Superluminal Wormhole Transport by the Phi-Based Solution to the Schrödinger Equation, Theorem of Residues and Cauchy Integral

RICHARD L. AMOROSO[§] & SALVATORE GIANDINOTO[¶]

[§]Noetic Advanced Studies Institute, Oakland, 94610-1422 CA USA
[¶]Advanced Laser Quantum Dynamics Research Institute
10321 Briar Hollow Drive, St. Louis, MO 63146 USA

Abstract. We demonstrate the transportation of high energy subatomic particles through wormholes at superluminal speeds through an 'elastic' wormhole effect which adjusts its diameter based upon the kinetic energy of the subatomic particle. This is demonstrated by the use of the Phi-based solution to the Schrödinger wave equation, the theorem of residues and the Cauchy integral formula of complex analysis. Furthermore, it will be shown that a possible new gravitational constant may shed light on the structure of the spin-2 graviton. It will be shown that the mathematical description of simple isolated singularities (poles) may be used to describe wormholes and their characteristics at the center of their corresponding black holes. It will also be shown that the expansion of the universe at the Planck time occurred with a kinetic energy of approximately 4.14 x 10^{29} eV.

Keywords: Singularities, superluminal, quantum gravity, complex analysis, Cauchy integral formula, Theorem of Residues, wormholes, black holes, sub-Planckian, parallel universes, Non-locality, Quantum entanglement.

1. Introduction

Using complex variable methods and the previously derived Phi-based solution to the Schrödinger Wave Equation [1], it will be shown that the mathematical description of simple isolated singularities (poles) may be used to describe wormholes and their characteristics at the center of their corresponding black holes.

Recently, it has been shown that the irrational number Phi (Φ) is intimately and precisely linked to the *g*-factors of the electron, proton and neutron via simple trigonometric identities and thus has become scientifically significant when compared to the measured NIST values of these quantum mechanical constants [2]. The model in this paper will demonstrate that wormholes are actually "elastic entities" that adjust their diameters according to the kinetic energy of the particles that enter them. Additionally, it will be shown that the particles entering such wormholes do so at superluminal (faster than light) velocities and that their velocities are solely dependent on the energy of the particles entering the wormhole. It will also be demonstrated that the diameter of the wormhole is of the order of sub-Planckian lengths and that this is crucial to the subsequent transportation of the subatomic particle to a parallel universe at superluminal velocities. It has been suggested numerous times in the current literature [3-8] that wormholes could act as possible superluminal gateways to parallel universes, but to date, no mathematical formalism incorporating complex variable methods have been derived to prove such a possibility.

The electron *g*-factor, g_e is mathematically equivalent to $g_e = \dfrac{4\mu_e m_e}{e\hbar}$. Per NIST, its value is -2.00231930437. Using the Phi-based equation for the *g*-factor, $g_e = \dfrac{-2}{Sin(\Phi)}$ we obtain -2.00223347323. The difference between the two values is a mere -0.004%. For the *g*-factor of the proton, the NIST value is 5.585694701. The Phi-based equation for the g-factor of the proton is given by $g_p = \frac{2\Phi}{Sin(\phi)}$ where $\phi = \frac{1}{\Phi} = \Phi - 1$. The Phi-based value for the proton g-factor is 5.58487815298. Again, the difference here is a mere -0.0146%. These Phi-based relationships appear to be scientifically significant due to their accurate results when compared to the actual 'measured' NIST values. There is always error and other phenomena involved when physical constants are measured. One case in point is that the electron, despite being an elementary particle, possesses a nonzero magnetic moment. One of the triumphs of the theory of quantum electrodynamics is its accurate prediction of the electron g-factor, which has been experimentally determined to have the value 2.002319... The value of 2 arises from the Dirac equation, a fundamental equation connecting the electron's spin with its electromagnetic properties, and the correction of 0.002319... arises from the electron's interaction with the surrounding electromagnetic field.

It is for this reason that we have chosen the Phi-based solution to the Schrödinger wave equation and have incorporated the concepts of complex analysis in order to better understand the physics of wormholes.

Complex numbers, in algebraic notation are of the form, ***z* = *x* + *iy***. The complex conjugate of ***z*** is therefore ***x* – *iy***. In Cartesian coordinates, complex numbers are represented by the complex-plane or Argand Diagrams (Fig. 1) as shown below:

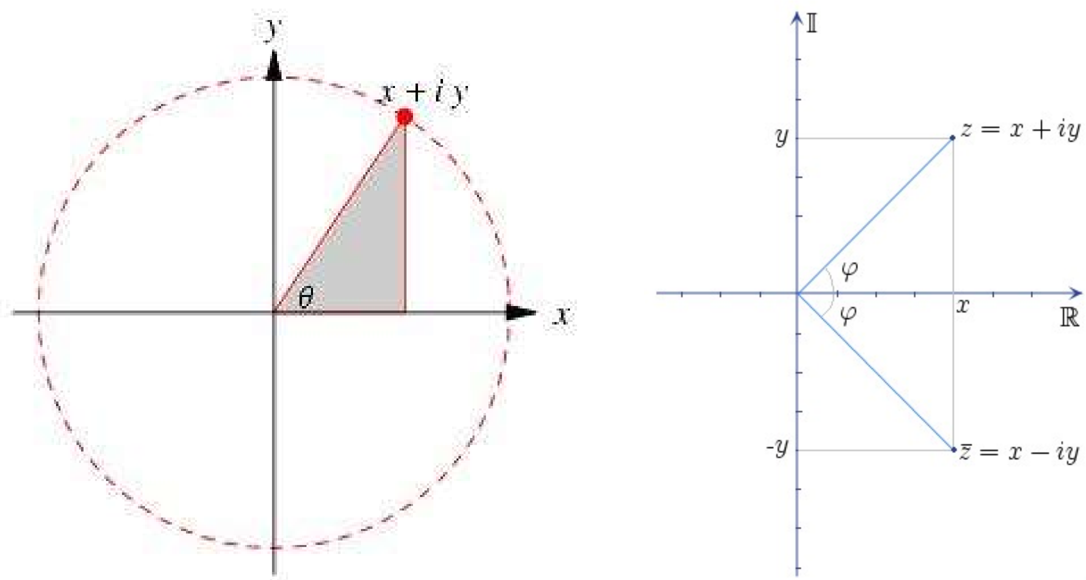


Figure 1

The real part of ***z*** is the number ***x*** and the imaginary part is i***y***. Likewise, the complex-plane is defined by its real axis as the Abscissa or ***x-axis*** and the imaginary axis as the Ordinate or ***y-axis.*** In polar coordinates the complex number can be written in "Phasor" form where $z = |z|(\cos\theta + i\sin\theta) = |z|e^{i\theta}$. $|z|$ is known as the "complex modulus" of ***z*** and the angle θ represents the "argument" of the complex number ***z***. Arg(***z***) is therefore equal to θ and to $\tan^{-1}\left(\frac{y}{x}\right)$. Using ***de Moivre's*** identity, $z^n = |z|^n(\cos n\theta + i\sin n\theta) = |z|^n e^{i\theta}$. Additionally, the dashed red circle represents the complex modulus $|z|$ of ***z*** as well and is equal to $\sqrt{x^2 + y^2}$. In trigonometric notation or *Euler's* form, $z = r(\cos\theta + i\sin\theta) = rcis\theta = re^{i\theta}$.

The ***Cauchy Integral Formula Theorem*** [9], a widely used formula in nuclear physics, is the following: ***If f (z) is regular inside and on a simple closed contour C, and if z_0 is any point within C, then*** $f\left(z_0\right)=\dfrac{1}{2\pi i}\oint_c \dfrac{f\left(z\right)}{z-z_0}dz$. It may also be shown further that the derivatives of a function $f^{(n)}\left(z_0\right)=\dfrac{n!}{2\pi i}\oint_c \dfrac{f\left(z\right)}{\left(z-z_0\right)^{n+1}}dz$.

The series $\sum_{n=-\infty}^{n=\infty} a_n\left(z-z_0\right)^n$ is the ***Laurent expansion*** of the function *f(z)* about the point z_0 where it can be shown that $a_n=\dfrac{1}{2\pi i}\oint_c \dfrac{f\left(z\right)}{\left(z-z_0\right)^{n+1}}dz$. Furthermore, we can rewrite the above expression for a_n , $n\geq 0$ using ***Cauchy's integral*** formula to obtain:

$f\left(z\right)=\sum_{n=0}^{\infty} f^{(n)}\left(z_0\right)\dfrac{\left(z-z_0\right)^n}{n!}$ where $f^{(n)}\left(z_0\right)$ denotes the n^{th} derivative of $f\left(z\right)$ at $z=z_0$.

This expansion of a regular function is known as the ***Taylor series*** for $f\left(z\right)$ about $z=z_0$. At this particular juncture it is both convenient and important to introduce some special terminology common to complex analysis. The series $\sum_{n=-\infty}^{n=-1} a_n\left(z-z_0\right)^n$ in a ***Laurent expansion*** about an isolated singularity at $z=z_0$ is known as the *principal part* of $f\left(z\right)$ and the coefficient a_{-1} is called the *residue* of $f\left(z\right)$ at $z=z_0$. However, if the principal part terminates (i.e., that $a_n = 0$ for all $n < -p$) then we refer to the isolated singularity at $z=z_0$ as a pole of order *p*. We talk of *simple, double* and *triple* poles when *p* = 1, 2 and 3 respectively. If the principal part is non-terminating then we speak of an *isolated essential singularity* of $f\left(z\right)$ at $z=z_0$.

1.) ***The Theorem of Residues***

If f(z) is regular inside and on a simple closed contour C except for a finite number of isolated singularities at the points z_r, where r = 1, 2,…n, then $\oint_c f\left(z\right)dz=2\pi i\sum_{r=1}^{n} R_r$ *where R_r is the residue of f(z) at the point z_r* [10].

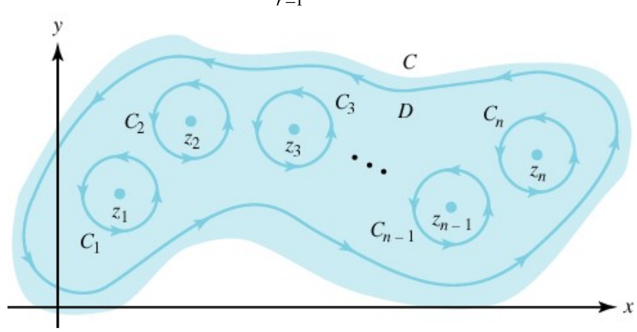


Fig. 2

The proof consists in showing the equivalence of the contour *C* to the set of contours C_r as depicted in Figure 2 above. This equivalence is fairly obvious from the construction of an open contour *C* that encompasses and is contiguous with the smaller contours C_r where $r = 1, 2, 3,\ldots$ *n-1,n.* The integral of *f(z)* around the contour of Fig. 2 is clearly zero by *Cauchy's Theorem* and so we have:

$$\left(\oint_c - \sum_{r=1}^{n} \oint_c \right) f(z)\,dz = 0.$$

Example 1: *If at* $z = z_0$*, f(z) has a simple pole of residue R, show that* $R = \lim_{z\to z_0} (z - z_0) f(z)$.

