The Unity of Space and Time

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Abstract

The purpose of this paper is to propose and support a simple theory: that space and time are complementary aspects of the exact same essence – a process that separates itself into both a physical and temporal aspect. This Unity Theory postulates that the spacetime continuum is primarily a unity that manifests as a duality with two seemingly independent base quantities and that treating one (space) as three-dimensional and the other (time) as one-dimensional unnecessarily complicates the math and distorts interpretation of the results. Because length and duration are different by definition, their independence cannot be disputed, but they are not different in essence, only in the way they are measured. It is also shown that measurement itself, being a snapshot of the aspect measured, locks the other aspect out of the equation forcing the conclusion comparable to concluding that one's image in the mirror can only look at itself.

The Unity model of spacetime is developed mathematically and explained by analogy with the two ways to describe the level in a glass of water (fullness and emptiness). Allowing balanced representation by each provides a perspective that transcends the two-dimensional plane in which space and time appear to be fundamentally separate.

Application of this theory to the Special Theory of Relativity provides a simple and sensible explanation of why the speed of light is constant as well as why distortions appear in both length and time for a particle approaching this limit. Application to Quantum Theory provides a common sense explanation of the particle-wave duality. The space-time diagram is used to illustrate the multivector that unifies all aspects of electromagnetic theory; it demonstrates a logical explanation for the arrow of time and provides the template for a Unified Field Theory.

Conclusion: Spacetime is the self-perpetuating process we perceive as life. The dual aspects of spacetime, when separated by relative motion, serve as coherent waves that holographically interfere with each other and materialize as matter. Matter is a state of relative constancy of seemingly separate forms whose existence induces restoring forces, which induce relative motion, which separates spacetime, resulting in a perpetual process of life and expanding awareness. Time does not exist as a separate linear entity that ticks away under its own control. Instead, it is a concept that simply allows our consciousness to make sense of the change that we experience by giving us the feeling that we only exist here and now rather than being part of an eternal process that transforms emptiness into truth. As part of the process, we are supremely accountable for our actions, for our lives, for each other and for our planet.

"It has become clear by now that we cannot resolve the five big problems [with physics] unless we think hard about the foundations of our understanding of space, time, and the quantum." -Lee Smolin, Ph. D.

I. INTRODUCTION

Physics is based on measurement. A small number of physical quantities, units of measurement such as length and time, were chosen by international agreement – and standards were assigned to them. But the magnitude of the standards were arbitrary and not based on the essence of what was measured. In the words of E. A. Burtt in *The Metaphysical Foundations of Modern Science*, (Burtt 226), "The ultimate nature of [space, time, gravity, etc] is unknown; it is not necessary for science that it be known, for science seeks to understand how it acts, not what it is." That may have been true at the beginning of our scientific exploration, but recent generations of physicists have been trying to figure out the real essence of that phenomenon we call time. Some say that time was created in the big bang, but that still doesn't explain what time actually is. In the January 2013 edition of Foundations of Physics, author Balasubramanian stated that "time remains the least understood concept in physical theory. While we have made significant progress in understanding space, our understanding of time has not progressed much beyond the level of a century ago when Einstein introduced the idea of space-time as a combined entity. (Balasubramanian)" How can we hope to interpret mathematical evidence for the universe's origin if we can't agree on the essence of the most fundamental components of the equation?

This paper does not suggest that the fundamentals of physics are wrong. Instead, it offers a different perspective of the foundations of physics and proposes profound implications. According to physicist Lee Smolin, String Theory has failed as a Theory of Everything specifically because it is missing the fundamental meaning of time (Smolin) and physicists who are advanced enough to work on the problem are far too advanced to concern themselves with fundamentals. This paper closely examines how space and time were defined and reevaluates the use and meaning of dimensions and coordinate systems. Readers are asked to patiently read and reflect on the fundamentals because the focus on the foundation is of primary importance and the central theme of this paper.

II. SPACE *DIVIDED BY* TIME?

Before Newton declared their independence, space and time were simply thought to be two different aspects of motion. (Burtt) Isaac Barrow, Newton's predecessor, made that clear in his "Geometrical Lectures", published in 1735.

"Time is commonly regarded as a measure of motion, and… consequently differences of motion (swifter, slower, accelerated, retarded) are defined by assuming time is known; and therefore the quantity of time is not determined by motion but the quantity of motion by time: for nothing prevents time and motion from rendering each other mutual aid in this respect." (Burtt 158)

The conceptual separation of space and time was initially understood to be a tool for predicting motion, but Barrow and Newton insisted that that they are fundamentally different in essence. They certainly seem to be fundamentally different; in fact they are effectively *opposites* (i.e. related to motion with inverse relationships) since velocity (v) is directly proportional to the measure of space (s) and inversely proportional to the measure of time (t) in the equation $v = s/t$. So Motion is *space divided by time.*

What does it mean to divide space by anything? It means (I submit) that the spacetime continuum can be separated into two conceptual dimensions by taking two different measurements. Each measurement is a snapshot that quantifies the two aspects of motion, creating a sense of constancy in something that is not constant, i.e. motion is change.

Postulate 1: The first postulate proposed by this paper is that the entire universe (the spacetime continuum) is a single, unified process and that length and time are two complementary measurable aspects of that process – two different ways of measuring the same unified essence, just as fullness and emptiness are complementary ways of measuring the level of liquid in a container.

In the development of the Minkowski space-time diagram, time and space were symbolized equally with one axis representing three-dimensional space (as a single dimension) and one representing time (as another, independent dimension), see Figure 1a. One unit on the time axis is shown as one second and one unit on the space axis is one light-second, or the distance (in any units) that light travels in one second.

But then, (perhaps because the idea that space and time are fundamentally different in essence is engrained in our way of thinking) the equation for spacetime was written as a four-vector ($x^2+y^2+z^2 - c^2t^2 = 0$) with space unfolded into three dimensions while time was left as one. This was supposedly depicted by the Minkowski diagram (Figure 1b) but in fact, there are only two dimensions of space shown. Something called a "light cone" was formed by revolving the line (c in Figure 1a) around the T axis. The light cone is used to represent the concept of causality (causal influences such as signals cannot travel faster than the speed of light) and the intersection of the time axis with the space plane is said to represent the moment Now. Since any material particle must have a velocity less than the speed of light, its path in space and time is represented by a curve (called a world line) inside the light cone. The space outside of the light cone is called *elsewhere*. Events that are elsewhere from each other are mutually unobservable, and therefore cannot be causally connected.

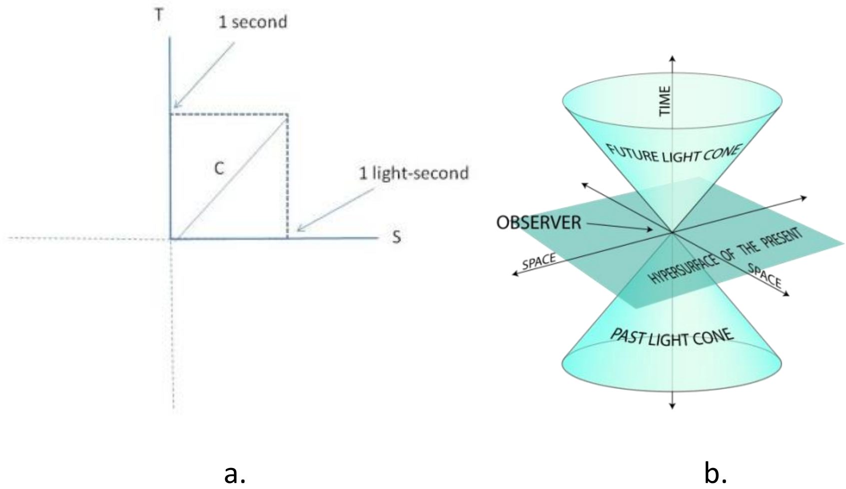


Figure 1 (a) A normalized plot of time vs. space that illustrates the point that light travels one unit of distance (light-second) in one unit of time (second) (b) Minkowski's interpretation of the time vs. space plot, expanded to include the past as negative time and the future as positive time. This is an abstract representation since space is shown as two dimensions, an anomoly that was dodged by calling it the event horizon, an "hyperspace" of the present.

Most mainstream physicists interpret spacetime as being a sort of blend rather than a continuum. When initially submitted for review by an astrophysicist, the unity of spacetime, (and the complementary nature of space and time) was rejected with the comment, "*your idea of time and space is interesting, but is not right when it comes to dimensions. Space really is 3 dimensional and time really is 1D. This is not an arbitrary division. Spacetime is unified in that different states of motion cause time and space to "mix", i.e. time moves at different rates to different observers. But a piece of paper is 2D because it takes two numbers to say where a point is. The room is thus 3D (3 numbers to describe position) and time is 1D because it takes only one number (the time) to say where you are in it*.[1]"

So according to Minkowski's model, time plays the role of a single dimension that is somehow different from the spatial dimensions. But why is three-dimensional space represented as a two-dimensional "hypersurface"? If space is truly three-dimensional then this, I submit, is a misrepresentation that results in a misinterpretation. Perhaps there is a better way to use the ST plot that does not create the same distortions or abstract starting point.

[1] Personal communication from a university Professor of Astrophysics in email dated May 15, 2013

If spacetime is a balanced continuum as postulated, meaning that space and time are NOT two different things that are somehow mixed, then they should be treated as two different aspects of the same unified field. To illustrate the balanced perspective, we need to consider the meaning of our fundamental units.

III. Fundamentals: Measurements of Space and Time

Units of measurement are introduced on the first day of Physics 101. Space is measured in units of length and anything that occupies space can be used as a standard unit of spatial measurement. Time is defined and measured in units of duration. Anything that changes in a consistent, measurable way can be used to define a standard unit of time. Suppose we use the same thing to define both - something that occupies space *and* changes in a consistent, measurable way. An arbitrary wave, say a piece of rope shaped like a wave in Figure 2 would do. It can be used to define one unit of length as *the distance from the beginning to the end of one cycle,* i.e. one wavelength (λ).

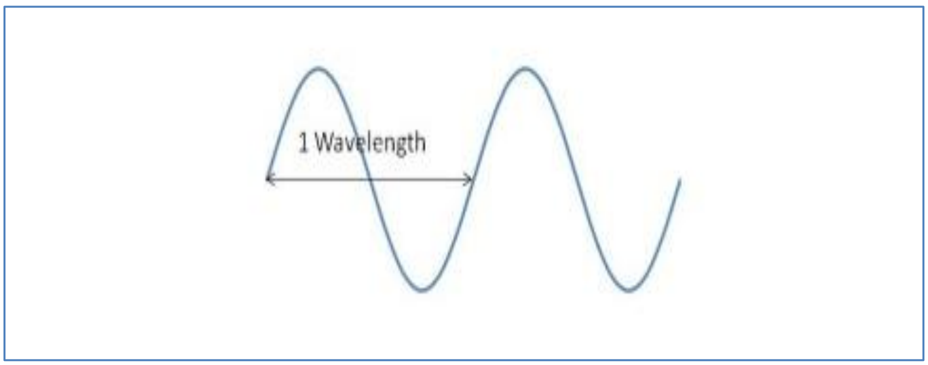


Figure 2 A wave can serve as a standard measure of space by defining one unit of measure as the distance between the beginning and end of one cycle.

If the exact same rope used to define length is made to *appear to be moving* with respect to another "stationary" reference (see Figure 3)**,** it can then also be used to define a unit of time. It doesn't matter whether the rope is moving or the reference frame is moving; the relative motion makes the wave appear to oscillate up and down and so one cycle can be defined as one unit of time – *the duration from the beginning to the end of one cycle*. We call that the wave's period (T).

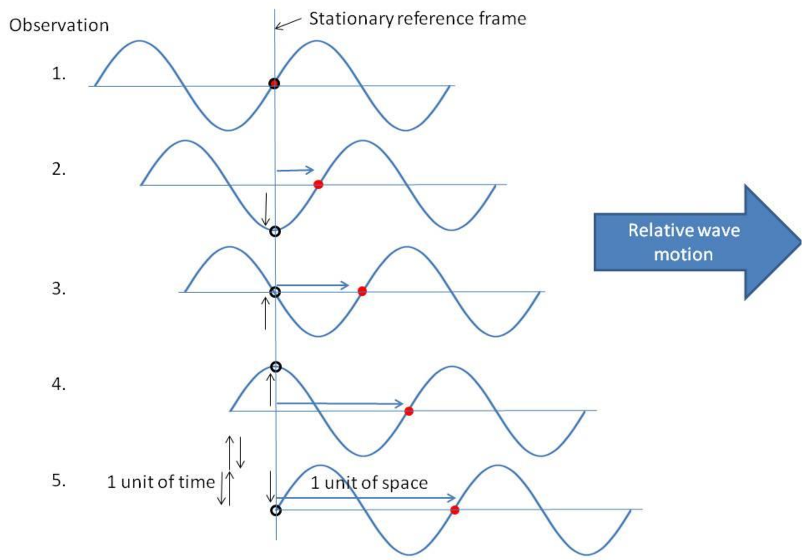


Figure 3 A stationary reference point allows motion of the same wave as to be used as a time standard. Each wave in the figure represents a snapshot as the wave moves to the right (red dot) and the intersection of the wave with the vertical line (small circle) moves down to the minimum, up to the maximum and back to the starting point. One unit of time is then defined as the duration between the beginning to the end of the cycle.

