The Law of Universal Specificity

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Abstract—**The Law of Universal Specificity quantifies the causal relationship between changes in total specific energy and time dilation. This law was the result of a path taken to induce the cause of kinetic time dilation and relate this cause to gravitational time dilation. These two sources of time dilation, previously understood to arise from two unrelated phenomena, are proved inductively in this paper to be causally related. It is demonstrated that changes in specific energy cause changes in time dilation, and changes in time dilation, from what is termed a time derivative gradient, causes changes in specific energy. In other words, kinetic time dilation and gravitational time dilation are causal reciprocals of each other—the former caused by specific work done and the latter causing specific work being done. This discovery required a new causal framework to induce a causal model of relativity, which meant foregoing previously accepted assumptions (which were used as a basis to build the legacy models), and instead follow the chain of available evidence via inductive proofs without accepting non-validated assumptions. It was discovered that the resulting conclusions are on significantly firmer footing, having a validated basis from which to draw conclusions and construct this relativistic causal model, which the legacy models lacked. This is not to say the legacy models are false, in the sense that they fail at predictions (not any more than Ptolemy's models failed to predict planetary motion); however, that is to say they lacked a consistent integrated causal footing, relatively speaking, as is demonstrated, which results in poor explanations for observed phenomena.**

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1. INTRODUCTION

The Law of Universal Specificity quantifies the causal relationship between changes in total specific energy and time dilation. In one sense, it revolutionizes how we think of relativity, in another it is only an adjustment of relativity's legacy model to a more consistently causal model. The legacy model is primarily a descriptive model, in that it makes certain assumptions and deduces a model consistent with observations. The power in transforming to a more consistently causal model is the ability to avoid having to make non-validated assumptions; therefore, one gains certainty in their foundation, when previously there was none, and it creates a new ability to discover new casual relationships that would be impossible otherwise.

The main difference in method between Einstein's derivations and those contained in this paper is a difference between deductive proof and inductive proof, respectively. Einstein used a deductive process, which required making assumptions to serve as premises from which conclusions—i.e., the legacy models—can be deduced. Some of these assumptions were not validated beforehand; and others required a revisit after conclusions were deduced—this never happened. For special relativity, Einstein assumed light speed is constant, velocity is relative (impossible to tell who is moving), and all non-accelerating reference frames are as good as any other. For general relativity, Einstein made an additional non-validated equivalence principle assumption: that an $9.81[m/s]$ accelerating reference frame on a rocket in deep space is equivalent to a reference frame on earth. This effectively got rid of gravity as a force causing motion, since free falling is considered inertial (or non-accelerating). So long as the legacy descriptive models, and their assumptions, continues to be consistent with observation, they continue to be accepted.

In contrast, inductive proofs do not need to make use of non-validated assumptions, so this paper does not make use of them in its proofs, and it revisits other assumptions that seemed valid until relativistic conclusions were drawn. Controlled thought experiments are leveraged to reveal which factors are the cause to an effect, and which are not. Then once a cause-effect relationship is discovered, it is used to deduce implications and to induce deeper causal relationships.

Descriptive Model Analogy

As an analogy, the relationship of a descriptive model to a causal model might be thought of as manipulating a causal equation until the causes involved are no longer recognizable. For a simple tractable example, consider what happens when this happens to the conservation of momentum equation, which states that for a closed system the total momentum before an interaction is the same as the total momentum after an interaction. Observe the result after mild manipulation, as shown in Equation (1) for two bodies before and after a collusion.

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$$p_1 + p_2 = p_3 + p_4 \tag{1a}$$
$$m_1 v_1 + m_2 v_2 = m_1 v_3 + m_2 v_4 \tag{1b}$$
$$m_1 \frac{\Delta x_1}{\Delta t} + m_2 \frac{\Delta x_2}{\Delta t} = m_1 \frac{\Delta x_3}{\Delta t} + m_2 \frac{\Delta x_4}{\Delta t} \tag{1c}$$
$$m_1 \Delta x_1 + m_2 \Delta x_2 = m_1 \Delta x_3 + m_2 \Delta x_4 \tag{1d}$$
$$m_1(\Delta x_1 - \Delta x_3) = m_2(\Delta x_4 - \Delta x_2) \tag{1e}$$
$$\frac{m_1}{m_2} = \frac{\Delta x_4 - \Delta x_2}{\Delta x_1 - \Delta x_3} \tag{1f}$$
$$\frac{m_1 gh}{m_2 gh} = \frac{(\Delta x_4 - \Delta x_2)}{(\Delta x_1 - \Delta x_3)} \tag{1g}$$
$$\frac{E_{P1}}{E_{P2}} = \frac{(\Delta x_4 - \Delta x_2)}{(\Delta x_1 - \Delta x_3)} \tag{1h}$$

Where :

E_{Pi} is the i^{TH} object′s potential energy

Δx_1 is the distance covered in some time interval for object 1 before collusion

Δx_2 is the distance covered in some time interval for object 1 after collusion

Δx_3 is the distance covered in some time interval for object 2 before collusion

Δx_4 is the distance covered in some time interval for object 2 after collusion

p is momentum

m is mass

v is velocity

Δt is some time interval

In this form, Equation (1h) out of context loses all meaning. After all, what does a potential energy ratio between two objects have to do with distances covered, in some time interval, before and after a collision? But if you measure and input the right variables, this meaningless descriptive model will be an impeccable predictor. Suppose you discovered this descriptive model isolated from any concept of conservation of momentum, then what could possibly be the next step in scientific progress?

Learning from History: A Historical View Point

This would not be the first time in history that a well predicting descriptive model was replaced by a more consistently causal model to great effect and advancement. Nor will it be the last. There seems to be a great need to start somewhere, and a descriptive model is a great place to start, supposing insufficient evidence is available to induce a causal model. Perhaps the greatest contrast in history, between a legacy and a causal model, is the earth centered descriptive planetary model vs the sun centered causal planetary model—i.e., Ptolemy's vs Kepler's planetary model.

Ptolemy assumed earth was fixed, a good starting place since it appears that way. Then he deduced a planetary model where the Planets revolved around the stationary earth. An additional assumption was made: planets move in circles, which it certainly appears that way when tracking them across the night sky over time. With these assumptions, Ptolemy deduced the math required for his model to accurately describe observations with a veneer of a casual explanation—e.g., planets move in circles around earth *because* the earth is fixed, which then causes what we observe.

Ptolemy also updated his assumptions, and model, to account for new observations that did not quite match the prior version of the model. In the end, he was able to predict planetary circular motion about an empty point in space, and this space's circular motion about another empty point near earth, and this second empty point circling around earth. Thus, his assumptions and descriptive model were able to remain consistent with observation.

With a detailed table, people were able (still are if they know how) to use his model to make amazing predictions, which only served to entrenched his descriptive model for over a millennium. The domain of astronomy stagnated for just as long because they lacked a causal understanding for their observations, and they did not know they lacked it—after all the assumptions remain consistent with observations. This is where the deductive approach to science necessarily stalls.

As Kepler came into the scene, his first task aimed to perfect Ptolemy's model with data made available by Brahe (the required evidence to induce a causal model). Once he did this, he found the same eccentricity in the Sun's and all the known planets' epicycles—i.e., their path around their respective empty points in space shared the same parameter. Why? This can only be explained by a motion common to all those body's—namely (and he did not know yet) the motion of the earth around the sun.

Answering *why* also required a different method of proof. This drove him to run analysis on the available data (comparing and contrasting) to see what possible cause integrates and explains this common motion, and he found that the Sun being the center of a planetary model was the only possible cause—the one remaining factor that causally unites all planetary motions into three, relatively simple, laws.

It was this transformation to Kepler's causal model that made Newton's causal (inductive) derivation of his Universal Law of Gravitation possible, which made the achievements of Einstein descriptive (deductive) general relativity model possible. These transformations to a causal model never mean legacy descriptive model's predictions are necessarily invalid. It only ever means that our understanding of observations become richer, explanations become simpler, we become more effective at prediction—the source of our cognitive power—and we become more equipped to discover deeper causal truths impossible to discover otherwise.

The critical historical point is this: like Ptolemy's model, relativity's legacy models contains elements of a descriptive model, and these elements, in effect, have stalled scientific progress in this domain. This domain will continue to stall, like Ptolemy's model caused its domain stall, until a Kepler-like causal model is offered and accepted. This paper attempts to make such an offer.

Key Concepts

Lastly, in order to keep the main discussions in this paper concise, it had to be assumed that the reader possessed an understanding of certain key concepts sufficiently in common with the author. If this turns out not to be the case, Appendix A further discusses many of these key concepts to help gain a better common understanding when necessary or desired. Sections that have references in this appendix are indicated as necessary.

Paper Organization

This paper is organized in the following sections: Section 2 quickly breaks down what induction is, how it compares to deduction, and why it is required; Section 3 presents the legacy special relativity model and its issues; Section 4 presents legacy attempts to resolve the twins paradox; Section 5 presents the inductive proof for what causes kinetic time dilation; Section 6 deduces the effect of a time derivative gradient given this newly discovered cause; Section 7 completes the inductive proof for the Law of Universal Specificity; and finally, Section 8 wraps up with a conclusion. Appendices contain richer content to provide more color to the material when desired, such as implications of the Law of Universal Specificity.

2. Inductive vs Deductive Proofs

Between the two proofs, inductive proofs are the lesser well known. They are causal proofs, and it requires: observation of the causal relationship, application of the law of identity to observed actions, and standardized measurements to quantify the causal relationship.

Deductive proofs, on the other hand, start with premises and then conclusions are deduced from them—think formal deductive logic. The problem with deduction is the problem of induction. Premises always include at least one generalization—e.g., all men are mortal—which can only be verified inductively. Therefore, one cannot verify a deductive conclusion before one has verified all the inductive conclusions that serve as the premises.

Both proofs have their place and uses. Neither is invalid; however, this relationship between induction and deduction means that when discovering something new, like a scientific discovery, induction is always required to achieve certainty. Only after achieving verified inductive conclusions, can one deduce its implications. More on induction vs deduction is covered in *Induction Vs Deduction* in Appendix A.

Causal Proofs

Causality is a law of nature. It is the law of identity applied to action. The law of identity states a thing is what it is, implying it cannot be what it is not. The law of causality, likewise, states that a thing must act, or change, in accordance with its nature, implying it cannot act, or change, contrary to its nature. Because of this, causal relationships always involve some change or action. In addition, causal proofs always involve observing and demonstrating what drive these changes through controlled experiments. The only known methods to prove a causal relationship through controlled experiments are Mill's Methods of induction—it cannot be done by making non-validated assumptions and deducing implications consistent with observations.

In contrast, much of scientific activity today involves making non-validated assumptions and finding models that accurately describe observation, and using these models to make predictions until observations fail, which drives an assumption update and model revision—the exact same method employed by Ptolemy, and by most in my profession, Artificial Intelligence.[2] This is a method that focuses on *what* happens, and making assumptions as to *why* it happens, rather than proving *why* it must happen.

[2]Thus the reason for my title to distinguish myself from those that use this method: Causal AI Architect.

Causal proofs, on the other hand, demonstrate *why* an observation is necessary *because* of the nature of the entities involved. The difference between a descriptive vs causal model is the difference between: (1) not being able to distinguish between coincidental observations and necessary observation, and (2) being able to distinguish between them. The indistinguishably from (1) stems from making a non-validated assumption, leading to the unanswerable question: is the assumption right, or is it wrong? No body knows, or can know, for sure until a causal relationship is inductively proven. Being continually consistent with observation will never prove the validity of an assumption, one way or the other.

Importance of Standards of Measurements to Experiments

Experiments that employ Mill's Methods assume standards of measurements are invariant—meaning you do not switch back and forth between different units of measurement without a conversion of equivalence. Invariant standards are critical to making causal discoveries and deriving their mathematical relationships.

Legacy relativity models show us that our standards for measuring time and measuring distance, and many more measurements that depend on those, change depending on the reference frame they are employed—i.e., the units of measurement change in a manner needing a conversion. This posses problems when considering relativistic thought experiments, and it leads to paradoxes (unresolved contradictions).

In order to resolve the paradoxes, first a conversion of equivalence must be found and used, and it must be knowable when to use it. The legacy model for relativity uses Lorentz transforms to do this conversion, but they make an implicit assumption as to when to use it, as we shall see in Section 4. Knowing explicitly when to use this conversion is made possible by a more consistent causal model of relativity as will be shown in Section 5.

Causality Has Limits

The last point made here on causality is that certain things are outside the domain of causality, and causal proofs, because they are *always* invariant. For example, the limit of speed, which is commonly referred to as *the speed of light*, is an invariant outside causal consideration. These invariant things, whatever they are, do no change; therefore, they cannot cause change in something else. In a sense, invariant things of this kind are more fundamental than causality, because all casual relationships must remain consistent with them.

For deeper discussion on causality, see *The Nature of Causality* in Appendix A.

3. The Legacy Relativity Model

In this section, the legacy relativity model accounting of time dilation is discussed, focusing primarily on special relativity because this is where the transformation to a more consistent causal model begins. The complexities of general relativity's model is also presented.

An important emergent property of special relativity is kinetic time differential—AKA time dilation.[3] Further discussion

[3]The term, *time differential*, is preferred over the term, *time dilation*, because *dilation* implies something gets bigger, like when pupils dilate. Differential, on the other hand, is a more general term because it only acknowledges

on how time differentials are conceptualized in this paper, see *Inertial Time Differential* in Appendix A. Also, review Appendix B for a legacy derivation of the kinetic time differential.

In the legacy model, changes in time differentials are due to the relative velocity between two observers, which is mathematically modeled in Equation (2) [6].

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

Where :

dt' is the time derivative of the stationary observer
dt is the time derivative for the moving observer
v is the relative velocity of the moving observer
c is the limit of the speed of light

This model describes what each observer sees, and helps predict future observations, but it also leads to many problems to include: a lack of measurement standards, a lack of universal simultaneity, mathematical complexities akin to the complexity found in Ptolemy's planetary model, and paradoxical contradictions.

Lacks Instrumental Grounding

The legacy relativity model lacks instrumental grounding. We learn from the legacy model that length contracts and time dilates, which are used to estimate velocity, forces, energy, and many more physical things. They are all relative depending on the reference of the observer. It is assumed that all inertial reference frames are equally valid; therefore, it is believed that no standards can exist. Indeed, a commonly held view is that two or more observers can all disagree in measurements and they are all correct.

Lacks a concept of Simultaneity of Events

Since it is assumed that all inertial references frames are equally valid, no one can determine if two unrelated events at two different locations occur simultaneously, or even which one came first.

Obviously something cannot happen both before and after another event, but we can lack an ability to discern which is true without the right tools. This is a limitation of the legacy model rather than some contradictory property of reality, since reality cannot contradict itself.

Parallel to Ptolemy's Model

General relativity, which is based on the foundation of special relativity with an additional equivalency principle assumption. This additional assumption necessarily lead to replacing gravitational forces with the curving of what is termed *space-time*. In order to reconcile this, very complex math was required to align this assumption with observation.

First, geodesic math tensors had to be introduced to replace the gravitational force, because gravity used to be thought as causing an acceleration which caused the motion we see of falling objects and orbiting objects. Now that gravity is no longer considered a force under the legacy model, space-time curvature now accounts for this motion. The effect is perceived acceleration is taken to actually be traveling in a non-accelerating straight line.

Then since the curvature changes depending on the strength of gravity, which fallows the inverse square law, metric tensors were required to capture this change in the form 40 *Christoffel Symbols*. All of this is defined over 4 dimensions in the *Riemann Curvature Tensor*, which is a $4 \times 4 \times 4 \times 4$ tensor (totaling 256 elements). Given certain permutations of the values in this Riemann Tensor, you can derive a smaller *Ricci Tensor* and *Ricci Scalar*.

Then finally the parameters of curved space can be equated to an Energy Tensor in *Einstein's Equation*, which is acknowledged to be unproven, but matches known observation so far. All said and done, there are (5) Tensors and (1) scalar, which informs an unproven equation, which is practically impossible to solve without making simplifying assumptions and using a computer to numerically solve. Also, when it comes to light they have to make special substitutions to make it all work out.

To sum up, general relativity makes one more assumption than special relativity (the equivalence principle), is very complex mathematically, and very difficult to comprehend; yet, this legacy model is still great at predicting known (and previously unknown) observations. Additionally, it is viewed that gravitational time differential and kinetic time differential are seemingly unrelated things driven by unrelated phenomena.

This is not unlike Ptolemy's descriptive model, which made a somewhat similar assumption to the equivalence principle—e.g., instead of assuming space is curving around earth, Ptolemy assumed celestial motion moved around earth—and Ptolemy derived an extremely complex math model from this assumption, it was impossible to comprehend planetary motion around nothing, and yet, it was excellent at making predictions. Additionally, there seemed to be no uniting cause for planetary motion.

The causal relativity model derived and offered in this paper eliminates the un-validated assumptions, simplifies the mathematical apparatus immensely, makes observations sensible, and most importantly, it unites seemingly different phenomena under a common cause; very much like what Kepler's model did for planetary motion.