Since *f(z)* has a simple pole at $z = z_0$ it has a *Laurent expansion* of the form:

$f(z) = \dfrac{R}{z - z_0} + a_0 + a_1(z - z_0) + \ldots$. Multiplying by $(z - z_0)$ we obtain

$$(z - z_0) f(z) = R + a_0(z - z_0) + a_1(z - z_0)^2 + \ldots$$

$= R + (z - z_0)F(z)$ where $F(z)$ is regular at $z = z_0$ since it has a *Taylor* expansion about this point. Hence, $R = \lim_{z\to z_0} (z - z_0) f(z)$.

Example 2: Calculate the residue of $f(z) = \dfrac{1}{1 - z^2}$ at $z = 1$.

We can rewrite our function in the form $f(z) = \dfrac{1}{1 - z^2} = \left(\dfrac{1}{1 - z}\right)\left(\dfrac{1}{1 + z}\right) = \dfrac{1}{z - 1} F(z)$.

$F(z)$ is regular at or near $z = 1$ and so can be expanded in a *Taylor* series:

$F(z) = a_0 + a_1(z - 1) + a_2(z - 1)^2 + \ldots$. Hence, near $z = 1$, $\dfrac{1}{(1 - z^2)}$ behaves like $\dfrac{a_0}{(z - 1)}$ and so possesses a simple pole at this point. The residue may thus be found using the limit formula shown above in Example 1 and ***L'Hôpital's*** rule:

$$R = \lim_{z\to 1}\left(\frac{z - 1}{1 - z^2}\right) = \lim_{z\to 1}\left(\frac{1}{-2z}\right) = \frac{-1}{2}$$

Example 3: Evaluate by contour integration $\int_0^{2\pi} (5 + 2\cos\theta)^{-1} d\theta$ and determine the residue of the pole which lies within the contour.

$\int_0^{2\pi} (5 + 2\cos\theta)^{-1} d\theta = -i\oint_c (z^2 + 5z + 1)^{-1} dz$ where $z = e^{i\theta}$ and C is the circle $|z| = 1$.

The integrand in the above equation has two simple poles at the points $z = \dfrac{1}{2}\left(-5 \pm \sqrt{21}\right)$.

Only one of these poles lies inside the contour *C:* $z = \dfrac{1}{2}\left(-5 + \sqrt{21}\right)$. The residue at this point can easily be found by using the method described above:

$$R = \lim_{z\to z_0} \frac{\left\{z + \frac{1}{2}\left(5 - \sqrt{21}\right)\right\}}{z^2 + 5z + 1} = \lim_{z\to z_0} \frac{1}{2z + 5} = \frac{1}{\sqrt{21}} \text{ where } z_0 = \frac{1}{2}\left(-5 + \sqrt{21}\right).$$

2. Quantum Gravity

From the previously derived Phi-based solution to the Schrödinger wave equation [1] we have:

$$\Psi_n(x,t) = \psi_n(x) e^{\frac{-2\pi ict}{\Phi^2 \lambda_{n+2}}} \tag{1.01}$$

This wavefunction can be re-written in the following manner:

$$\Psi_n(x,t) = \psi_n(x) f(z) \text{ where } f(z) = e^{\frac{-2\pi ict}{\Phi^2 \lambda_{n+2}}} \tag{1.02}$$

Cauchy's Theorem states that $f(z_0) = \frac{1}{2\pi i}\oint_c \frac{f(z)}{z-z_0}dz$ where at $z = z_0$ $f(z)$ has a simple pole of residue R where $R = \lim_{z \to z_0}(z-z_0) f(z)$. Likewise, the *Theorem of Residues* states the following: $\oint_c f(z)dz = 2\pi i \sum_{r=1}^{n} R_r$ wherever $f(z)$ is analytic, continuous and differentiable within and on the contour C that encloses any number of isolated poles (singularities). A simple pole is an isolated singularity in a complex manifold where the function where the function goes to infinity and is therefore undefined (i.e., 1/0). A black hole is treated as a singularity in space-time since the system collapses under extreme gravitational attractive forces in the observable universe. It is therefore appropriate and desirable to use the concept of isolated singularities within the framework of complex analysis in order to directly model black holes and to use black holes as both the universal and mathematical equivalent of an isolated singularity or 'pole' in the context of complex analysis.

With this concept in mind, we may now continue to derive certain wave-functions that implicitly incorporate the mathematical and experimental concept of a wave-function acting as a 'contour' which surrounds a singularity in space-time or a black hole.

Using eq. (1.02) where $f(z) = e^{\left(\frac{-2\pi ict}{\Phi^2 \lambda_{n+2}}\right)}$ and letting $z = \frac{-2\pi ict}{\Phi^2 \lambda_{n+2}}$ then $f(z) = e^z$. Differentiation gives us:

$\frac{df(z)}{dz} = e^{\left(\frac{-2\pi ict}{\Phi^2 \lambda_{n+2}}\right)} \frac{dz}{dt}$ where $\frac{dz}{dt} = \frac{-2\pi ic}{\Phi^2 \lambda_{n+2}}$ and

$\frac{df(z)}{dz} = \left(\frac{-2\pi ic}{\Phi^2 \lambda_{n+2}}\right) f(z)$. Multiplying by dz we obtain:

$$df(z) = \left(\frac{-2\pi ic}{\Phi^2 \lambda_{n+2}}\right) f(z) dz \tag{1.03}$$

Solving for $f(z)$ we obtain:

$$f(z) = \left(\frac{-\Phi^2 \lambda_{n+2}}{2\pi ic}\right) \frac{df(z)}{dz} \tag{1.04}$$

Substituting eq. (1.04) into eq. (1.02), we obtain the following:

$$\backslash\, \Psi_n(x,t) = \psi_n(x) \left(\frac{-\Phi^2 \lambda_{n+2}}{2\pi ic}\right) \frac{df(z)}{dz} \tag{1.05}$$

Multiplying both sides of eq. (1.05) by ***dz*** we obtain:

$$\Psi_n(x,t)\, dz = \psi_n(x) \left(\frac{-\Phi^2 \lambda_{n+2}}{2\pi ic}\right) df(z) \tag{1.06}$$

Integrating both sides of equation (1.06) with respect to ***z*** gives the following relationship:

$$\Psi_n(x,t)(z-z_0)=\psi_n(x)\left(\frac{-\Phi^2\lambda_{n+2}}{2\pi ic}\right)\left[f(z)-f(z_0)\right] \tag{1.07}$$

Expanding the right-hand side of equation (1.07) we obtain the following:

$$\Psi_n(x,t)(z-z_0)=\psi_n(x)\left(\frac{-\Phi^2\lambda_{n+2}}{2\pi ic}\right)f(z)-\psi_n(x)\left(\frac{-\Phi^2\lambda_{n+2}}{2\pi ic}\right)f(z_0)$$

Since $f(z)=e^{\left(\frac{-2\pi ict}{\Phi^2\lambda_{n+2}}\right)}$, we may re-write the above equation as:

$$\Psi_n(x,t)(z-z_0)=\psi_n(x)\left(\frac{-\Phi^2\lambda_{n+2}}{2\pi ic}\right)e^{\left(\frac{-2\pi ict}{\Phi^2\lambda_{n+2}}\right)}-\psi_n(x)\left(\frac{-\Phi^2\lambda_{n+2}}{2\pi ic}\right)f(z_0)$$

Factoring out $\psi_n(x)\left(\frac{-\Phi^2\lambda_{n+2}}{2\pi ic}\right)$ we obtain the following relationship:

$$\Psi_n(x,t)(z-z_0)=\left[\psi_n(x)\left(\frac{-\Phi^2\lambda_{n+2}}{2\pi ic}\right)\right]\left[e^{\left(\frac{-2\pi ict}{\Phi^2\lambda_{n+2}}\right)}-f(z_0)\right] \tag{1.08}$$

Dividing by $(z-z_0)$ we obtain:

$$\Psi_n(x,t)=\frac{\left[\psi_n(x)\left(\frac{-\Phi^2\lambda_{n+2}}{2\pi ic}\right)\right]\left[e^{\left(\frac{-2\pi ict}{\Phi^2\lambda_{n+2}}\right)}-f(z_0)\right]}{(z-z_0)} \tag{1.09}$$

Since $\frac{-1}{i}=i$, we may re-write eq. (1.09) as follows:

$$\Psi_n(x,t)=\frac{\left[\psi_n(x)\left(\frac{i\Phi^2\lambda_{n+2}}{2\pi c}\right)\right]\left[e^{\left(\frac{-2\pi ict}{\Phi^2\lambda_{n+2}}\right)}-f(z_0)\right]}{(z-z_0)} \tag{1.10}$$

Breaking up equation (1.10) into two parts,

$$\Psi_n(x,t)=\frac{\left[\psi_n(x)\left(\frac{i\Phi^2\lambda_{n+2}}{2\pi c}\right)\right]\left[e^{\left(\frac{-2\pi ict}{\Phi^2\lambda_{n+2}}\right)}\right]}{(z-z_0)}-\frac{\left[\psi_n(x)\left(\frac{i\Phi^2\lambda_{n+2}}{2\pi c}\right)\right]}{(z-z_0)}f(z_0) \tag{1.11}$$

or,

$$\Psi_n(x,t) = \frac{\left[\psi_n(x)\left(\frac{i\Phi^2\lambda_{n+2}}{2\pi c}\right)\right]\left[e^{\left(\frac{-2\pi ict}{\Phi^2\lambda_{n+2}}\right)}\right]}{(z-z_0)} - \frac{\left[\psi_n(x)\left(\frac{i\Phi^2\lambda_{n+2}}{2\pi c}\right)\right]}{(z-z_0)}\left(\frac{1}{2\pi i}\oint_{r\to r_s}\frac{f(z)}{z-z_0}dz\right) \tag{1.12}$$

which reduces to:

$$\Psi_n(x,t) = \frac{\left[\psi_n(x)\left(\frac{i\Phi^2\lambda_{n+2}}{2\pi c}\right)\right]\left[e^{\left(\frac{-2\pi ict}{\Phi^2\lambda_{n+2}}\right)}\right]}{(z-z_0)} - \frac{\left[\psi_n(x)\left(\frac{\Phi^2\lambda_{n+2}}{4\pi^2 c}\right)\right]}{(z-z_0)}\left(\oint_{r\to r_s}\frac{f(z)}{z-z_0}dz\right) \tag{1.13}$$

It may now be shown that as $z \to z_0$, the quantity $\dfrac{\oint_{r\to r_s}\left(\dfrac{f(z)\,dz}{z-z_0}\right)}{(z-z_0)}$ approaches the Schwarzschild radius (residue) of the black hole and is given by $r_s = \dfrac{2Gm}{c^2}$. Substituting terms, the right-hand side of equation (1.13) becomes:

$$-\left[\psi_n(x)\left(\frac{mG\Phi^2\lambda_{n+2}}{2\pi^2 c^3}\right)\right] \tag{1.14}$$

In equation (1.14), *m* is the mass of the gravitating object. The Schwarzschild radius r_s is a characteristic radius associated with every mass. The units of the constants and variables *m* and λ_{n+2} in parentheses in (1.14) come out to be centimeter-seconds (cm-sec) when the wavelength of the particle and mass are considered. However, if we replace λ_{n+2} with $\dfrac{h}{mc}$ we obtain the following: $-\left[\psi_n(x)\left(\dfrac{G\Phi^2 h}{2\pi^2 c^4}\right)\right]$. Or, in terms of Dirac's constant, $\hbar$, the expression becomes $-\left[\psi_n(x)\left(\dfrac{G\Phi^2\hbar}{\pi c^4}\right)\right]$. (1.15)

We now have an expression containing two unitless constants and three unit bearing constants. The numerical value of this constant is 7.2616 x $10^{-77}\,\dfrac{erg\cdot\sec^3}{g\cdot cm}$. This constant will be called the ***Giandinoto-Amoroso-Rauscher Quantum Gravitational Constant (GAR-QGC)*** and represents the quantum gravitational component of the wave-function of any subatomic particle. The dimensional analysis proving that $cm\cdot\sec$ is equal to $\dfrac{erg\cdot\sec^3}{g\cdot cm}$ is easily shown as follows: $cm\cdot\sec = \dfrac{erg\cdot\sec^3}{g\cdot cm}$, therefore $g\cdot cm^2 = erg\cdot\sec^2$ and $erg = \dfrac{g\cdot cm^2}{\sec^2}$ by definition.

