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Between Quantum Mechanics and General Relativity

Walter James Christensen Jr.

Department of Physics and Astronomy, Cal Poly Pomona University, Pomona, USA
Email: wjchristense@cpp.edu

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Abstract

The origin of elementary particle mass is considered as a function of n-valued graviton quanta. To develop this concept we begin in a cold region of "empty space" comprised of only microscopic gravitons oscillating at angular frequency ω. From opposite directions enters a pair of stray protons. Upon colliding, heat and energy are released. Customarily, this phase and what follows afterward would be described by Quantum Chromodynamics (QCD). Instead, we argue for an intermediary step. One in which neighboring gravitons absorb discrete amounts of plane-wave energy. Captured by the graviton, the planewave becomes a standing wave, whereupon its electromagnetic energy densities are converted into gravitational quanta. Immediately thereafter an elementary particle is formed and emitted, having both mass and spin. From absorption to conversion to emission occurs in less than 3.7×10^{-16} s. During this basic unit of hybrid time, general relativity and quantum physics unite into a common set of physical laws. As additional stray protons collide the process continues. Over eons, vast regions of spacetime become populated with low-mass particles. These we recognize to be dark matter by its effects on large scale structures in the universe. Its counterpart, dark energy, arises when the conversion of gravitational quanta to particle emission is interrupted. This causes the gravitational quanta to be ejected. It is recognized by its large scale effects on the universe.

Keywords

Dark Matter and Energy, Gravitational Quanta, Graviton Standing Wave, Schwarzschild Metric, General Relativity, Quantum Physics, Unified Field Theory, Blackholes

1. Introduction

One of the most puzzling and intriguing questions haunting physics today, is why there is not a single framework of physical law describing fundamental nature, rather than the two fundamental theories currently in use. Namely General Relativity and the Standard Model of Particle Physics based on quantum field theory. Surely, by Occam's razor and a consistent approach to nature, only one fundamental theory must prevail at the most essential level of nature [1] [2] [3]. To answer this question more thoroughly, we must first understand the heart of the matter. Let us consider what cosmologist Thanu Padmanabhan had to say about contact and conflict between quantum physics and general relativity. (*Padmanabhan was President of the Cosmology Commission of the International Astronomical Union and the Chairman of Astrophysics commission of IUPAP*; *he has written many papers and books on these subjects*) [4] [5] [6] [7]. As Padmanabhan explains concerning quantum fields and general relativistic theory:

> "Nobody knows why this mathematically non-rigorous, conceptually ill-defined, formalism of perturbative quantum field theory works. The miracle becomes even more curious when we notice that the bag of tricks fails miserably in the case of gravity." [8]

In regard to general relativity, Padmanabhan further explains in the same paper:

> "The Lagrangian describing classical gravity, treated as a function of $h_{ik} = g_{ik} - \eta_{ik}$, is not perturbatively renormalizable; in fact, there does not exist any simple redefinition of the field variables which will lead to a perturbatively renormalizable theory. So the most straight forward approach based on the belief that nature will continue to be kind to us, is blocked. The miracle fails."

In the work presented here, we intend to merge the disparate theories of quantum physics and general relativity through a modified time-energy uncertainty principle, applied to excited gravitons [9]. For reasons already mentioned, we will forgo a perturbative approach to gravity and instead construct an exact solution $g_{\mu\nu}$ for the general relativistic equations based on a classical Lagrangian and normal coordinates describing a field of oscillating particles. In particular, the particles chosen will be gravitons oscillating at invariant angular frequency ω [10]. Within this field we imagine a proton-proton collision taking place in otherwise "*empty space*". Immediately following the proton collision, we assume the field of vibrating gravitons is able to absorb discreet amounts of the plane-wave energy [11]-[18]. By acting on this spacetime metric $g_{\mu\nu}$ with the general relativistic wave equations, an n-valued energy momentum tensor $T_{\mu\nu}$ results. It is from the energy density component T_{00} that we are to calculate the precise mass of any elementary particle. From the coefficients of $T_{\mu\nu}$ the spin of the particle is ascertained. For example, we will calculate both the mass and spin for the Higgs boson. After comparing our theoretical results to the experimentally determined mass and spin, our theoretical results are in precise agreement with those provided by particle accelerators. We are also able to refine the experimental mass value of the Top Quark [19].

2. A Brief History to Present on Gravity Particles

Due to the innovative success of Heisenberg's mysteriously conceived manuscript titled: "Quantum-mechanical reinterpretation of kinematic and mechanical relations," published in 1925 [20], thereafter physicist began to view Einstein's geometric approach to gravity as: "sterile, a formalistic subject cut off from the mainstream of physics". Some went so far as to state in 1942: "general relativity was virtually dead—or at best dormant" [21]. But don't seeds always fall undeveloped before taking root? And so it was during the 1960's that Einstein's theory of general relativity underwent a golden renaissance [22] [23]. But decades prior, quantum physics began to flourish during the late 1920's, with its development by Paul Dirac, when he attempted to quantize the electromagnetic field. So much so that many prominent physicist began to turn away from Einstein's geometric approach to gravity, to pursue its particulate form [24] [25]. One of the first gravity particle theories to be developed was authored by M. Fierz and W. Pauli in 1939 [26]. It was referred to as "massive gravity" [27]. Using a variational principle, Fierz and Pauli calculated to first order, the gravitational field equations, for spin-2 particles (*gravitons*). The minimal variational condition applied is shown immediately below:

$$\delta\int L\mathrm{d}\Omega=0 \tag{1}$$

In this scenario the Lagrangian L is constructed term-by-term by increasing order. Under such a minimal condition only the consistent (*thus correct*) Lagrangian terms remain. Though the Fierz and Pauli Lagrangian field equations were consistent, and a unique representation for massive gravity, nevertheless during the 1970's, Veltman, van Dam and Zakharov independently demonstrated that by taking the limit as $m\to 0$, massive gravity does not uniformly reduce to general relativity [28]. Worse, the bending of light around the sun calculated from their heavy gravity formalism, only yielded three quarters the correct value; whereas general relativity measured the correct value.

Today, general relativity has too many successful experimental results to be a wrong theory, rather it simply remains incomplete and needs some modifications. This is so with quantum physics. The hope is, and the aim of this paper, is to show these two disparate theories can merge together under a common set of physical laws [29].

Because both massless and massive gravitons are central to our approach, let us consider the controversial linearized Fierz and Pauli Lagrangian term for massive gravitons:

$$L_{FP}=m^2\left(h^{\mu\nu}h_{\mu\nu}-\left(\eta^{\mu\nu}h_{\mu\nu}\right)^2\right) \tag{2}$$

Here, m is the mass of the graviton, $h_{\mu\nu}$ is the spin-2 graviton, and $\eta^{\mu\nu}$ represents flat Minkowski spacetime. It was the L_{FP} term that caused massive gravity to fail against the reality of nature. However, sometime in 2010 it was shown by de Rham and Gabadadze that a generalization of the Fierz-Pauli action through a decoupling scheme allowed for massive gravitons [30]. With the discovery of gravitational waves [31], the implications are that gravitons must be nearly massless or exactly zero [32]-[34].

Whether gravitons are massive or not, remains a topic of controversy and of much interest. What is certain, if gravitons are to carry the long-range gravitational force they must be massless, or at least most of the time [35] [36].

Though the Standard Model for particle physics describes three of the four fundamental forces, it is unable to unite them with the force of gravity [37]. Hence, the Standard Model, like General Relativity which is only a gravity theory, is incomplete. As Gupta writes in his seminal paper [38] [39] to the Proceedings of the Physical Society:

> "The main obstacles in the quantization of Einstein's field are overcome by expressing the field quantities in the Riemannian space as expansions in the flat space, and then splitting the gravitational field into the linear and the non-linear parts. The linear part of the gravitational field is regarded as the free gravitational field, while the non-linearity is treated as a direct interaction between the gravitons. This treatment is quite general, but it suffers from the usual limitations of the perturbation method."

