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, are inductively proven in this paper to be causally related. It is demonstrated that changes in specific energy cause changes in time dilation, and environmental 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 to be 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. As a result, the understanding of an observation's cause becomes richer, which makes explanations more understandable, which generates more confident in predictions, which equips those with this understanding with the ability to discover deeper causal truths impossible to discover otherwise. This is not to say the legacy models are wrong in their predictions; however, that is to say they lacked the full causal footing, relatively speaking, as is demonstrated, which results in poorer explanations for the cause of 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 sense it is only an adjustment of relativity's legacy model on time dilation to a more consistently causal model. The legacy model is able to predict when time dilation would occur and to what degree, but it is unable to explain why it occurs—a causal model is required to answer that question. The power in adopting a properly induced causal model is one's understanding of causes of observations become richer, which makes explanations for observations more understandable, which allows one to become more confident in their predictions, which equips one to discover deeper causal truths impossible to discover otherwise.

The primary difference in method between Einstein's derivations (for time dilation) and those contained in this paper is a difference between deductive proof and inductive proof, respectively. For the legacy time dilation model in special relativity, Einstein deduced implications from prior knowledge induced by Maxwell and others. For general relativity, Einstein made the equivalence principle assumption, and then he deduced its implications. The legacy models remain to this day, excellent predictors.

This paper investigated an additional question: why? What causes time dilation? Answering a question involving why requires induction [5]. Induction, unlike deduction, discovers causes to effects by conducting controlled experiments to reveal which factors are the cause to the sought after effect, and which are not. Then once a cause-effect relationship is discovered, this relationship is often used (as it is in this paper) to deduce implications, and with further evidence it is often used (as it is in this paper) to induce deeper causal relationships.

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 used to make time dilation predictions; Section 4 presents the inductive proof for what causes kinetic time dilation; Section 5 presents a physical interpretation of kinetic time and space dilation; Section 6 deduces the effect of a time derivative gradient given this newly discovered cause; Section 7 completes the inductive proof of The Law of Universal Specificity, which captures the precise cause of time dilation; and finally, Section 9 wraps up with a conclusion. Appendices contain richer content to provide more color to the material when desired.

2. INDUCTIVE VS DEDUCTIVE PROOFS

Between the two proofs, inductive proofs are the lesser well known. They are causal proofs, and each proof requires:

- Observing the relevant causal interactions
- Application of valid concepts to the effect
- Application of valid concepts to relevant antecedent factors being tested as the cause
- Conducting controlled experiments to tease out the precise cause.

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• Using standardized units of measurement to quantify the observed relationship between cause and its effect.

Deductive proofs, on the other hand, start with premises which logically imply the conclusions—think formal deductive logic. The problem with deduction is the problem of induction. At least one of the deduction's premises is always a generalization—e.g., all men are mortal—which can only be validated inductively. Therefore, one cannot validate a deductive conclusion before one has validated all the inductive conclusions that serve as its premises [5].

Both proofs have their place and uses, and neither is invalid when properly applied in their respective domains. The proper domain for induction is gaining new knowledge, and the proper domain for deduction is the application of acquired knowledge to determine implications. This implies that when seeking to discover something new, like a scientific discovery, induction is always required to achieve certainty. Only after validating inductive conclusions, can one deduce its implications with certainty.[2]

Using Deduction in the Inductive Domain

Some, who lack a complete understanding of the proper role and method of induction, attempt to use deduction in an inductive role. They try to acquire new knowledge via a method geared to finding implications of new knowledge. It is an exercise in futility, if certainty in the new knowledge is what you seek.

How the approach is typically carried out is this. Repeating patterns in observations are made, then a generalization is assumed in a manner that its implications would explain the observations.

A famous proponent of this method is Richard Feynman who said:

> We have to say "a few other assumptions" because we cannot prove anything unless we have some laws which we assume to be true, if we expect to make meaningful deductions [7].

If the assumed generalization explains all the observations within its domain, the theory is accepted as probably true. How much evidence is required to achieve certainty with this method? An infinite amount, which is to say it is impossible. The reason it is impossible is that only one counter example, whose existence cannot be disproved, is all it takes for the assumption to be invalidated.

What lends to this approach's plausibility is that those who use it believe it is the only way open to them; therefore, they believe certainty is impossible. If that were true, then you might as well make assumptions from observed patterns, and then deduce models consistent with observations; and adjust the models and assumptions as required. What else are you going to do, if a proper method of induction is closed to you?

Causal Proofs

Inductive proofs are causal proofs, and 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. This implies causal relationships always involve some change or action.

In addition, causal proofs always involve observing and demonstrating what drives these changes through controlled experiments. The only known methods to prove, as a matter of certainty, a causal relationship through controlled experiments are Mill's Methods of induction, which are used in this paper. Lastly, causal proofs go beyond deduced implications of *what* will happen, and demonstrate *why* an observation is necessary *because* of the nature of the entities involved.

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 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), which are resolved using the correct conversions properly.

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.[3]

3. The Special Relativity Model

An important emergent property of special relativity is the kinetic time differential—AKA kinetic time dilation.[4] The primary goal of this paper is to induce the precise cause of what changes time differentials, which will be covered in Sections 4, 6, and 7. In this section, I wish only to present the legacy model sufficiently to show when it predicts changes in time differentials will occur.

Einstein demonstrated that when the speed of light is constant for all inertial (zero net force) reference frame, then simultaneity of events at different locations becomes relative. It becomes necessary to transform time and space components between inertial reference frames, and this transformation from one inertial reference frame to another is termed the *Lorentz Transformation* and is given by Equation (1), where the origins of the two frames coincide at $t = t' = 0$ [6][7].

[2] More on induction vs deduction is covered in *Induction Vs Deduction* in Appendix A.

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

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

$$t = \gamma(t' - \frac{vx'}{c^2}) \tag{1a}$$
$$x = \gamma(x' - vt') \tag{1b}$$
$$y = y' \tag{1c}$$
$$z = z' \tag{1d}$$
Where :
$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{1e}$$

t' is the time measured by the stationary observer.
t is the time measured by the moving observer.
x' is the distance measured by the stationary observer in the $\mathrm{x-axis}$.
x is the distance measured by the moving observer in the $\mathrm{x-axis}$.
v is the relative velocity of the moving observer.
c is the limit of the speed of light.

If one solves for just the time differential with respect to velocity, one gets Equation (2).

$$\frac{dt}{dt'} = \sqrt{1 - \frac{v^2}{c^2}} = \frac{1}{\gamma} \tag{2}$$
Where :
$\frac{dt}{dt'}$ is the time differential between inertial frames

This model describes what the time differential between two frames is, and has utility in predicting future time differentials. Since this model logically fallows from other premises induction was not required to to determine *what* changes in time differentials occur; however, the question of *why* it changes remains open, which is the focus of the next section.

4. Cause of Kinetic Time Differential

What we seek is an inductive proof for what causes one reference frame to age faster than another. The precise cause of changes in 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 that seem potentially relevant are:

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

Before proceeding to any inductive proof, I will provide a brief description of eachq. Some have pointed out, regarding the twins paradox, that the twin that actually ages less accelerates, so it is plausible that the aging difference occurs during acceleration.[5] By far the largest group of people observe that if one applies the Lorentz Transformation correctly, then it describes which observer will age less, so changing of inertial frames seems like a plausible cause. Still others have pointed out that you cannot have a change in time derivative between two reference frame without some velocity between them; therefore, this antecedent factor seems like a plausible cause. The last two factors, as far as I know, are my novel contribution to the list of antecedent factors worth considering—it seemed reasonable to me to include the factors which cause all of the others.

[5]At one point Einstein tried to explain kinetic time differential during acceleration via general relative.

In the following subsections I will proceed via induction, to rule out each non-causal antecedent factor, and to prove which antecedent factor is the cause of changes in kinetic time differential.

Ruling out acceleration

This perspective seems plausible since we know, in the twins paradox[6], 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. This approach, therefore, concludes that the difference in aging must occur during acceleration. Even Einstein attempted a resolution assuming that gravitational time differential was responsible for the kinetic time differential during acceleration; however, this factor has been proven to not be the cause [9][10][11][12].

This approach is certainly on the right path, but two situations serve as a counter example:

1. The same acceleration profile can lead to different amounts of aging.
2. Acceleration can be eliminated altogether in a modified twins paradox, and the differences in aging still occurs.

An example of the first situation: if the traveling twin, in the twins paradox, traveled twice as far given the same acceleration profile, then that twin will be that much younger relative to the stationary twin. Figure 1 shows the age differences as a function of distance given the same acceleration profile.

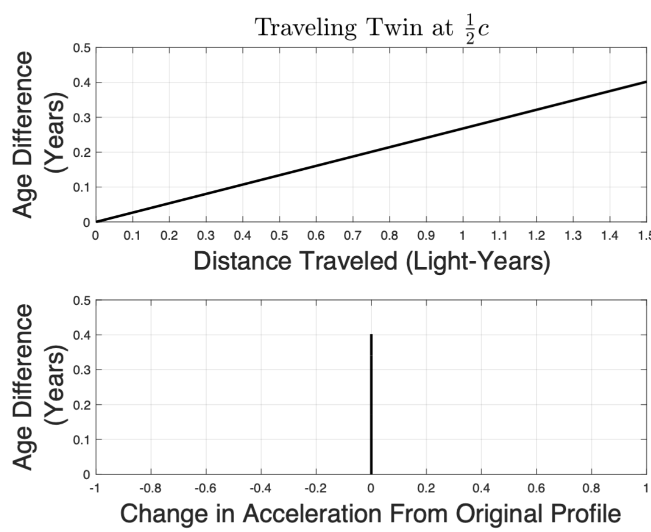

Figure 1. **Acceleration does not change, but age difference increases.**

As another example of the second situation: if you eliminate

[6]See Appendix B for a detailed presentation of the twins paradox.

