Time Dilation Is Caused by Changes in Specific Energy & The Theory of Electromagneticgravitism

Daniel Harris
Northrop Grumman
Huntsville, USA
daniel.harris2@ngc.com

***Abstract*—The causal discovery presented in this paper is that special and general relativity time dilation are both caused by the same phenomena—changes in specific energy—as apposed to being caused by two very different unrelated phenomena, as previously understood. This is a newly induced generalization, and a significant portion of this paper is a study of this new generalization's implications. The implications studied includes: the mass-energy equation, the photon momentum equation, the mass of photons, red/blue shifts in photon frequency. It turns out, $E = mc^2$ is a special case of the total relativistic energy equation, which is derived in this paper. The total relativistic energy equation is such that $E \leq mc^2$. This change from the mass-energy equation to the total relativistic energy equation has many implications. Firstly, it implies that mass and energy are not the same things, as previously understood. Energy remains an inseparable aspect of an object with mass, as it did under Newtonian Physics, which in turn implies photons have mass. Secondly, it implies a change is required in the photon's momentum equation, because that equation was derived from $E = mc^2$. The last covered implication is that a simple experiment, leveraging a photon's red/blue shifts, can test for, and measure, a photon's mass. Finally, the paper indulges in some speculation where the implication study was unable to prove an implication. This speculation posits a potential path towards integrating quantum mechanics and relativity, and that perhaps only three fundamental forces exist, where the other supposed forces are only a special combination of one of the three. These three forces are electric forces, magnetic forces, and gravitational forces, and a photon is responsible for these forces and are coupled together under electromagneticgravitatism, where each force operates orthogonality, one force in each spacial dimension.**

TABLE OF CONTENTS

1. SPECIAL RELATIVITY TIME DILATION

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

A simple thought experiment sets up the problem to derive time dilation given constant speed of light. First imagine a light clock on a stationary ship that emits light from a known location, the light travels some distance, Δy, strikes a mirror and returns the same distance back to the clock's receiver, as shown in Figure 1.

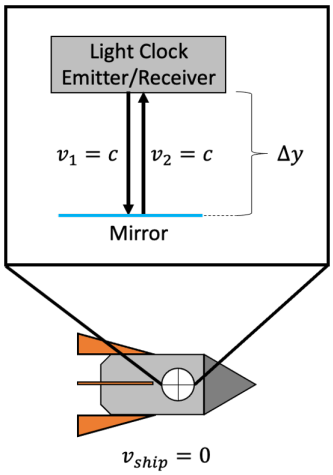
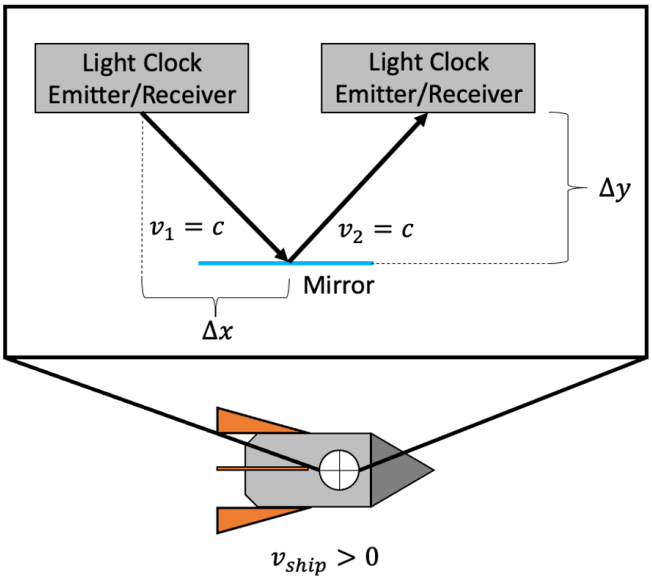


Figure 1. Light Clock At Rest.

