Measurement quantization unites classical and quantum physics

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ABSTRACT

Unifying quantum and classical physics has proved difficult as their postulates are conflicting. Using the idea of fundamental units and counts of those units, a unifying description is resolved. This description is presented as a set of postulates under which conversion between quantum and classical expressions can be made. Derivations of well-known expressions from different areas of physics (quantum mechanics, quantum physics, gravitation, cosmology, special and general relativity) exemplify the approach and mathematical procedures. The model offers insight into quantum measurement, quantization and black holes. Solutions are offered that provide insight to dimensionality, dark matter and dark energy. Quantized formulations of cosmological constants are presented. And finally physical predictions are made, both confirmed and to be measured.

POPULAR SUMMARY

In our effort to understand and describe the physical world around us, many have attempted to connect quantum and classical physics, our best understanding of the very small and its relation to the very large. Ideally success would be distinguished with a single equation or at least a single model from which everything may be understood and described. Alternatively, success might provide only a means to translate between quantum and classical expressions. In this paper a model is presented that accomplishes some of these goals.

To date, gravity has been the center of attention in this effort, the only force which has no formal relation with existing models nor a fundamental understanding as to why it exists. This paper begins with a geometric description that presents gravity. With that a new cosmological measure is discovered that leads to a host of discoveries, including insightful explanations to the underpinnings of dark matter and dark energy. Significant insights are presented regarding black holes, General Relativity and quantum uncertainty. The efforts of Planck regarding fundamental measures are also independently resolved and verified.

1. INTRODUCTION

Of the nature of electromagnetic radiation (ER) and its unique properties in relation to blackbody spectral emissions, Planck observed that the best description of light involved a model of quantized energy packets. He found ER adhered to the equation $E=nhv$ where the number of packets n times Planck's constant h and frequency v equaled energy E [1]. It was Planck's hypothesis that h denoted the smallest action that could exist in nature. With this, he proposed that each measure may be described such that

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

$$t_p = \left(\frac{\hbar G}{c^5}\right)^{1/2} s \text{ [2][3]}, \tag{2}$$

$$m_p = \left(\frac{\hbar c}{G}\right)^{1/2} kg \text{ [2][3]}. \tag{3}$$

Planck's work surrounding the idea of fundamental units is central to resolving a divide that separates quantum and classical physics. While there exists successful models in each of these disciplines, there has been no mechanism to interrelate them and some speculation that a relation may not exist [4].

The most promising efforts include M-theory [5] (an application that arises from string theory) and Loop Quantum Gravity (LQG) [6]. Each have had some success in contributing to a Theory of Everything (ToE) [7], but have not produced a straight-forward approach to interrelate quantum and classical expressions. This appears to stem from an inability to resolve fundamental values when using statistical, iterative, integrative, recursive and similar higher-order operators.

A second inhibitor to a successful ToE is the chosen framework. Some constructs can lead to nondimensionalization [8] which can be beneficial in gaining access to important quantum relations, but can also make it difficult to extend results back to meaningful physical expressions. In reflection of this work, many models incorporate constructs that inhibit or restrict access to quantum relations. Without a framework defined relatively in the least fundamental terms and implemented with the lowest-order operators, resolution of fundamental expressions can be significantly impeded or entirely excluded [9]. Planck's formulations, in contrast, rests on a nondimensionalized framework of fundamental measures that allow expressions of quantized relations, but suppress a grounded understanding of their origin. While the model herein also presents a framework of fundamental measures, it does not use Planck's formulations nor coincidental correlation as an origin of argument.

Taking the broader view, a quantized approach can also be a matter of conjecture as to what type of model best describes nature and such presumptions should be circumspect from all points of view. Where statistics would apply well to probabilistic behavior, low-order operators would find success with a universe inherently quantized. The unstated bias is that the universe is more quantum than quantized. It is this paper's opposing perspective that separate this approach over others.

M-theory appears least likely to resolve the bridge. The foremost cited understanding of M-theory is based on matrix theory [10], a quantum mechanical model on which many formulations of Edward Witten's idea [11] are described. LQG avoids some of these issues, specifically nondimensionalization, with formulation that arises from a framework with background independence [12]. LQG follows a relativistic construct built on fundamental units, but, like M-theory, implementations invest significantly in the use of higher-order operators. Specific constructs, such as expressions arising around quantum constraint, create an abstraction layer that make resolution of quantized terms difficult.

Described within is a whole-unit model that allows translation between quantum and classical expressions through the quantization of measurement. The model makes use of the lowest-order operators and is built on a background independent framework. The presentation begins with a geometric proposition that in turn presents a quantized description of gravity. These expressions then present argument that validate the significance of minimum measures as an attribute of observation. This in turn is correlated to data that supports their application. This presentation does not make use of Planck's formulations instead arising directly from a set of numerical and geometric postulates.

The model is successful in several areas inclusive of new physical predictions both quantum and macroscopic. For one, using the Bell state model presented by Shwartz and Harris, [11] as supporting evidence, expressions are presented that describe the existence of a relativistic effect at work in the measure of G and $\hbar$. This effect is mathematically characterized and then reflected in Einstein's, Planck's and Heisenberg's formulations. The work is furthered with formal expressions describing the dark matter and dark energy phenomenon. Conflicts with General Relativity (GR) are also addressed.

The model is referred to as Informativity, a term chosen in respect to a model in which conversion between quantum and classical expressions may be made in reflection of the idea that observation is an outcome defined entirely by the information within a system. And the system is a construct that gives definition to information by constraint; in this case a constraint to measure characterized by whole-unit integers.

2. METHODS

The model is based on the idea that three measures may be relatively defined: length, time and mass. They are identified with the symbols l_f, t_f and m_f, but are not assigned values. To distinguish the fundamental measures of Informativity from Planck's measures l_p, t_p and m_p we use the subscript $_f$. We also recognize that phenomenon may be understood with respect to a count of the unit measures, whole or fractional. This process of counting we call measurement.

Length and time are defined against light in a vacuum where $c=l_f/t_f$. We recognize that the ratio of l_f to t_f is fixed in consideration of support for an invariant value for c. Where $nl_f=nt_fc$, we also recognize that a count of l_f units will equal a count of t_f units. Lastly we recognize that l_f and t_f may take any value and as such a hypothetical value may be chosen for which no smaller value can be observed. The value does not need to be assigned or known to have physical significance.

There exists no motivation to define mass in this way. Thus, a mass phenomenon may be a whole or fractional count of m_f. Despite the modified definition for mass, we will refer to each of the measures as fundamental which only means that the measures are countable.

The model carries four outcomes which we will identify here and then discuss:

O_1: The model has units which are a whole-unit count of a fundamental measure: l_f or t_f.
O_2: The model also has mass units m_f which may be whole or fractional.
O_3: Any remainder of a whole-unit calculation of l_f or t_f describes an action.
O_4: Where the Pythagorean Theorem describes distance, side a is 1, the reference count against which counts of b and c are defined.

O_1 and O_2 recognize that measure is defined relatively, an underlying premise of the model. With a unit system applied, there exists an agreed upon framework by which phenomenon may be described by counting fundamental measures.

