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A RESOLUTION OF THE MEASUREMENT PROBLEM FROM A QUANTUM GRAVITY PERSPECTIVE

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Abstract

Recent advances in the theory of quantum gravity show that the Ricci flow serves as the time evolution operator for the vacuum energy density and that in the presence of baryonic matter, the Ricci flow is analogous to the heat equation in the presence of a heat sink. Here we show using the equations of quantum gravity, that quantum information can be modelled as a thermal fluid consisting of a superposition of weakly excited eigenstates of a quantum field and that each eigenstate vector has an associated eigenstate potential well. The depth of the potential well depends on the amplitude of the eigenstate vector. Measurement is then considered as a selection by tuning process which only allows an eigenstate resonating with the detector to be detected. During the detection process, the resonating eigenstate vector increases in amplitude, deepening its potential well such that the other weakly excited states rapidly drain their small excitation energies into it via the principle of minimum action. This draining process is the act of collapsing the wave function to a specific state. Also, the presence of the eigenstate potential wells is what cancels out the infinities from high energy interactions.

Keywords: Quantum Gravity; Measurement Problem; Quantum Field Theory

1. Introduction

Making sense out of Quantum Mechanics (QM) has long been a struggle for physicists and philosophers since the inception of the theory by Max Planck in 1900. Indeed the existence of several interpretations [1-7] of QM is a testimony to the exhaustive quest for a lucid and logically self-consistent interpretation of QM. At the heart of the search is a solution to the Measurement Problem. The Measurement Problem asks the question; given a quantum system described by $|\psi\rangle = a_0\varphi_0 + a_1\varphi_1 \cdots a_i\varphi_i$, why does the act of measurement$\langle\varphi_j|\psi\rangle$ collapse the wave function ψ to an eigenstateφ_j during the act of measurement? What happens to the other eigenstates during measurement? The incomplete description of this process is the source of various interpretations of QM.

Although the mathematical description of QM is in complete agreement with experiment, the underlying physical processes generating quantum phenomena are not understood. In this paper, we apply the recently developed quantum theory of gravity [8] to illuminate these underlying physical processes.

1.2 The Problem of quantum gravity and its relevance to the foundations of quantum theory

At present, physical phenomena are explained through either summoning the explanatory power of Quantum Mechanics (QM) or General Relativity (GR). Elementary particles and molecules including the strong nuclear force, the weak nuclear force and the electromagnetic interaction are elegantly described by QM. The fundamental concept at the core of QM is the wave function, which through the Born rule affords an explanation of microcosmic phenomena. GR on the other hand is a classical theory which explains gravity, the dominant interaction at macrocosmic scales, in terms of the geometry of space-time itself. Since the fundamental concept in GR is the description of gravity using the language of geometry of spacetime and that of QM is the esoteric wave function then the problem of quantum gravity (QG) is therefore to seek a description of gravity in terms of the principles of QM. To seek a geometric description of the microworld using GR is impossible since at this level GR yields infinities, which are a sure sign that the theory has reached its limits. On the other hand QM can provide insights on the properties of space-time at infinitesimal spacetime intervals. A direct attempt to apply the rules of QM to the problem of gravity at small scales yields infinities upon infinities, a situation which is much absurd than applying GR. Gravity therefore seems non quantizable and only accepting a classical geometric description.

The path to reconciling GR with QM as suggested by the author, require considering the following aspects:

1. GR is preferably interpreted as a theory of straight lines in curved spacetime and yet Einstein's equations can also be interpreted as curved lines in flat spacetime. By adopting the latter interpretation, one can start embarking on an alternative path to quantum gravity since QM is a theory built on flat spacetime and has curved lines that appear as sum over histories in the Feynman interpretation of QM. Moreover the Ricci tensor in GR is average of the possible paths a test particle can take in a gravitational field.
2. Secondly the non-localizability of gravitational energy hints at the Uncertainty Principle providing an important role in formulating a self-consistent quantum theory of gravity.

Once a self-consistent theory of quantum gravity is in place, it can reveal more about the underlying processes governing quantum weirdness such as the measurement problem and quantum entanglement which may provide new ideas in developing quantum computing.