Paradoxical Contradictions

The legacy model for kinetic time differential leads to many paradoxes such as the twins paradox, the ladder paradox, Ehrenfest's paradox, et. al.

Appendix C explains in more detail what the twins paradox is and why the twins paradox is really an accepted contradiction when unresolved. In short, the contradiction is this: one twin travels (to and from Alpha Centauri) at relativistic speed and ages less than the stationary twin, but both twins predict that the other will age less when they leverage the legacy model to aid their predictions.

Arriving at a contradiction ought to stop one in one's tracks for it means an error in thought has been made because contradictions cannot exist in reality.[4] This puts special relativity

there *might* be a difference in size, and it does not indicate whether the size difference is bigger or smaller.

[4]The nature of contradictions, and why it indicates an error, are further

on unsound footing until this paradox is sufficiently resolved. To date, despite claims from others, the twins paradox not been sufficiently resolved. This paper, in Section 5, will use this paradox to induce the cause of time differential, which is not velocity. But, before that, we cover two legacy attempts that were made to resolve the twins paradox in the next section.

4. Legacy Approaches to Twins Paradoxes

When it comes to the twins paradox, a resolution requires that one is able to determine (with certainty) which twin ages less before clocks can be compared. In other words, one must know the cause, and its effect, before the effect reveals itself.

Certain attempts were made in the past to figure this out, for which two distinct approaches will be presented in this paper. The first approach assumes slower aging is due to acceleration, and the other rejects this approach and assumes that the traveling twin being in different inertial frames is the cause.

Acceleration Approach

This perspective seems plausible since we "know" one twin accelerated and the other did not, and the "accelerated" twin does age less—it seems to be the difference that makes the difference. Even Einstein attempted a resolution assuming that gravitational time dilation was responsible for the time dilation; however, this has be proven false [7][8][9][10].

This approach is certainly on the right path, but all variations of this approach ignore one key fact, and the worst variation ignores two facts:

1. Slower aging is proven not to occur during acceleration because the same acceleration can lead to different amounts of aging, and acceleration can be eliminated altogether.
2. Acceleration is relative for the same reason velocity is relative.

An example of fact (1): if the twin traveled twice as far given the same acceleration profile, that twin will be that much younger. Also, if you eliminate acceleration all together, you still have the traveling clock tick slower. Say two ships are used to travel, one from earth towards Alpha Centauri, and one from Alpha Centauri towards earth. Then, once the ships reach top speed (i.e., stop accelerating) you send a start time to the moving ship from earth and that ship's light-clock maintains time. At a rendezvous point somewhere in the middle, the clock information transfers to the returning ship and its light-clock maintains time from there; this is all accomplished without acceleration. Finally, when the return ship reaches earth, the clock information transfers to earth to report the final time. The light-clocks maintained time all during moments of non-acceleration. The result? The moving clock ticked at a slower pace, proving via method of agreement that changes in time differential occurred during motion.

As an example of fact (2): when referencing the twins paradox in Appendix C, the twin traveling to Alpha Centauri can measure a relative acceleration of the other twin—meaning he can measure the acceleration of the twin on earth if he assumes himself to be stationary. The fact that the traveling twin feels a force could be explained as a temporary normal force to counter act a gravitational force—the net force is still zero. If this were the case, the other twin would have aged less. The feeling of acceleration, via an accelerometer registering some force, is not sufficient to determine which twin ages less.

This acceleration explanation, is on the right path, but it is missing something critical as we shall soon see in the next section.

Lorentz Transformation Approach

This claimed resolution assumes that acceleration is not relevant, and only relative velocity causes changes to the time differential. It uses the Lorentz Transform to switch back and forth between reference frames and will work *if* you know which inertial reference frame serves as the proper starting reference frame, which is the fatal flaw with this approach. This approach assumes that you start with a common frame to both twins, and the twin that ages less is the one that changes inertial frames. This is provably false for two reasons:

1. Changes to inertial frames can only be caused by acceleration.
2. An example exists where the traveling twin ages more.

If acceleration is not relevant to the time differential, then lets get rid of that information. All that remains, in terms of "relevant" information is relative velocities over the trip. Indeed, it becomes clear that acceleration is required to determine which inertial frames are different from our initial inertial frame. Even in the case where we "eliminated" acceleration with two ships traveling in opposite directions, those ships had to accelerate to achieve their changed inertial frame.

Even if you had the acceleration information to account for which inertial frames are different from the original, you will still not be able to predict which twin will age more than the other and by what degree. For example, a case exists where one twin travels away from the other at $0.2c$ and returns at $0.2c$ and ages more that the stationary twin. See Appendix D for details, but the short answer is that both twins accelerate to a common inertial frame that is $0.2c$ relative to the original inertial frame, the traveling twin decelerates to a stop, waits, then accelerates to $0.38c$ (or $0.2c$ as measured by the twins) until they rendezvous.[5]

These facts make clear that this argument is basically the same argument as the acceleration argument. Both get the right answer by assuming acceleration is important and accounting for it. This argument, however, relies on acceleration, while at the same time denying its important involvement—this contradiction is obviously self refuting.

The reason the Lorentz transformation was claimed to "resolve" the twins paradox, was because they implicitly took for granted that changes in time differentials had something to do with acceleration. Therefore, if the acceleration argument is not complete, then the Lorentz Transformation only hides this fact behind an implicit, unacknowledged assumption.

We now turn to inductive proof to determine the precise cause of changes to time derivative, in a kinematic context without gravity, which leads to a full resolution to the twins paradox.

discussed in *Contradictions* in Appendix A.

[5]This example demonstrates that there exists some point in the universe where time differential is largest, and might be considered the original inertial reference frame, but more at that in Section F.

Universal Inertial Frame

The modified twins paradox example in Appendix D implies that there is what is termed a *universal inertial frame* (UIF). This UIF would be the inertial frame where clocks tick the fastest. In the case of this modified example, additional joint accelerations could have occurred, even before they were born. The matter that makes up their body composition could have been traveling and accelerating over an eternity before they were born. Some means is required to determine the final effect in order to accurately use the Lorenz Transformation.

It ought to be possible to calibrate any location, in terms of time differential relative to this UIF, by sending fast moving clocks in all directions, and measuring which clocks tick slower or faster than those on earth. From this we ought to be able to measure any location's velocity relative to the UIF.

It is important to note, that this UIF is the tacitly assumed inertial frame for the set up of Einstein's Special Theory of Relativity [6]. It is the inertial frame we take for granted when considering the twins paradox, until we see the example in Appendix D; and, when not explicitly stated, the rest of this paper implicitly considers the initial inertial reference frame to be the UIF.

5. Cause of Kinetic Time Differential

The true cause of kinetic time differential has remained unproven deductively because it cannot be discovered deductively. Induction is required to test antecedent factors, via Mill's Method, to determine which one drives the effect. The antecedent factors worth considering, which might be the cause of kinetic time differential, are:

- Relative Velocity
- Acceleration
- Change in Inertial Frame
- Work Done
- Specific Work Done

Ruling out The First Three Factors

It might seem reasonable to think velocity is the cause of time dilation because it is the only variable in the original time dilation equation shown in Equation (2). We can certainly rule out relative velocity as the cause of changes in time derivative because of the twins paradox. As in, each twin measures their relative velocity to be the same, and both naively predict that the other ages less, which proves to be false—only one ages less. Invoking the method of difference, where the effect was different (one twin aged less), but where the antecedent factor of measured relative velocity remained the same, proves that relative velocity is not the cause for why one twin aged less.

As another more extreme example, suppose we modify the twins paradox into the triplet paradox, where two of triplets perform the same actions as the twins in the original paradox. Also suppose, the third triplet performs the opposite action as the traveling twin in the original paradox—i.e., he travels at the same speed profile, but in the opposite direction. The two traveling siblings will have a greater relative velocity with each other than either has with the stationary triplet; however, the traveling siblings pair-wise time differential is unity—i.e., neither ages more than the other. Invoking the method of agreement, where their relative velocities were in greater magnitude, but there was no difference in aging, proves that relative velocity does not cause their pair-wise time differential to change.

It was posited that time differential changes during acceleration, and goes back to normal after acceleration. It was proved that the time differential is changed during travel, as stated in the previous section. In the case where acceleration is eliminated, this conception of acceleration being the cause can be ruled out by invoking the method of agreement, where acceleration is eliminated but the effect remains the same (i.e., time differential still in effect). Additionally, in the case where the acceleration profile was the same, but the total time of constant velocity changes rules out acceleration by invoking the method of difference, where the acceleration is the same, but the effect changes.

Turning to changes in inertial frame as the possible cause, the modified twins paradox outlined in detail in Appendix D proves its not the cause by invoking the method of difference. This is a case where the traveling twin experiences the same change in inertial frame with respect to the stationary twin, but the effect is different (i.e., the traveling twin is older, instead of younger like the original paradox), proving changes in inertial frame is not the cause.

The Remaining Two Antecedent Factors

Two factors remain: work and specific work done. Before testing which is the causal factor we need to acknowledge what the testing shows us thus far. Changes in time differential occurs during translational motion between two reference frames, and never when their is no relative motion between the two frames. But in the case of the triplet paradox (presented in the previous subsection), translational motion does not cause any relative time dilation. Therefore, transnational motion is necessary, but not sufficient.

Additionally, whatever the cause is, it must match the effect in all cases covered so far: the twins paradox, the modified twins paradox, the triplets paradox, and the non-accelerating version of the twins paradox. Interestingly, the ruled out factors so far are an effect of the remaining antecedent factors. The only remaining antecedent factors that could be the cause of changes in time differential is some amount of force applied over some distance.

One might think this too leads to dead ends because you can eliminate any force being applied just like acceleration was eliminated. There is a key difference between this explanation and the explanation using acceleration. That difference is this: the time differential remains constant until work (or specific work) is done, which implies time differentials have an "inertia." This conception of the time differential having remaining constant for an inertial frame is termed *inertial time differential* (ITD), and is covered in more detail in *Inertial Time Differential* in Appendix A.

For the case where acceleration and force are "eliminated," they were not truly eliminated. The ships had to have some work done to cause their constant velocity state, and depending on that work done it would cause their ITD to be what it was for the resulting inertial frame. Their effected ITD changed as a consequence of the work done to them, and those ITD remain constant during the entire experiment, because their inertial frames remained constant. Work done caused both a change in relative velocity of the ship, and a change in ship's IDT.

Work explains all the other cases too. In the twins paradox, the traveling twin had work done. In the modified twins paradox example, where the traveling twin aged more (not less like the original paradox), both twins had work done in the beginning, which explains why the traveling twin aged more. In the triplet paradox, where the traveling triplets had the same work done, but the stationary twin had none, explains why the traveling siblings aged the same and less than the stationary triplet.

But to know for sure that these examples are satisfactorily explained by this common cause, we need more precision. First, we need to make the following consideration to narrow down the cause: does the same work applied to two different objects with two different masses experience the same change in ITD; or does it have more to do with specific work applied—i.e., work that is proportional to mass? Then, we need to derive a precise math model capturing the cause. The former is accomplished next and the latter is accomplished in the next subsection.

Let's put this question to the test via Mill's Method. Two simple thought experiments tells us that a change in specific work is the precise cause.

Proof:

First, let us evaluate force applied over some distance.

Case 1: Consider a planet that barley accelerates to some final velocity when some work is done to it versus the same work done to a tiny marble, which causes that marble to zoom to a much higher velocity. Observing both of their light clocks reveals that the marble experiences smaller ITD (slower clock) than the planet; therefore, invoking the method of difference, where each object experienced a different effect than the other, while having the same work done, proves that work cannot be the cause of changes in ITD.

Now, let us evaluate changes in specific work.

Case 2: Consider the same two objects as before, but now they have the same change in specific energy applied to them. By definition, their light clocks show the same change in their ITD; therefore, invoking the method of agreement, where each object experienced the same effect, while having the same change in specific kinetic energy, proves that change in specific kinetic energy is the cause of changes in ITD ■.

Work has a well known relationship to a change in kinetic energy, as defined in Equation (3). Equation (3d) is the relationship between specific work and change is specific energy. This relationship, of course, is the reason why measured velocity and acceleration are correlated to, but not the cause of, changes in ITDs.

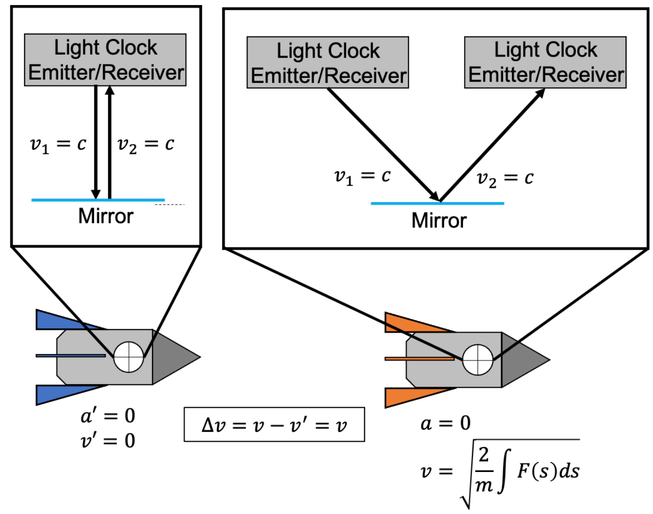

Figure 1. **Reframing the problem with what we know.**

$$W = \Delta E_K \tag{3a}$$

$$\int F(s)ds = \frac{1}{2}m\Delta v^2 \tag{3b}$$

$$\int a(s)ds = \frac{1}{2}\Delta v^2 \tag{3c}$$

$$w = \Delta e_K \tag{3d}$$

We now know that an object undergoing a non-zero net force applied over some distance causes its ITD to change (inversely proportional to its mass); and it also causes a change in its relative velocity to the initial inertial frame. Additionally, it is much more satisfying to base changes in ITDs to a relationship with force because forces are a special fundamental in physics—they are the driving cause of changes in motion. It causes the other eliminated factors too, to the point where they appeared correlated to the effect and were mistaken by many as the cause. It explains under what conditions the legacy Lorentz transformation works, and why the acceleration explanation for the twins paradox was a good start, but incomplete.

Knowing what we now know, we can derive a precise math model for a change in ITD in terms of precise causal factors.

A Causal Derivation of Kinematic Inertial Time Differential

Kinetic ITD can now be derived using geometry—similar to the legacy derivation in Appendix B, but this time we use causal terms instead of correlated terms. Figure 1 sets up the problem pictorially, and the time derivative relationship between the two frames is shown in Figure 2.

Using geometric and energy laws we get Equation (4):

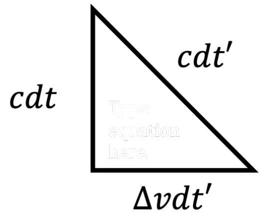

Figure 2. Updated Pythagorean relationship for distance traveled.

$$(cdt)^2 + (\Delta vdt')^2 = (cdt')^2 \tag{4a}$$

$$dt^2 + \frac{\Delta v^2 dt'^2}{c^2} = dt'^2 \tag{4b}$$

$$\frac{dt^2}{dt'^2} + \frac{\frac{1}{2}\Delta v^2}{\frac{1}{2}c^2} = 1 \tag{4c}$$

$$\frac{dt}{dt'} = \sqrt{1 - \frac{\Delta e_K}{e_{K,\max}}} = \frac{1}{\gamma} \ \blacksquare \tag{4d}$$

Or if you wanted this in terms of specific work and acceleration you get Equation (5).

$$\frac{dt}{dt'} = \sqrt{1 - \frac{w}{e_{K,\max}}} \tag{5a}$$

$$\frac{dt}{dt'} = \sqrt{1 - \frac{\int a(s)ds}{e_{K,\max}}} \tag{5b}$$

We now have an equation of ITD in terms of the causal factors, change in specific kinetic energy or specific work done. We use work done and change in kinetic energy interchangeably as representing reciprocals of the same causal phenomena—a non-zero net forces causes a change in kinetic energy, and changing the kinetic energy (e.g., a rocket engine sending hot gas away very fast) creates a force. We will see in the next section that kinematic time dilation is better represented by change in specific kinetic energy, while gravitational time dilation is better represented by specific work done.

It is again important to emphasise the difference between the meaning of Equation (2) and Equation (4). In Equation (2), v causes time differential for as long as there is a velocity difference—it applies over time. Equation (4), on the other hand, creates an ITD between the two reference frames up front during acceleration over some distance, and once the acceleration is complete, then the ITD remains constant until the object is acted upon by non-zero net force.[6] For example, the moving twin continues to age less until his specific energy state changes to match the stationary twin.

Why does the change in time differential persist? Because the change in specific kinetic energy persists—i.e., there is a difference in specific kinetic energy from the initial inertial frame and the new one. This difference will remain until the object is acted upon by an outside force, thus the use of the term ITD rather than just time differential.

Equation (4) is the remaining precision required to resolve all the cases tested thus far.

