Measurement Quantization Unites Special and General Relativity

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Unifying quantum and classical physics has proved difficult as their postulates are conflicting. Using the notion of counts of the fundamental measures—length, mass, and time—a unifying description is resolved. A theoretical framework is presented by which a conversion between expressions from quantum and classical physics can be made. With this framework dilation expressions for both special and general relativity are now possible that are valid for the entire measurement domain. This is accomplished with a new approach to equivalence that does not require the equivalence principle. As such, we recognize gravity as a special case of the existing laws of motion. In addition to the self-referencing measure expressions of the inertial frame, we also introduce a mathematical framework of self-defining expressions, measure defined against the universe as a system. With this, we may now describe dark energy, dark matter and the expansion of the universe. We also present expressions for the initial quantum fluctuation, inflation, the trigger event that causes inflation to cease and the integral role of relativity in the birth of the universe.

1. INTRODUCTION

Within this paper we will use the principles of Informativity [1], a model that recognizes the quantized nature of measurement, to derive Einstein's dilation expressions for Special and General Relativity (SR/GR) [2][3]. The derivation will take an approach that uses measurement quantization and the Pythagorean Theorem to resolve the dilation expressions of relativity.

Notably, the approach allows us to resolve an expression for equivalence that distinctly negates the need for an equivalence principle. Describing phenomena as a composite of counts of the fundamental measures enables us to remove measure from relativistic expressions leaving self-defining numerical descriptions. Where any measure at best can be defined relative to the other two, measurement quantization offers our first opportunity to approach physical descriptions entirely from a self-defining numerical framework of logical relations.

Of particular interest, we present a count expression describing the curvature of space-time not as a contraction of space, but as a count differential of the fundamental measure of length l_f. We also present a new genus of expression formally recognized as the *unity expression*. The *unity expression* for the first time allows us to resolve the relative values of the fundamental measures – length, time, mass.

Arising from the foundations of Informativity we also introduce a second form of relativity new to modern theory. The phenomenon is six orders in magnitude smaller than the effects of relativity, an outcome of measurement quantization. Where physical description is shown to be an outcome of the whole-unit quantization of measure, relationships that present fractional measure introduce quantum uncertainty and measurement dilation.

Finally, expanding on these concepts, the idea of the universe as a frame of reference is introduced. A mathematical approach is presented with example expressions describing several phenomena, each supported by our best measurement data. Notably, we find dilation also a factor between our frame of reference and that of the universe. The principles of self-referencing and self-defining frames of reference [1, see Section 3.9] are essential in describing expansion, dark energy, dark matter, inflation, the Cosmic Microwave Background (CMB) and several more phenomena that are properties ***of*** the universe.

For each of these applications an understanding of the principles of Informativity is valuable, but not a requirement to the expressions and analysis presented within. That said, our discussion will start with an exploration of measure and from there build the quantum expressions of relativity.

2. METHODS

We begin by refining our understanding of observation in terms of the three measures. Whereas Einstein presented his work on SR – expressions that describe measure with respect to an inertial frame – we ask a more immediate question. What defines measure?

Consider measure as a count of a known reference, where the reference is recognized as that measure for which no smaller measure has physical significance. Where the reference defines our understanding of measure and where we may understand measure only relative to the reference, we find ourselves in a referential paradox that does not allow fractional counts of measure. If there were a means to measure a fraction of the reference, then we violate our definition. Thus, the fraction would represent the reference where the prior becomes an error in assignment. We recognize that nature describes observation only as a whole-unit count of the reference.

Planck conjectured that there were physically significant units of measure [4]. His measure expressions are recognized as Planck's Units [5][6] and consist of the constants *G*, *c* and Planck's constant $\hbar$. Where Heisenberg's uncertainty principle [7] as applied to the position and momentum of a particle may be reduced to a measurement count expression centered on fundamental length l_f it may be shown where support for the principle is found, then it must also be found that the fundamental measures are physically significant ([1] see Eqs. (53-57)). With this, expressions may be presented built on the foundations of modern theory to reveal an unbounded quantum model of nature.

3. RESULTS

3.1. Special Relativity

Relativity is just one of several phenomena that are a natural consequence of a Pythagorean understanding of distance. That is to say, we may derive Einstein's dilation expressions without the need for a specific physical construct, so long as our derivation takes on the form of the Pythagorean Theorem.

To demonstrate, we present a true statement. Consider a target length count n_{Ll} that is equal to the length count $\mathrm{n_{Lc}}$ associated with the distance that light travels in one second,

$$\mathrm{n_{Lc}} = n_{Ll} \;. \tag{1}$$

We may allow the target length count n_{Ll} to vary by generalizing the expression with a third term, the observed length count n_{Lo}. Thus, multiply by n_{Lo} and square,

$$n_{Lo}^2 \mathrm{n_{Lc}^2} = n_{Ll}^2 n_{Lo}^2 \;. \tag{2}$$

Shift the right term, add $n_{Ll}^2\mathrm{n_{Lc}}^2$ and factor,

$$n_{Lo}^2 \mathrm{n_{Lc}^2} + n_{Ll}^2 \mathrm{n_{Lc}^2} - n_{Ll}^2 n_{Lo}^2 = n_{Ll}^2 \mathrm{n_{Lc}^2} \;, \tag{3}$$

$$n_{Lo}^2 + n_{Ll}^2 \frac{\mathrm{n_{Lc}^2} - n_{Lo}^2}{\mathrm{n_{Lc}^2}} = n_{Ll}^2 \;. \tag{4}$$