O_3 recognizes the possibility that some expressions may solve for fractional counts of fundamental measures. Fractional unit counts violate the definition against which l_f and t_f are defined. Thus, any expression that describes a change in distance equal to the fractional measures must also describe an action.

O_4 presents a tool for describing length, the Pythagorean Theorem. Where measure is relatively defined, the theorem must also incorporate a reference and the reference must be equal to a unit count of 1. Thus, side $a=1$ unit is the reference. Side b is any given unit count of distance. And side c (the hypotenuse) is the unknown unit count of distance. Each side is a count of the reference measure defined by a. This establishes the foundation for a background independent framework which requires recognition of a reference within the definition. $1^2+b^2=c^2$ describes an unknown distance c relative to b in terms of units of a. As desired, solutions to c result in values that are fractional leaving us to test the hypothesis that gravity may be described as a loss of the fractional measure counts of a whole-unit model.

While we recognize that the measure of fundamental units is limited, this does not mean they cannot be verified. Verification against existing data will be one goal of the model. Secondly, while we will be using the Pythagorean Theorem to understand distance, there is no specific argument to suggest that another geometric expression would not serve the same purpose. The theorem provides insight only so long as it allows the presentation of expressions that cannot be reduced by another means. Finally, the term *fundamental* was chosen as a general term that embodies the idea that measure has the characteristic of being countable and that phenomenon may be characterized as a count of fundamental measures. The term also serves to distinguish Planck's description of units of measure from those presented by Informativity.

While the unit expressions from Planck and Informativity are similar, the assumptions, origins, components and mathematical presentation differ. Thusly noted, Planck's formulations are referenced for context, but are considered only as a guide in the development of this model. It is understood that the model implies values for the fundamental measures as are resolved entirely under Informativity.

3. RESULTS

A. Gravity

We may now solve for side c, a count of length units representing the uncertain distance where side $a=1$ and side b is any chosen integer count.

$$c=\left(1+b_{Lf}^{2}\right)^{1/2} \tag{4}$$

Any non-whole-unit count is presented in the form of an action and may be described by rounding up *(repulsion)* or down *(attraction)*. The remainder lost to rounding will be denoted by the term Q_{Lf}. For all solutions, Q_{Lf} is less than half and thus attractive. The model presents a count of distance units that are closer at every instant in time.

$$Q_{Lf}=\left(1+b_{Lf}^{2}\right)^{1/2}-b_{Lf} \tag{5}$$

Note that the observed distance count r_{Lf} differs from the calculated distance count by Q_{Lf} such that side $c=r_{Lf}+Q_{Lf}$. With this we may compose an expression for gravity such that the loss of distance counts relative to observed distance counts is Q_{Lf}/r_{Lf}.

It is noted, that Q_{Lf} and r_{Lf} are unit counts of distance that are conjectured to represent an important dimensionless ratio that describes gravity. We may proceed with that hypothesis by presenting in meters per second squared where we multiply by l_f for meters and divide by t_f^2 together describing fractional distance losses at the maximum sampling rate, one sampling every t_f seconds per second.

$$\frac{Q_{Lf}l_f}{r_{Lf}t_f^2} \tag{6}$$

We now note that this framework is scaled and requires a scaling constant. Multiply by the speed of light c and divide by the scaling constant S. Then reduce where $r=r_{Lf}l_f$ and $c=l_f/t_f$.

$$\frac{Q_{Lf}l_f}{r_{Lf}t_f^2}\frac{c}{S}=\frac{Q_{Lf}c^2}{r_{Lf}t_f S}=\frac{Q_{Lf}l_f c^2}{r_{Lf}l_f t_f S}=\frac{Q_{Lf}c^3}{rS} \tag{7}$$

It should be noted that the scaling factor c/S may be understood as $1/kg$ or a maximum count of fundamental mass units. It may also be thought of as the corresponding mass frequency associated with gravity. Where $S=3.26239$, this expression is now equivalent to G/r^2 to five significant digits for all distance greater than 10^3 l_f differing by measures beyond current technology. Where quantum differences are not a consideration we may set (7) equal to G/r^2 such that

$$\frac{Q_{Lf}c^3}{rS}=\frac{G}{r^2} \tag{8}$$

$$Q_{Lf}rc^3=GS \tag{9}$$

There are several considerations regarding the development of this expression that we will now explore. The first and most concerning may be a unit analysis and under what circumstances is it appropriate to equate an expression with dimensionless terms to Newton's expression. The second involves the introduction of *S* where a straight-forward interpretation of *S* as momentum would resolve many issues. The detour is intentional and fundamental to this paper. The terms exposed here describe characteristics that violate the definitions against which they are defined and it is in the presentation of these paradoxes that new insights may be made. Where G/r^2 may take any value, infinitely large or small, Informativity may not. As a quantized model based on the counting of unit measures constrained by observations of light, there exist limits to how small and large a measure may exist. These limits impose rules, structure and relationships. To begin an investigation of the scaling constant, consider (9) where

$$\frac{c^3}{G}=\frac{S}{Q_{Lf}r}. \tag{10}$$

Multiply both sides by t_f to give us mass. Then reduce the right term where $r=r_{Lf}l_f$, $c=l_f/t_f$ and the $lim_{b\to\infty}f(Q_{Lf}r_{Lf})=1/2$ as noted in appendix 1. The term $Q_{Lf}r_{Lf}$ is referred to as the *Informativity differential* recognizing the central role it plays in describing how fractional values less than the theoretical limit reflect a distortion effect on measurement.

$$m_f=t_f\frac{c^3}{G}=t_f\frac{S}{Q_{Lf}r_{Lf}l_f}=\frac{2St_f}{l_f}=\frac{2S}{c}\ kg \tag{11}$$

Also note that we may reorganize (1) such that $c^3/G=\hbar/l_f^2$, then replace c^3/G from (10), substitute where $lim_{b\to\infty}f(Q_{Lf}r_{Lf})=1/2$ and replace $\hbar=h/2\pi$ such that

$$S=Q_{Lf}r\left(\frac{c^3}{G}\right)=Q_{Lf}r_{Lf}l_f\left(\frac{c^3}{G}\right)=\frac{l_f}{2}\left(\frac{\hbar}{l_f^2}\right)=\frac{\hbar}{2l_f}=\frac{h}{4\pi l_f}. \tag{12}$$

Finally, where $E=mc^2=2Sc$ from (11) and $E=hv=h/t_f$, then the difference ΔE between these two energy expressions is $2Sc\Delta E=h/t_f$. Solving for the ΔE and substituting $S=h/4\pi l_f$ from (12), then

$$\Delta E=\frac{h}{2ct_f}\frac{1}{S}=\frac{h}{2ct_f}\frac{4\pi l_f}{h}=2\pi. \tag{13}$$

Where Einstein's formulation is expressed using Informativity terms as a whole-unit count of energy *E* and Planck's equation describes the smallest energy unit, the difference must be a whole-unit count. The count cannot contain the value of π, a non-whole, non-repeating value. We are presented with an expression that violates the definitions against which the measures of kilograms, meters and seconds are defined.