Given the perturbation approach to gravity has failed since its inception more than seventy years ago, is it not time to take a different direction to merge gravity with quantum physics? Before we do, let us review what has been learned thus far:

Though a perturbative approach succeeds wonderfully for quantum physics, it fails with general relativity. So it seems another approach is merited. Or as Nobel Laurate Gerard t' Hooft explains:

> "Clearly, perturbative Quantum Gravity cannot answer the question as to what really happens at the Planck scale. Whenever the gravitational field becomes so strong that perturbative procedures no longer apply, new theoretical approaches are required, and indeed, new laws of physics may have to be searched for [10].
>
> With the 2012 discovery of gravitational waves, the existence of gravitons became even more likely [40] [41]. If gravitons exist, it is likely Einstein's geometric theory of gravity can be transformed into a particle theory. Once completed it would put gravity on equal footing with quantum physics.
>
> If gravitons have mass, the question arises: Will the mass of the graviton be so negligible as to render it or its effects unmeasurable? [42] Hence, becomes another kind of string theory? That is to say, becomes "its own discipline, independent of both physics and mathematics" [43].

In an attempt to bring clarity to the nature of gravitons, I wrote to Freeman Dyson two years after he had spoken on the subject on the measurability of gravitons at Nanyang University Singapore: "Is a graviton Detectable?" [44]. I received a reply from Dyson on June 17, 2015:

> "Dear Walter Christensen,
>
> Thank you for your friendly message. But there is no way to answer such

> questions briefly. I have never tried seriously to construct a theory of quantum gravity. I only ask the question whether a theory of quantum gravity would have observable consequences. Your questions are much more difficult to answer. Yours sincerely, Freeman Dyson"

A partial answer to measurability of graviton mass was provided in a manuscript published at CERN in 2023 [45]. In the manuscript the authors considered the energy density of a gravitational wave. They divided the wave up into gravitons of energy based on the graviton frequency *f*. This allowed determination of the number of quanta per de Broglie volume:

$$n\lambda_{dB}^3 = \frac{\pi h^2 M_{Pl}^2}{2 f^2} \cong 2\times 10^{35}\left(\frac{h}{10^{-22}}\right)^2\left(\frac{1\,\text{kHz}}{f}\right)^2 \tag{3}$$

where $f = \frac{\omega}{2\pi}$ is the linear frequency of the graviton, with $M_{Pl} = \sqrt{\frac{c\hbar}{8\pi G}} = 2.4\times 10^{18}\ \text{GeV}$ being the reduced Planck Mass. Because the number of gravitons was determined to be too large to separate during measurement, it was realized one could thin out the graviton density by considering gravitons having much higher frequencies, thereby allowing gravitons to be observed at the LIGO observatory.

Given the preceding information, of which some call for the possibility of the existence of gravitons [46], where do we go from here in terms of merging quantum physics with general relativity? As one who has worked on the problem his whole theoretical life, Gerard t' Hooft guides us with the following:

> "Ideally, a future all-embracing theory should be simple and straight forward, but we are still very much in the dark as for the fundamental axioms on which such a theory should be based." [47]

3. Mergence through the Spacetime Metric

In this section we construct a spacetime metric $g_{\mu\nu}$ representing a gravitational field comprised of massless gravitons—each oscillating at constant angular frequency ω [35] [48]. By acting on such a metric with the general relativistic wave equations, it produces an n-valued energy-momentum tensor $nT_{\mu\nu}$, where $n = 0,1,2,3,\cdots$. In this way we begin merging general relativity with quantum physics.

To construct our metric we consider a classical Lagrangian representing a system of particles vibrating about a point of equilibrium [49]:

$$L = \frac{1}{2}\left(T_{ij}\dot{\eta}_i\dot{\eta}_j - V_{ij}\eta_i\eta_j\right) \tag{4}$$

where the η_i's represent small deviations from the generalized coordinates q_{0i} expressed by the equation: $q_i = q_{0i} + \eta_i$. The η's subsequently become the generalized coordinates for the equations of motion, and are given by:

$$T_{ij}\ddot{\eta}_j - V_{ij}\eta_j = 0 \quad (\text{no sum over } i) \tag{5}$$

The preceding second-order differential equation represents a coupled system of particles undergoing simple harmonic motion. The solution has the form of normal coordinates describing a one-dimensional harmonic oscillator:

$$\eta_i = C_\kappa \mathrm{e}^{-i\omega_\kappa t} \tag{6}$$

To simplify matters, let the coefficients C_κ be set equal to one (*along with other small modifications to bring out clarity both mathematically and physically for this oscillating system of particles, but which do not alter the understanding of what is occurring physically*). From these normal coordinates we construct an ansatz spacetime metric $g_{\mu\nu}$. One describing a field of gravitons undergoing simple harmonic motion. That is to say, from the set of simple normal coordinates η_i undergoing harmonic motion, we begin construction of our general relativistic spacetime metric through a vierbein formalism [50], which is as follows:

$$g_{\mu\nu} \equiv \eta_\mu \cdot \eta_\nu = \mathrm{e}^{i\omega t} \delta^\mu{}_\nu = \mathrm{e}^{i\omega t} \eta_{\mu\nu} \tag{7}$$

From the Minkowski metric we recognize each spatial coordinate is multiplied by Euler's formula: $x^1 = x^2 = x^3 = \mathrm{e}^{i\omega t}$ [51] [52]. While the time coordinate is treated differently by virtue of its negative sign so that: $x^0 = -\mathrm{e}^{i\omega t}$. The preceding metric is nearly complete. However, due to the proton-proton collision releasing discrete energy, from which gravitons absorb a discrete amount of n-valued plane-wave energy—the natural number n needs to be introduced into the complex metric. Hence:

$$g_{\mu\nu} = \mathrm{e}^{i\omega t} \eta_{\mu\nu} \to \mathrm{e}^{\sqrt{n}(i\omega t)} \eta_{\mu\nu}; \quad n = 1, 2, 3, \cdots \tag{8}$$

Edward Witten (*awarded the Fields Medal and researcher of quantum gravity*) discusses the use of complex metrics as solutions to Einstein's equations and provides examples developed by others. In 1977 Gibbons and Hawkings upon using a Euclidean version of the Schwarzschild solution to study the thermodynamics of a Schwarzschild black hole, considered the Kerr solution—a rotating blackhole. "Upon continuation to complex time, the Kerr solution becomes complex." [51] [53]

Surprisingly by acting on our complex metric with the general relativistic equations, the resulting energy momentum tensor $T_{\mu\nu}$ becomes completely real. There is no need to take the real part, as is done in other subjects of physics and mathematics. Instead, the completely real energy momentum tensor results from the covariant way Einstein constructed his general relativistic equations.

4. Question of Time

One of the main obstacles preventing the mixing of general relativity with quantum physics, is need to established a common understanding of time inclusive to both theories. To understand the time problem let us briefly consider the different ways time was perceived and applied to four founding theories of physics.