Recognize that $\mathrm{n_{Lc}}^2$-n_{Lo}^2 is a count n_L of l_f associated with the distant traveled by a target with velocity *v* in one second, $n_L^2=\mathrm{n_{Lc}}^2-n_{Lo}^2$ which may be written in Pythagorean form as $n_{Lo}^2+n_L^2=\mathrm{n_{Lc}}^2$. Given n_{Lo} as a count of the reference l_f in the inertial frame, then n_L is a count respective of velocity and $\mathrm{n_{Lc}}$ a count of l_f that defines the speed of light. In terms of Informativity, $\mathrm{n_{Lc}}$ is referred to as the length frequency ([1], see Eq. (27)). It is the upper count bound that constrains all relativistic expressions and the Pythagorean Theorem is that expression suited to describe distance. Thus,

$$n_{Lo}^2 + n_{Ll}^2 \frac{n_L^2}{\mathrm{n_{Lc}^2}} = n_{Ll}^2 \;, \tag{5}$$

$$n_{Lo} = n_{Ll} \left(1 - \frac{n_L^2}{\mathrm{n_{Lc}^2}} \right)^{1/2} . \tag{6}$$

We have resolved the expression for length dilation in quantum form. Notably, the expression is characterized by the absence of measure, consisting only of counts of the fundamental measures. Where the dilation metric is

$$\frac{n_L^2}{\mathrm{n}_{\mathrm{Lc}}^2} = \frac{n_L^2}{\mathrm{n}_{\mathrm{Lc}}^2}\frac{l_f{}^2}{l_f{}^2} = \frac{(n_L l_f)^2}{(\mathrm{n}_{\mathrm{Lc}} l_f)^2} = \frac{v^2}{c^2}\,, \tag{7}$$

then the corresponding dilation expressions for time and mass are

$$n_{To} = n_{Tl}\left(1 - \frac{n_L^2}{\mathrm{n}_{\mathrm{Lc}}^2}\right)^{1/2}, \tag{8}$$

$$n_{Mo} = n_{Ml} \,/ \left(1 - \frac{n_L^2}{\mathrm{n}_{\mathrm{Lc}}^2}\right)^{1/2}. \tag{9}$$

Notably, dilation corresponds to the count ratio $n_L{}^2/\mathrm{n}_{\mathrm{Lc}}{}^2$ where traditionally recognized in the form v^2/c^2. That is, one measures the numerator (velocity) as a rate of change in position and dilation as a function of that change with respect to the upper bound n_{Lc}. But, dilation is a count differential n_L of l_f reflective of the ratio of the target's change in length count (i.e. velocity) to the count bound n_{Lc}. Thus, the introduction of l_f with respect to these counts is an unnecessary and superfluous operation that does not contribute to describing dilation. What this means is that the appropriate term for Einstein's dilation expressions is a *differential* with the emphasis being on count differentials. To avoid confusion, we will continue to use the term dilation, but forthwith it is implicitly understood that we are talking about a count dilation between the observer and a target.

As a demonstration of the quantum-to-macroscopic conversion procedure and for completeness of presentation, we may take the dilation expression for length, multiply by l_f and consolidate terms to place the expression in macroscopic form,

$$l_o = l_l\left(1 - \frac{n_L^2}{\mathrm{n}_{\mathrm{Lc}}^2}\right)^{1/2}, \tag{10}$$

$$l_o = l_l\left(1 - \frac{n_L^2}{\mathrm{n}_{\mathrm{Lc}}^2}\right)^{1/2} = l_l\left(1 - \frac{n_L^2 l_f^2}{n_T^2 t_f^2}\frac{n_T^2 t_f^2}{\mathrm{n}_{\mathrm{Lc}}^2 l_f^2}\right)^{1/2}, \tag{11}$$

$$l_o = l_l\left(1 - \frac{v^2}{c^2}\right)^{1/2}. \tag{12}$$

As such, we have started with an equality and derived Einstein's dilation expression for length as a property of the Pythagorean Theorem and measurement quantization.

Lastly, we should note that the count bounds of the fundamental measures are relatively the same:

$$n_L = 2.99792458\;10^8 \,/\, l_f \;= 1.85492\;10^{43}\ \text{units/s}, \tag{13}$$

$$n_M = 4.0371111\;10^{35} \,/\, m_f \;= 1.85492\;10^{43}\ \text{units/s}, \tag{14}$$

$$n_T = 1/t_f = 1.85492\;10^{43}\ \text{units/s}, \tag{15}$$

$$n_L = n_T = n_M\,. \tag{16}$$

As such, one may interchange the upper bound counts of length, mass and time as may apply to measurement of the target. While this can be useful, it emphasizes an abstraction that exists between measure and counts of the fundamental measures, the later being a sufficient and independent property describing the behavior of observed phenomena.

3.2. Pythagorean Differentials

Notably, all relativistic dilation expressions can take the form of a Pythagorean expression, $A^2+B^2=C^2$. Where there are two forms of relativity, the numerical basis for each is dramatically different. Einstein's expressions arise from geometric count differentials where a shared count term is fixed, that being the length count associated with the speed of light, n_{Lc}. In contrast, the *Informativity differential* ([1] see Eq. (9) and Appendix A) is new to modern theory and arises from the whole-unit quantization effects of measure. We will discuss each in further detail beginning with SR.

