dust, as illustrated in Figure 3, where the proper time for the flower is t'.

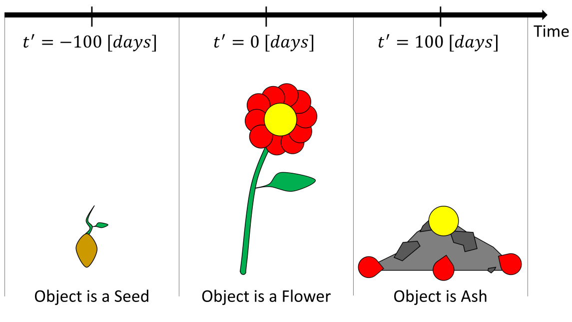

Figure 3: **Flower life cycle.**

We can use Equation (2) to determine t' for each of the scientists. Since $\gamma_K \approx 1$ when $v \leq |\pm 1\ [m/s]|$, t' simplifies to:

$$
\begin{aligned}
t' &= \gamma_K\left(t - \frac{v}{c^2}x\right) \\
t' &= -\frac{v}{c^2}x \\
\text{When}: x &\approx 82.137 \times 10^6\ [ly] \\
t' &= -\frac{v}{c^2}(82.136 \times 10^6\ [ly]) \\
&= -v(100 \times 24 \times 60 \times 60\ [m^{-1} \cdot s^2) \\
&= -v(100\ [m^{-1} \cdot s \cdot days]) \qquad (5)
\end{aligned}
$$

For Scientist A, where $v = 0\ [m/s]$, $t' = 0\ [days]$, meaning the scientist seated in the conference room predicts the

[4]The same argument applies to length contraction. Both frames predict that the other experiences contraction, leading to logical inconsistencies.

object is still a flower. For Scientist B, where $v = -1$ $[m/s]$, $t' = 100$ $[days]$, he predicts the object has turned to ash. For Scientist C, where $v = 1$ $[m/s]$, $t' = -100$ $[days]$, he predicts the object has returned to a seed.

At $t = 0$, we get three contradictory predictions about the flower from each scientist—the object is simultaneously predicted to be a seed, a flower, and ash. According to relativity, all are correct due to the relativity of simultaneity, even though moments before $t = 0$, when all scientists were seated in the conference room, they all agreed the object was a flower. Under relativity, objects do not adhere to the law of identity, indicating that relativity does not integrate with this fundamental law.

Even more absurd is what happens when, moments after $t = 0$, Scientist B turns around and joins Scientist C. According to relativity, this simple act transforms a past event for Scientist B into a future event—the object was just a flower in the past at $t = 0$, and now the object will be a flower at $t > 0$.

Equally absurd is the perspective of Scientist D, who is sitting with the flower on the spaceship far away. The inverse Lorentz Transformation, used by Scientist D, is derived by substituting the primed values for unprimed values and vice versa in Equation (2) and solving for unprimed values, as shown in Equation (6).

$$
\begin{aligned}
t &= \gamma_K(t' - \frac{v}{c^2}x') \\
x &= \gamma_K(x' - vt') \\
y &= y' \\
z &= z' \\
&\therefore \\
t' &= \gamma_K(t + \frac{v}{c^2}x') \\
x' &= \gamma_K(x + vt') \\
y' &= y \\
z' &= z
\end{aligned} \tag{6}
$$

We can use Equation (6) to determine t' for each scientist on Earth as predicted by Scientist D with the flower. Again, $\gamma_K \approx 1$ when $v \leq |\pm 1\ [m/s]|$, and by letting $t = 0$, t' simplifies to:

$$
\begin{aligned}
t' &= \gamma_K(t + \frac{v}{c^2}x) \\
t' &= \frac{v}{c^2}x \\
\text{When}: \ x &\approx -82.137 \times 10^6\ [ly] \\
t' &= -\frac{v}{c^2}(82.136 \times 10^6\ [ly]) \\
&= -v(100 \times 24 \times 60 \times 60\ [m^{-1} \cdot s^2) \\
&= -v(100\ [m^{-1} \cdot s \cdot days])
\end{aligned} \tag{7}
$$

Moments before $t = 0$, when Scientists A, B, and C were all sitting in the conference room, Scientist D predicts all three (A, B, and C) were sitting in the conference room simultaneously. At $t = 0$, everything changes drastically. For Scientist A, where $v = 0$ $[m/s]$, $t' = 0$ $[days]$, meaning Scientist D predicts that Scientist A is still seated in the conference room. For Scientist B, where $v = 1$ $[m/s]$, $t' = -100$ $[days]$, meaning Scientist D predicts that Scientist B has transported into the future by 100 $[days]$; thus, the negative result for t' corresponds to Scientist D being in Scientist B's past. For Scientist C, where $v = -1$ $[m/s]$, $t' = 100$ $[days]$, meaning Scientist D predicts that Scientist C has transported into the past by 100 $[days]$; thus, the positive result for t' corresponds to Scientist D being in Scientist C's future. Moments after $t = 0$, when Scientist B turns around to catch up with Scientist C, Scientist B travels from Scientist D's future to his past. Relativity predicts a confusing series of events out of chronological order, which contradictions the fact that Scientists A, B, and C all agree they existed simultaneously together in that conference room in those moments.

Why do all these absurdities arise from relativity? They all stem from its assumed speed of light model, **SR2**. These absurdities ultimately reflect a conflict between the law of identity and **SR2**, i.e., between the most fundamental principle and the foundations of relativity. When faced with a contradiction between a verified axiom and an assumed generalization, the decision should be straightforward: uphold the axiom and reject the assumed generalization.

3.4. Integrating Relativistic Effects with Identity

If the preferred frame model, **US2**, were used for predictions instead, all the absurd predictions of relativity would be explained as miscalculations due to using the wrong model. Using the preferred frame would involve the preferred frame velocity, v_p, or velocity relative to the preferred frame, rather than the relative velocity between objects. The Lorentz Transformation for a preferred frame would then be:

$$
\begin{aligned}
t' &= \gamma_K\left(t - \frac{v_p}{c^2}x\right) \\
x' &= \gamma_K(x - v_p t) \\
y' &= y \\
z' &= z
\end{aligned}
\tag{8}
$$

Where :

$$\gamma_K = \frac{1}{\sqrt{1 - \frac{v_p^2}{c^2}}}$$

$x, y, z, t \in \mathbb{R}$ are spatial and time measurements from preferred frame.

$x', y', z', t' \in \mathbb{R}$ are spatial and time measurements from frame in motion relative to the preferred frame.

v_p the velocity relative to preferred frame.

c is the speed of light.

We can use Equation (8) to determine t' for the flower as predicted by the scientists on Earth. If the flower were stationary relative to the preferred frame, then $v_p = 0$, and at $t = 0$, $t' = 0$ for all scientists. If the flower were moving relative to the preferred frame, then $|v_p| > 0$ for all scientists, and the predicted t' would deviate from t, but it would be the same for all scientists on Earth, and its deviation from t is explained as a miscalibration. The same applies from the perspective of the flower (Scientist D). t' might change because of a miscalibration, but t remains invariant.

No absurdities arise with the preferred frame because it integrates with the law of identity and, therefore, with causality (as identity applied to action)—even for unverifiable cases. Let us proceed to investigate the cause of time dilation.

4. Investigation 1: Conceptual Housekeeping

With the plausibility of relativity in question, we are free to begin anew from a different foundation—a foundation based on a preferred frame. We must be cautious, however, to avoid the fallacy of concept stealing (8). This occurs when a concept, whose base has been invalidated or is otherwise incompatible with the new foundation, is used. Any concept derived from relativity must be reevaluated to ensure a valid conceptual framework, which is critical for any scientific investigations seeking to make causal discoveries, as shown by Peikoff's refinement of Mill's method (7).

The concepts that require some amount of conceptual housekeeping are: *time*, *measurement*, *time dilation*, and *spacetime*.

4.1. Time

Understanding the concept of time correctly is as crucial for scientific progress as understanding Earth's place in the solar system and its shape was in the past. It will be shown that our current conception of time, like the past belief that Earth was the center of celestial motion or flat, is holding us back from further discovery.

Today, time is often thought to be an illusion—something wrongly perceived by the senses. As Einstein put it:

> The motion of clocks is also influenced by gravitational fields, and in such a way that a physical definition of time which is made directly with the aid of clocks has by no means the same degree of plausibility as in the special theory of relativity (13).

It is said that Newtonian mechanics assumes time to be absolute whereas relativity assumes that time is relative, e.g., relativity of simultaneity (3)(13). Either of these assumes a certain conception of time that cannot be reduced to verifiable observations.

When discussing time, it is important to ask what exactly is meant by time. Seeking a more informative definition is important. For instance, a quick online search defines time as, "the indefinite continued progress of existence and events in the past, present, and future regarded as a whole." This definition is circular since past, present, and future are concepts that depend on a conception of time. Thus, the definition effectively states: time is the continued progress of existence and events in time. This is not helpful for gaining insight into what time is.

If Wikipedia could be considered as representing the common understanding, then the common understanding of time is what a clock reads (18), which reflects Einstein's implied definition in the earlier quote (13). But this, too, is circular. Clocks are tools that measure time, so defining time as what a clock measures translates to: time is what is measured when measuring time—another unhelpful definition.

The best, and my preferred, definition of time is: *time* is the interval over which change occurs (19). This definition provides a clearer and more actionable understanding of time. To validate this conception, one must ask: what facts about reality give rise to the need for this concept?[5]

The facts that give rise to this concept are interesting to study and are twofold. Firstly, changes (to existents) from one state to another are never instantaneous. Despite what quantum physicists might say (3), it is certain, because of the law of non-contradiction, that both states (the before and after) cannot exist at the same instant in the same respect. Consequently, this transition from one state to another lasts for some duration (a series of instances).

Secondly, given the same essential conditions, we know for certain that the same changes last for the same duration because of the law of causality. In fact, changes in duration (the effect) imply changes in essential conditions (the cause). For example, the time it takes your coffee to reach room temperature might change depending on the temperature of the room, the initial temperature of your coffee, and the cup it is in; however, if all essential conditions remain the same as before, then the coffee will reach room temperature over the same time interval as before.

These two facts—that change is not instantaneous and its duration is repeatable under the same circumstances—give rise to the need for the concept of time to help quantify causal relationships. To underscore the need for this concept, without it, certain causal relationships would remain unknowable and, therefore, uncontrollable. For example, this conception of time is what allows us to cook our meals with reasonable certainty that they will complete after a predictable duration to our liking. In addition, it gives us a means to figure out why it does not, if it does not—e.g., testing might tell you if a change in altitude caused your timing to be off. As another example, it is what allows us to guide our present actions so that at some instant in time (ahead of now), people can meet up at a preplanned location and time. It is what allows us in countless other examples to control our lives for the better. To sum up, the primary need for this conception of time is to gain better command over reality by improving our obedience to causality. Thus, my preferred definition of time as "the interval over which change occurs to things" aptly captures the essence of this concept.

Implicit in this conception of time is that there is no existing past or future. Only the eternal present is omnipresent. Things that exist exist right now, and only right now. The past is simply the conceptualization that things in existence now had a previous configuration earlier. The future is simply the conceptualization that things in existence now will have a new configuration later. Indeed, if the configuration of things stopped changing, then time would cease as there would no longer be any change and, therefore, there would no longer be an interval of change.

[5] If one's conception of time is not based on any facts, then the concept itself becomes arbitrary, meaning it is outside reality, and therefore, it is useless in helping us understand reality (8).

Additionally, this conception of time implies the practical impossibility of time travel. To time travel, assuming the state of every existent is mechanically reversible[6], one would have to find a way to be omnipresent, omnipotent, and omniscient. In such a case, you could instantaneously apply the right mechanism everywhere to reverse all things, even the mechanisms used to reverse everything—impossible. Not to mention, once you start the process, how do you stop it?

4.2. Measurement

All measurements are relationships between the thing being measured and the unit serving as the standard of measurement. Like all measurements, time also needs a standard. The best standards for time, depending on the requirements of precision, are changes that complete at regular intervals, which means the essential conditions are easily made to be invariant resulting in consistent measures of duration. For example, the arc length traversed by a sundial's shadow, sand falling to the bottom of an hourglass, pendulum swings in a grandfather clock, or light traveling some known distance can be, and have been, used to measure a standard unit of time. These standards can then be compared to other changes in order to measure their duration. For example, when it takes two turns of an hourglass for your coffee to reach room temperature, we say it took two hours. Tomorrow it could take three hours, and because of this standard, we know it was longer than the day before and how much longer.

This next point is **critical** to understanding the basis of departure between universal specificity and the theory of relativity discussed in these investigations. Each method of measuring time can be placed in a different situation that changes essential conditions, which changes the duration that these instruments are measuring. For example, the sundial could be taken to a different latitude, or the hourglass and grandfather clock could be taken to a different altitude, and each would then measure a different duration compared to its original measurement. Likewise, with this conception of time, the light clock that undergoes a change in specific energy measures a different duration than before (see Section 6). It does not mean time sped up or slowed down; it only means the base units used for measurement have changed. As an example of changing units, the hourglass at a different altitude is measuring something other than an hour—i.e., the new "hour" being measured does not equal the original hour—i.e., the standard unit of measurement for the measuring device changed.

4.3. Time Dilation

The common definition given to time dilation is the lengthening of the time interval between two events (20). However, given these two refined conceptions of time and measurement, we can now improve upon this understanding of time dilation by changing the focus from a span between two events to something that happens to objects. Time dilation is an effect, probably best known from the twins paradox (13), whereby one twin makes a round trip to a distant star and back really fast. The traveling twin ages less than the earth twin.

To pose the question of what exactly is happening here concretely, allow me to modify this thought experiment slightly and make it about a flower. Suppose the twins each plant a seed, which are also identical twins. Each twin follows the same exact strict regimen of care (e.g., water, nutrients, light exposure, etc.). The expectation, with slight variations, is that given this regimen, the seed will grow into a flower after 100 days of being planted, and 100 days after that, the flower will turn to ash, as shown in Figure 4.

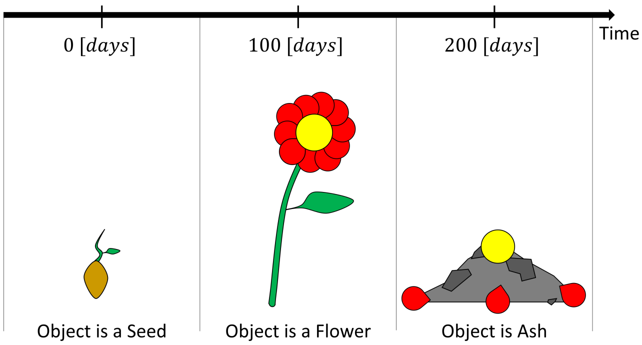

Figure 4: **Flower 200 day life cycle.**

After each twin plants their seed, the traveling twin with his planted seed starts his round trip. Upon returning, the twins find that the earth twin's flower has turned to ashes while the traveling twin's flower is still a young flower. When comparing identical clocks, the earth twin recorded 200 days exactly, and the traveling twin recorded 100 days with an identical clock. So, did 100 days pass or 200?

Given our conception of time and measurement, the solution is simple. The interval over which change occurred to the object remained the same for the earth twin, via the method of agreement, and the interval over which change

[6]What do you do with something as simple as a diode?

occurred to the object changed for the traveling twin, via the method of difference. The interval over which change occurred lengthened for the entire system traveling with the twin, where it simply took longer for the traveling seed to turn into a flower as evidenced at the trip's return.

The question of how many days passed, 100 or 200, is a bit misleading. The measuring instrument of time for the traveling twin changed such that the standard unit of time being measured was not a day. The standard unit of "day" being measured by the traveling twin's clock became something other than a day (on average, it was more than a day).

4.4. Spacetime

This refined conception of time and time dilation challenges the common notion that time is a property of the Universe, or as a property tied to space (as in spacetime), apart from the duration of any changes taking place (19). At no point do clocks measuring a different duration under different conditions suggest that time is a property of the Universe or tied to space; it only suggests that changes in conditions caused a change in what unit is being measured. In other words, something about the difference in conditions caused the duration of a state change to speed up or slow down, not time itself—there is no time itself. Time, being only a measure of change (to things), has no meaning by itself. To generalize that time is everywhere, because things could exist and undergo change anywhere, suffers from the fallacy of hasty generalization.

Applying Mill's method to a simple thought experiment on a relativity basis rules out space as being tied to how duration is measured. In this thought experiment, suppose two origins of two inertial frames occupy the same point in space at the same time.