Next we will consider a new argument from a different point of view. Using Planck's equation $E=nhv=h/t_f$ combined with Einstein's equation $E=mc^2$ with a difference of 2π (13), then note that $2\pi mc^2=h/t_f$ such that $m=h/2\pi l_f c=\hbar/l_f c$. Thus one Planck unit of momentum may be defined where $v=c$ such that

$$\rho_p = mv = \left(\frac{\hbar}{l_f c}\right)c = \frac{\hbar}{l_f}. \tag{14}$$

Starting with (12) where $S=\hbar/2l_f$ and replacing $\hbar/l_f$ with momentum, then

$$\rho_p = 2S. \tag{15}$$

Where $\rho_p= \hbar/l_f$ represents a fraction of the smallest action divided by the smallest length, then S must represent a value *2* times smaller. As well, it is inappropriate to introduce $\hbar$ where h is the smallest action in direct relation to the unit definitions, thus we will instead consider the relation $h=4\pi l_f S$. With this we find that the expression can be true only if there exists a property of nature in terms of h and l_f where l_f is smaller or h is larger, both which defy their definition. And with this we are again motivated to conclude that S cannot be a measure of kilograms, meters or seconds as any such description would violate the definitions against which these measures are defined.

A footnote in reflection of the above expressions that should be recognized is that S is not precisely momentum. It is one half of the momentum of a photon. This calls into question more than just a unit analysis, but what the significance of S might be in the description of light. This analysis also seriously calls into question the traditional point of view where starting with (9) and reducing with $lim_{b\to\infty} f(Q_{Lf} r_{Lf}) =1/2$ we get

$$S = \frac{Q_{Lf} rc^3}{G} = \frac{Q_{Lf} r_{Lf} l_f c^3}{G} = \frac{l_f c^3}{2G} \ \ kg\ m\ s^{-1}. \tag{16}$$

While this supports an interpretation of S as gravitational momentum, it factors out the *Informativity differential* reflecting an approach more similar to Planck's expressions presented in (1-3). The approach does address the unit issues discovered in the presentation of S nor does it expose a deeper understanding of S in relation to the constraints of a whole-unit model.

Consider now a hypothesis that resolves all these issues. Recognizing the regular appearance of 2π across many expressions in physics consider the geometric expression for the arc length of a circle $L=r\theta$. Where $L=\hbar/2$ is by definition a fraction of a circle and l_f is its radius then we may alternatively interpret (12) as a segment of a circle where the angle of the minor arc is

$$S = \theta = \frac{L}{r} = \frac{h}{4\pi l_f} = \frac{\hbar}{2l_f} \ \ radians. \tag{17}$$

The arc length defines a count of discreet units l_f representing a fraction of the circumference. Although this expression follows naturally, it would be challenging if it were not the definition of a minor arc, $L/circumference=\theta/2\pi$. With this expression for S now in radians, there are three complimentary considerations of support.

Note firstly that the radius of this circle is l_f. This follows naturally as this is the required reference measure of a background independent definition in the same way that side a must equal 1 unit of l_f in the presentation of the Pythagorean Theorem. Where we may now understand $\hbar/2$ as a measure of distance along the arc of a circle (the arc length) we find that there are θ radians of l_f in $\hbar/2$ such that the ratio $\hbar/l_f$ defines the momentum of a fundamental unit of mass. Note also where $C=2\pi r$, that there are 2π units of l_f in the circumference of a circle. And finally from (17) where $\hbar=2l_f\theta$ then we may reduce (19) to show that $C=2\pi r=2\pi l_f$ as a ratio of the arc length compared to the arc of a circle is

$$\frac{\hbar/2}{\theta\ rad}=\frac{X}{2\pi\ rad}, \tag{18}$$

$$X=\frac{\hbar\pi}{\theta}=\frac{2\pi l_f\theta}{\theta}=2\pi l_f. \tag{19}$$

While already resolved, this final expression constrains r and validates that no other combination of terms will satisfy all expressions. These expressions provide a precise mathematical interpretation that establish S as a radian measure.

Lastly, one might ask if there is a physical phenomenon that demonstrates S above its importance in describing gravity? There are several characteristics thus far outlined. The phenomenon should be a property of light on which the model rests. It should be an angular measure in radians. Naturally, it should have a value precisely equal to $Q_{Lf}rc^3/G$. It should represent either a property or measurement limit that describes an invariant quality of light at a threshold. And, finally it should posses a characteristic of duality, that in some situations appears as momentum while in others is reflected as an invariant limit in angular measure.

A review of optics research regarding properties of light reveals a measure that precisely matches such a description. Where S defines angular measure in radians, S also describes the angle θ_{si} of the k-vector required between beams of polarized X-rays to entangle photons at the degenerate frequency. The correlation between S and θ_{si} match in value, units and application. θ_{si} is known to five significant digits to be *3.26239 radians* identical in value to $Q_{Lf}rc^3/G$. A model representing angular measures for quantum entanglement using polarization entangled photons in pure Bell states at X-ray wavelengths was first presented by Shwartz and Harris in 2011. [11] Their model correlates and validates this measure precisely. Additional research is published in Nature where error in angular measurement is estimated to be less than 2 micro-radians [13].

If either the momentum of gravity or the signal and idler measures for quantum entanglement had not been invariant, the correlation of these values would be entirely coincidental. The fact that both are invariant quickly draws attention to the correlation and if not for the straight-forward derivations in (10-19), we might find ourselves without significant clues that firmly define S as a radian measure. As such, we will no longer refer to the scalar constant as S, but instead recognize it by the term θ_{si} denoting its significance as a fundamental cosmological measure important to the construct of the universe.

The presentation here is not that there exists a constant of gravitational momentum, but that θ_{si} and ρ_p are two expressions that describe a common phenomenon with characteristics reflective of wave-particle duality. θ_{si} appears as a valid interpretation where expressions denote quantum properties, such as light waves. ρ_p, in contrast, finds a greater applicability in respect to expressions that describe particles. With respect to measures of quantum entanglement, each of the *four* Bell states have angular measures for the pump, signal and idler and in this case the signal and idler are the scalar constant S. It is conjectured that each of the four Bell states correlate to one of the four fundamental forces of nature, but that will not be explored in this paper.

In reflection of Planck's work, one might argue that this approach is a presentation at its base a product of Planck's units. Informativity escapes this label arising entirely from a background independent geometric argument. The role of fundamental units at this point is only a mathematical construct, a proposed interpretation of the existing argument. The units are not correlated to physical measure and exist only in concept until formally resolved in the next section. And finally, while CODATA estimates may be used to guide our understanding of S, to this point no theoretical values are assumed. Our confidence in correlating S to θ_{si} rests in reflection of the presented paradoxes to unit definition and their resolution in (17).

One might also view this as an innovative alternative to Newtonian vector calculus thus side-stepping what might be an otherwise traditional understanding of gravitation. But such argument would also work against an underlying premise of this paper, that higher-order operators disguise fundamental constructs. Where a treatment using vector calculus would resolve the traditional presentation, the quantum relationship to θ_{si} would be lost or at least well disguised.