Classical Mechanical Time—by Issac Newton

> "Absolute, true and mathematical time, of itself, and from its own nature, flows equably without relation to anything external, and by another name is called duration: relative, apparent, and common time, is some sensible and external (*whether accurate or unequable*) measure of duration by means of motion, which is commonly used instead of true time; such as an hour, a day, a month, a year." [54]

Special Relativistic Time—by William Unruh

> "The change began with Special Relativity, the first theory in which time lost some part of its absolute and invariant character. Time became, at least in some small sense, mutable. It was precisely this conflict between a mutable notion of time and the absolute and unitary notion of time inherited from Newton, that has caused consternation and confusion." [55]

General Relativistic Time—by William Unruh

> "Gravity is the unequable flow of time from place to place. It is not that there are two separate phenomena, namely gravity and time and that the one, gravity, affects the other. Rather the theory states that the phenomena we usually ascribe to gravity are actually caused by time's flowing unequably from place to place."[1]

(*From this last idea one might go so far as to say time and gravity are interchangeable*).

Quantum Mechanical Time—by Eduardo O. Dias

> "Although time is one of our most intuitive physical concepts, its understanding at the fundamental level is still an open question in physics. For instance, time in quantum mechanics and general relativity are two distinct and incompatible entities. While relativity deals with events (*points in spacetime*), with time being observer dependent and dynamical, quantum mechanics describes physical systems by treating time as an independent parameter." [56]

Clarification of the Disparity of Time—by Alfredo Macías and Abel Camacho

> "Quantum theory does not provide a natural time parameter and the quantum constraints of general relativity do not contain any time parameter. For this reason, standard quantum mechanics needs to be generalized to accommodate quantum spacetime, very probably without a Hilbert space." [57]

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[1] From: Bill Unruh, Tuesday, January 30, 2024 1:32 PM To: Walter J Christensen Correspondence with William Unruh who replied to me with: Subject: "Gravity is an attribute of time. Time is the more fundamental, but one its manifestations, in its inequable flow, is gravity. Because of special relativity, we know that there is a very close relationship of time with distance as well, so gravity combines the inequable flow of time with the change of distance from time to time, which also encompasses subtler properties of gravity, and is the essence of gravitational waves."

5. Conceptual Framework for Hybrid Time

Having provided a varied landscape for the meaning of time, we are in a much better position to understand the necessity for a new kind of time that can merge with both general relativity and quantum physics into a single framework of natural laws and principles. This we call hybrid time.

Built into the metrical structure itself $g_{\mu\nu} = \mathrm{e}^{(\sqrt{n}t)i\omega}\eta_{\mu\nu}$ are foundational parts of each theory we want to merge. The most conspicuous notation related to quantum physics is n, representing the discrete amount of quantized collisional energy $nh\nu$ absorbed by neighboring gravitons (*a portion of the proton-proton planewave energy*). Just as all forms of energy can be converted from one into another, upon absorption by the graviton, the energy transforms into gravitational quanta. The physical mergence between quantum field theory and general relativity is clear, in that photon quanta transforms into the graviton quanta. This path flows in one direction. Overall, the spacetime metric is an exact solution for Einstein's gravity equations requiring no perturbation to reveal the graviton particle—the smallest functioning structure in nature, which comprises microscopic spacetime.

Continuing on, note, how the exponents ($\sqrt{n}t$) in the metric have been grouped. This was done to associate time t with discreteness. In this way we begin to reveal that the parameter (t) plays a different role in our hybrid approach than might have been expected at first. To clarify what role (t) does play. Let us regroup the exponents so that the emphasis shifts in the metric to: $g_{\mu\nu} = \mathrm{e}^{i(\omega t)\sqrt{n}}\eta_{\mu\nu}$. This regrouping ($\omega t$) reveals yet another relationship parameter t serves. In this situation t is coupled to the constant graviton frequency ω. Physically, the angular frequency ω represents an actual sea of microscopic metronomes—forming an array of Einstein clocks in special relativity. These are omnipresent clocks counting out time in the microscopic world. Moreover, ω is an invariant clock in this microscopic world, analogous to the invariant speed of light c in the macroscopic world of spacetime, allowing for the precise measurement of local distance and time. Likewise, the invariant pulsing beats of the graviton can be used to measure precise microscopic time. Since ω is the actual tick of time, embedded inseparably into microscopic spacetime, the question arises as to what purpose does (t) serve in our spacetime metric? It cannot physically represent clock-time, for that role belongs to the pulsating graviton. Yet it does serve the purpose of time for hybridized time which the general relativistic equations act on. After the second ordered partial derivatives do, the resulting energy momentum tensor is absent of (t) but retains ω^2, to describe particle and spin mass-energy. Taken together, within the metric, time t must act as a parameter for graviton-time. That is to say its main purpose is to be coupled to ω as (ωt).

Like any parameter in science and math its purpose is to be useful in helping describe some system in some way. But in which way? We note that time t coupled to the graviton angular frequency ω, appears as part of the Euler's formula, which in turn is part of the spacetime metric $g_{\mu\nu} = \mathrm{e}^{i(\omega t)\sqrt{n}}\eta_{\mu\nu}$. Because

Euler's formula generates a complex plane of real and imaginary parts, and can be rewritten as: $\cos\left(\sqrt{n}\omega t\right)+i\sin\left(\sqrt{n}\omega t\right)$, it becomes apparent that ($\sqrt{n}\omega t$) represents an n-valued radian angle. From this analysis it is realized that time (t) acts as a conversion unit parameter on (ω). In other words its purpose is simply to change inverse seconds into radian angle—a unitless quantity. Taken together in the Euler formula, the angular expression $\sqrt{n}\left(\omega t\right)$ in this context, comes in two types. First (ωt) steadily counts out the continuous pulses of graviton time as measured in radians. Secondly, coupled as $\sqrt{n}\left(\omega t\right)$, allows for erratic n-valued quantum-like jumps of radian angle. This jump intimately depends on how much proton collisional energy is absorbed by these gravitons to produce elementary particles with mass and spin. It is evident that that radian-time contained in the spacetime metric consists of two modes, both coupled to invariant graviton frequency. Hence hybrid time is understood to be both continuous and quantized. Just as one might expect when merging quantum physics with general relativity.

Given that $\omega = 2\pi\times10^{-12}$ rad/sec (*as shown in a subsequent section*) [58] [59] we now simplify the associated radian angle:

$$\begin{aligned}\sqrt{n}\left(\omega t\right) &= \sqrt{n}\left[2\pi\times10^{-12}\ \text{rad/sec}\right]\left[t\left(\text{sec}\right)\right]\\ &= \sqrt{n}\left[2\pi\times10^{-12}\ \text{rad}\right]\end{aligned} \tag{9}$$

Inserting this back into our spacetime metric, we have a continuous and discrete expression for the merging of quantum physics with and general relativity:

$$g_{\mu\nu} = \mathrm{e}^{i\left(\sqrt{n\left(4\pi^2\times10^{-24}\right)}\right)}\eta_{\mu\nu} \tag{10}$$

One can reinterpret the exponents of $4\pi^2$ to be analogous to the period of a simple gravity pendulum, given by: $T^2 = 4\pi^2 L/g$. Where the gravitational acceleration g is related to the universal gravitational constant G. This makes sense because the metric was born from oscillating gravitons. If we let gravitons have geometric attributes (*which general relativity is founded upon*), we can imagine L representing the diameter or length of one side of a vibrating, geometrically excited graviton.

6. Hybrid Time Calculation

As the great physicist and gentleman Steven Weinberg wrote [60]:

> "Dirac was grappling with an old problem: how to calculate the rate at which atoms in excited states would emit electromagnetic radiation and drop into states of lower energy. … This problem was of crucial importance, because the process of spontaneous emission of radiation is one in which 'particles' are actually created. … If quantum mechanics could not deal with processes of creation and destruction, it could not be an all-embracing physical theory. … The quantum-mechanical theory of such processes can best be understood by returning to the analogy between fields and oscillators. …

> This field-theoretic approach to matter had an immediate implication: given enough energy, it ought to be possible to create material particles, just as photons are created when an atom loses energy."