Inertial Space Differential

The legacy model assumes that something termed a *space differential*—AKA length contraction—also takes effect. This was proven with a thought experiment involving a spherical emission of light. All inertial frames need to observe this light sphere as spherical. If ITD is in effect only, then this sphere becomes an ellipsoid violating the constant speed of light assumption. The consequence of light sphere observed as spherical for all inertial reference frames is for space to have the same differential factor as time so they cancel out [6]. Work done must also cause this effect too for the same reasons stated above, and is termed the *inertial space differential* (ISD), which is given in Equation (6).

$$\frac{dx}{dx'} = \frac{1}{\gamma} = \sqrt{1 - \frac{\Delta SK_E}{SK_{E,max}}} \tag{6}$$

The correct interpretation of (6), as is demonstrated in Appendix C, is that the units of measurement for length for the moving observer has changed. A yard stick no longer measures a yard, it measures something greater than a yard—e.g., $\Delta x' = \gamma \Delta x \implies \Delta x' > \Delta x$. Thus, the appearance of length contraction is only an optical illusion, like refraction, which is created by the units of measurement changing without notice.

It is now well established that a change is specific kinetic energy causes ITD and ISD. We now turn to the reciprocal effect where a stationary object is in a field where the ITDs exist in a gradient.

6. Effects of Time Derivative Gradients

We know from observation that, what is termed here, a *Time Derivative Gradient* (TDG) exists around massed objects, and are defined by Equation (7). GPS clocks are known to tick faster in orbit than clocks do on earth's surface. Clocks tick faster the further away from a gravitational source it is, and this is measurable and predictable using the legacy model. The legacy model predicted TDGs by assuming the equivalency principle, but the existence of TDGs proves the equivalency principle false.

$$\nabla dt \triangleq \frac{dt' - dt}{dr'} \tag{7}$$

Where :

∇dt is time time derivative gradient

dt' is time derivative further away from gravitational source

dt is time derivative closer to gravitational source

dr' is distance between time derivatives

[6] See *ITD* in Appendix A for a more detailed illustration of ITD inertia.

Free falling is provably not equivalent to floating in empty space, and being on earth is provably not equivalent to accelerating in empty space; our inability to directly perceive a difference not withstanding. TDGs are zero in empty space, but they are non-zero near earth (or any massed object). Our inability to discriminate between zero and non-zero TDG environments should not come as a surprise, since we lack a sixth sense to measure TDGs. What we lack in natural perception can be overcome by well crafted instruments.

Rejecting The Equivalency Principle

TDGs can be measured with precise clocks arrayed in all three dimensions, and comparing their respective ITDs. A system of clocks that measure TDGs are termed *TDG detectors* (TDGDs). An example of a single dimension TDGD is show in Figure 3. Non-zero TDGs near earth and near zero TDGs in empty space is the difference that makes the difference; it invalidates the equivalency principle, because the TDGDs tells us non-zero and zero TDGs are not equivalent.

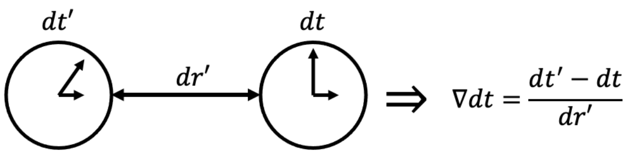

Figure 3. Single dimension time derivative gradient detector.

This breach of equivalence is well known, but the reason this principle remains accepted is because it is viewed as *approximately* true. For example, in really small spaces near gravity, $dt - dt'$ is almost zero, just like they are zero in empty space; however, what most do not seem to realize is that TDGs are also scaled by inverse dr', meaning TDGs converge to a non-zero value as the limit of dr' approaches zero. Besides, why settle for a truth that is *approximate*, when we can be *precise*?

This difference in TDGs is not trivial. It will be shown latter in this section, using our new causal model derived in the previous section, that TDGs cause a specific force to be applied to bodies within them. The legacy model removed gravity as a force because of the equivalency principle—gravity was replaced with the bending of space-time. This causal model returns gravity to its original Newtonian status of being a real force, and TDGDs can measure this force. Thus the causal model eliminates any need for curved space-time, and as we will see, this will make the math so much simpler.

Thus far, the herein derived causal model has explicitly avoided non-validated assumptions; however, in this case, this equivalence principle is completely rejected because it is provably false.

Universal Inertial Measurement Unit

Gravity being considered a real force again means we need to update the legacy model's definition of an inertial state (and inertial reference frame). An inertial state still remains a state in which the net forces are zero, meaning a state of non-acceleration; however, with gravity being a real force again, we need to account for this in our inertial state definition.

Combining TDGDs with an accelerometer and gyroscope, we can craft an *universal inertial measurement unit* (UIMU) that measures total net force (kinematic and gravitational). This new definition of an inertial state is one in which net forces are zero according to an UIMU. Interestingly, this can be equivalently stated as, an inertial frame is one in which its ITD is not changing with respect to the UIF.[7]

We now turn to derive how TDGDs can measure gravitational forces.

A Causal Model Accounting of Gravity

Since the concept of space-time, and its curvature, stems from assuming that the equivalence principle is valid. And since this principle has been rejected by the causal model as false, a new accounting for gravity is required. With the causal model in Equation (4), we know that changes in ITDs are caused by changes in specific kinetic energy, but we will now see that changes in specific kinetic energy can be caused by changes in ITDs.

I am not the first to suggest the idea that time causes gravity [14][15][16]; however, the novelty presented in this paper is a mathematical derivation based on a new causal model. Given the relationship between changes in ITDs and changes in specific energy in Equation (4), and given the definition of TDGs in Equation (7), I deduce TGS's relationship to acceleration as follows:

$$\nabla dt = \frac{dt' - dt}{dr'} = \frac{dt' - dt'\frac{1}{\gamma}}{dr'} \tag{8a}$$

$$\frac{1}{\gamma} = 1 - \nabla dt \frac{dr'}{dt'} \tag{8b}$$

$$\sqrt{1 - \frac{\Delta SE_K}{SE_{K,\max}}} = 1 - \nabla dt \frac{dr'}{dt'} \tag{8c}$$

$$\bar{g} dr' = \frac{1}{2} c^2 (1 - (1 - \nabla dt \frac{dr'}{dt'})^2) \tag{8d}$$

$$\lim_{r_1 \to r_2} \frac{\int_{r_1}^{r_2} g(r') dr'}{\int_{r_1}^{r_2} dr'} = \frac{c^2}{2dr'} (1 - (1 - \nabla dt \frac{dr'}{dt'})^2) \tag{8e}$$

$$GM \lim_{r_1 \to r_2} \frac{\int_{r_1}^{r_2} \frac{1}{r'^2} dr'}{r_2 - r_1} = \frac{c^2}{2dr'} (1 - (1 - \nabla dt \frac{dr'}{dt'})^2) \tag{8f}$$

$$GM \lim_{r_1 \to r_2} \frac{\frac{1}{r_1} - \frac{1}{r_2}}{r_2 - r_1} = \frac{c^2}{2dr'} (1 - (1 - \nabla dt \frac{dr'}{dt'})^2) \tag{8g}$$

$$GM \lim_{r_1 \to r_2} \frac{\frac{r_2 - r_1}{r_1 r_2}}{r_2 - r_1} = \frac{c^2}{2dr'} (1 - (1 - \nabla dt \frac{dr'}{dt'})^2) \tag{8h}$$

$$\lim_{r_1 \to r_2} \frac{GM}{r_1 r_2} = \frac{c^2}{2dr'} (1 - (1 - \nabla dt \frac{dr'}{dt'})^2) \tag{8i}$$

$$\lim_{r_1 \to r_2} \sqrt{g(r_1) g(r_2)} = \frac{c^2}{2dr'} (1 - (1 - \nabla dt \frac{dr'}{dt'})^2) \tag{8j}$$

$$g(r') = \frac{c^2}{2dr'} (1 - (1 - \nabla dt \frac{dr'}{dt'})^2) \blacksquare \tag{8k}$$

[7]It can be different from another frame, but its not becoming more or less different.

Where :

∇dt is time time derivative gradient

dt' is time derivative further away from gravitational source

dt is time derivative closer to gravitational source

dr' is distance between time derivatives

g is gravitational acceleration at location $\sqrt{\mathrm{r_1 r_2}}$, which is also equivalent to the geometric mean of accelerations at the dt and dt$'$ locations

Concrete examples using this equation are given in Appendix H. Also, note that g is measuring a difference in unit specific energy per unit length (e.g., Joule per meter per kilogram). This difference is caused by a TDG, which induces a specific force we call gravity—a force proportional to mass. This is also why everything falls at the same rate, because forces scale with mass, and this is why gravity is indeed a TDG force.

A new understanding emerges from the derivation shown in Equation (8): the relationship between changes in specific energy and changes in ITDs are reciprocal causal phenomena—changes in one causes changes in the other. With this understanding we can now see that if one believed that free falling does not involve a real applied force (as the equivalency principle suggests) and accelerating in deep space does, then they cannot possibly hope to reconcile the two time differentials. This is why the kinetic time derivative was considered as similar, but an unrelated to, the gravitational time differential. Knowing what we now know, to reject the notion that a real force causes free falling is to reject that changes in kinetic time derivatives requires a real force, which is to reject $F = ma$. Is is either both contexts require a real force or you accept a contradiction that violates a law of physics.

TDG's Relationship to Specific Energy

Given that a TDG induces a change in energy (proportional to mass), an object existing in this gradient is said to have specific potential energy—a potential to achieve some specific kinetic energy state caused by this gradient. Deriving a measure for this specific potential energy was completed a long time ago using Newtonian physics, which is $e_P = g(r)dr = \frac{GM}{r^2}dr$.

Two objects being at two radial inertial locations within a TDG means there is a change in their relative ITD. This change in ITD between the two objects is caused by the gravitational field consistent with Equation (4), meaning it is caused by a change in their specific potential energy between the two states. We can use Equation (4) to determine how much change in energy exists between the two objects, which determines their relative ITD. Essentially however much total work is required to get from one stationary point in the gradient to another is causally related to their relative change in ITD via Equation (4).

For example, if the initial location is the center of mass of a hollow gravitational source, then the ITD at the center vs some distance away is equal to ITD created by a change in specific kinetic energy necessary for the apex of the trajectory to reach said distance, as show in Figure 4. This is because this is how much work is done by the TDG between the two points.

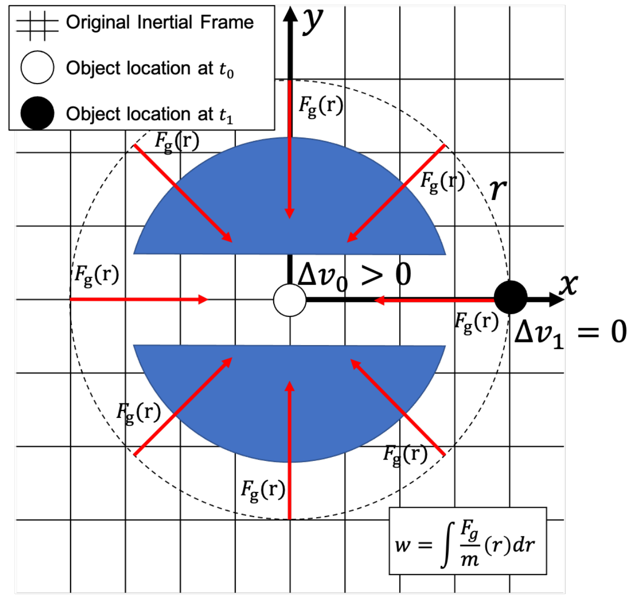

Figure 4. ITD at center relative to some point distance r away.

As another example, if the initial location is at some altitude away from the gravitational source, and the new location is infinitely far away, then the ITD at that altitude is equal to ITD created by a change in specific kinetic energy required to achieve escape velocity, because this is how much work is done by the gravitational force by the time the object is infinitely far away as given by Equation (10):

$$\frac{dt}{dt'} = \sqrt{1 - \frac{2GM}{rc^2}} \tag{10}$$

Where :

dt' is time derivative for object infinitely far

dt is time derivative for object r distance away

G is the gravitational constant

M is the mass of the gravitational source

r is the distance to center of gravitational source

c is the speed of light

Adjusting Equation (10) to be in its more general form, in terms of specific work done or change in specific potential energy, gives us Equation (11):

$$\frac{dt}{dt'} = \sqrt{1 - \frac{w}{e_{K,\max}}} \tag{11a}$$

$$\frac{dt}{dt'} = \sqrt{1 - \frac{\Delta e_P}{e_{P,\max}}} = \frac{1}{\gamma} \blacksquare \tag{11b}$$

Where :

dt' is time derivative before time differential

dt is time derivative after time differential

e_P is specific potential energy

This Only Takes The Cause of Gravity So Far

Kepler found that planetary motion was caused by the sun. Newton found that the sun exerts a force called gravity, causing planets to move. I found that this specific force operates via TDGs. This last step is certainly progress, but it only takes our understanding of the nature of gravity only so far. For example, the next logical question in this chain of causal discoveries is: what causes TDGs? I don't know for certain because this is as far as the evidence goes inductively. Additional evidence is required to induce further causes, but it certainly is not because a thing called space-time curves, as is hypothesised by the legacy model.

Integrating the causal formulation in Equation (4) and in Equation (11)—capturing the reciprocal relationship between TDGs and specific energy—gives us a new perspective on the total energy equation, as we will see in the next section.

7. The Law of Universal Specificity

It is no coincidence that ITDs are in terms of fractions of the limit of achievable specific energy for both specific potential energy and specific kinetic energy. Before we consider changes in total specific energy, let us first consider what effect changes between specific potential and specific kinetic energy has on changes to ITD, when total specific energy remains constant.

The Precise Cause of Changes in Inertial Time Differentials

We just proved that change in specific kinetic and potential energy are related to changes in ITDs, but as we shall soon see this is only half the picture because we tacitly assumed all else remained equal. Now we test what if all else does not remain equal to discover a more precise cause to changes in ITDs.

In reviewing Equation (4) and Equation (11), simple analysis reveals that transferring some amount of specific kinetic energy to some amount of specific potential energy (or vice versa) would cause the same ITD with respect to some initial inertial reference frame. ITD is conserved, and so is specific energy.

For this proof, we are an outside observer in the UIF observing an object that starts with some amount of specific potential energy, who then transfers all of it to kinetic energy (no longer in a gravity potential somehow).

Proof :

Let $\mathrm{SE_P} > 0$.

$$\text{Let } \frac{1}{\gamma} = \frac{\Delta t}{\Delta t'} \tag{12a}$$

$$\frac{1}{\gamma_P^2} = 1 - \frac{\Delta e_P}{e_{P,\max}} \tag{12b}$$

$$1 - \frac{1}{\gamma_P^2} = \frac{\Delta e_P}{e_{P,\max}} \tag{12c}$$

$$\left(1 - \frac{1}{\gamma_P^2}\right) e_{P,\max} = \Delta e_P = \Delta e_K \tag{12d}$$

$$\left(1 - \frac{1}{\gamma_P^2}\right) e_{K,\max} = \Delta e_K \tag{12e}$$

$$1 - \frac{1}{\gamma_P^2} = \frac{\Delta e_K}{e_{K,\max}} \tag{12f}$$

$$\frac{1}{\gamma_P^2} = 1 - \frac{\Delta e_K}{e_{K,\max}} \tag{12g}$$

$$\frac{1}{\gamma_P^2} = \frac{1}{\gamma_K^2} \blacksquare \tag{12h}$$

Invoking the method of agreement: observing that changes in specific potential energy and changes in specific kinetic energy induced no changes in ITD, proves that they are not the fundamental causes to changes in ITDs—they each play half a role.

The same change in total specific energy caused the same change in ITDs proves, via method of agreement, that changes in ITD are caused by a change in total specific energy. Let us now relate total specific energy to ITD.

Deriving Relativistic Total Specific Energy Equation

This derivation begins by solving for changes in specific potential energy and changes in specific kinetic energy and relating them to total specific energy, Δe_T.

$$\frac{1}{\gamma_P^2} = 1 - \frac{\Delta e_P}{e_{P,\max}} \tag{13a}$$

$$\Delta e_P = \left(1 - \frac{1}{\gamma_P^2}\right) e_{P,\max} \tag{13b}$$

$$\text{Let } \tau_{\mathrm{P}}^2 = 1 - \frac{1}{\gamma_P^2}$$

$$\Delta e_P = \tau_P^2 \frac{1}{2} c^2 \tag{13c}$$

$$\frac{1}{\gamma_K^2} = 1 - \frac{\Delta e_K}{e_{K,\max}} \tag{14a}$$

$$\Delta e_K = \left(1 - \frac{1}{\gamma_K^2}\right) e_{K,\max} \tag{14b}$$

$$\text{Let } \tau_{\mathrm{K}}^2 = 1 - \frac{1}{\gamma_K^2}$$

$$\Delta e_K = \tau_K^2 \frac{1}{2} c^2 \tag{14c}$$

$$\Delta e_T = \Delta e_P + \Delta e_K \tag{15a}$$

$$\Delta e_T = \tau_P^2 \frac{1}{2} c^2 + \tau_K^2 \frac{1}{2} c^2 \tag{15b}$$

$$\Delta e_T = (\tau_P^2 + \tau_K^2) \frac{1}{2} c^2 \ \blacksquare \tag{15c}$$

Values of τ ranges from $[0, 1]$ for both specific potential and kinetic energy contributions to ITD. If either are 1, then that form of specific energy is contributing the maximum amount it can to changes to the ITD—it has reached its limit of change in specific energy. For example, when $\tau_K = 1$ it is because $ax = \frac{1}{2}c^2$; or, when $\tau_P = 1$ it is because $gr = \frac{1}{2}c^2$.