Since the velocity of these reference frames differs from each other, special relativity tells us they measure different intervals over which the same physical change(s) occur. For example, one clock in one frame could measure two hours for your coffee to reach room temperature, and for that same cup of coffee an identical clock in the other frame could measure three hours instead. This means two different measures of time by identical clocks occur at the same instant in time and point in space.

What limits us to consider just two overlapping reference frames? Why not all possible reference frames at the same instant in time and point in space? What limits us to consider just a single point in space? Why not consider all possible frames overlapping at the same instant in time and over all possible points in space? What limits us to consider just one instance in time? Why not consider all possible frames overlapping in any given instant in time and all possible points in space?

Invoking the method of difference, whereby different effects occur—i.e., different rates of change of time measured by identical clocks—during the presence of the same antecedent factors—i.e., at the same (but any) instant in time and point in space—proves that instances in time and points in space have no effect on how time is measured. In other words, *how* time is measured is independent of *where* (and *when*) time is measured. The key takeaway is this: time is just a property of things in the Universe–i.e., the interval over which change occurs to *things*—not a property of the Universe nor an aspect of spacetime.

4.5. Blazing a New Trail

Assuming time is a property of the Universe or an aspect of spacetime prevents us from addressing important questions, which hinders scientific progress. Some of these questions include: what causes time dilation? What, then, causes gravity if not the bending of spacetime? Which frame is preferred? Addressing these questions, given this revised conceptual framework, is the focus of the remaining investigations into universal specificity contained in this paper.

5. Investigation 2: Why Does c Appear to be Isotropic in a Preferred Frame?

All observations are beyond reproach, but the interpretations of those observations are not—they may be riddled with conceptual errors. Universal specificity makes all the same verifiable predictions (potential observations) as relativity. However, specificity rejects the interpretations and causes of those predictions made by relativity. This would be akin to accepting Ptolemy's planetary model as a model that makes accurate predictions of the relative motion of planets, but not accepting the conclusion that planets actually orbit around nothing (i.e., epicycles) (21).

As an example of such disagreement, specificity makes use of the law of identity and asserts that distant events occur at specific instances in time and space. Specificity holds that the sequence of distant events only appears relative because of a model error in relativity involving an incorrect premise that light is constant in all directions for all inertial frames—it's only constant in the preferred frame. This implies that events at a distance have a certain sequence in which they occur and their simultaneity is not relative but only appears relative when using miscalibrated instruments. The one frame that predicts the true sequence, by assuming that light is constant in all directions for this frame, is the preferred frame we seek.

All of this implies the following:

- The speed of light is constant only in the preferred frame, while light's relative speed might be more or less than that in all other frames in certain directions (22).
- The speed of light appears to remain constant in any other frame due to the miscalibration of measuring instruments caused by time dilation and length contraction.

This section investigates how this could be the case.

5.1. Rotating Preferred Frame

In order to see these implications, consider any object traveling at any speed less than c with respect to the preferred frame, in any arbitrary direction. The preferred frame x-axis could easily be rotated such that the velocity of the object aligns with it, as shown in Figure 5 for two dimensions.

The equation for this rotation is the traditional rotation of axis, and its formulation is presented in matrix form in Equation (9).

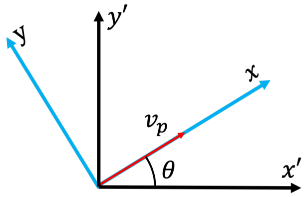

Figure 5: **Aligning velocity with preferred frame.**

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x' \\ y' \end{bmatrix} \tag{9}$$

Where :

$x', y' \in \mathbb{R}$ are preferred frame coordinates misaligned with velocity.

$x, y \in \mathbb{R}$ are preferred frame coordinates aligned with velocity.

5.2. The Null Result of the Michelson–Morley Experiment

Now consider the Michelson–Morley experiment (14), whose apparatus is illustrated in Figure (6). In this experiment light would arrive from a direction, and split in two orthogonal directions relative to the apparatus's reference frame (ARF), reflect off mirrors, and return to be combined again such that any interference in the combined rays (caused by differing arrival times) can be detected. The length of both paths is made to be identical measured in the ARF without calibration, which produces identical lengths when the ARF is stationary relative to the preferred frame.

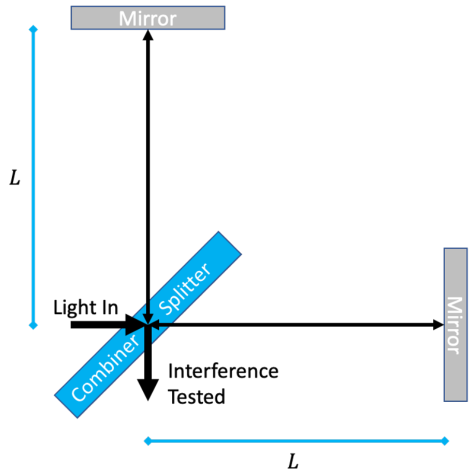

Figure 6: **Michelson–Morley experiment schematic.**

If light traveled at a constant c only in the preferred frame, it was hypothesized that this instrument would detect interference patterns if it were traveling at some positive velocity in the preferred frame. To ensure some velocity in the preferred frame, this instrument was tested at various points in Earth's orbit. It failed to detect interference patterns regardless of which part of Earth's orbit this experiment was conducted and regardless of which direction measurements were taken. Many consider this proof that the speed of light, c, is constant in all directions for all reference frames to the point where it became orthodox. The existence of a preferred frame implies the speed of light can only be constant in the preferred frame, so many take this to mean a preferred frame does not exist.

If a preferred frame exists, then we have to make sense of this experiment, and the first thing to consider is what the average (to the mirror and back) speed of light was expected to be.

5.3. Quantifying the Average speed of Light

Specificity quantifies the average speed of light in the ARF consistent with classical mechanics, i.e., Galilean relativity. For example, consider two cases. In the trivial case, the ARF is not moving relative to the preferred frame, $v_p = 0$, as shown in Figure (7a), and in the more interesting case, the ARF is moving, $v_p > 0$, as shown in Figure (7b). The dashed lines represent the trajectory each light beam takes to the mirror and back.

In the trivial case, the average speed of light in the ARF is straightforward, since the ARF is the preferred frame, which means the speed of light is by definition c in all directions; therefore, the average is c.

In the more interesting case, deriving the average speed of light in the ARF is more complex. While the apparatus is moving relative to the preferred frame, observers in the preferred frame see the light reflecting off the y-axis mirror following a "sawtooth" path, as shown in Figure 7; however, this is not what observers traveling with the ARF see. To them, only the y-component of the "sawtooth" is observed; therefore, the light appears to be going straight up and down along the ARF's y-axis. The average speed of light along this axis, c_y, is derived using trigonometric laws illustrated in Figure 8, and it turns out to be:

$$c_y = \sqrt{c^2 - v_p^2} \tag{10}$$

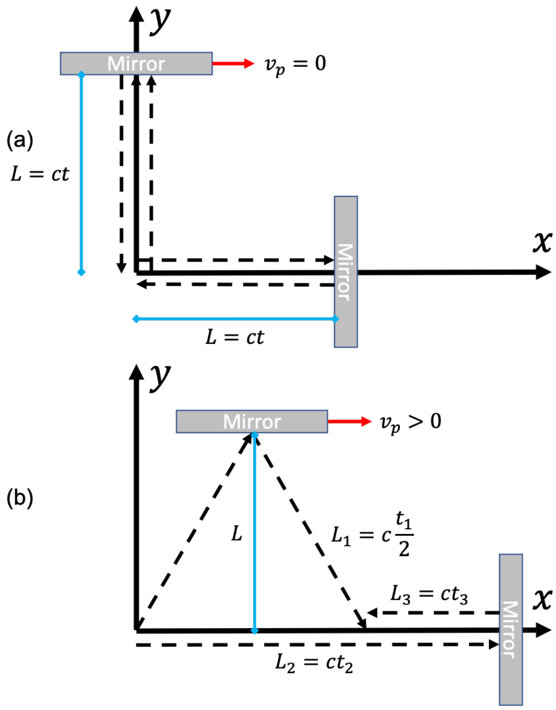

Figure 7: **Apparatus (a) Stationary (b) Moving**

The average speed of light in the x-axis, as seen in the ARF, is even more complex to derive, as shown in Equation (11).

$$\begin{aligned}
L_2 = ct_2 = L + v_p t_2 &\implies t_2 = \frac{L}{c - v_p} \\
L_3 = ct_3 = L - v_p t_3 &\implies t_3 = \frac{L}{c + v_p} \\
\therefore c_x = \bar{v} = \frac{2L}{t_2 + t_3} &= \frac{2L}{\frac{L}{c-v_p} + \frac{L}{c+v_p}} = \frac{2}{\frac{1}{c-v_p} + \frac{1}{c+v_p}} \\
&= \frac{2(c+v_p)(c-v_p)}{(c+v_p)+(c-v_p)} = \frac{2(c^2 - v_p^2)}{2c} \\
&= c - \frac{v_p^2}{c} = c\left(1 - \frac{v_p^2}{c^2}\right) \\
\text{Let } : \gamma_K &= \frac{1}{\sqrt{1 - \frac{v_p^2}{c^2}}} \\
\therefore c_x &= \gamma_K^{-2} c \quad \blacksquare
\end{aligned} \tag{11}$$

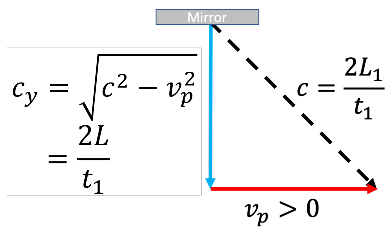

Figure 8: **Trigonometric derivation of c_y.**

Comparing c_x to c_y yields Equation (12).

$$\begin{aligned} c_x &= \gamma_K^{-2} c \\ c_y &= \sqrt{c^2 - v_p^2} = c\sqrt{1 - \frac{v_p^2}{c^2}} = \gamma_K^{-1} c \\ \therefore c_x &= \gamma_K^{-1} c_y \blacksquare \end{aligned} \tag{12}$$

The average speed of light in the ARF is not equal for both the x-axis and the y-axis when the apparatus is moving in the preferred frame. Within the ARF, light traveling along the x-axis is slower than light traveling along the y-axis (on average) by a factor of γ_K^{-1}.

5.4. The Average Effective Speed of Light

Given the existence of a preferred frame, the only way to reconcile the Michelson–Morley experiment is for the light to arrive at the combiner at the same time. The distance along the x-axis must contract by a factor of γ_K^{-1}, as shown in Equation (13), for this to occur.

$$\begin{aligned} t_1 &= t_2 + t_3 \\ \frac{2L}{c_y} &= \frac{L_x}{c - v_p} + \frac{L_x}{c + v_p} \\ \frac{2L}{\gamma_K^{-1} c} &= \frac{L_x(c + v_p) + L_x(c - v_p)}{c^2 - v_p^2} \\ \frac{\gamma_K 2L}{c} &= \frac{2L_x c}{c^2 - v_p^2} = \frac{2L_x}{c} \frac{1}{1 - \frac{v_p^2}{c^2}} = \frac{\gamma_K^2 2L_x}{c} \\ \therefore L_x &= \gamma_K^{-1} L \blacksquare \end{aligned} \tag{13}$$

Indeed, this is the exact value given to length contraction commonly mentioned in relativity and originally derived by Lorentz in his Lorentz Ether Theory (23)(24). This length contraction makes the average *effective* speed of light[7], c_0, in any reference frame the same in all directions, quantified in Equation (14).

$$c_0 = \gamma_K^{-1} c \tag{14}$$

5.5. Apparent Average Speed of Light is c

We must reconcile the fact that $c_0 < c$ within ARFs in uniform motion relative to the preferred frame, yet the measured speed is the same, $c_0' = c$, within those frames. This is due to the miscalibration of all temporal instruments. It truly does take longer for light to travel “there and back", but the duration for all changes lengthens in the ARF, meaning the recorded times for the truly longer period appear shorter by the same factor. The net effect is that the duration appears the same when measured in the ARF by miscalibrated clocks, even though it is longer. This miscalibration of time is called time dilation, and it affects not only clocks but also the interval over which all changes occur to things stationary relative to the ARF.

The miscalibrated time and length measurements are given by the Lorentz Transformation, except instead of using relative velocity, v, the velocity relative to the preferred frame, v_p, is used, as shown in Equation (8).

From this system of equations, the time dilation differential, dt/dt, which is a ratio of infinitesimal time intervals between the moving frame and the preferred frame, can be determined by evaluating an interval of time:

$$\text{Let } : dt' = t_2' - t_1'$$

[7] The term *effective* denotes the ignoring or abstracting away of length contraction. In other words, the *effective* distance covered between two points in a moving frame is the same distance covered if those two points were stationary relative to the preferred frame.

$$\begin{aligned}
\text{Let } &: dt = t_2 - t_1\\
t'_1 &= \gamma_K(t_1 - \frac{v_p}{c^2}x_1)\\
t'_2 &= \gamma_K(t_2 - \frac{v_p}{c^2}x_2)\\
dt' &= \gamma_K(dt - \frac{v_p}{c^2}dx)\\
&= \gamma_K(dt - \frac{v_p}{c^2}vdt)\\
&= dt\gamma_K\gamma_K^{-2}\\
\therefore \frac{dt'}{dt} &= \gamma_K^{-1} \ \in \mathbb{R} \leq 1 \blacksquare
\end{aligned} \tag{15}$$

Similarly, the length contraction differential, dx'/dx, which is a ratio of infinitesimal length intervals between the moving frame and the preferred frame, can be determined by evaluating an interval of length at an instant of time:

$$\begin{aligned}
\text{Let } &: dx' = x'_2 - x'_1 \text{ @ } t'\\
\text{Let } &: dx = x_2 - x_1 \text{ @ } t\\
x'_1 &= \gamma_K(x_1 - v_p t)\\
x'_2 &= \gamma_K(x_2 - v_p t)\\
dx' &= \gamma_K(x_2 - v_p t) - \gamma_K(x_1 - v_p t)\\
dx' &= \gamma_K(dx)\\
\therefore \frac{dx'}{dx} &= \gamma_K \ \in \mathbb{R} \geq 1 \blacksquare
\end{aligned} \tag{16}$$

To see why the miscalibrated instruments in the ARF measure the average speed of light as c, first consider what calibrated instruments measure in the ARF, as shown in Figure (9), then convert them to miscalibrated measures.

For the y-axis in Figure (9), we can apply Equation (15) to convert calibrated time, t_1, to miscalibrated time, t'_1, while the length remains calibrated, as in $L_y = L'_y$, as shown in Equation (17).

$$L_y = \frac{t_1}{2}\sqrt{c^2 - v_p^2} = L'_y = \frac{\gamma_K t'_1}{2}\sqrt{c^2 - v_p^2} \tag{17}$$

On this basis we can now derive the apparent average speed of light in the y-axis, c'_y, as shown in Equation (18).

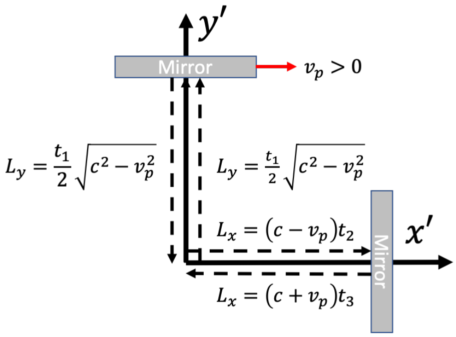

Figure 9: **Apparatus in ARF with calibrated Length.**

$$\begin{aligned}
&L'_y = \frac{\gamma_K t'_1}{2}\sqrt{c^2 - v_p^2} \implies c'_y = \gamma_K\sqrt{c^2 - v_p^2}\\
&\therefore c'_y = \gamma_K c\sqrt{1 - \frac{v_p^2}{c^2}} = \gamma_K c \gamma_K^{-1} = c \ \blacksquare
\end{aligned} \tag{18}$$

Similarly, for the x-axis in Figure (9), we can apply Equation (15) to convert calibrated times, t_2 and t_3, to miscalibrated times, t'_2 and t'_3, and apply Equation (16) to convert calibrated length, L_x, to miscalibrated length, L'_x, as shown in Equation (19).

$$L_x = t_2(c - v_p) = \gamma_K^{-1} L'_x = \gamma_K t'_2 (c - v_p) \implies t'_2 = \frac{L'_x}{\gamma_K^2 (c - v_p)}$$
$$L_x = t_3(c + v_p) = \gamma_K^{-1} L'_x = \gamma_K t'_3 (c + v_p) \implies t'_3 = \frac{L'_x}{\gamma_K^2 (c + v_p)} \tag{19}$$

On this basis we can now derive the apparent average speed of light in the x-axis, c'_x, as shown in Equation (20).

$$c'_x = \overline{v}' = \frac{2L'_x}{t'_2 + t'_3} = \frac{2L'_x}{\frac{L'_x}{\gamma_K^2(c-v_p)} + \frac{L'_x}{\gamma_K^2(c+v_p)}} = \frac{2}{\frac{1}{\gamma_K^2(c-v_p)} + \frac{1}{\gamma_K^2(c+v_p)}} = \frac{2(\gamma_K^2(c+v_p))(\gamma_K^2(c-v_p))}{\gamma_K^2(c+v_p) + \gamma_K^2(c-v_p)}$$
$$= \frac{2\gamma_K^2(c^2 - v_p^2)}{2c} = \gamma_K^2\left(c - \frac{v_p^2}{c}\right) = \gamma_K^2 c\left(1 - \frac{v_p^2}{c^2}\right) = \gamma_K^2 c \gamma_K^{-2} = c \;\blacksquare \tag{20}$$

The total effect of time dilation and x-axis length contraction is that not only do the light beams traveling both paths arrive at the combiner at the same time, but also their apparent average speed in any direction for any inertial reference frame is always c.