Rather than computing the rate at which atoms in excited states emit electromagnetic radiation, what is important in our presentation is to determine the how long it takes for excited gravitons to produce an elementary particle. This is duration is synonymous with the mean lifetime of an excited graviton.

The one fundamental tool we have to determine the mean lifetime of an excited graviton, comes from quantum mechanics—the time-energy uncertainty principle [61]. Because we are blending a classical theory with a nonclassical quantum theory, some level of uncertainty must disappear, yet some maintained when hybridizing the uncertainty principle [62].

The minimal modification that can be made to uncertainty principle $\Delta t\Delta E \ge \frac{1}{2}\hbar$ [63], while maintaining some uncertainty yet easing up on it, is to change the greater-than and equal-to-sign to a hard equality:

$$\Delta t\Delta E = \frac{1}{2}\hbar \tag{11}$$

This definition for time uncertainty, provides the shortest time scale on which an excited graviton will last before collapsing to emit an elementary particle. Let us solve for Δt by inserting the n-valued absorbed graviton energy density $\Delta E = \frac{T_{00}}{N_D}$, into the modified uncertainty (*see equation* (28) for graviton energy absorption):

$$\begin{aligned}\Delta t &= \frac{1}{2}\frac{\hbar}{\Delta E} = \frac{1}{2}\frac{\hbar}{\left(n+m^2\right)\frac{\left(\frac{3}{2}\omega^2\right)\left(\frac{c^4}{16\pi G}\right)}{1.00\times10^{39}}}\\ &= \frac{1.054571817\times10^{-34}\ \text{J}\cdot\text{s}}{2\left(n+m^2\right)\left(1.425801587\times10^{-19}\ \text{J}\right)}\\ &= \frac{7.396343409\times10^{-16}\ \text{s}}{2\left(n+m^2\right)}\end{aligned} \tag{12}$$

Here n and m are the counting numbers greater than or equal to one. Note the mean lifetime or an elementary particle decreases rapidly as the mass of the particle increases, since m and n are related to mass-energy of the particles being generated from a graviton. Because of graviton fusion, the lifetime of an excited graviton Δt can be altered slightly. Where Δt is called hybrid time. Since ΔE will be calculated from classical gravity (*see Equation* (29)), it has no inherent uncertainty. The maximum time of uncertainty for any excited graviton, is when the mass is smallest, corresponds to $m = 1$ and $n = 0$. That time interval would be:

$$\Delta t = 3.7\times10^{-16}\ \text{s} \tag{13}$$

7. Calculating the Energy Momentum Tensor

Although our constructed metric is complex $g_{\mu\nu}=\mathrm{e}^{i\left(\sqrt{n}\omega t\right)}\eta_{\mu\nu}$, and may be unfamiliar to many readers, nevertheless such notable physicists as Hawkings and Gibbons applied complex spacetimes to make sense of rotating black holes. [64] Other important physicist tell us that: "Einstein's equations work just as well with complex-valued metrics as with real-valued ones." [65] Einstein himself, applied complex metrics to try and answer the deepest questions of spacetime, to hybridize general relativity (*see below this section*). What is interesting about the complex metric we have constructed, by acting on it with the general relativistic equation, is the resulting energy momentum tensor $T_{\mu\nu}$ is completely real-valued as and be seen immediately below:

$$G_{\mu\nu}=\left[R_{\mu\nu}-\frac{1}{2}g_{\mu\nu}R\right]\Rightarrow T_{\mu\nu}=\frac{c^4}{16\pi G}\begin{pmatrix}-\frac{3}{2}n\omega^2 & 0 & 0 & 0\\ 0 & \frac{1}{2}n\omega^2 & 0 & 0\\ 0 & 0 & \frac{1}{2}n\omega^2 & 0\\ 0 & 0 & 0 & \frac{1}{2}n\omega^2\end{pmatrix} \tag{14}$$

In regard to complexification of the metric (*fait de rendre complexe, de devenir complexe*), in 1945 Einstein had published a paper on the generalization of the relativistic theory of gravitation. In this work he had proposed the use of a complex metric [66]. Therein, Einstein defined a tensor $g_{\alpha\beta}$ as having complex components: $g_{\alpha\beta}\equiv s_{\alpha\beta}+ia_{\alpha\beta}$. He imposed the conditions that $s_{\alpha\beta}=s_{\beta\alpha}$ (*symmetric*) and $a_{\alpha\beta}=-a_{\beta\alpha}$ (*antisymmetric*). Furthermore, the fields $s_{\alpha\beta}$ and $a_{\alpha\beta}$ were to be independent from each other. This meant the field equations were no longer expressed as a unified covariant entity, disregarding what Einstein had relied foundationally on, for much of his life. On this matter Antoci writes:

> "General relativity, however, is not just a field theory for macroscopic gravitation; it looks rather like the first, provisional achievement of a program aimed at representing the whole of physical reality in a new way that dispenses with the need of the inertial reference frame and posits a direct relation between spacetime structure and material properties; due to these essential novelties, common to all the generally covariant theories, one should be prepared to acknowledge that for these theories the issue of the relation between macro and microphysics may well require a totally different approach from the one successfully adopted with the theories that retain the inertial frame; it may be more appropriate then to draw free inspiration from the historical sequence of attempts that has led from the electron theory by Lorentz to quantum mechanics, rather than stick to the formal expression of the end results of that endeavor, that was rooted in so different a conceptual framework." [67]

Our approach has the advantage of being allowed to apply some of the founding principles of each of the two fundamental theories of current physics. That of general relativity and quantum mechanics. From the latter we are able to apply the time-energy uncertainty principle to temporarily circumvent any violations, such as maintaining covariance, so long as the uncertain duration is less than or equal to: $\Delta t \le 3.7\times 10^{-16}\ \text{s}$ and resolves into a covariant theory and mitigates other brief violations.

Before closing this section we mention the energy momentum tensor may be arranged so as to describe an energy density of a vibrational kinetic energy. This is done in the following way by defining:

$$I \equiv \frac{c^4}{16\pi G}\begin{bmatrix} -3 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix};$$

$$\tilde{\omega}^2 \equiv \begin{bmatrix} \omega^2 & 0 & 0 & 0 \\ 0 & \omega^2 & 0 & 0 \\ 0 & 0 & \omega^2 & 0 \\ 0 & 0 & 0 & \omega^2 \end{bmatrix} \tag{15}$$

where "*I*" represents the moment of inertia of the system, allowing us to write the energy momentum tensor in a generalized vibrational kinetic energy density form.

$$T_{\mu\nu} \equiv n\left(\frac{1}{2} I \tilde{\omega}^2\right) \tag{16}$$

where $n = 1, 2, 3, \cdots$. We also note the covariant and contravariant energy momentum tensors are conserved:

$$T^{\mu\nu}{}_{;\nu} = T_{\mu\nu;\nu} = 0 \tag{17}$$

By a consistency condition, [68] this implies our approach is mathematically and gravitationally correct—in as much as James Clerk Maxwell approach required the electromagnetic equations to be consistent. Since at the time they were not consistent, Maxwell added a single term to Amperes' law, to make them consistent. Upon doing so, he was the first to realize light was an oscillating magnetic and electric filed propagating through space.