It can now be seen how weak the gravitational force is when it is reconciled with this new constant. Furthermore, in Brian Greene's recent book, "***The Fabric of the Cosmos"*** Greene acknowledges that in an *n-dimensional* space the gravitational force is inversely proportional to the distance between the two objects raised to the power *n-1*. For example, consider the ordinary Newtonian 3-dimensional space. The gravitational force is given by $F = \dfrac{Gm_1m_2}{r^2}$. However, in String-Theory, the gravitational force becomes even weaker as we increase the number of dimensions.

For a 10-dimensional space, the gravitational force would be inversely proportional to r^9. Likewise, for a 6-dimensional space the gravitational force would be inversely proportional to r^5. As we can therefore see, the gravitational force becomes exceedingly and ever increasingly weaker as the number of dimensions of space increase.

The quantum of electromagnetic radiation, the photon, is represented by the famous and well known equation $E = h\nu$. In this case, the quantum constant is Planck's constant $h = 6.626 \times 10^{-27}\ erg \cdot \sec$. In the case of the ***Quantum Gravitational Constant (GAR-QGC)*** the numerical value is 45 orders of magnitude smaller than that of Planck's constant. As an example, let us use equation (1.14) for an electron of mass ($m_e = 9.109 \times 10^{-28}$ g) with a wavelength of 1 meter corresponding to a frequency of approximately 300 MHz. The value we obtain is 2.993×10^{-67} m-sec. We must remember that m_e is the rest mass of the electron and the wavelength λ_{n+2} is related to the kinetic energy of the electron.

Another example of the use of equation (1.14) is for that of a much more energetic electron having a wavelength of 10^{-12} m (1 picometer) or 3.0×10^{20} MHz or 300 YHz (Yotta Hertz). In this case the value obtained is $2.993 \times 10^{-79}\ m \cdot \sec$. It can thus easily be seen that the more energetic the particle, the smaller the value will become. Let us now consolidate equation (1.15) in terms of the Planck Length (l_p). The Planck length, $l_p = \sqrt{\frac{\hbar G}{c^3}}$, or $1.61624 \times 10^{-33}\ cm$. Using equation (1.15) we obtain the following relationship:

$$-\left[\psi_n(x)\left(\frac{G\Phi^2\hbar}{\pi c^4}\right)\right] = -\left[\psi_n(x)\frac{l_p^2\Phi^2}{\pi c}\right]. \tag{1.16}$$

As we can see, the ***GAR-QGC*** is directly proportional to the square of the Planck length and the square of Phi (Φ) and inversely proportional to π times the speed of light c. The Planck Time $t_p = \sqrt{\frac{\hbar G}{c^5}}$ may also be incorporated into equation (1.15) in the following manner:

$$-\left[\psi_n(x)\left(\frac{G\Phi^2\hbar}{\pi c^4}\right)\right] = -\left[\psi_n(x)\frac{t_p^2\Phi^2 c}{\pi}\right]. \tag{1.17}$$

In this case, the ***GAR-QGC*** is directly proportional to the square of the Planck time, Φ^2 and the speed of light and is inversely proportional to π.

The dimensions assigned to the gravitational constant (length cubed, divided by mass and by time squared) are those needed to make gravitational equations "come out right". However, these dimensions have fundamental significance in terms of the Planck units. When expressed in SI units, the gravitational constant is dimensionally and numerically equal to the cube of the Planck length divided by the Planck mass (m_p) and by the square of the Planck time (t_p). This is shown in the following equation:

$G = \frac{l_p^3}{m_p t_p^2}$ where m_p is the Planck mass. The Planck mass is expressed in the following equation: $m_p = \sqrt{\frac{\hbar c}{G}} \approx 1.2209 \times 10^{19}$ GeV/c^2 = 2.176×10^{-5} g. The Planck mass is the mass of a black hole whose Schwarzschild radius multiplied by π equals its Compton wavelength. The radius of such a black hole is approximately the Planck length, which is believed to be the length scale at which both General Relativity and Quantum Mechanics simultaneously become important.

Particle physicists and cosmologists typically use the "reduced Planck mass" which is:

$m_p = \sqrt{\frac{\hbar c}{8\pi G}}$. The addition of the 8π simplifies several equations in gravity.

A Planck particle is a hypothetical subatomic particle, defined as a tiny black hole whose Compton wavelength is the same as its Schwarzschild radius. Its mass is thus (by definition) equal to the Planck mass, and its Compton wavelength and Schwarzschild radius are equal (also by definition) to the Planck length.

Suppose we take equation (1.15) and substitute the gravitational constant G with the aforementioned equation involving the Planck time, Planck mass and Planck length:

$$-\left[\psi_n(x)\left(\frac{G\Phi^2\hbar}{\pi c^4}\right)\right] = -\left[\psi_n(x)\left(\frac{l_p^3\Phi^2\hbar}{\pi c^4 m_p t_p^2}\right)\right] \tag{1.18}$$

The quantity in parentheses in equation (1.18) is known as the modified ***Giandinoto-Amoroso-Rauscher Quantum Gravitational Constant (GAR-QGC).***

3. Superluminal Transportation of Subatomic Particles through Wormholes

The superluminal transportation of subatomic particles through wormholes may now be readily realized through the use of the ***GAR-QGC.*** This concept can now be shown using the numerical value of the ***GAR-QGC*** and the frequency (kinetic energy) of the subatomic particle entering the wormhole. The following relationships have been shown to exist.

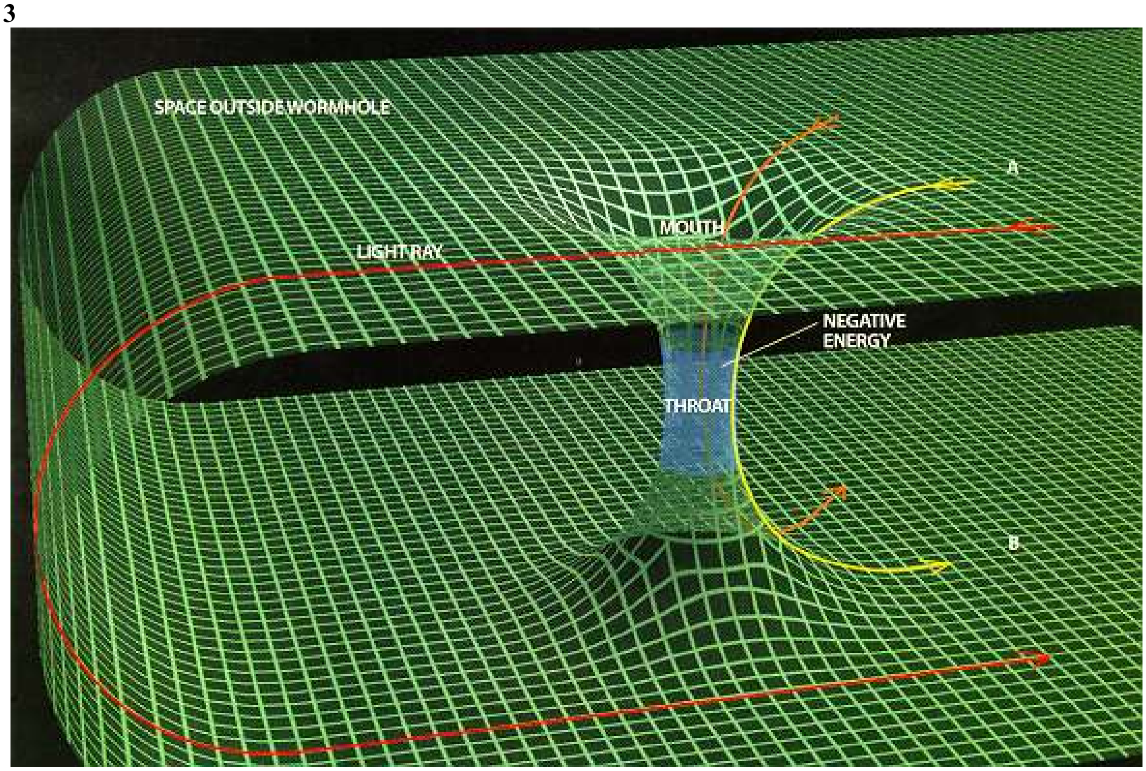
$$\left[\left(\frac{G\Phi^2\hbar}{\pi c^4}\right)\right] = \left[\frac{l_p^2\Phi^2}{\pi c}\right] = \left[\frac{t_p^2\Phi^2 c}{\pi}\right] = \left[\left(\frac{l_p^3\Phi^2\hbar}{\pi c^4 m_p t_p^2}\right)\right] = 7.2616X10^{-77}\,\frac{erg\cdot s^3}{g\cdot cm}. \tag{1.19}$$

The equivalence of the units $cm\cdot s$ and $\frac{erg\cdot s^3}{g\cdot cm}$ is readily apparent since the wavelength λ_{n+2} is indeed equal to $\frac{h}{mc}$. If we now take an example of a subatomic particle having a frequency of 10^{24} Hz (1.0 Yottahertz or YHz, well into the gamma-ray range) and multiply this by the ***GAR-QGC*** we obtain 7.2616 x 10^{-53} cm . 1Hz equals 1sec^{-1}. This value of the diameter of the wormhole is well below the Planck length of 1.61624 x 10^{-33} cm by a factor of approximately 20 orders of magnitude! If we use a smaller frequency, say 10^6 Hz we obtain 7.2616 x 10^{-71} cm which is about 38 orders of magnitude shorter than the Planck length. This demonstrates that the width of the wormhole is dependent on the frequency of the subatomic particle entering it. It also demonstrates that the wormhole is an "elastic entity" and accommodates subatomic particles based solely on their frequency or kinetic energy. Therefore, the higher the energy of the particle the wider becomes the width of the wormhole. Also, vice-versa, the lower the energy of the particle the smaller becomes the width of the wormhole.

Since the speed of light is exactly equal to $\frac{l_p}{t_p}$, it stands to reason that any dimensional sizes that are smaller than the Planck Length l_p or the Planck Time t_p are indicative of superluminal characteristics such as velocities exceeding the speed of light. Such superluminal velocities can only be achieved by particles entering a wormhole and re-entering a parallel universe. This mode of superluminal transportation also explains the non-locality principle of quantum mechanics. The probability of finding any subatomic particle anywhere in the observable universe is thus probable and its actual probability is related to the square of the quantum mechanical wavefunction (*i.e.,* $|\Psi|^2$). Superluminality also explains the "so-called" quantum-entanglement principle whereby the collapse of the wavefunction of one photon from the same source as that of another photon (*i.e.,* the annihilation of a positron and an electron to form two gamma-ray photons that propagate at 180° from each other at the speed of light) causes the wavefunction of the other photon to collapse instantaneously no matter what the separation distance between the two photons is. In other words, if the two photons are separated by thousands of light years, the collapse of the wavefunction of photon A occurs simultaneously (instantaneously or superluminally) with the collapse of the wavefunction of photon B.