So wavelength and period are different *by definition*. But are they really different in essence? Both units were defined by their own measurement and although it is true that they are measured differently, there is no *fundamental difference* in what was measured in Figure 2 and Figure 3 – it was *the change from the beginning to the end of one cycle.*

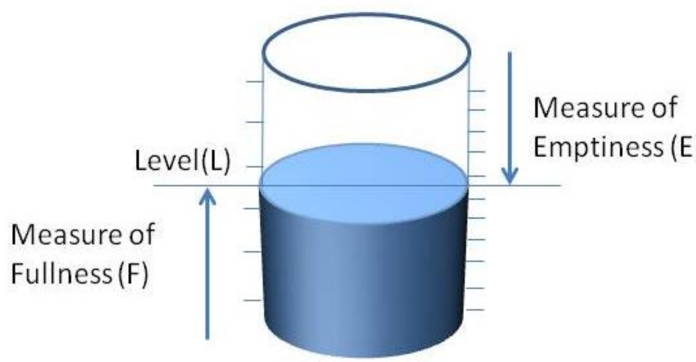
Change was measured. The difference in the values was a result of the way they were measured. In one case, the spatial measurement, the reference that defined the beginning and end was on the same inertial reference frame as the wave. There was no need for another reference to see that the wave (at rest) changed in space. So it might seem logical to conclude that a measurement of space, and therefore space itself, exists independent of time. But *there is no such thing as an object at rest*, except from the perspective of the object itself. As long as there is another moving object anywhere in the universe, there is relative motion. Therefore, *if a particle exists, it is in motion* - it has relative velocity. Even though change (from one position to another) is required for a spatial measurement, the fact that the rope can be *perceived* as a constant at rest, when in reality it is not, is a misperception – an illusion that space is separate from time.

Time, on the other hand allows the perception of change to be recorded in a different form. We know that something in the universe is moving relative to the wave that we perceive as stationary, and we believe that time is passing, but for this thought experiment, imagine that the wave-shaped rope is the only thing in existence. Without a moving reference it just sits there; it just is – it's timeless. Or is it? Could we even observe the rope at rest without motion (in the form of subatomic orbitals, particle spin, light reflecting on the rope and delivering information to our eyes, etc.)? The experience of timelessness only means that the passage of time was not perceived, not that it doesn't exist. A moving reference allows us to experience or *deduce time* from the apparent change with respect to (perpendicular to) the axis of motion, so clearly the measurement of time required motion in space. It was accomplished by observing the point on the rope as it appeared to move. This suggests that *motion (change) is primary*, that neither time nor space are independent but rather that they are both measureable aspects of a process, that is, motion. A process is both a noun ("a natural outgrowth, projection, or appendage") and a verb ("to convert into another form"). The word should bring to mind some*thing* (a physical aspect) that changes continuously (temporal aspect). Measurements of physical space allow us to focus our attention on something tangible, and time is the other component of the same process. We consider the tangible part to be real, but it cannot exist without the intangible part, just as fullness cannot exist without emptiness.

IV. Analogy of Spacetime

Consider another system that can be measured and expressed using two complementary aspects, to serve as an analogy of spacetime. It may seem trivial but it will illustrate how complementary concepts can become disguised as something abstract and distorted when analyzed under the assumption that they are fundamentally separate and different. Suppose we refer to the level (L) of water in a glass, whose total capacity is C, first as the distance from the bottom, call it fullness (L_f) and then as the distance from the top, call it emptiness (L_e), see Figure 4.

Figure 4. Analogy of spacetime. The water level (L) in a glass is the transition between the water (substance) and the space available in the glass (potential). The same level can be referred to either as a measure of fullness (L_f) or as a measure of emptiness (L_e). Both are valid measurements and equivalent ways of pointing to the level, but they can be quantified differently, which may make them appear to be different in essence.



The measurable values L_f and L_e are measurably different from each other, but they are the same in essence in that they both refer to the same level, which itself is just the transition between water and air, and they use the same kind of units. Notice that fullness is an indirect measure of the actual substance (volume) in the glass. The actual volume requires three dimensions of length, and if we were focused only on the physical aspect of the system, we could simply refer to fullness as a volume and ignore emptiness.

Now if we want to mathematically describe the level as it changes, we need some kind of reference to which the change can be compared. Normally, we use a time standard to express a fill rate (inches per second, gallons per hour, etc.) but since we are trying to understand the essence of time, let's go back to before time was defined and use a unit of emptiness instead of a unit of time.

We simply need to define a standard by filling a glass with a constant flow and record the change as the level reaches each unit on the emptiness scale. Imagine that you can see the level rising and that you hear a snap sound as the level reaches each e mark. As long as you can keep this mental metronome snapping in your mind with a constant rhythm it will be a "motion scaler"[2] calibrated to one snap (s) per e division or $1\ s/e$. Notice that you can invert this *calibration factor* and it will seem like a speedometer indicating that the level is moving at $1\ e/s$ where s still stands for snap (chosen to illustrate the analogy to seconds). Of course that "speed of level" would not be a real indication of rapidness-of-motion because regardless of how fast the glass is filling, there would always be one snap per e so the value of "speed" would always be a constant $1\ e/s$.

Once you have the rhythm, you can forget about the glass of water used to define the scale and move in your mind to anything else that changes and measure how it changes *per snap*. You could define one *snap* as the fundamental unit of *scale*. If you ever need to explain what a snap is or how you invented your scaler you could admit that you created it in your mind with motion, that a snap is really a snap *per unit change,* which you could quantify as a unit of e. You just decided to ignore the e because it has a value of one unit and is useless for your purposes.

If someone argues that a snap is imaginary because you created it and are now imagining it in your mind, then you could argue that it is as real as change. In fact it *is* change. You quantified it using the ratio of two different gauges, and then inverted the ratio to allow you to normalize it to one unit so you could use it as a scale for any kind of change. You could make it "real" by inventing a machine that snaps, clicks or ticks with the same rhythm. You could even take it to the National Institute of Standards and Technology and use it as a standard scaler. The same thing happened when a unit of time was defined. A second does not exist by itself; it was defined as the duration of change.

[2] as in something that scales; intentionally avoiding to the word "timer" since this thought experiment takes place before the concept of time was invented.

Time and Emptiness in the Wave Equation

To illustrate how emptiness takes on the exact same role as time, define a standard unit of fullness, n_f and a standard unit of emptiness, n_e by marking the glass with a total of C_f and C_e divisions respectively. The ratio of the two scales is a factor, $c = \frac{C_f}{C_e}$ that can be used to convert from one system to the other, but also indicates the relative size of each unit-type. The level could then be expressed as either $\boldsymbol{L}_f = n_f\hat{b}$, or $\boldsymbol{L}_e = n_e\hat{t},$ where $\hat{b}$ means it is measured from the bottom and $\hat{t}$ means measured from the top. This notation is a vector notation in that it includes magnitude (n) and direction (from the bottom $\hat{f}$ or top $\hat{t}$), but it also includes information about which system of units applies (the subscript in n_f and n_e) just as would be included (although not explicitly part of the vector notation) if we used meters and inches with a position vector.

Obviously it would be more sensible to use the same units for each regardless of which direction you measure it, but the purpose of this analogy is to show that the process of separating a unified concept into different aspects creates new information and insight[3]. Either definition (fullness or emptiness) is sufficient for measuring level just as length is sufficient for measuring an object in space. But since we want to describe a *change* in that level, we need another variable. In fact, we will need the other unit and the complement of each to illustrate how emptiness also plays the role of electromagnetic potential.

Emptiness is a measure of the *potential* fullness of the glass (where the level will be if water is added). From the opposite perspective, fullness is a measure of potential emptiness. Both perspectives are important because the equation that describes the system as a whole will contain both terms.

So the following variations apply (see Figure 5):

$\boldsymbol{L}_f = n_f\hat{b}$ means n fullness units measured from the bottom

$\boldsymbol{L}_e = n_e\hat{t}$ means n emptiness units measured from the top

$\tilde{\boldsymbol{L}}_f = c\boldsymbol{L}_e = n_f\hat{t}$ means n potential fullness units measured from the top

$\tilde{\boldsymbol{L}}_e = \frac{1}{c}\boldsymbol{L}_f = n_e\hat{b}$ means n potential emptiness units measured from the bottom

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[3] Once the units are defined, they are etched in glass (so to speak) so the relationship between them (c) is constant. Just like all fundamental constants in physics, including the speed of light, there's nothing special about the value of the constant, since it depends entirely on the size of the divisions, which are arbitrary. But it is an important number to remember because it has to be used to convert from one set of units to the other.

Even if emptiness can't be measured, (if for example, the glass is infinitely large), it can be calculated from the total capacity (which is 100% for an infinite glass). The total capacity of the glass $\boldsymbol{C_T}$ is the sum of fullness and emptiness

$$\boldsymbol{C_T} = \boldsymbol{L}_f + \boldsymbol{L}_e = n_f\hat{b} + n_e\hat{t}. \tag{4.1}$$

It could also be written in fullness units as

$$\boldsymbol{C}_f = \boldsymbol{L}_f + \tilde{\boldsymbol{L}}_f = \boldsymbol{L}_f + c\boldsymbol{L}_e, \tag{4.2}$$

or, it could be written in emptiness units as

$$\boldsymbol{C}_e = \tilde{\boldsymbol{L}}_e + \boldsymbol{L}_e = \frac{1}{c}\boldsymbol{L}_f + \boldsymbol{L}_e, \tag{4.3}$$

where $c = \frac{C_f}{C_e}$ is the unit conversion factor.

Although the total capacity is symbolized three different ways, they all represent the same glass and therefore have the same physical magnitude, but the symbols ($\boldsymbol{C}_e, \boldsymbol{C}_f$, and $\boldsymbol{C_T}$) have different meanings and different numerical values. $\boldsymbol{C}_e$ and $\boldsymbol{C}_f$ represent the total number of divisions on each respective scale. The L term represents the level and the $\tilde{L}$, represents the potential, which can be expressed in the same units as L and C by using the conversion factor. For example, $\boldsymbol{L}_f$ is the measure of fullness and $\tilde{\boldsymbol{L}}_f = c\boldsymbol{L}_e$ is the potential fullness, i.e. emptiness in units of fullness. $\boldsymbol{C_T}$ represents a value that is not a physical measurement, but mathematically combines the measures of capacity in both units; $\boldsymbol{C_T}^2 = \boldsymbol{C}_e{}^2 + \boldsymbol{C}_f{}^2$. This is represented graphically as a vector in Figure 5.

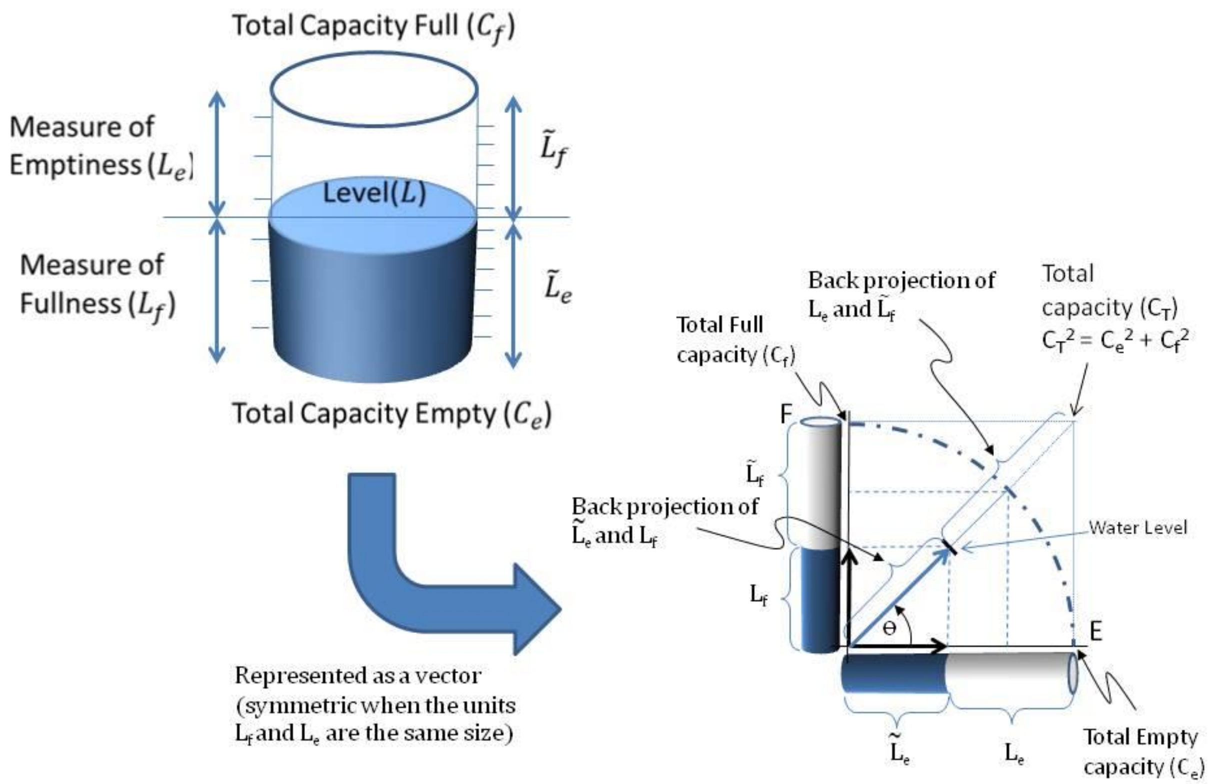

Figure 5 For the purpose of analysis, the two terms for measuring level are graphically represented on a two-dimensional plot. This illustrates how the concepts begin to get enfolded onto each other and how the actual measure and its complement (potential) can be used to project information about the total capacity of the glass without having to measure the whole glass. It will also illustrate how the two become entangled by the angle that relates them to the unit circle, which will represent the whole (glass).

Several points to notice:

1) Graphically, the two components plotted on the orthogonal dimensions that represent the water level as measured from the bottom are L_f in units of fullness and $\tilde{L}_e$ in units of emptiness. Combining the two perspectives into a vector will serve to illustrate how measurements of complementary aspects can create the appearance of contraction or dilation, especially if the magnitudes of the two scales are different. In this case however, the graph in Figure 5 is symmetrical because the scales are equal.

2) Symbolizing the measureable quantity (level) really only required one variable (one dimension; fullness), however the existence of one perspective

automatically required the existence of the other complementary perspective (emptiness) and a complete description of the system, which includes actual and potential, demanded equal representation of both perspectives. Although one may be more useful than the other for a particular application, both perspectives are equally correct methods of representing level;

3) The angle (θ) that relates the two projections to the diagonal is a constant whose magnitude is dependent on the unit conversion factor. In this case it is shown as if both units are the same ($c = 1$ and $\theta = 45^{\text{o}}$)

4) The vector representing level (the diagonal line) is the vector sum of the projections of $L_f, which$ is the real measurement of level in units of fullness, and the *complement* of emptiness, $\tilde{L}_e$. It is also a back-projection of the horizontal and vertical components, a conformal map of the two different perspectives through the same angle, (θ).