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; therefore, any time dilation that may have occurred during acceleration has been eliminated. The result? The moving clocks still ticked at a slower pace than the stationary clock.

If acceleration were the cause, you would see a constant acceleration corresponds to a constant and proportional effect; however, this is not the case, the effect changes independently of this antecedent factor. Invoking the method of difference, where the effects differs while the acceleration is constant or non-existent, proves inductively that acceleration is where the differences in aging occur.

Ruling out Change in Inertial Frame

Most seem content with the Lorentz Transforms accurately predicting when changes in time differentials will occur, as in most do not posit a cause, but some do. This posited cause is a claim that a change in time differential occurs where there is a change in inertial reference frame, not during acceleration making acceleration irrelevant as the cause of changes in time differential.

They are not wrong in noticing a change in inertial frame is key, but which inertial frame is the proper starting frame? This is the fatal flaw with this approach. The legacy model assumes there is no universal inertial frame, from which all other inertial frames shall be judged—which is why the theory is called relativity instead of specificity. Therefore, per the legacy model, there is no absolute inertial reference frame, meaning a frame of reference every observer agrees is at rest.

In the case of the twins paradox you start with the inertial frame common to both twins at the start since the traveling twin changes from from this initial frame and eventually returns to it. The traveling twin is therefore the twin that ages less because this twin is the one that changes inertial frames to travel away and come back. Unfortunately for this approach, a counter example exists.

A case exists where one twin accelerates away from the other at $0.2c$ and returns at $0.2c$ and ages more than the stationary twin. See Appendix C 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, then the traveling twin decelerates to a stop, waits, then accelerates to $0.38c$ (or $0.2c$ between the twins, as measured by the twins) until they rendezvous. The result is that the traveling twin who changes reference frames, ages more than the stationary twin, who did not change reference frames from the start of the exercise.

Changing reference frame is inductively proven not to be the precise cause of changes in time differentials by invoking the method of difference. This is a case where the traveling twin in this modified twins paradox experiences the same change in inertial frame as did the traveling twin in the original paradox with respect to the stationary twin—i.e., the antecedent factor is the same. However, the effect is different—i.e., the traveling twin is older, instead of younger like the original paradox—proving a change in inertial frame is not the cause.

Before proceeding onto ruling out another antecedent factor, the modified twins paradox, where both twins accelerate at first gives rise to a novel concept worth mentioning—a *universal inertial frame*.

Universal Inertial Frame

The modified twins paradox example in Appendix C implies that there is what is termed a *universal inertial frame* (UIF)—AKA an absolute inertial reference frame. This UIF would be the inertial frame where identical clocks tick the fastest relative to every other inertial frame. In the case of this modified twins paradox example, additional joint accelerations could have occurred, even well before the twins 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 of all historical accelerations, in order to know how to employ the Lorentz Transformation so that one arrives at the correct prediction.

Given that entropy of information prevents any knowledge of a complete history, other means besides a complete accounting is necessary to determine the final effect of all historical accelerations. It ought to be possible to calibrate any inertial reference frame in the universe, 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 at the inertial reference frame in question. From this we ought to be able to measure any inertial reference frame's velocity relative to the UIF.

Herein lies the first major departure of the causal model from the legacy model. The evidence from the modified twins paradox demonstrates that not only is a UIF necessary, but it is also measurable.

It is also 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 only way his thought experiment would match reality precisely. It is the inertial frame we take for granted when considering the twins paradox, until we consider the modified twins paradox in Appendix C. When not explicitly stated, the rest of this paper implicitly considers the initial inertial reference frame to be the UIF.

I now return to ruling out antecedent factors in the next subsection.

Ruling out Relative Velocity

It might seem reasonable to think velocity is the cause of changes in time differentials between two frames because it is the only variable in the original time differential equation, see 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, but 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 inductively 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 triplets perform the same actions as the twins did in the original paradox. Also suppose, the third triplet performs the opposite action as the traveling twin did in the original paradox—i.e., he travels at the same speed profile, but in the opposite direction. The two traveling siblings can have any magnitude of relative velocity with respect to each other; however, neither one ages more than the other, as shown in Figure 2.

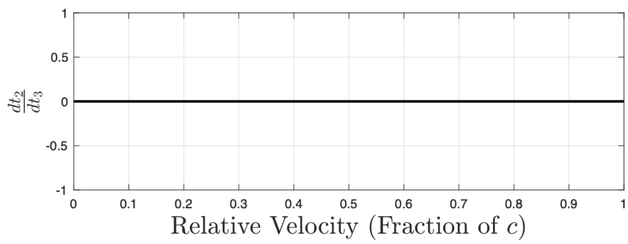

Figure 2. **Velocity changes, but time differential remains unchanged.**

Invoking the method of agreement, where the antecedent factor changed, but the effect remained constant, proves inductively that relative velocity does not cause their pair-wise time differential to change.

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 their pair-wise time differential to depart from unity. 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. As pointed out earlier, the ruled out antecedent factors 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. That would be reasonable, except 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 remaining constant for an inertial frame is termed *inertial time differential* (ITD).[7]

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 the changed ITD remain constant during the entire experiment, because their inertial frames remained constant. Work done caused: (1) a change in relative velocity of the ships; (2) the ships to accelerate; (3) the ships' change of inertial frames; and (3), a change in the ships' IDTs.

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 with respect to each other, but 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 mathematical model that precisely captures the cause's relationship to the effect. The former is accomplished in the next subsection and the latter is accomplished in the following subsection.

Ruling out Work and Inducing Specific Work

Let's put the remaining two factors 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. Using the Lorentz Transformation in Equation (1) 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 inductively 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 specific work applied to them. Using the Lorentz Transformation in Equation (1) reveals the same change in their ITD; therefore, invoking the method of agreement, where each object experienced the same effect, while having the same specific work applied, proves inductively that specific work applied causes a change in ITD ■.

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). Additionally, it is much more satisfying to base changes in ITDs on a non-zero net force applied over some distance because forces are a special fundamental in physics—they are the driving

[7]This concept is covered in more detail in *Inertial Time Differential* in Appendix A.

cause of changes in motion. As stated a couple of times before, specific work causes changes in the other eliminated antecedent factors, to the point where they were correlated to the effect, and therefore, were mistaken by many intelligent people as the cause of changes in ITD.

It took careful study of several controlled experiments to wring out the precise cause of changes in kinetic ITD between two frames. The precise cause explains under what conditions the Lorentz Transformation works, and why the acceleration explanation was a good start, but incomplete.

Knowing what we now know, we can derive a precise math model for changes in kinetic ITD in terms of the precise causal factor.

Deriving The Causal Math Model

The change in kinetic ITD can now be derived in terms of its cause using geometry. Figure 3 sets up the problem pictorially, and the time derivative relationship between the two frames is shown in Figure 4.

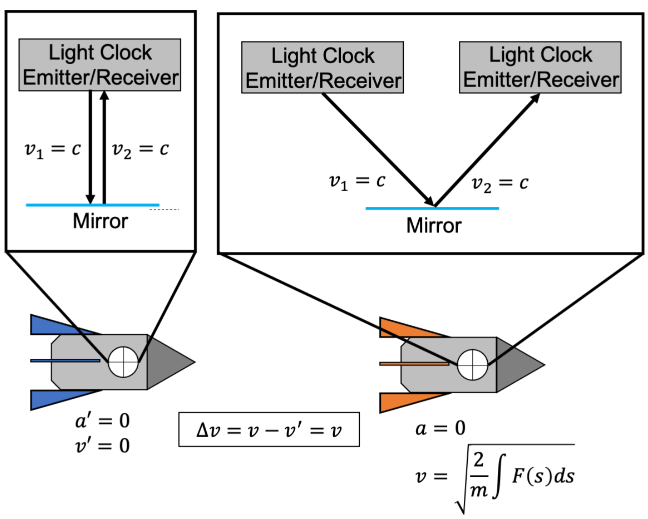

Figure 3. **Reframing the problem with what we know.**

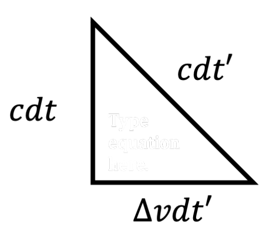

Figure 4. **Pythagorean relationship for distance traveled.**

Using geometric and energy laws we get Equation (3):

$$(cdt)^2 + (\Delta v dt')^2 = (cdt')^2 \tag{3a}$$

$$\frac{dt^2}{dt'^2} + \frac{\Delta v^2}{c^2} = 1 \tag{3b}$$

$$\frac{dt'}{dt'} - \frac{dt}{dt'} = 1 - \sqrt{1 - \frac{\frac{1}{2}\Delta v^2}{\frac{1}{2}c^2}} \tag{3c}$$

$$\frac{\Delta dt}{dt'} = 1 - \sqrt{1 - \frac{\Delta e_K}{e_{K,\max}}} \tag{3d}$$

$$\frac{\Delta dt}{dt'} = 1 - \sqrt{1 - \frac{\int a(s)ds}{e_{K,\max}}} \tag{3e}$$

$$\frac{\Delta dt}{dt'} = 1 - \sqrt{1 - \frac{w}{e_{K,\max}}} = 1 - \frac{1}{\gamma} \blacksquare \tag{3f}$$

Where :

dt' is time derivative closest to UIF in relative velocity
dt is time derivative farthest from UIF in relative velocity
Δdt is the change in time derivative caused by specific work
w is specific work done
e_K is specific kinetic energy

We now have an equation for ITD (and γ) 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.