8. Sum of Energy Densities

In this section we show the origin of elementary particle mass to be a function of n-valued gravitational quanta. As before, we imagine a vast region of "empty" space comprised microscopic gravitons oscillating at invariant angular frequency ω. From somewhere across the cosmos, and from opposing directions, enters two stray protons. Upon colliding they release intense heat and energy. Customarily, this phase of the collision and afterward would be described by Quantum Chromodynamics (QCD) [69]. Instead, we argue for an intermediary step. One in which neighboring gravitons trap discrete amounts of the released collisional plane-wave energy. The planewave absorbed by the interior of the graviton changes into a standing wave complete with nodes and antinodes. Conversion into gravitational quanta is completed when the graviton's internal vibratory energy mixes with the standing wave energy along with other graviton attributes [70]. The end result is the formation and emittance of a single elementary particle with mass and spin. Particle creation processes are made simpler than those proposed by quantum chromodynamics (QCD). From absorption, to conversion, to emission occurs in less than 3.7×10^{-16} s—the basic unit of hybrid time, wherein general relativity and quantum physics unite into a single governing body of natural laws.

The following provides additional information concerning graviton energy absorption and conversion into gravitational quanta:

- Immediately after a proton-proton collision, electromagnetic planewaves propagate outward and become trapped within the confinements of vibrating gravitons to form a standing wave.
- The standing wave energy density consists of both magnetic and electric energy densities given by:

$$\mu_B = \frac{1}{2\mu_0} B^2 \tag{18}$$

$$\mu_E = \frac{1}{2} \epsilon_0 E^2 \tag{19}$$

Without loss of generality, let us assume the standing wave's electric-field $E(x, y, z, t)$ oscillates back and forth as a standing wave in the x-direction while magnetic field $B(x, y, z, t)$ oscillates out of phase in y-direction as shown immediately below:

$$E(x, y, z, t) = A\cos(\omega t)\cos(kz)\hat{x} \tag{20}$$

$$B(x, y, z, t) = \frac{A}{c}\sin(wt)\sin(kz)\hat{y} \tag{21}$$

These magnetic and electric field equations satisfy Maxwell's equations. Their respective energy densities can now be expressed as:

$$U_E = \frac{1}{2}\epsilon_0 E^2 = \frac{\epsilon_0}{2} A^2 \cos^2(\omega t)\cos^2(kz) \tag{22}$$

$$U_B = \frac{1}{2\mu_0} B^2 = \frac{\epsilon_0 c^2}{2} A^2 \sin^2(\omega t)\sin^2(kz) \tag{23}$$

These last two results reveal when the electric energy density is at a maximum, the magnetic energy density is zero. The opposite is true as well, meaning the oscillating energy densities are completely out of phase.

- Furthermore, once the oscillating magnetic and electric energy densities are absorbed into the graviton, these densities quickly combine with the internal vibrational energy density of the graviton. The sum of the mixing forms into gravitational a hybrid gravitational quanta density. This energy density is expressed by the time component of the energy momentum tensor:

$$T_{00} = n\left(\frac{3}{2}\omega^2\right)\left(\frac{c^4}{16\pi G}\right) \tag{24}$$

- Gravitational quanta contains three fundamental constants integral to foundational nature and hybrid physics. The invariant graviton angular frequency ω coupled to the gravitational constant G, together with light speed c. In this way, macroscopic gravity is linked to the world of microscopic gravitons, which connect through the doorway of light.
- During graviton quanta formation there are two possible end results: a) The energy may prematurely disperse from the graviton, leaving behind an inert graviton shell. Such graviton quanta functions as dark energy [71]-[73]. b) Or the graviton shell may partly dissolve into the gravitational quanta to form an elementary particle having its own particular properties such as mass and spin.
- Based on a recent report, combination of quantum mechanics and gravitation results in creation of all fundamental properties of elementary particles, such as mass, charge and spin of an electron as a micro black hole [74].
- Should two protons collide with enough energy, the intense heat released can cause neighboring gravitons to fuse together—if and only if each graviton is at the same energy level as the others. If so, their discrete energies sum together. If nothing interrupts the graviton's conversional energy process, then the fused graviton quanta will sum to form a single elementary particle of equivalent mass-energy to that planewave energy absorbed.
- Since gravitons are the smallest functional structures in nature, and can only absorb miniscule amounts of collisional energy, it may take as many as 10,000 fertile gravitons to fuse together to create the heaviest of the elementary particles. For example the Top Quark and the Tau Lepton. In contrast only a single n-valued excited graviton is required to produce the lighter elementary particles such as the electron neutrino, or those cold dark matter particles having a tiny mass in the eV/c^2 range.
- A modified gravity-holographic approach to General Relativity, provides for alternative approach to the production of dark matter [75]. We await to observational confirmation of this approach.
- As a possible example of this interplay between dark matter and dark energy let us consider one of the most curious celestial discoveries recently observed. That of the Luminous Fast Blue Optical Transients (*LFBOTs*). Each of the seven BOTs observed thus far have produce more energy than hundreds galaxies. They brighten and dim in minutes or hours [76] [77]. They have been sighted by the International Gemini Observatory, the Chandra X-ray Observatory and Hubble Space Telescope and others [78]. The origins of these LFBOTs are poorly understood [79]. In particular the BOT—AT 2023 fhn (*nicknamed the Finch*), was determined to be located between two galaxies in what appears to be open space [80]. One of the two galaxies (*a spiral*) was measured to be about 50,000 light-years away from the Finch BOT, while the other about 15,000 light-years from away. Under these conditions it appears

the Finch Bot arose from cold-dark "empty" space. If so, there are limited options as to what could generate such a supernova-like explosion. As a possibility to explain such a powerful cosmic event, it seems if in this region a sphere of dark matter had aggregated together with volatile gas molecules—mainly hydrogen, and within the core of this dark matter sphere was trapped a smaller sphere of dark energy, then a very powerful and unstable arrangement had coalesced. And more so as the aggregate of the outer sphere of dark matter under gravitational attraction tries to pull the aggregate material inward, only to be countered by dark energy pressure, which attempts to expand outward. With the slightest catalyst to cause instability, the volatile mixture of dark matter and interstellar molecules having been in equilibrium with dark energy, is now allowed to collapse inward into a decreasing volume. At the same time, dark energy (*by its very nature*) rushes outward into increasing volume. The overall result is a two part explosion resembling a massive supernova—one far more violent, and occurring in a far shorter duration.

9. The Mass Function Calculator

It is from the energy momentum tensor $T_{\mu\nu}$—specifically from its energy-density time component, T_{00}, that a mass function calculator can be assembled for purposes of computing elementary particle mass. With that consideration the following information is intended to bring clarity and guidance for assembly of the mass calculator:

- To make matters as simple as possible imagine a cold-dark region in space sparsely filled with low-mass particles. Everywhere within this region macroscopic spacetime is nearly flat. Whereas microscopic spacetime acts like a massless substrate comprised of oscillating gravitons, all vibrating at invariant angular frequency ω.
- As one might imagine in such a cold, lightless location, the overall energy available to excite gravitons into producing gravitational quanta, is minimal. Any particles produced from the gravitational quanta will be in the eV/c^2 mass range. For instance that of electron neutrinos and low mass dark particles [81]. Furthermore, due to small heat flow in this region, fusion between gravitons occurs rarely in comparison to warm regions. That is to say, creation of any low mass particles will be in one-to-one correspondence with the excited graviton that produced these low mass particles.
- Should a pair of stray protons enter this frigid and lightless region (*previously having engaged in various interactive processes while travelling the immense distance before collision*) the collisional energy released will only be enough to excite gravitons to produce more of the same type of extant particles in the eV/c^2 mass range—hence more dark matter. This is supported by various types of observations [82] [83].
- The process of dark matter particle production has been an ongoing process for eons. After a while, accumulation of dark matter and its exfil produces a

steady dark condition achieving a matter density of approximately: 1.0 × 10^{-27} kg/m^3 [84]-[86].