As described in Fig. 1, length dilation exists specifically because of the invariant nature of light, n_{Lc}, along sides *a* (the reference) and *c* (the unknown distance). When expressed in Pythagorean form,

$$n_{Lo}^2\ \mathrm{n}_{\mathrm{Lc}}^2 + n_L^2\ n_{Ll}^2 = \mathrm{n}_{\mathrm{Lc}}^2\, n_{Ll}^2\,, \tag{17}$$

this is not easy to see. But where the expression is organized into its dilation form,

$$n_{Lo} = n_{Ll}\left(1-\frac{n_L^2}{\mathrm{n}_{\mathrm{Lc}}^2}\right)^{1/2}, \tag{18}$$

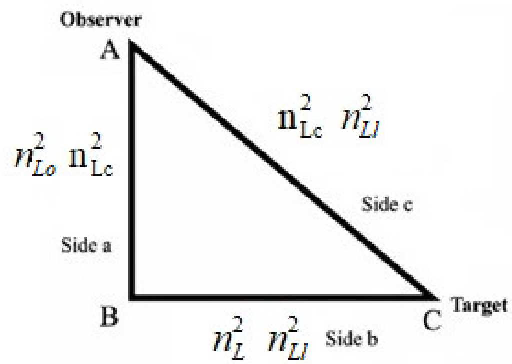

Figure 1. Einstein's dilation expression for length presented in Pythagorean form.

we find that a fixed count for n_{Lc} will not allow a one-for-one correspondence between length counts in the local n_{Lo} and target n_{Ll} frames in the presence of motion n_L. If the speed of light constraint simply did not exist, the expression would reduce to

$$n_{Lo} = n_{Ll}\,(1)^{1/2}\,, \tag{19}$$

thus negating relativistic dilation.

In contrast, the *Informativity differential* is an entirely different effect. The effect applies only to gravitational fields and when presented in terms of the Pythagorean Theorem (Fig. 2), the effect is specific to the case where side *a* is always equal to a count of 1 l_f and side *b* is a known count of l_f between the observer and a center of gravity. Where measure is relative and as such can take on only a whole-unit count of the reference (i.e. side *a*), we find that more precise solutions to the unknown distance (side *c*) carry a fractional component Q_{Lf} in excess of the whole-unit count. This excess fractional count is lost at every count of t_f and is expressed as motion (i.e. gravity) ([1] see Eqs. (5-9)).

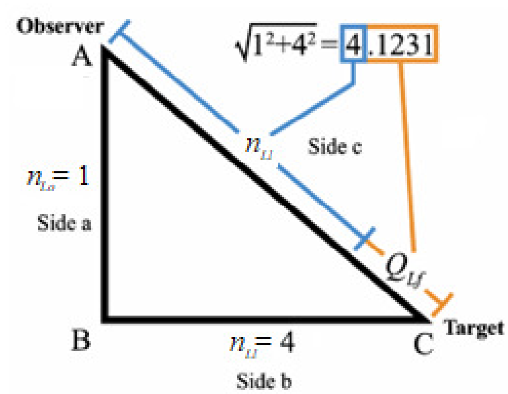

Figure 2. Count of distance measures between an observer and target where $n_{Ll}=4$.

3.3. The Equivalence Principle

When developing expressions for GR, one will typically develop an expression for escape velocity in a gravitational field and then set the expression equal to a motion expression such as the dilation expressions of SR. While the mathematics of this equality are supported experimentally and without issue in the development of expressions from many points of view, there exists no prerequisite, requirement or even measurable experiment that definitively mandates that the equivalence principle is a required outcome of nature.

With Informativity we can present an expression that one-for-one correlates the gravitational field with the dilation effects of motion as a numerical equality. This may be accomplished with the *Informativity differential* ([1] see Eq. (31), $n_{Ll}=r_{Lf}$),

$$Q_{Lf}n_{Ll}=\frac{t_f\theta_{si}}{l_f m_f}, \tag{20}$$

which provides a quantum description of gravitation Q_{Lf}/n_{Ll} . The ratio may be resolved into the more familiar macroscopic form G/r^2 where from the Shwartz and Harris experiments θ_{si}=3.26239 radians [8], then

$$\frac{Q_{Lf}l_f}{n_{Ll}t_f^2}\frac{c}{\theta_{si}}=\frac{Q_{Lf}c^2}{n_{Ll}t_f\theta_{si}}=\frac{Q_{Lf}l_fc^2}{n_{Ll}l_ft_f\theta_{si}}=\frac{Q_{Lf}c^3}{r\theta_{si}}=\frac{G}{r^2}. \tag{21}$$

Using Fig. 3 as a guide, we then construct a generalized Pythagorean expression for distance. Where side *a* is $l_o=n_{Lo}l_f$ and $n_{Lo}=1$ and where side *b* is $l_l=n_{Ll}l_f$ for any whole-unit count of the reference l_f then

$$l_o^2+l_l^2=(Q_{Lf}+l_l)^2, \tag{22}$$

$$n_{Lo}^2l_f+n_{Ll}^2l_f=(Q_{Lf}+n_{Ll})^2l_f, \tag{23}$$

$$n_{Lo}^2+n_{Ll}^2=Q_{Lf}^2+2Q_{Lf}n_{Ll}+n_{Ll}^2, \tag{24}$$

$$1=Q_{Lf}^2+2Q_{Lf}n_{Ll}, \tag{25}$$

$$n_{Ll}=\frac{1}{2}\left(\frac{1}{Q_{Lf}}-Q_{Lf}\right). \tag{26}$$

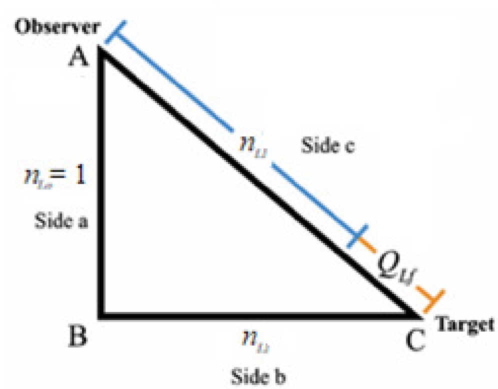

Figure 3. Count of distance measures between an observer and target in a gravitational field $Q_{Lf}/n_{Ll}l_f$.