It is again important to emphasise the difference between the meaning of Equation (2) and Equation (3). In Equation (2), a relative velocity with respect to the UIF causes time differential for as long as there is a relative velocity—it applies over time. Equation (3), on the other hand, creates an ITD between the two reference frames up front in response to some non-zero net force (proportional to mass) applied over some distance, and the moment the net force is zero, then the ITD maintains its effected change until a non-zero net force acts on the object.[8] For example, the twins continue to age differently until their specific energy state changes to match each other.

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 (3) is the remaining precision required to resolve all the cases tested thus far, and its detailed application to the twins paradox is presented in Appendix B.

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

Inertial Space Differential

The legacy model assumes that something termed a *space differential*—AKA length contraction—also takes effect. This was proven deductively by Einstein 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 the light sphere being observed as spherical for all inertial reference frames is for space to have the same differential factor as time so they cancel out [6]. Specific work done must also cause a change in space differential too for the same inductive reasons stated above, and this differential is termed the *inertial space differential* (ISD), and its change via causal terms is given in Equation (4).

$$\frac{\Delta dx}{dx'} = 1 - \sqrt{1 - \frac{w}{e_{K,\max}}} = 1 - \sqrt{1 - \frac{\int a(s)ds}{e_{K,\max}}} \tag{4a}$$

$$\frac{\Delta dx}{dx'} = 1 - \sqrt{1 - \frac{\Delta SK_E}{e_{K,\max}}} = 1 - \frac{1}{\gamma} \tag{4b}$$

We now turn to a physical interpretation of these space and time differentials.

5. Physical Interpretation

The correct interpretation of Equation (3) and Equation (4), as is demonstrated in Appendix B, is that the units of measurement (for time and space) for the moving observer has changed. For the moving reference frame, an hour no longer measures an hour, it measures something greater than an hour—e.g., $\Delta t' = \gamma \Delta t \implies \Delta t' > \Delta t$. Additionally, a meter stick no longer measures a meter, it measures something greater than a meter—e.g., $\Delta x' = \gamma \Delta x \implies \Delta x' > \Delta x$. Thus, the appearance that an hourglass still measures an hour, or a meter stick still measures a meter, for any observer who had a change in specific kinetic energy is an optical illusion, like the refraction of a pencil half in water creates the illusion of a bent pencil. These illusions are created by the units of measurement changing without taking proper notice, and hence, our experience in any inertial frame remains constant when ignoring this change of units.

For example, say both twins in the twins paradox lost their acceleration information, and both twins observe time and space units of measurement proper to their frame—an hour still seems to be the same as it always has been, and a meter appears the same too. Both twins wonder if their frame is the one unchanged, or was it their twins' frame that had change, or did both change. Additionally, if they observe the other twin, they will see evidence to suggest the other twin has the changed units of measurements; however, they know it could be an illusion. But when the twins calibrate their relative velocity to the UIF they quickly learn the reality of the changed differentials.

One plausible physical explanation for this phenomena, where change in specific energy changes differentials, is a consequence of the speed of light being an upper limit on kinetic energy, even for particles composing physical objects. Normal internal particle interactions happen at a certain rate governed by their nature and limited by the speed of light. When an object changes energy states, all the particles add to its translational energy reducing the rate at which things happen internally to adhere to their nature and the speed of light limit. This would explain why energy needs to scale by the amount of matter, since the change in energy distributes across all the internal particles—you need enough energy for all of them. As an example, suppose a system comprised of one particle needs some X change in energy to have Y change in ITD. Then, a similar system with two of those particles requires $2X$ change in energy, a single X for each particle, to have the same Y effect on each particle.

Herein lies the second major departure of the causal model from the legacy model. The legacy model supposes the relativity of simultaneity. Where if you assume an hour and meter in two different inertial frames measure the same unit of measurement, you have an impossible time determining if two events at two locations occurred at the same time, or one before the other.

However, if you adopt the optical illusion interpretation, as the causal model does, then using the UIF we can know the sequence of events with certainty, and what illusions are at play for the other inertial frames. This gives rise to the notion of universal specificity, where all events in the universe happen at specific times and locations with respect to the UIF, with which every observer agrees universally, trusting their well crafted instruments to pierce through the illusion.

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 physical objects, and are defined by Equation (5). GPS clocks are known to tick faster in orbit than identical 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.

$$\nabla dt \triangleq \frac{dt' - dt}{dr'} \tag{5}$$

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

The legacy model predicted TDGs by assuming the equivalency principle, but armed with the cause of ITDs, the existence of TDGs proves the equivalency principle is false—the third and last major departure of the causal model from the legacy model.

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, valid concepts, and logic (both inductive and deductive).

Rejecting The Equivalency Principle

TDGs can be measured with precise clocks arrayed in all three dimensions, and measuring their respective ITDs. A system of clocks that measure TDGs are termed *gravimeters*. An example of a single dimension gravimeters is show in Figure 5. Non-zero TDGs near earth and zero TDGs in empty space is the difference that makes the difference. It is the difference that invalidates the equivalency principle, because a gravimeter tells us if we are in a non-zero or zero TDGs environment—and these environments are not equivalent.

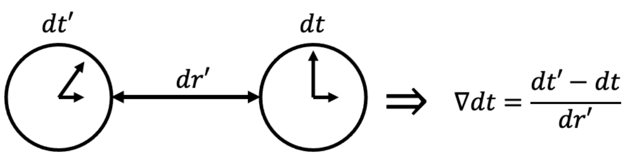

Figure 5. **Single dimension gravimeter.**

This breach of equivalence is well known, but the reason the equivalence principle remains accepted is because it is viewed as *approximately* true. For example, in infinitesimally 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*?

These non-zero TDGs are very small (1.0925×10^{-16} $[s/m]$ near earth's surface), but this is non-trivial. It will be shown later in this section, using our newly acquired causal understanding, that TDGs cause a specific force to be applied to physical bodies within them.

The legacy model used geometry to represent gravity as a pseudo force (like centrifugal force) because the equivalency principle equates free fall with inertial space. In other words, the force of gravity was replaced with the bending of space-time.

The herein induced causal model returns gravity to its original Newtonian status as being a real measurable force, and gravimeters 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.

Universal Inertial Measurement Unit

Gravity being considered a real force again means we need to update the legacy model's definition of an inertial reference frame. An inertial reference frame, as always, is a frame 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 when net forces are measured.

Combining gravimeters 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, with respect to the UIF, is not changing.[9]

We now turn to derive how gravimeters can measure gravitational specific 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 (3), 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 [16][17][18]; however, the novelty presented in this paper is a mathematical derivation based on a newly induced causal model. Given this causal model and the definition of TDGs in Equation (5), I deduce the TDG's causal relationship to specific force as follows:

$$\nabla dt = \frac{dt' - dt}{dr'} = \frac{dt' - \frac{1}{\gamma}dt'}{dr'} \tag{6a}$$

$$\frac{1}{\gamma} = 1 - \nabla dt \frac{dr'}{dt'} \tag{6b}$$

$$\sqrt{1 - \frac{\Delta e_K}{e_{K,\max}}} = 1 - \nabla dt \frac{dr'}{dt'} \tag{6c}$$

$$\bar{g} dr' = \frac{1}{2} c^2 \left(1 - \left(1 - \nabla dt \frac{dr'}{dt'}\right)^2\right) \tag{6d}$$

$$\text{Let} : \nabla \tau = \left(1 - \left(1 - \nabla dt \frac{dr'}{dt'}\right)^2\right)$$

$$\lim_{r_1 \to r_2} \frac{\int_{r_1}^{r_2} g(r') dr'}{\int_{r_1}^{r_2} dr'} = \frac{c^2}{2dr'} \nabla \tau \tag{6e}$$

$$GM \lim_{r_1 \to r_2} \frac{\int_{r_1}^{r_2} \frac{1}{r'^2} dr'}{r_2 - r_1} = \frac{c^2}{2dr'} \nabla \tau \tag{6f}$$

$$GM \lim_{r_1 \to r_2} \frac{\frac{1}{r_1} - \frac{1}{r_2}}{r_2 - r_1} = \frac{c^2}{2dr'} \nabla \tau \tag{6g}$$

$$GM \lim_{r_1 \to r_2} \frac{\frac{r_2 - r_1}{r_1 r_2}}{r_2 - r_1} = \frac{c^2}{2dr'} \nabla \tau \tag{6h}$$

$$\lim_{r_1 \to r_2} \frac{GM}{r_1 r_2} = \frac{c^2}{2dr'} \nabla \tau \tag{6i}$$

$$\lim_{r_1 \to r_2} \sqrt{g(r_1) g(r_2)} = \frac{c^2}{2dr'} \nabla \tau \tag{6j}$$

$$g(r') = \frac{c^2}{2dr'} \nabla \tau \blacksquare \tag{6k}$$

[9] 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 magnitude at location $\sqrt{\mathrm{r_1 r_2}}$, which is also equivalent to the geometric mean of accelerations at the dt and dt$'$ locations. Its direction is from where dt$'$ was measured toward where dt was measured.

Concrete examples using Equation (6j) for single dimension cases are given in Appendix D. Also, note that g is measuring unit specific force (e.g., Newton per kilogram). A non-zero TDG 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—as in, the TDG affects every particle to the same degree—and this is why gravity is indeed a real (specific) force.

A new understanding emerges from the derivation shown in Equation (6): the relationship between changes in specific energy and changes in ITDs are reciprocal causal phenomena—changes in one causes changes in the other.

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 $e_P = \int g(r)dr = \int \frac{GM}{r^2}dr$.

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 (3), meaning it is caused by a change in their specific potential energy between the two states. We can use Equation (3) to determine how much change in specific energy exists between the two objects, which determines their relative ITD. Essentially, however much specific 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 (3).

For example, if an object's initial location is at 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 6. This is because this is how much specific work is done by the TDG between the two points.