B. Fundamental units

The fundamental units l_f, t_f and m_f may be resolved by substituting $r=r_{Lf}l_f$ in (9) and solving for l_f. Then reduce where $lim_{r\to\infty}f(Q_{Lf}r_{Lf}) = 1/2$ such that

$$l_f = \frac{G\theta_{si}}{Q_{Lf}r_{Lf}c^3} = \frac{2G\theta_{si}}{c^3} = \frac{2*6.67408\ 10^{-11}*3.26239}{(299792458)^3} = 1.61620\ 10^{-35}\ m. \quad (20)$$

Where time follows from the definition $t_f=l_f/c$ then

$$t_f = \frac{l_f}{c} = \frac{2G\theta_{si}}{c^4} = \frac{2*6.67408\ 10^{-11}*3.26239}{(299792458)^4} = 5.39106\ 10^{-44}\ s. \quad (21)$$

And finally consider (9) in the following form

$$\frac{c^3}{G} = \frac{\theta_{si}}{Q_{Lf}r}. \quad (22)$$

Where $r=r_{Lf}l_f$, expand r and multiply both sides by t_f. Then reduce the right term where $lim_{r\to\infty}f(Q_{Lf}r_{Lf}) = 1/2$, reduce where $c=l_f/t_f$ and resolve $2\theta_{si}/c$ which is mass.

$$t_f\frac{c^3}{G} = t_f\frac{\theta_{si}}{Q_{Lf}r_{Lf}l_f} = \frac{2\theta_{si}t_f}{l_f} = \frac{2\theta_{si}}{c} = \frac{2*3.26239}{299792458} = m_f = 2.17643\ 10^{-8}\ kg \quad (23)$$

Where we may consider θ_{si} as momentum, then the units will work out as desired. This is a matter of perspective, but has no bearing on our understanding of θ_{si} as a measurement characteristic that presents two forms in a wave-particle duality. Also note, where l_f and t_f are proposed to be the smallest possible measures, m_f is not. m_f does play a central role in many expressions because it is a product of the first two and for that reason we distinguish the term.

The Informativity formulations parallel Planck's formulations although they are presented in quantized terms and are entirely formulated under the background independent framework of Informativity. The fundamental unit expressions are not theoretical coincidence. They arise from our comparison of geometric and Newtonian expressions for gravity (8) and are defined in terms of c, G and θ_{si}. The ability to resolve the fundamental units entirely as a product of physical expression is an important and decisive difference in this model in comparison to Planck's formulations.

It should be noted that the fundamental units can never be directly resolved. This would defy their definition. The fundamental units are the reference against which everything is defined. It would be neither possible or meaningful to measure a reference where the most appropriate reference is the reference itself. Fundamental units can only be inferred as a characteristic of phenomenon that indicate their significance. The best example of such work was pioneered by Planck and presented in his formulation $E=nhv$.

C. Gravitational acceleration

Using (8) to calculate G will show a difference from Newton's presentation at the quantum scale. Is G variable [14]? No. The difference is a reflection of the difference between the more precise geometric model of Informativity in comparison to Newton's presentation. The difference is a combination of this difference along with a measurement distortion effect described by the *Informativity differential* $Q_{Lf}r_{Lf}$.

TABLE 1: Informativity Difference in Gravitational Acceleration from G/r^2

	$50\ l_f$	$100\ l_f$	$200\ l_f$	$300\ l_f$	$500\ l_f$	$1000\ l_f$
Difference	0.00100%	0.00250%	0.00062%	0.00028%	0.00010%	0.00003%

For clarity, we will work through a calculation in detail. Also note that uncertainty in the value of l_f has no measurable effect on the result so long as a reasonable macroscopic distance is chosen. A distance of one meter is intentionally selected against which G is defined. Using (20) for l_f, the inverse gives us a count in one meter such that $b=6.18735\ 10^{34}$.

$$Q_{Lf} = c - b = \sqrt{1+b^2} - b = \sqrt{1+(6.18735\ 10^{34})^2} - 6.18735\ 10^{34} = 8.08100\ 10^{-36} \tag{24}$$

$$\frac{Q_{Lf}c^3}{r\theta_{si}} = \frac{8.08100\ 10^{-36} * (299792458)^3}{1 * 3.26239} = 6.67407\ 10^{-11} m/s^2 \tag{25}$$

This is G/r^2 at a distance of one meter, which is G. It should be noted that CODATA [2][15] regarding estimates of the fundamental values and measures of constants have changed from the inception of this paper. A review of CODATA has found that estimates have been supportive of the expressions of Informativity.

D. Resolving the Planck discrepancy

Until section B this paper had not resolved the fundamental measures. The relations that correlate the scalar constant *S* with the signal and idler measures θ_{si} for quantum entanglement are resolved in expression, but calculation of those measures has not been explored. In this section, we will investigate how the use of different terms affect that calculation. This investigation also builds on the prior presentation in section C. We start with (9), divide by *G,* substitute $r=r_{Lf}l_f$ and separate out c^3/G for presentation only.

$$\theta_{si} = \frac{Q_{Lf} r c^3}{G} = \left(\frac{c^3}{G}\right) Q_{Lf} r_{Lf} l_f = \frac{c^3 l_f}{2G} = 3.26239 \ \ radians \tag{26}$$

This is an accurate presentation in keeping with the definitions of each of these terms. The measure for θ_{si} exactly matches measurements made by Shwartz and Harris as described in their paper [11]. In comparison, now consider Planck's formulation in (1) expressed in terms of fundamental units as

$$\frac{c^3}{G} = \frac{\hbar}{l_f^2}. \tag{27}$$

Replace c^3/G with the right portion of Planck's formulation and reduce.

$$\theta_{si} = \left(\frac{c^3}{G}\right) Q_{Lf} r_{Lf} l_f = \left(\frac{\hbar}{l_f^2}\right) Q_{Lf} r_{Lf} l_f = \frac{\hbar}{2 l_f} = 3.26250 \ \ radians \tag{28}$$

The later formulation violates the prerequisites on which these terms are defined. It is only in consideration of term definition that Planck may have realized his relations were at best approximations.

As noted in (8), drawing a parallel to Newton's expression for G/r^2 is accurate only where distance is great. Secondly, the Informativity differential equals 0.5 only under the same circumstances. These two prerequisites disqualify the introduction of a quantum term such as $\hbar$ into the expression as it is currently defined. Although we may remove the assumption $lim_{b\to\infty} f(Q_{Lf} r_{Lf})=1/2$, at best we find that calculation of θ_{si} matches (26) at a quantum distance of $85 l_f$. This calculation is not significant because the base formulation from (9) is predicated on measurement at a distance and as such the terms are still inappropriately applied.

We may gain a better understanding of this issue as we did with the gravitational constant by solving for Planck's constant using (28) such that

$$\hbar = \frac{l_f^2 \theta_{si}}{Q_{Lf} r_{Lf} l_f} = \frac{l_f \theta_{si}}{Q_{Lf} r_{Lf}}. \tag{29}$$

In this form, we may solve for various values between 85 l_f and 14 billion light years displayed here in Table 2.