2. Fundamentals of Nexus Paradigm of Quantum Gravity

In this section we reproduce in detail and review the formulation of the Nexus paradigm of quantum gravity as described in [8].

For a free falling observer, measurements in GR take place in a local patch of spacetime which can be considered as a flat Minkowski space. The line element in Minkowski space which is the subject of measurement, can be computed through the inner product of the local coordinates as

$$\Delta x^{\mu}\Delta x_{\mu} = \Delta x^2 + \Delta y^2 + \Delta z^2 - c^2\Delta t^2$$

$$= (A\Delta x + B\Delta y + C\Delta z + iDc\Delta t)(A\Delta x + B\Delta y + C\Delta z + iDc\Delta t) \quad (1)$$

If one multiplies the right hand side one notes that to make all the cross terms such as $\Delta x\Delta y$ to cancel out one must make the following assumption:

$$AB + BA = 0 \; A^2 = B^2 = \cdots = 1 \quad (2)$$

The above conditions therefore imply that the coefficients (A, B, C, D) generate a Clifford algebra and therefore must be matrices. These coefficients can be re-written in the 4-tuple form as $(\gamma^1, \gamma^2, \gamma^3, \gamma^0)$ which may be summarized using the Minkowski metric on spacetime as follows

$$\{\gamma^{\mu}, \gamma^{\nu}\} = 2\eta^{\mu\nu} \quad (3)$$

The gammas are of course the Dirac matrices. Thus one can express a displacement 4-vector as

$$\Delta x^{\mu} = r_{HS}\gamma^{\mu} \quad (4)$$

Where r_{HS} is the Hubble radius. Here the Hubble diameter is considered as the maximum dimension of the local patch of space since it is physically impossible to interact with objects beyond the Hubble 4- radius.

In order to express GR in terms of the language of QM one must make the radical assumption that the displacement vectors in Minkowski space are pulses of 4-space which can be expressed in terms of Fourier functions as follows

$$\Delta x_n^{\mu} = \frac{2r_{HS}}{n\pi}\gamma^{\mu}\int_{-\infty}^{\infty} sinc(kx)e^{ikx}dk$$

$$= \gamma^{\mu}\int_{-\infty}^{\infty} a_{nk}\varphi_{(nk)}dk \quad (5)$$

Where $$\frac{2r_{HS}}{n\pi} = \sum_{k=-\infty}^{k=+\infty} a_{nk} \quad (6)$$

Here $\varphi_{(nk)} = sinc(kx)e^{ikx}$ are Bloch energy eigenstate functions.The Bloch functions can only allow the four wave vector to assume the following quantized values

$$k^{\mu} = \frac{n\pi}{r_{HS}^{\mu}} \quad n = \pm 1, \pm 2 \ldots 10^{60} \quad (7)$$

The minimum 4-radius in Minkowski space is the Planck 4- length since it is impossible to measure this length without forming a black hole. The 10^{60} states arise from the ratio of Hubble 4-radius to the Planck

4-length.The displacement 4-vectors in each eigenstate of space-time generate an infinite Bravais 4-lattice. Also, condition (7) transforms Eqn.(5) to

$$\Delta x_n^{\mu} = \gamma^{\mu} \int_{-nk_1}^{nk_1} a_{nk} \varphi_{(nk)} dk \quad (8)$$

The second assumption of the Nexus formulation of quantum gravity is that each displacement 4-vector is associated with a conjugate pulse of four momentum which can also be expressed as a Fourier integral

$$\Delta p_n = \frac{2np_1}{\pi} \gamma_{\mu} \int_{-nk_1}^{nk_1} \varphi_{(nk)} dk$$

$$= \gamma_{\mu} \int_{-nk_1}^{nk_1} c_{nk} \varphi_{(nk)} dk \quad (9)$$

Where $p_1$is the four momentum of the ground state.

A displacement 4-vector and its conjugate 4-momentum satisfy the Heisenberg uncertainty relation

$$\Delta x_n \Delta p_n \geq \frac{\hbar}{2} \quad (10)$$

The Uncertainty Principle plays the important role of generating variations in the geodesic path which generates a set of curvilinear trajectories within the local flat patch of spacetime

$$\bar{x}^i = x^i(k) + \alpha w^i(k) \quad (11)$$

These small variations are proportional to the phase of the Bloch energy eigenstate functions.