5.6. Conclusion

In conclusion, an existing preferred frame has many implications: the average speed of light relative to any moving frame is not constant; the average speed of light is different along the x-axis and y-axis (axes parallel and perpendicular to velocity, respectively) in a moving frame; and length contraction allows light to travel a shorter distance along the x-axis to compensate for the slower average speed of light in the x-axis. This results in identical round-trip times of light for both paths in the Michelson–Morley experiment, regardless of the apparatus' velocity in the preferred frame. Therefore, the average effective speed of light, c_0, is identical in any direction for any inertial reference frame, and less than c by a factor of γ_K^{-1} for any moving frame.

The average effective speed of light, c_0, being slower than c, means light's travel time over the same distance relative to the moving frame takes longer; and the reason this longer duration is undetectable is because of a phenomenon known as time dilation. This causes the apparent average speed of light to always be c in all directions for any inertial frame. The next investigation in this series will induce the cause of time dilation using Mill's method.

6. Investigation 3: What Causes Kinetic Time Dilation?

Prior investigations determined that time, when properly conceptualized, is the interval over which change occurs to *things* and is not an independent property of the Universe. This led to the understanding of time dilation as a change in the interval over which objects change. Furthermore, it was found that a preferred frame must exist, leading to the discovery that the average effective speed of light, c_0, relative to a uniformly moving object is identical in all directions and depends on the object's velocity, relative to the preferred frame, v_p, as shown in Equation (21).

$$c_0 = c\sqrt{1 - \frac{v_p^2}{c^2}} = \gamma_k^{-1} c \tag{21}$$

Since c_0 is less than c, light's travel duration takes longer. This longer duration is undetected due to time dilation, which makes the apparent average speed of light c in any direction for any inertial frame.

The form of kinetic time dilation most suitable for studying its cause is expressed as the ratio of infinitesimal intervals over which identical changes occur, but in different reference frames:

$$\frac{dt'}{dt} = \sqrt{1 - \frac{v_p^2}{c^2}} \tag{22}$$

Here, dt' is the infinitesimal time interval for a change in a moving frame with velocity v_p relative to the preferred frame, dt is the interval for the identical change but in the preferred frame, and c is the speed of light relative to the preferred frame. This formulation allows us to focus on *why* this differential (the ratio of infinitesimals) becomes less than one.[8]

Orthodoxy holds that Equation (22) applies to any inertial frame, not just the preferred frame (see Section 3.3). In this context, v_p can be replaced by v, the relative velocity between any two frames in uniform motion, making time dilation applicable to any frame in motion relative to another. This form will be referred to as orthodox Equation (22).

6.1. List of Plausible Causes

I have identified three plausible causes proposed by others and one abdication of any need for a cause. The abdication involves relying on the Lorentz Transform to predict time dilation measurements, which it does precisely. However, I aim to discover *why* we observe these effects.

In addition to the three posited causes, I have added two of my own—work done and specific work done. The compiled list of plausible causes is, and a brief description of why each is considered plausible:

- **Frame-Wise Relative Velocity**: $dt'/dt < 1$ observed only when two frames exhibit relative velocity.
- **Velocity Relative to Preferred Frame**: it appears to be the only controllable parameter in Equation (22).
- **Acceleration**: it is thought to resolve the twin paradox.
- **Work Done**: velocity and acceleration result from work done on an object.
- **Specific Work Done**: same reason as work done but requires work to scale by the inertia of an object.

6.2. Ruling out Velocity

Frame-wise relative velocity is the velocity between any two frames with relative motion, not just between the preferred frame and another. It might seem reasonable to consider velocity as the cause of time dilation differential changes due to its presence in the Orthodox Equation (22), but this is not necessarily the case.

For example, consider modifying the twin paradox such that both twins travel with the same speed profile but in opposite directions in the preferred frame. Despite any relative velocity between them, no difference is observed in the interval over which change occurs in their respective frames, dt'_1/dt'_2, as shown in Figure 10.

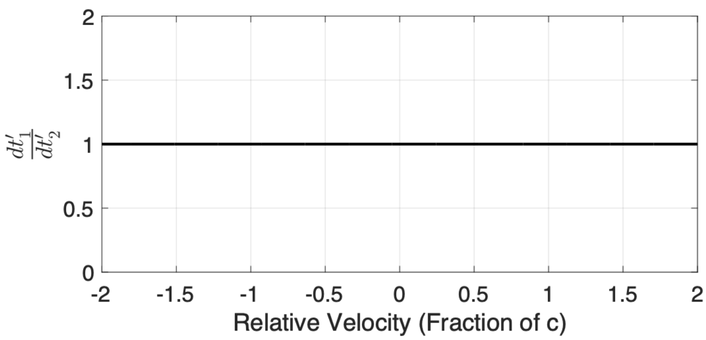

Figure 10: **Time dilation differential versus velocity.**

Using the method of agreement, where the effect remains invariant despite changes in the plausible causal factor, shows that v does not cause changes in the time dilation differential between two reference frames.

In addition, this thought experiment disproves v_p as the cause too since the effect remained the same when v_p changed—e.g., $-v_p$ and v_p produce the same dt'/dt value dispite $-vp \neq v_p$. Thus, using the method of agreement proves inductively that v_p does not cause dt'/dt to change.

While v_p is the only parameter in the time dilation differential equation that can be manipulated, it is a squared term, equivalent to a vector dot product with itself, $v^2 = \vec{v} \cdot \vec{v}$. This implies that only the magnitude squared of v_p matters, not its direction, since v_p and $-v_p$ produce the same results.

Thus, speed relative to the preferred frame, $|v_p|$, might seem to cause time dilation changes, but speed is an aspect of velocity, which must have a direction. It does not make physical sense to talk about speed without direction. Therefore, speed is not fundamental because it is merely an aspect of physical action.

[8] It takes the least amount of time for change to occur in the preferred frame, as this differential is always less than or equal to one.

Moreover, $|v_p|$ can be ruled out as the fundamental cause since it results from specific work (or a change in specific kinetic energy), a more fundamental cause, as shown below:

$$w_K = \Delta e_K = \frac{1}{2}v_p^2 \tag{23}$$

$$\therefore |v_p| = \sqrt{2w_K} = \sqrt{2\Delta e_K} = \int a(s)ds \tag{24}$$

You cannot have a non-zero speed with respect to the preferred frame without doing specific work relative to the preferred frame, w_K.

An analogy, consider the following career advice to increase net income: (a) gaining more money or (b) becoming more productive. Gaining more money does not provide actionable steps. In contrast, becoming more productive provides actionable steps that provides a basis for which to increase income. Similarly, specific work done is the more fundamental cause of time dilation, as it involves an actionable process that changes an object's speed relative to the preferred frame. Thus, if specific work causes time dilation, then $|v_p| > 0$ and $dt'/dt < 1$ would both be correlated effects of specific work.

6.3. Ruling out acceleration

In the twin paradox, one twin accelerated and the other did not, and the accelerated twin's clock slows down compared to the other twin's clock on earth—acceleration seems to be the difference that makes the difference. This approach, therefore, concludes that the time dilation differential is less than unity only during acceleration. Einstein even attempted a twin paradox resolution assuming that the gravitation was responsible for the kinetic time dilation differential during acceleration; however, this plausible factor has been disproved in many sources (25)(26)(27)(28).

6.4. Ruling out Work and Inducing Specific Work

Work and specific work are similar to acceleration arguments. The difference being: time dilation differentials remain constant until work (or specific work) is done, implying that time dilation has an "inertia," where the differential remains constant until acted upon by an external force. This concept is termed *inertial time differential* (ITD).

Let's test the remaining two factors with two thought experiments to reveal that specific work is the precise cause. Proof:

1. First, consider the effects of work done on two object initially at rest in the preferred frame. A planet that barely accelerates to a final velocity when work is done compared to a marble that reaches a much higher velocity with the same work done. Using the Lorentz Transformation shows that the marble experiences more time dilation than the planet, proving that work done is not the precise cause since different effects occur with the same amount of work.
2. Now, consider the effects of specific work done. The same two objects with the same specific work done on them. Using the Lorentz Transformation reveals the same change in their ITD; thus, invoking the method of agreement, where the same effect occurs with the same specific work done, proves inductively that specific work done causes the change in ITD $\blacksquare$.

It has been inductively proven that an object undergoing a non-zero net specific force applied over some distance causes its ITD to change. Considering the specific work done in the earlier counterexample to velocity explains why the ITD between two reference frames had to be unity despite their relative velocity—they had the same specific work done. See relevant properties of specific work done in Appendix A.

6.5. Deriving The Causal Math Model

To derive a precise mathematical model that captures the relationship between kinetic time dilation and specific work done, we start with the understanding that kinetic energy and work are reciprocals of the same causal phenomenon. In this context, a non-zero net force leads to a change in kinetic energy, and altering kinetic energy creates a force.

Given this reciprocal relationship, we can relate Equation (22) to specific work as shown in Equation (25).

$$\frac{dt'}{dt} = \sqrt{1 - \frac{v_p^2}{c^2}} = \sqrt{1 - \frac{2\Delta e_K}{c^2}} = \sqrt{1 - \frac{2\int a(s)ds}{c^2}} = \sqrt{1 - \frac{2w_K}{c^2}} \blacksquare \tag{25}$$

6.6. Conclusion

In summary, the investigation into the cause of kinetic time dilation reveals it is the change in specific kinetic energy. Time dilation is understood as the change in the interval over which change occurs to objects moving relative to a preferred frame. The causal relationship is derived from the reciprocal nature of kinetic energy and work, confirming that specific work done relative to the preferred frame directly influences the ITD.

The derived mathematical model, given by Equation (25), demonstrates this relationship by linking time dilation to specific work. This new understanding opens up further avenues of exploration into how specific energy impacts relativistic effects and sets the stage for subsequent investigations.

7. Investigation 4: How Does Specific Energy Relate to Time Dilation?

Prior investigations established that time, when properly conceptualized, is the interval over which change occurs to *things* and is not a property of the Universe independent of physical changes. This led to the proper understanding of time dilation as a change in the interval over which objects change. Furthermore, it was determined that a preferred frame of reference must exist, which led to discovering that the average effective speed of light, c_0, relative to an object is the same in all directions for any object in uniform motion relative to this preferred frame. This effective speed is a function of the object's velocity relative to the preferred frame, v_p, as shown in Equation (26). Consequently, it was found that the cause of kinetic time dilation is a change in the object's specific kinetic energy relative to the preferred frame, as indicated in Equation (27).

$$c_0 = c\sqrt{1 - \frac{v_p^2}{c^2}} = \frac{1}{\gamma}c \tag{26}$$

$$\begin{aligned}\frac{dt'}{dt} &= \sqrt{1 - \frac{v_p^2}{c^2}} = \sqrt{1 - \frac{2\Delta e_K}{c^2}} \\ &= \sqrt{1 - \frac{2\int a(s)ds}{c^2}} = \sqrt{1 - \frac{2w_K}{c^2}} \;\blacksquare\end{aligned} \tag{27}$$

Definition of terms:

- dt' is the interval over which change occurs to an object.
- dt is the interval over which the same change occurs to the object when at rest with respect to the preferred frame and far from gravitational sources.
- The ratio of time derivatives, dt'/dt, termed the *inertial time differential* (ITD), remains constant for any object until specific work w_K or w_P is done. Specific work done is conservative in the preferred frame (see Appendix A).
- c_0 is the average effective speed of light relative to an object.
- c is the speed of light in a vacuum relative to the preferred frame, unaffected by gravitational potentials.
- Δe_K is an object's change in specific kinetic energy relative to the preferred frame.
- w_K is the specific kinetic work done on the object relative to the preferred frame, resulting in Δe_K.

Relating specific energy to time dilation introduces an intriguing new relationship, which is the focus of this investigation.

7.1. Relativistic Kinetic Energy

By exploring how energy was first thought to relate to relativistic effect, it illuminates the path to relate specific energy to relativistic effects.

Relativistic kinetic energy was first introduced in a thought experiment devised by Einstein, which derived a relationship between an object's mass and internal energy. In this thought experiment, Einstein considered an object at rest emitting energy in the form of radiation in two opposite directions but in equal amounts. He then considered the same object, with the same emission, viewed from a different inertial reference frame moving relative to the object along an arbitrary axis. Figure 11 illustrates this thought experiment (29).

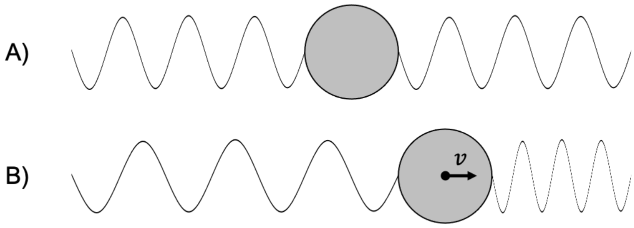

Figure 11: **A) Object at rest. B) Object in motion.**

Einstein began by comparing the total energies measured by the two reference frames. Let E represent the total energy of the object as measured from its own inertial reference frame, and H represent the total energy of the object as measured from the reference frame with relative motion. Einstein noted, "It is clear that the difference $H - E$ can differ from the kinetic energy [ΔE_K] of the body, with respect to the other [reference frame with relative motion], only by an additive constant C..." The resulting model is: $H - E = \Delta E_K + C$ (29).

Feynman's derivation is particularly useful to see on what the total energy model and kinetic energy model used by Einstein depend. Feynman derives the total energy relation to kinetic energy from the relativistic mass model that conserves momentum (30), as shown in Equation (28).

$$
\begin{aligned}
m &= \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} = m_0\left(1-\frac{v^2}{c^2}\right)^{-1/2} = m_0\left(1+\frac{1}{2}\frac{v^2}{c^2}+\frac{3}{8}\frac{v^4}{c^4}+\dots\right) \\
m &\approx m_0 + \frac{1}{2}m_0\frac{v^2}{c^2} \\
mc^2 &\approx m_0c^2 + \frac{1}{2}m_0v^2 \blacksquare
\end{aligned} \tag{28}
$$

According to this model, the total energy, mc^2, of an object is its internal energy[9], m_0c^2, plus its kinetic energy, $(\gamma_K - 1)m_0c^2$. This aligns with $H - E = \Delta E_K + C$ as follows:

$$H = mc^2 \tag{29a}$$

$$E = m_0c^2 \tag{29b}$$

$$\Delta E_K = H - E = mc^2 - m_0c^2 \tag{29c}$$

$$\therefore C = 0 \text{ in this case} \tag{29d}$$

The models depend on the relativistic mass model representing an object's inertia. To see this dependency, one can derive the kinetic energy model in Equation (29c) from Newtonian principles, as shown in Equation (30).[10]

$$
\begin{aligned}
\text{Let} &: \gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \\
m\gamma^{-1} &= m_0 = \text{invariant}
\end{aligned}
$$

$$\Delta E_K = \int F(s)ds = \int \frac{dp}{dt}ds = \int v d(mv) = \int v d(\gamma m_0 v) = m_0 \int v d(\gamma v)$$

[9]Traditionally called rest energy, but in the context of a preferred frame, internal energy is more appropriate.
[10]The full derivation is detailed here (31).

$$= (\gamma - 1)m_0c^2 = mc^2 - m_0c^2 \blacksquare \tag{30}$$

Energy is defined as an object's ability to do work, and can be viewed as the integration of both a motion component and an inertia component. Deriving specific kinetic energy from Equation (30) is not as simple as factoring out m_0 because inertia changes as a function of v_p (29). To isolate inertia's contribution, one can simply remove inertia before integration, thus deriving specific kinetic energy directly as shown in Equation (31).

$$\Delta e_K = \int f(s)ds = \int \frac{d(\frac{p}{m})}{dt}ds = \int v dv = \frac{1}{2}v^2 \blacksquare \tag{31}$$

Thus, the relativistic specific kinetic energy model matches the Newtonian specific kinetic energy model. Since the preferred frame model makes the same verifiable predictions as relativity (13), this is also the specific kinetic energy in the preferred frame when v is replaced with v_p.