Scaling Equation (15c) by mass gives us a relativistic total energy equation, shown in Equation (16).

$$m\Delta e_T = \Delta E_T = (\tau_P^2 + \tau_K^2) \frac{1}{2} mc^2 \tag{16}$$

When both τ_P and τ_K are less than unity, then Equation (16) simplifies to the very familiar Equation (17).

$$E_T = mgh + \tfrac{1}{2}mv^2 \tag{17}$$

Solving for ITD as a function of change in total specific energy gives us Equation (18d):

$$\Delta e_T = (\tau_P^2 + \tau_K^2) \frac{1}{2} c^2 \tag{18a}$$

$$\Delta e_T = \tau_T^2 e_{\max} \tag{18b}$$

$$\frac{\Delta e_T}{e_{\max}} = 1 - \frac{1}{\gamma_T^2} \tag{18c}$$

$$\frac{1}{\gamma_T} = \frac{dt}{dt'} = \sqrt{1 - \frac{\Delta e_T}{e_{\max}}} \tag{18d}$$

This now gives us changes in ITD as a function of its precise cause, change in total specific energy. This completes the inductive proof of the Law of Universal Specificity, which unites all forms of changes in ITDs to a common cause: changes in total specific energy.

8. Conclusion

In conclusion, we conduct one final model comparison and summarize what has been inductively proven and its significance.

A Final Model Comparison

The legacy model and the causal model will agree on most predictions, just as Kepler's model agreed with Ptolemy's (after he perfected Ptolemy's). The Legacy model's math for special relativity needs no revising in terms of being able to predict changes in ITDs, assuming you select the correct inertial frame from which to start the Lorentz transformation. The correlation between velocity and time dilation is caused because of changes in specific kinetic energy; therefore, the causal model in this domain will necessary match observation just as well as the legacy model.

The predictive power of the causal model is not improved in the context of special relativity, but this changed served a great purpose. With this change our understanding of observations became richer, explanations became simpler, we become more effective at predicting when the Lorentz Transforms will work, and we become more equipped to discover deeper causal truths impossible to discover otherwise.

Being equipped to discover deeper causal truths impossible to discover otherwise is the real value to switching to a causal model. Substituting one model for an equally capable model is a waste of time if both suffice. But if one allows to go deeper in discovery, that is the value of the whole exercise in inducing a causal model. This exercise applied to relativity certainly bore fruit, since it made possible the detection of errors made in the equivalency principle, and made a causal correction possible.

Where the legacy model diverges from this causal model lies in the domain of general relativity. This divergence is subtle and may require a level of precision beyond our current capability. Despite not being able to measure a difference, the causal model is superior because it stand on solid ground via inductive proof, which cannot be said of the legacy model since assumptions used to deduce the model cannot be validated, especially since they have been invalidated.

Summary of Findings and Its Significance

It has been inductively proven that changes in ITDs and changes in total specific energy are causal reciprocals—changes in either causes changes in the other. Einstein's math still works to make predictions, but our explanations depart from Einstein's and have become richer. Why has Einstein's and Ptolemy's explanations been rejected, but not Newton's and not Kepler's? Because Einstein and Ptolemy employed a different method of reasoning, than was employed by Newton and Kepler.

Newton and Kepler employed a correct method of induction, which make their causal findings true for all time—to the extent the evidence inductively proves and in the context in which it applies. Einstein, on the other hand, employed a deductive method of reasoning when induction was required, preventing Einstein from identifying the precise cause of the matter; thus removing any solid footing the model might have in any explanation for why things occur as predicted.

To further progress in science, we need solid causally induced relationship to tell us which causal questions to ask next, and what experiments will help us answer them. The question left open in this paper is: what is the cause of time derivative gradients? We can hypothesize for now, but only a proper method of induction following new experimental observations can answer this question conclusively for all time. Scientific deduction is impotent in this regard, and it needs to be rejected when a proper inductive method is made possible by the available evidence.

Appendices

Using Figure 4, consider an object at the center of a massive, but hollow, gravitational source. At t_1, the object has some initial positive velocity, v', to the right. Once the object leaves the center, it experiences a gravitational force the the left. Then at $t2$ the object reaches its apex and is to the left of the original inertial frame. The work is calculated, and it creates overall negative work (or potential) because of the negative force applied over positive distance. Negative work can be plugged into Equation (5), and you get Equation (11).

The reason $SE_{K,\max}$ is used, instead of an equivalent specific potential energy, is because this is the maximum kinetic energy possible at t_1.

One can also derive gravitational ITD starting from a different inertial reference frame, which is an infinite distance away from a gravitational source. This is the common way to define potential energy. The gravitational force would be extremely small, approaching zero, but not zero. Assuming no other influences, and given enough time, an object starting at that reference frame with zero velocity relative to it, would accelerate towards the gravitational source and achieve some velocity relative to that initial frame, which is not accelerating. Then if that object decelerated to a stop relative to the initial frame, and applied equal counter force to the gravitational force, then that object would stop accelerating relative to the initial reference frame too, but it would be experiencing ITD. If you accounted for the total work done, applied it to Equation (4), you would find that the object's gravitational ITD (relative to the initial frame) is a function of GM/r, which is the specific potential energy at its current location. This result matches the common form for gravitation ITD shown in Equation (10, because the common form for for this equation assumes the initial reference frame is infinitely far away from the gravitational source. Now we have a form applicable to any reference frame contained in Equation (11).

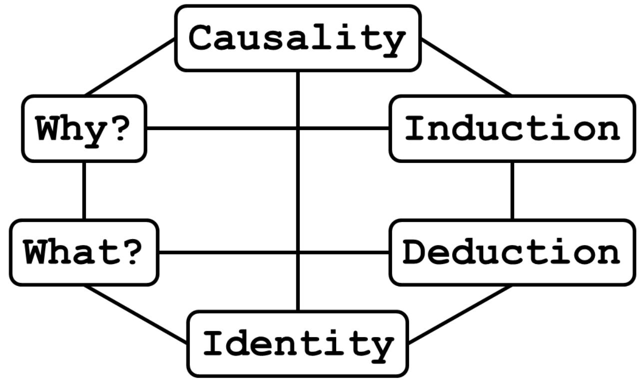

Figure 5. **Conceptual network of reinforcing connections.**

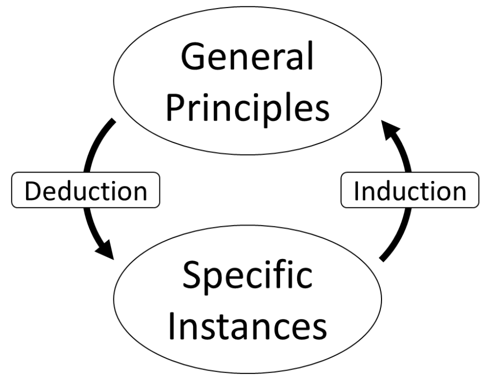

Figure 6. **Induction vs deduction.**

A. Discussion of Key Concept

When building any structure, foundation is key, but it is often taken for granite—pun intended. In this case, the conceptual foundation plays a central role in the structure being built, which will become a network of interconnecting concepts. To that end, this Appendix presents the definition and implication of the following key concepts: induction, deduction, law of identity, law of causality, and finally the differences between *what* and *why* questions. As indicated earlier, these are not isolated concepts, but rather they belong to a network with reinforcing connections that complement each other. Their networked connections are illustrated in Figure 5.

How the concept *ITD* is conceptualized is also discussed in this Appendix.

Induction vs Deduction

Induction is observing something about particular instances and using this observation to form a generalization about all instances, while *deduction* in contrast is the application of a generalization about all instances to a particular observed instance(s). In short, induction is going from some to all, and deduction is going from all to some. The contrast between induction and deduction is shown in Figure 6.[8]

An example of an inductive proposition, albeit an invalid proposition, is: I observed these men are mortal; therefore, all men are mortal. The instances being observed are "these men are mortal", and the generalization being formed is "all men are mortal." An example of a deductive proposition is: all men are mortal, Socrates is a man; therefore, he is mortal. The generalization that is being applied to a particular instance is "all men are mortal", while the particular instance to which this generalization is being applied is "Socrates is mortal." In summary, the process by which one arrives at "all men are mortal" is induction, while the process that uses this generalization to inform on a particular instance is deduction.

Formal logic teaches that for a deductive proposition to be sound—i.e. align with reality—the following must hold:

D1) The proposition needs to be valid—i.e., it possesses no internal inconsistencies or fallacies.
D2) The premises must be true.

The premises in our earlier example on mortality are "all men are mortal", which is a generalization, and "Socrates is a man", which is an identification—i.e., an application of the law of identity. Also at the risk of being obvious, every valid deductive proposition is composed of a set of premises in which at least one is a generalization. This is the reason why deduction is considered an application of a generalization to a particular instance(s). This implies a profound consequence, which is that ensuring the truthfulness of deductive propositions relies on the truthfulness of generalizations. Moreover, for deductions to establish truth, we first need a method of induction that establishes truthful generalizations—i.e., to be able to correctly deduce truths we must first correctly induce truths. Ultimately, induction is the primary means by which

[8]**P5** is demonstrated within this paragraph.

we can discover truth.[9]

Another profound consequence of **D2** and of at least one premise being a generalization is this: when a new true generalization is attained, it necessarily comes with implications. This is because a new set of sound deductions is possible since a new true premise (the new true generalization) is available. This new premise can be combined with other established true premises to form new sound deductions; the result is a set of new implications made possible by the new generalization. This profound consequence is connected to *why* questions and causality, as will be shown shortly, but before that onto our next concept.

Identity and Causality

The *law of identity* states that "to be is to be something"—that is to be something *specific*. In other words, every existent is what it is—it possesses a certain identity or set of properties because of what it is. If it did not have those properties then it would be something else. So when you detect a proton, for example, you do not have to measure its electric charge each and every time; you know what it is because this invariant property was measured before from other protons; and this proton (like the others before it) is what it is, because of its identity as a proton. You also know all of its other properties are those inherent to a proton, such as mass, etc. This also includes all of its yet to be discovered properties.

One should not interpret this to mean that every property of an object is invariant, because such is not the case. For example, a Labrador Retriever must take on a color. That much is invariant, but which color any particular instance takes on may vary among Labrador Retrievers and yet each instance belongs to the same species. All objects possess a set of invariant and variant properties owing to their respective identities. We know all of this about objects in relation to their properties because of the law of identity.[10]

Causality is the law of identity applied to action. A thing must act in a certain way under certain conditions in accordance with its nature—i.e. in accordance with its identity. In fact, everything with the same properties—i.e., the same identity—must react in this same way under the same conditions without fail; otherwise, it would violate its identity, which implies a contradiction[11]. In short, it is because of a thing's identity that it must act as it does. Therefore, objects interact with the physical world around them according to their nature and according the nature of the things they interact with in their environment. For example, ice melts when rinsed with lukewarm water, because of the ice's and water's identities. As another example, carbon is formed into diamonds when under sufficient pressure at high temperatures, because of the carbon's identity.

A causal relationship is of the form: Y affected by X will cause Z. The reason why this relationship exists is because of the identities of the entities involved and their interaction. Note that "Y affected by X will cause Z" is implicitly a generalization. As in algebra, "Y" stands for "*any* instance of Y" and "X" stands for "*any* instance of X"; therefore, all instances with those identities apply. Translating the causal relationship into a form that is explicitly a generalization would be: any/all Y affected by any/all X will cause Z. This means causal discovery falls under the "problem of induction"—i.e., causal discoveries are made via induction.

It must be mentioned that this conception of causality is fundamentally different from the common conception and also from the physics conception of causality. The common conception is that X is said to cause Y if X contributes to Y's manifestation, and if Y's manifestation depends (at least partly) on X [19]. The physics conception is that the relationship between cause and effect is operationalized so that the effect must consistently follow (in a timeline) the cause [20]. Both conceptions are of course true, but each necessarily limits the value of the concept because each describes *what* causality is, while the conception used in this paper explains *why* causality is.

What vs Why

This leads us to consider the differences between *what* and *why* questions generally. A *what* question is asking for a mere description of the observation, while a *why* question is asking for its cause [21].[12] It is important to understand the essential difference between the two types of questions, if you want to learn how to obey nature. To see this difference, consider the effects of asking *what* happened versus asking *why* it happened. By observing the effects of this next example, it ought to be fairly evident that an answer to *why* provides us with a dynamic understanding of the law of identity—i.e. a causal view—while an answer to *what* only provides a static understanding.

Consider the question: *what* are the motions of the planets? The success (and failure) of Ptolemy's earth centered model, shown in Figure 7, was due to how well it was able to describe observations leading to useful predictions. Although originally adopted with the veneer of a causal explanation—i.e., divine perfection demanded circles because they are perfect so God *somehow* made their motions circular—it was in fact a noncausal explanation for how the planets (and sun) moved around the earth. In the end, something happening *somehow* is not an explanation of *why*, but rather of *what*. An equivalent explanation would be: the planets move in circles around the earth because, from an observer's perspective on earth, they seem to move around the earth in circles—this is a description of *what* they appear do.

Compare the last question to this question: *why* do planets move as they do? This is a question Ptolemy tried to answer, but ultimately could not; and it stumped humankind for over a millennium while Ptolemy's model remained the dominant view. It was not until Kepler proposed the sun as the common

[9] **P2** is demonstrated within this paragraph.

[10] For those unfamiliar with the proof for the law of identity, it follows that of axiomatic proofs. Any arguments denying the law of identity's validity rely on its acceptance, creating a contradiction that is only resolvable by denying the denial. Try to deny it and see if any parts (or the whole) of your argument assumed the law of identity to be true. This make any argument against the law of identity self-refuting.

[11] An important side note for those not intimately familiar with the law of non-contradiction is that a contradiction may be arrived at through a process of thought, but contradictions do not exist in reality. Arriving at a contradiction implies an error in thought, not in reality. Indeed the only way we know that an error in thought has occurred is because one arrives at a contradiction, meaning the considered ideas do not align with reality. The reasoning behind why contradictions do not exist is because a thing may never be itself and not itself at the same time in the same respect, which is the converse of the law of identity. When you believe you have discovered a contradiction in reality, check your premises; you will discover that at least one of them is wrong. Indeed the best way (if not the only way) to know that something is right is the realization that its denial results in a contradiction that can only be resolved by denying the denial.

[12] That is of course unless you ask a *what* question in the form of, "*what* caused this to happen?", which is the same as asking *why* it happened. One can safely assume throughout this paper that a *what* question is never formed as a *why* question unless explicitly stated otherwise.

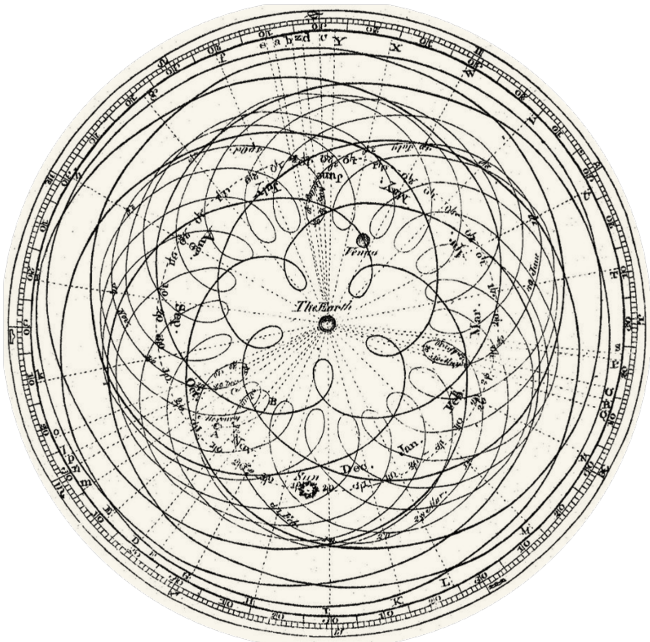

Figure 7. **Ptolemy's causeless planetary model.**

cause uniting all planetary motion (including the earth's), that someone like Newton was able to ultimately boil down the cause of all celestial motion to a force called gravity. The reason *why* planets move the way they do is predominantly due to the gravitational forces exerted on them by the sun [5].