- The next step in constructing our mass calculator is to determine the mass of a single graviton—just as many highly-qualified astronomers and astrophysicists have tried to determine the upper bound graviton mass [87]-[89]. But with our approach there is no single graviton mass. Only varied gravitonic states of excitement. So what then was being measured to yield the well-established upper bound graviton mass having the tiny mass range of value:

$$10^{-55}\ \text{kg} \rightarrow 10^{-69}\ \text{kg} \tag{25}$$

The simplest explanation, it represents a kind average "effective" mass value based on graviton quanta forming and dissipating throughout the vast cold regions of space, as they comingle with massless gravitons. In other words the measured graviton mass represents the rise and fall of the graviton absorption of collisional energy, then converting it to gravitational quanta to produce and emit an elementary mass particle amongst an ocean of massless gravitons. We choose a slightly smaller mass than the average, so as to negate any multiplicity effects. The effective graviton mass selected from the range above is given by:

$$1.0\times10^{-66}\ \text{kg/particle} \tag{26}$$

- The next step in assembling our matter function is to divide the effective graviton mass (*which represents excited gravitons, not the massless ones*) into the measured dark matter density [90] [91]. Carrying through with the division yields:

$$N_D = \frac{1.0\times10^{-27}\ \text{kg/m}^3}{1.0\times10^{-66}\ \text{kg/particle}} = 1.0\times10^{39}\ \frac{\#\ \text{excit grav}}{\text{m}^3} \tag{27}$$

- Next the number density N_D of excited gravitons is divided into the energy density T_{00} of excited gravitons, to yield an n-valued energy per graviton:

$$\frac{T_{00}}{N_D} = n\frac{\left(\frac{3}{2}\omega^2\right)\left(\frac{c^4}{16\pi G}\right)}{1.00\times10^{39}} = nE \tag{28}$$

[Note: N_D can be finetuned later by working backwards after experimentally determining an elementary particle mass. As it turns out] [our result for N_D is accurate enough to calculate all Standard Model particle masses and some yet to be discovered] [to a high level of precision].

- Let us complete the computation for then-valued energy per graviton nE by inserting the respective constants into the equation above. Those constant values are as follows:

$$\omega = 2\pi\nu_g = 2\pi\left(1.000000000\times10^{-12}\right)\text{s}^{-1};$$

$$c = 299792458\ \text{m/s};$$

$$G = 6.67428(67)\times10^{-11}$$

Plugging these three fundamental constants into the equation above, yields the n-valued excited energy for a single graviton oscillator:

$$E_n = n\left(1.425801587\times10^{-19}\right)\frac{\text{J}}{\text{grav}} \tag{29}$$

- Our mass function calculator is nearly complete. However, because our overall approach merged general relativity and quantum physics together through the spacetime metric, it will be informative to compare our graviton-oscillator energy levels to the quantum harmonic oscillator energy levels given by:

$$E_n = \hbar\omega\left(n+\frac{1}{2}\right) \tag{30}$$

- Even though the quanta energies expressed by a graviton oscillator and the quantum mechanical oscillator are physically different types of quanta, both expressions for discrete energy reveal a commonality of increasing linearly with n. This is reassuring for it shows nature has a consistency about itself. Just as it is so with gravity and electrodynamics, where the electric and gravitational forces both drop off as $\frac{1}{r^2}$.
- There is more to consider. In hindsight and upon further consideration, our a graviton model initially left out an additional degree of freedom representing an additional mode energy. This absence can be rectified by considering another quantum mechanical mode of energy and relating it to the interior of a graviton. This additional energy mode may be understood upon considering—when a graviton absorbs acollisional planewave of heat and energy, trapping the wave within the interior of the graviton forms a standing wave, complete with nodes and antinodes. By applying the wave-particle duality principle to the interior of the graviton, the standing wave becomes a particle trapped in a "box" oscillating back and forth within the interior of the graviton. In quantum mechanics the energy levels are given by:

$$E_n = m^2\left(\frac{h}{8mL^2}\right),\ m = 1,2,3,\cdots \tag{31}$$

- Because we have merged general relativity with quantum physics, it informs us to include an m^2 energy term necessary to account for the interior energy of the graviton. In concordance we have:

$$E_m = m^2\left(1.42580\times10^{-19}\right)\frac{\text{J}}{\text{grav}},\ m = 0,1,2,3 \tag{32}$$

The total energy per graviton after absorption of electromagnetic energy, converting it into gravitational quanta during the proton-proton collision, lasting 10^{-16} s, is therefore given by:

$$E_{n,m} = \left(n+m^2\right)\left(1.42580\times10^{-19}\,\frac{\text{J}}{\text{grav}}\right) \tag{33}$$

Keep in mind light energy quanta $h\nu$ is not the same as gravitational quanta having as it constituent fundamental constants as: G, c and ω [92]. Furthermore once light radiation is absorbed it disappears into the mix to form an elementary particle. It is only released upon particle annihilation. Upon dividing this last result through by c^2, elementary particle masses (*epe*) emitted by excited graviton collapsing back to ground state are determined to be given by:

$$m_{epe} = \left(n + m^2\right)\left(1.586418216 \times 10^{-36} \frac{\text{kg}}{\text{grav}}\right) \tag{34}$$

Of note, when $m = 0$, we can assume n may take on negative integer values of $n = -1, -2, -3, \cdots$. Then the mass becomes negative, thereby representing anti-particles. Since m squared is always positive, and grows rapidly in value, the sum of the two integers will cause negative mass to be added away. Thus by the very nature of particle creation, the bulk of matter will be positive.

- Finally a simple rule is established for n, m^2. The natural number m must be chosen first, so that m^2 generates a mass as close to the actual mass value as possible (*without ever exceeding it*). Though this value can never be known to some tiny precision, the mass generator by assumption can produce mass results more precise than those of experimental determination.

10. Examples of Mass Generated Particles

As example on how the mass function calculator works let us consider the heaviest of all elementary Quark particles—that of the Top Quark having an experimentally determined mass of $172.13\frac{+0.76}{-0.77}$ GeV/c^2 [93]. The particle's uncertainty of +0.76 GeV/c^2 (*given by CMS Collaboration*)provides an opportunity to refine the Top Quark mass, via the mass function calculator (*Equation* (34)). After applying the mass function to calculate the Top Quark mass (*see Equations* (35)-(37)), it reveals the experimental mass value needs to be increased 0.69 GeV/c^2 (*which is less than the maximum uncertainty*). That is the actual value becomes: 172.82 GeV/c^2. Converting to SI units and rounding off to four decimal places, yields the corrected experimental mass of (3.0808×10^{-25} kg). To demonstrate more clearly how this actual mass value was achieved through the mass function calculator generating the actual mass value for the Top Quark, we begin with the mass function calculator:

$$m_{epe} = \left(n + m^2\right)\left(1.586418216 \times 10^{-36} \frac{\text{kg}}{\text{grav}}\right).$$

Before we continue any further, we recognize that the mass function calculator has an exponent of 10^{-36} kg, while the experimental mass exponent value is 10^{-25} kg. At first this seems to be a severe problem for no tiny graviton can possibly absorb enough collisional energy to produce 10^{11} worth of mass necessary to manufacture an elementary particle mass in the range of 10^{-25} kg. Nor would we expect a single graviton to turn around and produce the lightest elementary particles in the 10^{-36} mass range. The solution to this conundrum as was previously discussed is graviton fusing with other gravitons so their quanta energies sum together. For the Top Quark particle this requires (1×10^4) gravitons fuse together. This is only possible iff each graviton has attained the same identical energetic state. Keep in mind gravitons are the smallest functional structure in nature. That they comprise the fabric of microscopic spacetime. And that it is true that nature tends to build from tiny to large. For example, subatomic particles form into protons. In turn protons form into atoms along with neutrons and electrons. These continue to make gaseous, liquids and solids. Which are what planets and stars are made of. Together planets, dust, gas, liquids and solids form entire galaxies and superclusters. Should it be surprising that underneath it all the smallest functional element in nature are gravitons comprising all things?