Example

Imagine the glass is divided into $C_f = 10f$ units and $C_e = 20e$ units. The ratio of units is $c = \frac{C_f}{C_e} = \left(\frac{10}{20}\frac{f\text{ units}}{e\text{ units}}\right)$. Now fill the glass to $L_f = 4f\hat{b}$ (that's 4 fullness units from the bottom). On the emptiness scale, that's $\tilde{\boldsymbol{L}}_e = \frac{1}{c}L_f = \left(2\frac{e\text{ units}}{f\text{ units}}\right)4f\hat{b} = 8e\hat{b}$ (emptiness units measured from the bottom). We can therefore write the level as measured from the bottom in vector format as $\boldsymbol{L} = \boldsymbol{L}_f + \tilde{\boldsymbol{L}}_e = 4_f\hat{b} + 8_e\hat{b}$.

This expression is the superposition of level as measured from the bottom, expressed in both units. Now imagine that the glass (as the analogy for infinite potential of spacetime) is infinitely large. We would not be able to measure fullness from the bottom (an absolute measurement) or emptiness from the top. We can only work with relative values. As long as we have the two scales we can analyze *changes* in the water level. In the example above, the conversion $\frac{C_e}{C_f}\boldsymbol{L}_f$ is the same as $\frac{\boldsymbol{L}_f}{C_f}C_e$ which just normalizes fullness to a fraction of total capacity (i.e. regardless of the magnitude, $\frac{\boldsymbol{L}_f}{C_f}$ means percent full; in the example, the glass is 40% full) so emptiness is just the remaining percentage. But we can't measure $\boldsymbol{L}_f$ either so we have to solve for $\Delta\boldsymbol{L}_f$ and $\Delta\boldsymbol{L}_e$.

First we solve the equation $\boldsymbol{C}_f = \boldsymbol{L}_f + c\boldsymbol{L}_e$ for the actual level, $\boldsymbol{L}_f = \boldsymbol{C}_f - c\boldsymbol{L}_e$. A change in the level from $\boldsymbol{L}_{f2}$ to $\boldsymbol{L}_{f1}$ would be

$$\Delta\boldsymbol{L}_f = \boldsymbol{L}_{f2} - \boldsymbol{L}_{f1} = \left(\boldsymbol{C}_f - c\boldsymbol{L}_{e2}\right) - \left(\boldsymbol{C}_f - c\boldsymbol{L}_{e1}\right) = -c\Delta\boldsymbol{L}_e \tag{4.4}$$

This yields

$$\Delta \boldsymbol{L}_f = -c\Delta \boldsymbol{L}_e \tag{4.5}$$

We know that a change in the surface level of the water is the same whether we symbolize it as a change in fullness or a change in emptiness, but mathematically, if we use one as an independent variable and calculate a change in the other with respect to it, then what we are actually calculating is a *fractional change*. The result will depend on the relative magnitude of each, equal to the ratio of the units, i.e. from equation (4.5) $\frac{\Delta \boldsymbol{L}_f}{\Delta \boldsymbol{L}_e} = -c$.

If we use differential calculus to make the independent variable (emptiness in this case) approach zero

$$\frac{d}{dL_e}\left(\boldsymbol{L}_f\right) = \lim_{\Delta \boldsymbol{L}_e \to 0}\left(\frac{\Delta L_f}{\Delta \boldsymbol{L}_e}\right) = -c \tag{4.6}$$

we can think of change as if the second variable is constant. It would be equally correct to choose fullness as the independent variable, in which case we would have

$$\frac{d}{d\boldsymbol{L}_f}(\boldsymbol{L}_e) = \lim_{\Delta L_f \to 0}\left(\frac{\Delta \boldsymbol{L}_e}{\Delta \boldsymbol{L}_f}\right) = -\frac{1}{c}. \tag{4.7}$$

The ratio of equations (4.6) and (4.7) represents how a fractional change in level from one perspective is related to the same fractional change from the other perspective:

$$\frac{d\left(\boldsymbol{L}_f\right)\Big/ d\boldsymbol{L}_e}{d(\boldsymbol{L}_e)\Big/ d\boldsymbol{L}_f} = \frac{-c}{-\frac{1}{c}} = c^2 \quad \text{or} \quad \frac{d\left(\boldsymbol{L}_f\right)}{d\boldsymbol{L}_e} = c^2\frac{d(\boldsymbol{L}_e)}{d\boldsymbol{L}_f} \tag{4.8}$$

Because a measure of fullness is a measure of the difference between the bottom of the glass and the actual level, the term $\boldsymbol{L}_f$ symbolizes a gradient. And because this scale is marked up the entire glass (including the part that is empty) it is the same gradient as potential fullness, $\nabla\tilde{\boldsymbol{L}}_f$. Therefore the derivative of $\boldsymbol{L}_f$is the derivative of the gradient or the second derivative of potential. The same logic applies to the emptiness scale, so the resulting equation is exactly the same format as a classical wave equation

$$\frac{\partial^2\left(\tilde{L}\right)}{\partial^2 \boldsymbol{L}_e} = c^2\frac{\partial^2\left(\tilde{L}\right)}{\partial^2 \boldsymbol{L}_f} \xrightarrow{\text{same format as}} \frac{\partial^2(\emptyset)}{\partial^2 t} = c^2\frac{\partial^2(\emptyset)}{\partial^2 s} \tag{4.9}$$

The solution for this kind of differential equation is just the Euler exponential $e^{(c\boldsymbol{L}_e+\boldsymbol{L}_f)}$ which is simply a way of expressing a circle (the dashed circle shown in Figure 5 is just the first quadrant, since $\boldsymbol{C}_f = c\boldsymbol{L}_e + \boldsymbol{L}_f$). There's nothing strange going on. All that we've done is used two complementary symbols to represent the exact same thing, level, the same way that perpendicular lines can be bisected by complementary angles. The closest thing to magic is the fact that it takes a third dimension (looking down at the plane from above) to allow you to see the unity in the opposites (i.e. complementary angles). From the isomorphic expressions in equation (4.9) we conclude that the units of measurement known as length and time in the classical wave equation are complementary measures (fullness and emptiness respectively) of spacetime.

Postulate 2: Time is the unit of measurement that is complementary to the unit used to symbolize the measure of space. Length is the measure of fullness (of spacetime) and time is the measure of emptiness (of the same spacetime). Together, they provide the components of the primary unified function that describes motion (change).

Think about the water level conversion factor in the example above, calculated to be $c = \frac{1f}{2e}$. It quantifies the relationship between the size of the two units of measurement (which we know to be length or distance between marks in both cases) permanently marked on the glass. Regardless of how fast we fill the glass, the ratio will never change. But that is also true about a calibrated timer. Isn't that why it is calibrated – to remove the changing aspect of motion, to normalize or quantize it by creating a consistent, quantifiable, independent metric to which other motion could be compared? It was the same trick used to normalize capacity of the infinite glass in the example by defining some random number of emptiness units per fullness unit then multiplying the measurement of fullness by the inverse of the conversion factor. If we want to quantify a different fill rate, we would use the scaler to make snaps and the measured fill rate would simply be quantified relative to it.

In spacetime, velocity is a fraction of (relative to) a conversion factor as well. (The relative value will be described further in the section on Special Relativity.) Motion is not something that is instantly created when one object starts moving relative to the other. It is the inverse of the calibration factor – the concept that already exists in *potential* but instantly becomes *actual* the moment it is perceived. A particle at rest is truly at rest from its own perspective, but it is also (simultaneously) in motion relative to some other particle that is not in the same *at-rest state*. Its velocity already exists *in potential* but "instantly" becomes *actual* the moment it is perceived or measured. Measurement, taking a snap-shot, the act of observing the motion, would then "collapse the wave function" which is simply a mathematical description that includes time (emptiness or potential fullness). This will be explained after special relativity.

To expand the level analogy to three-dimensional space, imagine that the glass of water is a spherical container, like a drop of water, described by real space, as $L^2 = \mathrm{x}^2 + y^2 + z^2$ and that the water level is the wave front of a sphere of light. This is exactly the same space that was labeled "S" in the spacetime diagram in Figure 1, but unfolded into 3 dimensions, x, y, and z. If you measure the rate that the wave front fills the emptiness of space using a real clock (calibrated to 1 second/snap) and a standard ruler, calibrated to 1 meter/division, you would measure "fullness" (the distance in meters that light travels in 1 second) per unit "emptiness" (1 second), and your result would be the calibration factor, 3 x 10^8 meters/sec.

Postulate 3: The speed of light, c is the calibration factor that relates the space scale and time scale. Light is the factor that does not change or move but provides the backdrop upon which change can be perceived by relative changes in the two complementary measurable aspects of spacetime.

V. A new look at the space-time continuum

Consider the space-time diagram from Figure 1. Imagine that a light source flashes at position, $s = s_0$ and time, $t = t_0$ and the light moves *outward* as a spherical wave – a function of space and time, $f(s,t)$ as illustrated in Figure 6. The velocity, $v(s,t) = \lim_{\Delta t \to 0} \frac{\Delta s}{\Delta t}$, is constant ($c \, \frac{Lightsec}{sec}$) in a vacuum. Notice that this graph required the axes in Figure 1 to be switched, putting time on the horizontal in order to be consistent with the definition of velocity, i.e. the change in position (space) with respect to time, $v(s,t) \stackrel{\text{def}}{=} \Delta S/\Delta T$, not $\Delta T/\Delta S$.

In contrast to the Minkowski interpretation of the ST plot, Figure 6 represents possible measurements (i. e. measurements that someone could actually perform; you can't measure the past or hyperspace) and therefore only the positive values have any real meaning. Just as the radius of a sphere is a positive measure from the infinitesimal center of a sphere outward, positive S values represent outward-directed change in space. A negative direction on the S axis would represent inward, toward the infinitesimal center of the point from which the flash originated. On the ST plot, this is the point where the two dimensions intersect. So unlike the Minkowski diagram,

- there are no negative axes;
- the present is represented as t_0; the past is between the infinitesimal point at the intersection and t_0; the future is to the right of t_0; and
- there is no abstract hyperspace or event horizon.

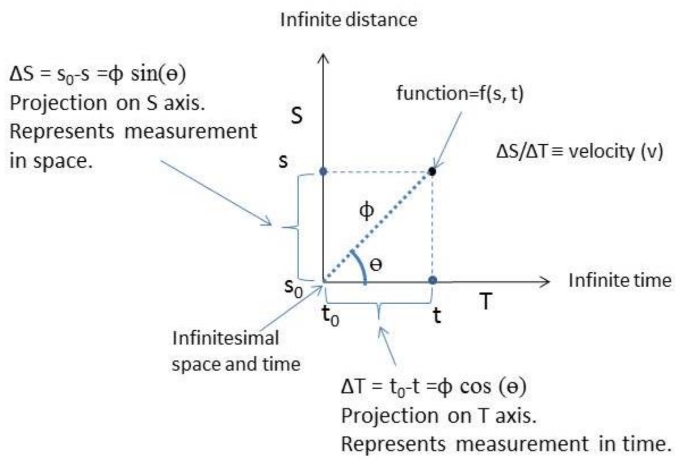

Figure 6 The space-time diagram similar to Figure 1 that represents a flash of light that happened at a position s_o in space and t_o in time. Notice that the axes are switched as compared to Figure 1 to correspond with the definition of velocity, $v \stackrel{\text{def}}{=} \Delta S/\Delta T$. Notice also that rather than considering the origin to be zero, it is considered to be infinitesimal. There is no meaning assigned to negative space or negative time.

Figure 6 is similar to the Minkowski diagram in that the line labeled ∅, drawn from the intersection of the axes, refers to the light wave front, $f(s,t)$ and the slope of that line represents the speed of light. However, it is important to emphasize that the *slope* of the line (not the line itself) represents velocity and the slope is not what is plotted. Slope is the calculated ratio the two orthogonal components. It describes the behavior of one component with respect to the other.

Similarly, velocity is not a measurement; it is a *process* that derives a value from measurements of changing position and time. It is a function of both space and time, $v = f(s,t)$ and thus describes the behavior of space with respect to time (the function that describes how position is *related to* time i.e. $s = f(t)$). Velocity is sometimes superimposed onto a plot of position vs. time, as the tangent of $f(t)$, but a velocity vector drawn on the ST plane is *a conformal map* of velocity. A conformal map is projected from the dimension that is tangent to the ST plane. So a graphical representation of motion will require a third dimension. This STM plot will be used in the unified field section below. Conformal mapping preserves angle relationships, but also results in rotations, translations, expansions and contractions so interpretation of a function that is mapped from another representation can be misleading. Hence the wise old adage, "don't mistake the map for the territory." It will be shown to be responsible for length contraction and time dilation that are foundational to special relativity.

The line, ∅ is the back-projection of the two measurements onto the ST plane. The projection of ∅ on the S axis ($s = \emptyset \sin\theta$) represents the radius (measureable in 3D space) of the moving light field at the instant $t = 1$ unit of time (a snapshot) and the projection of ∅ on the T axis ($t = \emptyset \cos\theta$) represents the elapsed time of $t = 1$ unit (also a snapshot, measurable quantity). Now if space and time are truly equivalent, it should be equally correct to switch the axes (back to the way they were in Figure 1) as shown in Figure 7.

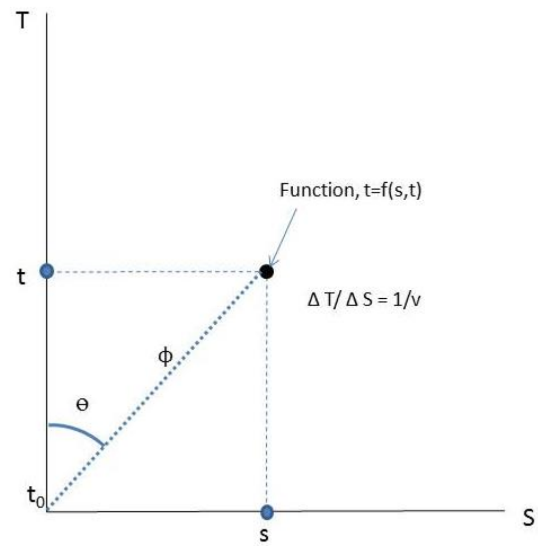

Figure 7 There should be no difference in representing space as the horizontal axis and time as the vertical axis, but since velocity is defined as $v \stackrel{\text{def}}{=} \Delta S/\Delta T$ the line representing the change in one with respect to the other is the inverse of velocity.