The derivation takes advantage of a condition unique to the *Informativity differential*; all distance expressions are respective of a reference which is inclusive in the expression, $n_{Lo}=1$. Where techniques common in modern theory may reduce length dilation only to a function of l_o, l_l, v and c, the Informativity approach allows reduction of the expression to two variables, a *value* and its *definition*. The correlation defines one state for each given value.

> ***O_1:*** *It is with the one-to-one correspondence between n_{Ll} and Q_{Lf} that the equivalence principle is no longer needed. Rather, as shown, we directly equate the phenomenon of gravity as expressed by Q_{Lf} to the phenomenon of motion dilation as expressed with the count differential n_{Ll}.*

Both Q_{Lf} and n_{Ll} are numerical counts removing measure from equivalence and as such describing the dilation effects of motion and gravitation in a single self-defining manner. We emphasize that this is a numerical equality and when presented as such we side-step the traditional approach of arguing physical equivalence. The equivalence principle is no longer needed.

3.4. General Relativity

The *Informativity differential* $Q_{Lf}n_{Ll}$ is notoriously difficult to work with and for this reason the term is often incorporated into Informativity expressions at either the quantum or cosmological limit depending on the nature of the phenomenon being described. In this case, we consider cosmological phenomena where

$$Q_{Lf}n_{Ll}=\left(\sqrt{1+n_{Ll}^{\ 2}}-n_{Ll}\right)n_{Ll}\,, \tag{27}$$

$$\lim_{n_{Ll}\to\infty}\left(\frac{Q_{Lf}^{\ 2}}{2}+Q_{Lf}n_{Ll}\right)=\frac{1}{2}\,. \tag{28}$$

Thus, where distance $l_l=n_{Ll}l_f$ and where $lim_{nLl\to\infty}f(Q_{Lf}n_{Ll})=½$, then we may generalize the quantum description of gravitational dilation due to the *Informativity differential* as physically indistinguishable from the ratio of one-half where distance is great. Notably, we may also reorganize the *Informativity differential* and reveal that the expression is precisely the same as used above to demonstrate equivalence:

$$\frac{Q_{Lf}}{2}+n_{Ll}=\frac{1}{2}\left(\frac{1}{Q_{Lf}}\right), \tag{29}$$

$$n_{Ll}=\frac{1}{2}\left(\frac{1}{Q_{Lf}}-Q_{Lf}\right). \tag{30}$$

Thus, from Eq. (21) where

$$\frac{G}{r^2}=\frac{Q_{Lf}}{n_{Ll}}\frac{c^3}{l_f\theta_{si}} \tag{31}$$

we find the expression for escape velocity a macroscopic notation for correlating the relativistic effects of motion to a gravitational field. The expression is inclusive of the *Informativity differential* and, as noted, demonstrates and incorporates equivalence. For convenience of familiarity, we may start by demonstrating that the expression for escape velocity $v_e=(2GM/r)^{1/2}$ is implicit of the definition for gravitation with respect to the quantum distance of the reference l_f where

$$G=\frac{Q_{Lf}rc^3}{\theta_{si}}=\frac{Q_{Lf}r_{Lf}l_fc^3}{\theta_{si}}=\frac{c^3l_f}{2\theta_{si}}=\frac{c^3t_f}{m_f}=\frac{l_f}{t_f}\frac{l_f}{t_f}\frac{l_f}{t_f}\frac{t_f}{m_f}\,, \tag{32}$$

$$2\frac{l_f}{t_f}\frac{l_f}{t_f}=2\frac{Gm_f}{l_f}\,, \tag{33}$$

$$\sqrt{2}c=\left(\frac{2Gm_f}{l_f}\right)^{1/2}. \tag{34}$$

The expression correlates the numerical change in length count √2c (i.e. velocity) with respect to a gravitational field for the specific case where Pythagorean sides *a* and *b* are each a count of 1 (i.e.

$(1^2+1^2)^{1/2}=\surd 2)$. To generalize the expression to encompass velocity as corresponds to any mass $n_M m_f$ with respect to any radial distance from a center of gravity $n_{Lr} l_f$, we substitute the respective count terms associated with each measure. This is more complex for the left term as the $\surd 2$ is also a Pythagorean relationship which must first be expanded. To do so, we recognize that the sum of the squares of sides a, $n_{Lo} l_f$, and b, $n_{Ll} l_f$ is the square of side c, $n_L l_f$ and substitute $\surd 2$ with only the numerical count values $(n_{Lo}^2+n_{Ll}^2)^{1/2}$ which we recognize as the change in length count n_L respective of the target's escape velocity,

$$\sqrt{2}c=\sqrt{1^2+1^2}\,c=\sqrt{n_{Lo}^2+n_{Ll}^2}\,c=\sqrt{n_L^2}\,c=n_L c\ . \tag{35}$$