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 specific work is done by the gravitational force by the time the object is infinitely far away as given by Equation (8):

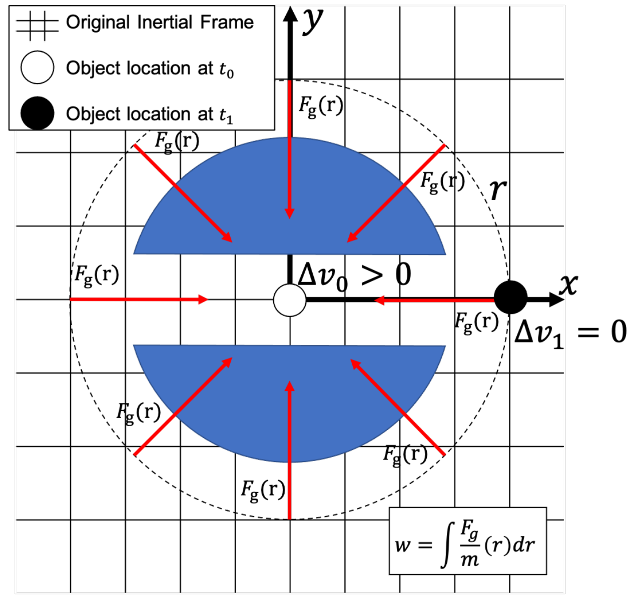

Figure 6. ITD at center relative to some point distance r away.

$$\frac{\Delta dt}{dt'} = 1 - \sqrt{1 - \frac{2GM}{rc^2}} \tag{8}$$

Where :

dt' is time derivative for object infinitely far

$\Delta dt'$ is the change in time derivative caused by gravitational specific work which brings the 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 (8) to be in its more general form, in terms of specific work done or change in specific potential energy, gives us Equation (9):

$$\frac{\Delta dt}{dt'} = 1 - \sqrt{1 - \frac{w}{e_{K,\max}}} = 1 - \sqrt{1 - \frac{\int g(r')dr'}{e_{K,\max}}} \quad (9a)$$

$$\frac{\Delta dt}{dt'} = 1 - \sqrt{1 - \frac{\Delta e_P}{e_{P,\max}}} = 1 - \frac{1}{\gamma} \quad (9b)$$

Where :

dt' is time derivative further away from gravity source

Δdt is the change in time derivative caused by gravitational specific work which brings the object closer

w is specific work done

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 specific 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 am aware of one decent hypothesis, but I cannot determine the cause for certain because this is as far as the evidence goes inductively. However, it cannot possibly be because an something called space-time bends, because the equivalence principle on which that concept depends was proven false.

Integrating Equation (3) and in Equation (9) gives us a new perspective on the total energy equation, as we will see in the next section.

7. The Law of Universal Specificity

ITDs can be written in terms of fractions of the limit of achievable specific energy for both specific potential energy and specific kinetic energy, which means a relationship between ITD and total specific energy exists. Before deriving this relationship, 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 (3) and Equation (9), 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 the UIF.

For this proof, consider 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 $\mathrm{e_P} > 0$.

$$\text{Let } \frac{1}{\gamma} = \frac{dt}{dt'} \quad (10a)$$

$$\frac{1}{\gamma_P^2} = 1 - \frac{\Delta e_P}{e_{P,\max}} \quad (10b)$$

$$1 - \frac{1}{\gamma_P^2} = \frac{\Delta e_P}{e_{P,\max}} \quad (10c)$$

$$\left(1 - \frac{1}{\gamma_P^2}\right) e_{P,\max} = \Delta e_P = \Delta e_K \quad (10d)$$

$$\left(1 - \frac{1}{\gamma_P^2}\right) e_{K,\max} = \Delta e_K \quad (10e)$$

$$1 - \frac{1}{\gamma_P^2} = \frac{\Delta e_K}{e_{K,\max}} \quad (10f)$$

$$\frac{1}{\gamma_P^2} = 1 - \frac{\Delta e_K}{e_{K,\max}} \quad (10g)$$

$$\frac{1}{\gamma_P^2} = \frac{1}{\gamma_K^2} \blacksquare \quad (10h)$$

Invoking the method of agreement: observing that changes in specific potential energy and changes in specific kinetic energy induced no changes in ITD, proves inductively 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 inductively, via method of agreement, that changes in ITD are caused by a change in total specific energy, and vice versa. 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, shown in Equations (11) and (12); and it ends with relating the results to changes in total specific energy, Δe_T, shown in Equation (13).

$$\frac{1}{\gamma_P^2} = 1 - \frac{\Delta e_P}{e_{P,\max}} \quad (11a)$$

$$\Delta e_P = \left(1 - \frac{1}{\gamma_P^2}\right) e_{P,\max} \quad (11b)$$

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

$$\Delta e_P = \tau_P^2 \frac{1}{2} c^2 \quad (11c)$$

$$\frac{1}{\gamma_K^2} = 1 - \frac{\Delta e_K}{e_{K,\max}} \quad (12a)$$

$$\Delta e_K = \left(1 - \frac{1}{\gamma_K^2}\right) e_{K,\max} \quad (12b)$$

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

$$\Delta e_K = \tau_K^2 \frac{1}{2} c^2 \quad (12c)$$

$$\Delta e_T = \Delta e_P + \Delta e_K \quad (13a)$$

$$\Delta e_T = \tau_P^2 \frac{1}{2} c^2 + \tau_K^2 \frac{1}{2} c^2 \quad (13b)$$

$$\Delta e_T = (\tau_P^2 + \tau_K^2) \frac{1}{2} c^2 \ \blacksquare \quad (13c)$$

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. This occurs when:

- $\tau_K = 1$ because $\int a(s)ds = \frac{1}{2}c^2$
- $\tau_P = 1$ because $\int g(r)dr = \frac{1}{2}c^2$.

Scaling Equation (13c) by mass gives us a relativistic total energy equation, shown in Equation (14).

$$m\Delta e_T = \Delta E_T = (\tau_P^2 + \tau_K^2) \frac{1}{2} mc^2 \quad (14)$$

When both τ_P and τ_K are less than unity, then Equation (14) simplifies to the very familiar Equation (15).

$$E_T = \int g(r)dr + \int a(s)ds = mgh + \tfrac{1}{2}mv^2 \quad (15)$$

Solving for the change in ITD as a function of change in total specific energy gives us Equation (16e):

$$\Delta e_T = (\tau_P^2 + \tau_K^2) \frac{1}{2} c^2 \quad (16a)$$

$$\Delta e_T = \tau_T^2 e_{\max} \quad (16b)$$

$$\frac{\Delta e_T}{e_{\max}} = 1 - \frac{1}{\gamma_T^2} \quad (16c)$$

$$\frac{1}{\gamma_T} = \frac{dt}{dt'} = \sqrt{1 - \frac{\Delta e_T}{e_{\max}}} \quad (16d)$$

$$1 - \frac{1}{\gamma_T} = \frac{\Delta dt}{dt'} = 1 - \sqrt{1 - \frac{\Delta e_T}{e_{\max}}} \quad (16e)$$

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. Revisiting $\mathbf{E = mc^2}$

It was curious to me that Equation (14) did not seem to conform to $E = mc^2$, so I investigated not knowing what I would find. The possible discoveries from such an investigation seemed to be:

1. An Error Exists in the derivation of $E_T = (\tau_P^2 + \tau_K^2)\frac{1}{2}mc^2$
2. $E_T = (\tau_P^2 + \tau_K^2)\frac{1}{2}mc^2$ and $E = mc^3$ are relatable in a reasonable way
3. An Error Exists in the derivation of $E = mc^2$

A two more cases exists (if one were to draw up a truth table) where both are invalid or both are valid, but unrelated to each other. I did not include the former because I would find out either way in this investigation. I did not include the latter because it would seem to imply there are two different kinds of energy unrelated to each other—this seemed like a contradiction not worth investigating.

Having just derived $E_T = (\tau_P^2 + \tau_K^2)\frac{1}{2}mc^2$ in what seems like the most valid way—via induction—I turned my investigation to finding some means to relate the two. When that failed, I turned my attention to finding some possible error in the $E = mc^2$ derivation, which was discovered in the use of the binomial expansion approximation.

Incompatibility With $E = mc^2$

Looking at Equation (14), it is apparent that $E_T \leq mc^2$. 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 $E_T = mc^2$.

If $E_T = mc^2$, then the ITD would become imaginary—a clear contradiction. In fact it is well known that even light, at the event horizon slows to a stop—so even for light, when $\tau_P^2 = 1$, then $\tau_K^2 = 0$. Therefore, the only available conclusion is that $E_T = (\tau_P^2 + \tau_K^2)\frac{1}{2}mc^2 \leq \frac{1}{2}mc^2$.

Feynman Derivation Error for $E = mc^2$

It is easiest to first show Feynman's derivation error, then Einstein's original error. Feynman demonstrated using relativistic momentum that like time, our measure for mass also comes with its own change of units, as shown in Equation (17) [7].

$$m = \gamma m_0 \quad (17)$$

Where :

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

m is the measure of mass of a moving object

m_0 is the measure of mass of that same object from its own inertial frame

From this equation, Feynman took the binomial expansion of γ and kept the first order terms, as shown in Equation (18) [7].

$$m = \gamma m_0 \tag{18a}$$
$$m = m_0 \left(1 - \frac{v^2}{c^2}\right)^{-1/2} \tag{18b}$$
$$m = m_0 \left(\sum_{i=0}^{\infty} (-1)^i \binom{-1/2}{i} \left(\frac{v^2}{c^2}\right)^i\right) \tag{18c}$$
$$m = m_0 \left(1 + \frac{1}{2}\frac{v^2}{c^2} + \frac{3}{8}\frac{v^4}{c^4} + \dots\right) \tag{18d}$$
$$m \approx m_0 + \frac{1}{2} m_0 \frac{v^2}{c^2} \tag{18e}$$
$$mc^2 \approx m_0 c^2 + \frac{1}{2} m_0 v^2 \tag{18f}$$

At this point Feynman says Einstein sees the $\frac{1}{2} m_0 v^2$ term as kinetic energy and concludes that mc^2 is also kinetic energy. The $m_0 c^2$ is the energy if the object is at rest, or just *rest energy* for short [7].