In this case, the function $T = f(s)$ is the time measurement and its derivative, $f'(s) = \lim_{\Delta s \to 0} \frac{\Delta T}{\Delta S}$ is, from the definition of velocity, $\frac{1}{v(s,t)}$. Compared to the water level analogy, $f(s)$ and $f(t)$ represent the same level (surface of the wave front), so a change in one with respect to the other must be the same as a change in the other with respect to the first. Thus a ratio of the two derivatives should be equal to one. However, only $f'(t)$ - the perspective that holds time as an independent variable – was *defined* (velocity). The other, $f'(s)$ was not given a name so the ratio of the two comes out to be

$$\frac{f'(t)}{f'(s)} = \frac{v}{1/_v} = v^2 \tag{5.1}$$

which only equals one when $v = 1$. Rearranging terms and writing the derivatives in standard form,

$$\frac{d(f(t))}{dt} = v^2 \frac{d(f(s))}{ds} \tag{5.2}$$

This is the same format as equation (4.8) that represented a change in the water level, but since the two variables are now space and time, it is recognizable as an advective transport equation, which is an equation that governs the motion of a conserved scalar field as it is transferred (advected) by a velocity vector field. An advection equation for a conserved quantity described by a scalar field (∅) is a continuity equation. The field itself doesn't change (it's conserved), but the two measurable units that describe the field change with respect to each other. The functions $f(s)$ and $f(t)$ symbolize partial perspectives of the field by artificially representing it in a form that allows a change in one variable while holding the other one constant, the same as a partial derivative. The conventional term for this partial derivative is *the gradient*: ∇∅

- $f(s) = \nabla_s\emptyset$, i.e. $\nabla_s\emptyset = \frac{\partial\emptyset}{\partial s}$ is change with respect to the space-aspect (the projection on the S axis) if time could be held constant.

- $f(t) = \nabla_t\emptyset$, i.e. $\nabla_t\emptyset = \frac{\partial\emptyset}{\partial t}$ is change with respect to the time-aspect (the projection on the time axis) if space could be held constant.

Substituting these into equation (5.2) makes it the classical wave equation

$$\frac{\partial^2(\emptyset)}{\partial^2 t} = v^2\,\frac{\partial^2(\emptyset)}{\partial^2 s} \tag{5.3}$$

Using separation of variables, i.e. $\emptyset(s,t) = S(t)T(s)$ a classical solution is (Jackson 68)

$$\emptyset(s,t) = e^{\pm i(ks-\omega t)} \tag{5.4}$$

where $(ks - \omega t) = \frac{2\pi}{\lambda}(s - vt)$, which is the standard representation of a wave propagating at velocity, v in one dimension, s. In this case, s is a one-dimensional representation of three-dimensional space so equation (5.4) is a spherical wave state function.

In order to gain more insight into the meaning of this spherical wave state function, imagine you are an observer at the source of the flash of light (s_o, t_o). You could measure the "light unit" expand symmetrically in all directions with respect to the reference point (yourself) and your measurement would give you a constant velocity of 1 light-sec/sec outward in all directions. (1 light unit =1 light-sec/sec = (20 light-sec)/(20 sec)). *Now imagine you are the light sphere* and can measure your own surface with respect to yourself. You will not be able to tell that you are expanding because each time you observe yourself, you will see yourself as being constant light unit (a point on the ST plot) and it will appear that the observer who flashed the bulb is shrinking at your center. Regardless of how much time/distance passes, you will still consider yourself a unit (sphere, photon, particle, etc) because all of your measurement reference points correspond to your surface and each time you observe it, it will be "here" and "now". Your at-rest state function will be <u>*the state of being*</u>. Your ST plot will be a single point, your radius will be one light unit and as long as you ignored the observer at your center, there will be no need for the T axis.

Now imagine you look out at the world outside your wave front "self"; everything you see (assume for now that nothing is moving with respect to you and nothing gives an indication of passing time) appears to you as existing in the same now. If you then flashed another light bulb, a spherical wave would travel outward away from your surface at the speed of light in all directions. It doesn't matter that your "body" is a sphere of light moving outward. The light from the flash that you made will still move outward at the speed of light. It will reach other objects in the amount of time that it takes for light to travel that distance. If you plotted those distance/time values on the ST plot, every object would be represented as a point along the diagonal line (the Universe line in Figure 8).

But what happens when you observe the universe, i.e. the light that reflected off those objects and returned to your eyes? Everything you perceive as the outside world at an instant in time is composed of the light that hits your eyes at the same time (the same value on the t axis). So in addition to representing the surface of your wave front, your "now line" represents the entire universe as you perceive it. Each observation (each snapshot of now) of everything in the universe would correspond to the same point where the vertical line intersects the Universe line at the instant, t.

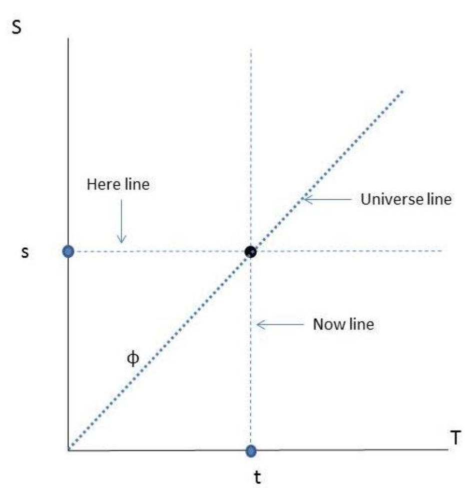

Figure 8 Here and now. Everything we can perceive with our eyes is perceived by the light that enters our eyes at an instant in time (t). This would be represented on the ST plot as a projection of the Universe line onto the vertical line at t.

In order to better understand this projection of space at an instant in time, as well as the effect of motion and the projection of velocity (as a fraction of the calibration factor mentioned above) onto the space-time plane, it is necessary to review the Special Theory of Relativity.

VI. Special Relativity

The Special Theory of Relativity is based on the postulate that the velocity of light in free space has the same constant value in all directions and in all inertial reference frames. The following thought experiment is from a Fundamentals of Physics text (David Halliday 1111). Sally is on a train that is moving at a uniform velocity, v, toward the station where Sam is standing. Sally flashes a light bulb (see event 1 in Figure 9a) directly at a mirror mounted on the ceiling (at a distance D) of the train and measures the time, t_0, required for the pulse to travel to the mirror and back, as measured by her clock on the train. The elapsed time is

$$\Delta t_0 = \frac{2D}{c} \tag{6.1}$$

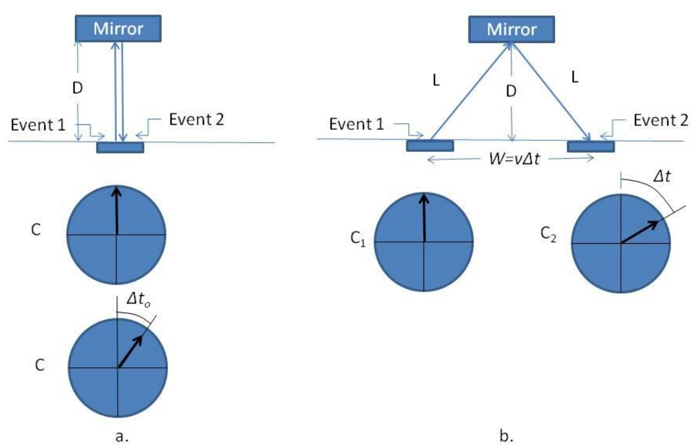

Figure 9 (a) Sally and a mirror are on the train. Sally flashes a light bulb and measures the pulse of light move a distance of 2D using a single clock (labeled C) to measure the elapsed time Δt_o. (b) Sam is on the stationary platform from where he observes the pulse of light move toward the mirror and measures a distance of 2L on his stationary ruler while the train and mirror continue down the track. He measures the elapsed time Δt using two separate, synchronized clocks (C_1 and C_2).

Since the two events (1 and 2) occur at the same place on the train, she only needs a single clock to measure both events. The time interval is therefore called the *proper time interval*.

Sam observes the same events from the platform, but since the train is moving, the measurements are displaced in space during the time interval between the flash (event 1) and when the light hits the source (event 2), measured by his clocks (he uses two synchronized clocks, C_1 and C_2). Because the speed of light is constant for all observers, it travels a larger distance, $2L$ as measured in Sam's coordinate system. And the time interval measured by Sam is

$$\Delta t = \frac{2L}{c} \tag{6.2}$$

where

$$L = \sqrt{\left(\frac{1}{2}v\Delta t\right)^2 + D^2} \tag{6.3}$$

Using equation (6.1) to eliminate D, this is written as

$$L = \sqrt{\left(\frac{1}{2}v\Delta t\right)^2 + \left(\frac{1}{2}c\Delta t_o\right)^2} \tag{6.4}$$

And, using equation (6.2) to eliminate L, we get the Lorentz transformation

$$\Delta t = \frac{\Delta t_o}{\left(\sqrt{1 - {v^2}/{c^2}}\right)} = \gamma \Delta t_o \tag{6.5}$$

which shows that the time Δt measured on the platform will be longer than the proper time, Δt_o (as measured on the moving train). The symbol γ is the Lorentz factor

$$\gamma = \frac{1}{\left(\sqrt{1 - {v^2}/{c^2}}\right)} \tag{6.6}$$

It is also shown that the distance L on the platform between events will be smaller (as seen from the moving train) than its "proper" length, i.e. its rest length (L_0), by an amount given by $L = \frac{L_0}{\gamma}$.

An important point to notice, something that was not brought out in the text, is that the speed of the train v, is maintained throughout the problem, i.e. $v = \frac{w}{\Delta t_o}$. But if time itself changed in Sam's world, then he would measure the velocity of the train to be $v' = \frac{w}{\Delta t}$. If this is used in equations (6.3) – (6.5), and c is eliminated in equation (6.5) by equation (6.2), the result is

$$\frac{2D}{\Delta t_o} = \frac{2L}{\Delta t} \tag{6.7}$$

which is the same thing we would get by equating c in equations (6.1) and (6.2). Therefore the apparent "warping" of space and time is entirely dependent on the perspective of the observer (in agreement with interpretations of special relativity). In other words, the time warp and space warp in Sam's world can only be seen by Sally. Sam would measure L and Δt so in his world, $c = \frac{2L}{\Delta t}$ just as it should; Sally would measure $2D$ and Δt_o, so in her world, $c = \frac{2D}{\Delta t_o}$ also as it should. Experiments prove time dilation and space contraction, but what do they really tell us about the essence of reality? Do they confirm that spacetime is actually warped? The Unity Theory suggests that the relative magnitude of *measurements,* i.e. the perspective of the devices used to take measurements of space and time in different inertial reference frames, is what is different. But if our measurement devices measure the warp, then the end result is yes, space and time are actually warped, but spacetime as a whole is not. The space-time plot provides another perspective that allows us to make sense of what is happening.

Space-time plots of the two worlds are shown in Figure 10. In both cases, $c = \frac{\Delta space}{\Delta time}$ is the slope of the diagonal line that connects the origin of the ST plot to the point representing one light-second/second. Graphically, it is shown that the two slopes can be the same constant magnitude if the components of each are projections from two different coordinate systems that rotate about a common origin. In the figure, bold solid lines represent Sally's coordinate system, and bold dashed lines represent Sam's. From Sally's perspective, the light travels in space a distance of $2D$ in time Δt_o. This is shown as a projection of the solid diagonal line with a slope of $\frac{2D}{\Delta t_o}$ in space (the vertical axis, S_{Sally}) and in time (the horizontal axis, T_{Sally}). From Sam's perspective, the light travels in space a distance of $2L$ in Δt. This is shown as a projection of the dashed diagonal line with a slope of $\frac{2L}{\Delta t}$ on the rotated vertical axis (S_{Sam}) and in time (T_{Sam}). Regardless of who is considered to be moving, the relative motion between Sally and Sam creates a *rotational phase shift* in their coordinate systems by the angle θ,

where

$$\theta = \tan^{-1}\frac{w}{\Delta t_o} = \tan^{-1} v \tag{6.8}$$

The distance, w, is measured on the stationary platform yet the elapsed time, Δt_o, is measured in the moving frame. So v and θ provide a link between the two frames of reference.

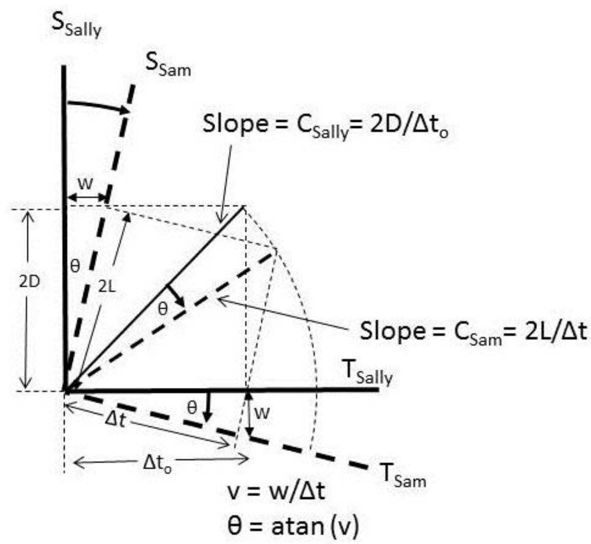

Figure 10 Relative velocity between two inertial reference frames can be represented as a rotational transformation in the space-time plot. In this example, the source of the light is on the train (in Sally's coordinate system) so it is shown to travel a distance of 2D in time Δt_o. The relative velocity of the two reference frames is represented as a rotation of Sam's space-time coordinate system with respect to Sally's perspective. In Sam's world, the same light traveled 2L in time Δt.