Now imagine that the ship instead has some positive and constant velocity, v_{ship}, then the light clock can be observed to emit light at the source, bounce off the mirror and return to the receiver but the overall path was different. The light traveled the same vertical distance as before, but this time the light is traveling some non-zero horizontal distance, as show in Figure 2.

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

Following geometric laws gives us a relationship between time experienced on the moving ship, Δt, and time experienced on the stationary ship, $\Delta t'$. A *differential* exists between how time passes between the two reference frames. Given the above relationship between Δt and $\Delta t'$, deriving time dilation is as follows:



$$\Delta t'_{clock} = \frac{2\sqrt{\Delta x^2+\Delta y^2}}{c}[per\ cycle]$$

Figure 2. Light Clock In Motion.

$$\Delta x = v_{ship}\frac{\Delta t'}{2} \tag{1}$$

$$\Delta t' = \frac{2\sqrt{\Delta x^2 + \Delta y^2}}{c} \tag{2a}$$

$$\Delta t' = \frac{2\sqrt{\left(v_{ship}\frac{\Delta t'}{2}\right)^2 + \Delta y^2}}{c} \tag{2b}$$

$$c^2\Delta t'^2 = (v_{ship}\Delta t')^2 + 4\Delta y^2 \tag{2c}$$

$$(c^2 - v_{ship}^2)\Delta t'^2 = 4\Delta y^2 \tag{2d}$$

$$\Delta t'^2 = \frac{4\Delta y^2}{c^2 - v_{ship}^2} \tag{2e}$$

$$\Delta t' = \frac{2\Delta y}{\sqrt{c^2 - v_{ship}^2}} \tag{2f}$$

$$\Delta t' = \frac{c\Delta t}{\sqrt{c^2 - v_{ship}^2}} \tag{2g}$$

$$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{v_{ship}^2}{c^2}}} \blacksquare \tag{2h}$$

From equation (2h) it seems reasonable to conclude v_{ship} caused the time dilation because the speed of light is constant and the only variable is v_{ship}. As will be shown, via the method of difference and agreement, velocity cannot be the cause. Velocity is actually correlated to time dilation because velocity is an effect to the real cause of time dilation.

The issue with thinking velocity is the cause is that it leads to a contradiction because velocity is only a relative measurement. For example, suppose you're on a ship (orange) that is not accelerating, and you observe another ship (blue) outside your window with a relative velocity such that you see it moving from right to left outside your window, as shown in Figure 3.

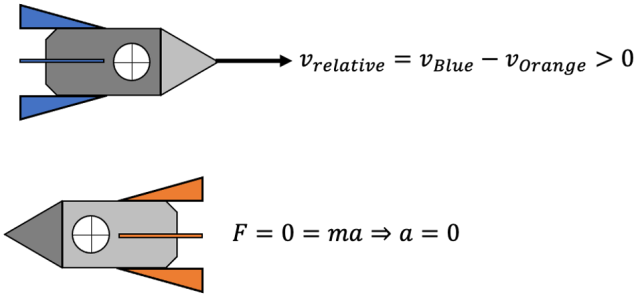


Figure 3. Relative Motion Between Two Ships.

Insufficient information exists to determine which ship is actually moving, and in what direction, and to what degree in any absolute sense—i.e., it's all relative, thus the term relativity. In fact, an infinite set of possible situations exist that lend themselves to the observed relative motion, and Figure 4 illustrates the unique situation (unique in signs for V_{Orange} and V_{Blue}).

This relativity conundrum leads to what is termed the twins paradox, where a twin takes off in a ship at some velocity towards Alpha Centauri, stops, turns around and upon returning home discovers that his twin aged more than himself.[2] In this paradox, both twins had the same relative motion at the same time, and both calculated the other would experience time dilation, but only one aged more than the other. At the risk of stating the obvious, this is a contradiction—they both ought to have experienced the same time dilation, according to Equation (2h), but only one did; therefore, invoking the method of difference proves that velocity cannot be the cause of time dilation.