The resulting trajectories are best described by a curvilinear coordinates system within the local flat patch.

The wave pack et described by Eqn.(8) is essentially a particle of four-space. The spin of this particle can be determined from the fact that each component of the four displacement vector will transform according to the law

$$\Delta x'^{\mu}_n = \exp(\tfrac{1}{8} \omega_{\mu v}[\gamma_{\mu}, \gamma_v]) \Delta x_n^{\mu} \quad (12)$$

Where $\omega_{\mu v}$ is an antisymmetric 4x4 matrix providing the parameterization of the transformation. Thus, a component of the 4-vector has a spin half. A summation of the four half spins yields a total spin of 2. The name, Nexus graviton, is given to this particle of 4-space since the primary objective of quantum gravity is to find the nexus between the concepts of GR and QM.

From Eqn.(7) the norm squared of the 4- momentum of the n-th state graviton is

$$(\hbar)^2 k^{\mu} k_{\mu} = \frac{E_n^2}{c^2} - \frac{3(nhH_0)^2}{c^2} = 0 \quad (13)$$

where H_0 is the Hubble constant (2.2 x 10^{-18} s^{-1}) and can be expressed in terms of the cosmological constant, Λ as

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$$\Lambda_n = \frac{E_n^2}{(hc)^2} = \frac{3k_n^2}{(2\pi)^2} = n^2\Lambda \quad (14)$$

One can infer from Eqn.(14), that the Nexus graviton (or displacement 4-vector) in the n-th quantum state generates a compact flat manifold via the Uncertainty Principle which consists of curvilinear coordinates of positive Ricci curvature that can be expressed in the form

$$G_{(nk)\mu v} = n^2\Lambda g_{(n,k)\mu v} \quad (15)$$

where $G_{(nk)\mu v}$ is the Einstein tensor of space-time in the n-th state. Eqn.(15) depicts a contracting geodesic ball and as explained in [9] this is Dark Matter (DM) which is an intrinsic compactification of the elements space-time in the n-th quantum state. This compactification is a result of the superposition of several plane waves as described by Eqn.(2.8) to form an increasingly localized wave packet as more waves are added. Similary the converse is also true. The loss of harmonic waves expands the elements of spacetime which gives rise to Dark Energy (DE). Thus the DE arises from the emission of a ground state graviton such that Eqn.(15) becomes

$$G_{(nk)\mu v} = (n^2 - 1)\Lambda g_{(n,k)\mu v} \quad (16)$$

These are Einstein's vacuum field equations in the quantized spacetime.If the graviton field is perturbed by the presence of baryonic matter then Eqn.(16) becomes

$$\begin{aligned} G_{(nk)\mu v} &= kT_{\mu v} + (n^2 - 1)\Lambda g_{(n,k)\mu v} \\ &= kT_{\mu v} + (n^2 - 1)k\rho_{DE} g_{(n,k)\mu v} \end{aligned} \quad (17)$$

Where ρ_{DE} is the density of DE.

It is important to keep in mind that in the Nexus Paradigm, unlike in the standard intepretation of GR, Eqn(17) is interpreted as describing curved world lines in a flat spacetime.

A solution to (15) as provided in [9] is

$$ds^2 = -\left(1 - \left(\frac{2}{n^2}\right)\right)c^2dt^2 + \left(1 - \left(\frac{2}{n^2}\right)\right)^{-1} dr^2 + r^2(d\theta^2 + sin^2\theta d\varphi^2) \quad (18)$$

This implies that at high energies where n is large, the world line does not deviate from a linear trajectory because the uncertainties in its 4-position are negligible. The metric begins to deviate substantially at low energies or small values of n wherein the uncertainties in its 4-position are large. Thus gravity is a low energy phenomenon where the world line becomes degenerate.

A more remarkable feature of the same equation is the lack of a singularity at the quantum state (n =1) which is present in classical GR.