This seems all well and good, so where is the error? The error comes in when one sees $\frac{1}{2} m_0 v^2$ and immediately concludes this must be kinetic energy, when it could also easily be some fraction of it. Fore example perhaps it ought to be like Equation (19).

$$\frac{1}{2} mc^2 \approx \frac{1}{2} m_0 c^2 + \frac{1}{2}\left(\frac{1}{2} m_0 v^2\right) \tag{19}$$

Which means the term $\frac{1}{2} m_0 v^2$ in Equation (18) it is only half of kinetic. It stands to reason that $\frac{1}{2} m_0 v^2$ in Equation (18) is only a fraction of kinetic energy because as you include the rest of the truncated terms, that fraction grows as show in Equation (20).

$$mc^2 = m_0 c^2 + \left(\frac{1}{2} + c^2 \sum_{i=2}^{\infty} (-1)^i \binom{-1/2}{i} \left(\frac{v^2}{c^2}\right)\right) m_0 v^2 \tag{20}$$

The $m_0 v^2$ term is no longer recognizable as kinetic energy. What does it converge to? The exact solution has been solved for, as shown in Equation (21).

$$m = \gamma m_0 = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{21a}$$
$$m^2 \left(1 - \frac{v^2}{c^2}\right) = m_0^2 \tag{21b}$$
$$m^2 c^2 - m^2 v^2 = m_0^2 c^2 \tag{21c}$$
$$\frac{1}{2} mc^2 = \frac{m_0}{m}\frac{1}{2} m_0 c^2 + \frac{1}{2} m v^2 \tag{21d}$$
$$\frac{1}{2} mc^2 = \frac{1}{\gamma}\frac{1}{2} m_0 c^2 + \gamma \frac{1}{2} m_0 v^2 \tag{21e}$$

Equation (21) is the exact solution, so why settle for an approximate. It becomes obvious that total energy is $\frac{1}{2} mc^2$ when the rest of the terms are included. There is a reason why kinetic energy has a half term—it's not arbitrary. It had to do with acceleration to that final velocity, which is why that half term is there. It should have raised some alarm bells when energy was related to c without that half term.

The error in Feynman's derivation of $E = mc^2$ can be summarized as follows:

- Start be relating relativistic masses via γ, which is a non-linear term.
- Proceeding directly required the use of the binomial expansion of γ to linearize it.
- The error was arbitrarily associating one of the terms, $\frac{1}{2} m_0 v^2$, in the infinite series of $k_i \frac{1}{2} m_0 v^2$, as *the* kinetic energy term because it looked like it, rather than realizing that the $\frac{1}{2}$ was merely an unrelated coefficient to $m_0 v^2$.

As we will see Feynman only made the same error Einstein made, but was using a different starting point.

Einstein Derivation Error for $E = mc^2$

Einstein went about deriving $E = mc^2$ starting from a different place. Einstein used a thought experiment involving an object emitting light from the perspective of the object's inertial frame and from the perspective of an inertial frame that observes the object as moving. In the end he reaches a relationship of kinetic energy and the energy of the emitted light as shown in Equation (22).

$$K_0 - K_1 = L_0(\gamma - 1) \tag{22}$$

$$\text{Where :}$$
$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}}$$
$$K_0 \text{ is difference in kinetic energy between two frames before emission of light}$$
$$K_1 \text{ is difference in kinetic energy between two frames after emission of light}$$
$$L_0 \text{ is the emitted energy as seen from the object's inertial frame}$$

Einstein them proceeds to make the same error as shown in the previous subsection, where the binomial expansion was used and the $\frac{1}{2}m_0v^2$ term was confused as *the* kinetic energy term, as shown in Equation (23).

$$K_0 - K_1 \approx \frac{1}{2}\frac{L_0}{c^2}v^2 \tag{23}$$

From Equation (23), Einstein concludes from this that, "If a body gives off the energy L in the form of radiation, its mass diminishes by $\frac{L_0}{c^2}$."

Using the same patter as before, with relativistic mass, we can solve for relativistic energy relationship precisely and correct Einstein's error, as shown in in Equation (24).

$$L = \gamma L_0 \tag{24a}$$
$$\frac{1}{2}Lc^2 = \frac{1}{\gamma}\frac{1}{2}L_0c^2 + \gamma\frac{1}{2}L_0v^2 \tag{24b}$$
$$\gamma L_0 = \frac{1}{\gamma}L_0 + \gamma\frac{L_0}{c^2}v^2 \tag{24c}$$
$$L_0 = \frac{1}{\gamma^2}L_0 + \frac{L_0}{c^2}v^2 \tag{24d}$$
$$L_0 = 0 + \frac{1}{2}\frac{2L_0}{c^2}v^2 \tag{24e}$$

Using the precise solution from Equation (24), I conclude that if a body gives off the energy L in the form of radiation, its mass diminishes by $\frac{2L_0}{c^2}$. Additionally, following the correct pattern laid out by Einstein, a more general conclusion can be drawn from this conclusion: the mass of a body is a measure of its energy content; if its energy changes, then its corresponding amount of mass changes as well.

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 (25) below:

$$p = mc = \frac{E}{c} \tag{25}$$

But with our new understanding of relativistic total energy we now get Equation (26) instead:

$$p = mc = \frac{2E}{c} \tag{26}$$

9. 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 transformation. Indeed, the causal model was induced using prediction made by the legacy model; therefore, both models will remain consistent with observations and each other.

The predictive power of the causal model is not improved in the context of special relativity, but this model change still served a great purpose. With this change our understanding of causes of observations became richer, which made explanations more understandable, which allowed us to become more confident in when to use the Lorentz Transformation, and we became 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 in switching to a causal model. Substituting one model for an equally capable model is a waste of time; however, if the causal model permits one to go deeper in causal discovery, then that is the value in the whole exercise of 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.

Here is a summary of the departures of the causal model from the legacy model, in the order they were presented:

1. The legacy model assumes there exists no universal inertial frame (UIF) in which all other reference frames agree is stationary. The new causal model shows why a UIF necessary, and how to measure any reference frames relative velocity to it.
2. The legacy model supposes the relativity of simultaneity. The new causal model shows that given changes in units of measurement and a UIF, there necessarily exists a universal standard for simultaneity.
3. The legacy model assumes the equivalency principle holds, and therefore, rejects gravity as a real force. The new causal model rejects the equivalency principle as provably false, as proven in this paper, and reinstates gravity as a real force.

If any deviation in prediction exists because of these divergences, then it is necessarily subtle, since the legacy models are excellent predictors, and may require a level of precision beyond our current capability. The purpose of the causal model was not to improve the legacy model's predictive power, but rather understand what causes changes in time differentials, which was achieved.

Summary of Findings and Its Significance

The Law of Universal Specificity has been inductively proven, and it states that changes in ITDs and changes in total specific energy are causal reciprocals—changes in either causes changes in the other. The legacy models still function as excellent predictors, but the causal explanations for why the predicted observations have become richer.

Why have Einstein's and Ptolemy's models failed at causal explanations, but Newton's and Kepler's have not? Because Einstein and Ptolemy employed a different method of reasoning, than was employed by Newton and Kepler.

Newton and Kepler employed a proper method of induction to induce the causes of phenomena, which make their causal explanations true for all time—to the extent the evidence inductively proves and in the context in which it applies. Einstein and Ptolemy, on the other hand, employed a deductive method of reasoning, which can only deduce implications of already established information, meaning anyone employing deduction is incapable of discovering a new cause.

To achieve continuous scientific progress, we need to maintain solid causal footing to tell us which causal questions to pursue 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 can help establish an excellent predictive model, which can help with setting up controlled thought experiments to induce the actual cause of the matter. The deductive model, should one be needed, needs to be replaced as soon as the proper inductive method is made possible by the available evidence.

APPENDICES

The appendices serve to enrich the content of the main argument, should that be desired. The appendices are organized as follows: Appendix A expounds on key concepts; Appendix B presents the twins paradox and how the causal model resolves it; Appendix C presents a modified twins paradox where the traveling twin ages more than the stationary twin; and finally Appendix D presents two examples of how to measure the gravitational acceleration of an object given it is in a TDG.

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 7.

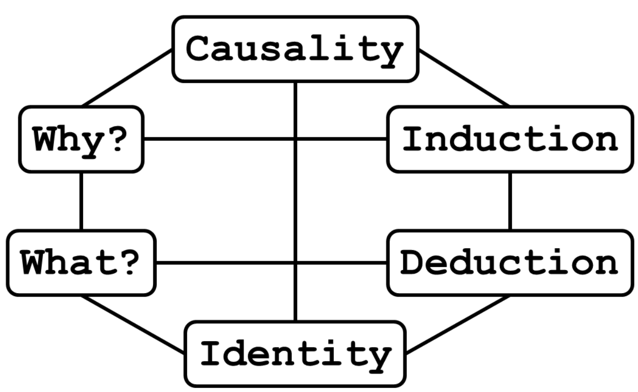

Figure 7. **Conceptual network of reinforcing connections.**

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 8.[10]

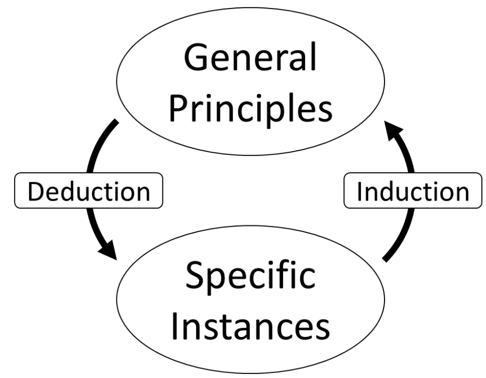

Figure 8. **Induction vs deduction.**

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 we can discover truth.[11]

Another profound consequence of **D2** and of at least one

[10] **P5** is demonstrated within this paragraph.
[11] **P2** is demonstrated within this paragraph.