Notice that rotation of the ST plot reveals important differences between this and the Minkowski interpretation of the ST plot as mentioned above. To review, Minkowski labeled the axes to mimic a Cartesian coordinate system, i.e. the axes cross at zero and point to infinity in both "directions" so he interpreted the opposite (negative) side of the time axis to represent the past. This makes the space axis somewhat meaningless since there is no such thing as negative space. He dodged this by rotating the space axis around the time axis, giving it the appearance of a plane (something that occupies space) and calling the plane hyperspace of the present (the "event horizon"). In this paper, there is no need for negative space or negative time. Both axes represent positive values (suggesting that negative time or negative space mean toward the origin). And rather than using the origin as a zero reference, it is interpreted as an infinitesimal point. Space and time are both represented as infinite (both inward and outward). The "past" simply means *a series of events that occurred between two positive values of time.* Event 1 is our reference so the origin of ST plot is referenced to that event. It does not apply to events preceding event 1.

Another important feature that is revealed by this presentation is the expansion of spacetime with motion. If we were to use a three-dimensional plot of space to do this problem, we would graph the position of the light starting at zero and increase on each spatial axis as it moves away from the source. Then after reflecting off of the mirror, the position coordinate would decrease and return to the same location on the plot. However on the ST plot, the distance traveled by the light is represented as a continuous movement (outward from the center – moving a total distance of 2D on the train and 2L on the platform) rather than moving outward and then returning to the starting point. This is a clue about the nature of spacetime. It suggests that, in addition to separating spacetime into space and time, *motion expands spacetime in one direction, creating the expansion of space and the arrow of time*.

Our perception of time is based on observations, each of which is made in its own at-rest state. But there are two different spacetime states that co-exist simultaneously: what appears to be "at-rest" and what appears to be "in-motion". The phrase "appears to be" is used because these are relative perspectives that depend on the observer, who is always in his or her own at-rest state, or state of *being*. Given two objects in relative motion, we are free to choose which one we want to consider to be in the at-rest state. The other is then in the in-motion state, or "state of *moving*" (some might call it the state of *becoming*). Neither perspective should be considered "correct" or "proper" since there is no absolute reference frame, but the term "proper size" is acceptable because it refers to the size measured with respect to an object's own at-rest reference frame. Everything in the universe that is at-rest with respect to each other is in the same inertial reference frame, *in phase* with each other, and agrees on the measurement of this proper size. They would also agree on a measurement of proper time. They all seem to share the same spacetime coordinate system and the same Universe line, but they are separated in space so each object has its own ST origin along the S axis and its own now point synchronized to the same projection from the T axis.

Therefore, superimposing ST plots as they were in Figure 10 does not illustrate what we actually perceive. We perceive that we share the same universe. What happens if the ST plots are rotated so that the Universe lines coincide? The Lorentz factor comes into play. From Sally's perspective, Sam's world is distorted (stretched) by the Lorentz factor and from Sam's perspective, Sally's world is also distorted, but by the inverse Lorentz factor (contracted). The space-time plot in Figure 10 allows us to view both worlds from a higher perspective (where space and time are complementary aspects of the same relative motion) from which neither is distorted. The distortions come from the alignment of the two coordinate systems, which we do to fit our perceptions. Aligning the Universe lines and synchronizing the time axes superimposes the two space-time plots as shown in Figure 11.

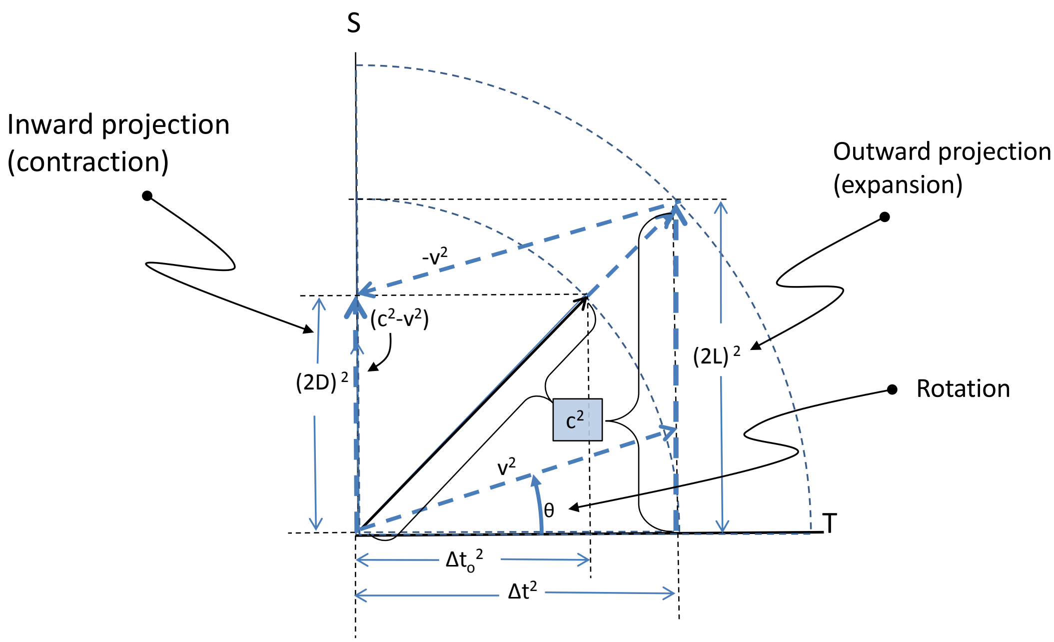

Figure 11 Because relative velocity is the same magnitude regardless of who is considered to be moving, the two perspectives are shown to have the same units of measurement (coordinate systems). However, superimposing the two perspectives onto a common set of axes reveals the effect of conformal mapping, which causes the two perspectives to become distorted. From Sally's perspective Sam's world appears to be stretched. From Sam's perspective, Sally's world appears to be contracted.

From equations (6.2) and (6.4), eliminating L and cancelling out the ½

$$(c\Delta t)^2 = (v\Delta t)^2 + (c\Delta t_o)^2 \tag{6.9}$$

This equation represents the superposition of two worlds because Δt_o is in Sally's world and Δt is in Sam's world. So let's put Sam on the left and Sally on the right.

$$(c\Delta t)^2 - (v\Delta t)^2 = (c\Delta t_o)^2 \tag{6.10}$$

factor out Δt^2

$$\Delta t^2(c^2 - v^2) = \Delta t_o{}^2 c^2 \tag{6.11}$$

and rearranging we get

$$\frac{(c^2 - v^2)}{\Delta t_o{}^2} = \frac{c^2}{\Delta t^2}. \tag{6.12}$$

This equation represents two different ways to write *the slope of the diagonal* just like equation (6.7). It is the same as rotating Figure 10 through the angle θ so that the Universe lines coincide, which also aligns the coordinate axes. Regardless of whose perspective you take, light always travels one light-second in one second, so it is a scalar – a conserved quantity. But because 2L is longer than 2D, this rotation has the effect of stretching Sam's Universe line or shrinking Sally's, depending on whose perspective you take. In other words, Figure 11 is a plot of two different states of motion mapped onto the same coordinate system. Sally perceives a conformal projection of Sam's world and vice versa. Because the angles are conserved in a conformal map, it is easy to see that the left side of equation (6.12) is the slope (rise over run); the numerator, $(c^2 - v^2)$ is the vertical rise and the denominator $({\Delta t_o}^2)$ is the horizontal run. The right side of the equation tells how much the measurement in Sam's world had to stretch – enough to fit the magnitude of the diagonal vector labeled c^2.

The light sphere expands at speed c, but c^2 is plotted because it is mathematically tied to v^2 by the equation $(c^2 - v^2)$ so distances are squared in the plot as well for consistency. The graph shows how the measurement of distance (the proper or at-rest length) in Sam's world $(2L)^2$ appears expanded (projected outward in space) to Sally. Notice that the solid light line labeled c^2 is the radius of the inner circle so the length of the leg (the outward projection labeled (expansion)) is also the size of c^2. But since v was measured using Sally's clock i.e. proper or at-rest time, the magnitude and angle of v^2creates a different perspective $(c^2 - v^2)$ giving Sam the impression that the sphere is contracted (an inward projection in space) so it appears to be $(2D)^2$ instead of $(2L)^2$. The greater the relative velocity, the smaller Sally's world, i.e. the source of the light, will appear to Sam. The scaling factor that relates the hypotenuse to the inward projection is

$$c^2/(c^2 - v^2) = \frac{1}{\left(1 - \frac{v^2}{c^2}\right)} = \gamma^2, \tag{6.13}$$

where γ *is the Lorentz factor* and by similar triangles (both 45° isosceles) the scaling factor that relates the outward projection to the hypotenuse of the large triangle is *the inverse of the Lorentz factor*.

How is it possible for real measurements of real physical matter to be stretched and shrunk? Are we saying that the physical mass is actually smeared out like a photograph of moving lights and then pulls itself back together when the motion stops? The answer is no. If that were the case, both worlds would be smeared out from the other perspective and there would be no inward projection. But that is not the case. Nothing is actually happening to the "moving" object that would make it stretch or shrink. It is important to reiterate that the apparent distortion is *not a warping of spacetime*; it is a distortion in our *perception* (created by measurement) of spacetime resulting from the difference in the fractional change in one set of units as compared to the other. Despite the fact that physic is based on measurement, we have to concede that measurement can be misleading.

To better understand how the constant (conserved magnitude of spacetime) can appear as measured variables, let's look again at the water level graph from Figure 5, shown below as Figure 12.

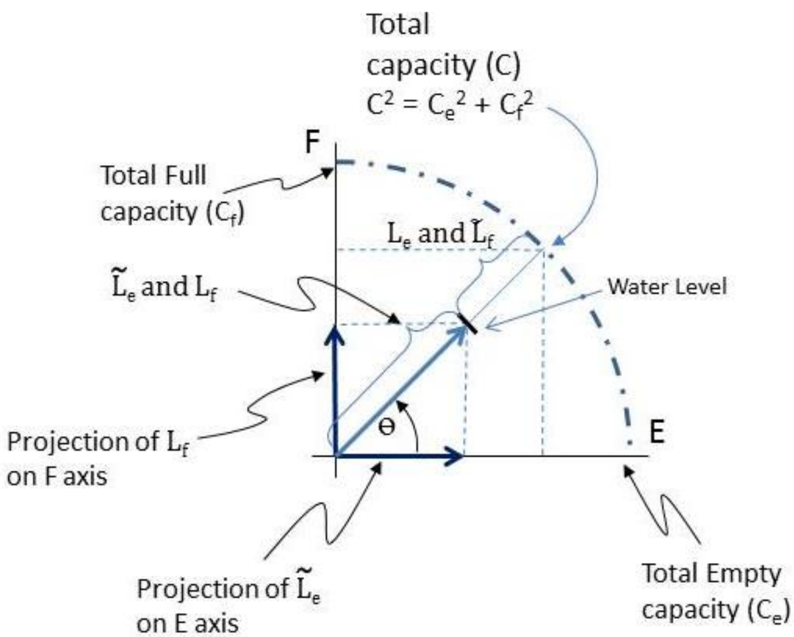

Figure 12 Another look at the water level graph shown in Figure 5. As it is, it cannot be used to model a change in water level because the factor that relates fullness to emptiness is a constant.

The conversion factor that relates the two scales is a constant $c = \frac{C_f}{C_e}$. None of the components in that equation can change (gauge-invariant). However, it is used to convert the representation of level, which *does* change, from one set of units to the other: $L_f = c\tilde{L}_e$ and therefore $c = \frac{L_f}{\tilde{L}_e}$. Both numerator and denominator change as the glass fills, but the ratio doesn't. And when we looked at a change in level in section IV, equation (4.6), we found that $\frac{\Delta \boldsymbol{L}_f}{\Delta \boldsymbol{L}_e} = -c$. Notice that the denominator in the equation ($c = \frac{L_f}{\tilde{L}_e}$) is the complement of emptiness, i.e. ($\tilde{L}_e$) but in the second equation, ($\frac{\Delta \boldsymbol{L}_f}{\Delta \boldsymbol{L}_e} = -c$) the denominator is the *change* in emptiness, $\Delta \boldsymbol{L}_e$. The ratios are the same because the second equation is the ratio of change, and change is measured with respect to a *unit* of measurement so it doesn't matter if we use the empty part or the full part of the glass, the magnitude of the unit of change is the same. But still, c is a constant that cannot change. It refers to the relative magnitude of real units ($\Delta \boldsymbol{L}_f$ and $\Delta \boldsymbol{L}_e$) that are etched in glass. What is needed is a way to represent the variable level as it moves up the glass, referenced to the constant diagonal line. For this we need to change the name of the factor (c) to a dummy variable $v = \frac{\Delta L_f}{\Delta L_e}$ so it represents the slope of the same line but reference it to a different (rotating) coordinate system. In this analogy, v stands for "variable" (to illustrate the role played by velocity).

Graphically, c is the constant slope of the line representing the actual water-glass system (substance as well as the potential) as shown in Figure 13. If we superimpose the set of axes that can rotate about the origin, as represented by F and E, the projections of C onto those axes will change with the angle of their rotation. Figure 13 shows the special case of one-to-one relationship between the units (F and E) in order to compare it with the ST plot above. With coordinate systems aligned, this represents equilibrium (half full = half empty).

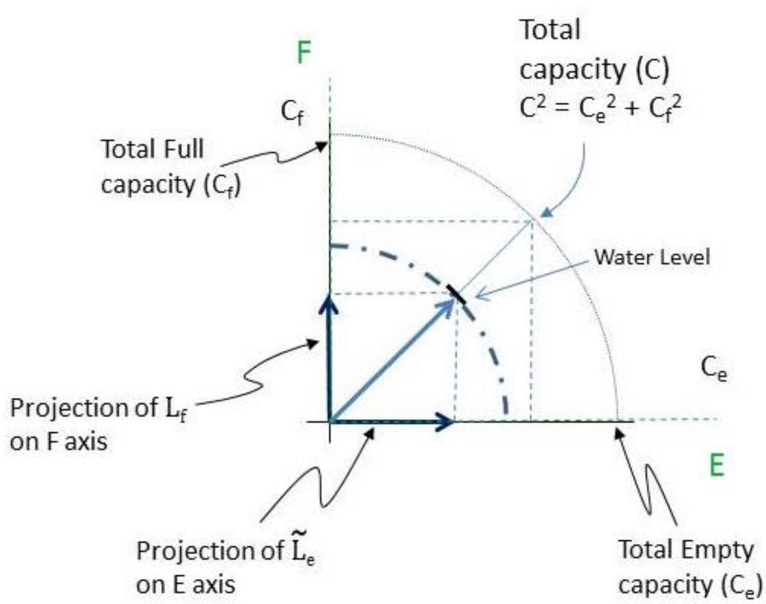

Figure 13 The same graph as above with a new set of axes (F and E) that can rotate about the origin. This provides another way of referring to the level as it changes from empty to full while maintaining the relationship to the whole glass. In the condition shown here, the glass is half full and half empty, but notice that the projections onto the E and F axes are not half of the total capacity. Therefore, an accurate measure of level is still represented by the diagonal vector.