Figure 3 below provides an illustration of a typical wormhole. It shows the mouth, throat and the two connecting parallel universes A and B of the wormhole. The width of the throat is directly related to the ***GAR-QGC*** as discussed above. The throat necessarily expands to accommodate higher energy particles and contracts to accommodate lower energy particles as previously described.

Fig. 3



4. *Zitterbewegung* and the Gauthier Model of the Photon and Electron

Zitterbewegung is the German word for "jitter" in reference to "quantum type jitters". It is a theoretical helical or circular motion of elementary particles, especially electrons, which is responsible for producing their spin and magnetic moment. This motion was first proposed by Erwin Schrödinger in 1930 as a result of his analysis of wave-packet solutions of the Dirac equation for relativistic electrons in free space, whereby an interference between positive and negative energy states produces what appears to be a fluctuation at the speed of light of the position of an electron around the median having a circular frequency of $\frac{2mc^2}{\hbar}$ or approximately 1.6 x 10^{21} Hz.

In Gauthier's model [11] a photon is considered to be an uncharged superluminal quantum moving at $c\sqrt{2}$ along an open helical 45° trajectory with a radius of $R = \frac{\lambda}{2\pi}$ where λ is the helical pitch or wavelength. Gauthier continues to point out that a mostly spatial representation (model) of an electron is composed of a point-like quantum circulating at an extremely high frequency of 2.5 x 10^{20} Hz in a closed, double-looped helical trajectory whose helical pitch is one Compton wavelength $\frac{h}{mc}$. Gauthier continues to assert that the quantum has energy and thus momentum but not rest mass and so its velocity is not restricted or limited to the speed of light. According to Gauthier, the quantum's velocity is superluminal 57% of the time and subluminal 43% of the time, passing through c twice in each trajectory cycle. The quantum's maximum speed in the electron's rest frame is 2.515c and its minimum speed is $\frac{c}{\sqrt{2}}$. Gauthier's electron's model helical trajectory parameters are selected to produce the electron's spin $\frac{\hbar}{2}$ and approximately (without small QED corrections) the magnetic moment, the Bohr magneton $\mu_B = \frac{e\hbar}{2m}$ as well as its Dirac equation-related ***Zitterbewegung*** angular frequency $\frac{2mc^2}{\hbar}$, amplitude $\frac{\hbar}{2mc}$ and internal velocity c. According to Gauthier's hypothesis, the two possible helicities of the electron correspond to the electron and the positron. This hypothesis is very reasonable considering that the bound state of the electron and positron "positronium" is composed of an electron and a positron. Additionally, each of these particles is identical with respect to *CPT* symmetry (*i.e., a positron is simply an electron going backwards in time and an electron is a positron going backwards in time*). Gauthier proposes that an electron is like a "closed circulating photon". He continues to purport that the electron's inertia is related to the electron model's circulating internal Compton momentum mc. Gauthier finalizes his theory with the statement, "The internal superluminality of the photon model, the internal superluminality/subluminality of the electron model, and the proposed approach to the electron's inertia as "momentum at rest" within the electron, could be relevant to possible mechanisms of superluminal communication and transportation".

5. Cosmological Redshift in Spin Exchange Vacuum Compactification and Nonzero Restmass Photon Anisotropy

Amoroso, R.L. *et.al.,* [12] in 1998 cast shadows of doubt and critical re-evaluation on the inflationary model of the universe based on Einstein's refinement of Newtonian gravitation repeated for General Relativity (GR) by quantum cosmology. Amoroso, *et.al.,* continue to purport that the Hubble redshift is shown not to result from Doppler velocity but rather from anisotropic coupling to vacuum zero-point fluctuations through harmonic structure described in terms of the Wheeler-Feynman absorber theory of radiation in the context of a Dirac polarized vacuum and compactification dynamics. The quantum gravity of the co-moving hyper-structure of a universe that is topologically both open and closed like that of a Klein bottle, also implies that frequency shift in photon propagation over cosmological distances is an inherent part of the spin exchange process thus removing the *ad hoc* criticism of the well-known Vigier theory of "tired light".

Photon propagation applies spin exchange quantum gravity (SEQG) to issues of cosmology. SEQG requires photon rest mass anisotropy and a radical new view of compactification. The self-reference aspect of general relativity's (GR) equivalence principle induced conformal map between a curved Einstein-Riemannian 4-space and a locally conformally flat Lorentzian spacetime manifold, solved the propagation problem inherent in a "Maxwellian ether" after the null results of the Michelson-Morely experiment. However, Einstein said that relativity did not compel us to exclude the possibility of an ether-namely spacetime itself. Since GR endows space with physical qualities; 'space without ether is unthinkable' (Einstein 1922)[13]. Photon anisotropy requires vacuum zero point coupling, and its propagation can therefore no longer be considered independent of the Dirac vacuum (Amoroso, Kafatos & Ecimovic, 1998b)[14]. Furthermore, the fluctuation of the vacuum zero-point field is consistent with the Sakharov-Puthoff model of gravitation (Sakharov, [15]; Puthoff,[16]).

Einstein, Schrödinger and de Broglie have demonstrated the significance of non-zero photon rest mass. Frequency anisotropy results from a putative 10^{-65}g of periodic nonzero photon rest mass according to $E = h\nu = mc^2\left[1-\frac{v^2}{c^2}\right]^{-1/2}$ (Narlikar, Pecker & Vigier, 1990)[17]. Additionally, the Wheeler-Feynman absorber theory of radiation as refined by Cramer, 1986[18] and others is utilized since the emitter-absorber transaction model is logically consistent with SEQG.

6. Photon Propagation and The Vigier Tired Light Hypothesis

Dissipative redshift mechanisms have remained *ad hoc* curiosities due to little empirical support and conflict with the apparent strident success of the standard BB model. Amoroso, *et.al.,* expands Vigier's explanation of frequency shift by extending the Sakharov [19], Puthoff [20] vacuum gravitation model to SEQG in a Dirac ether providing a deeper theoretical framework that explains the origin of the nonzero rest mass photon anisotropy in terms of a spin exchange photon propagation process that is a component topology of Planck scale vacuum compactification (i.e., such as the collapse of N-dimensions to the 4-Dimensional Minkowski spacetime continuum.

Most physicists believe that the photon is massless since a massive photon would destroy the mathematics of gauge theories and would violate Einstein's theory of special relativity since $m \to \infty$ as the velocity of the particle approaches the speed of light via the relativistic change in mass as well as the well-known relativistic (Lorentzian) time dilation equation depicted below:

$m = \frac{m_0}{\sqrt{1-v^2/c^2}}$ and $t = \frac{t_0}{\sqrt{1-v^2/c^2}}$ where *v* is the velocity of the particle, m_0 is the rest mass of the particle and t_0 is the initial time for a particle at rest. However, the existence of light pressure, which has been known for a long time [21], is a function of irradiance *I* over *c* (p = *I/c* for absorbed photons and 2*I/c* for reflected photons) suggests that photons carry a linear momentum and energy which can readily be calculated using Einstein's mass-energy relation $h\nu = mc^2$. The de Broglie wavelength relationship for massive particles using the accepted value for R (radius of the universe) applied to the Vigier mass m_λ of the photon is: $m_\lambda = \frac{h}{\lambda c}$ where $\lambda = R \approx 10^{28} cm$, then $m_\lambda \approx 2.2x10^{-65} grams$. Furthermore, $m \Rightarrow 0$ *only if* $R \Rightarrow \infty$. The de Broglie hypothesis was verified by Davisson & Germer in 1927 (Fowles, 1989) for the wavelength of a material particle. A photon mass of 10^{-65} g is in total agreement with Vigier's tired light hypothesis [22].

It is inherently obvious that the photon is annihilated when brought to rest; therefore it is suggested that the photon has a rest mass with a half-life on the order of the Planck time of 10^{-44} sec, which would still preserve gauge in the domain of the standard model of elementary particles and allow for anisotropic vacuum zero point coupling of the photon which if it occurs in the limit of the Planck time can be a "virtual" interaction.

7. The Gravitational Field of a Finite Light Pencil in the Weak-Field Approach

For the linearized weak-field approximation (WFA) Aichelburg & Sexl, [23], assume $m_\lambda = 0$, is point-like and $c = G = 1$. For Einstein's field equations: 1. $R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = 8\pi T_{\mu\nu}$ and 2a. $g_{\mu\nu} = \eta_{\mu\nu} + 2h_{\mu\nu}$ and 2b. $\eta_{\mu\nu} = diag(1,-1,-1,-1)$ and 2c. $\left(h_{\mu\nu}\right)^2 \approx 0$ yields the following linearized field equations:

$\Box^2 \Psi^{\mu\nu} = 8\pi T^{\mu\nu}$ and $\Psi^{\mu\nu} = -\frac{1}{2}\eta^{\mu\nu} h_l^l$.

8. Derivation of The Gravitational Field of Radiation

The Vigier mass of the photon is derived using the Tolman, Ehrenfest, Podolsky (TEP) [24] model of spacetime curvature induced by a finite light pencil. The TEP equations are summarized below and include Einstein's weak field approximation (WFA) applied to a mass-free radiation field. Accordingly, the WPA is linear, deviating only to the first order in the Galilean case suggesting that the model is local in the immediate vicinity induced by the light pencil's spacetime curvature. This notation is within the context of classical GR theory.

Only the non-zero components of the energy momentum tensor T_μ^ν are those in energy density ρ. Since the line element integral diverges for an infinitely-long light pencil (L_p) and energy density ρ, the pencil length is taken to a finite value L_p with ρ also finite. Therefore, the expression for the Galilean deviation yields an elementary function:
$h_\mu^\nu := \delta^{\nu\alpha} h_{\mu\alpha}$ *with* $h := h_\alpha^\alpha$ for a L_p traveling along the positive axis of an orthogonal Lorentzian 3-sphere. The linearized WFA from TEP, 1931[25] is:

$$\left[h_\mu^\nu - \frac{1}{2}\delta_\mu^\nu h\right](x,y,z,t) = -4\iiint \frac{\left[T_\mu^\nu\right]\left(\bar{x},\bar{y},\bar{z},t-r\right)}{r} d\bar{x}d\bar{y}d\bar{z}\,. \tag{1.20}$$

Equation 1.20 represents coupling of the metric distribution of matter and energy taken over all elements of spatial volume $d\bar{x}d\bar{y}d\bar{z}$ for time *r*. If we use the above WFA solution for the energy momentum tensor $\left[T_\mu^\nu\right]$ for electromagnetic radiation for an L_p parallel to the x-axis, the only density components ρ will be $T_1^1 = -\rho$; $T_4^4 = \rho$; $T_1^4 = -\rho$ and $T_4^1 = \rho$ (TEP, 1931)[26].