After a couple of quick trial calculations we determine the *m*-number type (*which by the m-rule must be chosen first*) together *with* (1×10^4) *gravitons, to achieve a gravitational quanta to manufacture a mass range of* 10^{-25} kg. With a little trial and error we determine that $m = 44$. Similarly we determine that $n = 60$—though it has its own number of fused gravitons. Plugging these values one-at-a time into our mass function calculator we compute:

$$m_{T1} = m^2 \frac{E}{c^2} = \left(44 \times 10^4\right)^2 \left(1.586418216 \times 10^{-36}\ \text{kg}\right) = 3.071305666 \times 10^{-25}\ \text{kg} \quad (35)$$

$$m_{T2} = n \frac{E}{c^2} \left(60 \times 10^7\right) \left(1.586418216 \times 10^{-36}\ \text{kg}\right) = 9.518509296 \times 10^{-28}\ \text{kg} \quad (36)$$

Adding the two masses together yields the mass calculator Top Quark mass to be:

$$\begin{aligned} M_{TQ} &= m_{T1} + m_{T2} \\ &= 3.071305666 \times 10^{-25}\ \text{kg} + 9.518509296 \times 10^{-28}\ \text{kg} \\ &= 3.080824175 \times 10^{-25}\ \text{kg} \end{aligned} \quad (37)$$

Rounding off to four significant figures we have: $M_{TQ} = 3.0808 \times 10^{-25}\ \text{kg}$. We immediately determine the refined Top Quark mass of 3.0808×10^{-25} kg is within the limits of uncertainty, and more importantly agrees with our mass calculator value that we assume is able to generate the correct mass for any elementary particle.

At this point we can provide the upper bound relation limiting what values *m* and *n* can be chosen to be. Given that the Top Quark is the most massive of all elementary particles at current accelerator technology, and so has the largest *m*-value of 44, so to do Tau Leptons. No other particle may exceed this value of *m*. Likewise for the same holds for *n*-value of 60. Together the sum of *n* and *m* yields an upper bound value on all Standard Model particles to be:

$$m + n \le 104 \quad (38)$$

The number *m* has the rule that it must be chosen first. Also *m* and *n* are linked to particle mass. Hence are linked to the modified uncertainty principle which defines hybrid time, $\Delta t = \dfrac{7.396343409 \times 10^{-16}\ \text{s}}{2\left(n + m^2\right)}$.

The greater *n* or *m*, the less the mean lifetime for the excited graviton (*fusion of gravitons causes some complications*). Plugging in 44 for *m* and 60 for *n*, yields a hybrid time or graviton mean lifetime to produce a Top Quark amongst a cubic meter of gravitons of: 1.8528×10^{-19} s. This is the time once fused gravitons absorb the same level collisional energy, the graviton has to manufacture gravitational quanta and emit a Top Quark. Notice any greater *m* approaches a limit, because of the practical limit on decreasing graviton lifetimes.

We now are ready to calculate Higg's boson mass. As of March 27, 2023, the reported value measure of the Higgs boson mass is 124.94 GeV ± 0.17(stat.) ± 0.03 (syst.) [94]. Converted to SI kilograms equals 2.2272578 × 10^{-25} kg, or 2.227 × 10^{-25} kg [95]. By selecting $n=32$, and $m=37$, The number of fused gravitons each having $m=37$ is also 1 × 10^4:

$$\begin{aligned} m_{H1} &= m^2\frac{E}{c^2} = \left(37\times10^4\right)^2\left(1.586418216\times10^{-36}\ \text{kg}\right) \\ &= 2.171806538\times10^{-25}\ \text{kg} \end{aligned} \tag{39}$$

And for $n=35$ with 1 × 10^7 fused gravitons we have:

$$\begin{aligned} m_{H2} &= n\frac{E}{c^2} = \left(35\times10^6\right)\left(1.586418216\times10^{-36}\ \text{kg}\right) \\ &= 5.552463756\times10^{-27}\ \text{kg} \end{aligned} \tag{40}$$

Adding these values together yields a Higgs mass of:

$$2.171806538\times10^{-25}\ \text{kg} + 5.552463756\times10^{-27}\ \text{kg} = 2.227331176\times10^{-25}\ \text{kg} \tag{41}$$

Comparing the Higgs experimental mass value of: 2.227 × 10^{-25} kg with our theoretically derived Higgs mass value of: 2.227 × 10^{-25} kg, we see they are in precise agreement—no adjustment to the experimental mass is required.

Before closing this section, mention that if spacetime conditions become too extreme, the process of graviton particle creation becomes complicated and often interrupted—for example inside stars and black holes. Such conditions are beyond the scope of this current discussion. Though the foundational graviton approach can still be applied when taking the complications into account.

11. Emergence of Spin

Extrapolating from our founding premise—that elementary particles are physically generated from excited gravitons and that the mass of each type of particle is expressed mathematically through the energy momentum tensor $T_{\mu\nu}$, particle spin must be too. Indeed, this turns out to be true by assessing its four diagonal component-coefficients. The three spatial coefficients of $T_{\mu\nu}$ express the related spin rational number of $+\frac{1}{2}$, while the single time component-coefficient yields $-\frac{3}{2}$:

$$T_{\mu\nu} = \frac{\left(n+m^2\right)c^4}{16\pi G}\begin{pmatrix} -\frac{3}{2}\omega^2 & 0 & 0 & 0 \\ 0 & \frac{1}{2}\omega^2 & 0 & 0 \\ 0 & 0 & \frac{1}{2}\omega^2 & 0 \\ 0 & 0 & 0 & \frac{1}{2}\omega^2 \end{pmatrix} \tag{42}$$

Aligning the energy momentum coefficient-components with Standard Model particle spin, informs us that the three spatial coefficients describe all the elementary spin particles belonging to Leptons and Quarks, which all have mass. Because spin is integral to all elementary particles and both spin and mass are created by gravitons, it must be that spin and mass are integral to each other.

12. Force Carrying Bosons and Spin

Excluding the graviton—because it is the originator of all particles and their attributes, and also temporarily setting aside the Higgs Boson for the moment, all the remaining force carriers of the Standard Model of particle physics, have spin-1. This type of spin requires the sum of two spatial coefficient components of the energy momentum tensor $T_{\mu\nu}: \frac{1}{2}+\frac{1}{2}=1$, which provides motivation to assume force carrier bosons need a mechanism to transfer information. Moreover, because bosons have spin, it tells us the force carriers themselves are also generated out of gravitonic processes. Doubly so since their spin is revealed through the energy momentum tensor coefficients, just like all elementary mass particles are.

However, we note gluons and photons are massless, whereas their counterparts, the Z and ±W Bosons are massive implies the Z and ±W Bosons must play a dual role in elementary particle. That is they act as both a force carrier but also as a unique massive particle. This is demonstrated in the weak nuclear force approximated to be $F(r) \approx g^2 \frac{\mathrm{e}^{-\alpha mr}}{r^2}$, with *αm* being proportional to the mass of the ±W and Z bosons, and *g* is the strength of the weak force. This shows these three bosons in their dual role capacity, act as both a force carrier and a mass particle inherent to the force. Finally the strong force is a function of *r*, not time.

The exception to all the Standard Model particles is the Higgs Boson having spin-0. To achieve zero spin requires the sum of all the energy momentum tensor coefficients: $\frac{1}{2}+\frac{1}{2}+\frac{1}{2}-\frac{3}{2}=0$. It is apparent by now the Higgs particle has nothing to do with elementary particle mass generation. Its specialness, has to do with its spin being born from the components of space and time from gravitonic processes which are ubiquitous as are massless graviton. The implications being the Higgs Boson is and information carrier, a spin carrier having to do with quantum spin entanglement [96] [97].