Velocity was not the only antecedent factor. Something else occurred, which was unique to the twin who actually experienced time dilation (i.e., the twin that aged less), and that factor was his acceleration profile. For the twin that aged less, his acceleration over some distance is the only remaining antecedent factor that could have caused the time dilation; therefore, invoking the method of difference, acceleration over some distance is the cause of time dilation, and it is also the cause of the observed relative velocity. As we can now see, relative velocity is only correlated to time dilation, not the cause of it. Updating Equation (2h), but substituting out correlated terms for causal terms gives us Equation (3) below:

[2] Just to clarify, it is assumed the stationary twin is in uniform space, i.e., not in the vicinity of any source of gravity.

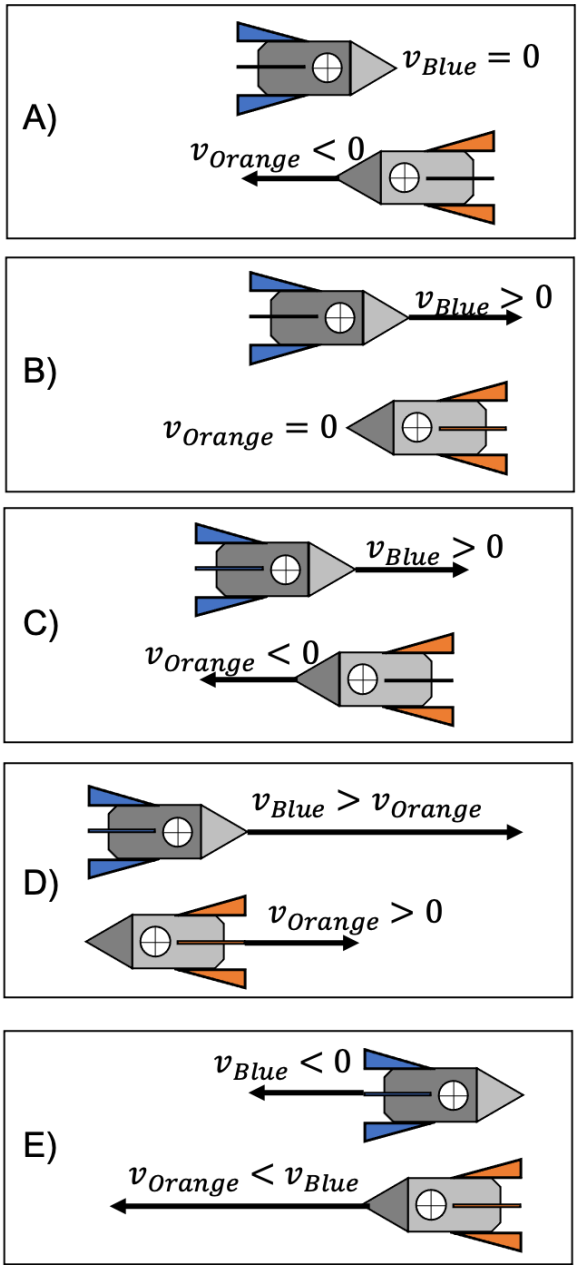


Figure 4. Possible Situations Lending to The Observed Relative Motion Between Two Ships.

Relating ax to v^2 :

$$v = at$$
$$x = \frac{1}{2}at^2$$
$$ax = \frac{1}{2}(at)^2$$
$$ax = \frac{1}{2}v^2$$
$$v^2 = 2ax$$

Updating Equation (2h) :

$$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{2ax}{c^2}}} \tag{3}$$

2. General Relativity Time Dilation

General relativity also has it's own time dilation, as defined in Equation (4).

$$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{2MG}{rc^2}}} \tag{4}$$

Where :

M is the mass creating the gravity potential
r is the distance to center mass
G is the gravitational constant

Equation (4) can also be rearranged into Equation (5), which is also in terms of acceleration applied over some distance:

Relating $\frac{2\text{MG}}{\text{r}}$ to 2gr :

$$F = \frac{GMm}{r^2} = gm$$
$$\frac{2MG}{rc^2} = \frac{2MG}{rc^2}\frac{r}{r} = \frac{2gr}{c^2}$$

Updating Equation (4) :

$$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{2gr}{c^2}}} \tag{5}$$

Where :

g is gravitational acceleration
r is the distance to center mass

3. Time Dilation's Common Cause

It is no coincidence that both special and general relativity time dilation are both in terms of acceleration applied over some distance, which is a change specific energy. A change is specific energy is what causes time dilation for both special and general relativity. Changes in special relativity time dilation are due to changes in specific kinetic energy, and changes in general relativity time dilation are due to changes in specific potential energy. Below is a proof that time dilation is caused by changes in specific energy.

The approach this proof takes is that it assumes:

1. An object is at rest some distance, r, away from some gravity potential causing local gravitational acceleration to be, g.
2. All the specific potential energy is transferred to specific kinetic energy

If time dilation is caused by changes in specific energy, then the time dilation before and after the transfer ought to be the same since all the specific energy transferred from specific potential energy to specific kinetic energy.

Proof :

$$\text{Let } \gamma = \frac{\Delta t}{\Delta t'} \tag{7a}$$

$$\gamma_P^2 = \gamma_K^2 \tag{7b}$$

$$1 - \frac{2gr}{c^2} = 1 - \frac{ax}{c^2} \tag{7c}$$

$$\frac{2gr}{c^2} = \frac{ax}{c^2} \tag{7d}$$

$$gr = \frac{1}{2}ax \tag{7e}$$

$$gr = \frac{1}{2}v^2 \blacksquare \tag{7f}$$

This proves that time dilation is the same before and after the energy transformation, because assuming otherwise would contradict a basic specific potential-kinetic energy identify in Equation (7f). gr from Equation (7f) is the max possible potential energy that could be transfer to kinetic, which assumes the source of gravity is a point source (a dot without dimension). If the object under the influence of gravity fell r, then it would reach the center of mass, and then would have no more potential left to transfer. If all the potential transferred to kinetic, then the result would be a velocity that equals: $(2gr)^{\frac{1}{2}}$.

Invoking the method of agreement, as in the same change in the amount of specific energy caused the same time dilation, proves that time dilation is caused by a change in specific energy.

To sum up, time dilation between two reference frames in general relativity terms is due to changes specific potential energy; and time dilation between two reference frames in special relativity terms is due to changes in specific kinetic energy. Or in short, time dilation is caused by changes in specific energy.

4. IMPLICATIONS

We will see from this next proof that the famous $E = mc^2$ is actually not the whole story—its a special case unlikely to ever happen in any meaningful because $E \leq mc^2$, and most of the time E is much less than mc^2.

Total Relativistic Energy Equation

This proof begins by taking specific potential and specific kinetic energy's relationship to γ^2 and solve for energy, E.

Proof :