3. Canonical transformations in the Nexus Paradigm.

In classical mechanics, a system is described by n independent coordinates $(q_1, q_2, \dots q_n)$ together with their conjugate momenta$(p_1, p_2, \dots p_n)$. In the Nexus Paradigm, the labelling $q_n$refers to a creation of a Nexus graviton in the n-th quantum state associated with a conjugate momentump_n. The Hamiltonian equation

$$\dot{q}_n = \frac{\partial H}{\partial p_n} \tag{19}$$

refers to the rate of expansion or contraction of space-time generated by the graviton creation or annihilation operations and

$$\dot{p}_n = -\frac{\partial H}{\partial q_n} \tag{20}$$

refers to the force field associated with the graviton creation or annihilation. It is important to note that this force field generates an isotropic expansion or contraction of space-time within the spatio-temporal dimensions of the graviton.

We can also rewrite the Hamiltonian equations in terms of Poisson brackets which are invariant under canonical transformations as

$$\dot{q}_n = \{q_n, H\} \quad , \quad \dot{p}_n = \{p_n, H\} \tag{21}$$

The Poisson brackets provide the bridge between classical and quantum mechanics (QM) and in QM, these brackets are written as

$$\dot{\hat{q}}_n = [\hat{q}_n, \hat{H}] \quad , \quad \dot{\hat{p}}_n = [\hat{p}_n, \hat{H}] \tag{22}$$

and obey the following commutation rules

$$[\hat{q}_n, \hat{q}_s] = 0 \ , \ [\hat{p}_n, \hat{p}_s] = 0 \ , \ [\hat{q}_n, \hat{p}_s] = \delta_{ns} \tag{23}$$

4. The Hamiltonian formulation for the quantum vacuum

The Nexus graviton is a pulse of space-time which can only expand or contract and does not execute translational motion implying that the Hamiltonian density of the system is equal to the Lagrangian density.

$$H = L \tag{24}$$

GR is a metric field in which the energy density in 4-space determines its value. Since the Bloch energy eigenstate functions determine the energy of space-time, it is therefore imperative to express the metric in terms of the Bloch wave functions. Since the eigenstate four space components of the Nexus graviton in the k-th band are

$$\Delta x^{\mu}_{nk} = z^{\mu}_{nk} = a_{nk}\gamma^{\mu} sinc(kx)e^{ikx} \tag{25}$$

then an infintesimal four radius within the k-th band is computed as

$$dr^{\mu}_{nk} = \frac{\partial z^{\mu}_{nk}}{\partial k^{\mu}} dk^{\mu} = ix_{\mu}a_{nk}\gamma^{\mu} sinc(kx)e^{ikx}dk^{\mu} \tag{26}$$

In Eqn.(26) the first order derivative of the periodic sinc function is equal to zero for all integral values of n.

The interval within the band is then computed as

$$ds^2 = dr^{\mu}_{nk}dr^{\mu}_{nk} = \frac{\partial z^{\mu}_{nk}}{\partial k^{\mu}}\frac{\partial z^{\mu}_{nk}}{\partial k^{\nu}} dk^{\mu}dk^{\nu}$$

$$= b_{\mu}c_{\nu}\gamma^{\mu}\varphi_{(n,k)}\gamma^{\nu}\varphi_{(n,k)}dk^{\mu}dk^{\nu} \tag{27}$$

Here the interval is described in terms of the reciprocal lattice and $b_{\mu} = ix_{\mu}a_{nk}$ and $c_{\nu} = ix_{\nu}a_{nk}$. The metric tensor of four space in the k-th band is therefore associated with the Bloch energy eigenstate functions of the quantum vacuum as follows

$$g_{(n,k)\mu\nu} = \gamma_{\mu}\gamma_{\nu}\varphi_{(n,k)}\varphi_{(n,k)}$$

$$= \eta_{\mu\nu}\varphi_{(n,k)}\varphi_{(n,k)} \tag{28}$$

Eqn.(28) translates the geometric language of GR into the wave function language QM. We initiate the translation procedure of GR into QM by first finding the Lagrange density for Eqn. (16) which following Einstein and Hilbert is found to be

$$L_{EH} = k(R - 2(n^2 - 1)\Lambda) \tag{29}$$

Given that the Einstein tensor in a compact manifold is equal to the Ricci flow

$$-\partial_t g_{\mu\nu} = \Delta g_{\mu\nu} = R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = G_{\mu\nu} \tag{30}$$