TABLE 2: Informativity Difference in Planck's reduce constant ħ

	85 l_f	*100 l_f*	*200 l_f*	*300 l_f*	*500 l_f*	*14 bly*
Difference	0.00001%	0.00097%	0.00285%	0.00319%	0.00337%	0.00347%

And with this, we are motivated to consider that Planck's reduced constant can be corrected if we consider measurement at a distance. Where the CODATA value for $\hbar=1.05457\ 10^{-34}$ [2], we may resolve ħ by solving (29) where $\lim_{b\to\infty} f(Q_{Lf} r_{Lf})=1/2$ such that

$$\hbar = \frac{l_f \theta_{si}}{Q_{Lf} r_{Lf}} = 2\theta_{si} l_f = 1.05454\ 10^{-34}\ Js. \tag{30}$$

With this new value for Planck's reduced constant, the Informativity and Planck formulations become mathematically equivalent.

$$\frac{2G\theta_{si}}{c^3} = \left(\frac{\hbar G}{c^3}\right)^{1/2} \tag{31}$$

$$\frac{2G\theta_{si}}{c^4} = \left(\frac{\hbar G}{c^5}\right)^{1/2} \tag{32}$$

$$\frac{2\theta_{si}}{c} = \left(\frac{\hbar c}{G}\right)^{1/2} \tag{33}$$

Each expression may be reduced to

$$4G\theta_{si}^2 = \hbar c^3 \tag{34}$$

We may now understand the fundamental constants in respect to a new measure. Where there exist uncertainty in the derivation of l_f, t_f and m_f, we may express fundamental units in terms of θ_{si} instead of ħ. At the same time, this expression also confirms that any geometric distortion in ħ is proportionally compensated with the same in *G*. While this discovery does not remove the distortion effect presented in Table 2, it does bring to our attention that the *Informativity differential* plays an important role in measurement. This presentation also confirms that these two very different approaches arrive at precisely the same results.

E. Fundamental units correlated

In (20-23), we used limits to resolve the fundamental units and while that is sufficient for macroscopic observation, it is not representative of a quantum formulation. Here, we will resolve the quantum formulations which require that we regress back to the formal definitions in our solution for gravitational acceleration. To solve for mass we begin by solving for time with (7).

$$t_f = \frac{Q_{Lf} c^2}{r_{Lf} A_G \theta_{si}} \tag{35}$$

Utilizing the $\Delta(t_f \rightarrow m_f)$ transform from (76) where $m_f = t_f c^3/G$, multiply by c^3/G and then replace the left side by m_f. Then in (37) substitute where $A_G = G/r^2$ and $G = Q_{Lf} r c^3/\theta_{si}$ from (9).

$$t_f \left(\frac{c^3}{G}\right) = \frac{Q_{Lf} c^2}{r_{Lf} A_G \theta_{si}} \left(\frac{c^3}{G}\right) \tag{36}$$

$$m_f = \frac{Q_{Lf} c^5}{r_{Lf} A_G \theta_{si} G} = \frac{Q_{Lf} c^5}{r_{Lf} \theta_{si} G} \frac{r^2}{G} = \frac{Q_{Lf} c^5 r^2}{r_{Lf} \theta_{si} G^2} = \frac{Q_{Lf} c^5 r^2}{r_{Lf} \theta_{si}} \frac{\theta_{si}^2}{Q_{Lf}^2 r^2 c^6} = \frac{\theta_{si}}{Q_{Lf} r_{Lf} c} \tag{37}$$

Note again, the *Informativity differential* $Q_{Lf} r_{Lf}$ with limits as noted in appendix 1. Informativity describes measure as a function of distance. This is an entirely different effect than that of GR. To continue, we may translate (37) to length and time by multiplying by the fundamental transforms $\Delta(l_f \rightarrow m_f)$ where $l_f c^2/G = m_f$ (75) and $\Delta(t_f \rightarrow m_f)$ where $t_f c^3/G = m_f$ (76). Each also carry the Informativity effect.

$$l_f = \frac{\theta_{si} G}{Q_{Lf} r_{Lf} c^3} \tag{38}$$

$$t_f = \frac{\theta_{si} G}{Q_{Lf} r_{Lf} c^4} \tag{39}$$

We may further reduce mass (37) with $c = l_f/t_f$ (74), length (38) with $G/c^3 = t_f/m_f$ (76) and time (39) with $G/c^2 = l_f/m_f$ (75). With this we factor out G and c further reducing each of the measures.

$$m_f = \frac{\theta_{si} t_f}{Q_{Lf} r_{Lf} l_f} = \frac{t_f}{l_f} \left(\frac{\theta_{si}}{Q_{Lf} r_{Lf}}\right) \tag{40}$$

$$l_f = \frac{\theta_{si} t_f}{Q_{Lf} r_{Lf} m_f} = \frac{t_f}{m_f} \left(\frac{\theta_{si}}{Q_{Lf} r_{Lf}}\right) \tag{41}$$

$$t_f = \frac{\theta_{si} l_f}{Q_{Lf} r_{Lf} m_f c^2} = \frac{\theta_{si} l_f t_f^2}{Q_{Lf} r_{Lf} m_f l_f^2} = \frac{Q_{Lf} r_{Lf} m_f l_f}{\theta_{si}} = m_f l_f \left(\frac{Q_{Lf} r_{Lf}}{\theta_{si}} \right) \tag{42}$$

And finally, combining all three where $lim_{b\to\infty} f(Q_{Lf} r_{Lf})$, then

$$l_f m_f = 2\theta_{si} t_f . \tag{43}$$

With this we may understand each measure with respect to the other two, but no less. Their definition is inescapably circular. We may observe:

> *O_5: Where $m_f=2\theta_{si}/c$, mass (energy) is constant and does not change with time, ever* [16].
> *O_6: Where $l_f=t_f(2\theta_{si}/m_f)$* and *$t_f=l_f(m_f/2\theta_{si})$ the forward motion of time 'requires' increasing length – dark energy.*
> *O_7: Mass is a composite of length and time and alone can say little about the prior.*

With this we may now resolve values for energy using mass from (37) and Einstein's equation where n_{mf} is a count of mass units.

$$E = mc^2 = n_{Mf} \left(\frac{\theta_{si}}{Q_{Lf} r_{Lf} c} \right) c^2 = n_{Mf} \left(\frac{\theta_{si} c}{Q_{Lf} r_{Lf}} \right) \tag{44}$$

Simplified where $n_{mf}=1$ and $lim_{b\to\infty} f(Q_{Lf} r_{Lf})=1/2$ we may also write

$$E = 2\theta_{si} c. \tag{45}$$

In comparison, Planck's formulation $E=nhv= \hbar/t_f$ where $\hbar$ is expressed as described in (30) is

$$E = n_{Mf} hv = \frac{n_{Mf} \hbar}{2\pi t_f} = \frac{n_{Mf} 2\theta_{si} l_f}{2\pi t_f} = n_{Mf} \left(\frac{\theta_{si} c}{\pi} \right). \tag{46}$$

As noted in (13), the difference in energy between a unit of mass (45) and a photon (46) is precisely 2π reflective of a geometric presentation in radians. Note also that the *Informativity differential* is missing from the description of light. Light is invariant to distance; the measured energy is fixed.