$$\gamma_P^2 = 1 - \frac{2gr}{c^2} \tag{8a}$$

$$\gamma_P^2 = 1 - \frac{2gr}{c^2}\frac{E_P}{E_P} \tag{8b}$$

$$\gamma_P^2 = 1 - \frac{2gr}{c^2}\frac{E_P}{mgh} \tag{8c}$$

$$\text{Let r} = h$$

$$\gamma_P^2 = 1 - \frac{2}{c^2}\frac{E_P}{m} \tag{8d}$$

$$\frac{2}{c^2}\frac{E_P}{m} = 1 - \gamma_P^2 \tag{8e}$$

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

$$E_P = \tau_P^2 \frac{1}{2}mc^2 \tag{8f}$$

$$\gamma_K^2 = 1 - \frac{2ax}{c^2} \tag{9a}$$

$$\gamma_K^2 = 1 - \frac{2ax}{c^2}\frac{E_K}{E_K} \tag{9b}$$

$$\gamma_K^2 = 1 - \frac{v^2}{c^2}\frac{E_K}{\frac{1}{2}mv^2} \tag{9c}$$

$$\gamma_K^2 = 1 - \frac{2}{c^2}\frac{E_K}{m} \tag{9d}$$

$$\frac{2}{c^2}\frac{E_K}{m} = 1 - \gamma_K^2 \tag{9e}$$

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

$$E_K = \tau_K^2 \frac{1}{2}mc^2 \tag{9f}$$

$$E_T = E_P + E_K \tag{10a}$$

$$E_T = \tau_P^2 \frac{1}{2}mc^2 + \tau_K^2 \frac{1}{2}mc^2 \tag{10b}$$

$$E_T = (\tau_P^2 + \tau_K^2)\frac{1}{2}mc^2 \blacksquare \tag{10c}$$

Qualities of τ ranges from $[0, 1]$ for both specific potential and kinetic energy contributions to time dilation. If either are 1, then that form of specific energy is contributing the maximum amount it can to time dilation. For example, when $\tau_K = 1$ it is because $ax = c^2$; or, when $\tau_P = 1$ it is because $2gr = c^2$. It is apparent from Equation (10c) that $E \leq mc^2$. Equally apparent, most of observable space is empty and far away from massed objects; therefore, for most of space, $\gamma_P \approx 0$.

This means that mass cannot be converted into energy, as theorized before in the sense that mass disappears and pure energy without mass appears. It turns out, that energy is not some separate entity from mass, but rather energy is an inseparable aspect of an object, which by definition, has mass.

Lets consider a case where an object is believed to have no mass, such as a photon. Let's assume that a non-accelerating object with some mass, m, is not in vicinity of any gravity

potential. If this object were to disintegrate into nothing but photons, What would the total energy be of all the released photons (considered in the reference from from which the object started)? If we assume that mass is conserved, then the total mass of the photons is m, and its speed is c by definition. Therefore, $\tau_P^2 = 0$ and $\tau_K^2 = 1$ and plugging these values into the total relativistic energy equation we get: $E_T = \frac{1}{2}mc^2$.

Now, if instead this same object started near a gravity potential, such that $\tau_P^2 = 1$, then the total energy of all the disintegrated photons would be: $E = mc^2$ instead because in addition of the specific kinetic energy there is also the specific potential energy. Figure 5 helps visualize this situation.

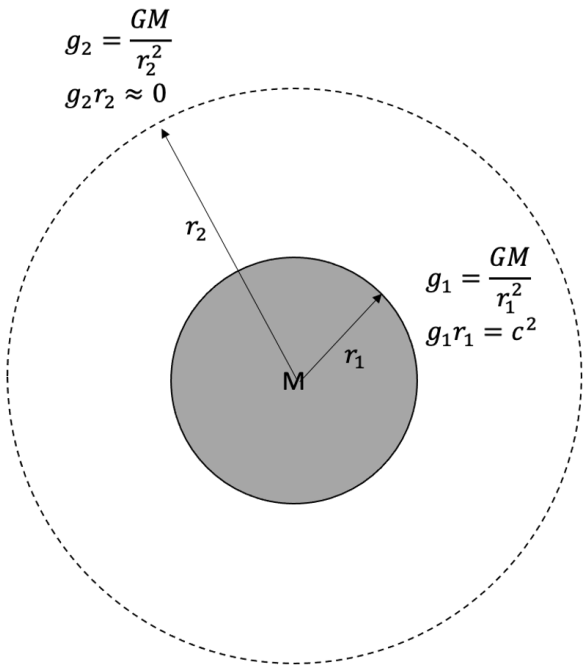


Figure 5. **Comparing $\tau_P^2 = 1$ to $\tau_P^2 = 0$.**

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

Reinterpreting Red/Blue Shift Reveals Photon Mass

We know from electromagnetism that the energy of a photon particle is defined by Equation (11).