7.2. Deriving A New Specific Energy Model

The analysis leading to Equation (31) implies that simply factoring out m_0 from internal energy, in Equation (29b), is also not sufficient to derive specific internal energy, since contributions of inertia in the remaining quantity would necessarily remain. A slight modification to Feynman's method of deriving the total energy equation can be used to derive the total specific energy equation, which includes the specific internal energy component, as shown in Equation (32).

$$\begin{aligned}
m &= \frac{m_0}{\sqrt{1 - \frac{v_p^2}{c^2}}} = \gamma_K m_0 \\
m^2\left(1 - \frac{v_p^2}{c^2}\right) &= m_0^2 \\
m^2 &= m_0^2 + m^2\frac{v_p^2}{c^2} \\
c^2 &= \frac{m_0^2}{m^2}c^2 + v_p^2 \\
\frac{1}{2}c^2 &= \gamma_K^{-2}\frac{1}{2}c^2 + \frac{1}{2}v_p^2 \\
e_T &= e_I + \Delta e_K \blacksquare
\end{aligned} \tag{32}$$

According to this model, the total specific energy, $c^2/2$, is the specific internal energy, $\gamma_K^{-2}c^2/2$, plus the specific kinetic energy, $v_p^2/2$. We will get to why $e_I = \gamma_K^{-2}c^2/2$ in a moment, but this model is analogous to Einstein's total energy model where total energy is internal plus kinetic energy. Unlike Einstein's model, however, the specific internal energy of an object diminishes as it gains specific kinetic energy, while its total specific energy remains conserved.

This conservation implies that when an object is at rest, its total specific energy is fully attributed to its specific internal energy, meaning there is no motion relative to the preferred frame. Conversely, as an object's velocity relative to the preferred frame increases, its specific internal energy decreases correspondingly, and specific kinetic energy increases. At the limit where an object's velocity approaches the speed of light, its specific internal energy approaches zero, and its total specific energy is wholly kinetic, meaning there is no inner motion because the duration for any internal change becomes infinite.

It is noteworthy that Equation (32) falls out even for older concepts of mass, like longitudinal mass where $m = \gamma^3 m_0$:

$$\begin{aligned}
m &= \gamma_K^3 m_0 \\
m\gamma_K^{-2} &= \gamma_K m_0
\end{aligned}$$

$$
\begin{aligned}
m\left(1-\frac{v_p^2}{c^2}\right) &= \gamma_K m_0 \\
m - m\frac{v_p^2}{c^2} &= \gamma_K m_0 \\
m &= \gamma_K m_0 + m\frac{v_p^2}{c^2} \\
mc^2 &= \gamma_K m_0 c^2 + m v_p^2 \\
c^2 &= \gamma_K \frac{m_0}{m} c^2 + v_p^2 = \gamma_K \gamma_K^{-3} c^2 + v_p^2 \\
\frac{1}{2}c^2 &= \gamma_K^{-2}\frac{1}{2}c^2 + \frac{1}{2}v_p^2 \\
e_T &= e_I + \Delta e_K \blacksquare
\end{aligned} \tag{33}
$$

Integrating this discovery back into Equation (27), we discover that the $2/c^2$ term is indeed the inverse of the total specific energy, e_T^{-1}, as shown in Equation (34).

$$
\frac{dt'}{dt} = \sqrt{1-\frac{2\Delta e_K}{c^2}} = \sqrt{1-\frac{\Delta e_K}{e_T}} = \sqrt{1-\frac{\int a(s)ds}{e_T}} = \sqrt{1-\frac{w}{e_T}} \blacksquare \tag{34}
$$

This implies that time dilation is a function of the ratio of specific kinetic energy to total specific energy. Another connection emerges between time dilation and the ratio of specific internal energy to total specific energy, as shown in Equation (35).

$$
\frac{dt'}{dt} = \sqrt{1-\frac{\Delta e_K}{e_T}} = \sqrt{\frac{e_I}{e_T}} \blacksquare \tag{35}
$$

While this relationship does not indicate that changing e_I causes time dilation, it does captures the connection between the increase in the interval over which change occurs and the reduction of specific internal energy. It can be said that a change in specific internal energy, Δe_I, causes time dilation, through the effect of specific work on Δe_I, making Δe_I an intermediary cause rather than a fundamental one. Additionally, if Δe_I represents the difference in specific internal energy between when the object is at rest in the preferred frame and when it is moving, then $\Delta e_I = -\Delta e_K$, as shown below. Therefore, the change in specific kinetic energy remains the primary cause of time dilation.

$$
\begin{aligned}
\Delta e_I &= e_{I,v_p} - e_{I,0} \\
e_{I,0} &= e_I \text{ when } v_p = 0 \\
\therefore e_{I,0} &= e_T \\
\Delta e_I &= e_{I,v_p} - e_T = -\Delta e_K \blacksquare
\end{aligned} \tag{36}
$$

Why would $e_I = \gamma^{-2} e_T$ as suggested by Equation (32)? The relationship between e_I and e_T can be further explored when considering that e_I might actually be dependent on c_0. Indeed if we keep in mind the relationship between c_0 and c, shown in Equation (26), while reviewing the e_I term in Equation (32), then we see that c_0 was there all along, as shown in Equation (37).

$$
\begin{aligned}
\frac{1}{2}c^2 &= \frac{1}{2}c_0^2 + \frac{1}{2}v^2 \\
e_T &= e_I + \Delta e_K
\end{aligned} \tag{37}
$$

e_I being dependent on c_0, creates a new perspective on the kinship between e_I and e_T. e_T is determined by the speed of light in the preferred frame, just as e_I is determined by the average effective speed of light in the moving frame. In this way, therefore, e_I can be thought of as total specific rest energy. Indeed, when an object's velocity relative to the preferred frame becomes zero, the average effective speed of light *is* c for that object's frame, and therefore, $e_I = e_T$.

Thus, the relationship between time dilation and e_I in Equation (35), and the relationship between e_I and c_0 in Equation (37) leads to a relationship between time dilation and c_0:

$$\frac{dt'}{dt} = \sqrt{\frac{e_I}{e_T}} = \sqrt{\frac{\frac{1}{2}c_0^2}{\frac{1}{2}c^2}} = \frac{c_0}{c} \blacksquare \tag{38}$$

This direct relationship between time dilation and c_0 suggests that time dilation results from a reduction in c_0. It has been said that the maximum speed that can link two events causally (as in event A affects event B) is the speed of light—i.e., the speed of light is the speed of causality (32). Equation (38) is consistent with the notion that the speed of light represents the speed of causality. Kinetic time dilation is fundamentally caused by specific work done relative to the preferred frame, but the intermediary effect is a reduction in c_0 relative to the moving object. This reduction slows the speed of causality, thereby increasing the interval over which change occurs—an effect known as time dilation. This effectively makes c_0 a fundamental parameter in the causal dynamics of the Universe—the metronome of the Universe.

7.3. Conclusion

In conclusion, the complete causal chain for time dilation is this: a change in net specific work done relative to the preferred frame, which is the prime cause, causes a change in the magnitude of an object's velocity relative to the preferred frame; which causes a change in c_0 relative to the object; which causes a change in the object's speed of causality; which finally causes a change in the interval over which the object changes, which also manifests as a change in the object's e_I. Specific work done can still properly be said to cause kinetic time dilation, but only because of all the intermediary (and simultaneous) steps in between this primary cause and the final effect.

This refined understanding of the causal chain—specific work leading to changes in velocity, affecting c_0, and subsequently influencing time dilation—offers a comprehensive perspective on how kinetic time dilation arises. It highlights how the fundamental principles of energy and motion interplay to produce observable relativistic phenomena.

Furthermore, this new understanding provides the necessary ingredients to address this investigative series' next question: what, then, causes gravity if not the bending of spacetime? In short, time dilation gradients around massed objects, are caused by a spatially variable c_0, which implies $\nabla e_I > 0$ within other objects near those massed objects, which induces a specific force, $\vec{g}(r)$, to act on those objects, causing all massed objects to gravitate towards each other. The focus of the next investigation is to fully demonstrate this.

8. Investigation 5: Do Time Dilation Gradients Imply Specific Energy Gradients?

Prior investigations revealed that time, when properly conceptualized, is the interval over which change occurs to *things*, rather than a separate property of the Universe. This led to the understanding of time dilation as a change in the interval over which objects change. Furthermore, it was determined that a preferred frame must exist, which in turn led to discovering the cause of kinetic time dilation (Equation (39)), and the derivation of a specific energy model (Equation (40)).

$$\frac{dt'}{dt} = \frac{c_0}{c} = \sqrt{1 - \frac{\Delta e_K}{e_T}} = \sqrt{1 - \frac{w_K}{e_T}} = \frac{1}{\gamma_K} \tag{39}$$

$$\begin{aligned} e_T = \frac{1}{2}c^2 &= e_I + \Delta e_K \\ &= \frac{1}{2}c_0^2 + \frac{1}{2}v_p^2 \end{aligned} \tag{40}$$

Definition of terms:

- dt' is the interval over which change occurs to an object.
- dt is the interval over which the same change occurs to the object when at rest with respect to the preferred frame and far from gravitational sources.
- The ratio of time derivatives, dt'/dt, termed the *inertial time differential* (ITD), remains constant for any object until specific work w_K or w_P is done. Specific work done is conservative in the preferred frame (see Appendix A).
- c_0 is the average effective speed of light relative to an object.
- c is the speed of light in a vacuum relative to the preferred frame, unaffected by gravitational potentials.
- Δe_K is an object's change in specific kinetic energy relative to the preferred frame.
- w_K is the specific kinetic work done on the object relative to the preferred frame, resulting in Δe_K.
- e_T is the total specific energy of the object, $c^2/2$.
- e_I is the specific internal energy of the object, $\frac{1}{2}c_0^2$.

Given this basis, we now investigate the implications of time dilation gradients.

8.1. Gravitational Time Dilation

According to the Schwarzschild Metric (33), which describes time dilation within a gravitational field for a spherical body stationary in the preferred frame, the ITD measured within a gravitational field at zero velocity in the preferred frame is given by Equation (41).

$$\frac{dt'}{dt} = \sqrt{1 - \frac{GM/r}{e_T}} \tag{41}$$

Here, GM/r represents the Newtonian gravitational potential. The relationship between ITDs and specific work done continues beyond kinetic ITDs, as shown in Equation (41). GM/r is the specific work done by the gravitational field, w_P, on the object as it travels from a point infinitely far away to a distance r from the center of mass, given by: $\int_\infty^r g(r)\,dr$. Replacing this specific work in Equation (41) yields:

$$\frac{dt'}{dt} = \sqrt{1 - \frac{\int_\infty^r g(r)dr}{e_T}} = \sqrt{1 - \frac{w_P}{e_T}} = \sqrt{1 - \frac{\Delta e_P}{e_T}} = \frac{1}{\gamma_P} \tag{42}$$

Given the relationship between gravitational ITDs and specific work done, and the fact that a change in kinetic time dilation is caused by a change in c_0, it stands to reason that gravitational time dilation might be fundamentally caused by the same mechanism—a change in c_0. This is straightforward to demonstrate:

> According to the Schwarzschild metric, the coordinate radial speed of light, c_r, is $\gamma_P^{-2}c$, while the coordinate transverse speed of light, c_t, is $\gamma_P^{-1}c$ (33). This mirrors the kinetic case where the calibrated two-way average speed of light relative to a moving object along its velocity dimension, c'_x, is $\gamma_K^{-2}c$, and the calibrated two-way average speed of light relative to a moving object perpendicular to its velocity dimension, c'_y, is $\gamma_K^{-1}c$. The reason why the average effective speed of light, c_0, is $\gamma_K^{-1}c$ in all directions for the kinetic case is due to length contraction along the velocity dimension, where $L_x\gamma_K = L_y = L$, since the slower traveling light along this dimension is offset by the reduction in distance traveled (see Section 5.4). According to the Schwarzschild metric, the same length contraction is operative in the radial dimension for the gravitational case, where $L_r\gamma_P = L_t = L$ (33), because the slower traveling light along the radial dimension is offset by the reduction in distance traveled; thus, c_0 is $\gamma_P^{-1}c$ in all directions for the gravitational case as well. ■

This fact implies that refraction could play a role in gravitational effects, and prior work in this area demonstrated that "the equations of motion for [refracted] light are formally identical to those predicted by general relativity" (34). Additionally, the fact that time dilation gradients correspond to a gradient in c_0 leads to an interesting fact about specific energy gradients, as discussed in the next subsection.

8.2. Implications of Time Dilation Gradients

Given that observations for gravitational ITDs match Equation (41), it follows that a time dilation gradient (TDG), $\nabla(dt'/dt)$, exists around physical objects and is defined by Equation (43).

$$\nabla\frac{dt'}{dt} \triangleq \frac{d\left(\frac{dt'}{dt}\right)}{dr}\hat{r} = \frac{\gamma_g}{2e_T}\frac{GM}{r^2}\hat{r} \tag{43}$$

We immediately see the connection between TDG and the specific force of gravity, since $-(GM/r^2)\hat{r} = \vec{g}(r)$; however, this relationship is only correlated, not causal. The time dilation gradient implies a specific internal energy gradient, ∇e_I, which would causally relate to a specific force, as all energy gradients do. This is derived as follows:

$$\begin{aligned}
\text{given}:\ \frac{dt'}{dt} &= \sqrt{\frac{e_I}{e_T}} = \sqrt{1-\frac{GM/r}{e_T}}\\
\therefore\ \vec{f}(r) = -\nabla e_I &= -e_T\nabla\frac{e_I}{e_T} = -e_T\nabla\frac{dt'^2}{dt^2}\\
&= -e_T\frac{d\left(1-\frac{GM/r}{e_T}\right)}{dr}\hat{r} = -\frac{GM}{r^2}\hat{r}\\
&= \vec{g}(r)\ \blacksquare
\end{aligned} \tag{44}$$

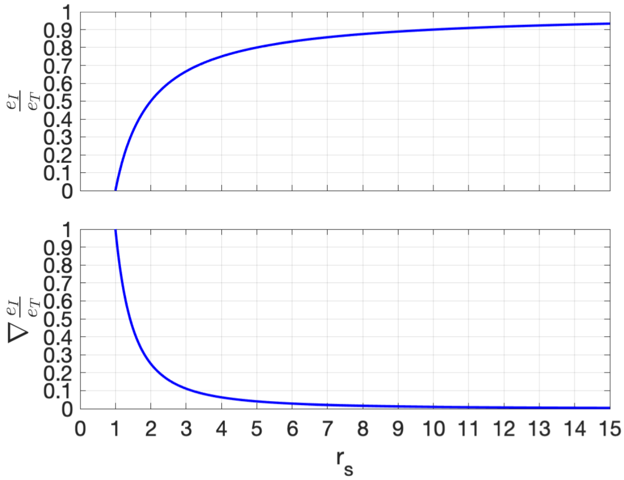

Figure 12: **ITD^2 and SEG in units of r_s.**

Equation (44) applies to any generic gravitational field described by the Schwarzschild metric. Figure 12 illustrates the causal relationship captured by Equation (44), where r is in units of the Schwarzschild Radius, r_s, and $\nabla(e_I/e_T)$ is in units of $1/r_s$.

Given that TDGs imply ∇e_I, it is evident that the equivalence principle is falsifiable under this new paradigm. In other words, free falling is not equivalent to floating in empty space, and sitting on Earth is not equivalent to accelerating in empty space.

The difference is that ∇e_I exists around earth, but not in empty space. The same was said about tidal force existing around earth and not in empty space, but the response to tidal forces has been that the equivalence principle is accepted as *approximately* true since for infinitesimally small points tidal forces vanish (35). The argument has been that tidal forces approaches zero for infinitesimal points near earth, just like they are zero in empty space; however, this argument does not apply to ∇e_I because, as we can see in Figure 12, ∇e_I converges to a non-zero value at infinitesimal points. Therefore, the equivalence principle must be rejected on the grounds that non-zero ∇e_I have significant consequences—they cause a specific force to be applied to objects that experience non-zero ∇e_I values.