9. Gravitational action of a light pencil

The gravitational field in the neighborhood of a finite L_p with a constant linear energy density ρ passing along the x-axis between a source at x = 0 and an absorber at x = 1 (TEP, 1931[27]; Wheeler-Feynman, 1945[28]; Cramer, 1986[29]) contributes to the radiation according to:
$4\int \frac{[\rho]dV}{r} = -h_{11} = -h_{44} = h_{14} = h_{41} = 4\rho \log \frac{\left[\left(l-x^2\right)+y^2+z^2\right]^{1/2}+l-x}{\left[x^2+y^2+z^2\right]^{1/2}-x}$. The equation $m_\lambda = \frac{h}{\lambda c}$ where $\lambda = R \approx 10^{28}\,cm$ and $m_\lambda \approx 2.2x10^{-65}\,grams$ describes the gravitational contribution only in L_p and neglects any contribution for the source of the absorber [30] as well as any internal conditions, vacuum zero point coupling or other spin exchange which may also effect propagation. Finally, for the acceleration of a test particle towards the L_p along the negative y-axis, determined by a geodesic originating midway between the two ends of the pencil, [31] arrive at the simple result in equation (1.21):

$$-\frac{d^2y}{dt^2} = \frac{2pl}{v\left[\left(\frac{l}{2}\right)^2 + v^2\right]^{1/2}} \tag{1.21}$$

This is significant because the equivalency of the gravitational and inertial mass of a L_p justifies the application of the de Broglie relationship to the photon thus verifying the Vigier hypothesis of $m_\lambda \approx 2.2x10^{-65} grams$! For which as the de Broglie relationship was applied as stated above ($m_\lambda = \frac{h}{\lambda c}$ where $\lambda = R \approx 10^{28} cm$, then $m_\lambda \approx 2.2x10^{-65} grams$), the Vigier mass m_λ of 10^{-65}g is determined. The quintessential characteristic achieved is that conservation of momentum is preserved since, as expected, the acceleration is exactly twice that calculated from Newtonian theory by taking the equivalence of gravitational and inertial mass!

10. Internal Structure of the Photon

According to Einstein, rest mass results from external or internal structural motion of a particle. Unlike Fermi-like materials that are localized in all spatial dimensions and maintain a well developed internal kinetic structure even when at rest, photons immediately release their more open spin structure when brought to rest and immediately dissipate their energy. For photons, this internal transformation undergoes oscillation and the rest mass fluctuates harmonically from zero to > 0 which signifies according to $E = mc^2$ a change in energy from inward reflection and interaction with the vacuum to outward displacement through space. Fluctuation in mass-energy is not mysterious as it is generally known that inertial and gravitational masses are an aspect of this movement. At the DESY laboratory, recent experimental results have shown that the photon has extra layers of activity [32]. "In other words, the transformation of "matter" into "energy" is simply a change from one form of movement (inwardly, reflecting, to-and-fro) into another form (e.g., outward displacement through space). The possibility for objects of zero rest mass exists provided that they are moving at the speed of light. For if rest mass is "inner" movement, taking place even when an object is visibly at rest, it therefore follows that something without "rest mass" has no such inner movement, and that *all* of its movement is outward, in the same sense that it is involved in displacement through space. Therefore, light (photons) does not have the possibility of being "at rest" since it does not posses any such inner movements" [33].

SEQG is based on the fundamental premise that the energetic interplay of mass, inertia, gravitation and spacetime is based on a unified symmetry of internal spin and spin exchange compactification with the photon ultimately being the quantum of action and control. Spin exchange symmetry through the interplay of a unique topological package orders compactification providing a template from which superstring or a twistor theory may be completed. One purpose of compactification dynamics is to allow the three sphere of temporal reality to stochastically 'surf' on the superstructure of higher dimensional eternity allowing nonlocal interactions not possible with Newtonian absolute space or completely described by quantum theory. In other words, the domain of quantum uncertainty separates classical linear causality from the nonlinear causality of the unitary field or type III nonlocality. Type I nonlocality arises from spatial nonlocality and Type II nonlocality is defined as temporal nonlocality arising from quantum theory and a form of a complementarity. Type III nonlocality refers to the undivided wholeness of the unified field [34]; from which the elemental particles of quantum gravity originate [35]. For these reasons, Amoroso, R.L. questions the validity of the Hubble mechanism arising from the adiabatic expansion, and conclude that it originates from an inherent spacetime mechanism resulting from the spin exchange spacetime compactification dynamics of quantum gravity.

The localized appearance of compactification has been interpreted as a structure fixed in an early Big Bang era, but SEQG delocalizes compactification in a rich dynamic hyperstructure of continuous spacetime symmetry transformation of constant N-dimensional collapse to the 3-sphere of Minkowski space. The boundary conditions of which determine the speed of light *c* the constant acceleration of which balances the GR through the principle of equivalence, and orders the arrow of time. Spacetime is quantized as a discontinuous Planck scale raster determined by the fundamental constants *c, G & h.* This comprises a basic unit of the Dirac vacuum with the properties of a microscopic Klein bottle and Planck scale black hole. The Planck constant h is a product of the uncertainty principle; a complement of the Planck length l_p and Planck time t_p comprising the event horizon of nonlocality.

11. Closed Cosmological Solutions to Einstein's Field Equations

Rauscher, E.A., in 1972 [36] proposed a "prescription" for geometrizing the space-time manifold as an extension of Wheeler's wormhole theory [37]. Rauscher presented a method of using a set of variables termed "quantal units" and introduced them into the cosmological equations. Wheeler [38] tried to geometrize the space-time manifold in terms of a quantum unit of length termed the Wheeler wormhole which we now know as l_p. In Wheeler's model, he pictures the metric of his space as fluctuations in a multiple-connected foam-like structure in which the micro-curvature has a scale or size of l_p characteristic of his topology. This topology described by Wheeler makes use of the quantal or Planck units and applies to the topology of the universe as a whole and to systems having less than atomic dimensions [39]. Also, the micro-curvature sets a lower limit on the "meaningful" intervals of length and time. Wheeler also discusses a quantum of mass now known as m_p and a quantum of energy, $E = \sqrt{\hbar c / G}$. Rauscher [40] delineates the Universal quantal units in Table 1:

Table 1 – *Universal Quantal units.*

Unit	Quantal unit in terms of force, l and l' (*a*)	Numerical Value of Quantal Unit (*b*)
$l = \left(G\hbar / c^3\right)^{1/2}$ length	$l = \left(l'/F\right)^{1/2}$	1.60 x 10^{-33} cm
$t = \left(G\hbar / c^5\right)^{1/2}$ time	$t = (l/F)^{1/2}$	5.36 x 10^{-44} sec
$m = \left(c\hbar / G\right)^{1/2}$ mass	$m = \left(lF / c^2\right)^{1/2}$	2.82 x 10^{-5} g
$E = \left(c^5\hbar / G\right)^{1/2}$ energy	$E = \left(l'F\right)^{1/2}$	1.25 x 10^{16} ergs
$L = \hbar$ angular momentum	$L = \hbar$	1.06 x 10^{-27} erg-sec
$F = c^4 / G$ force	$F = F$	1.22 x 10^{49} dyn
$c = c$ velocity	$c = c$	3.00 x 10^{10} cm/sec
$a = \left(c^7 / G\hbar\right)^{1/2}$ acceleration	$a = \left(c^2 F / l\right)$	5.72 x 10^{53} cm/sec^2
$p = c^5 / G$ power	$p = cF$	3.66 x 10^{59} dyn-cm/sec
$\mathrm{P} = c^7 / G^2\hbar$ Pressure	$\mathrm{P} = F^2 / l'$	4.75 x 10^{114} dyn/cm^2
$\rho = c^5 / G^2\hbar$ density	$\rho = F^2 / c^2 l$	6.50 x 10^{93} g/cm

(*a*) The quantal units are expressed in terms of the universal force, $F = c^4 / G$, l, l' and c. The quantities l and l' are defined as $l = \hbar / c$ and $l' = c\hbar$.
(*b*) In the evaluation of the quantal units, the values of $l = 3.50$ x 10^{-38} g-cm and $l' = 3.15$ x 10^{-17} erg-cm have been used.

We may now show how the quantal force, $F = c^4/G$ is prominently manifest in Einstein's field equations and how the quantal units can act as an additional constraint to yield closed cosmological solutions in an idealized universe that is isotropic and homogeneous in nature and isotropic in nature. Consistent with this, Rauscher uses the Robertson uniform line-element [40], equation (1), which is a variant of the Schwarzchild metric and the Friedmann-Lemáitre-Robertson-Walker (FLRW) metric:

$$ds^2 = \left(1 - \frac{2Gm}{c^2 r}\right)^{-1} dr^2 + dr^2\left(d\theta^2 + \sin^2\theta d\phi^2\right) - c^2\left(1 - \frac{2Gm}{c^2 r}\right)dt^2$$ (Schwarzchild metric)

$$ds^2 = \left(1 - \frac{2m}{r}\right)dt^2 + \left(1 - \frac{2m}{r}\right)^{-1} dr^2 + r^2\left(d\theta^2 + \sin^2\theta d\phi^2\right)$$ (exterior Schwarzchild metric)

$$ds^2 = dt^2 - a(t)^2\left(\frac{dr^2}{1 - kr^2} + r^2 d\theta^2 + r^2\sin^2\theta d\phi\right)$$ (FLRW metric)

$$ds^2 = c^2 dt^2 - \frac{\Re^2(t)}{\left(1 + 1/4kr^2\right)^2}\left(dr^2 + r^2 d\theta^2 + r^2\sin^2\theta d\phi\right) \tag{1}$$

For this particular metric, the intervals of cosmic time t are measured along worldlines orthogonal to a spatial hyper-surface of uniform curvature which is mapped with (r, θ, ϕ) co-moving coordinates. The curvature constant of the metric k = 0, 1, -1, corresponds respectively to Euclidian, closed and open curvatures (universes). The Schwarzchild metric is shown in equation (2) below:

$$ds^2 = c^2\left(1 - \frac{2Gm}{c^2 r}\right)dt^2 - \left(1 - \frac{2Gm}{c^2 r}\right)^{-1} dr^2 - r^2 d\Omega \tag{2}$$

where G is the gravitational constant, m is the mass of the gravitating object and $d\Omega = d\theta^2 + \sin^2\theta d\phi^2$ is the standard metric on the 2-sphere. Note that as $m \to 0$ or as $r \to \infty$ one obtains the Minkowski metric $ds^2 = c^2 dt^2 - dr^2 - r^2 d\Omega$. The figures 1-3 below represent some illustrative diagrammatic pictures of the Schwarzschild spacetime:

Superluminal Wormhole Transport

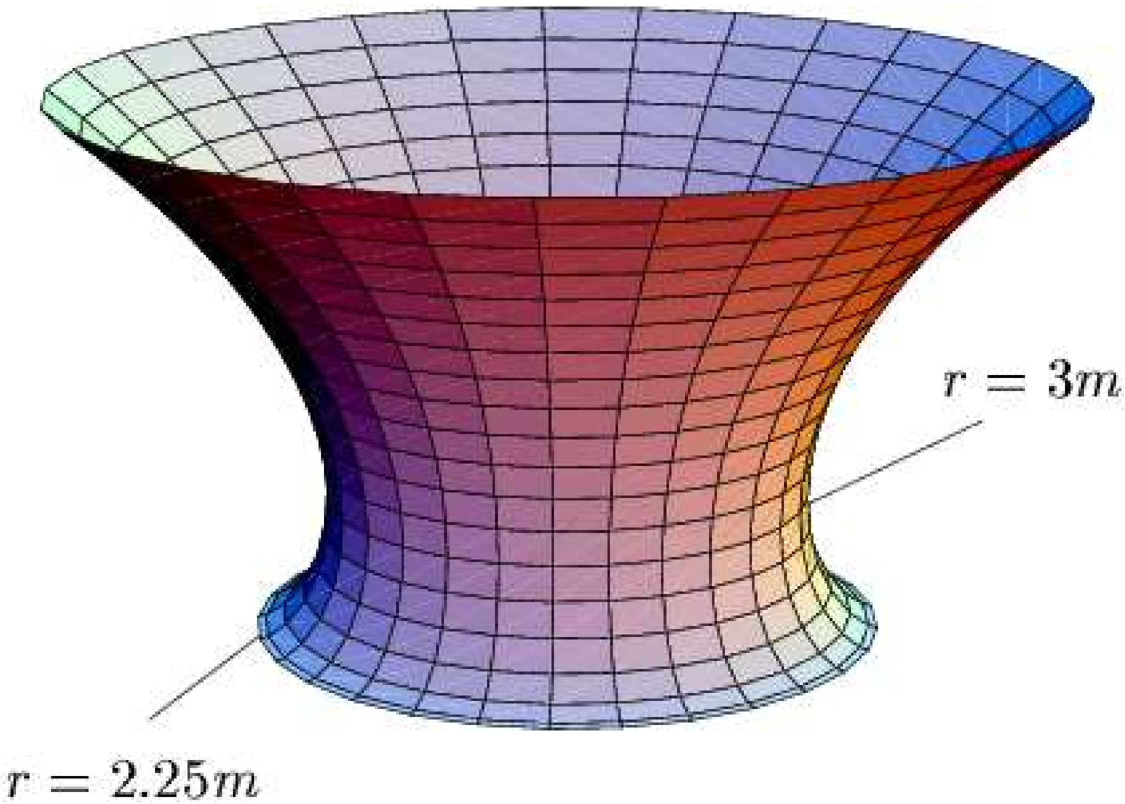


Figure 1 *Fermat geometry of the equatorial plane of the Schwarzschild spacetime, embedded as a surface of revolution into Euclidean 3-space. The neck is at r =3m (i.e.,* $\bar{r} \approx 1.87m$*), the boundary of the embeddable part at r =2.25m (i.e.,* $\bar{r} \approx m$*). The geodesics of this surface of revolution give the light rays in the Schwarzschild spacetime.*

Proceeding from the General Relativity equation with the constraint that the cosmological constant $\Lambda = 0$, we obtain:

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R_{\nu\nu} = -\frac{8\pi G}{c^4} T_{\mu\nu} \qquad (3)$$

For $8\pi G / c^4$ and for $F = c^4 / G$ we have $8\pi G / c^4 = 8\pi / F$ or $F = c^4 / G$. The stress-energy tensor, $T_{\mu\nu}$, for the idealized model is given as $T_{44} = \rho c^2$ for the density ρ and $T_{11} = T_{22} = T_{33} = P$ for the isotropic pressure, *P*. The term $\left(8\pi G / c^4\right) T_{\mu\nu}$ in (3) then becomes:

$$\frac{8\pi G T_{\mu\nu}}{c^4} = \frac{8\pi F^2}{F l'} = \frac{F}{l'} \qquad (4)$$

where l' is defined in Table 1.

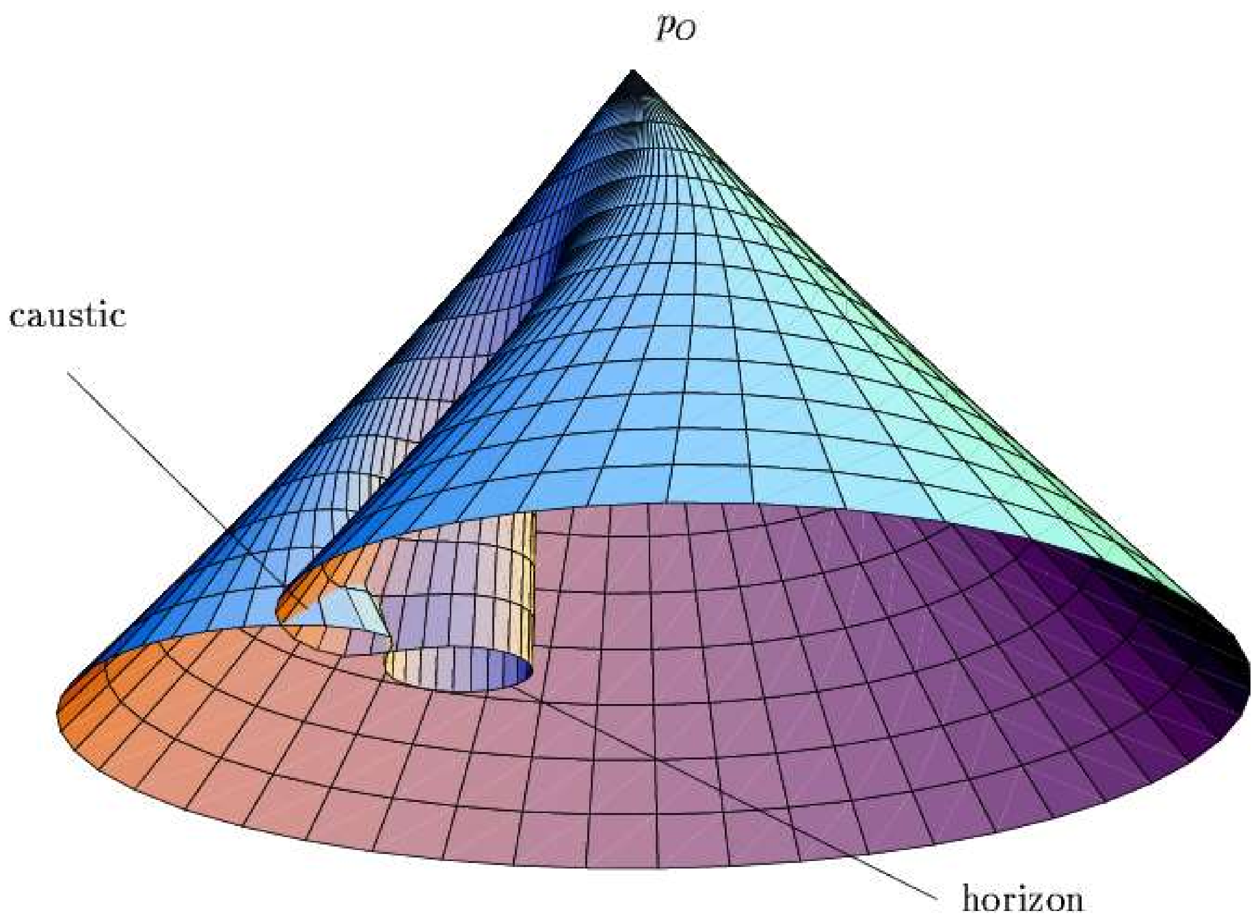


Figure *2* Past light cone in the Schwarzschild spacetime. One sees that the light cone wraps around the horizon, then forms a tangential caustic. In the picture the caustic looks like a transverse self-intersection because one spatial dimension is suppressed. (Only the hyperplane $\vartheta = \pi / 2$ is shown.) There is no radial caustic. If one follows the light rays further back in time, the light cone wraps around the horizon again and again, thereby forming infinitely many tangential caustics which alternately cover the radius line through the observer and the radius line opposite to the observer. In spacetime, each caustic is a spacelike curve along which r ranges from $2m$ to ∞, whereas $\boldsymbol{t}$ ranges from $-\infty$ to some maximal value and then back to $-\infty$.

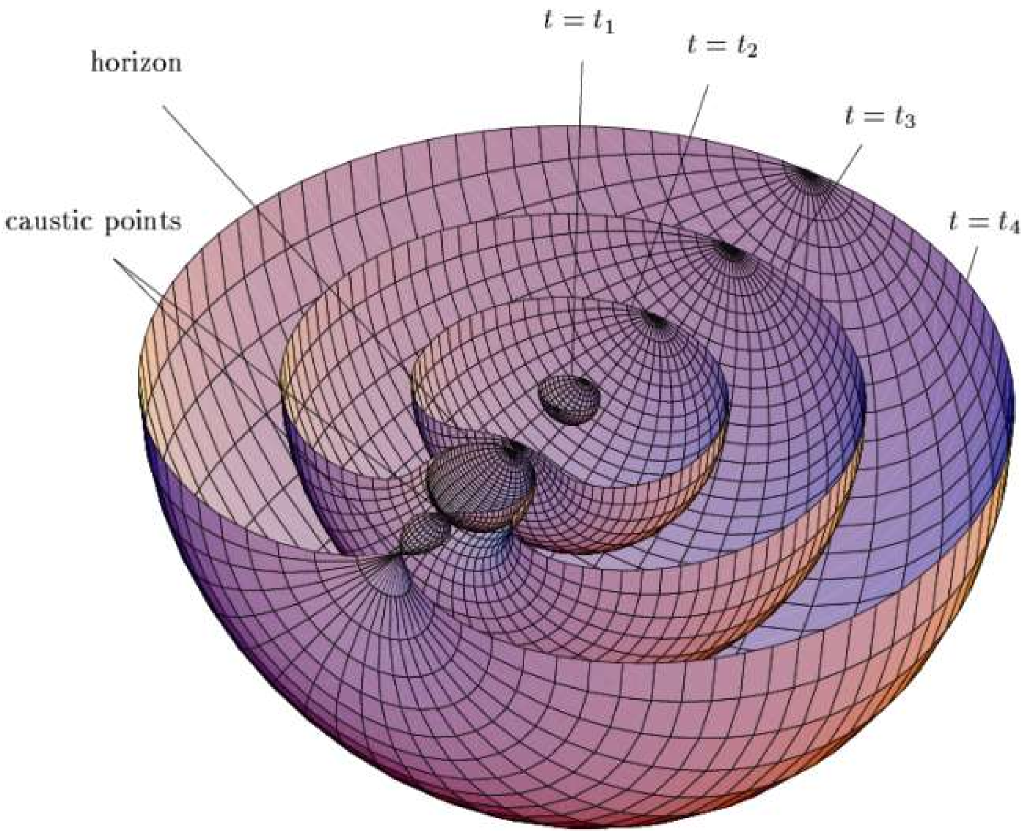


Figure 3 *Instantaneous wave fronts of the light cone in the Schwarzschild spacetime. This picture shows intersections of the light cone in Figure 2 with hyper-surfaces* ***t = constant*** *for four* ***t****-values, with* $t_1 > t_2 > t_3 > t_4$*. The instantaneous wave fronts wrap around the horizon and, after reaching the first caustic, have two caustic points each. If one goes further back in time than shown in the picture, the wave fronts another time wrap around the horizon, reach the second caustic, and now have four caustic points each, and so on. In comparison to Figure 2, the representation in terms of instantaneous wave fronts has the advantage that all three spatial dimensions are shown.*

Using (1) and (3), the solution of this equation gives:

$$\frac{\dot{\Re}^2}{\Re^2} = \frac{8\pi G\rho}{3} - \frac{kc^2}{\Re^2} \qquad (4a)$$

and $\dfrac{8\pi GP}{c^2} = \dfrac{2\Re\ddot{\Re} + \dot{\Re}^2 + kc^2}{\Re^2}$ (4b) where k is the curvature constant and the dots denote differentiation with respect to time. By substituting the quantal units of density and pressure and also making the additional substitutions of $\Re = 1 = (l'/F)^{1/2}$, the quantal length; $\dot{\Re} = c$, the quantal velocity and the quantal acceleration $\ddot{\Re} = (c^2 F/l)^{1/2}$ we obtain

$$\left(\frac{c}{l}\right)^2 = \frac{8\pi F}{3l} - k\left(\frac{c}{l}\right)^2 \qquad (5)$$