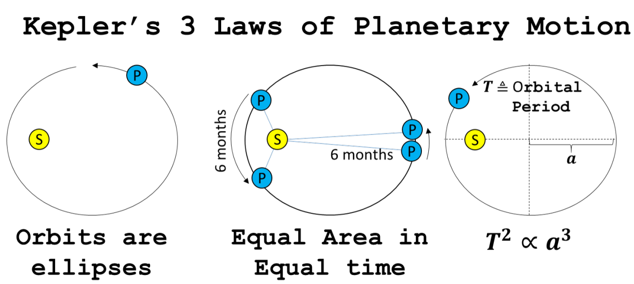

Figure 8. **Kepler's laws where the sun is the cause.**

What does an answer to *why* buy us that *what* does not? Recall that (1) answering a *why* question identifies a cause, (2) a discovered cause is a new generalization, and (3) a new generalization implies that new sound deductions are possible. Therefore, new implications are made possible from discovering new causes arising from answering *why* questions. An answer to *why* buys us greater understanding because of the implications contained within the answer, while an answer to *what* comes with no implications—it just is *what* it is.

When we want to command nature, it is insufficient to know *what* it is doing; we need to know *why* it is doing it so we can understand the implications and take appropriate action in order to realize our vision for nature. As an example, the implication of the discovery of gravitational force is that the sun's, earth's, and moon's gravitational forces affect all bodies within their influence. It was Newtonian physics that allowed us to go to the moon because we understood the implication of the answer to *why* planets move as they do. We needed to understand *why* planets move so its implications reveal how to obey nature. Only then could we command nature to direct our motion to the heavens according to our vision.[13]

In contrast, imagine trying to go to the moon on Ptolemy's planetary model and the descriptive noncausal understanding of planetary motion that went along with it. Given the context of their understanding, would not a divine act seem required to go to the moon? When compared to *what*, knowing *why* is the primary means by which we gain command over nature.

Inertial Time Differential

As an analogy for interpreting what changes in *inertial time differential* (IDT) does, imagine a system of cogs turned by a hand crank attached to the ITD cog, which drives the others. For this analogy, the original inertial reference frame time drives that hand crank at the same revolutions per minute (RPM) regardless of ITD. When ITD occurs, then that original ITD cog is swapped out for a smaller cog. From then on the hand crank spins the system of cogs at a slower RPM than before ITD, and will continue to do so until that cog is swapped out again (by another change in specific kinetic energy). Figure 9 illustrates this analogy.

B. Legacy Derivation of Special Relativity Time Dilation

The cause of time differential—AKA time dilation—in special relativity, has been attributed to relative velocity. As we shall soon see, relative velocity is correlated to time differential, but it is not the cause of time differential. The reason relative velocity has been attributed as the cause of time differential is derived from geometric laws when you assume the speed of light is constant. The original idea of the speed of light being constant stems from Maxwell's wave equations. In addition, the speed of light has been empirically measured to be constant from Michelson's experiments, who was actually attempting to prove it was not constant [2].

A simple thought experiment sets up the problem to derive time differential given constant speed of light. First imagine a light clock on a stationary ship that emits light from a known location, the light travels some distance, Δy, strikes a mirror and returns the same distance back to the clock's receiver, as shown in Figure 10.

Now imagine that the ship instead has some positive and constant velocity, v, then the light clock can be observed to emit light at the source, bounce off the mirror and return to the receiver but the overall path was different. The light traveled the same vertical distance as before, but this time the light is traveling some non-zero horizontal distance, as show in Figure 11.

Traditional Newtonian physics would have v_1 and $v2$ be greater than c since the motion of the ship would contribute to the total velocity of the light. However, since the speed of light is constant in all references frames, then $v1$ and $v2$ remain c—the same speed the light was traveling when the ship was at rest.

[13]The implications also explain why Ptolemy's planetary model got close, but ultimately missed the mark with inexplicable model failures. Nor are these implications invalidated by Einstein's theory of general relativity. Einstein simply found a more general principle which explains even more things, whose equations simplify to Newton's under certain conditions.

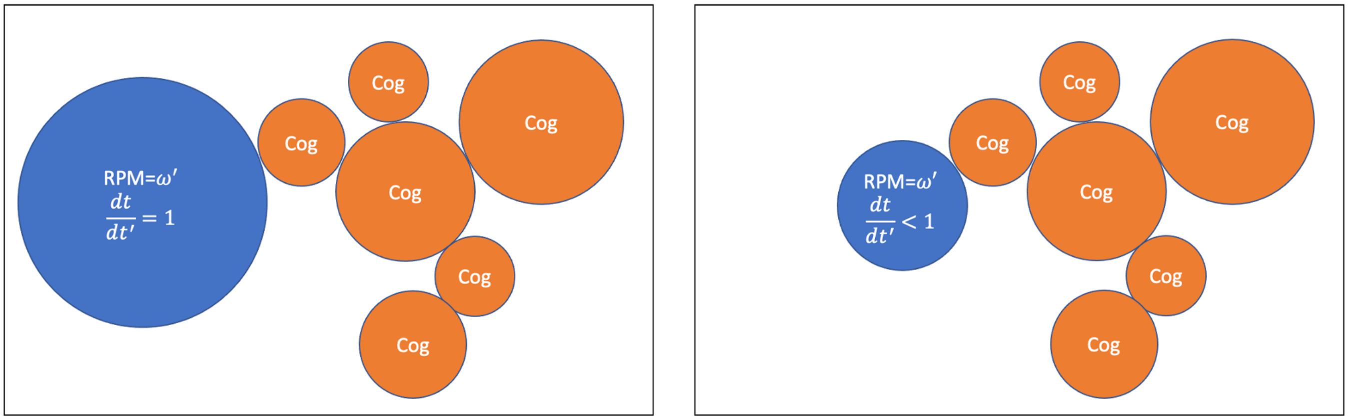

Figure 9. **Left: system of cogs with unity ITD. Right: system of cogs with non-unity ITD.**

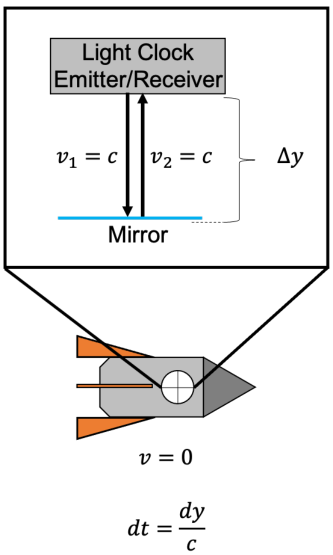

Figure 10. **Light Clock At Rest.**

Following geometric laws gives us a relationship between time experienced on the moving ship, Δt, and time experienced on the stationary ship, $\Delta t'$. A *differential* exists between how time passes between the two reference frames. Pythagorean's theorem may be leveraged compare how much distance is covered by the light of the two clocks, as shown in Figure, to derive time differential.

Using geometric laws we get:

$$(cdt)^2 + (vdt')^2 = (cdt')^2 \tag{19a}$$

$$dt^2 + \frac{v^2 dt'^2}{c^2} = dt'^2 \tag{19b}$$

$$\frac{dt^2}{dt'^2} + \frac{v^2}{c^2} = 1 \tag{19c}$$

$$\frac{dt}{dt'} = \sqrt{1 - \frac{v^2}{c^2}} \blacksquare \tag{19d}$$

From equation (19) it seems reasonable to conclude v caused the time differential because the speed of light is constant and

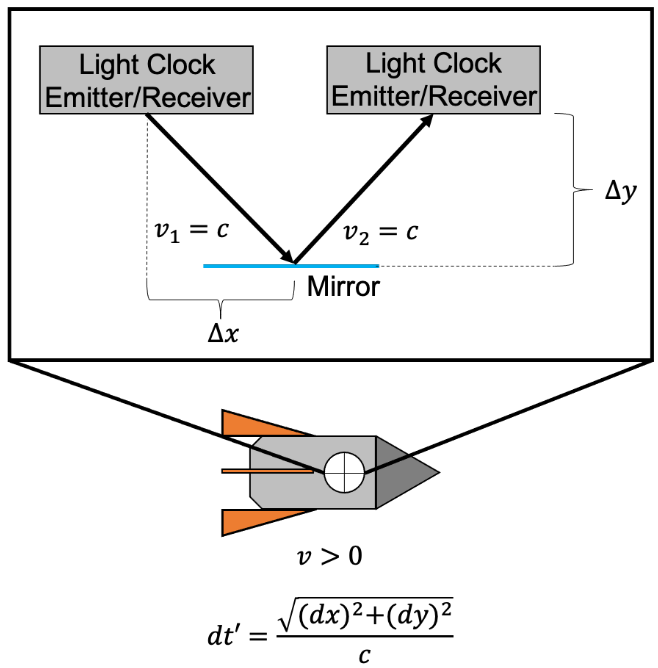

Figure 11. **Light Clock In Motion.**

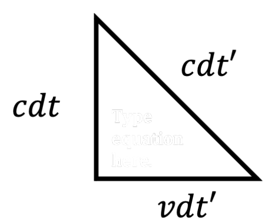

Figure 12. **Pythagorean relationship for distance traveled.**

the only variable is v_{ship}. As will be shown, via the method of difference and agreement, velocity cannot be the cause. Velocity is actually correlated to time differential because velocity is an effect to the real cause of time differential.

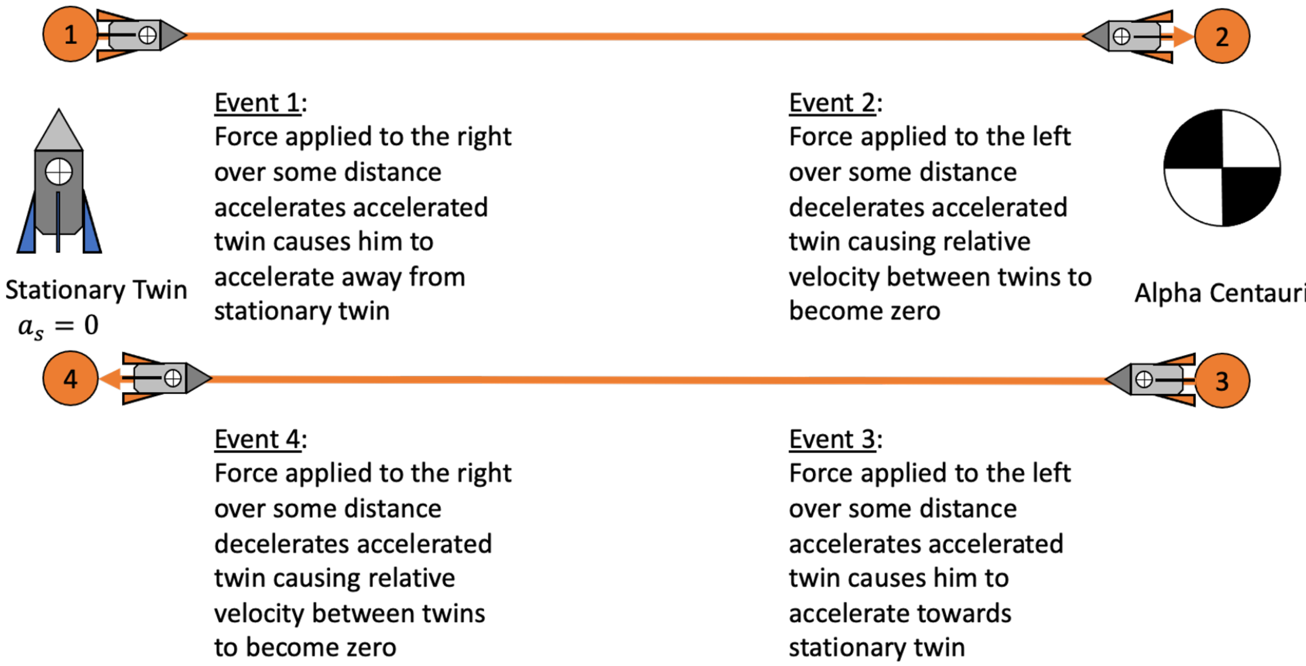

Figure 13. Events Leading to The Twins Paradox.

C. Twins Paradox

The Legacy Setup

Assuming that velocity is the cause of special relativity, then time differential leads to what is termed *The Twins Paradox*, and the events of this paradox are illustrated in Figure 13. In this paradox, a twin takes off in a ship at some velocity towards Alpha Centauri, arrives, stops, turns around and upon returning home discovers that his twin aged more than himself.[14] This is a paradox because, according to special relativity's account for time differential each twin fully expected that the other would have aged less. Why? Because on the flight out and back, each twin perceived that the other was moving, so the other's light clock would have looked like Figure 11. Both twins in fact observed the other's light clock looking like Figure 11.

Both clocks appeared to look like Figure 11, but only one aged. This tells us something very important because it reveals a contradiction in our assumptions. It was assumed that perceived velocity causes time differential, because it creates a time clock that looks like Figure 11, which means time differential occurs. And yet for one twin, time differential did not occur. Invoking the method of difference, where each twin experienced a different effect than the other, while having the same relative velocity, proves that velocity cannot be the cause of time differential. Then what is?

The Causal Resolution

Applying Equation 5 to the four events as shown in Figure 13, and assuming the same magnitude of acceleration was applied over the same magnitude of distance, gives us Equation (20) :

Event 1 :
$$\frac{dt_1}{dt'} = \sqrt{1 - \frac{ax_a}{SK_{E,max}}} \tag{20a}$$
Event 2 :
$$\frac{dt_2}{dt'} = \sqrt{1 - \frac{ax_a + (-a)x_a}{SK_{E,max}}} = 1 \tag{20b}$$
Event 3 :
$$\frac{dt_3}{dt'} = \sqrt{1 - \frac{ax_a + (-a)x_a + (-a)(-x_a)}{SK_{E,max}}} \tag{20c}$$
Event 4 :
$$0 = ax_a + (-a)x_a + (-a)(-x_a) + (a)(-x) \tag{20d}$$
$$\frac{dt_4}{dt'} = \sqrt{1 - \frac{(0)}{SK_{E,max}}} = 1 \tag{20e}$$
Where :

dt' is the time derivative before time differential
dt_1 is the time derivative for the accelerating twin after event 1
dt_2 is the time derivative for the accelerating twin after event 2
dt_3 is the time derivative for the accelerating twin after event 3
dt_4 is the time derivative for the accelerating twin after event 4

As might be expected, ITD is unity after event 2 and event 4.

[14] Just to clarify, it is assumed the stationary twin is in uniform space, i.e., not in the vicinity of any source of gravity; that the distance being accelerated is so small of fraction of the total distance covered it can be ignored; and the relative velocity between the stationary twin and Alpha Centauri is zero.

Relative Velocity and the Space Differential

Although the cause for why the accelerated twin was the twin that experienced ITD, one last question remains to be answer before the paradox is resolved. Why would both twins perceive the other twin's light clocks behaving exactly the same way? In is no longer certain that they would see the same thing, given this new causal understanding. The relative velocity measured by the moving observer can be faster, slower, or the same. We test each and determine that we can prove it cannot be faster or slower, which only leaves that the relative velocity must be measured the same for both observers.

We start with assumption that both twins measure the same relative velocity, and its consequence to space differential—AKA length contraction—is shown in Equation (21).

$$\text{Proof :}$$

$$v' = v \tag{21a}$$

$$\frac{dx'}{dt'} = \frac{dx}{dt} \tag{21b}$$

$$\frac{dx'}{dt'} = \frac{dx}{dt'\sqrt{1 - \frac{\Delta SK_E}{SK_{E,max}}}} \tag{21c}$$

$$\frac{dx}{dx'} = \sqrt{1 - \frac{\Delta SK_E}{SK_{E,max}}} = \frac{1}{\gamma} \blacksquare \tag{21d}$$

Where :

v' is measured velocity from inertial frame
v is measured velocity from moving frame
dx' is space derivative before time differential
dx is space derivative after time differential
dt' is time derivative before time differential
dt is time derivative after time differential

The effect is that both clocks to appear to behave the same regardless of observer.

If we assume that both clocks did not appear the same because relative velocity appears faster for the moving twin, then we get Equation (23) instead:

$$\frac{dx}{dx'} > \frac{1}{\gamma} \tag{23}$$

The effect is that both clocks to appear different depending on observer.

If we assume instead assume relative velocity appears slower for the moving twin, then we get Equation (24):

$$\frac{dx}{dx'} < \frac{1}{\gamma} \tag{24}$$

Only Equation (21) avoids any contradictions, making it the only remaining option. Observe each equations effects on relative velocity measured by the moving observer, as shown by the y-axes in Figure 14. We can see in the top plot of the figure, that if the moving observer were to see a velocity less than that of the stationary observer, you get the interesting contradiction where added velocity reduces velocity; therefore, we can eliminate that option. We can see in the bottom plot of the figure, that if the moving observer were to see a velocity greater than that of the stationary observer, you get the contradiction where measured velocity exceeds the speed of light; therefore, we can eliminate that option. Therefore, the only remaining option is that pair-wise measured relative velocities must remain equal for both pair-wise observers.

An interpretation of Equation (21) is that the units of measurement for length for the moving observer has changed. A yard stick no longer measures a yard, it measures something greater than a yard—e.g., $\Delta x' = \gamma \Delta x \implies \Delta x' > \Delta x$. This is only an optical illusion, like refraction, as illustrated by the following example.