The equations of motion of the quantum vacuum obtained from Eqn.(29) yield the following quantized field equations

$$-\partial_t(\gamma_{\mu}\varphi_{(n,k)}\gamma_{\nu}\varphi_{(n,k)}) = (n^2 - 1)\Lambda(\gamma_{\mu}\varphi_{(n,k)}\gamma_{\nu}\varphi_{(n,k)}) \tag{31}$$

which can be written as

$$\partial_t(\gamma_\mu \varphi_{(n-1,k)} \gamma_\nu \varphi_{(n+1,k)}) = \frac{-i^2}{(2\pi)^2} \gamma_\mu \nabla \varphi_{(n-1,k)} \gamma_\nu \nabla \varphi_{(n+1,k)}$$

$$= \frac{1}{4\pi^2} \gamma_\mu \nabla \varphi_{(n-1,k)} \gamma_\nu \nabla \varphi_{(n+1,k)} \tag{32}$$

where

$$\varphi_{(n-1,k)} = sinc((n-1)k_1 x) e^{i(n-1)k_1 x} \tag{33}$$

$$\varphi_{(n+1,k)} = sinc((n+1)k_1 x) e^{i(n+1)k_1 x} \tag{34}$$

$$\frac{3k_1^2}{(2\pi)^2} = \Lambda \tag{35}$$

For large values of n the Bloch functions satisfy the condition

$$\varphi_{(n-1,k)} \approx \varphi_{(n,k)} \approx \varphi_{(n+1,k)} \tag{36}$$

The quantum vacuum can therefore be interpreted as a system in which there is a constant annihilation and creation of quanta as implied by Eqn.(33) and Eqn.(34) .

Upon close inspection, Eqn.(32) shows a quantum vacuum consisting of fermion fields in the $n-1$ state entangled with those in the $n+1$ state. The entanglement arises from the fact that

$$\gamma_\mu \varphi_{(n-1,k)} \gamma_\nu \varphi_{(n+1,k)} - \gamma_\mu \varphi_{(n+1,k)} \gamma_\nu \varphi_{(n-1,k)} \neq 0 \tag{37}$$

This can also be interpreted as a temporal entanglement of a fermion field in the past $n+1$state with its future $n-1$ state .The states are separated by an energy gap of

$$E_g = 2\sqrt{3} \cdot hH_0 \tag{38}$$

Spacetime is therefore an emergent phenomenon from the entangled of vacuum fermion fields. The idea that spacetime emerges from quantum entanglement has become topical and an active area of research [10-12].

5. The Hamiltonian formulation in the presence of matter fields

We now seek to introduce matter fields into the quantum vacuum. If we compare the quantized metric of Eqn.(18) with the Schwarzschild metric we notice that

$$\frac{2}{n^2} = \frac{2GM(r)}{c^2 r} \tag{39}$$

This yields a relationship between the quantum state of space-time and the amount of baryonic matter embedded within it as follows

$$n^2 = \frac{c^2 r}{GM} = \frac{c^2}{v^2} \tag{40}$$

Eqn(40) reveals a family of concentric stable circular orbits $r_n = \frac{n^2 GM}{c^2}$ with corresponding orbital speeds of $v_n = c/n$. Thus in the Nexus Paradigm, unlike in GR, the innermost stable circular orbit ocurrs at $n = 1$or at half the Schwarzchild radius which implies that the event horizon predicted by the Nexus Paradigm is half the size predicted in GR. Also Eqn.(40) reveals how the Nexus graviton in the n-th quantum state imitates DM if M is considered as the apparent mass of the DM. Through this comparision, we can also deduce that the deflection of light through gravitational lensing by spacetime in the n-th quantum state is

$$\alpha = 4/n^2 \qquad (41)$$

Thus gravitational lensing can be used to constrain the value of the quantum state n of space-time within a lensing system.