Substituting $(c/l)^2 = 1/t^2 = F/l$ in (5), we get $F/l = \frac{8\pi}{3}\left(\frac{F}{l}\right) - k\left(\frac{F}{l}\right)$ so that $1 - \frac{8\pi}{3} = -k$ or $k = \frac{8\pi}{3} - 1 \approx 8.4 - 1 \approx 7.4$ or $k \geq 1$. This therefore gives a positive curvature solution. Considering (4b) and substituting the quantal form of the variables $P, \Re, \dot{\Re}, \ddot{\Re}$ we have $\frac{8\pi GP}{c^2} = \frac{8\pi c^2}{F} P = \frac{8\pi c^2}{F}\frac{F^2}{l'} = \frac{8\pi F}{l}$ for the left of (4b). For the right side of (4b) we have $\frac{2\Re\ddot{\Re}}{\Re^2} = \frac{2a}{l} = \frac{2F}{l}$ for the first term, $\frac{\dot{\Re}^2}{\Re^2} = \left(\frac{c}{l}\right)^2 = \frac{F}{l}$ for the second term and $\frac{c^2}{\Re^2} = \left(\frac{c}{l}\right)^2 = \frac{F}{l}$ for the third term. Upon substitution, (4b) becomes $\frac{8\pi F}{l} = \frac{2F}{l} + \frac{F}{l} + k\left(\frac{F}{l}\right)$ or $8\pi + 1 = k$ or $k \approx 26.3$. More clearly can be seen, we have obtained a larger positive value of k from the second solution than from the first. Equation (4b) appears to be a stricter criterion on the curvature of space-time structure. However, for both cosmological solutions to the general relativity equation, the extra constraint of the universal constants in quantal unit form give closed (positively curved) cosmological solutions. This model could therefore be used to describe a continuously oscillating Universe. For more discussion of these models see Khalatnikov and Lifshitz
[41] and Rauscher [42].

12. The Minkowski Metric for a Multidimensional Geometry

Rauscher, E.A. had previously presented a new geometrical description in terms of a multidimensional space [43]. The dimensions of this manifold were expressed in terms of a generalized set of physical variables termed "quantal units". Rauscher denotes the quantal-unit dimensions of the multidimensional space or Descartes space as $\{x_j\}$ and the associated quantized variables as v_j, where the index *j* runs over the dimensionality of the space. The quantal units represent the geometrical structure of the manifold and can be expressed in metrical form as a generalized Minkowski metric, which is an extension of Minkowski's four-dimensional geometry [44]. Rauscher constructs the generalized Minkowski metric for a multidimensional geometry in terms of the quantal units (as previously shown in Table 1), and present light-cone relations implied by this metric.

Invariant relations hold for (***x***, *t*) and (***p***, *E*) in terms of the constancy of the universal constant *c*. Thus, we have the usual special-relativistic expression

$$s_1^2 = x_1^2 + x_2^2 + x_3^2 - c^2 t^2 \tag{1}$$

where s_1^2 is the four-vector invariant for $(x,t) = (x_i, t_i)$ for the vector length
$\boldsymbol{x} = (x_1, x_2, x_3)$ and the scalar time $t = (t, 0, 0)$, where the index *i* runs from 1 to 3. The four-vector invariant for (p_i, E) is given as:

$$s_2^2 = p_1^2 + p_2^2 + p_3^2 - \frac{E^2}{c^2} \tag{2}$$

for the momentum vector $\boldsymbol{p} = (p_1, p_2, p_3)$ and the scalar energy $E = (E, 0, 0)$. The invariance is extended to include invariance in terms of other universal constants (including *c*), or quantities expressed in terms of universal constants such as the quantal units. A space $\{x_j\}$ is thus formed for $1 \leq j \leq n$ for n orthogonal dimensions, where n is the number of physical-variable dimensions considered for a particular space. Each dimension such as space, time, momentum or energy is considered to be on an equal footing and thus forming a multidimensional space Descartes space.

From any two physical-variable dimensions, μ and η, of the set $\{x_j\}$, we can therefore form an invariant line-element s_{jk}^2 in terms of the matrix element m_{jk} of the Minkowski metrical matrix ***M***. We thus have the general expression:

$$s_{jk}^2 = \mu_{ij}^2 + m_{jk}\eta_{ij}^2 \tag{3}$$

The index i runs from 1 to 3 as before and the indices j and k run from 1 to n, where n is the dimensionality of the space.

We may thus now introduce a super-space of eight components, $N = 8$, which is constructed in terms of the three components of x, the three components of p and the two scalars t and E. This super-space covers a 4-space, $n = 4$, with dimensions $\{x_j\}$, where a single scalar component of x and p is considered so that each dimension of the space is expressed in terms of a single physical variable $\{x_j\} = \{x, t, p, E\}$. The metrical elements m_{jk} of the generalized Minkowski metric ***M*** can thus be written as:

$$m_{jk} = \begin{pmatrix} 1 & c^2 & \dfrac{c^2}{F} & \dfrac{1}{F^2} \\ \dfrac{1}{c^2} & 1 & \dfrac{1}{F^2} & c^2F \\ \dfrac{F}{c^2} & F^2 & 1 & c^2 \\ F^2 & \dfrac{1}{c^2F} & \dfrac{1}{c^2} & 1 \end{pmatrix}, \tag{4}$$

constructed explicitly in terms of the scalar dimensions $\{x_j\}$.

13. Superluminal Transformations in Complex Minkowski Spaces and Non-Abelian Gauge Groups for Real and Complex Amended Maxwell's Equations

Rauscher, E.A., [45] has analyzed, calculated and extended the modification of Maxwell's equations in a complex Minkowski metric, M_4 in a C_2 space using the SU_2 gauge, SL(2,c) and other gauge groups such as SU_n for $n > 2$ expanding the U_1 gauge theories of Weyl. This work yielded the many additional predictions beyond the electroweak unification scheme. Some of the predictions are: 1) modified gauge invariant conditions, 2) short range non-Abelian force terms and Abelian long range force terms in Maxwell's equations, 3) finite but small rest mass of the photon, 4) a magnetic monopole like term and 5) longitudinal as well as transverse magnetic and electromagnetic field components in a complex Minkowski metric M_4 in a C_4 space.

Rauscher developed an 8-dimensional complex Minkowski space $M_4(1)$ composed of four real dimensions and four imaginary dimensions which is simultaneously consistent with Lorentz invariance and analytic continuation in the complex plane [46]. A unique feature of this geometry is that it admits a nonlocality consistent with Bell's theorem, (EPR paradox), possibly Young's double slit experiment, the Aharonov-Bohm effect and the multi mirrored interferometric experiment.

Complexification of Maxwell's equations require a non-Abelian gauge group, amending the usual theory, which uses the usual unimodular Weyl U_1 group. Rauscher has examined the modification of gauge conditions using higher symmetry groups such as SU_2, SU_n and other groups such as the SL(2,c) double cover group of the rotational group SO(3,1) related to Shipov's Ricci curvature tensor [47] and a possible neo-aether scenario. This complexification leads to a new and interesting physics involving extended metrical space constraints (transverse and longitudinal), non-Hertzian electric and magnetic field solutions to Maxwell's equations possibly leading to new communication systems and antenna theory, non-zero solutions to $\nabla \bullet \underline{B}$, and possibly a finite but small rest mass of the photon. Comparison of Rauscher's theoretical approach is made to the work of J.P. Vigier [48], T.W. Barrett [49] and H.F. Harmuth's [50] work on amended Maxwell's theory.

Rauscher expands the line element metric $ds^2 = g_{\mu\nu} dx^\nu dx^\mu$ in the following manner: Consider a complex 8-D space, M_4 constructed so that $Z^u = X^\mu_{\mathrm{Re}} + iX^\mu_{\mathrm{Im}}$ and likewise for Z^ν where the indices ν and μ run 1 to 4 yielding (1, 1, 1, -1). This now creates a new complex 8-dimensional metric as $ds^2 = \eta_{\nu\mu} dZ^\nu dZ^\mu$. The Penrose twistor SU(2,2) or U_4 is constructed from 4-spacetime, $U_2 \otimes \widetilde{U}_2$ where U_2 is the real part of the space and $\widetilde{U}_2$ is the imaginary part of the space. The twister Z can be a pair of spinors U^A and π_A which are said to represent the twister. The conditions for these representations are 1) the null infinity condition for a zero-spin field is $Z^e \overline{Z}_e = 0$, 2) conformal invariance and 3) independence of the origin. The twistor is derived from the imaginary part of the spinor field. The underlying principle of twistor theory is that conformally invariant fields occupy a fundamental role in physics and may very well yield new physics and/or physical principles. Other researchers have examined complex dimensional Minkowski spaces. In reference [51], Newman shows that an M_4 space does not generate any major "weird physics" or anomalous physics predictions and is consistent with an expanded or amended special and general relativity. In fact, the Kerr metric falls naturally out of this formalism as demonstrated by Newman [52].

Twisters and spinors are related by the general Lorentz conditions in such a manner that all signals are luminal in the usual four N-Minkowski space but this does not preclude super or trans-luminal signals in spaces where N>4. Rauscher finds that the twistor algebra of the complex 8-D, M_4 space is mapable (1 to 1) with the twistor algebra C_4 space of the Kaluza-Klein 5-D electromagnetic-gravitational metric [53, 54].

Some of the predictions of the complexified form of Maxwell's equations are:
1) a finite but small rest mass of the photon, 2) a possible magnetic monopole, $\nabla \bullet \underline{B} \neq 0$, 3) transverse as well as longitudinal B(3) like components of $\underline{E}$ and $\underline{B}$, 4) new extended gauge invariance conditions to include non-Abelian algebras and 5) an inherent fundamental nonlocality property of the manifold. Vigier also explores longitudinal $\underline{E}$ and $\underline{B}$ components in detail and finite photon rest mass [55].

First we consider both the electric and magnetic fields to be complexified as $\underline{E} - \underline{E}_{\mathrm{Re}} = iE_{\mathrm{Im}}$ and $\underline{B} - \underline{B}_{\mathrm{Re}} = iB_{\mathrm{Im}}$ for $E_{\mathrm{Re}}, E_{\mathrm{Im}}, B_{\mathrm{Re}}$ and B_{Im} are all real quantities. Then, substitution of these two equations into the complex form of Maxwell's equations yields, upon separation of real and imaginary parts, two sets of Maxwell-like equations. The first set is:

$$\begin{aligned} &\nabla \bullet \underline{E}_{\mathrm{Re}} = 4\pi\rho_e \qquad \nabla \times E_{\mathrm{Re}} = -\frac{1}{c}\frac{\partial \underline{B}_{\mathrm{Re}}}{\partial t} \\ &\nabla \bullet \underline{B}_{\mathrm{Re}} = 0 \qquad \nabla \times \underline{B}_{\mathrm{Re}} = \frac{1}{c}\frac{\partial \underline{E}_{\mathrm{Re}}}{\partial t} = \underline{J}_e \end{aligned} \tag{1}$$

The second set is:

$$\begin{aligned} &\nabla \bullet \left(i\underline{B}_{\mathrm{Im}}\right) = 4\pi i \rho_m \qquad \nabla \times \left(i\underline{B}_{\mathrm{Im}}\right) = \frac{1}{c}\frac{\partial \left(i\underline{E}_{\mathrm{Im}}\right)}{\partial t} \\ &\nabla \bullet \left(i\underline{E}_{\mathrm{Im}}\right) = 0 \qquad \nabla \times \left(i\underline{E}_{\mathrm{Im}}\right) = \frac{1}{c}\frac{\partial \left(i\underline{B}_{\mathrm{Im}}\right)}{\partial t} = i\underline{J}m \end{aligned} \tag{2}$$

The real part of the electric and magnetic fields yield the usual Maxwell's equations and the complex parts generate "mirror" equations. For example, the divergence of the real component of the magnetic field is zero, but the divergence of the imaginary part of the electric field is zero and so forth. The structure of the real and imaginary parts of the fields is parallel with the electric real components being substituted by the imaginary part of the magnetic fields and the real part of the magnetic field being substituted by the imaginary part of the electric field.