$$E = \frac{hc}{\lambda} = hf \tag{11}$$

Now that we have the total relativistic specific energy equation from Equation (10c), we can use that with Equation (11) to estimate the mass of a photon using red/blue-shift measurements as proven below:

Proof :

$$\Delta E = \frac{hc}{\Delta\lambda} = h\Delta f = (\Delta\tau_P^2 + \Delta\tau_K^2)\frac{1}{2}mc^2 \tag{12a}$$

$$\frac{hc}{\Delta\lambda} = (\Delta\tau_P^2 + 0)\frac{1}{2}mc^2 \tag{12b}$$

$$m = \frac{2h}{\Delta\tau_P^2 \Delta\lambda c} = \frac{2h\Delta f}{\Delta\tau_P^2 c^2} \tag{12c}$$

Therefore, given the change in specific potential energy and the measured shift in wavelength (or frequency) can yield the mass of a photon. This seems like a relatively (pun intended) easy experiment to set up. What is required already exists most likely. With an emitter at a location on earth, with a known gravity potential, emitting light at a known wavelength (can be constant emission), and with a receiver in orbit, with a known gravity potential, you can collect all the required measurements to estimate the mass of a photon.

I would not assume that the photons at various wavelengths to have the same mass. In fact, it stands to reason, that they would not have the same mass given certain other observations.

Reinterpreting Photon Momentum

Because it was formerly assumed that $E = mc^2$, it was also assumed that the momentum of a photon was defined as Equation (13) below:

$$p = \frac{E}{c} \tag{13}$$

But with our new understanding of total relativistic specific energy we get Equation (14) below instead:

$$p = \frac{2E}{(\tau_P^2 + \tau_K^2)c} \tag{14}$$

This suggests that momentum changes as total specific energy changes—this much makes sense. But, since changes in specific energy induce a color shift, then it seems there is a relationship between a photon's mass and its wavelength (and frequency), assuming constant velocity. I am uncertain how to reconcile this implication with conservation of mass, because the same photon might shift its color and these relationships suggests that its mass also changes. Experimental evidence shows that a photon's momentum is a function of its wavelength, and its energy is also a function of its wavelength.

Solving for a photon's mass as a function of wavelength or frequency yields:

$$m = \frac{2h}{(\tau_P^2 + \tau_K^2)\lambda c} \tag{15a}$$

$$m = \frac{2hf}{(\tau_P^2 + \tau_K^2)c^2} \tag{15b}$$

This reconciliation will have to wait on future work and additional experimental evidence making use of the progress contained in this work. Even though I have taking this reasoning as far as I can, I will indulge in speculation in what this reconciliation my be, and therefore, what it might mean.

5. SPECULATIONS

It is important to delineate what scientific work is based on causal proofs and what is speculation. Unfortunately today, this delineation is obscured far too often largely due to a general ignorance on a valid method of induction. I do not like the popular approach of picking an arbitrary hypothesis and treating as if it were true until proven otherwise—it is a regression to a prescience era.

Do not misunderstand me, I am no Einstein; if I were ignorant of the valid method of induction, this paper would likely not exist. If this work has merit, it is only because I know what contradictions means when I see them, I know how to conduct the causal discovery process[3], and I know how to integrate and find implications of newly discovered generalizations to material I am familiar with [3][4][5]—anyone could have done what I did using those powerful cognitive tools and methods.

The causal discovery in this paper was that special and general relativity time dilation are both caused by the same phenomena—changes in specific energy—as apposed to being caused by two very different unrelated phenomena, as previously understood. This is a newly induced generalization, and the rest of the paper, up to this point, has been a study of the implications via deductive reasoning. I have taken the deductions as far as I can, and now I a will begin to speculate.