Not only is the equivalence principle falsifiable, it was shown in the last subsection that, in terms to what happens to c_0, it is the exact opposite—free falling towards earth is akin to accelerating in empty space and sitting on earth is akin to floating in empty space. In the kinetic case, a change in the object's specific energy state causes a reduction in c_0, while in the gravitational case, the change in c_0 along the radial direction causes a change in the object's energy state. They are reciprocal phenomena in this way, where a change in either c_0 or specific energy state causes a change in the other.

To summarize, TDGs are the result of a gradient in c_0, which implies a gradient in an object's specific internal energy, thus, causing observable gravitational effects. This understanding provides a novel perspective on gravity and opens up new avenues for research into the interplay between gravity, time dilation, and the permeability and permittivity of free space.

8.3. Historical Context

The concept of a spatially variable speed of light, or spatially-VSL, has been explored by several theorists in the past (36). Einstein himself considered the possibility of spatially-VSL in several of his papers leading up to the formulation of general relativity (37)(38)(39)(40)(41)(42)(43), and he continued to address it even after developing his general theory of relativity (44)(45).

Dicke was the first to formalize the spatially-VSL approach in a manner that aligned with the predictive power of general relativity. He took into account the length contraction implied by the Schwarzschild metric, which had been previously overlooked (46). Dicke's work demonstrated how the speed of light varies around massed objects and provided insights into the time delay of light signals near massive bodies, as exemplified by Shapiro's predictions and subsequent experimental confirmations (47)(48).

While the spatially-VSL model successfully explains the motion of light in gravitational fields through refraction, it previously lacked a causal mechanism for how this model explains the motion of massed objects. Dicke correlated spatially-VSL with gravitational potential, effectively describing gravitational motion as predicted by general relativity, but did not address the underlying cause of this correlation.

The present investigation provides a missing causal mechanism within the spatially-VSL framework by identifying the gradient in specific internal energy, ∇e_I, as the underlying cause of the observed gravitational effects. This new causal insight bridges the gap between the spatially-VSL model and the gravitational phenomena it seeks to explain.

8.4. Possible Implications

The discovery that the gradient in specific internal energy, ∇e_I, causes the specific force of gravity represents a significant advancement in understanding gravitational phenomena. This approach marks a departure from Newton's concept of gravity as an action at a distance, instead framing it as a local effect resulting from an object's internal energy gradient. Specifically, this gradient arises from the spatially variable c_0.

While this provides a more localized view of gravity, it raises further questions about the underlying causes of changes in the permittivity and/or permeability of free space around objects. To address this, future investigations might explore the role of neutrinos and their potential impact on time dilation (49).

Interestingly gravity, once thought to be a fundamental force independent of light, involves light, which is responsible for the electromagnetic force. Equally interesting, electromagnetism (EM) is a force orthogonal to light's velocity, while gravity acts parallel to its velocity; in other words, in all three dimensions of light, a different force is operative—electrical, magnetic, and gravitational—one force for each spatial dimension.

This connection between gravity and light introduces a possibility that gravity could be coupled with EM into a unified framework termed *electromagnetgravitism* (EMG). Unlike *gravitoelectromagnetism* (GEM), which only draws analogies between gravity and EM (50), EMG would seek to integrate these forces into a single theoretical model.

One interesting fact about GEM, is that the only known representation that resolves the scaling issue and asymmetries of historical solutions to GEM involves making use of complex numbers to enforce gravitational and EM orthogonality and it succeeds in integrating both fields into a single set of equations (51). The derivation of this solution is contained in Appendix B.

Einstein had looked into a unified field theory coupling gravity with EM (52)(53)(54)(55)(56)(57), but he lacked the concepts and the newly discovered causal link between gravity and EM that we now possess. The possibility of EMG being the only force in existence would be an interesting question to look into, and we are better prepared to investigate this now than ever before, but it will have to wait for a future investigation.

If future investigations find that EMGs are a true coupling, then one really needs to consider the possibility that light is the only force carrier in existence and that the other known forces—the week and strong nuclear forces—might really be just an aspect of EMG. Meaning EMG might be the only force in existence, where the strong/week nuclear forces are simply a manifestation of the never before considered couplings of electrogravitism (EG) and magneticgravitism (MG). That is EG would be a form of EMG with the magnetic component neutralized, and MG is a form of EMG with the electric component neutralized, just like EM is a form of EMG with the gravitational component neutralized.

8.5. Conclusion

In conclusion, the investigation into time dilation gradients has revealed several key insights. It was demonstrated that gravitational time dilation follows the same principles as kinetic time dilation with respect to specific work done within the preferred frame, and the reduction in c_0.

The existence of time dilation gradients (TDGs) indicates that gravitational fields create specific internal energy gradients within objects. This gradient causes the specific force of gravity experienced by these objects. This finding suggests a significant shift in understanding gravity, from a field-based force to one rooted in local variations of specific internal energy.

The relationship between c_0 and gravity uncovered in this investigation opens the door to further theoretical developments. It hints at the possibility of a unified field theory that integrates gravity and electromagnetism into a coherent framework. Future research will need to explore how these insights can be synthesized with existing models and investigate the implications for a broader unification of fundamental forces.

The next phase of research will focus on incorporating these findings into a comprehensive total ITD model. This integration necessitates an update to the specific energy model to incorporate a change in specific potential energy, which is also covered in the next investigation.

9. Investigation 6: What Causes Total Time Dilation?

Prior investigations have established that time, when properly conceptualized, is the interval over which change occurs to *things* and is not a separate property of the Universe. This understanding led to the conceptualization of time dilation as a change in the interval over which objects change. Furthermore, it was determined that a preferred frame must exist, which in turn led to discovering the cause of kinetic time dilation (Equation (45)), the derivation of a specific energy model (Equation (46)), and to discovering the cause of gravitational time dilation (Equation (47)). This, in turn, revealed that gravity is caused by a specific internal energy gradient (Equation (48)).

$$\frac{dt'}{dt} = \frac{c_0}{c} = \sqrt{1 - \frac{\Delta e_K}{e_T}} = \sqrt{1 - \frac{w_K}{e_T}} = \frac{1}{\gamma_K} \tag{45}$$

$$\begin{aligned} e_T = \frac{1}{2}c^2 &= e_I + \Delta e_K \\ &= \frac{1}{2}c_0^2 + \frac{1}{2}v_p^2 \end{aligned} \tag{46}$$

$$\begin{aligned} \frac{dt'}{dt} = \frac{c_0}{c} &= \sqrt{1 - \frac{\Delta e_P}{e_T}} = \sqrt{1 - \frac{w_P}{e_T}} = \frac{1}{\gamma_P} \\ &= \sqrt{1 - \frac{\int_\infty^r \vec{g}(r)dr}{e_T}} = \sqrt{1 - \frac{\int_\infty^r -\nabla e_I dr}{e_T}} \end{aligned} \tag{47}$$

$$\vec{g}(r) = -\nabla e_I = -\frac{d(e_I)}{dr}\hat{r} \tag{48}$$

Definition of terms:

- dt' is the interval over which change occurs to an object.
- dt is the interval over which the same change occurs to the object when at rest with respect to the preferred frame and far from gravitational sources.
- The ratio of time derivatives, dt'/dt, termed the *inertial time differential* (ITD), remains constant for any object until specific work w_K or w_P is done. Specific work done is conservative in the preferred frame (see Appendix A).

- c_0 is the average effective speed of light relative to an object.
- c is the speed of light in a vacuum relative to the preferred frame, unaffected by gravitational potentials.
- Δe_K is an object's change in specific kinetic energy relative to the preferred frame.
- w_K is the specific kinetic work done on the object relative to the preferred frame, resulting in Δe_K.
- Δe_P is the change in specific potential energy of the object.
- w_P is the specific work done by gravity on the object, resulting in Δe_P.
- e_T is the total specific energy of the object, $c^2/2$.
- e_I is the specific internal energy of the object, $\frac{1}{2}c_0^2$.
- $\vec{g}(r)$ is the specific gravitational force.
- ∇e_I is the gradient of the object's specific internal energy.

This investigation now examines changes in ITDs relative to changes in specific total external energy, Δe_t, by holding e_I constant and changing the components of Δe_t—i.e., Δe_K and Δe_P. The updated total specific energy model will be impacted by what we find.

9.1. Time Dilation Equivalence

Changes in specific kinetic or potential energy affect ITDs, but these factors alone are insufficient for a complete understanding. To refine our understanding, we must consider cases where these variables do not remain constant when ITDs do.

Equations (45) and (47) suggest that transferring specific kinetic energy to an equal amount of specific potential energy (or vice versa) does not alter the ITD. For instance, an object with a given amount of specific potential energy that transitions to a state with the same specific kinetic energy but no potential energy should exhibit equivalent ITDs in both states. Equation (49) demonstrates that the ITDs in each state are the same.

$$
\begin{aligned}
&\text{Let } \Delta e_P > 0.\\
&\text{Let } \frac{1}{\gamma} = \frac{dt'}{dt}\\
&\frac{1}{\gamma_P^2} = 1 - \frac{\Delta e_P}{e_T}\\
&\Delta e_P = e_T\left(1 - \frac{1}{\gamma_P^2}\right)\\
&\Delta e_P \Longrightarrow \Delta e_K\\
&\therefore \Delta e_K = e_T\left(1 - \frac{1}{\gamma_P^2}\right)\\
&\frac{\Delta e_K}{e_T} = 1 - \frac{1}{\gamma_P^2}\\
&1 - \frac{\Delta e_K}{e_T} = \frac{1}{\gamma_P^2}\\
&\frac{1}{\gamma_K^2} = \frac{1}{\gamma_P^2} \blacksquare
\end{aligned}
\tag{49}
$$

Using the method of agreement: since changes in specific potential energy and kinetic energy occurred without changes in ITD, it follows inductively that neither factor alone is the fundamental cause of changes in ITD—they each contribute partially.

The same change in specific total external energy, Δe_t, corresponds to the same change in ITDs. Inductively, via the method of agreement, this implies that changes in ITD are caused by Δe_t or specific total work done, w_t.

We can now see why Einsteins prediction here (58), that a clock will tick slower at earth's equator than its twin at the pole, failed. The experiments ran to confirm this prediction instead found that identical clocks ran the same regardless of their location on earth, and now we have the tools to understand why this has to be the case. The reason why time dilation across earth's surface is identical is because the specific total energy across earth's surface is identical. Einstein was just considering the kinetic effects on time dilation when he made that prediction. What creates this balance is that the equator bulges away from the center of mass of the earth due to its kinetic energy counteracting gravity more than the poles. The gain in specific kinetic energy at the equator is balanced perfectly by the loss in specific potential energy, thus, the specific total energy remains invariant leading to the same time dilation effect.

9.2. Deriving the Causal Math Model

I start by solving for the ITD of an object stationary within a gravitational field. Then, I analyze how a change in specific kinetic energy, as measured from this stationary position within the gravitational field, affects the overall ITD. This scenario is illustrated in Figure 13.

To compute the overall ITD, dt'_2/dt, for a moving object within the gravitational field, we can measure dt'_1/dt and dt'_2/dt'_1. These ITDs relate to the total effective ITD via the chain rule, as shown in Equation (50):

$$\frac{dt'_1}{dt} = \sqrt{1 - \frac{\Delta e_{P1}}{e_T}}$$

$$\frac{dt'_2}{dt'_1} = \sqrt{1 - \frac{\Delta e_{K2|P1}}{e_T}}$$

$$\frac{dt'_2}{dt} = \frac{dt'_2}{dt'_1}\frac{dt'_1}{dt} = \sqrt{1 - \frac{\Delta e_{K2|P1}}{e_T}}\sqrt{1 - \frac{\Delta e_{P1}}{e_T}} \tag{50}$$

This calculation generalizes to any situation where an object with kinetic energy is within a stationary gravitational field, as shown in Equation (52).

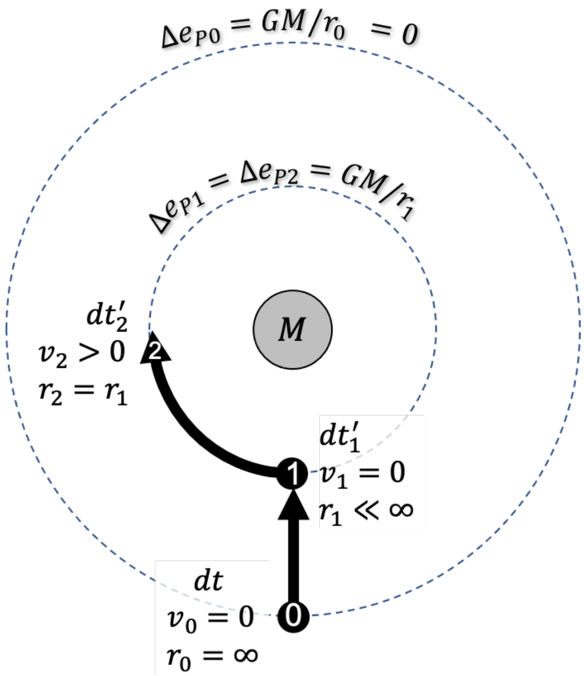

Figure 13: **Total time dilation example.**

$$\text{Let}: \frac{1}{\gamma_P} = \frac{dt'_P}{dt} = \sqrt{1 - \frac{\Delta e_P}{e_T}}$$

$$\text{Let}: \frac{1}{\gamma_{K|P}} = \frac{dt'_K}{dt'_P} = \sqrt{1 - \frac{\Delta e_{K|P}}{e_T}}$$

$$\frac{1}{\gamma_T} = \frac{1}{\gamma_{K|P}}\frac{1}{\gamma_P} = \sqrt{1 - \frac{\Delta e_{K|P}}{e_T}}\sqrt{1 - \frac{\Delta e_P}{e_T}} \tag{52a}$$

$$\frac{1}{\gamma_T} = \sqrt{1 - \frac{\gamma_P^{-2}\Delta e_{K|P} + \Delta e_P}{e_T}} \tag{52b}$$

$$\frac{1}{\gamma_T} = \sqrt{1 - \frac{\Delta e_K + \Delta e_P}{e_T}} = \sqrt{1 - \frac{\Delta e_t}{e_T}} \blacksquare \tag{52c}$$

Equation (52b) reveals that the object's effective speed slows down by the same factor that c_0 is reduced due to gravity, by a factor of γ_P^{-1}. The object's actual speed in the radial direction slows down by an additional factor of γ_P^{-1} because length contraction is abstracted out in the concept of effective speed.

For completeness, consider another scenario where the gravitational potential is moving rather than stationary, as shown in Equation (53).

$$\text{Let}: \frac{1}{\gamma_{P|K}} = \frac{dt'_P}{dt'_K} = \sqrt{1 - \frac{\Delta e_{P|K}}{e_T}}$$

$$\text{Let}: \frac{1}{\gamma_K} = \frac{dt'_K}{dt} = \sqrt{1 - \frac{\Delta e_K}{e_T}}$$

$$\frac{1}{\gamma_T} = \frac{1}{\gamma_K}\frac{1}{\gamma_{P|K}} = \sqrt{1 - \frac{\Delta e_K}{e_T}}\sqrt{1 - \frac{\Delta e_{P|K}}{e_T}} \tag{53a}$$

$$\frac{1}{\gamma_T} = \sqrt{1 - \frac{\Delta e_K + \gamma_K^{-2}\Delta e_{P|K}}{e_T}} \tag{53b}$$

$$\frac{1}{\gamma_T} = \sqrt{1 - \frac{\Delta e_K + \Delta e_P}{e_T}} = \sqrt{1 - \frac{\Delta e_t}{e_T}} \blacksquare \tag{53c}$$

Equation (53b) indicates that the observed gravitational effects in the moving frame are effectively miscalibrated by a factor of γ_K^2, matching the results of the thought experiment found in Appendix C.