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.

Law of Identity

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.

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 makes any argument against the law of identity self-refuting.

The Law of Non-Contradictions

The *law of non-contradiction* is implied by the law of identity. By stating a thing is itself, it implies that it cannot be something else. To be itself and not itself at the same time in the same respect is a contradiction. contradiction may be arrived at through a process of thought, but contradictions do not exist in reality. In addition you cannot integrate a contradiction with the rest of your knowledge without harming yourself—in the sense you damage your ability to think. Indeed, we know an idea to be in error because it results in a contradiction, and we know an idea to be certain when its rejection results in a contradiction—the proper method of induction relies on this fact. When you believe you have discovered a contradiction in reality, check your premises; you will discover that at least one of them is wrong.

Contradictions can be accepted in a manner consistent with observation, which is why when someone insists that something is true because it is consistent with observation (or predicted observation) it is a ridiculous erudition of the irrational, who does not know they are speaking non-sense. These explanations are worthy of immediate dismissal if no further evidence is offered supporting the claim.

This next example illustrates what happens when we accept a contradiction in a manner consistent with observation. Suppose the contradiction we wanted to believe was that any leaf could be all red and all green at the same time in the same respect. Can you picture it? I doubt you can. Can you believe it none the less? Yes you can, and below is a common pattern I find people make to believe contradictions.

Suppose you concluded that the only reason you cannot picture that leafs are all red and all green is because there is something wrong with *you* and not the *idea*; therefore, you decide to fully believe the contradiction. What would you have to honestly conclude to remain consistent with observation? It is quite simple. You could believe leafs can be all red and all green, and remain consistent with observation, when they are all red and all green when no one is looking.

In other words, in order to truly believe a contradiction of this kind you would conclude something akin to Schrödinger's cat example, which states that a quantum entangled environment is in all possible states, not just one and we do not know it.

This is clearly a confusion of epistemological concepts for metaphysical concepts. It confuses an "I don't *know*" for an "*it is*." Such is the nature, and pattern, of of accepting contradictions consistent with observations.[12]

The Nature of Causality

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 (past, present, and future); otherwise, it would violate its identity, which implies a contradiction. 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 [21]. 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 [22]. Both conceptions are of course true, but each

[12] I hope someone else will do it, but if I must I will upend Quantum Mechanics and put it on a proper causal and non-contradictory footing.

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 [23].[13] 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 9, 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.

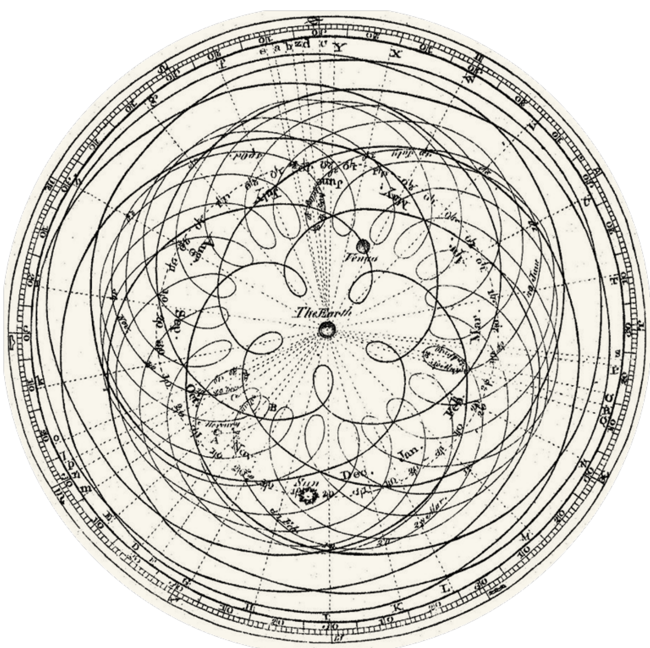

Figure 9. **Ptolemy's causeless planetary model.**

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 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].

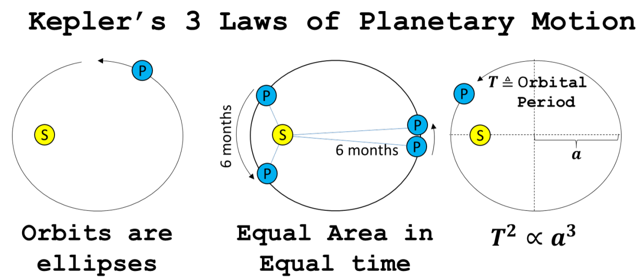

Figure 10. **Kepler's laws where the sun is the cause.**

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.[14]

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

[13] 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.

[14] 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.

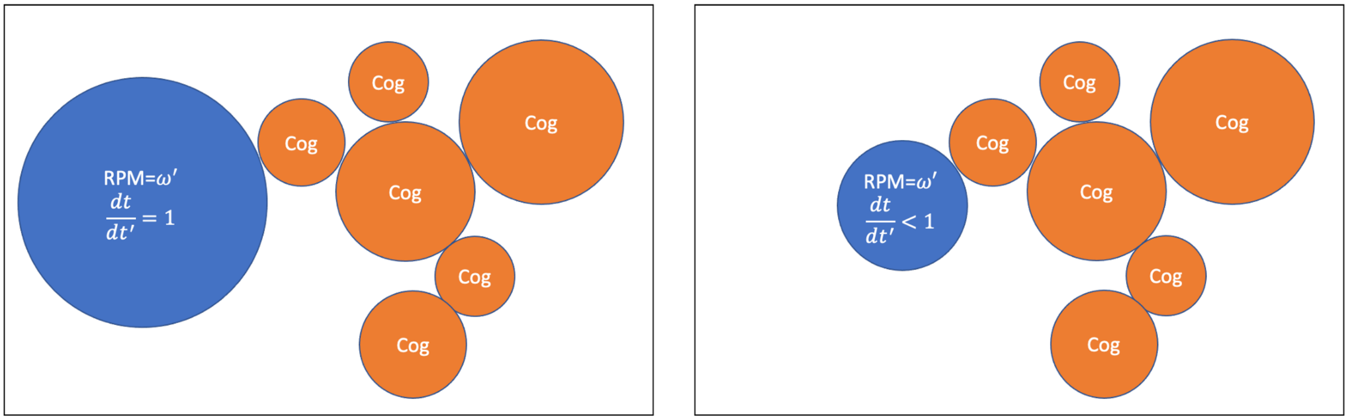

Figure 11. **Left: system of cogs with unity ITD. Right: system of cogs with non-unity ITD.**

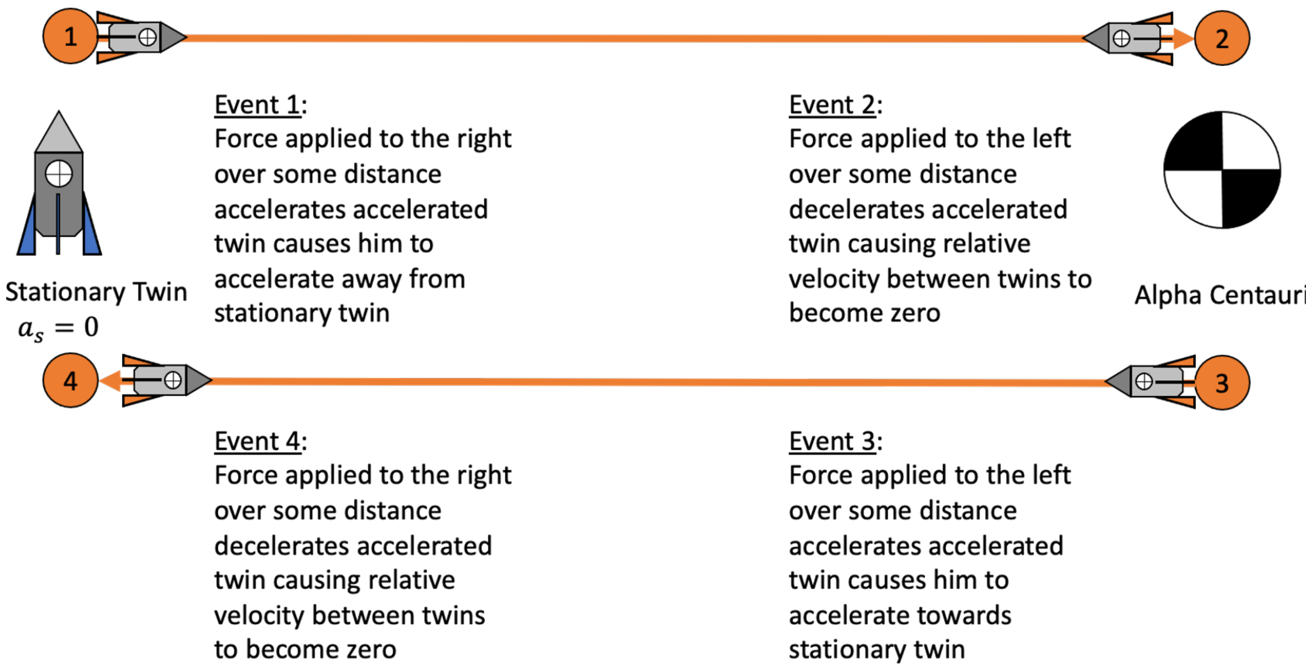

Figure 12. **Events Leading to The Twins Paradox.**

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 11 illustrates this analogy.