F. Quantum uncertainty

With the fundamental units properly formulated, we may turn our attention to Heisenberg's uncertainty principle [17]

$$\sigma_X \sigma_P \geq \frac{\hbar}{2}. \tag{47}$$

With respect to Informativity we find that the product is correct, but the components are not. Where the standard deviation in position and momentum are respectively $\sigma_x=f(r_{Lf}l_f)$ and $\sigma_p=f(m_f v)$, we may use mass (37), replace the arc length $\hbar/2$ with (30), set $v=c$ and where mass incorporates the *Informativity differential* $Q_{Lf}r_{Lf}$, we introduce the same in position:

$$\sigma_X \sigma_P = f(r) f(mv) = (r_{Lf} l_f Q_{Lf} r_{Lf}) \left(\frac{\theta_{si}}{Q_{Lf} r_{Lf} c} v \right) \geq \theta_{si} l_f \tag{48}$$

This provides us with the expanded form of Heisenberg's uncertainty principle. Where the *Informativity differential* in the standard deviation of position and momentum cancel out, what differs are the individual standard deviations. Relative to the interaction, the calculation of position or momentum will have differing certainty. This observation is predicated on our understanding of mass. If not for that understanding we would not realize that position must also carry the *Informativity differential*.

As a last note, the above formulation is easy to validate. Where the *Informativity differential* $Q_{Lf}r_{Lf}$ in position and momentum each cancel we may look at their respective limits and reduce. Setting $v=c$ and $r_{Lf}=1$, then

$$\sigma_X \sigma_P = ((1) l_f Q_{Lf} r_{Lf}) \left(\frac{\theta_{si}}{Q_{Lf} r_{Lf} c} c \right) = \theta_{si} l_f \geq \theta_{si} l_f . \tag{49}$$

G. Limits to dimensions

Informativity prescribes limits in observation regarding interactions of bodies in dimension. Where interaction has been found to conform to expressions composing terms defined against a whole-unit model, solutions exist only for *(3D+t)*. The ability to resolve relationships is a particular strength of Informativity, but also one that depends on measurement counts. Thus, to understand how length and time are related, we look back to (43) and reintroduce counts.

$$nl_f m_f = 2\theta_{si} nt_f \tag{50}$$

In this form we see that the counts of length $nl_f=nt_f(2\theta_{si}/m_f)$ and time $nt_f=nl_f(m_f/2\theta_{si})$ are proportional and equivalent. We may understand each, not in their respective measures, but as counts of those measures each as discreet unit coordinates in a four dimensional Cartesian system. It follows that if no whole-unit solutions exist, then there exist no means for physical interaction.

The conjecture is one that rests on the geometric and numerical limitations of mathematical systems. If nature exhibited no such characteristics, expressions that presented limits as physical characteristics would fail to provide meaningful representations. Thus far, that has not been the case. We have found that the energy that separates $E=mc^2$ from $E=nhv$ is precisely 2π, the circumference of a circle. We have found that momentum and angular measure are one and the same in our understanding of the scalar constant *S*. We have found that gravity may be described entirely as a construct of the Pythagorean Theorem. And where there are other examples of nature conforming to geometry, this proposal is an extension. Thus,

In a system of unit measure counts, interactions may exist only where there are whole-unit solutions for every relation.

$$n_{Lf}^2 + n_{Lf}^2 + n_{Lf}^2 + n_{Tf}^2 = (2n_{Vf})^2 \tag{51}$$

This sample expression of a *(3D+t)* coordinate system may be generalized where dimensions *d* times the squared term *n* equals the square of a solution *s*. Where each term *n* is the same, then $dn^2=s^2$ and thus

$$s = n\sqrt{d} \tag{52}$$

Thus, whole-unit solutions exist only where the square root of dimensions is a whole-unit number: *1, 4*, *9 … n^2* dimensions. But, as each system of measure is defined relatively against a reference, all solutions are multiples of the first two states: identity *(1D)* and *(3D+t)*. That is, higher dimensional systems provide no distinguishing features of measure as their presentation is an indistinguishable extension of lower relations. This interpretation restricts several competing models such as string theory and M-Theory.

H. Black holes

$$v_e = \left(\frac{2GM}{r}\right)^{1/2} \text{ [18]} \tag{53}$$

Given escape velocity we may substitute the speed of light *c* for v_e, (8) for *G* and (37) for *M*. In that (37) represents one fundamental unit of mass, we will need to multiply by a count of mass units n_{Mf} that represent the gravitational object.

$$c = \left(\frac{2}{r}\frac{Q_{Lf}rc^3}{\theta_{si}}\frac{n_{Mf}\theta_{si}}{Q_{Lf}r_{Lf}c}\right)^{1/2} = \left(\frac{2n_{Mf}c^2}{r_{Lf}}\right)^{1/2} \tag{54}$$

Square both sides, cancel out *c* and carry r_{Lf}.

$$r_{Lf} = 2n_{Mf} \tag{55}$$

The most interesting observation as is true throughout Informativity is that this limit is entirely described by counts of the fundamental units, two units of mass for each unit of length. In reflection of the presentation regarding dimensionality, we again find a characteristic of nature bound by a mathematical relationship of whole-unit counts?

We may ask what this expression says about the interior of a black hole. As noted above, the relation describes mass and length at a limit. To extrapolate, we may say that any ratio that suggests a count of more than two units of mass per unit of length would imply an escape velocity greater than c. Such an argument has no support. Thus, the relation prescribes a maximum density for black holes.

To explore this interpretation, we may apply the formulation to a recently detected binary black hole event recorded on September 14th, 2015 (GW150914). Respectively calculated as 29_{-4}^{+4} and 36_{-4}^{+5} solar masses, the recorded black holes reached an orbital frequency of 75 Hz. Using the bounds of a sum of the Schwarzschild radii, the net distance would adhere to $2GM/c^2 \gtrsim 210\ km$ [19]. Where $r=r_{Lf}l_f$ and $n_{Mf}=M_s/m_f$, then the sum calculated with Informativity would consume $106+86=192\ km$ of the relative distance:

$$r = 36 * 2n_{Mf}l_f \frac{1\ km}{1000\ m} = \frac{72M_s l_f}{1000\ m} = 106\ km \tag{56}$$

$$r = 29 * 2n_{Mf}l_f \frac{1\ km}{1000\ m} = \frac{58M_s l_f}{1000\ m} = 86\ km \tag{57}$$

The similarity suggests support for the expression. But, this also suggests the Schwarzschild formulations presume that black holes have a density that is less than the theoretical limit. If a valid discrepancy exists, significant amounts of radiation would escape.

I. General relativity

GR and Informativity are in contention only in principle, differing primarily in paradigm. In the observational record, both models reflect identical measures. And as such, we are not asking whether one model is right or wrong, but which model provides expressions that lead to the simplest understanding of nature.