Thus, for any number of N combinations of changes to specific kinetic and potential energy, where $N \in \mathbb{Z}^+$, and for all $i = \{1..N\}$, the overall ITD is given by:

$$\text{Let}: dt'_0 = dt,\ \Delta e_{1|0} = \Delta e_1,\ \&\ \frac{1}{\gamma_{T,0}} = 1$$

$$\begin{aligned}\frac{1}{\gamma_{T,i}} = \frac{dt'_i}{dt} = \prod_{j=1}^{i}\frac{dt'_j}{dt'_{j-1}} = \prod_{j=1}^{i}\sqrt{1 - \frac{\Delta e_{j|j-1}}{e_T}} = \sqrt{1 - \frac{\sum_{j=1}^{i}\frac{1}{\gamma_{T,j-1}^2}\Delta e_{j|j-1}}{e_T}} \\ = \sqrt{1 - \frac{\Delta e_K + \Delta e_P}{e_T}} = \sqrt{1 - \frac{\Delta e_t}{e_T}} \blacksquare\end{aligned} \tag{54}$$

9.3. Total Specific Energy Model

We can now use the tools developed to update the specific energy model from Equation (46) to incorporate the Δe_P term along with e_I and Δe_K, as shown in Equation (55).

$$\frac{dt'}{dt} = \frac{1}{\gamma_T} = \sqrt{1 - \frac{\Delta e_t}{e_T}}$$

$$\frac{1}{\gamma_T^2} = 1 - \frac{\Delta e_t}{e_T}$$

$$e_T = \frac{1}{\gamma_T^2}e_T + \Delta e_t = e_I + \Delta e_K + \Delta e_P$$

$$\frac{1}{2}c^2 = \frac{1}{2}c_0^2 + \frac{1}{2}v^2 + \int_\infty^r -\nabla e_I dr \;\blacksquare \tag{55}$$

Solving Equation (55) for c_0/c yields Equation (56). This reveals a recurring pattern: c_0/c is equivalent to total time dilation, dt'/dt.

$$\frac{c_0}{c} = \sqrt{1 - \frac{\Delta e_t}{e_T}} = \frac{dt'}{dt} \tag{56}$$

This suggests that total time dilation is a consequence of a reduction in c_0; thus, c_0 remains the metronome of the Universe under this more general condition. The speed of light represents the speed of causality (32), and c_0 reflects a reduction in the average effective speed of light relative to an object, thereby lengthening the interval over which it might change.

The causal chain for time dilation, in this general context, can be summarized as follows: a reduction in c_0 causes time dilation, regardless of the source. Specifically, in kinetic scenarios, w_K causes a reduction in c_0, while in gravitational scenarios, a reduction in c_0 causes w_P.

9.4. Conclusion

In conclusion, the investigation demonstrates that changes in the interval over which change occurs to an object are ultimately caused by a change in c_0 relative to that object, which links to the specific internal energy of the object. This leads to two significant integrations:

1. Kinetic and Gravitational Time Dilation: These are two manifestations of the same underlying causal phenomenon—a reduction in c_0, the speed of causality.
2. Total Specific Energy: A comprehensive total specific energy model must include a specific potential energy term for completeness.

This series of investigations has developed the necessary tools and concepts to address one of the original questions of this investigative series: Is there an objective method to determine the preferred inertial reference frame? This will be the focus of the next and final investigation.

10. Investigation 8: How is the Preferred Frame Determined?

Prior investigations have established that time, when properly conceptualized, is the interval over which change occurs to *things* and is not a separate property of the Universe. This understanding led to the conceptualization of time dilation as a change in the interval over which objects change. Furthermore, it was determined that a preferred frame must exist, leading to the idea that gravity results from a specific internal energy gradient (Equation (59)), which in turn led to discovering the cause of total time dilation (Equation (57)), and subsequently to a complete specific energy model incorporating specific internal energy, specific kinetic energy, and specific potential energy (Equation (58)).

$$\begin{aligned} \frac{dt'}{dt} = \frac{c_0}{c} &= \sqrt{1 - \frac{w_t}{e_T}} = \sqrt{1 - \frac{w_K + w_P}{e_T}} \\ &= \sqrt{1 - \frac{\Delta e_t}{e_T}} = \sqrt{1 - \frac{\Delta e_K + \Delta e_P}{e_T}} \end{aligned} \tag{57}$$

$$\begin{aligned} e_T = \frac{1}{2}c^2 &= e_I + \Delta e_K + \Delta e_P \\ &= \frac{1}{2}c_0^2 + \frac{1}{2}v_p^2 + \int_\infty^r -\nabla e_I dr \end{aligned} \tag{58}$$

$$\vec{g}(r) = -\nabla e_I = -\frac{d(e_I)}{dr}\hat{r} \tag{59}$$

Definition of terms:

- dt' is the interval over which change occurs to an object.
- dt is the interval over which the same change occurs to the object when at rest with respect to the preferred frame and far from gravitational sources.
- The ratio of time derivatives, dt'/dt, termed the *inertial time differential* (ITD), remains constant for any object until specific work, w_K or w_P, is done. Specific work done is conservative in the preferred frame (see Appendix A).
- c_0 is the average effective speed of light relative to an object.
- c is the speed of light in a vacuum relative to the preferred frame, unaffected by gravitational potentials.
- Δe_t is the change in specific total energy of the object.
- w_t is the specific total work done on the object, resulting in Δe_t.
- Δe_K is an object's change in specific kinetic energy relative to the preferred frame.
- w_K is the specific kinetic work done on the object relative to the preferred frame, resulting in Δe_K.
- Δe_P is the change in specific potential energy of the object.
- w_P is the specific work done by gravity on the object, resulting in Δe_P.
- e_T is the total specific energy of the object, $c^2/2$.
- e_I is the specific internal energy of the object, $\frac{1}{2}c_0^2$.
- $\vec{g}(r)$ is the specific gravitational force.
- ∇e_I is the gradient of the object's specific internal energy.

We now revisit an original question in this investigative series: is there a way to objectively determine which inertial reference frame is preferred?

10.1. Defining a Preferred Frame

A preferred frame is the only inertial reference frame that can be considered "still" (no velocity) in the Universe, defined as the frame where the speed of light (in the absence of gravity) is constant in all directions. A preferred frame is apparent in rotational contexts, where it is straightforward to identify the frame with no angular velocity, $\omega_p = 0$. For instance, a simple bucket of water experiment can reveal whether the bucket's reference frame is rotating. If the bucket rotates, the water's surface will form a bowl shape; otherwise, it will remain flat (see Figure 14) (59).

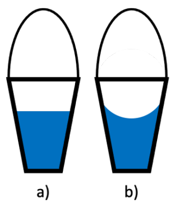

Figure 14: **Water bucket a)** $\omega_p = 0$**. b)** $\omega_p \neq 0$**.**

In contrast, a similar experiment cannot determine if a reference frame has velocity relative to the preferred frame (see Figure 15).

Michelson and Morley attempted to determine Earth's motion relative to the preferred frame by measuring the speed of light at different points in Earth's orbit (14). They instead found that the speed of light appeared constant in any inertial frame (see sections 3 and 5). This indicates that translational velocity is special compared to rotational velocity, where any inertial frame with translational velocity appears stationary, while rotational velocity is more immediately noticeable.

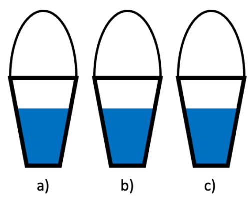

Figure 15: **a)** $|v_p| = 0$ **b)** $|v_p| = 0.5c$ **c)** $|v_p| = 0.\overline{9}c$

Our goal is to design an experiment that can objectively measure motion relative to the preferred frame. Several experiments have been proposed (60) to measure motion relative to the preferred frame, given the correctness of various theories (22). However, a peculiarity of kinetic time dilation is that, despite changes in units of miscalibrated instruments, all reference frames agree on their relative velocities. This suggests why translational velocity is special and nearly impossible to detect given known methods of measurement.

10.2. A Survey of Unit Changes

It is known that any two observers agree on their relative speed (61). Although the units of measurement for space and time change when specific kinetic work is done, measures of relative velocity remains unaffected. This invariance is captured in Equation (60).

$$
\begin{aligned}
&|v_1| = |-v_2| \\
&\frac{dx}{dt} = \frac{dx'}{dt'} \\
&\frac{dt'}{dt} = \frac{dx'}{dx}
\end{aligned}
\tag{60}
$$

Take note that while dt'/dt is the time dilation differential dx'/dx is not length contraction, which assumes no interval of time passes when measuring an interval of length between two different points (see Equation (16)). In Equation (60), dx'/dx does assume a time interval elapsed when measuring an interval of length traversed by a single point.

Using a laser to measure the relative velocity of an object involves measuring dt as the interval of time it took light to travel to the object and back. In the example in Figure 16, suppose the blue object is estimating the range rate of the red object using laser return times, then a minimum of two returns are needed to estimate the range rate. The measured round trip elapse time is the difference in time of emission and time of return, $t_1 - t_0$. Assuming the one-way speed of the laser pulse is c for there and back, then ping1 occurred at a distance, s_1, given by:

$$s_1 = \frac{1}{2}(t_1 - t_0)c \tag{61}$$

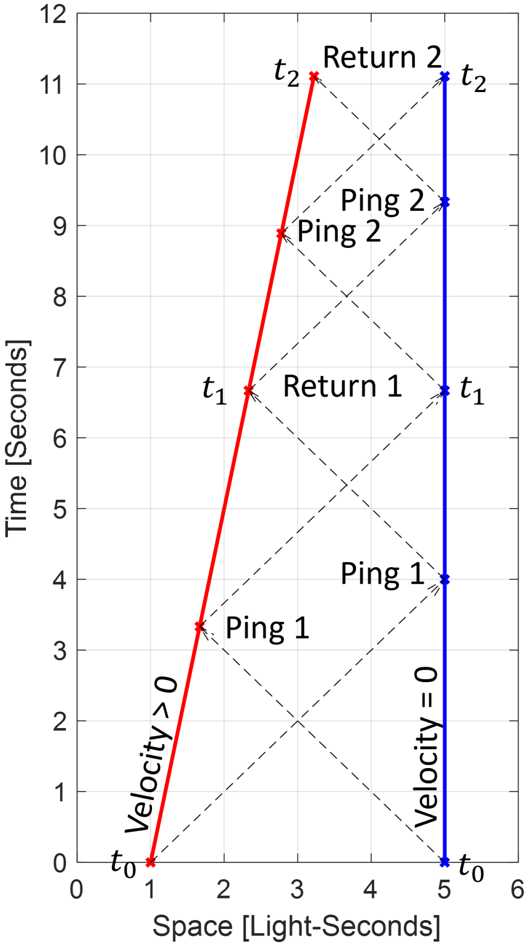

Figure 16: **Estimating velocity using ping returns.**

Given the Galilean geometry of absolute space and time, the red object (if it sent the laser signal at $t0$ as well) experiences a round trip time of of $t_1 - t_0$ as well, but due to time dilation, its measure of t_1 and t_0 are off, represented by the primed symbols, t_1' and t_0' respectively. Their relationship is as expected, $t_1' = \gamma_K^{-1} t_1$ and $t_0' = \gamma_K^{-1} t_0$; therefore, the red object measures an elapsed time of $\gamma_K^{-1}(t_1 - t_0)$, which is less than the blue object measures. Assuming the one-way speed of the laser pulse is c for there and back relative to the red object's frame[11], then the ping1 is measured at a distance, s_1' given by:

[11] A false assumption, but assumed nonetheless.

$$s_1' = \gamma_K^{-1}\frac{1}{2}(t_1 - t_0)c = \gamma_K^{-1}s_1 \tag{62}$$

This same process is repeated to estimate the distance of ping2:

$$s_2 = \frac{1}{2}(t_2 - t_1)c \tag{63}$$

$$s_2' = \gamma_K^{-1}\frac{1}{2}(t_2 - t_1)c = \gamma_K^{-1}s_2 \tag{64}$$

The magnitude of their relative velocity[12], estimated as the change in distance over the change in time, remains consistent regardless of which frame estimates it:

$$|v| = 2\frac{s_2 - s_1}{t_2 - t_0} \tag{65}$$

$$|v'| = 2\frac{s_2' - s_1'}{t_2' - t_0'} = 2\frac{\gamma_K^{-1}(s_2 - s_1)}{\gamma_K^{-1}(t_2 - t_0)} = |v| \blacksquare \tag{66}$$

The ratio of the apparent distance traveled to the apparent elapse time remains unaffected by unit changes, illustrating why relative velocity measurements are invariant.

Attempts to measure the motion relative to a preferred frame typically involve measuring light's speed in various ways (60)(62). These methods have failed because any miscalibrations cancel out in the velocity measurements. To determine the preferred frame, we need a measurement that does not nullify the effects of being in a different reference frame. What is required is a means to observe the unit change caused by specific work done, so that we can calculate an object's velocity in the preferred frame. Then we can relate that object's velocity to everything else using known methods.

10.3. Determining Which Frame is Preferred

To detect the preferred frame, experimenting with acceleration is crucial, as relative observers do not agree on pairwise acceleration estimates (63). In fact, if one takes a closer look at the bucket experiment, one notices that this rotational test also involved acceleration.

We need a test involving translational acceleration. There are two forms of translational acceleration involving unit changes: kinetic and gravitational. Of these, only gravitational acceleration is useful for our purpose.

A kinetic acceleration experiment, such as accelerating a rocket to Alpha Centauri and back (akin to the twin paradox setup), is impractical. It relies on remote measurements using signals that have a velocity, which nullifies the effects we seek to measure. Consequently, this experiment cannot detect the preferred frame.

In contrast, a gravitational acceleration experiment relies solely on local measurements. One possible experiment involves using six identical gravimeters, as illustrated in Figure 17. This setup, if properly configured, can help determine the preferred frame.

According to the gravity model derived in Section 8.2, measurements of $\nabla(dt'/dt)$ relate to gravity as shown in Equation (67):

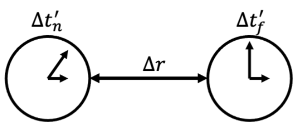

Figure 17: **Gravimeter.**

$$\vec{g}(r) = -2e_T\gamma_g^{-1}\nabla\frac{dt'}{dt} \tag{67}$$

In practice, Equation (67) represents the theoretical value assuming infinitely precise instruments. The measured value, $\hat{g}(r)$, ends up being:

[12]Speed can also be estimated as a change in frequency due to the Doppler effect, but the measured frequency due to the Doppler effect is already known to be a function of relative velocity and not velocity in the medium.

$$\hat{g}(r) = -2e_T \frac{\Delta t'}{\Delta t} \frac{\frac{\Delta t'_f}{\Delta t} - \frac{\Delta t'_n}{\Delta t}}{\Delta r} \hat{r} \tag{68}$$

Assuming $\Delta t' \approx \Delta t'_n$ and $(\Delta t'_n/\Delta t)^2 \approx 1$, Equation (68) simplifies to:

$$\hat{g}(r) \approx -2e_T \frac{\Delta t'_n}{\Delta t} \frac{\frac{\Delta t'_f}{\Delta t} - \frac{\Delta t'_n}{\Delta t}}{\Delta r} \hat{r} = -2e_T \frac{\Delta t'_n}{\Delta t} \frac{\Delta t'_n}{\Delta t'_n} \frac{\frac{\Delta t'_f}{\Delta t} - \frac{\Delta t'_n}{\Delta t}}{\Delta r} \hat{r} = -2e_T \left(\frac{\Delta t'_n}{\Delta t}\right)^2 \frac{\frac{\Delta t'_f}{\Delta t'_n} - \frac{\Delta t'_n}{\Delta t'_n}}{\Delta r} \hat{r} \approx -2e_T \frac{\frac{\Delta t'_f}{\Delta t'_n} - 1}{\Delta r} \hat{r} \tag{69}$$

Using Equation (69), six gravimeters measuring gravitational acceleration, $\hat{g}(r)$, in three orthogonal dimensions (two per dimension) would allow for the determination of the preferred frame. Figure 18 shows the experimental setup.

In this experiment, identical light clocks count cycles of light bouncing back and forth within each gravimeter. As the nearest end of the gravimeter reaches a marked threshold at radius r from the massive object, it tracks the counts from both clocks. The count stops when the gravimeter's nearest end reaches another marked threshold closer to the massive object.

Each gravimeter, calibrated to the same initial inertial frame, assumes Δr is consistent. Variations in $\Delta t'_f/\Delta t'_n$ due to kinetic time dilation are canceled out, leaving variations in $\Delta t'_f/\Delta t'_n$ due to kinetic length contraction at play. When Δr is farther apart for gravimeters moving slower relative to the preferred frame, measures of $\Delta t'_f/\Delta t'_n$ will depart from one more than when Δr is closer together for gravimeters moving faster relative to the preferred frame. This distinction will allow us to estimate how fast the massive object is moving in the preferred frame.