According to the Law of Universal Specificity, a cog only swaps out when the system undergoes a change in total specific energy. Additionally, the universal inertial reference frame is the reference frame with the biggest cog, in which all other inertial frames have smaller cogs in accordance with the Law of Universal Specificity.

B. Twins Paradox

In this appendix we cover the legacy setup of the paradox and the causal resolution using the Law of Universal Specificity. But I highly recommend going through the inductive proof of the law before seeing the resolution.

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 12. 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.[15] This is a paradox because, each twin fully expected, using the Lorentz Transformation from their inertial frame, that the other twin would have aged less. Why? Because on the flight out and back, each twin perceived their own light clock to look like Figure 13, while their twin's light clock looked like Figure 14.

Both perceived the other's clock to look like Figure 14, but only one aged less. This tells us something very important

[15] 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.

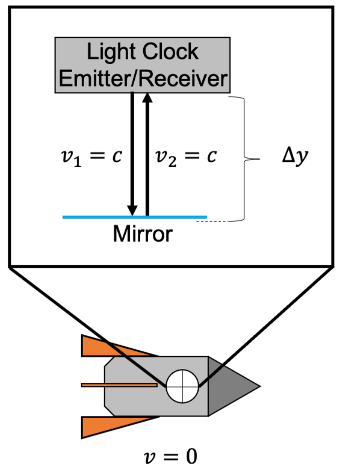

Figure 13. **Light Clock At Rest.**

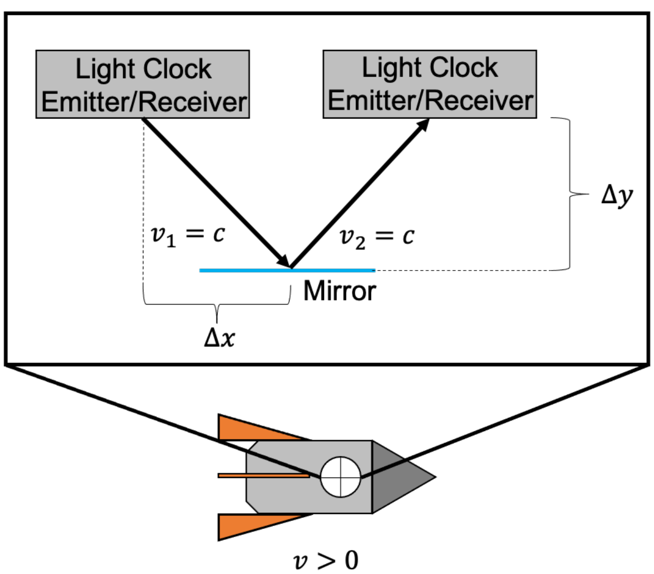

Figure 14. **Light Clock In Motion.**

because it reveals a contradiction in our assumptions. But in reality there is no contradiction, thus the paradox.

The Causal Resolution

Applying Equation 3 to the four events as shown in Figure 12, and assuming the same magnitude of acceleration was applied over the same magnitude of distance, gives us Equation (27) :

Event 1 :

$$\frac{dt_1}{dt'} = \sqrt{1 - \frac{ax_a}{SK_{E,max}}} \tag{27a}$$

Event 2 :

$$\frac{dt_2}{dt'} = \sqrt{1 - \frac{ax_a + (-a)x_a}{SK_{E,max}}} = 1 \tag{27b}$$

Event 3 :

$$\frac{dt_3}{dt'} = \sqrt{1 - \frac{ax_a + (-a)x_a + (-a)(-x_a)}{SK_{E,max}}} \tag{27c}$$

Event 4 :

$$0 = ax_a + (-a)x_a + (-a)(-x_a) + (a)(-x) \tag{27d}$$

$$\frac{dt_4}{dt'} = \sqrt{1 - \frac{(0)}{SK_{E,max}}} = 1 \tag{27e}$$

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.

The Space Differential

Although the cause satisfactorily explains why the accelerated twin was the twin that experienced ITD, one last question remains to be answer before the paradox is fully resolved. Why would both twins perceive the other twin's light clocks behaving exactly the same way?

It may not be certain that they would see the same thing, given this new causal understanding. Given an ITD, perhaps the relative velocity measured by the moving observer can be faster, slower, or the same as measured by the non-moving observer. We test each and determine that we can inductively prove it cannot be faster or slower, which only leaves that the relative velocity must be measured the same for both observers. The consequence is that there is also a space differential at play to counter act the time differential so when we measure velocity (some distance over some time) the result is the same regardless of inertial frame.

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 (28).

Proof :

$$v' = v \tag{28a}$$

$$\frac{dx'}{dt'} = \frac{dx}{dt} \tag{28b}$$

$$\frac{dx'}{dt'} = \frac{dx}{dt'\sqrt{1 - \frac{\Delta SK_E}{SK_{E,max}}}} \tag{28c}$$

$$\frac{dx}{dx'} = \sqrt{1 - \frac{\Delta SK_E}{SK_{E,max}}} = \frac{1}{\gamma} \; \blacksquare \tag{28d}$$

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 (30) instead:

$$\frac{dx}{dx'} > \frac{1}{\gamma} \tag{30}$$

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 (31):

$$\frac{dx}{dx'} < \frac{1}{\gamma} \tag{31}$$

Only Equation (28) 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 15. 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.

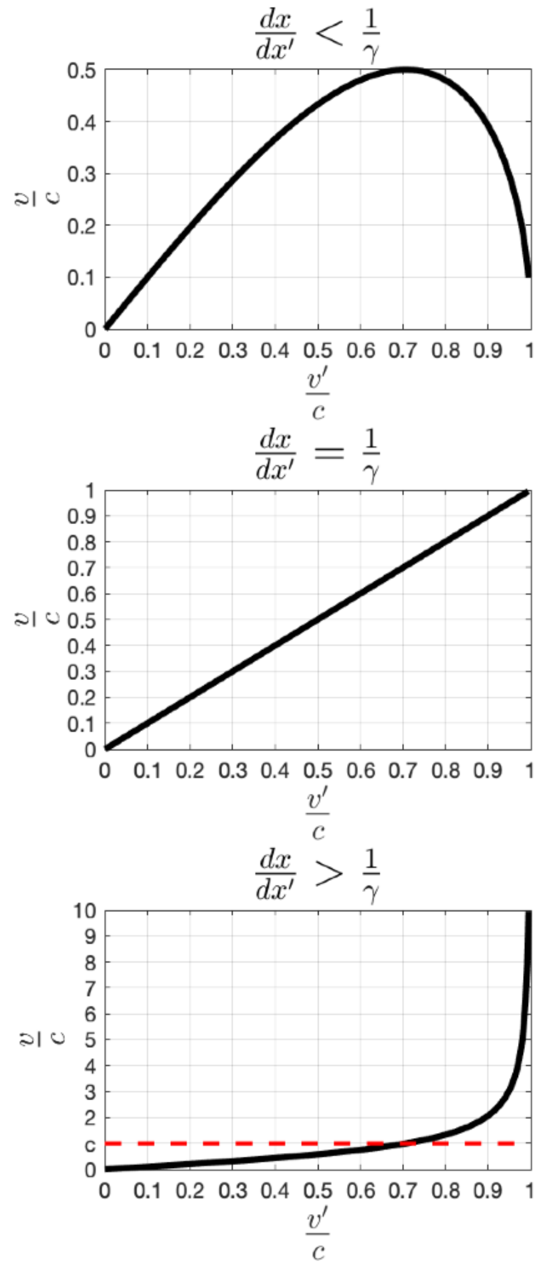

Figure 15. Top: relative velocity is slower for moving observer. Middle: relative velocity is the same for both observers. Bottom: relative velocity is faster for moving observer.

Interpreting the Physical Meaning of Space Differential

An interpretation of Equation (28) is that the units of measurement for length for the moving observer has changed. A meter stick no longer measures a meter, it measures something greater than a meter—e.g., $\Delta x' = \gamma \Delta x \implies \Delta x' > \Delta x$. Thus, the appearance that a meter stick still measures a meter for any observer who had a change in specific kinetic energy is an optical illusion, like the refraction of a pencil half in water creates the illusion of a bent pencil. These illusions are created by the units of measurement changing without taking proper notice.

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 the units of measurement were affected, it appeared closer, which is the meaning of Equation (28).

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.

C. 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, which is extremely unlikely, 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 left.
3. Then instantly the relative velocity, as seen by twins, becomes $0.2c$, causing them to 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.

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 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 $0.2c$. 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 started the transformation from the last inertial frame the twins shared before departure, 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.