Where length count n_L is a second order differential metric with respect to gravitation, a first order differential metric, we must square the left term n_L to match the generalized portion on the right side. As discussed in Eq. (4), we may then substitute $n_L^2=\mathrm{n_{Lc}}^2-n_{Lo}^2$ relative to $\mathrm{n_{Lc}}^2$ (i.e. $c=l_f/t_f$, the count of l_f relative to the upper count bound of t_f, where $\mathrm{n_{Tc}}=\mathrm{n_{Lc}}$, Eq. (16)) to resolve escape velocity,

$$n_L^2 c^2=\frac{n_{\mathrm{Lc}}^2-n_{Lo}^2}{n_{\mathrm{Lc}}^2}\frac{l_f^2}{t_f^2}=v_e^2\,, \tag{36}$$

$$v_e^2=\left(\frac{2Gm_f}{l_f}\right)^{1/2}\,. \tag{37}$$

Where the $\surd 2c$ is the non-general quantum case of escape velocity v_e^2 and where $G=t_f c^3/m_f$, then

$$v_e^2=\frac{2Gn_M m_f}{n_{Lr} l_f}=n_M m_f\,\frac{2}{n_{Lr} l_f}\frac{t_f c^3}{m_f}=\frac{2n_M t_f c^3}{n_{Lr} l_f}\,, \tag{38}$$

$$v_e^2=\frac{2n_M t_f c^3}{n_{Lr} l_f}=\frac{2n_M c^3}{n_{Lr} c}=\frac{2n_M c^2}{n_{Lr}}\,, \tag{39}$$

$$\frac{v_e^2}{c^2}=2\frac{n_M}{n_{Lr}}\,. \tag{40}$$

Where v_e^2 is a subset of v^2 (i.e. Eqs. (11-12), $v^2/c^2=n_L^2/\mathrm{n_{Lc}}^2$) and specifically where we may set two numerical ratios equal to one another, then length dilation in a gravitational field is

$$\frac{n_L^2}{\mathrm{n}_{\mathrm{Lc}}^2}=2\frac{n_M}{n_{Lr}}\,, \tag{41}$$

$$n_L=\mathrm{n}_{\mathrm{Lc}}\left(2\frac{n_M}{n_{Lr}}\right)^{1/2}\,. \tag{42}$$

Notably, 2, $\mathrm{n_{Lc}}$, n_M and n_{Lr} are system specific; the count $\mathrm{n_{Lc}}$ of l_f traveled by light in a second, the count n_M of m_f describing the system mass and the count n_{Lr} of l_f between an inertial frame and the center of gravity each contribute to describe a change in position $n_L l_f$ per second in SI units (i.e. when multiplied by l_f/t_f). It should also be noted that the expression describes only the effects of relativistic dilation, but can incorporate the effects of the *informativity differential* where we do not rounded $Q_{Lf} n_{Ll}=½$.

Finally, where v^2/c^2 includes v_e^2/c^2 in its domain we incorporate equivalence not as a principle but as a numerical equivalent in the description of gravitation. The dimensionless ratio $(2n_M/n_{Lr})^{1/2}$ establishes the relationship between n_L and the upper bound $\mathrm{n_{Lc}}$ with respect to n_M, Eq. (41). Thus, gravitational dilation

(GR) with respect to mass is properly described by replacing the SR dilation terms with the value equivalent dilation metric.

$$t_o = t_l\left(1-2\frac{n_M}{n_{Lr}}\right)^{1/2}, \tag{43}$$

$$l_o = l_l\left(1-2\frac{n_M}{n_{Lr}}\right)^{1/2}, \tag{44}$$

$$m_o = m_l / \left(1-2\frac{n_M}{n_{Lr}}\right)^{1/2}. \tag{45}$$

While Einstein disliked the concept of relativistic mass [9], measurement quantization describes gravitational dilation without undefined values throughout the entire measurement domain. Notably, there is an upper bound to mass density and as such there are no undefined results for relativistic mass. That bound may be shown where

$$v_e = \left(\frac{2GM}{r}\right)^{1/2}, \tag{46}$$

$$c = \left(\frac{2}{r}\frac{Q_{Lf}rc^3}{\theta_{si}}\frac{n_M\theta_{si}}{Q_{Lf}n_{Ll}c}\right)^{1/2} = \left(\frac{2n_Mc^2}{n_{Ll}}\right)^{1/2}, \tag{47}$$

$$n_{Ll} = 2n_M. \tag{48}$$

Thus, baryonic matter may not have a density of more than two fundamental units of mass per fundamental unit of length. Doing so would imply a relative count ratio greater than the speed of light and that in turn would violate the count bound n_L=2.99792458 $10^8/l_f$=1.85492 10^{43} units/s where c=n_Ll_f/n_Tt_f.

Finally, note that all dilation expressions inclusive of those that describe count differentials within a gravitational field, (i.e. Eq. (45)), take the form of the Pythagorean Theorem, $A^2+B^2=C^2$, and as such length dilation may also be presented as

$$n_{Lo}^2 n_{Lr} + 2n_{Ll}^2 n_M = n_{Ll}^2 n_{Lr}. \tag{49}$$

Lastly, we bring to your attention Einstein's identification of the speed of light as a term instrumental in describing the curvature of space. The quantized dilation expressions presented here-within are independent of measure and as such reveal that macroscopic terms inclusive of measure introduce an unnecessary descriptor into our understanding of nature. Rather, dilation is a function of counts of the fundamental measures, specifically n_{Lo}, n_{Ll} and n_M with respect to a center of gravity n_{Lr}. We may state,

> ***O_2*:** *Where SR presents a squared differential metric n_L^2/n_{Lc}^2, GR is a first order phenomenon n_M/n_{Lr}.*
> ***O_3*:** *The dilation effects of gravitation are* ***'not'*** *a stretching of l_f (i.e. of space-time), but a count differential.*

One might ask, if the measure of space does not change around a massive body yet the unit count does, then what accounts for the 'missing space' respective of a reference where gravity is greater?

The missing space nearer a mass is still there and has been identified with the term Q_{Lf}, but it cannot be measured because it is smaller than the reference measure l_f. We have described this space as the *Informativity differential*; it is what gives rise to the phenomenon of gravitation.