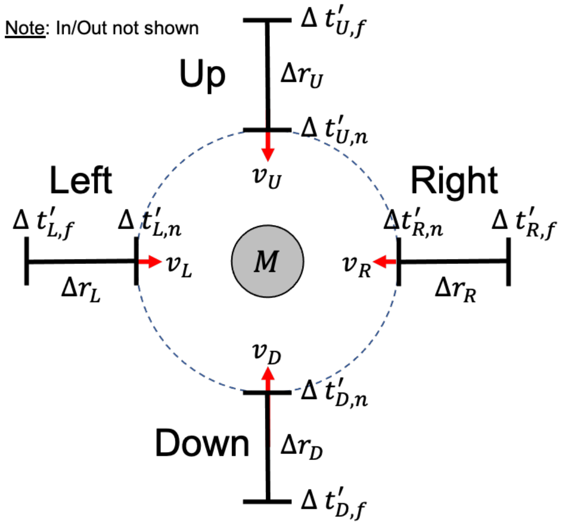

Figure 18: **Experimental setup.**

The gravitational acceleration measurements from the gravimeters would then be compared with simulated results to determine the massive object's velocity relative to the preferred frame. The simulation, detailed in the Appendix E, uses parameters such as:

- Uncalibrated mass of massive object, M, measured in the massive object's frame: 1000 $[Solar\ Masses]$
- Uncalibrated distance between clocks, Δr, measured in the gravimeter's frame: 1 $[km]$
- Uncalibrated distance from center of massive object, r, measured in the massive object's frame: 0.5 $[AU]$
- Uncalibrated speed of gravimeters, $|v|$, measured in the massive object's frame: 0.1 $[fraction\ of\ c]$

Figure 19 displays the simulation results, showing how the massive object's speed relative to the preferred frame affects gravimeter readings.

If the actual experiment yielded gravitational accelerations of 21.75 $\left[\text{ms}^{-2}\right]$ and 24.05 $\left[\text{ms}^{-2}\right]$, it would suggest that the massed object has a velocity of $0.5c$ relative to the preferred frame in the direction of the gravimeter that measured 21.75 $\left[\text{ms}^{-2}\right]$.

Practically, three probes in highly elliptical orbits around the Sun, whose semi-major axes are all mutually orthogonal, could be used to determine how fast the sun is moving relative to the preferred frame. Over time, integrating the data collected, from multiple passes for each of the six directions towards the sun, would eventually reveal the preferred frame as the counts between near and far clocks widen.

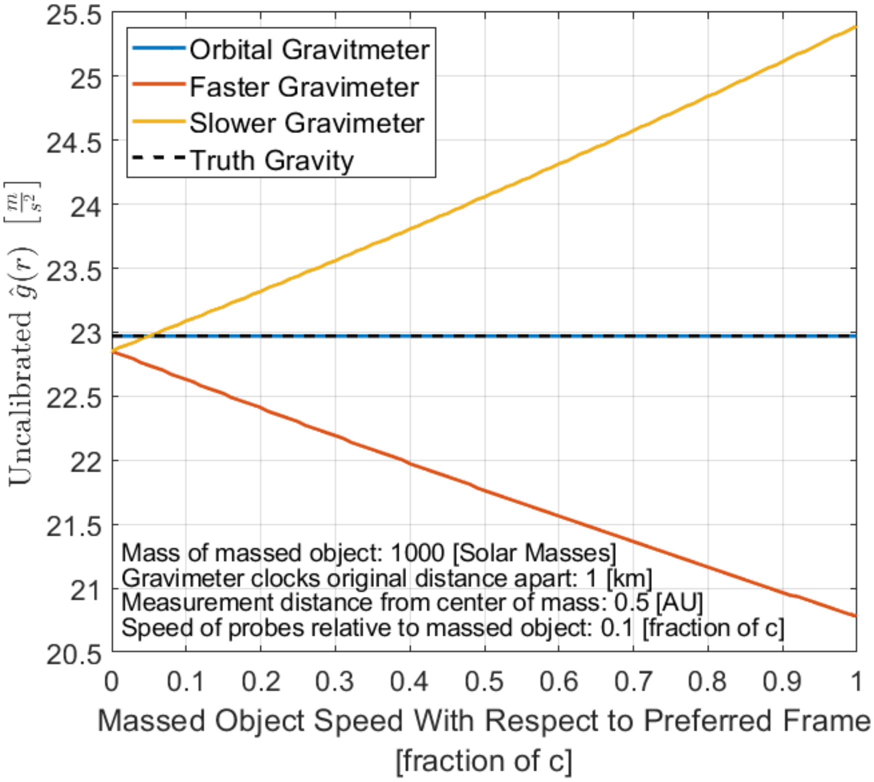

Figure 19: Simulated results.

10.4. Conclusion

In conclusion, detecting the preferred frame is feasible through experiments that utilize gravitational acceleration and local measurements. The proposed experiment with gravimeters near a massive object can effectively verify the existence of a preferred frame, supporting the validity of universal specificity over relativity.

11. Conclusion

This paper has explored the concept of a preferred frame of reference in the context of the speed of light, time dilation, specific energy, and gravitation. By using Peikoff's method of induction and applying Mill's Method, we proposed a mechanistic counterpart to Einstein's relativity, highlighting the possibility of detecting a preferred frame through gravitational experiments.

Our investigation established that time is fundamentally an interval over which change occurs to things rather than a separate property of the Universe, which has been instrumental in shaping our understanding. This conceptualization led to the redefinition of time dilation as a change in the interval over which physical changes occur to things. Building on this, we established that a preferred frame of reference must exist. This insight allowed us to identify the cause of kinetic time dilation, as shown in Equation (45), and derive a specific energy model, detailed in Equation (55).

Furthermore, we identified the cause of gravitational time dilation, as presented in Equation (47), leading to the understanding that gravity results from a gradient in an object's specific internal energy, described by Equation (48). This lead to the discovery that kinetic and gravitational time dilation are the same effect with a common cause described by Equation (57). These findings not only reinforce the concept of a preferred frame but also offer a new perspective on the mechanisms underlying time dilation, specific energy, and gravity.

Additionally, our investigation demonstrates that gravitational acceleration experiments, particularly those using gravimeters, offer a viable method for identifying which frame is preferred. The analysis and simulations conducted show that, under appropriate conditions, the measurements of gravitational acceleration can reveal the velocity of a massive object relative to this preferred frame. This finding has profound implications for our understanding of the fundamental nature of time and space.

The results indicate that such experiments are feasible with current technology and could be implemented using gravimeters in highly elliptical orbits around massive bodies like the Sun. The insights gained from these measurements could challenge or validate existing theories and pave the way for new theoretical developments in physics.

11.1. Future Work

Several avenues for future research emerge from this study:

1. Experimental Verification: The most immediate next step is to conduct real-world experiments using gravimeters to verify the theoretical predictions made in this paper. Such experiments should focus on refining measurement techniques and accounting for potential sources of error to enhance accuracy.
2. Extended Simulations: Further simulations could explore a broader range of scenarios, including varying the mass of the test objects, different orbital configurations, and other dimensions beyond those considered in this study. This would help in understanding the robustness of the proposed method and in addressing any unforeseen complexities.
3. New Investigations: Future investigations into the causes of changes in permeability and permittivity of free space could land on insights into a unified field theory and producing artificial gravity or neutralizing existing gravitational effects, paving the way to improve transportation and lift capabilities.
4. Broader Implications: Investigating how the concept of a preferred frame affects other physical phenomena and theories could provide deeper insights into the nature of space, time, and gravity. This includes exploring potential implications for space travel, cosmology, and high-energy physics.

By pursuing these directions, we can further elucidate the nature of time dilation, refine our understanding of specificity, and potentially uncover new principles that govern reality.

12. Declaration of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work the author used ChatGPT in order to to improve the spelling, grammar, clarity and conciseness of the content within. After using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the content of the published article.

13. Funding Sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

A. properties of specific work

The properties of specific work discussed in this appendix are as follows:

- Specific work done can be positive or negative.
- Specific work is the sum of its orthogonal components.
- Total specific work done is the sum of a set of isolated incidents of specific work done.
- Specific work done is conservative.

In any isolated incident of specific work done, it is positive when an object is accelerating with respect to the preferred frame, and negative when an object is decelerating. The reason is that the components used to calculate specific work are vectors, e.g., net specific force and the direction of travel, as shown in Equation (A1).

$$w = \mathbf{a} \cdot \mathbf{s} \tag{A1}$$

Additionally, any isolated incident of specific work done is the sum of each spatial dimension's specific work done, as shown in Equation (A2).

$$\begin{aligned} w &= w_x + w_y + w_z \\ w &= \mathbf{a_x} \cdot \mathbf{s_x} + \mathbf{a_y} \cdot \mathbf{s_y} + \mathbf{a_z} \cdot \mathbf{s_z} = \mathbf{a} \cdot \mathbf{s} \ \blacksquare \end{aligned} \tag{A2}$$

When it comes to combining a set of isolated incidents of work being done, the total specific work done is the sum of the set of isolated incidents. As an example, suppose earth's reference frame is the preferred frame for the twin paradox scenario. The twin accelerating away from earth is the result of positive specific work done. The twin decelerating to a stop at the turnaround point is the result of negative specific work done. The net effect at this point of the scenario is that the positive and negative specific work combines and cancels exactly—total specific work done is zero. The same goes for the return trip.

The net effect of all these properties is that specific work done is conservative to any inertial reference frame. This means when any object returns back to its original state (position and velocity), then the total specific work done is zero, regardless of the path taken. Additionally, when any object goes from one frame to another, the same amount of specific work is done, regardless of the path taken. This is why objects in the same frame are always synchronized temporally—e.g., it is impossible for one twin to "progress through time" slower than the other, when they are both in the same reference frame at the same time.

Specific work being conservative means we do not need to know the entire history of work done to evaluate the total specific work done. All that is required is to evaluate what specific work is required to change from one reference frame to another.

B. Gravitoelectromagnetism Equations

Using complex numbers is an intelligent means to represent orthogonal effects, which allows gravitation and EM to be combined into a single set of equations. The first step was to convert charge into unit mass, M_e, via a scaling factor as shown below (51):

$$M_e \triangleq \frac{q}{\sqrt{4\pi\varepsilon_0 G}}, \frac{1C}{\sqrt{4\pi\varepsilon_0 G}} \approx 1.16042 \times 10^10 \, kg \tag{B1}$$

We can see that this form fits into Newton's law of gravitation except for the leading sign being positive instead of negative (51):

$$\vec{F}_e = \frac{1}{4\pi\varepsilon_0]} \frac{q_1 q_2}{r^2} \hat{r} = +G \frac{M_{e1} M_{e2}}{r^2} \hat{r} \tag{B2}$$

This positive sign is resolved by interpreting mass and charge as being mutually orthogonal in a complex plain, by the property $-1 = i^2$. This orthoginal coupling is consistent with what the investigations within this paper found. Gravitational fields acts parallel to light's velocity vector, when c_0 changes, while EM fields acts perpendicular to light's velocity vector. This allows ordinary mass, $M_g = m$, to relate to charge, $M_e = q/\sqrt{4\pi\varepsilon_0 G}$ in the following way (51):

$$M = M_g + iM_e = m + i\frac{q}{\sqrt{4\pi\varepsilon_0 G}} \tag{B3}$$

This imaginary mass has nothing to do with tachyons, as is typical with this notation (64)(65), rather it simply represents the orthogonal characteristics between gravitation and EM (51). The GEM version as an analogy is as follows (51):

$$\begin{aligned}
&\nabla\cdot\vec{G}_g = -4\pi G\rho_g && \nabla\cdot\vec{E} = \frac{\rho'}{\varepsilon_0}\\
&\nabla\cdot\vec{B}_g = 0 && \nabla\cdot\vec{B} = 0\\
&\nabla\times\vec{G}_g = -\frac{\partial\vec{B}_g}{\partial t} && \nabla\times\vec{E} = -\frac{\partial\vec{B}}{\partial t}\\
&\nabla\times\vec{B}_g = -\frac{4\pi G}{c^2}\vec{J}_g + \frac{1}{c^2}\frac{\partial\vec{G}_g}{\partial t} && \nabla\times\vec{B} = -\frac{1}{\varepsilon_0 c^2}\vec{J}' + \frac{1}{c^2}\frac{\partial\vec{E}}{\partial t}
\end{aligned} \tag{B4}$$

Applying the charge to mass conversions consistent with Equation (B1) yields the following change of variables, where ρ_e and $\vec{J}_e$ are charge density and electric current converted into mass density and mass current, and $\vec{G}_e$ and $\vec{B}_e$ are EM fields converted into GEM fields (51):

$$\begin{aligned}
&\rho_e \triangleq \frac{\rho'}{\sqrt{4\pi\varepsilon_0 G}} && \vec{J}_e \triangleq \frac{\vec{J}'}{\sqrt{4\pi\varepsilon_0 G}}\\
&\vec{G}_e \triangleq -\sqrt{4\pi\varepsilon_0 G}\vec{E} && \vec{B}_e \triangleq -\sqrt{4\pi\varepsilon_0 G}\vec{B}
\end{aligned} \tag{B5}$$

With these conversions the asymmetries between GEM and EM can be eliminated (51):

$$\begin{aligned}
&\nabla\cdot\vec{G}_g = -4\pi G\rho_g && \nabla\cdot\vec{G}_e = -4\pi G\rho_e\\
&\nabla\cdot\vec{B}_g = 0 && \nabla\cdot\vec{B}_e = 0\\
&\nabla\times\vec{G}_g = -\frac{\partial\vec{B}_g}{\partial t} && \nabla\times\vec{G}_e = -\frac{\partial\vec{B}_e}{\partial t}\\
&\nabla\times\vec{B}_g = -\frac{4\pi G}{c^2}\vec{J}_g + \frac{1}{c^2}\frac{\partial\vec{G}_g}{\partial t} && \nabla\times\vec{B}_e = -\frac{4\pi G}{c^2}\vec{J}_e + \frac{1}{c^2}\frac{\partial\vec{G}_e}{\partial t}
\end{aligned} \tag{B6}$$

Next the complex number i is multiplied by Maxwell's equations of EM to impose the orthogonality between gravitation and EM, such that (51):

$$\begin{aligned}
&\rho = \rho_g + i\rho_e && \vec{J} = \vec{J}_g + i\vec{J}_e\\
&\vec{G} = \vec{G}_g + i\vec{G}_e && \vec{B} = \vec{B}_g + i\vec{B}_e
\end{aligned} \tag{B7}$$

Given the linear properties of the $\nabla\cdot$ (divergence) and $\nabla\times$ (curl), Equation (B6) can be into a single set below, by using the generalized quantities in Equation (B7) (51).

$$\begin{aligned}
\nabla \cdot \vec{G} &= -4\pi G\rho \\
\nabla \cdot \vec{B} &= 0 \\
\nabla \times \vec{G} &= -\frac{\partial \vec{B}}{\partial t} \\
\nabla \times \vec{B} &= -\frac{4\pi G}{c^2}\vec{J} + \frac{1}{c^2}\frac{\partial \vec{G}}{\partial t} \blacksquare
\end{aligned} \tag{B8}$$

These equations combine both gravitational and EM fields into a unified set of equations, and whether Equation (B8) could well represent EMG is an interesting question to look into, and we are better prepared to investigate this now than ever before, but it will have to wait for a future investigation.

C. Kinetic Effects on Gravity

This appendix section considers the kinetic effects on gravitational forces, specifically kinetic time dilation effects. Suppose we managed to craft four Osnium[13] orbs, each having the same shape and size. Assuming each orb has a radius of 0.1 $[m]$, then the rest mass of each would be identical and roughly 92 $[kg]$. The first pair of orbs are setup stationary in the preferred frame with an initial distance of 100 $[m]$ between their center of masses. It would take about four months, in the orb's proper time, for their gravitational forces to bring them into contact.

Now, suppose the other pair of orbs were sent away, in the twins paradox fashion, but otherwise the same initial conditions.[14] Supposing they returned at the moment the preferred frame orbs touched, then the traveling orbs, being "younger" due to kinetic time dilation, would not be touching, as shown in Figure 20.

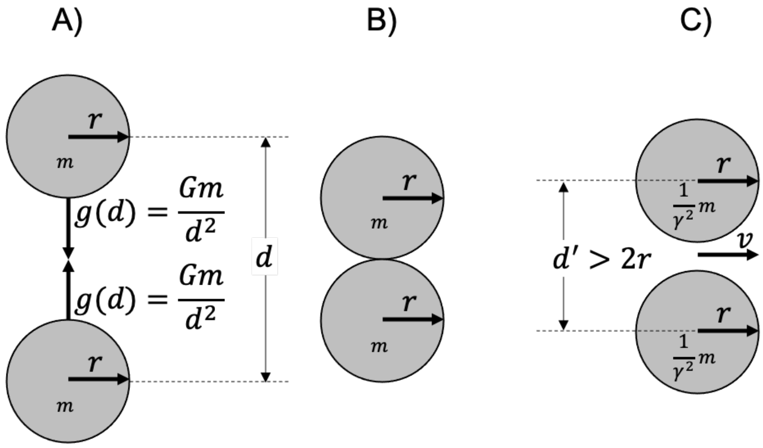

Figure 20: A) Initial conditions. B) Preferred orbs after four months. C) Traveling after four months.