Matter is Comprised of Photons

If atomic particles (electron, neutron, photon, positron, etc.) were simply many structured photons then the total relativistic energy of all the photons might be $E = mc^2$. This would occur if the structure of the photons were such that the distance between photons caused $\tau_P^2 = 1$ (we already know $\tau_K^2 = 1$ for photons).

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

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

Perhaps all there is is light in the universe, and the seeming variety of matter found in the periodic table of elements, and their various states, are each simply a unique structure of photons. If so, then the energy of all the photons comprising traditional matter could be $E = mc^2$.

Theory of How Photons Create Gravity and Gravitational Relativity

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

Why might our measure for the amount of matter change? What could cause this to happen? One plausible reason is that photons with the same intensity (amplitude), but different frequency, interacts with different amounts of space over the same time period, as shown in Figure 6. This gives the appearance, in how its modeled anyway, that one frequency is "more dense" than the other.

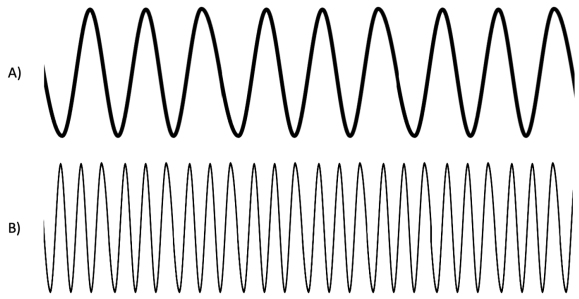


Figure 6. (A) being a smaller frequency seems "less dense" than (B).

This concept—increasing frequency increases the photon's "density"—is consistent with what is found in Equation (15b), $m \propto \frac{f}{(\tau_P^2+\tau_K^2)}$, but I acknowledge that it could be a coincidence.

What could this mean if it were the true reason? Perhaps every photon is exactly the same frequency, and the only difference that gives the appearance of a frequency change is difference in time dilation causing a shrinking of the space between wave peaks.

What if they do not all go the same speed? Maybe each photon goes so fast, a limit approaching c, that they only appear to all go the same speed. Perhaps changes in specific energy causes imperceptible difference in speed, which then causes their frequency to shift, and therefore, the space between peaks of the wave would shrink or grow accordingly.

I am not sure of the exact reason and I can prove these

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

speculations, but perhaps how me measure mass has more to do the space between peaks, so how we measure their mass changes—the existing standards of measurement dilates—but the amount of matter remains unchanged.

If distance between peaks affects how we measure mass, then perhaps it also affects what we perceive as gravity. Maybe what we are observing with differences in frequency are differences in space-time density. Reconciling this issue satisfactorily might lead to the integration between quantum mechanics and gravity.

Some experimental observations lending to the plausibility of this theory include, refraction observations, and the energy of a photon is known to be related to its frequency and if its speed is the same, then how we measure mass might dilate (or perhaps its speed changes imperceptibly). Also, it is well established that blue light refracts more than red when changing mediums light travels in from a vacuum to something more dense. If blue photons have a greater gravitational force, but they have the same amount of matter as red photons, it might explain why blue bends more than red.

Theory of Electromagneticgravitism

If photons are responsible for gravity, then photons are responsible for three forces: electrical forces, magnetic forces, and gravitational forces. Electromagnetism would be a special case of *electromagneticgravitism*, where each force operates orthogonality to the others, and gravitational force operates longitudinally (along the light path) as a function of the frequency of electromagnetism, which makes gravity's coupling with electromagnetism fundamentally different from the electromagnetic coupling. It is an interesting coincidence if photons were responsible for three forces, one force in each spatial dimension. Maybe those are the only three forces because there are only three dimensions, and the nuclear forces are actually a special case of *electromagneticgravitism*—each being a different combination of two of the three fundamental forces. These combinations are most likely electrogravitism and magneticgravitism since electromagnetism is well understood.

Perhaps Velocity Is Just a Useful Construct

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

REFERENCES

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

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

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

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

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