13. Spin $\pm\frac{3}{2}$

Finally we address *spin* $\pm\frac{3}{2}$. So far no such a spin particle has been discovered. Nevertheless *spin* $\pm\frac{3}{2}$ particles do appear in theoretical dark matter models as it does in ours [98].

In closing this section, a more comprehensive approach to particle spin may be investigated through the spacetime metric itself: $g_{\mu\nu} = \mathrm{e}^{i\left(\sqrt{n\omega t}\right)}\eta_{\mu\nu}$. Upon inspection of the metric, one can see the Minkowski metric is coupled to the Euler formula. That will be the starting point, though it is our intent to only lay down a few founding ideas, and leave the more substantial work on particle spin for future endeavors.

Let us begin with a thought experiment, in which we imagine our metric $g_{\mu\nu}$ shrinking down so small it is able to monitor a single graviton. Keep in mind at this microscopic level, spacetime is comprised of oscillating gravitons. This motion is accounted for by Euler's formula coupled to the Minkowski metric contained in $g_{\mu\nu}$. In regard to the Minkowski metric, let each of its real coordinate axis be denoted by: x, y, z, p (*where letter p is chosen to remove any confusion with time* (t) *in the Euler formula* $\mathrm{e}^{\left(i\sqrt{n\omega}\right)t}$). Recall from it, the energy momentum tensor was calculated from the hybrid general relativistic equation applicable during hybrid time. Along with time-energy uncertainty principle and the energy density component T_{00} divided by N_D, hybrid time was developed. The (t) in the metric is only serves as a parameter to convert seconds to radians, via multiplication of the angular frequency ω.

Because the Euler formula $\mathrm{e}^{\left(i\sqrt{n\omega}\right)t}$ is coupled to the Minkowski metric $\eta_{\mu\nu}$, with its real coordinate axis—together they create a complex plane. All points in this complex plane can be expressed as a two-tuple, with imaginary and real parts for each of the four complex planes: $(x, ai);(y, bi);(z, ci)$ and (p, di). Where $a, b, c, d \in \mathbb{R}$ .Associated with each complex plane, one can identify a rotor vector making angles $\sqrt{n}(\omega t)$, such that $\mathrm{e}^{\left(i\sqrt{n\omega}\right)t} = \cos\left(\sqrt{n\omega t}\right) + i\sin\left(\sqrt{n\omega t}\right)$. This rotor vector can be identified with the spinor used in quantum physics to elucidate many things, including particle spin [99]:

"A four-component, spin-one-half field invented by Dirac describes the quarks and leptons of the standard model… Dirac equation immediately yields the spinors at finite momentum. The paper then shows that with these spinors, a Dirac field transforms appropriately under charge conjugation, parity, and time reversal. The paper also describes how a Dirac field may be decomposed either into two 4-component Majorana fields or into a 2-component left-handed field and a 2-component right-handed fields." [100]

14. Geodesic Equation Schwarzschild Metric

When massless gravitons become impregnated by collisional energy, they enlarge becoming spherical in shape as it is about to emit an elementary particle. Thus, by the nature of general relativity, some infinitesimal distance away from the graviton spacetime may be described by a Schwarzschild Metric.

As an elementary particle is about to be emitted, the node of the graviton collapses losing its excited energy. Hence $n = 0$ resulting in what was once quasi-spacetime to go Minkowski completely flat. That is: $g_{\mu\nu} = \mathrm{e}^{0i(\omega)t}\eta_{\mu\nu} = \eta_{\mu\nu}$.

That is to say when $0i = 0$, the imaginary axes intersect the real axis, so that the metric becomes real valued metric flat $\eta_{\mu\nu}$. This complete particle creation and allows a real mass particle to pass into curved spacetime. The emitted particle's path is guided by Schwarzschild geodesic which is remnant due to a hysteresis effect left cover from the decaying graviton.

In this infinitesimal neigborhood, flat spacetime is sandwiched between quasi-spacetime inside the graviton and curved spacetime outside the graviton. In between quantum physics combine with special relativity combine into a single apparatus. This allows the Minkowski geodesic [101] to be joined to the curved spacetime geodesic of general relativity—in particular to the Schwarzschild geodesic is given by:

$$\frac{\mathrm{d}^2 x^i}{\mathrm{d}s^2} + \Gamma^i_{jk} \frac{\mathrm{d}x^j}{\mathrm{d}s} \frac{\mathrm{d}x^k}{\mathrm{d}s} = 0 \tag{43}$$

The separation values between the two geodesics (*flat and curved*) can be computed by the following equation:

$$\frac{\mathrm{d}^2 \xi^\alpha}{\mathrm{d}s^2} = R^\alpha_{\beta\gamma o} \mu^o \mu^\beta \xi^\gamma \tag{44}$$

It shows the separation between the two flat and curved geodesics is proportional to the Riemann tensor. Where ξ^μ is the separation vector between the two geodesics. Moreover, curved spacetime and flat spacetime are geodesically connected and measurable. This results further coalesces the two theories of quantum physics and general relativity.

15. Discussion

We began with a field of oscillating gravitons in otherwise "empty" space. Entering from opposing directions, two protons collided releasing heat and energy. Traditionally, quantum chromodynamics would be applied to describe the collision and unfolding of events (*without the gravitons*). Instead, we had argued for an intermediary step. One in which a proton-proton collision in "empty spacetime" (*excepting for gravitons comprising spacetime*), light is released during the collision in the form of planewaves. Neighboring gravitons absorb discrete amounts of the planewave light. Transforming the propagating lightinto a standing inside the graviton. In turn the standing wave energy density was converted into gravitational quanta and finally emitted as an elementary particle having mass and spin. To calculate the gravitonic duration of this process, the quantum mechanical time-energy uncertainty principle was modified and applied to calculate the mean lifetime of an excited graviton going from absorption to emission of a particle. Because ΔE—which is the increase in energy of a graviton through energy absorption, can be calculated precisely, the uncertainty principle becomes more certain. This left hybrid time Δt uncertainty a function of the counting numbers: $n + m^2$. Modification could then be kept at a minimal by changing its greater than or equal sign to a hard equals sign.

$$\Delta t \Delta E = \frac{1}{2}\hbar \tag{45}$$

Hybrid time Δt can be seen as a function gravitational quanta. The merging of the disparate theories of quantum physics and general relativity, is expressed after the angular frequency value is inserted into the metric:

$$g_{\mu\nu} = \mathrm{e}^{i\left(\sqrt{\left(4\pi^2\right)N}\right)\times 10^{-12}} \eta_{\mu\nu} \tag{46}$$

where $N = n + m^2$ (where m was added after consideration of internal graviton energy). One can reinterpret the exponents of $4\pi^2$ to be analogous to the period of a simple pendulum, given by: $T^2 = 4\pi^2 L/g$, which involves the gravitational acceleration g, related to the universal gravitational constant G. Where L would now represent the diameter or one side length of a vibrating, geometrically shaped graviton. Though the graviton has absorbed an increase in its mass-energy, analogous to a simple gravity pendulum, the graviton does not alter its period or angular frequency. In this way microscopic spacetime acts as tiny synchronized clocks stationed everywhere throughout the cosmos—the heartbeat of natural reality.

Because of a modified time-energy uncertainty principle, together with the quasi-spacetime metric representing a field of oscillating gravitons absorbing quanta of electromagnetic energy converting $nh\nu$ into gravitational quanta to form elementary particles. Not only has general relativity merged with quantum physics into a single theory, the graviton dynamics describe in this hybrid concept, it continues within unruly spacetimes such as inside black holes and supernovae.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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