The result of Eqn.(40) are added to Eqn.(32) to yield the time evolution of the quantum vacuum in the presence of baryonic matter as

$$\partial_t(\gamma_\mu \varphi_{(n-1,k)} \gamma_\nu \varphi_{(n+1,k)}) = \frac{1}{4\pi^2} \gamma_\mu \nabla \varphi_{(n-1,k)} \gamma_\nu \nabla \varphi_{(n+1,k)} - n^2 \Lambda \gamma_\mu \varphi_{(n,k)} \gamma_\nu \varphi_{(n,k)} \qquad (42)$$

Thus the time evolution of the quantum vacuum in presence of matter resembles thermal flow in the presence of a heat sink. The second term of Eqn.(42) is an 8-cell or 4-cube that operates as a sinc filter with a four-wave cut-off of

$$k = nk_1 = 2\pi \sqrt{\frac{\Lambda}{3} \cdot \frac{c^2 r}{GM(r)}} \qquad (43)$$

The filtration of high frequencies from the vacuum lowers the quantum vacuum state and generates a gravitational field in much the same way as the Casimir Effect is generated.

We now introduce a test particle of mass m, into the quantum vacuum perturbed by matter fields. The particle will flow along with the Ricci flow and the Hamiltonian of the system becomes

$$\hat{H}\left(\gamma^\mu \varphi_{(n-1,n,k,x)} \gamma^\nu \varphi_{(n+1,n,k,x)}\right) = \frac{1}{2m}(\gamma^\mu \hat{P} \varphi_{(n-1,k,x)} \gamma^\nu \hat{P} \varphi_{(n+1,k,x)}) - V(\gamma^\mu \varphi_{(n,k,x)} \gamma^\nu \varphi_{(n,k,x)}) \qquad (44)$$

Here

$$V = n^2 \frac{\hbar^2}{2m} \Lambda = \frac{rc^2}{GM} \cdot \frac{3\hbar^2 k_1^2}{2m} \qquad (45)$$

$$\hat{P} = -i\hbar \nabla \qquad (46)$$

$$\hat{H} = -i\hbar\, \partial_t \qquad (47)$$

Eqn.(44) is equivalent to Eqn.(24) in which the Hamiltonian is equal to the Lagrangian.

$$\widehat{H}\left(\gamma^{\mu}\varphi_{(n-1,n,k,x)}\gamma^{\nu}\varphi_{(n+1,n,k,x)}\right) = \mathrm{L}(\gamma^{\mu}\ \varphi_{(n-1,n,k,x)}\gamma^{\nu}\varphi_{(n+1,n,k,x)}) \tag{48}$$

Eqn.(45) is the gravitational interaction in reciprocal space-time. The weakness of the gravitational interaction is due to the small value of the cosmological constant such that the energy of a quantum of gravity is

$$E = \sqrt{3}\cdot hH_0 \tag{49}$$

6. Line elements and information in K-space

A close inspection of Eqn(28) reveals the relationship between a line element in 4-space and its conjugate line in K-space

$$ds^2 = b_{\mu}c_{\nu}d\kappa^2 \tag{50}$$

where

$$d\kappa^2 = \gamma^{\mu}\varphi_{(n,k,x)}\gamma^{\nu}\varphi_{(n,k,x)}dk^{\mu}dk^{\nu} \tag{51}$$

The terms $\gamma^{\mu}\varphi_{(n,k,x)}\gamma^{\nu}\varphi_{(n,k,x)}$ refers to the normalized information flux density passing through an elementary surface $dk^{\mu}dk^{\nu}$ in K-space.The gradient of the flux density yields the baseband bandwidth $k_{(n)\mu}$

$$\partial_{\mu}\gamma^{\mu}\varphi_{(n,k,x)}\gamma^{\nu}\varphi_{(n,k,x)} = k_{(n)\mu}\gamma^{\mu}\varphi_{(n,k,x)}\gamma^{\nu}\varphi_{(n,k,x)} \tag{52}$$

This gradient is also a measure of the acutance or sharpness of the information. A large bandwidth provides detailed information while a small bandwidth provides diffuse information. Eqn(44) describes the diffusion of information as it flows into a gravitational well. Unitarity is globally preserved if the flux is summed over the total diffusion surface and multiplied by a normalization factor.