These results suggest to me that the inertia of the traveling orbs increased (assuming the force of gravity remained the same), but to what? Through testing, it was found that the resulting increase in inertia is $\gamma_K^2 m_0$. This result makes intuitive sense, because distance traversed during gravitational acceleration is related to time squared, and the interval over which change occurs in the traveling frame is longer than the interval over which an equivalent change occurs in the preferred frame by a factor of γ_K. This can be seen analytically by studying displacement perpendicular to velocity of the system, s_y, as a function of gravitational acceleration, as shown in Equation (C1).

$$s_y = s'_y$$

[13] Atomic number 76.

[14] With the distance between their center of masses being orthogonal to the velocity direction.

$$
\begin{aligned}
t &= \gamma_K t' \\
s_y &= \frac{1}{2} g(r) t^2 \\
s'_y &= \frac{1}{2} g'(r) t'^2 \\
\therefore g(r) &= \gamma_K^{-2} g'(r) \blacksquare
\end{aligned}
\tag{C1}
$$

Studying displacement parallel to velocity of the system, s_x, as a function of gravitational acceleration, as shown in Equation (C2).

$$
\begin{aligned}
s_x &= \frac{1}{\gamma_K} s'_x \\
t &= \gamma_K t' \\
s_x &= \frac{1}{2} g(r) t^2 \\
s'_x &= \frac{1}{2} g'(r) t'^2 \\
\therefore g(r) &= \gamma_K^{-3} g'(r) \blacksquare
\end{aligned}
\tag{C2}
$$

If one is just concerned with the time difference in which the two pairs of orbs touch, then one ignores $s_x = \gamma_K^{-1} s'_x$ in Equation (C2), resulting in $g(r) = \gamma_K^{-2} g'(r)$, which is as before with Equation (C1).

Suppose we conducted another similar experiment; however, for this experiment two new orbs are crafted just like the others, except their radii are reduced to grantee that their mass, m'_0, equals $\gamma_K^{-2} m_0$. Let these new smaller orbs take the place of the stationary orbs. Given this new setup, we would find that upon the traveling orbs return, both pairs of orbs would be the same distance closer.

I actually simulated several trials of such an experiment, numerically solving for the dynamics in each reference frame, and the code is provided in Appendix D. Each trial had the same velocity for the traveling orbs, but each trial tested different return times. At the end of each trial, I compared the two pairs of orbs to see if each traveled the same distance. The results are presented in Figure 21.

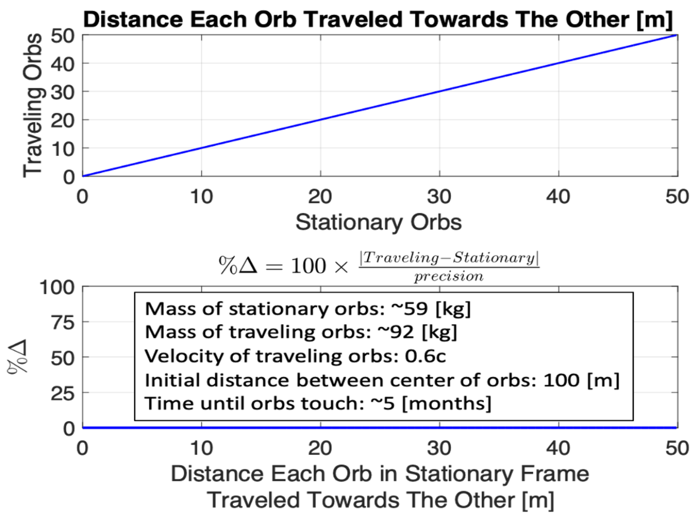

Figure 21: Results of experiments.

The two pairs of orbs had the same gravitational behavior. Therefore, invoking the method of agreement, whereby the same gravitational effect occurred in both cases, proves inductively that gravitational effects reduce (when the source of the gravitational potential is not stationary), by a factor of γ_K^{-2}.

D. Matlab Code: Kinematic Effects on Gravitation

```
%% constants and functions
G                   = 6.6744e-11; % [m^3/(kg s)] gravitational constant
gamma               = @(v) 1./sqrt(1-v.^2);
seconds2months      = 12/60^2/24/365;

%% Traveling orbs
% initial conditions
rho     = 22000;        % [kg/m^3] density of osmium
r       = 1e-1;         % [m]      radius of each orb
vol     = 4*pi*r^3/3;   % [m^3]    volume of each orb
m       = rho*vol;      % [kg]     mass of each orb
d       = 1e2;          % [m]      initial distance between orbs' surfaces
d_min   = 2*r;          % [m]      minimum distance between center mass of orbs
gd1     = 2*G*m/(d);    % [J/kg]   initial relative xspecific potential energy
v       = 0.6;          % [-]      fraction of the speed of light of orbs
gamma_v = gamma(v);     % [-]      1/sqrt(1-v^2/c^2)

% initialize other variables
dy  = (d-d_min)/1e4;      % increment steps to numerical solution
ds  = d:-dy:d_min;        % all numerical steps
gds = ones(size(ds))*gd1;% specific potential energy
vs  = zeros(size(ds));    % relative velocity of orbs
ts  = zeros(size(ds));    % proper time passed

% incremental solution of orb pairs relative velocity and time passed
for id = 2 : length(ds)
    % this relative specific potential energy for orbs
    gds(id) = 2*G*m/(ds(id));

    % delta relative specific potential energy for orbs
    delta_gd = gds(id)-gd1;

    % relative velocity between them
    vs(id) = sqrt(2*delta_gd);

    % time for distance to close by mean relative velocity
    ts(id) = ts(id-1) + dy/mean([vs(id),vs(id-1)]);
end

% total passage of proper time until orbs contact in years and months
total_time_months = max(ts)*seconds2months;

%% Stationary orbs
my      = m/gamma_v^2; % [kg]   mass of stationary orb is traveling orb's mass
gd1_my  = 2*G*my/(d);  % [J/kg] initial specific potential energy

% time passed, as measured by stationary orbs
ts_gamma = ts*gamma_v;

% total passage of proper time until orbs contact in years and months
total_time_months_my   = max(ts_gamma)*seconds2months;
```

```

% initialize stationary orbs with mass my distance steps
dy_my = dy;              % increment steps to numerical solution
ds_my = d:-dy_my:d_min; % all numerical steps

% initialize other variables
vs_my  = zeros(size(ds_my));
gds_my = ones(size(ds_my))*gd1_my;
ts_my  = zeros(size(ds_my));

% incremental solution of orb pairs relative velocity and time passed
for id = 2 : length(ds_my)
    % this relative specific potential energy
    gds_my(id) = 2*G*my/(ds_my(id));

    % delta relative specific potential energy
    delta_gd_my = gds_my(id)-gd1_my;

    % relative velocity between them
    vs_my(id) = sqrt(2*delta_gd_my);

    % time for distance to close by mean relative velocity
    ts_my(id) = ts_my(id-1) + dy_my/mean([vs_my(id),vs_my(id-1)]);
end

%% Plot Results
figure(1);
% plot the movement of each orb makes towards its pair
subplot(2,1,1)
plot((d-ds)/2,(d-interp1(ts_my,ds_my,ts_gamma))/2,'-b','LineWidth',1.5)
xlim([0 d/2]);
ylim([0 d/2]);
grid on
xlabel('Stationary Orbs','FontSize',20);
ylabel('Traveling Orbs','FontSize',20);
title({'Distance Each Orb Traveled Towards The Other [m]'},'fontsize',16);

% plot the percent difference in movement between pairs of orbs
percent_difference = 100*abs((d-interp1(ts_my,ds_my,ts_gamma))/2 - (d-ds)/2)
    ./(dy);
subplot(2,1,2)
plot((d-ds)/2,percent_difference,'-b','LineWidth',2)
xlim([0 d/2]);
ylim([0 100]);
grid on
xlabel({'Distance Each Orb in Stationary Frame'...
    ,'Traveled Towards The Other [m]'},'FontSize',20);
ylabel({'\%$\Delta$'},'FontSize',20,'Interpreter','latex');
title({'\%$\Delta=100\times\frac{|Traveling-Stationary|}{precision}$'}...
    ,'Interpreter','latex','fontsize',16);

% print ellapsed proper (AAK wall) time for each pair or orbs
```

```
fprintf('Elapsed Time for Traveling Orbs: %0.1f [months]\n',total_time_months);
fprintf('Elapsed Time for Stationary Orbs: %0.1f [months]\n',total_time_months_my);
```

E. Matlab Code: Detecting the Preferred Frame

```
% Code designed to demonstrate detection of preferred frame
function preferred_frame_detection_via_g()
%% initializations, constants and simple functions
% initialization
clear all
clc
close all

% constants
c    = 299792458;  % [m/s] speed of light
G    = 6.6744e-11; % [m^3/(kg s)] gravitational constant
Me   = 5.97219e24; % [kg] earth's mass
Ms   = 333000*Me;  % [kg] sun's mass
e_T  = 0.5*c^2;    % [m^2/s^2] specific total energy
AU   = 152.03e9;   % [m] distance from sun to earth

% simple functions
r_s            = @(M) G*M/e_T;
gamma_inv_K    = @(v) 1./sqrt(1-v.^2);
add_vel        = @(v1_in,v2_in) (v1_in+v2_in)/(1 + v1_in*v2_in);
r_2_gravObj    = @(M,r) G*M/r^2;
gamma_inv_P    = @(M,r) sqrt(1-r_s(M)./r);
gravimeter     = @(dtnear_dtfar,dr) (2*e_T/dr)*(1/dtnear_dtfar-1);
prop_dist      = @(M,r1,r2) (r2*gamma_inv_P(M,r2) + 0.5*r_s(M)*log(2*r2*(gamma_inv_P(M,r2)+1)-r_s(M))) ...
    - (r1*gamma_inv_P(M,r1) + 0.5*r_s(M)*log(2*r1*(gamma_inv_P(M,r1)+1)-r_s(M)));

%% experiement: travel two gravimeters (probes) towards center of massed object (MO)
% set conditions (in MO's frame)
M_MO          = 1e3*Ms; % [kg] mass of object at center of experiment
r_measure     = AU/2;   % [m] nearest clock distance from center of MO
probe_dv      = 0.1;    % [frac of c] speed of probes relative to MO
dr_orb_MO_0   = 1e3;    % [m] clocks distance apart when stationary in zero gravity

% initialize
gr_orbit_all  = [];
gr_probe1_all = [];
gr_probe2_all = [];

% loop through range of MO velocities
v_obj_all = [0:0.01:0.99 0.99:0.001:0.999]; % [frac of c] speed of MO (in preferred frame)
for ivo = 1 : length(v_obj_all)
```

```
    % (in preferred frame)
    v_obj          = v_obj_all(ivo);              % [frac of c] velocity of MO
    v_p1           = add_vel(v_obj,probe_dv);     % [frac of c] velocity of probe1
    v_p2           = add_vel(v_obj,-probe_dv);    % [frac of c] velocity of probe2
    drPF_drp_obj   = gamma_inv_K(v_obj);          % [-] kinetic differential for MO
    drPF_drp_p1    = gamma_inv_K(v_p1);           % [-] kinetic differential for probe1
    drPF_drp_p2    = gamma_inv_K(v_p2);           % [-] kinetic differential for probe2
    drp_p1_drp_obj = drPF_drp_obj/drPF_drp_p1; % [-] kinetic differential WRT MO
    drp_p2_drp_obj = drPF_drp_obj/drPF_drp_p2; % [-] kinetic differential WRT MO

    % determine miscalibration effects on grivimeters (in MO frame)
    r2        = solve_for_r2(M_MO,r_measure,dr_orb_MO_0);
    dr_orb_MO = (r2-r_measure);             % [m] clocks distance apart in gravity, no velocity
    dr_p1_MO  = dr_orb_MO*drp_p1_drp_obj; % [m] clocks distance apart in gravity with velocity
    dr_p2_MO  = dr_orb_MO*drp_p2_drp_obj; % [m] clocks distance apart in gravity with velocity

    % determine effects on gravimeter from orbit of MO (in MO frame)
    r_f_orbit     = r_measure+dr_orb_MO;                        % [m] farthest clock distance to MO
    r_n_orbit     = r_measure;                                  % [m] nearest clock distance to MO
    dtn_dtf_orbit = frames_dtn_dtf(M_MO,r_f_orbit,r_n_orbit); % [-] clock differential
    g_m_orbit     = gravimeter(dtn_dtf_orbit,dr_orb_MO);        % [m/s^2] measured g

    % determine effects on gravimeter from probe 1 (in MO frame)
    r_f_probe1     = r_measure+dr_p1_MO;                          % [m] farthest clock distance to MO
    r_n_probe1     = r_measure;                                   % [m] nearest clock distance to MO
    dtn_dtf_probe1 = frames_dtn_dtf(M_MO,r_f_probe1,r_n_probe1); % [-] clock differential
    g_m_probe1     = gravimeter(dtn_dtf_probe1,dr_orb_MO);        % [m/s^2] measured g

    % determine effects on gravimeter from probe 2 (in MO frame)
    r_f_probe2     = r_measure+dr_p2_MO;                          % [m] farthest clock distance to MO
    r_n_probe2     = r_measure;                                   % [m] nearest clock distance to MO
    dtn_dtf_probe2 = frames_dtn_dtf(M_MO,r_f_probe2,r_n_probe2); % [-] clock differential
```

```
    g_m_probe2      = gravimeter(dtn_dtf_probe2,dr_orb_MO);       % [m/s^2] measured g

    % store results
    gr_orbit_all  = [gr_orbit_all g_m_orbit];
    gr_probe1_all = [gr_probe1_all g_m_probe1];
    gr_probe2_all = [gr_probe2_all g_m_probe2];
end

% plot results
fig = figure(1);
hold off
plot(v_obj_all, gr_orbit_all,'LineWidth',2);
hold on
plot(v_obj_all, gr_probe1_all,'LineWidth',2);
plot(v_obj_all, gr_probe2_all,'LineWidth',2);
plot([v_obj_all(1) v_obj_all(end)], [r_2_gravObj(M_MO,r_measure) r_2_gravObj(M_MO,r_measure)],'k--','LineWidth',2)

% clean up plot
legend('Orbital Gravitmeter','Faster Gravimeter','Slower Gravimeter','Truth Gravity','FontSize',16,'location','NW');
xlabel({'Massed Object Speed With Respect to Preferred Frame','[fraction of c]'},'FontSize',16);
ylabel('Uncalibrated $\hat{g}(r)~\left[\frac{m}{s^2}\right]$','FontSize',16,'Interpreter','latex');
grid on
xticks([0:.1:1]);
a = get(gca,'XTickLabel');
set(gca,'XTickLabel',a,'fontsize',16)
annotation(fig, 'textbox', [.13 .10 .8 .2], 'String'...
    ,sprintf('Mass of massed object: %d [Solar Masses]',M_MO/Ms)...
    ,'EdgeColor','none','FontSize',14);
annotation(fig, 'textbox', [.13 .07 .8 .2], 'String'...
    ,sprintf('Gravimeter clocks original distance apart: %d [km]',dr_orb_MO_0/1e3)...
    ,'EdgeColor','none','FontSize',14);
annotation(fig, 'textbox', [.13 .04 .8 .2], 'String'...
    ,sprintf('Measurement distance from center of mass: %0.1f [AU]',r_measure/AU)...
    ,'EdgeColor','none','FontSize',14);
annotation(fig, 'textbox', [.13 .01 .8 .2], 'String'...
    ,sprintf('Speed of probes relative to massed object: %0.1f [fraction of c]',probe_dv)...
    ,'EdgeColor','none','FontSize',14);

%% supporting function
    function dtn_dtf = frames_dtn_dtf(M,r_f,r_n)
        % (in MO frame)
        dt_f      = gamma_inv_P(M,r_f);    % time dilation of clock farthest from MO
        dt_n      = gamma_inv_P(M,r_n);    % time dilation of clock nearest to MO
```

```
        dtn_dtf    = dt_n/(dt_f);     % relative time differential between
            closest and farthest clock
    end

    function r2 = solve_for_r2(M,r1,dr)
        % initial guess
        r2_upper = r1 + 2*dr;
        r2_lower = r1;
        r2 = (r2_lower + r2_upper)/2;
        dr_guess = prop_dist(M,r1,r2);
        error = dr_guess - dr;
        while (1e-9 < abs(error) || dr/(2^25) > abs(r2_upper-r2_lower))
            if 0 < error
                r2_upper = r2;
            else
                r2_lower = r2;
            end
            r2 = (r2_lower + r2_upper)/2;
            dr_guess = prop_dist(M,r1,r2);
            error = dr_guess - dr;
        end
    end
end
```

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