We will first establish this correlation by starting with Einstein's relativistic formulations and translate them each into whole-unit counts of the fundamental measures. Using time dilation from Special Relativity (SR) [20][21] which is traditionally adapted to a gravitational field by substituting the equation for escape velocity in place of the value v where t_l and t_o are time in the local and observed frame then

$$t_o = t_l \left(1 - \frac{v^2}{c^2}\right)^{1/2} = t_l \left(1 - \frac{2GM}{rc^2}\right)^{1/2}. \tag{58}$$

Next where $2GM/r=2n_{Mf}c^2/r_{Lf}$ from (53) and (54), then we may make the substitution and reduce Einstein's expression entirely to a count of the fundamental measures.

$$t_o = t_l \left(1 - \frac{1}{c^2}\frac{2GM}{r}\right)^{1/2} = t_l \left(1 - \frac{1}{c^2}\frac{2n_{Mf}c^2}{r_{Lf}}\right)^{1/2} = t_l \left(1 - \frac{2n_{Mf}}{r_{Lf}}\right)^{1/2} \tag{59}$$

The relation is simple and entirely quantized. It differs little from our investigation of black holes (55), the correlation of length and the time (52) or gravity (5). While both theories are accurate in the delivery of calculated physical characteristics, Informativity suggests that the formulations of GR are abstract presentations of existing geometric relationships. The same application applies also for length [22] and mass.

$$l_o = l_l \left(1 - \frac{2n_{Mf}}{r_{Lf}}\right)^{1/2} \quad (60)$$

$$m_o = m_l / \left(1 - \frac{2n_{Mf}}{r_{Lf}}\right)^{1/2} \quad (61)$$

While Einstein strongly disliked the concept of relativistic mass [23], Informativity skirts the issue by describing the observation of mass in a gravitational field as a geometric distortion relative to the local frame.

J. Dark energy and dark matter

With further inspection $l_f m_f = 2\theta_{si} t_f$ from (43) may also be applied to the universe. Multiply by the universe's diameter $D_u = n_{TfD}$ (billion light-years) and age $A_u = n_{TfA}$ (billion years) as a count of fundamental units times t_f. Where $l_f = ct_f$ reduce.

$$(n_{TfA} n_{TfD} t_f) l_f m_f = 2\theta_{si} t_f (n_{TfA} n_{TfD} t_f) \quad (62)$$

$$(n_{TfD} t_f) m_f \left(\frac{n_{TfA} t_f c}{n_{TfD} t_f}\right) = 2\theta_{si} (n_{TfA} t_f) \quad (63)$$

$$D_U m_f \left(\frac{A_U c}{D_U}\right) = 2\theta_{si} A_U \quad (64)$$

A single solution exists for each moment in time D_U and A_U, where $(A_U c/D_U) = 1/m_f$ cancels m_f.

$$D_U = 2\theta_{si} A_U = 2 * 3.26239 * 13.799 = 90.0354 \ billion\ light\ years \quad (65)$$

$$m_f = \frac{D_U}{A_U c} = \frac{90.0354}{13.799 * 299792458} = 2.17643\ 10^{-8}\, kg \quad (66)$$

Providing A_U gives us D_U, m_f and their relation. Current measurements for D_U and A_U are respectively 91 billion light-years and 13.799 +/- 0.021 billion years [24]. Thus, as the universe ages its diameter 'must' expand. Informativity suggests that the geometric relations of our universe are changing with respect to time and that change is affecting our understanding of distance. In 2011, formulations by Barrow and Douglas comparing the cosmological constant and the age of the universe had been worked out predicting a constant relationship [25]. In 2015, analysis of WMAP data by Gasanalizade and Hasanalizade furthered our understanding confirming a constant correlation between the age of the universe and its expansion [26]. Each of these studies confirm the expressions presented here.

In reflection of the formulations regarding dark energy Informativity offers an opportunity to conjecture a possible cause for dark matter. While the mechanism for the expansion of space (geometric distortion) is not fully understood, there does exist ample data to confirm that we are observing an expansion. The magnitude of that expansion is decipherable from (65) where $2A_U$ represents the diameter of the universe, then θ_{si} represents the expansion factor. Using M/r^2 as a representative understanding of the mass that might exist in a typical galaxy, we may apply the expansion factor to distance to resolve what mass we should actually find. Where M_l is the observed mass and M_o the expected mass, then we should see

$$M_l = \frac{M_o}{\theta_{si}^{\,2}} = \frac{100\%}{(3.26239)^2} = 9.39568\% \tag{67}$$

of the expected mass.

In short, if a galaxy appears larger than expected and at the same time we are aware of a geometric distortion affecting distance measurement, it would not be unexpected to realize that the angle of incoming light is in fact accurate because the galaxy is closer than our understanding of distance measure suggests. This is not to say that galaxies are closer than they appear, only that there is a disconnect between our understanding of distance in the local frame in comparison to galactic measure. Observational studies suggest a total baryonic mass within galaxies of 12-15% of the amount needed to gravitationally bind their stars [27] complimenting a geometric distortion effect. When accounted for, there is no missing mass.

4. DISCUSSION

Investigations of the scalar constant S are truly one of the most revealing aspects of Informativity. Here within we use S to resolve a quantized valuation of Planck's reduced constant, build fundamental solutions for length, time and mass and equate Informativity to Planck's relations to realize a new fundamental expression that correlates Planck's constant to angular measure θ_{si}. The foundations of Planck's formulations and Informativity have little in common, but each model in their own way may be used to resolve the fundamental measures.

To all of this, we build on a foundation of geometric measure that describes light and matter in simple terms of the radius and circumference of a circle. Where Q_{Lf}, r, c^3 and G are used to describe gravity we find that the scalar constant S is $Q_{Lf}rc^3/G$ which is also $\hbar/2l_f$. And with that we find that $C=2\pi r=2\pi l_f$ compared to the arc length of θ_{si} precisely describes the minor arc of that circle in terms of angular measure or momentum, depending on whether we are working with a particle or a wave. And lastly, where $C=2\pi r$, we find that 2π units of l_f also separate $E=nh\nu$ from $E=mc^2$. All these expressions provide a single unifying understanding of the foundations of light and matter. There are three tests of the predictions of Informativity.

A. Measurements of predicted values

Bell's state measure for the signal and idler θ_{si} is so prevalent in Informativity that it may have been taken to be a fundamental constant of nature. This is not a role that has ever been assigned. θ_{si} is a prediction of this model that does not arise until following (19) where it is introduced. As a matter of clarification, θ_{si} is a derived value based on existing expressions that describe gravity. As such θ_{si} is a predicted value. The reverse argument may also be made, that our knowledge of θ_{si} allows us to derive an expression for gravity. But, both arguments cannot be made at the same time. Where one phenomenon is understood, the other must be an outcome. For this reason, a case is put forth that this paper presents argument that leads to verifiable expressions of physical phenomenon.

On January 31, 2011, S. Shwartz and S. E. Harris published a model of Bell's state measures based on their measure of θ_{si} exactly equal to that predicted by Informativity [11]. The model conforms to their observational data on nonlinear x-ray optics which provides measures of relative angular precision to 10^{-5} radians. As well, measurements to 10^{-6} radians will be possible in 2017 at the European X-ray Free Electron Laser facilities (XFEL) in Hamburg, Germany.