$$\frac{4e^{-2ikx}}{\pi^2}\iint_0^{\Sigma}\gamma^{\mu}\varphi_{(n,k,x)}\gamma^{\nu}\varphi_{(n,k,x)}dk_{\mu}dk_{\nu} = 1 \tag{53}$$

Here the integral implies that one bit of information is found on a surface $\Sigma = k_n^2$ in K-space which corresponds to an area $A_n = \frac{4\pi^2}{k_n^2}$ in 4-space. The k_1 bandwidth permitted within a black hole generates the smallest elementary surface or pixel in K-space of k_1^2 suggesting that information inside a blackhole is diluted to one bit per area equivalent to the square of the Hubble 4-radius in 4-space or from Eqn(43) the information surface density is $k_1^2 = \frac{4\pi^2\Lambda}{3}$. Thus the cosmological constant can also be interpreted as a unit of information surface density. The ratio of the Planck surface in K-space to the smallest elementary surface in K-space yields 10^{120}. This huge number represents the maximum number of pixels that can fit on the largest surface in K-space. Hence the expression $W = \frac{k_{\mathrm{p}}^2}{k_{\mathrm{n}}^2}$ represents the number of empty pixel slots available in the n-th quantum state or the number of degenerate energy levels.

$$|\varphi\rangle_n = c_1|\psi_1\rangle_n + c_2|\psi_2\rangle_n \ldots c_W|\psi_W\rangle_n. \tag{54}$$

The entropy of the n-state therefore becomes

$$\begin{aligned} S &= k_B ln\, W \\ &= k_B ln\, \frac{k_{\mathrm{p}}^2}{k_{\mathrm{n}}^2} \\ &= k_B ln\, \frac{A_n}{l_{\mathrm{p}}^2} = k_B ln\, \frac{c^3 A_n}{\mathrm{G}\hbar} \end{aligned} \tag{55}$$

7. Application of quantum gravity to the measurement problem

The current QM interpretation of the scalar product $\langle\varphi|\psi\rangle$ is that it computes the probability amplitude of state ψ collapsing into state φ. Here we interpret this product as a calculation of the portion of the information field ψ that has leaked into the state φ. In this regard, we treat the information field as a thermal fluid which intrinsically flows into various available states or degrees of freedom. Each available degree of freedom or eigenstate is associated with a potential well and for degenerate systems, the potential well is the same. The evolution of the state ψ can be expressed in terms of the degrees of freedom and their associated potentials in the form

$$\partial_t\, |\psi_\mu\rangle|\psi_\nu\rangle = \frac{1}{4\pi^2}\sum_{i=1}^{j}\gamma_\mu \nabla\varphi_{i(n,k)}\gamma_\nu\nabla\varphi_{i(n,k)} - n^2\Lambda\sum_{i=1}^{j}\gamma_\mu\varphi_{i(n,k)}\gamma_\nu\varphi_{i(n,k)}. \tag{56}$$

Here we have assumed that at high energies$\varphi_{(n-1,k)} \approx \varphi_{(n,k)} \approx \varphi_{(n+1,k)}$. However if we make this assumption, then the quantum vacuum assumes a state of dynamic equilibrium since the covariant derivatives will make the middle term identical to the last term on the right. This dynamic equilibriuim is essentially an adiabatic process in which the kinetic and potential energies of the quantum system are mutually interchanging while the total energy of the system remains constant. In other approaches to quantum gravity, such as Loop Quantum Gravity [13-15] this leads to the problem of time whereas in the Nexus Paradigm it is seen as a state of dynamic equilibrium and not a static state of the quantum vacuum. The presence of the eigenstate potencial wells is what cancels out the infinities from high energy interactions. Thus QG via the Nexus graviton plays an important role in high energy physics.

We observe from Eqn.(56), that the depth of the potential $-n^2\Lambda$ of each eigenstate depends on the amplitude of the term $\gamma_\mu\varphi_{i(n,k)}\gamma_\nu\varphi_{i(n,k)}$. The deeper the potential, the more likely that the quantum thermal information fluid drains into it via the principle of minimum action.