Consider an accelerated observer headed towards some destination at velocity, v'. Suppose the ITD is affected such that it is halved. Then when the measurement of time is halved it also makes distance traveled appear halved—e.g., instead of Alpha Centauri being about four light years away, the trip was made as if it were two light years. The true distance of things did not change in reality, but because time was affected, it appeared closer, which is the meaning of Equation (21).

Wrapping up The Twins Paradox, The accelerated twin experiences less than unity ITD and a space differential to match. As this appendix shows, the twins paradox is resolved when the causal model is applied.

D. Twins Age On a Continuum

This is a concrete example for not having acceleration information and predicting which twin ages. As a concrete example suppose the relative velocity between twins starts off as zero, then there is a relative velocity of v_s causing twins to separate, then there is a relative velocity of v_c causing twins to converge back together until finally they are together and their relative velocity is zero again. Which twin ages less? There are indeed an infinite set of possibilities resulting in a continuum of possibilities.

Below includes specific numbers, with just the relative velocity information, and results presented shortly after. Assuming you do not predict the result beforehand, it will prove the point.

1. Relative velocity, as seen by twins, is 0. This is the start of the twins common reference frame.
2. Then instantly the relative velocity, as seen by twins, becomes $0.2c$, causing them to move apart. One twin can be said to be moving left, the other right. This continues for 3.5 $[sec]$, as measured from the right twin that sees the other moving right to converge.
3. Then instantly the relative velocity, as seen by twins, becomes $0.2c$, causing them to move converge. This continues for 3.8 $[sec]$, as measured from the right twin again—the time it takes for the twins to rendezvous.
4. Experiment ends after rendezvous. Twins instantly decelerate to 0. Clocks are compared.

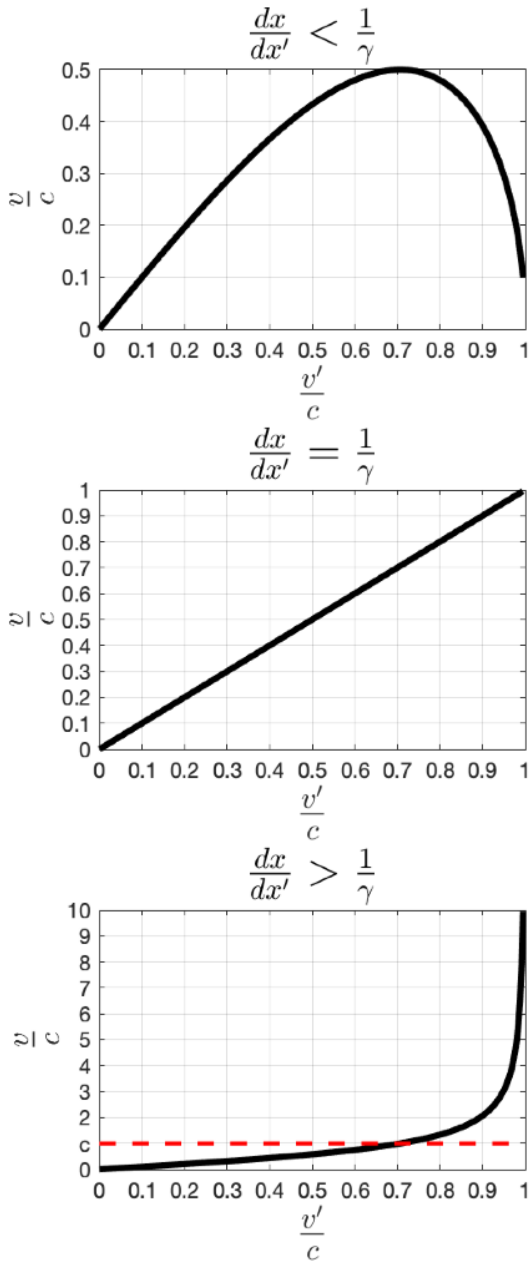

Figure 14. Top: relative velocity is slower for moving observer. Middle: relative velocity is the same for both observers. Bottom: relative velocity is faster for moving observer.

Make a prediction, for which twin ages less, then see these results: Total scenario time for primary reference frame is 10.4 $[sec]$. The left "moving" twin ages 9.2 $[sec]$, and the right twin ages 7.4 $[sec]$, according to their respective clocks.

Why? Here is the remaining relevant information:

1. Both twins instantly accelerate to $0.2c$ to the right, with respect to primary inertial reference frame. Relative velocity, as seen by twins, is 0. This is the start of the twins common reference frame.
2. "Moving" twin instantly accelerates to $0.2c$ left, with respect to primary inertial reference frame—essentially stopping. Relative velocity, as seen by twins, is $0.2c$. This continues for 5 $[sec]$, as measured from primary inertial reference frame's clock.
3. "Moving" twin instantly accelerates $0.38c$ to the right, with respect to primary inertial reference frame. Relative velocity, as seen by twins, is $0.2c$.[15] This goes on for 5.4 $[sec]$, as measured from primary inertial reference frame's clock—the time it takes for the twins to rendezvous.
4. Experiment ends after rendezvous. Twins instantly decelerate to 0. Clocks are compared.

This is a case where if you starting initial inertial reference frame from when both twins accelerated together, you might expect the left accelerating twin to age less, but he ages more. This suggests that it might be possible for there to be a universal origin where all clocks tick fastest, or that accelerating away from earth may have different effects depending on the direction you go—towards this possible origin might age you faster, and going away might age you slower.

E. Deduced Implications

Many implications result from this new causal discovery, even more than what is contained in this paper. A few implications are covered here to include implications creating a need to revisit: the Schwarzschild metric, $E = mc^2$, mass-energy relationship, a photon's mass, and a photon's momentum.

Revisiting The Schwarzschild Metric

In my research I stumbled up an example here [17]. Basically, the example answers the question: given measurements from an observer really far away from a planet's gravitational field, what is the ITD between two objects on the planet's surface (some distance r from its center), when one object is stationary and the other is falling with observed (from the distant observer) velocity, v'?

Appendix I contains the detailed calculations, but the results derived using the legacy model and the Schwarzschild Metric is shown in Equation (25).

$$\frac{dt_f}{dt_s} = \sqrt{1 - \frac{\gamma_P^4 v'^2}{c^2}} \tag{25}$$

Where :

dt_f is the falling object's time derivative

dt_s is the stationary object's time derivative

γ_P is γ only considering specific potential energy

v' is velocity of the falling object as measured by distant observer

Appendix I contains the detailed calculations, but the results derived using the Law of Universal Specificity is shown in Equation (26).

[15] The relative velocity is found using the velocity addition equation in relativity, see Equation 32 in Appendix G.

$$\frac{dt_f}{dt_s} = \sqrt{1 - \frac{\gamma_P^2 v'^2}{c^2}} \tag{26}$$

Appendix I has the detailed argument, but the conclusion is this: both models agree that the falling object's velocity measured on the surface is greater than when it is measured by the distant observer. The legacy model gets the additional γ^2 factor by assuming space-time curves and the speed of light (measured by a distant observer) is constant in a gravity potential, which is proven to not match observations when refracting light through higher gravity potential mediums, as is discussed in the next subsection.

Revisiting $E = mc^2$

Looking at Equation (16), it is apparent that $E_T \leq mc^2$. Additionally, light is also assumed to be eternal, because of conservation of mass and energy; therefore, for light, $\tau_P^2 + \tau_K^2 \geq 1$.

If an object were, with respect to an inertial UIMU described in Section 6, accelerated to c, and close to a gravity potential such that $\tau_P^2 = 1$, then this would result in that objects total energy being $E_T = mc^2$. This does not seem possible given that, according to Equation (18d), the ITD would become imaginary—a clear contradiction.

It seems more reasonable to conclude that the max energy for any object is always limited by $\frac{1}{2}mc^2$, as Equation (18d) suggests, in order to avoid imaginary ITDs. In which case, everything is limited by: $\tau_P^2 + \tau_K^2 \leq 1$. Combining this inequality with the inequality at the beginning of this section, gives us $\tau_P^2 + \tau_K^2 = 1$ for light.

Two pieces of evidence strongly suggest that light travels less than c when in vicinity of a gravitational ITD and other contexts. This evidence is found in the domain of refraction, where light is known to travel less than c, and in a thought experiment involving a light clock that operates parallel to the velocity vector. The thought experiment is discussed in Appendix G, while refraction is discussed here.

Taking a fresh look at refraction with this possibility in mind, what would this mean? It means the index of refraction, n, is related to gravitational ITD. In fact, when one attempts to relate n in terms of gravitational ITD, then the result is Equation (27).

$$n = \frac{c}{v} \tag{27a}$$

$$\frac{1}{n} = \frac{c - \Delta v}{c} \tag{27b}$$

$$\frac{1}{n} = 1 - \frac{\Delta v}{c} \tag{27c}$$

$$\frac{\Delta v}{c} = 1 - \frac{1}{n} \tag{27d}$$

$$\frac{dt}{dt'} = \sqrt{1 - \left(1 - \frac{1}{n}\right)^2} \tag{27e}$$

$$\frac{1}{\gamma_P^2} = 1 - \left(1 - \frac{1}{n}\right)^2 \tag{27f}$$

$$\left(1 - \frac{1}{n}\right)^2 = 1 - \frac{1}{\gamma_P^2} = \tau_P^2 \tag{27g}$$

$$\frac{1}{n} = 1 - \tau_P \tag{27h}$$

$$n = \frac{1}{1 - \tau_P} \ \blacksquare \tag{27i}$$

Where :

dt' is time derivative outside refracting object
dt is time derivative inside refracting object
n is the index of refraction
v is the velocity of light inside refracting object
Δv is light's change in velocity

This would explain a few things, like

1. Why light curves under the influence of gravity is related to refraction.
2. Why light changes direction once during refraction.
3. Why the light's wavelength gets smaller.
4. Why increased density is correlated to increased refraction angle and slower light speeds.
5. Why it requires something like refraction to observe light slowing down.

It explains why light curves under the influence of gravity is related to refraction, because gravity is a form of refraction. The cause is the same in both cases, a TDG. Snell's law can now be employed to predict the curvature of a light path due to gravity.

It explains why light changes direction once, because the the TDG exists only at the entry point and the exit point of the refracting material, and it is flat everywhere else.

It explains why the wavelength gets smaller, because of the conservation of energy where $\gamma_P^2 + \gamma_K^2 = 1$ for light, more of its energy is now accounted for in the γ_P^2 term. Thus, it's frequency, as measure of its energy, remains unchanged while its wavelength gets smaller. Also, from the light's perspective, which would measure its speed as c, it blue shifted—just as light blue shifts when light descends into greater gravitational potential anywhere else.[16]

[16]More precise integration of color shifting in the domains of the Doppler Effect, gravitation, and refraction is presented in Appendix J.

It explains why increased density is correlated to increased refraction and the slowing down of light. The distance between gravity sources, within the material, decreases, which increasing the gravitational potential and ITD. The angle is more severe with higher density because the forces induced at the TDGs located at the entry and exit points are stronger.

It explains why refraction allows us to see light slowing down, because space does not bend as it is assumed to in the legacy model. Observing light slow down during refraction is an outside view looking into a domain with slower time without bending space. This is why Schwarzschild Metric example in Appendix I is in error.

Given this new understanding of the available evidence, it is reasonable to adjust prior assumptions about light speed and the total energy of massed objects. It is now reasonable to split the single concept previously under *constant speed of light* into two concepts: (1) the speed light is traveling (situations where $\tau_P > 0$), and (2) the upper speed limit anything can travel (situation where $\tau_K = 1$). Additionally, it is now reasonable to conclude that the total energy of massed objects is $\frac{1}{2}mc^2$ and not mc^2.

What about the prior assumption that mass and energy are interchangeable? This concept must also be revisited.

Revisiting Mass-Energy Relationship

Nothing from the relativistic total specific energy equations gives rise to the notion that mass and energy are interchangeable—that mass can be converted into energy or vice versa. Given relativity's more consistent causal model's new foundation, we must dismiss this notion as arbitrary, lacking any evidence. Energy remains an inseparable aspect of an object having some relationship to the object's mass—as it did in Newtonian physics. Therefore, mass cannot be converted into energy, as theorized before, in the sense that mass disappears and pure energy without mass appears. The energy that appears, in say splitting the atom, is a bunch of fast moving massed objects that are extremely tiny—the same amount of mass lost by the original object.

Lets consider a case involving a massed object comprised of many entangled photons, a particle the legacy model assumed to have no mass. Let's also consider that this object is inertial according to an UIMU, and has some mass m. If this object were to disintegrate into nothing, but free moving photons, What would the total energy be of all the released photons? If we assume that mass is conserved, then the total mass of all the photons is m, and their speed would c by definition—not being influenced by their neighbors gravitational ITD any longer. Therefore, $\tau_P^2 = 0$ and $\tau_K^2 = 1$ and plugging these values into the total relativistic energy equation we get: $E_T = \frac{1}{2}mc^2$.

If a photon is not massless, like many formerly supposed, then what is its mass? We now have the tools to measure this.

Revisiting a Photon's Mass

Integrating the photon energy equation, in Equation (28), with the relativistic total energy equation, in Equation (16), and with light being eternal, gives us the relationship between the mass of a photon and its frequency[17] as shown in Equation (29).

$$E(\nu) = h\nu \tag{28}$$

$$E(\nu) = h\nu = (\tau_P^2 + \tau_K^2)\frac{1}{2}mc^2 \tag{29a}$$

$$m(\nu) = \frac{h\nu}{\lambda(\tau_P^2 + \tau_K^2)e_{\max}} = \frac{h\nu}{e_{\max}} = \frac{2h\nu}{\lambda c^2} \tag{29b}$$

$$\begin{aligned} &\text{Where :} \\ &\qquad E \text{ is the total energy of a photon.} \\ &\qquad h \text{ is Planck's constant.} \\ &\qquad \nu \text{ is the photon's frequency.} \end{aligned}$$

The mass of a photon is a function of its frequency. It stands to reason, given certain other observations about a photon's momentum, which also must be revisited.

Revisiting a Photon's Momentum

Because it was formerly assumed that $E = mc^2$, it was inferred that the momentum of a photon was defined as Equation (30) below:

$$p = mc = \frac{E}{c} \tag{30}$$

But with our new understanding of relativistic total energy we now get Equation (31) instead:

$$p = mc = \frac{2E}{c} \tag{31}$$

Experimental evidence shows that a photon's momentum is a function of its frequency, and its energy is also a function of its frequency. This much does not contradict observation, but it suggests something very peculiar. If photon undergoes a color shifts—red-to-blue or blue-to-red—then its mass changes. If the masses are different for the same photons of different frequency, then we need to revisit what mass means. I am not entirely certain how to reconcile this, but I speculate in the next section, that while the quantity of matter is not subject to change, that its measurement may be subject to measurement differentials, just like time and space—i.e., the units of measurement change, but not what is being measured.

The complete reconciliation, of a photon's mass and frequency, will have to wait on future work and additional experimental evidence making use of the progress achieved by this work. I will, however, indulge in hypothetical speculation in what this reconciliation may be, and therefore, what it might mean for a theory of everything that is light.

[17] We know from refraction that wavelength does not do a good job relating to its total specific energy. Thus frequency is best used to satisfy conservation of mass in cases of refraction.

In Summary

In summary, we revisited and made corrections to the following topics: the Schwarzschild metric, $E = mc^2$, mass-energy relationship, a photon's mass, and a photon's momentum. We now move onto implications that are suggested, but could not be deductively proven.

F. Hypothetical Implications

It is important to delineate what scientific work is based on causal or deductive proofs and what is speculation. Unfortunately today, this delineation is obscured far too much largely due to common practice of accepting non-validated assumptions to deduce descriptive models.

Do not misunderstand me, I am no Einstein. The only significant thing that separates me from others in this field is the cognitive method I employ—the inductive scientific method. Which means, I do not accept non-validated assumptions, I know how to clearly detect and root cause contradictions, I know what they mean when I see them, I know how to conduct the causal discovery process[18], and I know how to integrate and find implications of newly discovered generalizations to material I am familiar with [3][4][5]—anyone could have done the same with those same powerful cognitive methods.

The causal discovery in this paper was that kinetic and gravitational ITDs are both part of the same phenomena, as apposed to being caused by two very different unrelated phenomena, as previously understood—contained in the Law of Universal Specificity. This is a newly induced generalization, and up to this point, the paper has presented an inductive proof of this law, and a study of its implications via deductive reasoning. I have taken the deductions as far as I can, and now I a will begin to speculate.

Theory of How Photons Create Gravity

I acknowledge up front that there is a possible issue with conservation of mass and a photon mass being related to its frequency, because its mass could change simply because its color shifts. A photon would weigh more inside a gravity well. I do not think the quantity of matter (measured as mass) is actually changing, but our measure for it might change depending on our reference frame. We understand that our measure for time, and space change in a relativistic sense. Is it so unrealistic to assume that our measure for the amount of matter might change as well, that it too might be susceptible to a measurement differential (a changing of units)?