3.5. Frames of Reference

Within this paper our focus has been in regards to the relative nature of observation with respect to self-referencing frames of reference. But, what does that mean?

It should not go unsaid that the relative nature of measure, although a byproduct of distance as described by the Pythagorean Theorem, adheres to a set of behaviors that are relative to the observer. Relativity has been crucial to our understanding of measure and how we perceive nature. Within Informativity, we indentify mathematical expressions defined with respect to the inertial frame as *self-referencing*.

In contrast, there are also phenomena that are an outcome of measure as defined against the universe. We call these *self-defining*. A mathematical approach to self-defining systems may be built on a foundation of fundamental measures by first taking the *fundamental expression*, setting a fundamental measure to a value of 1 and then resolving the corresponding count ratio with respect to the universe,

$$m_u = \frac{2\theta_{si}}{c}\frac{n_{Tu}}{n_{Lu}} = 1, \tag{50}$$

$$\frac{2\theta_{si}}{c} = \frac{n_{Lu}}{n_{Tu}}, \tag{51}$$

$$m_f = \frac{n_{Lu}}{n_{Tu}}. \tag{52}$$

Where n_{Lu} is a count of l_f and n_{Tu} is a count of t_f, we may now express phenomena which are self-defining. ([1] see Section 3.9) For example, several physical predictions with the same precision and value as our best measurement data are mass accretion M_{acr}, the diameter D_U and age A_U of the universe and the expansion of the universe H_U, respectively

$$M_{acr} = \frac{n_{Mu}}{n_{Tu}} = \theta_{si}\left(\frac{\theta_{si}^2 + 2}{2} - 1\right), \tag{53}$$

$$D_U = \frac{n_{Lu}}{n_{Tu}} c A_U, \tag{54}$$

$$H_U = \frac{n_{Lu}}{n_{Tu}} c = 2\theta_{si}. \tag{55}$$

Understanding self-referencing and self-defining systems is also important to balancing units in Informativity expressions. While units will differ between frames of reference, the values associated with physical expressions are the same. This quality is central to understanding more complex relationships such as angular measure $\theta_{si}=h/4\pi l_f$ and momentum $\theta_{si}=l_f c^3/2G$ which if set equal to one another resolve Planck's well-known expression for Planck's length,

$$l_p = \left(\frac{\hbar G}{c^3}\right)^{1/2} \text{ m. [10][11][12]} \tag{56}$$

3.6. Relativistic Differentials of the Universe

Relativistic effects will appear anywhere we perceive distance and that applies not only to self-referencing systems of measure. Specifically, the universe is an example of a self-defining system, a system defined against itself. And how we perceive measure with respect to the universe is also subject to the effects of relativity. We will consider the mass expression ([1] see Eq. (118)) where

$$2M_{tot}M_f = M_{obs}(M_{tot} + M_f)\ . \tag{57}$$

We begin by placing the expression into Pythagorean form. As presented in Fig. 4, where the total M_{tot}, observable M_{obs}, and fundamental M_f masses of the universe are compared to the expression for length dilation

$$n_{Lo}^2\ \mathrm{n}_{\mathrm{Lc}}^2 + n_L^2\ n_{Ll}^2 = \mathrm{n}_{\mathrm{Lc}}^2\, n_{Ll}^2\ , \tag{58}$$

$$M_{obs}M_{tot} + M_{obs}M_f = 2M_{tot}M_f\ , \tag{59}$$

we find that both expressions correspond not only in form, but one-for-one for each term:

- $n_{Lo}^2 \triangleq M_{obs}$ observed
- $n_{Lc}^2 \triangleq M_{tot}$ upper bound
- $n_{Ll}^2 \triangleq M_f$ target count
- $n_L^2 \triangleq M_f$ target change in count.

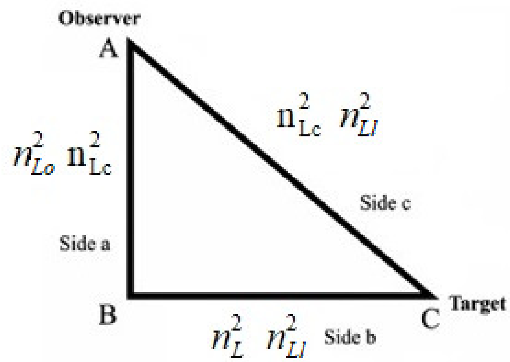

Figure 4. Einstein's dilation expression for length presented in Pythagorean form.

The two expressions match where length dilation is a composite expression consisting of counts of l_f defined with respect to the local frame (self-referencing) and mass distribution is a composite expression of counts of m_f defined with respect to the universe (self-defining).

For correctness, the mass distribution expression must first be reduced to its count form where

$$n_{Mobs}n_{Mtot} + n_{Mobs}n_{Mf} = 2n_{Mtot}n_{Mf}\ . \tag{60}$$

Its general form is more common as the macro expression is applicable using mass values in kilograms or percentage distribution values with respect to the total. And finally, where both expressions are one and the same in form, we may easily present mass distribution as a relativistic dilation expression,

$$M_{obs} = M_f\left(2 - \frac{M_{obs}}{M_{tot}}\right), \tag{61}$$

demonstrating that the observed mass M_{obs} is the fundamental mass M_f after applying the effects of relativity. The self-defining dilation metric is 2-(M_{obs}/M_{tot}). The correlation is significant in that it validates our understanding of fundamental mass as an upper bound to the observation of mass events (i.e. the mass frequency). Secondly, the expression provides us a conversion metric between measure in the local frame with respect to the self-defining frame, the universe. This is important when resolving an understanding of conditions prior and up to the birth of the universe.