In synthesis, measurement is filtration of undesired information from a quantum mechanical system. The filtration begins when the experimenter selects a region of spacetime where large excitations of a quantum field are likely to be present. The second stage of filtration begins when the experimenter tunes his detector to sense a particular quantum field, ψ_μ . This is done by multipying Eqn.(56) with $\langle\psi_\nu|$ and summing it over all possible frequencies –a frequency jamming procedure.

This operation filters out quantum fields of no interest to the experimenter and reduces Eqn.(56) to the Dirac equation of the quantum field in which each eigenstate vector is associated with a potential well

$$\partial_t |\psi_\mu\rangle = \frac{1}{4}\sqrt{n^2\Lambda}\sum_{i=1}^{j}\gamma_\mu\,\partial\varphi_{i(n,k)} - \frac{\pi}{2}n^2\Lambda\sum_{i=1}^{j}\gamma_\mu\varphi_{i(n,k)} + 0 \tag{57}$$

Where $0 = -\frac{1}{4\pi}\sqrt{n^2\Lambda}\sum_{n=1}^{\infty}\langle\gamma_\nu\varphi_{i(n,k)}|\gamma_\nu\partial\varphi_{i(n,k)}\rangle + \frac{1}{2}n^2\Lambda\sum_{n=1}^{\infty}\langle\gamma_\nu\varphi_{i(n,k)}|\gamma_\nu\varphi_{i(n,k)}\rangle$ is a vacuum term that stems from the fact that

$$\sum_{n=1}^{\infty}\langle\gamma_\nu\varphi_{n(n,k)}|\gamma_\nu\varphi_{n(n,k)}\rangle = \sum_{n=1}^{\infty} sinc^2 nk_1x = \left(\frac{\pi}{2}-\frac{1}{2}\right) \tag{58}$$

The final third stage of filtration begins when the experimenter desires to measure a specific eigenstate $\gamma_\mu\varphi_{J(n,k)}$ of the quantum field. By tuning his detector to this eigenstate frequency, the amplitude and hence the potential well associated with eigenstate increases due to the resonance between detector and eigenstate frequency. This is done by multipying Eqn.(57) with $\langle\gamma_\mu\varphi_{j(n,k)}|$. This operation reduces Eqn.(57) to

$$\partial_t\langle\gamma_\mu\varphi_{J(n,k)}|\gamma_\mu\varphi_{J(n,k)}\rangle = \frac{1}{4}\sqrt{n^2\Lambda}\langle\gamma_\mu\varphi_{J(n,k)}|\gamma_\mu\partial\varphi_{J(n,k)}\rangle - \frac{\pi}{2}n^2\Lambda\langle\gamma_\mu\varphi_{J(n,k)}|\gamma_\mu\varphi_{J(n,k)}\rangle = 0 \tag{59}$$

The other eigenstates drain their excitation or activation energies into the selected eigenstate due to the fact that the term $\langle\gamma_\mu\varphi_{J(n,k)}|\gamma_\mu\varphi_{J(n,k)}\rangle$ reduces to $sinc^2 nk_1x$ – a localized orbital with a behavior $\lim_{x\to 0} sinc^2 nk_1x = 1$. This localized orbital is what is observed as a particle and implies that the total dynamical energies $\frac{\pi}{2}n^2\Lambda$ is now stored as potential energy in the eigenstate $\gamma_\mu\varphi_{J(n,k)}$. Thus, the draining process is the act of collapsing the wave function to a specific state $\gamma_\mu\varphi_{J(n,k)}$. Detection can also be considered as the removal of the envelope function $\boldsymbol{e^{ikx}}$ from the Bloch function. Soon after the measurement, the thermal energy begins to flow back into other eigen states of the quantum field via Eqn(57) as the adiabatic process resumes.

Discussion

A plausible mechanism to explain the measurement problem has been advanced taking insights from quantum gravity. Here we see that Schrodingers cat is either dead or alive and not in a superposition of the two states after measurement. The other state is non existent since it drains away its activation energy to the measured state. The thermal fluid model could assist in developing a working theory of quantum computing and accelerate the development of the technology.

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Conflict of interest

The author declares no conflict of interest.

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