Why might our measure for the amount of matter change? What could cause this to happen? One plausible reason is that photons with the same intensity (amplitude), but different frequency, interacts with different amounts of space over the same time period, as shown in Figure 15. This gives the appearance, in how its modeled anyway, that one frequency is "more dense" than the other.

This concept—increasing frequency increases the photon's "density"—is consistent with what is found in Equation (29), $m \propto \nu$, but I acknowledge that it could be a coincidence—i.e., a description of *what* is rather than *why* it is.

What could this mean if it were the true reason? If distance

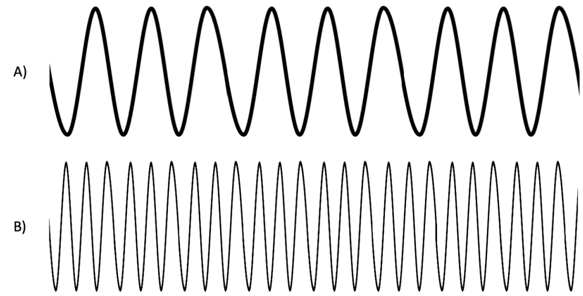

Figure 15. (A) being a smaller frequency seems "less dense" than (B).

between peaks affects how we measure mass, then perhaps it also affects gravity—i.e., the strength of TDGs. If blue photons have a greater TDGs, but they have the same quantity of matter (not to be confused with mass) as red photons, it might explain why blue light bends more than red during refraction.

Theory of Electromagneticgravitism

If photons are responsible for gravity, then photons are responsible for three known forces: electrical forces, magnetic forces, and gravitational forces. Electromagnetism would actually be a special case of *electromagneticgravitism*. Interestingly, each force operates orthogonality to the others, and gravitational force operates longitudinally (along the light path) as a function of the frequency of electromagnetism, which would make gravity's coupling with electromagnetism fundamentally different from the electromagnetic coupling.

It would be an interesting coincidence if photons were responsible for three forces, one force in each spatial dimension. Maybe those are the only three forces because there are only three dimensions light interacts with, and the nuclear forces are really just a special case of *electromagneticgravitism*—each being a different combination of two of the three fundamental forces. These combinations would most likely be electrogravitism and magneticgravitism since electromagnetism is well understood. This would explain why only five forces had been claimed to be discovered to date.

How might light influence gravity? Perhaps like this. We used to think that the red-shift of light leaving a gravitational source was due to the gravity, but what if we have cause and effect backwards? Suppose the red-shifting is a natural phenomena of waves generally, like Figure 16 captures for water. The water undergoes "red-shift" without any gravitational source at the start of the ripple.

If the ripple effect is a wave property such that the wavelength lengthens the further away from a source it goes, then this is what causes red-shifting of light. The red-shifting of light creates a TDG because its wavelength is changing. The TDG causes gravitational force.

Matter is Comprised of Photons

(Absolute zero thermal temperature means no thermal radiation, no photon radiation, meaning no photons remain).

If atomic particles (electron, neutron, photon, positron, etc.) were simply many structured photons then the total relativistic energy of all the photons might be $E = mc^2$. This would occur if the structure of the photons were so tightly packed

[18] And that this process is the only known valid method of induction.

Figure 16. **Ripple effect causes wavelengths to widen the further the wave propagates [18].**

that the distance between photons caused $\tau_P^2 = 1$ (we already know $\tau_K^2 = 1$ for photons).

There is compelling evidence that conventional matter (found on the periodic table) are nothing but light: every massed object emits and absorbs photon radiation constantly, and split atoms releases a significant amount of photons. It might explain why Planck's Law operates as it does, since higher energy implies higher temperature, which implies more kinetic energy for the atomic particles and more kinetic energy is related to blue shifts in photons.

If this were the case, it might lead to the discovery of certain photon structures that combine electromagnetic waves in such a manner that it causes charged patterns or magnetic patters. For example, the structure of photons comprising an electron, could be a photon structure that causes a net negative electric charge while the magnetic part cancels out completely in destructive interference. A difference structure of the same photons might create a positron, which has a positive electric charge, and no magnetic field. As another example, a certain structure of structures (structure of photons, neutrons and electrons) might disrupt the destructive interference of the magnetic part of a photon such that a magnetic field is created. Or when you consider the dynamics of electric or magnetic particles as simply moving light structures, then this might explain how electricity generates magnetism and vice versa.

Perhaps all there is is light in the universe, and the seeming variety of matter found in the periodic table of elements, and their various states, are each simply a unique structure of photons. If so, then the energy of all the photons comprising traditional matter could be $E = mc^2$. However, the released energy can only be $E = \frac{1}{2}mc^2$ because the released photons are no longer in close proximity to each other, and $\tau_P = 0$. The original object still lost mc^2 energy, because that much mass dissipated as released photons, so where did half the energy go? Half the energy was used to achieve escape velocity—i.e., to escape from neighboring photons.

If structured photons comprise matter, there may be a sense in which gravity my be caused by length contraction. First observe that change in specific kinetic energy, which causes a blue shift when moving towards something and red when moving away. A change in potential kinetic energy, which causes a blue shift when moving towards something and red when moving away. This may not be a coincidence.

Perhaps gravity is what we experience with length contraction when a photon experiences changes in its kinetic energy. If this be the case, then perhaps structured photons are constant changing direction, which by definition has to occur since the massed objects move slower than, c; otherwise, the photons would escape, and some do. Perhaps like changes in electrical flux causes a magnetic field and changes in magnetic flux causes an electrical field, the perhaps changes in electromagnetic flux causes a gravitation field via length contraction. If the center of mass had the most length contraction and it reduced as $\frac{1}{r^2}$, then this could explain what causes gravity—length contraction. Since length contraction occurred for changes in kinetic energy, then is it so hard to believe it also occurs for changes in potential energy.

Gravity: Force At Close Proximity

Light ripple effect means light will propagate outward and naturally red shift (red shift not caused by gravity). This red shift creates a TDG, which causes gravity. Light propagates outward via inverse square law, and so does gravity. Planck's law tells us how much light is emitted across the spectrum based on the object's temperature, spectral emissivity and area. The ratio of photon flux to gravitational acceleration is invariant—they are certainly correlated quantities. Method of difference might show that light causes changes ITDs given the right experimental parameters.

Origin of Inertia

Why things cannot occupy the same space. You're fighting eternity. This is why kinetic force is felt via pressure, while gravitational force is not. press your hand against a ball and it does not pass through it, it stops at eternity. Add more energy transfers that energy into the ball's motion, which takes time for the ball's particles to speed up together as a system, this is felt as resistance.

Theory of Everything that is Light

This explains a great deal. The more we understand about light, the more we understand about everything made up of light. What causes changes to light causes changes to everything else made of light. So changes in specific energy causes changes in ITD, causes changes in light's behavior (color shifting).

Ether It Is or It Isn't

The center of the universe is where $\tau_K^2 = 0$.

Perhaps the only states in terms of motion is a non-accelerating and an accelerating state. Perhaps velocity only serves to measure the different between the states of motion. As in, what we call velocity is only a relational measurement between two states, which is useful because it tells us how much acceleration is required to transition from on state to another.

G. Parallel Time Clock

In this example using a light clock, the light clock will be parallel to the velocity vector, as shown in Figure 17 and Figure 18.

This example is interesting because if light travels at the same speed, then the ITD seems to be different depending on direction—e.g., coming from left has a larger ITD than coming from right—which does not make sense. From the stationary ship's perspective, observing the moving orange

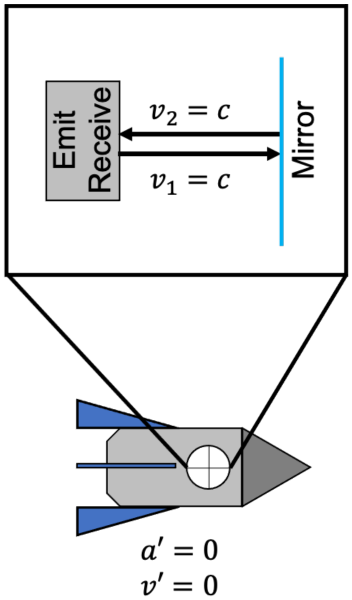

Figure 17. **Stationary parallel light clock.**

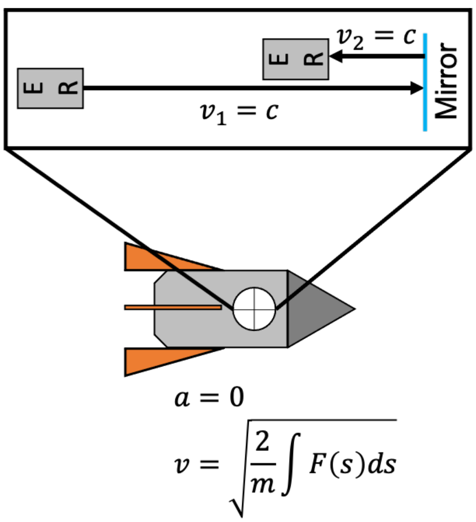

Figure 18. **Moving parallel light clock.**

ship in Figure 18, light takes longer to travel from the emitter to the mirror than it does from the mirror to the receiver. While from the perspective of the person in the ship, as seen in Figure 17, the time it takes to go to the mirror is the same time it takes for the light to go back to the receiver.

How is this reconciled given that light is constant? I fail to find any reconciliation without rejecting the assumption that light travels at different speeds, albeit imperceptibly different. If we treat light as a third traveling object with its own speed subject to change, then it is not surprising why both appear to see the light traveling at the same speed when it is imperceptibly different.

Consider a case where two objects travel in opposite directions at half the speed of light. Do they see eachother as traveling, $c = 0.5c + 0.5c$=c? No, you need to employ the relativity velocity addition formula shown in Equation (32), which tells you that the ships traveling at $0.5c$ in opposite directions will measure their relative velocity as $0.8c$.

$$v_{12} = \frac{v_{01} + v_{02}}{1 + \frac{v_{01}v_{02}}{c^2}} \tag{32}$$

Where :

v_{12} is the velocity of the moving objects seen by the other moving object

v_{01} is the velocity of the first moving object seen by the inertial frame

v_{02} is the velocity of the second moving object seen by the inertial frame

Taking Equation (32) to the extreme, where the speeds are close to c, one's ability to distinguish between changes in velocity becomes vanishingly small, as shown in Figure 19. While distinct observers might agree to each other's perceived relative velocity, they will necessarily disagree what they perceive a third object's relative velocity will be, except for objects traveling near c. Those extremely fast objects, like light, might appear to have the same relative velocity for all observers, when really it is imperceptibly different. In this case, with the parallel light clock, the person viewing the moving light clock is observing imperceptibly faster light from emitter to mirror (compared to the return trip from mirror to receiver). The person moving with the clock would experience no difference in the light's speed during its trip to and from the mirror.

H. Time Derivative Gradient Examples

Two examples are provided to show how the TDG relates to gravitational acceleration. The first example involves the earth's TDG and its respective gravitational acceleration; and the second example involves the Sun's TDG and its respective gravitational acceleration.

The Earth's TDG Example

In this example, we form a TDG estimate between a location, r_1, on the earth's surface and another location, r_2, 1000 meters above r_1. Assuming that our base time derivative is dt_2, then we get the ITD from Equation (33):

$$\text{Let : r}_1 = 6371000 \; [m]$$
$$\text{Let : G} = 6.6744 \times 10^{-11} \; [m^3 kg^{-1} s^{-1}]$$
$$\text{Let : M} = 5.97219 \times 10^{24} \; [kg]$$

$$\frac{dt_1}{dt_2} = \sqrt{1 - \frac{\Delta e_P}{e_{\max}}} = \sqrt{1 - \frac{\int_{r_1}^{r_2} \frac{GM}{r^2} dr}{e_{\max}}} \tag{33a}$$

$$\frac{dt_1}{dt_2} = \sqrt{1 - \frac{9.81 \times 10^3}{e_{\max}}} = 1 - 1.0925 \times 10^{-13} \tag{33b}$$

The resulting TDG is given in Equation (34).

$$\text{Let} : \mathrm{dt}_2 = 1 \implies dt_1 = 1 - 1.0925 \times 10^{-13}$$
$$\nabla dt \triangleq \frac{dt_1 - dt_2}{dr'} \tag{34a}$$
$$\nabla dt \triangleq \frac{-1.0925 \times 10^{-13}}{1000} = -1.0925 \times 10^{-16} \tag{34b}$$

Using Equation (8), we can find the resulting acceleration as show in Equation (35):

$$\sqrt{g(r_1)g(r_2)} = \bar{g} = \frac{c^2}{2dr'}(1 - (1 - \nabla dt \frac{dr'}{dt'})^2) \tag{35a}$$
$$\bar{g} = \frac{c^2}{2dr'}(1 - (1 - \nabla dt \frac{dr'}{dt'})^2) \tag{35b}$$
$$\bar{g} = 9.8185 [^m/_s] \tag{35c}$$

Comparing results from Equation (35) to what we would get with the geometric mean of known gravitational acceleration values, using Newton's Law of Universal Gravitation, is shown in Equation (36). It shows that errors are within limits of precision of the machine used to do the calculation (percent error is 0.0036% or 36 in million):

$$\sqrt{g(r_1)g(r_2)} = 9.8185 \tag{36a}$$
$$\sqrt{(9.8204)(9.8174)} = 9.8185 \tag{36b}$$
$$9.8189 \approx 9.8185 \blacksquare \tag{36c}$$

The Sun's TDG Example

What about when the distances are really far apart when measuring the TDG? In this example we form a TDG estimate between a location, r_1, a distance from the sun that is earth's mean orbital radius, and another location, r_2, a half light second further away. Assuming that our base time derivative is dt_2, then we get the ITD from Equation (37):

$$\text{Let} : \mathrm{r}_1 = 1.5203 \times 10^{11} \; [m]$$
$$\text{Let} : \mathrm{G} = 6.6744 \times 10^{-11} \; [m^3 kg^{-1} s^{-1}]$$
$$\text{Let} : \mathrm{M} = 1.9887 \times 10^{30} \; [kg]$$
$$\frac{dt_1}{dt_2} = \sqrt{1 - \frac{\Delta e_P}{e_{\max}}} = \sqrt{1 - \frac{\int_{r_1}^{r_2} \frac{GM}{r^2} dr}{e_{\max}}} \tag{37a}$$
$$\frac{dt_1}{dt_2} = \sqrt{1 - \frac{8.7352 \times 10^8}{e_{\max}}} = 1 - 9.7192 \times 10^{-9} \tag{37b}$$

The resulting TDG is given in Equation (38).

$$\text{Let} : \mathrm{dt}_2 = 1 \implies dt_1 = 1 - 9.7192 \times 10^{-9}$$
$$\nabla dt \triangleq \frac{dt_1 - dt_2}{dr'} \tag{38a}$$
$$\nabla dt \triangleq \frac{-9.7192 \times 10^{-9}}{\frac{c}{2}} = -2.1628 \times 10^{-25} \tag{38b}$$

Using Equation (8), we can find the resulting acceleration as show in Equation (39):

$$\sqrt{g(r_1)g(r_2)} = \bar{g} = \frac{c^2}{2dr'}(1 - (1 - \nabla dt \frac{dr'}{dt'})^2) \tag{39a}$$
$$\bar{g} = \frac{c^2}{2dr'}(1 - (1 - \nabla dt \frac{dr'}{dt'})^2) \tag{39b}$$
$$\bar{g} = 1.9438 \times 10^{-8} [^m/_s] \tag{39c}$$

Comparing results from Equation (39) to what we would get with the geometric mean of known gravitational acceleration values, using Newton's Law of Universal Gravitation, is shown in Equation (40). It shows that errors are within limits of precision of the machine used to do the calculation (percent error is 0.049% or 490 in million):

$$\sqrt{g(r_1)g(r_2)} = 1.9438 \times 10^{-8} \tag{40a}$$
$$\sqrt{(0.0057)(6.573 \times 10^{-14})} = 1.9438 \times 10^{-8} \tag{40b}$$
$$1.9429 \times 10^{-8} \approx 1.9438 \times 10^{-8} \blacksquare \tag{40c}$$

TDG Examples Takeaway

The key takeaway with these two examples, with both near and far estimates of TDG, is that observations match within errors of precision. The TDG model, relating the TDG to acceleration, is a causal model that matches observation.

I. Law of Universal Specificity vs Schwarzschild Metric

This appendix contains the details on an example that answers the question: given measurements from an observer really far away from a planet's gravitational field, what is the ITD between two objects on the planet's surface (some distance r' from its center), when one object is stationary and the other is falling with observed (from the distant observer) velocity, v'?

This example is worked out using the Law of Universal Specificity and the Schwarzschild metric in order to form a comparison between the legacy model and the causal model for relativity.