The totally-empty state would be represented by rotating the F-E axis by an angle $\alpha = -45°$, as in Figure 14a so that the E axis lines up with the C line. As the glass fills, the projection on F increases from zero and the projection on E decreases until, at $\alpha = +45°$ the F axis lines up with the C line and the plot represents totally full, as in Figure 14b.

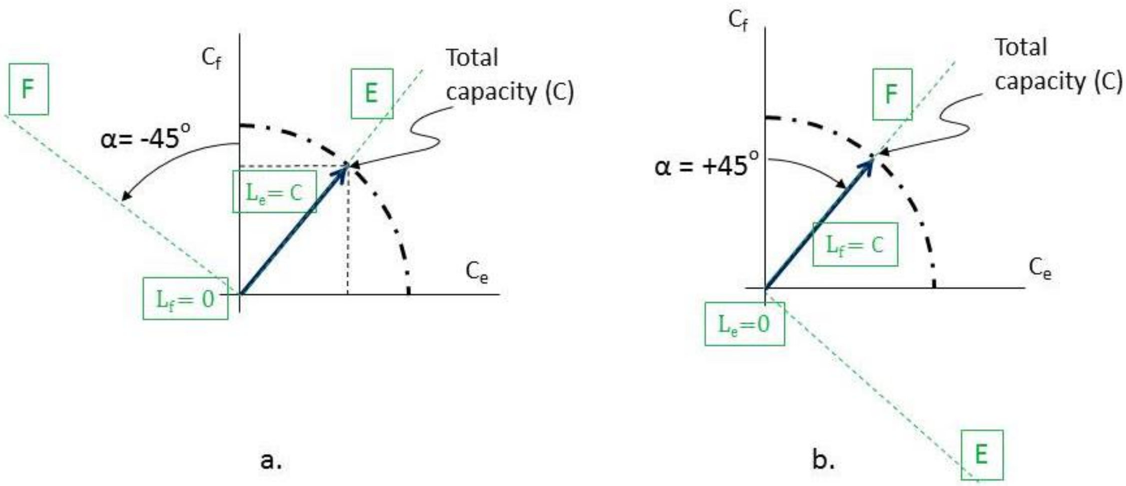

Figure 14 (a) By rotating the $E - F$ axes to -45° the E axis lines up with the C line (the actual glass) representing an empty glass ($F = 0$ and $E = C$). As the glass fills, the level rises and the $E - F$ axes rotate to the right (Figure 13 is half full) until (b) the F axis lines up to represent full.

Of course an infinitely large glass could never be empty or full, and because neither absolute fullness nor emptiness can be measured, we have to use *a change* in level ($\Delta \boldsymbol{L}_f$ and $\Delta \boldsymbol{L}_e$) rather than absolutes. We also have to set meaningful references. In terms of the moving axes $\frac{\Delta L_f}{\Delta L_e} = v$ equals zero when $\Delta L_f = 0$ i.e. the level is constant. In that case, the horizontal axis, ΔE as shown in Figure 15, is lined up with the diagonal glass-line and any non-zero angle (referenced to a fixed ΔF-ΔE coordinate system) represents continuous change in the level[4]. Keep in mind that the magnitude of v will depend on the relative magnitudes of the units, so the conversion factor (c), is chosen as the reference magnitude and the graph is normalized to one unit $\Delta L_e = 1$.

[4] Negative represents filling because a change in fullness is the opposite of a change in emptiness. Therefore, we have to use v^2 when referring to magnitude.

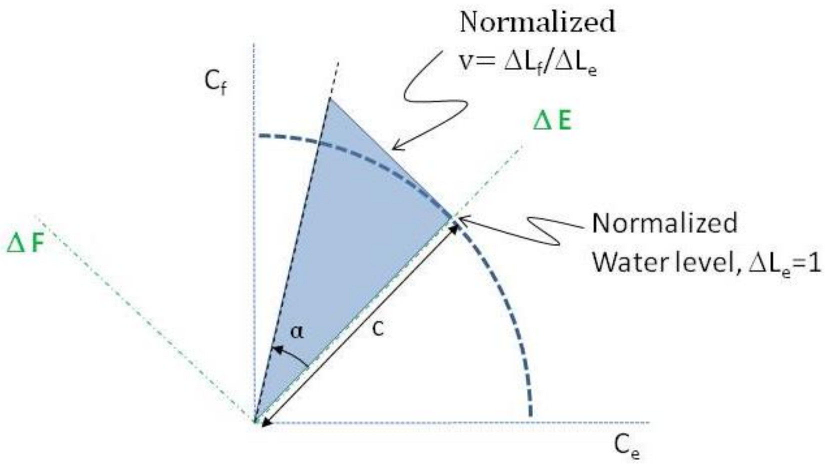

Figure 15 The variable level is superimposed (conformally map) on the same graph (scale) as fullness and emptiness. The angle is referenced to zero change in fullness and the magnitude is referenced to the conversion factor, c. A non-zero angle represents motion of the level (filling or emptying). The magnitude of v is zero when the fill rate is zero.

Now imagine that the glass is filling at a rate equal to $v = c$ (as shown in Figure 16a) and compare the resulting triangle to one shown in Figure 16b, which is used as a mnemonic device in the Fundamentals of Physics text (David Halliday 1122) for remembering the equation for total energy of a particle, E where

$$E^2 = (pc)^2 + (mc^2)^2 \tag{6.14}$$

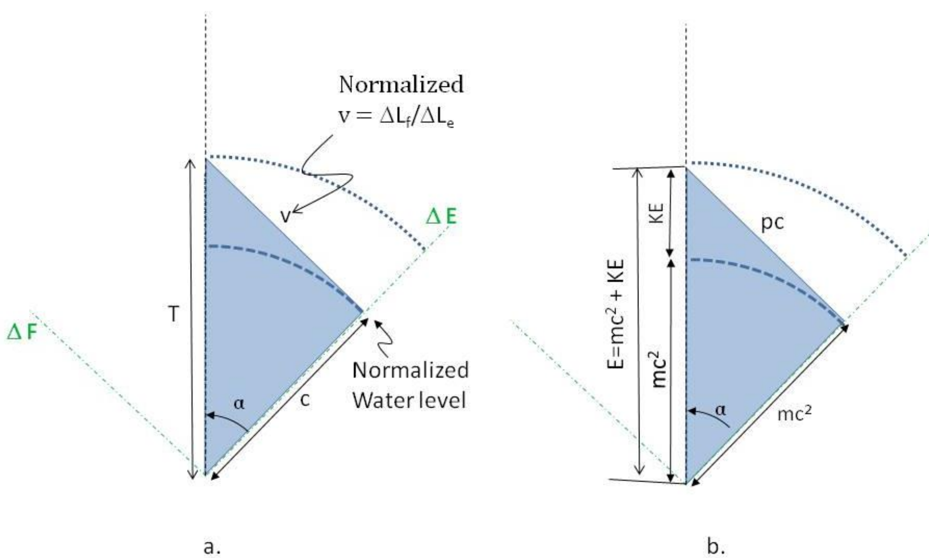

Figure 16 (a) The graphical representation of the water glass analogy, which level increasing at a constant rate equal to the conversion factor, c. (b) This diagram is the text-book example taken from Halliday and Resnick Fundamentals of Physics 4th ed, ch 42 as a mnemonic device for remembering the relativistic relations between rest energy, kinetic energy and momentum of a particle.

They are similar triangles, identical if you scale the hypotenuse and legs in Figure 15 by mc, which is constant for a given mass, to get $Tmc,\ mvc$ and mc^2 respectively. The hypotenuse of the triangle in Figure 16b is the total energy of a particle: its rest energy (mc^2) plus relativistic kinetic energy (KE),

$$KE = mc^2(\gamma - 1) \tag{6.15}$$

which reduces to

$$E = mc^2 + KE = mc^2 + mc^2(\gamma - 1) = mc^2(\gamma). \tag{6.16}$$

Therefore

$$E = mc^2(\gamma). \tag{6.17}$$

From an at-rest particle's perspective, it is not moving so $KE = 0$. This is the same situation as the water filling at the rate equal to c. Even at rest, a particle has *potential* momentum, $p = \frac{h}{\lambda}$ and the energy associated with it can be described in terms of motion as $E = pc = \frac{hc}{\lambda} = hf$. This suggests that frequency (f) is a way of representing different "levels" of the surface of a particle, which we already know is a field of energy in spacetime. Figure 17 shows the same triangle on a graph of E vs. f. Here the slope of the light-line on the frequency plot, the factor that scales the units of time to the units of energy is Plank's constant, h.

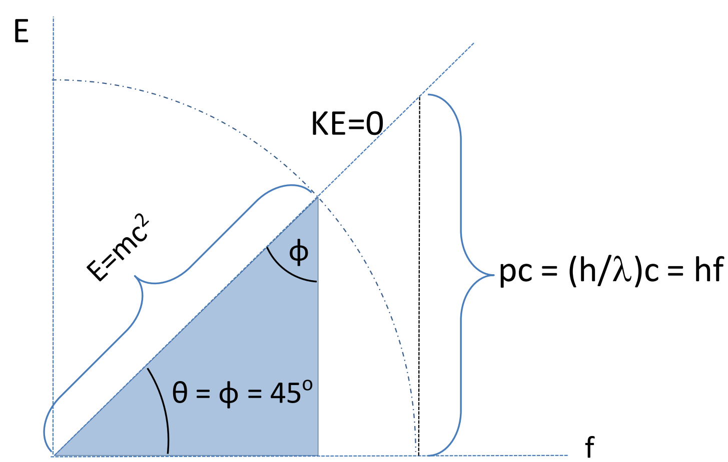

Figure 17 Isolated particle energy versus frequency

The conclusion from this analysis is that Figure 16b represents a field that can be measured as an at-rest particle (which means a time-independent "snapshot" measurement) with rest energy $E = mc^2$. Compared to the ST plot, Figure 16b agrees with the interpretation that units of mass, m are just another way of expressing energy and the relationship (the slope of the line) is a conversion factor (the square of the conversion factor (c) that converts units of m to units of E). It relates the particle's total energy (potential motion) collapsed into or *inwardly projected* onto measured space at an instant in time. Figure 17 represents the same field measured as an at-rest particle with the same rest energy but relates it to the potential motion as $E = hf$ where h is the conversion factor that relates the particle's total energy (potential motion) to the frequency that would result if the time aspect (f) were to be measured. The figures also represent the kinetic energy *that could be measured* with respect to another reference frame moving at velocity, v. The greater the relative velocity of the moving reference frame, the larger the projection and scaling factor (apparent mass.) This does not affect the actual particle. From its perspective, its physical characteristics don't change. What changes is our ability to measure it.

The triangle in Figure 16 may have only been considered a mnemonic device by Halliday because the relative magnitudes don't seem to fit for a particle at rest. The Lorentz factor doesn't seem to be a factor because $v = 0$ so $\gamma = 1$. However, the same magnification is apparent in Figure 17 where momentum, a concept that represents a *variable,* conformally maps from the constant (mc^2) as an outward projection.

The apparent magnification of the vector representing the water level in section IV was also a form of the Lorentz factor and it is the same apparent magnification of Sam's world as seen from Sally's coordinate system. The situation (as far as what stretches and what shrinks) was exactly the same whether we consider Sally to be moving or Sam. However, things would be different if Sam flashed the light rather than Sally. In the first case, Sally's world appeared collapsed to Sam. But if Sam flashed the light, his world would appear collapsed to Sally.

What if they both flashed a light, each in their own reference frame? The perspective that each would see would depend on which light sphere they focused on. To Sam, Sally's light sphere would appear collapsed and to Sally, Sam's would appear collapsed. Does that make any sense? Not if you think of light as something that moves. However, it makes perfect sense if you think of light as spacetime - a process that illuminates reality, rather than something that moves through space. Keep in mind, it is our measurements of space and time that change and we use them to derive the concept of motion.

It may be hard to grasp the idea of light as something that does not move. You could argue that light *does* move as quantized photons that can be measured to move at c meters per second. But it's the waves of interference (interference patterns of space and time that create perceivable, intelligible contrast – like the interference patterns of a hologram) that are moving, not the spacetime itself. Our senses and our measurements separate spacetime; the separation creates the waves and the waves are what move. The constant that we call the "speed of light" is the spacetime conversion factor. Therefore, what we measure may be more appropriately considered the "speed of interference" or even the speed at which darkness is being illuminated by light.

Now consider what qualifies as a source of light. Did Sally and Sam need to flash a light bulb for this experiment to work? No. Every object that is illuminated by the lights inside the car or on the platform can be considered a source of light. Although we normally think of reflection macroscopically, as something that happens at the surface of matter, the reflection of light actually happens at the atomic level, where the distance between particles is the same order of magnitude as the wavelength of the light. In fact, it was the reflection of electron waves by crystals that provided evidence of the wave structure of matter in experiments conducted in 1927 by Davidson, Germer and Thomson. (Anderson 141-144) Whether the incident light is absorbed or not is dependent on the wavelength of the light and the atomic structure of the target.

According to Huygen's Principle, all points on a wavefront serve as point sources of spherical secondary waves. (David Halliday 1050) Therefore reflection is effectively a re-transmission of light that was absorbed, and every atom is literally a source of the light we perceive when we look at an object. So even if two observers are in the same room, the wave front (the interference pattern that allows one observer to observe the other) is moving at the speed of light. So when Sam focuses on Sally, her light spheres (the atoms that make up her world) appear collapsed to him and when Sally focuses on Sam, his light spheres appear collapsed to her as well. In other words, even if they are both made up of expanding spherical wave fronts, they appear normal (not expanding) to each other.