B. Measurements of gravitational lensing

With gravitational lensing, we may also determine the precision needed to differentiate Informativity from GR in the deflection of light grazing our sun [28]. Where θ is the angle of deflection, r and M the radius and mass, G the gravitational constant and c the speed of light, then

$$\theta = \frac{4GM}{rc^2} = \frac{G}{r^2}\frac{4rM}{c^2} = 8.5\ 10^{-6}\, radians. \tag{68}$$

We see that measuring the effects of Informativity only require that we be able to detect the difference between these models where

$$\Delta X = \frac{G}{r^2} - \frac{Q_{Lf}c^3}{r\theta_{si}} = \frac{6.67408\ 10^{-11}}{(6.96900\ 10^8)^2} - \frac{1.159563\ 10^{-44} * (299792458)^3}{(6.96900\ 10^8) * 3.26239} = 1.071\ 10^{-34} \tag{69}$$

and then use that to solve for the radian difference between GR and Informativity.

$$\theta = \Delta X \frac{4rM}{c^2} = 1.071\ 10^{-34} * \frac{4 * 6.96900\ 10^8 * 1.98855\ 10^{30}}{(299792458)^2} = 6.606\ 10^{-12}\ \ rad \tag{70}$$

The effect resolves to many orders in magnitude less than the effects of GR. A search of existing data does not show precision that would reveal this effect. While current technology may not afford a measurement at this scale, there do exist other stellar objects that may offer a reasonable measurement opportunity.

C. Measurements of gravitational wave strength

With the LIGO data of GW150914, an opportunity exists to confirm a hypothesis of Informativity in signal strength. If the conjecture regarding dark matter has substance as prescribed by (67), then gravitational waves should appear stronger than expected.

Thus far analysis of signal versus expected magnitude may be found in the literature as a function of signal to noise ratios. But the signal strength in relation to the intrinsic properties of the event is inferred based on models and binary star comparisons used to gauge the most appropriate model [29]. Without a redshift source [30] there lacks a basis for empirically understanding signal strength which complicates calculation. At this time there exist no direct observational data to empirically measure how much gravitational energy was released.

4. APPENDIXES

Appendix 1: Numerical limits of the product of $Q_{Lf}r_{Lf}$

Throughout this paper, we will find the term $Q_{Lf}r_{Lf}$ repeatedly. This term is referred to as the *Informativity differential* recognizing the central role it plays in describing how fractional values less than the theoretical limit reflect a distortion effect on distance measurement. Knowing the limits to $Q_{Lf}r_{Lf}$ is also essential in resolving the fundamental measures.

The product of $Q_{Lf}r_{Lf}$ is (5) multiplied by b.

$$Q_{Lf}r_{Lf} = \left(\sqrt{1+b^2} - b\right)b. \tag{71}$$

Note, what is observed always reflects a whole-unit measure and where $a=1$ we find that $b=r_{Lf}$ for all values. This is easily verified such that the highest value for Q_{Lf} is at $b=1$ where $(1+1^2)^{0.5} - 1 = 0.414$ and as such the 'observed' distance of c presented as a count r_{Lf} always rounds down to a value equal to the count b with $Q_{Lf}=0.414$ at its highest and quickly approaching 0 with increasing b. Thus,

$$Q_{Lf}r_{Lf} = \left(\sqrt{1+{r_{Lf}}^2} - r_{Lf}\right)r_{Lf}. \tag{72}$$

The lower limit where $r_{Lf}=1$ is easily produced, $\lim_{r=1} f(Q_{Lf}r_{Lf}) = \sqrt{2}-1$. Conversely, if we divide by r_{Lf}, then add r_{Lf}, square, subtract r_{Lf}^2 and divide by 2 we find that

$$\frac{{Q_{Lf}}^2}{2} + Q_{Lf}r_{Lf} = \frac{1}{2}. \tag{73}$$

Q_{Lf} decreases within increasing r_{Lf} until the left term drops out. Distance does not need to be significant to reduce the *Informativity differential* to 0.5. At just $10^4\ l_f$, $Q_{Lf}r_{Lf}$ rounds to 0.5 to nine significant digits.

Appendix 2: Fundamental transforms

On repeated occasion we find the need to translate from one measure to another. For instance, we may have an expression in terms of time, but desire to create an expression in terms of length which may be accomplished by multiplying by c, the speed of light. Within this paper this process is referred to as applying a fundamental transform. Each of the transforms may be derived from the definitions of the fundamental units presented in (20-23). For brevity I will provide translations in one direction with the understanding that a translation in the opposite direction may easily be realized.

Where our goal is to transform length to time $\Delta(l_f \rightarrow t_f)$, then we compare (20) to (21) such that

$$\Delta(l_f \rightarrow t_f)\frac{2G\theta_{si}}{c^3} = \frac{2G\theta_{si}}{c^4} \tag{74}$$

Therefore $\Delta(l_f \rightarrow t_f) = 1/c$ and as such, $l_f/c = t_f$. This transform is not typically mentioned as it is a definition of the model.

Where our goal is to transform length to mass $\Delta(l_f \rightarrow m_f)$, then we compare (20) to (23) such that

$$\Delta(l_f \rightarrow m_f)\frac{2G\theta_{si}}{c^3} = \frac{2\theta_{si}}{c}. \tag{75}$$

Therefore $\Delta(l_f \rightarrow m_f) = c^2/G$ and as such, $l_f c^2/G = m_f$.

Where our goal is to transform time to mass $\Delta(t_f \rightarrow m_f)$, then we compare (21) to (23) such that

$$\Delta(t_f \rightarrow m_f)\frac{2G\theta_{si}}{c^4} = \frac{2\theta_{si}}{c}. \tag{76}$$

Therefore $\Delta(t_f \rightarrow m_f) = c^3/G$ and as such, $t_f c^3/G = m_f$.

Appendix 3: Definitions

There are several values for which it is convenient and important to understand the details as to what values were used. Many expressions are strongly noted for this reason. For instance, there are very similar terms such as Planck's expressions for l_p, t_p and m_p as opposed to the fundamental expressions l_f, t_f and m_f. These terms have almost nothing in common. They were developed under entirely different models with different underlying constructs. They have different values. For this and many other reasons, an appendix is provided here to help clarify what values are being used in this paper. Where not otherwise defined, values are acquired from the 2015 CODATA [2].

- G the gravitational constant – 6.67408(31) 10^{-11} $m^3/kg\ s^2$
- c the speed of light – 2.99792458 10^8 m/s
- h Planck's constant – 6.62606957(29) 10^{-34} m^2 kg / s
- l_p Planck length – $(\hbar G/c^3)^{1/2}$=1.616199(97) 10^{-35} m

- t_p Planck time – $(\hbar G/c^5)^{1/2}$=5.39106(32) 10^{-44} s
- m_p Planck mass – $(\hbar c/G)^{1/2}$=2.17651(13) 10^{-8} kg
- θ_{si} Angle of the signal and idler in quantum entanglement – 3.26239 radians
- S The scalar constant in terms of momentum – $l_f c^3/2G$=3.26239 kg m/s

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