3.7. Relativistic Differentials and the Cosmic Microwave Background

With Informativity, we can present expressions that describe the birth of the universe from a quantum fluctuation, the ensuing inflationary expansion and the trigger event that causes inflation to cease, releasing the accumulated radiation into what we see today as the CMB ([1] see Section 3.15). What has not been expressed in equation form is why the calculated age of the CMB points to an elapsed time of 363,309 years [13] while the events that end inflation define a trigger at 678,889 years in the local frame. Time dilation is the factor at play and is an important and unique application of relativity not yet considered in modern theory. That is, there exists dilation between the quantum events that gave rise to the universe and our self-referencing frame from within the universe.

In a straight-forward manner, the expansion of the universe from our point of view introduces a skewed time perspective from the events that led to the conclusion of CMB production. Taking the integral of the radius of the universe at the time of the CMB trigger event, we may solve for the age of the universe as

$$A_U = e^{\sqrt{3}\theta_{si}^3/2} = 1.14652\ 10^{13}\ \text{s}. \tag{62}$$

Where the radius of the universe at the CMB trigger may be resolved with $R_U = A_U\theta_{si}c$, then the difference between the self-referencing age $A_{s\text{-}ref}$ and the self-defining age A_U is a function of the spatial frame in three dimensions (i.e. volume where $V=(4/3)\pi R^3$) such that

$$\frac{(4/3)\pi(A_{s-ref}\theta_{si}c)^3}{(4/3)\pi(A_U\theta_{si}c)^3} = 2\theta_{si}\ , \tag{63}$$

$$A_{s-ref} = \left(2\theta_{si}\right)^{1/3} A_U = 2.14241\ 10^{13}\ . \tag{64}$$

To resolve dilation between the two frames of reference, we organize time with respect to motion where

$$\frac{n_{To}}{n_{Tl}} = \left(1 - \frac{n_L^2}{\mathrm{n}_{\mathrm{Lc}}^2}\right)^{1/2}\ . \tag{65}$$

To match, we then modify the expression for the self-referencing age of the universe such that

$$A_{s-ref} = A_U\left(2\theta_{si}\right)^{1/3}, \tag{66}$$

$$n_{Tl} = n_{To}\left(2\theta_{si}\right)^{1/3}, \tag{67}$$

$$\frac{n_{To}}{n_{Tl}} = \frac{1}{\left(2\theta_{si}\right)^{1/3}}\ . \tag{68}$$

Setting the expressions equal to one another, we then resolve the dilation,

$$\frac{1}{\left(2\theta_{si}\right)^{1/3}} = \left(1 - \frac{n_L^2}{\mathrm{n}_{\mathrm{Lc}}^2}\right)^{1/2}\ , \tag{69}$$

$$n_L^2 = \mathrm{n}_{\mathrm{Lc}}^2 - \frac{\mathrm{n}_{\mathrm{Lc}}^2}{\left(2\theta_{si}\right)^{2/3}}\ , \tag{70}$$

$$n_L = n_{Lc}\sqrt{1-\frac{1}{(2\theta_{si})^{2/3}}}\ . \tag{71}$$

We find that the dilation metric $1^2/((2\theta_{si})^{1/3})^2$ corresponds to Einstein's metric v^2/c^2. Multiplied by $l_f/n_T t_f$, the dilation expression corresponds to a relative velocity of 84.4755% of the speed of light. The expansion metric $2\theta_{si}$ describes the self-referencing lower bound to a three-dimensional volume with radius $3l_f$ (i.e. the quantum trigger event that causes inflation to cease where $\sqrt{3}>\frac{1}{2}>\sqrt{2}$). The cube root resolves the one-dimensional vector with respect to the reference l_f in the self-defining frame. Subtracting the ratio from one and taking the square root gives us the dilation metric between the self-defining and self-referencing frames.

3.8. What Defines Measure

If we step back and consider that all measure and thus all information is defined relative to other measures, then we might ask what defines measure? Why, for instance, is the fundamental measure for length l_f=1.61620 10^{-35} m?

We can look to the *fundamental expression*, $l_f m_f=2\theta_{si}t_f$, but that doesn't provide us a great deal of clues. After all, an expression that defines the three measures relative to one another only confirms our understanding that all measure is relatively defined. But the conundrum helps us to realize that we are seeking something that is even more fundamental to measure than the fundamental measures.

Counts of the fundamental measures are that quality of physical expression that is more fundamental. They are in themselves self-defined. When we say that there is an undefined quantity and it is equal to 2 or 3, no further definition is needed. We have an understanding of counts that is universally applicable. For instance, we may write 2+3=5. The terms are not relatively defined and thus are self-defining.

We may expose the relationship that exists between counts and measures with the dilation expression from above. Organized in Pythagorean form this expression is presented in Fig. 5 and may be written as

$$\frac{1}{(2\theta_{si})^{2/3}}+\frac{n_L^2}{n_{Lc}^2}=1\,. \tag{72}$$

There are three components. Firstly, there is a fixed value, in this case the value of 1. Secondly, there is a minimum. That is, there is a term which represents the lower bound to measure, $1/(2\theta_{si})^{2/3}$. And lastly, there is a maximum, a term which represents the upper bound to measure, n_L^2/n_{Lc}^2.

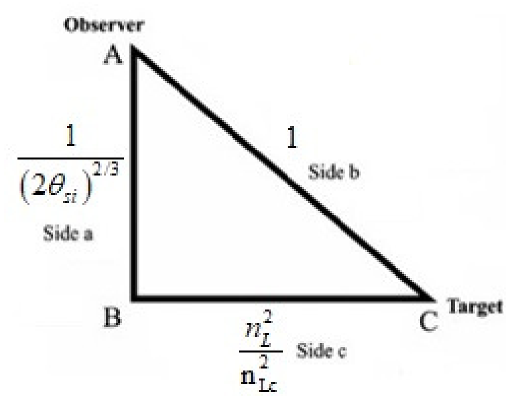

Figure 5. The Unity Expression, presenting the lower (side a) and upper bound (side b) ratios that define unity.