This is exactly what is suggested by quantum mechanics - that a quantum particle is both a particle and a wave and observation results in a collapse of the wave function. An observation (which is a snap-shot in time - a measurement in a particular reference frame that removes the temporal variable) simply changes the observer's perspective. By deciding to take a measurement, the observer changes the model from one that includes space and clock time to one that only includes space at an instant. Nothing happens to the substance or form of the particle/wave. Only the perspective, and therefore the mathematical model that described that perspective, changes. The same thing happens when an at-rest particle is suddenly considered to be moving the instant the physicist realizes that another particle is moving somewhere else in the universe. The imagination of the physicist takes a quantum leap from one model to another, not the particle/wave.

This is different from the Copenhagen interpretation, which states that the quantum wave function is an equation that describes the probability of measuring a particle at a particular position. When it is actually observed at a particular location, then the wave function collapses and the probability of the particle being at that position becomes 100%. In contrast, the Unity interpretation presented here is that the equation is one of two mental models - *imaginary* (symbolic) descriptions of reality. When an observation is made, the mental model that includes time no longer applies to that observer. The particle/wave remains a particle/wave regardless of Observer A's measurement because, if Observer B is driving by and watching everything from a different, moving reference frame, the wave equation would still apply. If probability is part of the interpretation, it should refer to the observer rather than the particle. It's not the probability that the particle will be in the location when it is measured, but the probability that the observer takes the measurement.

The idea that mathematical equations refer more to the mind rather than material deserves some explanation. An "imaginary symbolic description of reality" requires the use of (appropriately named) imaginary numbers. We already know that the mathematics of the wave function requires the use of imaginary numbers so it is important to understand what imaginary numbers represent.

VII. Imaginary Numbers and the Quantum Wave Function

The imaginary number $i = \sqrt{-1}$ was not very popular when first introduced. In fact, the name "imaginary" was initially used as a derogatory term that was intended to mean that it was not real, that it was all in the mind and therefore useless. But we now know that it is indispensable for describing electromagnetic waves as well as other phenomena that vary with time. Graphically, it is represented as an axis that is perpendicular to what we call the real axis. Euler's formula,

$$e^{i\theta} = \cos\theta + i\sin\theta \qquad (7.1)$$

describes a unit circle on the complex plane. But any unit circle, can be represented in vector format as

$$\vec{R} = \cos\theta\hat{\rho} + \sin\theta\hat{\imath}, \qquad (7.2)$$

where $\hat{\rho}$ and $\hat{\imath}$ symbolize the two perpendicular dimensions (unit vectors) *S* and *T*. If the S axis is considered to be real (the cosine projection) and the T axis is considered imaginary (the sine projection), then Equation (7.2) is the same as Euler's formula.

The imaginary part of Euler's formula is only "imaginary" in the sense that its values can change without having any effect on the other "real" dimension. It simply means that one dimension is independent (perpendicular or orthogonal) of the other.

The same format could be used with the x and y axes to give

$$e^{y\theta} = \cos\theta + \sin\theta\hat{y} \qquad (7.3)$$

where $\cos\theta$ is understood to be the *x* component so no symbol is used. There's nothing magic about i; it's just a symbol that plays the role of a unit vector and symbolizes an orthogonal dimension. In Geometric (Clifford) Algebra, i is called a spinor that acts as a rotation operator to rotate an axis by 90°. Spinors are also used in quantum mechanics to operate on complex multi-dimensional tensors. It may be more complete to say it represents a "flipper-spinor" since $\left(i = \frac{i^2}{i} = -\frac{1}{i}\right)$.

So multiplying a vector by i has the effect of flipping it (multiplying by -1) and spinning it (turning it into it's own inverse). It represents a perpendicular dimension that has the value of zero ($i = 0$) at the point of intersection as well as infinite $\left(\frac{1}{i} = \frac{1}{0} = \infty\right)$ at the same point on the real axis. But in general, dimensions are *concepts* that represent orthogonality and the imaginary number is simply a unit vector that allows equations to refer to these dimensions.

Therefore the common form of Euler's equation serves to model the space-time plot. But since only positive values apply in the Unity Theory version of the space-time plot, we use the squared equation for the at-rest state function, $\boldsymbol{\psi}$.

$$\psi^2 = e^{2i(\theta)} \tag{7.4}$$

The angle (θ) models the circle as the superposition of two wave functions, which can be written as having either wavelength and position or frequency and velocity. The circle itself is not waving, but the mathematical model is a two-part complex function that is coupled by the angle. The standard relationships (David Halliday 479-480) used to separate θ into a spatial component and a temporal component is

$$\theta = \frac{2\pi}{\lambda}(r - vt) \;=\; (kr - \omega t) \tag{7.5}$$

where λ is the wavelength but also the circumference of the circle. The factor $2\pi/\lambda$ is the wave number, k but it is also the factor that scales the angle to radians so that one unit of θ equals one unit of arc length ($\text{arc length} = r\theta$) on the circumference. The factor $2\pi/\lambda$ serves as a coordinate transformation; regardless of what the value of λ is, and whether it measures length or duration, the radius, expressed as *2π/λ,* will always be constant and equal to one revolution around the circle or one cycle. Therefore, a unit (quanta) of spacetime can be written as

$$\psi^2 = e^{2i(kr - \omega t)} \tag{7.6}$$

Substituting this into the classical wave equation, rearranging and taking the first derivative with respect to time yields

$$\frac{d^2(\psi)}{d^2r} - \frac{(-2i\omega)}{v^2} \times \frac{d(\psi)}{dt} = 0 \tag{7.7}$$

According to the de Broglie relationship, a particle has an associated wavelength *λ=h/p,* where *h* is Planck's constant and *p* is momentum. Since the velocity of a wave is wavelength (λ) times frequency *(f),*

$$v = \lambda f = \frac{h}{p} f \xRightarrow{rearranging} pv = hf \tag{7.8}$$

and since $p = mv$, then

$$mv^2 = hf. \tag{7.9}$$

Using this result, ω/v^2 in equation (7.7) can be written as

$$\frac{\omega}{v^2} = \frac{m\omega}{mv^2} = \frac{m\omega}{hf} = \frac{m(2\pi f)}{hf} = \frac{m}{\hbar} \tag{7.10}$$

where

$$\hbar = \frac{h}{2\pi} \tag{7.11}$$

Substituting, $\frac{m}{\hbar}$ for $\frac{\omega}{v^2}$, and rearranging terms, equation (7.7) becomes

$$\frac{\hbar^2}{2m}\frac{d^2(\psi)}{d^2r} + i\hbar\frac{d(\psi)}{dt} = 0 \tag{7.12}$$

which is the free particle Schrodinger equation[5].

Schrödinger’s equation is the quantum wave equation that fully describes an elementary particle. According to David Ward and Sabine Volkmer, “most students and professors will tell you that Schrödinger’s equation cannot be derived.” (Ward and Volkmer) They then proceed to derive it much like above, by starting with the classical wave equation and substituting de Broglie wave relations, but they make approximations to the Klein-Gordon equation, just as they say it was done by Schrödinger.

The approach used here did not make any assumptions, normalizations or approximations and it suggests that Schrödinger’s equation is simply a partially evaluated

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[5] This is in the same form as Ward and Volkmer (Ward and Volkmer) as well as eqn. (9.45) in "Quantum Mechanics" by A. Goswami, (Goswami, Quantum Mechanics) pg 190. Note that for a free particle, *V(r)=O.*

classical wave equation - a mathematical model of a conserved field that includes the whole spacetime unit, both the inside (actuality) and the outside (potentiality) of any unit of spacetime.

Considering its application to both Relativity and Quantum Mechanics, it seems clear that the Unity Theory can be expressed as a Unified Field Theory.

VIII. Unified Field Theory

"In the mid-19th century James Clerk Maxwell formulated the first field theory in his theory of electromagnetism. Then, in the early part of the 20th century, Albert Einstein developed general relativity, a field theory of gravitation. Later, Einstein and others attempted to construct a unified field theory in which electromagnetism and gravity would emerge as different aspects of a single fundamental field. They failed, and to this day gravity remains beyond attempts at a unified field theory. " (Britannica) Although, according to Smolin, String Theory has captured the attention of most physicists, it has failed as a theory of everything and there are some who continue to investigate the similarities between electromagnetic radiation and gravitational radiation. This was the subject of a very recent publication by Richard Price, (Price, Belcher and Nichols) et al. The Formal analogy between electromagnetism and gravitational forces is known as Gravitoelectromagnetism, or GEM. This analogy dates back to 1893 before general relativity but GEM is also discussed in the context of general relativity (Mashhoon). In this paper, the analogy is much simpler and does not require the complexities of Einstein's field equations.

Before applying the space-time-motion (STM) model to neutral particles, application to the electromagnetic field equations will be illustrated.

Electromagnetic Multivector in spacetime

David Hestenes combined all of Maxwell's equations into a single multivector format using Geometric Algebra (Hestenes). Starting with a description of a geometric product

$$\vec{a}\vec{b} = \vec{a} \cdot \vec{b} + i\vec{a} \times \vec{b} \tag{8.1}$$

and the definitions

$$\vec{a} \cdot \vec{b} = ab\cos\theta, \tag{8.2}$$

$$\vec{a} \times \vec{b} = ab\sin\theta \tag{8.3}$$

he showed that the electromagnetic field can be written as a single multivector $F(x,t) = E(x,t) + iB(x,t)$ of the form $M = \alpha + \vec{a} + i\vec{b} + i\beta$ and with the definition of a vector derivative

$$\vec{E} = \nabla \cdot \vec{E} + i\nabla \times \vec{E} \tag{8.4}$$

and the continuity equation,

$$\left(\frac{1}{c}\partial_t + \nabla\right)\vec{F} = \rho - \frac{1}{c}\vec{J} \tag{8.5}$$

with charge density $\rho = \rho(x,t)$ and charge current $\vec{J} = \vec{J}(x,t)$ as sources. He then showed that this is equivalent to the standard set of four equations (Jackson 818 - Heaviside-Lorentz format)

$$\nabla \cdot \vec{E} = \rho, \;\; \nabla \cdot \vec{B} = 0$$

$$\nabla \times \vec{E} = -\frac{1}{c}\frac{\partial \vec{B}}{\partial t}, \text{and}$$

$$\nabla \times \vec{B} = \frac{1}{c}\left[\vec{J} + \frac{\partial \vec{E}}{\partial t}\right]. \tag{8.7}$$

The scalar, vector, bivector, and pseudoscalar parts of the multivector were identified as

$$M = \{\alpha + (\vec{a})\} + i\{\beta + (\vec{b})\} \tag{8.8}$$

where α and β are scalars and $\vec{a}$ and $\vec{b}$ are vectors. Substituting components from Maxwell's equations scalars: $\alpha = \nabla \cdot \vec{E}$, $\beta = \nabla \cdot \vec{B}$; and vectors: $\vec{a} = \frac{1}{c}\partial_t\vec{E} - \nabla \times \vec{B}$ and $\vec{b} = \nabla \times \vec{E} + \frac{1}{c}\partial_t\vec{B}$, the ***electromagnetic multivector*** was written as

$$\rho - \frac{1}{c}\vec{J} = \left\{\nabla \cdot \vec{E} + \left(\frac{1}{c}\partial_t\vec{E} - \nabla \times \vec{B}\right)\right\} + i\left\{\nabla \cdot \vec{B} + \left(\nabla \times \vec{E} + \frac{1}{c}\partial_t\vec{B}\right)\right\}. \tag{8.9}$$

A STM plot provides a geometric view of this multivector (see Figure 18). Consider first a charge density, ρ at a point in spacetime. It produces a field with a gradient, $\vec{E}(s,t) = \nabla\emptyset$ in three-dimensional spacetime. Because there's no such thing as an isolated charge, there is relative motion somewhere in the universe so there is a field in the ST plane (shown at an angle, θ). The electric field that diverges in three-dimensional space is the divergence, which is the projection of $\vec{E}$ onto S:

$$\nabla \cdot \vec{E} = \vec{E}\cos(\theta). \tag{8.10}$$

The curl, $\nabla \times \vec{E} = \overrightarrow{\imath E} sin(\theta)$ is the projection of $\vec{E}$ on the T axis, i. e. a time varying component $\frac{\partial \vec{E}}{\partial t}$, which exists for a static charge due to all the other moving charges in the universe. This time-varying component of the field induces the magnetic field that appears in Maxwell's equation (considering for a static charge with $\vec{J} = 0$) as the curl of $\vec{B}$ as follows:

$$\frac{\partial \vec{E}}{\partial t} = c\left(\nabla \times \vec{B}\right) \tag{8.11}$$

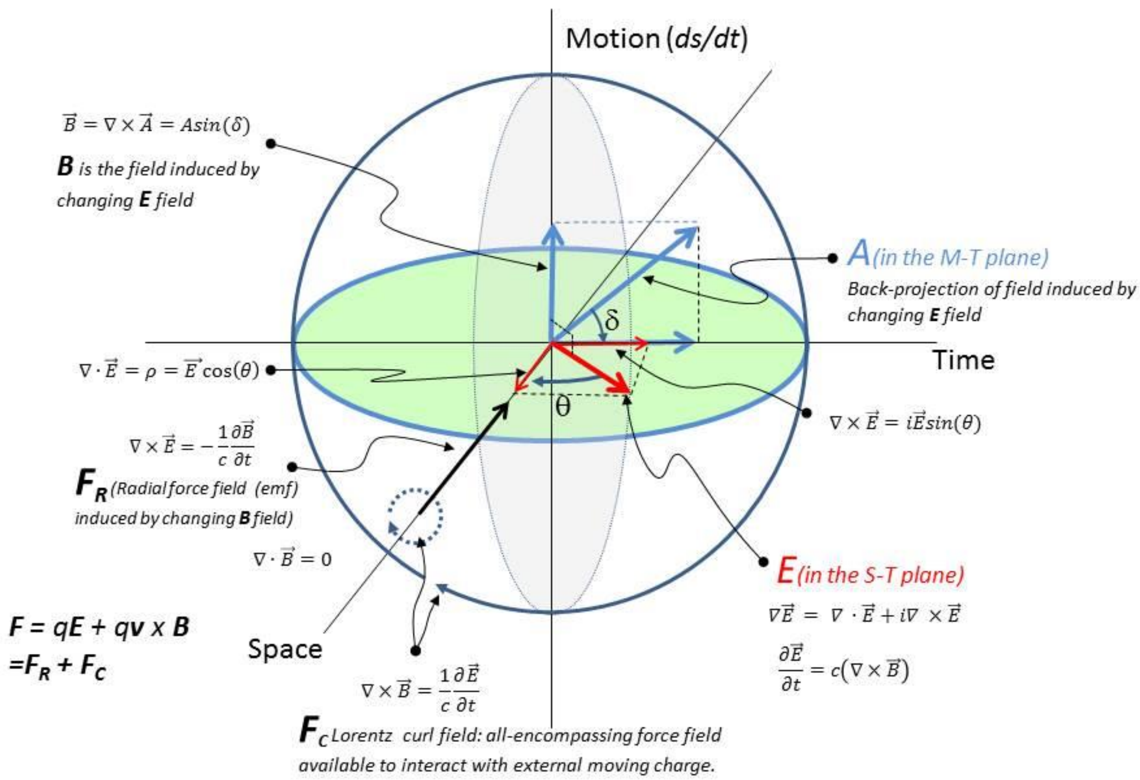

Figure 18 Electromagnetic multivector equation illustrated on the space-time-motion (STM) plot.