In the second set of equations, (2), the *i*'s cancel out so that the quantities in the equations are real, hence $\nabla \bullet B_{\mathrm{Im}} = 4\pi\rho_m$, and not zero, yielding a term that may be associated with some classes of monopole theories [56]. The charge density and current density are expressed as complex entities based on the separation of Maxwell's equations above. Therefore, in generalized form $\rho = \rho_e = i\rho_m$ and $J = J_e + iJ_m$ where it may be possible to associate the imaginary complex charge with the magnetic monopole and conversely the electric current has an associated imaginary magnetic current.

Using the invariance of the line element $s^2 = x^2 - c^2t^2$ for $r = ct = \sqrt{X^2}$ and for $X^2 = x^2 + y^2 + z^2$ for the distance from an electron charge, we may write the following relations:

$$\frac{1}{c}\frac{\partial\left(iB_{im}\right)}{\partial t} = iJm \quad \text{or} \quad \frac{1}{c}\frac{\partial B_{im}}{\partial t} = J_m$$

$$\nabla \times \left(iE_{\mathrm{Im}}\right) = 0 \text{ for } \underline{E}_{\mathrm{Im}} = 0 \quad \text{or} \quad \frac{1}{c}\frac{\partial\left(iB_{\mathrm{Im}}\right)}{\partial t} = iJm \tag{3}$$

In a series of papers, Barrett, Harmuth and Rauscher have examined the modifications of gauge conditions in modified or amended Maxwell's equations. The Rauscher approach, as described above, is to derive complexified Maxwell's equations in consistent form to complex Minkowski space.

The T.W. Barrett amended Maxwell theory uses non-Abelian algebras and leads to some very interesting predictions. He utilizes the noncommutative SU_2 gauge symmetry rather than the U_1 symmetry. Although the Glashow electroweak theory utilizes both U_1 and SU_2, albeit in a different manner, his theory does not lead to the interesting and unique predictions of the Barrett theory.

T.W. Barrett's amended Maxwell theory predicts that the velocity of the propagation of signals is not the velocity of light. He presents the magnetic monopole concept resulting from the amended Maxwell picture. His ideas and motives go beyond standard Maxwell formalism and generate new physics utilizing a non-Abelian gauge theory [57].

The SU_2 group gives us symmetry breaking to the U_1 group (and this is absolutely key) which can then act to create a mass splitting symmetry that yields a finite but necessarily small photon rest mass which may be created as self energy produced by the existence of the vacuum. This finite photon rest mass can constitute a propagation signal carrier less than the velocity of light.

We can construct the generators of the SU_2 algebra in terms of the fields $\underline{E}$, $\underline{B}$ and $\underline{A}$. The usual potentials, A_μ is the important four vector quantity $A_\mu = \left(\underline{A}, \phi\right)$ where the index runs 1 to 4. One of the major purposes of introducing the vector and scalar potentials, and also their physicality, is the desire by physicists to avoid action at a distance. In fact, in gauge theories, A_μ is all there is! Yet, it appears that, in fact, these potentials yield a basis for a fundamental non-locality!

Addressing the specific case of the SU_2 group and considering the elements of a non-Abelian algebra such as the fields with SU_2 (or even SU_n) symmetry, then we have the commutation relations such that $XY\text{-}YX \neq 0$ or $[X,Y] \neq 0$. This is reminiscent of the Heisenberg uncertainty principle non-Abelian gauge. Barrett explains that SU_2 fields can be transformed into U_1 fields by symmetry breaking. For the SU_2 gauge amended Maxwell theory additional terms appear in the form of operators such as $A \bullet E, A \bullet B$ and $A \times B$ and their non-Abelian converses. For example $\nabla \bullet B$ no longer equals zero but is given by $\nabla \bullet B = -jg\left(A \bullet B - B \bullet A\right) \neq 0$ where $[A,B] \neq 0$ for the dot product of A and B and therefore we have a magnetic monopole term and *j* is the current and *g* is a constant. Also, Barrett gives references to the Dirac, Schwinger and G. t'Hooft monopole work. Further commentary on the SU_2 gauge conjecture of H.F. Mamuth [58], states that under symmetry breaking, electric charge is considered but magnetic charges are not. Barrett further states that the symmetry breaking conditions chosen are to be determined by the physics of the problem. These non-Abelian algebras have consistence to quantum theory.

In Rauscher's analysis, using the SU_2 group there is automatic introduction of short-range forces in addition to the long-range force of the U_1 group. U_1 is one dimensional and Abelian, whereas the SU_2 group is three dimensional and is non-Abelian. Also, U_1 is a subgroup of SU_2. The U_1 group is associated with the long range $1/r^2$ force and SU_2, such as for its application to the weak force yields short range associated fields. Also, SU_2 is a subgroup of the useful SL(2,c) group of non-compact operations on the manifold. SL(2,c) is a semi simple 4-D Lie group and is a spinor group that is relevant to the relativistic formalism and is isomorphic to the connected Lorentz group associated with the Lorentz transformations. It is a conjugate to the SU_2 group and contains an inverse. Therefore, the double cover group of SU_2 is SL(2,c) where SL(2,c) is a complexification of SU_2. Also, SL(2,c) is the double cover group of SU_3 related to the set of rotations in 3-D space [59]. Topologically, SU_2 is associated with and isomorphic to the three dimensional spherical O_3^+ (or 3-D rotations) and U_1 is associated with the O_2 group of rotations in two dimensions. The ratio of Abelian to non-Abelian components, moving from U_1 to SU_2 gauge is 1 to 2 so that the short-range components are twice as many as the long-range components.

Instead of using the SU_2 gauge condition, Rauscher uses the SL(2,c) and therefore a uses a non-Abelian gauge whereby quantum theory is therefore included. Since this group is a spinor and is the double cover group of the Lorentz group (for spin ½), the formalism becomes relativistic. On the other hand, Barrett's formalism is non-relativistic. SL(2,c) is the double cover group of SU_2 but utilizing a similar approach using twister algebras yields relativistic physics.

It thus appears that complex geometry can yield a new complementary unification of quantum theory, relativity and allow a domain of action for non-locality phenomena, such as that displayed in the results of the Bell's theorem tests of the EPR paradox [60], and in which the principles of the quantum theory hold to be universal. The properties of the non-local connections in complex four-space may be mediated by non or low dispersive loss solutions. Rauscher solved the Schrödinger equation in complex Minkowski space in 1981[61].

Rauscher concludes that by utilizing the complexification of Maxwell's equations with the extension of the gauge condition to non-Abelian algebras, yields a possible metrical unification of relativity, electromagnetism and quantum theory. Rauscher also states that this unique approach yields a universal non-locality. No radical spurious predictions result from the theory, but some new predictions are made which can be experimentally tested. Additionally, this unique approach in terms of the twister algebras may lead to a broader understanding of both macro and micro non-locality and possible transverse electromagnetic fields observed as non-locality in collective plasma states and other types of media.

14. Conclusions

Using the Phi-based solution of the Schrödinger wave equation, the Theorem of Residues and the Cauchy Integral Formula, we have derived a quantal unit of gravity called the ***Giandinoto-Amoroso-Rauscher Quantum Gravitational Constant (GAR-QGC)*** that is equal to 7.2616 x 10^{-77} $\dfrac{erg \cdot \sec^3}{g \cdot cm}$. From the work presented in this paper, it appears likely that this constant is the long sought-after quantum gravitational constant of the spin-2 graviton. All of the known physical forces in the universe thus far, except gravity; electromagnetic, weak nuclear and strong nuclear have been quantized and/or mediated by their bosonic counterparts. The electromagnetic force is quantized and/or mediated by the photon, the weak force by the $W^{\pm}$, Z^0 bosons and the strong nuclear force by the gluons. The unification of the electromagnetic force with the weak nuclear force (electroweak- theory) by the Salam-Weinberg-Glashow model showed that a boson need not be 'massless' due to symmetry breaking of the U(2) gauge for the weak interaction. The photon is governed by the U(1) gauge and is considered 'massless'. However, as we have seen by the work of Amoroso, R.L., *et.al.*, the photon may have a small but finite rest mass. The breaking of U(2) gauge-symmetry is hypothesized to occur via the yet still elusive Higgs boson. Therefore, it only stands to reason that gravity is also quantized since all of the other known forces are. The numerical value of the ***GAR-QGC*** is consistent with the exceedingly weak force of gravity compared to the other three forces being about 50 orders of magnitude smaller than that of the Planck constant *h* (6.626 x 10^{-27} $erg \cdot s$), the quantum unit of the electromagnetic force. Furthermore, it is highly unlikely that the graviton will ever be detected with today's modern equipment due to its exceedingly small interaction with matter. Even the three flavors of neutrinos (ν_e, ν_μ, ν_τ) are extremely difficult to detect although they are still subject to the force of gravity in a most minuscule manner.

Additionally, it is extremely interesting to note, that according to equation (1.19) when quantal length l_p (space) is used, the denominator contains the constant speed of light c. However, according to eq. (1.19) when quantal time t_p is used, the speed of light c is in the numerator of the ***GAR-QGC.***

Also, it appears likely that space-time itself is "quantized" and that an ether or vacuum is indeed present with particles and virtual particles popping in and out of the quantum vacuum due to the zero point energy (ZPE) field. This field has been cited by many to be of enormous magnitude on the order of $\approx 10^{98}$ ergs/cm^3.

Finally, this paper demonstrates that wormholes are at the center (singularities) of black holes and that their diameters are of sub-Planckian lengths dependant on the kinetic energy of the particles entering them. Wormholes themselves are thus 'elastic entities' capable of adjusting their 'throat' diameters to accommodate the energetic particles. These wormholes thus may possibly be used for superluminal transportation of particles/matter to parallel universes. Using the ***GAR-QGC,*** the kinetic energy of a particle would need to be on the order of 10^{44} Hz in order for the diameter of the wormhole to reach the Planck length. The kinetic energy associated with this particle would be on the order of approximately 6.63 x 10^{17} ergs. This corresponds to a kinetic energy of approximately 4.14 x 10^{29} eV or 414,000 Yotta eV! We speculate that approximately this amount of energy may have been the total kinetic energy of the big bang singularity at the Planck time (5.4 x 10^{-44} s). The total mass-energy of the universe is believed to be approximately 2.5 x 10^{88} eV if all of the mass in the universe were converted to energy using $E = mc^2$.

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