To further break down our understanding of this expression, we need to separate the elements that define their relation; that is, we need to separate the squared component terms that make up the Pythagorean Theorem from the component terms themselves. We might also want to substitute out $2\theta_{si}$ with the fundamental measures that we are seeking to define. And with that we may write a final self-defining expression which describes and gives rise to the relatively defined values of the fundamental measures. We call this the *unity expression*,

$$\left(\left(\frac{t_f}{l_f m_f}\right)^{1/3}\right)^2 + \left(\frac{n_L}{\mathrm{n_{Lc}}}\right)^2 = 1\,. \tag{73}$$

Note that the first term contains each of the three measures and for each dimension we must take the root to conform the term to the one-dimensional vector expression of the Pythagorean Theorem. Secondly, the three measures are the lower bound terms that define length, mass and time; the product of length and mass (3.51755 10^{-43} kg m) being the smallest significant value with respect to time (5.39106 10^{-44} s), the smallest value bound.

The second term is a count relation representing the upper bound portion of the relation. It consists of a ratio which measures against the upper bound, $\mathrm{n_{Lc}}$. Together, we have a singular correlation between measures and counts.

If we were to imagine a universe that differed from our own, then that difference would be expressed here. Any change in the expansion as expressed in n_L would precisely identify only one set of fundamental measures, specifically where $c=l_f/t_f$, respective of that universe. It is for this reason that we identify this expression as the *unity expression*.

3.9. Relation and Boundary Expressions

Notably, we should not conclude our discussion on relativity without bringing to your attention two classes of expressions that are physically distinct: relations and bounds.

All relations may be reduced to the *fundamental expression*, $l_f m_f = 2\theta_{si} t_f$. Relations such as the distributions of mass—visible, observable, fundamental, dark and total—are each modifications of the *fundamental expression*. Other examples include the diameter D_U and age A_U of the universe and the Planck $\hbar$ and Newton G constants,

$$M_{obs}M_{tot} + M_{obs}M_f = 2M_{tot}M_f\,, \tag{74}$$

$$D_U = 2\theta_{si} A_U\,, \tag{75}$$

$$4G\theta_{si}^2 = \hbar c^3\,. \tag{76}$$

But not all principles, laws or rules of nature are relations. There are also bounds, such as the speed of light c, mass density n_M and gravity G, respectively

$$c = l_f / t_f\,, \tag{77}$$

$$n_{LI} = 2n_M\,, \tag{78}$$

$$G = \frac{l_f}{t_f}\frac{l_f}{t_f}\frac{l_f}{t_f}\frac{t_f}{m_f}\,. \tag{79}$$

These expressions are important because they define upper and lower bound constraints to length, mass and time frequency and combinations thereof. Bounds may incorporate relations and may also contain variables which are specific to the scope of measured phenomena. We may, for instance, use a relation such as the *fundamental expression*, to make like substitutions to a bound and resolve other bounds. Starting with the expression for the gravitational constant G, we may resolve escape velocity,

$$\frac{Gm_f}{l_f} = \frac{l_f}{t_f}\frac{l_f}{t_f}, \tag{80}$$

$$\sqrt{2}c = \left(\frac{2Gm_f}{l_f}\right)^{1/2}, \tag{81}$$

$$\sqrt{1^2+1^2}\,c = \left(\frac{2Gm_f}{l_f}\right)^{1/2}. \tag{82}$$

The bound for escape velocity $v_e=(2GM/r)^{1/2}$ arises from the expression for gravity. When multiplied by the fundamental measure for time,

$$\sqrt{1^2+1^2}\,l_f = t_f\left(\frac{2Gm_f}{l_f}\right)^{1/2}. \tag{83}$$

the expression describes distance using the Pythagorean Theorem, distance $C=(A^2+B^2)^{1/2}$. Naturally, where $c=l_f/t_f$, the lower bound to escape velocity times the fundamental time t_f is $\sqrt{2}$ units of l_f which resolves to the reference l_f on side *a* defined against itself, l_f on side *b*.

Distinguishing relations from bounds is instrumental in recognizing that there exists no common '*unified field equation*' uniting them. Efforts to unite gravity with the other fundamental forces are an example of this disconnect. Gravity, as demonstrated here, is a geometric property best described by the Pythagorean Theorem as a distance phenomenon subject to whole-unit measurement limitations.

4. DISCUSSION

Measurement quantization has revealed several notable properties that apply to our understanding of space-time, to our understanding of relativity and our understanding of cosmological phenomena that present themselves as properties of our universe. While we may describe these phenomena in several mathematical forms, if it were not for measurement quantization, we would not see the numerical qualities of dilation and how the Pythagorean Theorem plays into that description. We would also have no recourse with which to gain a greater understanding of measure, constrained to a self-referencing framework of fundamental values.

Informativity brings us not just a new model of physical expression, but a self-defining framework for the description of phenomena. With this perspective, we are able to provide a more refined understanding of gravitation, of equivalence and as expressed in the *unity expression*, an underlying description of measure and the geometric constraints that bind their values.

Notably, we are able to expand on our understanding of relativity to not only include the self-referencing inertial frame of the observer, but also the self-defining frame of the universe. Without this broader understanding, we would find ourselves without a firm understanding of some of the greater cosmological mysteries such as dark energy, dark matter and the expansion of the universe.

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