The Schwarzschild Metric Solution

This solution was originally derived from here [17]. It is assumed that the person at that reference solved it correctly, as we spotted no errors. The Schwarzschild metric produces Equation (41) to compare time derivatives from the distant observer to the objects on the ground of the planet.

$$c^2dt = (1 - \frac{r_s}{r'})c^2dt' - \frac{dr'^2}{1 - \frac{r_s}{r'}} - r'^2d\theta'^2$$
$$- r'^2sin^2\theta' d\phi'^2 \quad (41a)$$
$$r_s = \frac{2GM}{c^2} \quad (41b)$$

Where :

dt' is time derivative for distant observer
dt is time derivative for objects from planet center
dr' is the radial derivative for objects as measured by distant observer
$d\theta'$ is the azimuth derivative for objects as measured by distant observer
$d\phi'$ is the elevation derivative for objects as measured by distant observer
G is the gravitational constant
M is the mass of the gravitational source
r_s is the Schwarzschild radius
r' is the distance, measured by distant observer, of objects to center of gravitational source
c is the speed of light

It is assumed that the planet is not rotating, and the distant observer is directly above the objects being measured. This way Equation (41) can simplify to Equation (42):

$$c^2dt = (1 - \frac{r_s}{r'})c^2dt' - \frac{dr'^2}{1 - \frac{r_s}{r'}} \quad (42)$$

For the falling object $dr' = v'dt'$ and substituting this in gives us Equation (43):

$$c^2dt_f = (1 - \frac{r_s}{r'})c^2dt' - \frac{(v'dt')^2}{1 - \frac{r_s}{r'}} \quad (43a)$$
$$\frac{dt_f}{dt'} = \sqrt{1 - \frac{r_s}{r'}}\sqrt{1 - \frac{v'^2/\left(1 - \frac{r_s}{r'}\right)^2}{c^2}} \quad (43b)$$

For the stationary object $dr' = 0$ and substituting this in gives us Equation (44):

$$c^2dt_s = (1 - \frac{r_s}{r'})c^2dt' - \frac{0}{1 - \frac{r_s}{r'}} \quad (44a)$$
$$\frac{dt_s}{dt'} = \sqrt{1 - \frac{r_s}{r'}} \quad (44b)$$

Relating Equation (43) and Equation (44) gives us Equation (45), which is the Schwarzschild metric solution to this problem:

$$\frac{dt_f}{dt_s} = \frac{\frac{dt_f}{dt'}}{\frac{dt'}{dt_s}} = \sqrt{1 - \frac{v'^2/\left(1 - \frac{r_s}{r'}\right)^2}{c^2}} \quad (45a)$$
$$\frac{dt_f}{dt_s} = \sqrt{1 - \frac{\gamma_P^4 v'^2}{c^2}} \quad (45b)$$

The Law of Universal Specificity Solution

To solve this problem using The Law of Universal Specificity, we need to measure the difference in total specific energy between the distant observer and the objects, and relate this value to the resulting ITD.

For the falling object this relationship becomes Equation (46):

$$\frac{dt_f}{dt'} = \sqrt{1 - \frac{\Delta e_T}{e_{\max}}} \quad (46a)$$
$$\frac{dt_f}{dt'} = \sqrt{1 - \frac{\Delta e_P + \Delta e_K}{e_{\max}}} \quad (46b)$$
$$\frac{dt_f}{dt'} = \sqrt{1 - \frac{\frac{1}{r'}GM + \frac{1}{2}v'^2}{e_{\max}}} \quad (46c)$$

For the stationary object this relationship becomes Equation (47):

$$\frac{dt_s}{dt'} = \sqrt{1 - \frac{\Delta e_T}{e_{\max}}} \quad (47a)$$
$$\frac{dt_s}{dt'} = \sqrt{1 - \frac{\Delta e_P + \Delta e_K}{e_{\max}}} \quad (47b)$$
$$\frac{dt_s}{dt'} = \sqrt{1 - \frac{\frac{1}{r'}GM + 0}{e_{\max}}} \quad (47c)$$
$$\frac{dt_s}{dt'} = \sqrt{1 - \frac{\frac{1}{r'}GM}{e_{\max}}} \quad (47d)$$

Relating Equation (46) and Equation (47) gives us Equation (48), which is the Law of Universal Specificity solution to this problem:

$$\frac{dt_f}{dt_s} = \frac{\frac{dt_f}{dt'}}{\frac{dt'}{dt_s}} = \sqrt{1 - \frac{\frac{1}{2}v'^2/\left(1 - \frac{\frac{1}{r'}GM}{e_{\max}}\right)}{e_{\max}}} \quad (48a)$$
$$\frac{dt_f}{dt_s} = \sqrt{1 - \frac{\gamma_P^2 v'^2}{c^2}} \quad (48b)$$

Comparing The Law of Universal Specificity and The Schwarzschild Metric Solutions

The interesting part about this problem is that if we just had relative velocity, v, as measured by the objects themselves then we could simply use the specific kinetic energy side of special relativity ITD equation. The reason you need to use the total specific energy, or the Schwarzschild metric, is because measurements are made from a distant observer and this distant observer is trying to relate the objects' time derivatives.

Comparing Equation (45b) and Equation (48b), one observes a single difference—a factor scaling v' by γ_P to some power, where γ_P is just the gravity potential contribution to the ITD conversion, $\frac{dt'}{dt}$. The factor is γ_P^4 for the Schwarzschild metric solution, and it is γ_P^2 for the Law of Universal Specificity solution. Each are scaling v' in order to convert v' to v, which then becomes the special relativity ITD equation.

Which is right, both cannot be. Does $v = \gamma_P v'$ or does $v = \gamma_P^2 v'$? The answer is the former (explained shortly); however, when γ_P is very close to one, like on earth, then $\gamma_P \approx \gamma_P^2$ to the point where I doubt instruments are sensitive enough to tell the difference. This explains why observation has not contradicted predictions so far,e.g., consider GPS—or at these minute differences, if they were detectable, they could have easily been attributed to precision error in measurements.

Before answering why $v = \gamma_P v'$, let us first consider why, in special relativity, $v = v' \neq \gamma_K v'$. In special relativity, $v = v'$ because $\frac{dx}{dx'} = \frac{dt}{dt'}$ which implies $\frac{dx}{dt} = \frac{dx'}{dt'}$, or $v = v'$. This causes two different observers, one moving and one stationary, to report that the other's velocity are v (the same for both observers).

Getting back to our example with a gravity potential, the reported velocities for two observers (e.g., on on a planet's surface and one really far away) are no longer consistent. Why? Because $\frac{dx}{dx'} \neq \frac{dt}{dt'}$ given gravitational caused ITDs. This much is agreed upon between the Schwarzschild metric solution and the Law of Universal Specificity solution—they only disagree as to the degree of the difference.

Converting $\frac{dr'}{dt'}$ to v we get:

$$\frac{dr}{dt} = \frac{dr'}{dt'}\frac{dt'}{dt}\frac{dr}{dr'} \tag{49a}$$

$$= \frac{dr'}{dt'}\gamma_P\frac{dr}{dr'} \tag{49b}$$

The extra γ^2 term found using the Schwarzschild Metric is from the additional assumption of space-time curvature replacing the force of gravity. The causal model making no such non-validated assumption does not have this term. This is the main difference between the models.

Since light is known to take longer to travel through a gravity potential than it would if that space were empty, it is assumed by the legacy model that the space inside the gravity potential gets longer; therefore, it takes longer for light to travel through. This is the reason behind a need for space-time curvature, because light is assumed to travel at c inside a gravity potential as measured by the distant observer, thus explaining why it takes longer and travels at c.

The Law of Universal Specificity causal model, however, does not assume the speed of light remains the same. Gravitational ITD can slow the speed of light down when measured by an outside observer, as proven by refraction discussed in Section E.

To sum up, both models agree that the falling object's velocity measured on the surface is greater than when it is measured by the distant observer. The legacy model gets the additional γ^2 factor by assuming space-time curves and the speed of light (measured by a distant observer) is constant in a gravity potential, which is proven to not match observations when refracting light through higher gravity potential mediums.

J. Integrating Color Shifting Cases

In this section we integrate the color shifting of light due to the Doppler Effect, gravitation, and refraction.

Doppler Effect Color Shift

For the Doppler Effect color shift, the relationship is given by Equation (50).

$$f\lambda = f'\lambda' = c \tag{50a}$$

$$\text{Blue Shift :}$$

$$f = \gamma f' \tag{50b}$$

$$\lambda = \frac{1}{\gamma}\lambda' \tag{50c}$$

$$\text{Red Shift :}$$

$$f = \frac{1}{\gamma}f' \tag{50d}$$

$$\lambda = \gamma\lambda' \tag{50e}$$

$$\text{Where :}$$

$$f' \text{ is source frequency}$$
$$f \text{ is received frequency}$$
$$\lambda' \text{ is source wavelength}$$
$$\lambda \text{ is received wavelength}$$

Gravitational Color Shift

For observers at the location of the light being measured, gravitational color shift is the same relationship as the Doppler Effect color shift. Outside observers, far away from the gravity potential, need an outside perspective, like in the case of refraction.

Refraction Shift

In this case there are three perspectives:

1. Light properties before refraction.
2. Light properties after refraction, but as seen from inside the medium with a change in ITD.
3. Light properties after refraction, but as seen from outside the medium without a change in ITD.

The first two perspectives follow gravitational color shifting, which is to say they follow the Doppler Effect color shifting. The last perspective is interesting, because the speed of the light is not c.

The frequency for this third perspective is assumed to remain constant. We do not wish to make this assumption. In fact since changes in space differential are an optical illusion, it makes more sense that the frequency (the time component of the wave) would change. Either way it truly goes (even if somewhere in the middle), it is inconsequential to observation.

The relationship between this third perspective and the other two are given in Equation (51), assuming frequency is constant:

$$\begin{aligned}
&\text{Given}: \\
&\quad f_3\lambda_3 = v && \text{(51a)} \\
&f \text{ constant}: \\
&\quad f_3 = f' && \text{(51b)} \\
&\quad n = \frac{c}{v} = \frac{f'\lambda'}{f_3\lambda_3} && \text{(51c)} \\
&\quad f_3\lambda_3 = \frac{v}{c} f'\lambda' && \text{(51d)} \\
&\quad f'\lambda_3 = \frac{v}{c} f'\lambda' && \text{(51e)} \\
&\quad \lambda_3 = (1-\tau_P)\lambda' && \text{(51f)} \\
&\lambda \text{ constant}: \\
&\quad \lambda_3 = \lambda' && \text{(51g)} \\
&\quad f_3 = (1-\tau_P)f' && \text{(51h)} \\
&\text{other}: \\
&\quad f_3\lambda_3 = (1-\tau_P)f'\lambda' && \text{(51i)} \\
&\text{Where}: \\
&\quad f' \text{ is source frequency} \\
&\quad f_3 \text{ is frequency inside medium measured from outside} \\
&\quad \lambda' \text{ is source wavelength} \\
&\quad \lambda_3 \text{ is wavelength inside medium measured from outside}
\end{aligned}$$

REFERENCES

[1] *Gravitational Time Dilation*, Wikipedia, 10-Feb-2022. [Online]. Available: https://en.wikipedia.org/wiki/Gravitational_time_dilatio. [Accessed: 10-Feb-2022].

[2] M. Fowler, *The Michelson-Morley Experiment* U. Va. Physics, 10-Feb-2022. [Online]. Available: http://galileoandeinstein.physics.virginia.edu. [Accessed: 10-Feb-2022].

[3] D. Harris and D. Dunham "Understanding Causal AI: The Key to Learning How to Make AI Succeed," *2023 IEEE Aerospace Conference*, Big Sky, MT, 2023.

[4] D. Harris and D. Dunham "Induction in Machine Learning," *2021 IEEE Aerospace Conference*, Big Sky, MT, 2021.

[5] D. Harriman, *The Logical Leap: Induction in Physics*, NYC: Berkley, 2010.

[6] A. Einstein, "On the electrodynamics of Moving Bodies," *Special Theory of Relativity*, pp. 187–218, 1970.

[7] B. Schutz, *Gravity from the ground up an introductory guide to gravity and general relativity*, Cambridge: Cambridge Univ. Press, 2013.

[8] P. Gibbs, "Can Special Relativity Handle Acceleration?," *UC Riverside, 1996*, [Online]. Available: https://math.ucr.edu/home/baez/physics/Relativity/SR/acceleration.html [Accessed: 06-Aug-2022].

[9] "How does relativity theory resolve the twin paradox?," *Scientific American, 2003*, [Online]. Available: https://www.scientificamerican.com/article/how-does-relativity-theor/. [Accessed: 06-Aug-2022].

[10] D. Halliday, R. Resnick, and J. Walker, *Fundamentals of physics*, Milton: John Wiley, 2020.

[11] T. Debs, M. Redhead, and J. Walker, "The twin "paradox" and the conventionality of simultaneity," *American Journal of Physics*, vol. 64, no. 4, pp. 384–392, 1996.

[12] J. Kennedy, *Space, time and Einstein: An introduction*, Abingdon, Oxon: Routledge, 2014. p. 39

[13] R. Mould, *Basic relativity*, New York: Springer, 2002. p. 39

[14] *The REAL source of Gravity might SURPRISE you...*, YouTube, 2021.

[15] *Does Time Cause Gravity?*, YouTube, 2021.

[16] *How Time Dilation Causes Gravity, and How Inertia Works*, YouTube, 2021.

[17] "Gravity - time dilation and Freefall (follow up and simplification)," *Physics Stack Exchange*, 27-Dec-2015. [Online]. Available: https://physics.stackexchange.com/questions/226055/time-dilation-and-freefall-follow-up-and-simplification. [Accessed: 29-Jul-2022].

[18] "Ripples Splash Ripple Effect Water Drop Impact," *maxpixel*. [Online]. Available: https://www.maxpixel.net/photo-1759703. [Accessed: 5-Aug-2022].

[19] *Causality*, Wikipedia, 03-Jan-2022. [Online]. Available: https://en.wikipedia.org/wiki/Causality. [Accessed: 03-Jan-2022].

[20] *Causality (Physics)* Wikipedia, 03-Jan-2022. [Online]. Available: https://en.wikipedia.org/wiki/Causality_(physics). [Accessed: 03-Jan-2022].

[21] J. Pearl, and D. Mackenzie, *The Book of Why: the New Science of Cause and Effect*, NYC: Hachette Book Group Inc., 2018.

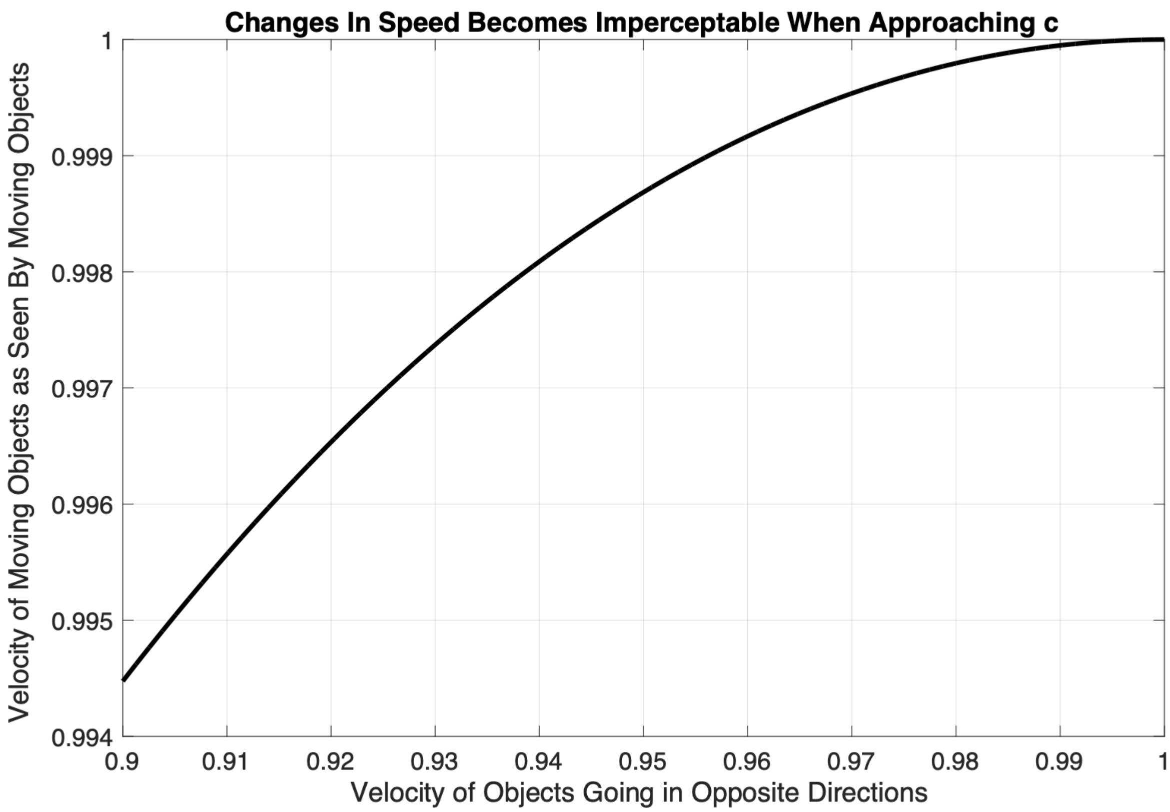

Figure 19. **Changes in speed becomes increasingly indistinguishable the closer to light.**