Recognizing that the derivative $\left(\frac{\partial \vec{E}}{\partial t}\right)$ is the slope of the line $\vec{E}$ in the S-T plane, the induced field, $c\left(\nabla \times \vec{B}\right)$, is in the perpendicular dimension M and describes the projection of another field (vector potential: $\vec{A}$) onto the M axis. Therefore $\vec{A}$ is the back-projection of $\vec{B}$ into the M-T plane at some angle, δ. Since $\vec{B} \equiv \nabla \times \vec{A} = A\sin(\delta)$ and $\text{Lorentz Force} = \frac{q}{c}\vec{v} \times \vec{B}$, this term represents the tangential force that another charge would experience in addition to the electrostatic force *if it was moving* in space. The factor c is the scaling factor that relates space measurements to time measurements. Since there is no component of $\vec{A}$ or $\vec{B}$ on the S axis, there is no divergence in space and $\nabla \cdot \vec{B} = 0$.

The slope of $\vec{A}$ is the time-varying potential magnetic field, $\frac{\partial \vec{B}}{\partial t}$ which induces another vector field perpendicular to the M-T plane (i.e. in space).

$$\frac{\partial \vec{B}}{\partial t} = -c\left(\nabla \times \vec{E}\right) \qquad (8.12)$$

This field is the same magnitude as the projection of $\vec{E}$ on the T axis, scaled by c, but it is directed inward toward the center of the particle. This term is interpreted here to be a restoring force induced by the separation of spacetime, drawing it back together and producing the spherical force field that is perceived as the surface of the particle as well as the force field that draws other opposite charges toward its center, i.e. electrostatic force field.

For this particle at rest, the Poynting vector, the flux of electromagnetic power per unit cross section, $\vec{E} \times \vec{B}$, is in the future “direction” on the time axis – the arrow of time.

Momentum-Acceleration Multivector in spacetime

Now consider a neutral particle. Recall that every particle, even one that is at rest, has momentum - relative motion associated with it (projected onto it) by any or all of the other particles in the universe. But since it can be *conceptually isolated* and mathematically defined as being at rest, the *potential* for being in-motion (momentum, $\vec{p} = m\vec{v}$) is represented as a field.

Changing the potential motion of a particle requires an external force, a force such as gravity that would exist in the presence of another particle. This correlates directly to the electric potential associated with a charged particle as illustrated in Figure 19 .

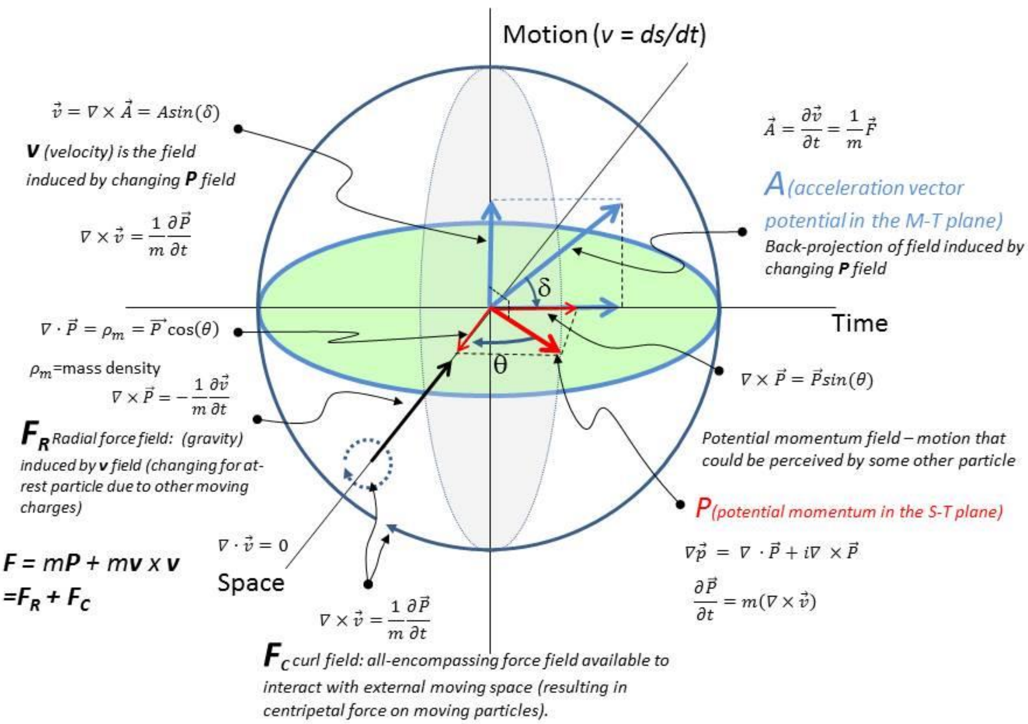

Figure 19 The momentum-acceleration (PA) multivector. An exact duplicate of the EM multivector with each term directly correlated to an equivalent field.

An electric field is a concept that mathematically describes the force a charged particle would experience *if* another charged particle were present at some distance. Just as the electric field is the gradient of electric potential, we can identify a **momentum field** $(\vec{\boldsymbol{P}})$ as the gradient of **the momentum potential** $(\boldsymbol{p})$.

$$\vec{P} = \nabla p = \nabla \cdot \vec{P} + i\nabla \times \vec{P} \tag{8.13}$$

Just as the scalar projection of the electric field is the charge density, $\nabla \cdot \vec{E} = \rho$, the scalar projection of the momentum field is the amount of substance defined as the mass density of the particle

$$\nabla \cdot \vec{P} = \rho_m. \tag{8.14}$$

The curl of momentum is the projection on the time axis, equal in magnitude (scaled by m) to the projection in space and available to manifest as a force that will oppose a change in motion. Just as with the electric charge, motion is the third dimension and the vector potential that correlates to the magnetic vector potential is the vector acceleration, $\vec{A}$.

Acceleration, expressed as the change of velocity with respect to time, is induced by changing the velocity field of a particle, just as a magnetic field is induced by changing the electric field of a charge. We normally think of the magnetic field as something we induce by moving the charge but since a particle is only at-rest in its own reference frame, an electron already has a magnetic field induced by all of the other moving charges in the universe. If we pick a reference frame and one direction of motion in that frame, we can measure and identify the net direction of the circulating magnetic field, but if all relative motion in the universe is considered, the magnetic field is always induced and must be all-encompassing. An all-encompassing, circulating magnetic field around the charge is a shell that would give the field the characteristics of a solid particle. From this perspective, the particle-wave duality makes perfect sense.

For a neutral particle, the all-encompassing force field is acceleration, a measurable field that presents as inertia - resistance to a change in momentum. It is perpendicular to the M-T plane, which as a dimension in spacetime, is the dimension of space. In other words, acceleration is a vector potential in space that we can experience and measure as force; $\vec{A} = \frac{1}{m}\vec{F}$. Mass is just a quantity that describes the amount of field (energy), in the form of substance, being acted on. Just as standard units of length and time were defined, mass was defined by arbitrary assignment of itself, and simply provides a factor that scales the magnitude of the force to the amount of substance.

The acceleration field is the same magnitude as the projection of $\vec{P}$ on the T axis, but in space it is directed inward toward the center of the particle, resisting change in any direction of motion. Like the magnetic field, it is interpreted to be a restoring force induced by the separation of spacetime, drawing it back together and producing the spherical force field that is perceived as the surface of the particle as well as the force field that draws other objects toward its center, i.e. *gravitational force field*. So as long as the particle is at rest (constant velocity), it may not experience a net force in space, but it still experiences acceleration as an induced force directed toward its center - the origin of its STM plot.

It would be reasonable to argue that the difference between electric force and gravitational force is that electric charges only attract oppositely charged particles whereas neutral particles attract each other. However, the STM model depicts the *space-time opposites* as being the particle and the *surrounding space*. This means that the gravitational force actually attracts the *space* rather than the other particle and since the other particle also attracts the space surrounding it, the two potential forces (in the same format of mass/distance (m/r) as electric potential, charge/distance (q/r)) are superimposed on each other.

$$\vec{F} = \vec{P}_1 \cdot \vec{P}_2 \approx \frac{m_1}{r} \cdot \frac{m_2}{r} \tag{8.15}$$

The net result is that the two neutral particles attract each other with the inverse-squared relationship. This has the same effect as (and is easier to conceptualize than) the idea that mass warps space like a rubber diaphragm as interpreted by the general theory of relativity. It is also in agreement with the equivalence principle, that the gravitational force as experienced locally while standing on a massive body is actually the same as the pseudo-force experienced by an observer in a non-inertial (accelerated) frame of reference (Equivalence principle, http://en.wikipedia.org/wiki/Equivalence_principle).

By replacing terms in the EM multivector, the complete multivector for the unified field would be

$$\rho_m - \frac{1}{m}\vec{p} = \left\{\nabla \cdot \vec{P} + \left(\frac{1}{m}\partial_t \vec{P} - \nabla \times \vec{v}\right)\right\} + i\left\{\nabla \cdot \vec{v} + \left(\nabla \times \vec{P} + \frac{1}{m}\partial_t \vec{v}\right)\right\}. \tag{8.16}$$

Compare this with

$$\rho - \frac{1}{c}\vec{J} = \left\{\nabla \cdot \vec{E} + \left(\frac{1}{c}\partial_t \vec{E} - \nabla \times \vec{B}\right)\right\} + i\left\{\nabla \cdot \vec{B} + \left(\nabla \times \vec{E} + \frac{1}{c}\partial_t \vec{B}\right)\right\}. \tag{8.17}$$

It should also be pointed out that the last term in both multivectors $\left(\nabla \times \vec{P} + \frac{1}{m}\partial_t \vec{v}\right)$ and $\left(\nabla \times \vec{E} + \frac{1}{c}\partial_t \vec{B}\right)$ gives us another clue about the nature of time. The curl is the projection onto the time axis, yet it also describes the inward-directed force. This is in agreement with the glass-of-water analogy, that if space is a measure of the substance of matter (the level of fullness) then time is the measure of emptiness – the complement of the space that is filled with the energy of matter, the empty space into which the universe expands transforming potentiality into actuality.

IX. Conclusion

If the Unity Theory is correct, it confirms an ancient idea that the underlying essence of reality is a unified process that manifests as a dualism of space and time. Although physical reality can be measured as a collection of material particles, the physical particles themselves cannot exist without motion, because motion (a process) is what actually causes the physical world to materialize and what creates the perception of time. Modeled as coherent waves, space and time support the theory of the holographic nature of matter. This idea was proposed in 1991 and has been the subject of investigation (Cho), (Carver and Nelson), (Germine) as well as the topic of a popular book, The Holographic Universe by Michael Talbot (Talbot). According to Talbot, many applications make more sense if it is true than if it is not. However, there is one fundamental question that has not been answered, that is, where would the coherent waves necessary for creating a hologram come from to form the holographic universe? The Unity of Space and Time presented here suggests that because spacetime separates itself into two equivalent wave-like aspects, space and time *are* themselves the coherent waves and that simple motion provides the driving mechanism that makes the process work. Several authors, including David Bohm (Bohm), Amit Goswami (Goswami, The Self Aware Universe- How Consciousness Creates the Material Universe) and Mark Germine (Germine) have proposed the same idea of wholeness, unity, the One Mind Model, etc. to *describe* what is necessary for an understanding of consciousness. The Unity Theory goes one step further to help explain it.

The dual aspects of spacetime, when separated by relative motion, serve as coherent waves that holographically interfere with each other and materialize as matter. Matter is a state of relative constancy of seemingly (measurably) separate forms whose existence induces restoring forces. These forces induce relative motion resulting in more separateness - a perpetual and eternal process expanding awareness, which then intentionally separates spacetime in an effort to understand itself. The apparent separateness disguises the fundamental unity, but combined with the restoring forces this process brings the universe to life and motivates it to achieve self-awareness.

The most profound conclusion is that time does not exist in the form (that many people have believed for centuries), as a separate linear entity that ticks away under its own control. Instead, it is a concept that simply allows our consciousness to make sense of the change that we experience by giving us the feeling that we only exist here and now rather than being part of an eternal process. There are many reasons why this so profound. First, it means that life itself, like spacetime, is a continuous, timeless process with no beginning and no end, but an expanding “sphere whose center is everywhere and whose circumference is nowhere” (in the words of twelfth century theologian Alain de Lille when describing “God”). It suggests that the Universe is expanding because awareness is expanding. Second, it means that the future already exists (in potential) and that the past still exists, as an integral part of us. It suggests that every moment and every experience, good, bad or indifferent, has transformed into the molecules of our DNA (a concept for future research). So everything that happened in the lives of our ancestors (remember we are the same DNA as them) is also a part of us, part of our expanding sphere of consciousness. This is supreme and ultimate accountability for our actions, for our lives, for each other and for our planet. It is our duty and responsibility to help each other find the way to rise above our differences and together, wake up in Unity.

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