D. 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 (32):

$$\begin{aligned}
&\text{Let} : \mathrm{r}_1 = 6371000\ [m] \\
&\text{Let} : \mathrm{G} = 6.6744 \times 10^{-11}\ [m^3 kg^{-1} s^{-1}] \\
&\text{Let} : \mathrm{M} = 5.97219 \times 10^{24}\ [kg] \\
&\frac{dt_1}{dt_2} = \sqrt{1 - \frac{\Delta e_P}{e_{\max}}} = \sqrt{1 - \frac{\int_{r_1}^{r_2} \frac{GM}{r^2} dr}{e_{\max}}} \qquad (32a) \\
&\frac{dt_1}{dt_2} = \sqrt{1 - \frac{9.81 \times 10^3}{e_{\max}}} = 1 - 1.0925 \times 10^{-13} \qquad (32b)
\end{aligned}$$

The resulting TDG is given in Equation (33).

$$\begin{aligned}
&\text{Let} : \mathrm{dt}_2 = 1 \implies dt_1 = 1 - 1.0925 \times 10^{-13} \\
&\nabla dt \triangleq \frac{dt_2 - dt_1}{dr'} \qquad (33a) \\
&\nabla dt \triangleq \frac{1.0925 \times 10^{-13}}{1000} = 1.0925 \times 10^{-16} \qquad (33b)
\end{aligned}$$

Using Equation (6), we can find the resulting acceleration as show in Equation (34):

$$\sqrt{g(r_1)g(r_2)} = \bar{g} = \frac{c^2}{2dr'}\left(1 - \left(1 - \nabla dt \frac{dr'}{dt'}\right)^2\right) \qquad (34a)$$

$$\bar{g} = 9.8185[{}^{m}/{}_{s}] \qquad (34b)$$

Comparing results from Equation (34) 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 (35). 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):

$$\sqrt{g(r_1)g(r_2)} = 9.8185 \tag{35a}$$
$$\sqrt{(9.8204)(9.8174)} = 9.8185 \tag{35b}$$
$$9.8189 \approx 9.8185 \blacksquare \tag{35c}$$

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 (36):

$$\text{Let} : \mathrm{r}_1 = 1.5203 \times 10^{11} \; [m]$$
$$\text{Let} : \mathrm{G} = 6.6744 \times 10^{-11} \; [m^3 kg^{-1} s^{-1}]$$
$$\text{Let} : \mathrm{M} = 1.9887 \times 10^{30} \; [kg]$$
$$\frac{dt_1}{dt_2} = \sqrt{1 - \frac{\Delta e_P}{e_{\max}}} = \sqrt{1 - \frac{\int_{r_1}^{r_2} \frac{GM}{r^2} dr}{e_{\max}}} \tag{36a}$$
$$\frac{dt_1}{dt_2} = \sqrt{1 - \frac{8.7352 \times 10^8}{e_{\max}}} = 1 - 9.7192 \times 10^{-9} \tag{36b}$$

The resulting TDG is given in Equation (37).

$$\text{Let} : \mathrm{dt}_2 = 1 \implies dt_1 = 1 - 9.7192 \times 10^{-9}$$
$$\nabla dt \triangleq \frac{dt_2 - dt_1}{dr'} \tag{37a}$$
$$\nabla dt \triangleq \frac{9.7192 \times 10^{-9}}{\frac{c}{2}} = 2.1628 \times 10^{-25} \tag{37b}$$

Using Equation (6), we can find the resulting acceleration as show in Equation (38):

$$\sqrt{g(r_1)g(r_2)} = \bar{g} = \frac{c^2}{2dr'}\left(1 - \left(1 - \nabla dt \frac{dr'}{dt'}\right)^2\right) \tag{38a}$$
$$\bar{g} = 1.9438 \times 10^{-8} [m/s] \tag{38b}$$

Comparing results from Equation (38) 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 (39). 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):

$$\sqrt{g(r_1)g(r_2)} = 1.9438 \times 10^{-8} \tag{39a}$$
$$\sqrt{(0.0057)(6.573 \times 10^{-14})} = 1.9438 \times 10^{-8} \tag{39b}$$
$$1.9429 \times 10^{-8} \approx 1.9438 \times 10^{-8} \blacksquare \tag{39c}$$

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.

E. Parallel Time Clock

In this example using a light clock, the light clock will be parallel to the velocity vector, as shown in Figure 16 and Figure 17.

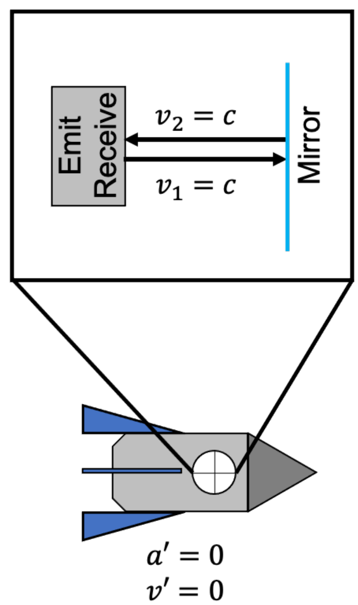

Figure 16. Stationary parallel light clock.

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 ship in Figure 17, 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 16, 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

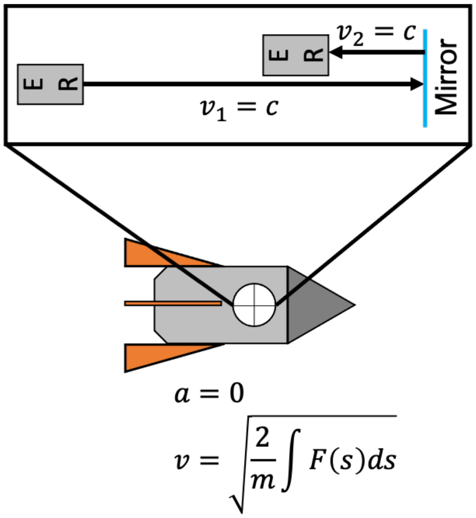

Figure 17. **Moving parallel light clock.**

traveling, $c = 0.5c + 0.5c$=c? No, you need to employ the relativity velocity addition formula shown in Equation (40), which tells you that the ships traveling at $0.5c$ in opposite directions will measure their relative velocity as $0.8c$.

$$v_{12} = \frac{v_{01} + v_{02}}{1 + \frac{v_{01}v_{02}}{c^2}} \tag{40}$$

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 (40) 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 18. 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.

F. 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 (41).

$$f\lambda = f'\lambda' = c \tag{41a}$$

Blue Shift :

$$f = \gamma f' \tag{41b}$$

$$\lambda = \frac{1}{\gamma}\lambda' \tag{41c}$$

Red Shift :

$$f = \frac{1}{\gamma} f' \tag{41d}$$

$$\lambda = \gamma\lambda' \tag{41e}$$

Where :

f' is source frequency

f is received frequency

λ' is source wavelength

λ 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 (42), assuming frequency is constant:

Given :

$$f_3\lambda_3 = v \tag{42a}$$

f constant :

$$f_3 = f' \tag{42b}$$

$$n = \frac{c}{v} = \frac{f'\lambda'}{f_3\lambda_3} \tag{42c}$$

$$f_3\lambda_3 = \frac{v}{c}f'\lambda' \tag{42d}$$

$$f'\lambda_3 = \frac{v}{c}f'\lambda' \tag{42e}$$

$$\lambda_3 = (1-\tau_P)\lambda' \tag{42f}$$

λ constant :

$$\lambda_3 = \lambda' \tag{42g}$$

$$f_3 = (1-\tau_P)f' \tag{42h}$$

other :

$$f_3\lambda_3 = (1-\tau_P)f'\lambda' \tag{42i}$$

Where :

f' is source frequency

f_3 is frequency inside medium measured from outside

λ' is source wavelength

λ_3 is wavelength inside medium measured from outside

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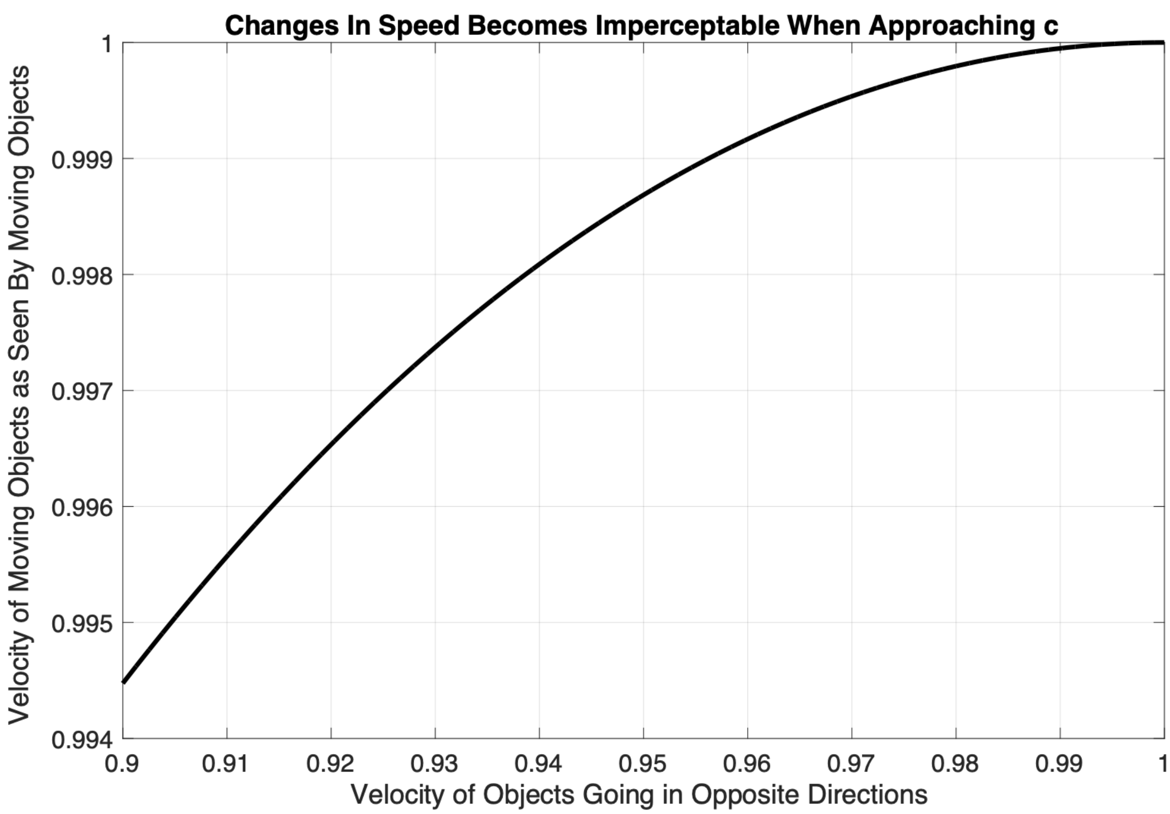

Figure 18. **Changes in speed becomes increasingly indistinguishable the closer to light.**