Hindawi
Advances in High Energy Physics
Volume 2021, Article ID 5588662, 8 pages
https://doi.org/10.1155/2021/5588662

Research Article

On the Electromagnetic Vacuum Origins of Dark Energy, Dark Matter, and Astrophysical Jets

Stuart Marongwe [1,2]

[1] *Advanced Aerospacetime Concepts Project, Deep Time Technologies, P.O. Box 45, Tutume, Botswana*
[2] *Department of Physics, McConnell College, P.Bag 005 Tutume, Botswana*

Correspondence should be addressed to Stuart Marongwe; stuartmarongwe@deeptimetechnologies.com

Received 10 February 2021; Revised 25 March 2021; Accepted 26 March 2021; Published 12 April 2021

Academic Editor: Saibal Ray

We use a semiclassical version of the Nexus paradigm of quantum gravity in which the quantum vacuum at large scales is dominated by the second quantized electromagnetic field to demonstrate that a virtual photon field can affect the geometric evolution of Einstein manifolds or Ricci solitons. This phenomenon offers a cogent explanation of the origins of astrophysical jets, the cosmological constant, and a means of detecting galactic dark matter.

1. Introduction

In general relativity (GR), gravity is the curvature of a four-dimensional space-time manifold due to the presence of matter. This description of gravity has allowed accurate predictions of the kinematic behaviour of astrophysical objects at both the solar system and cosmic scales. Notably, the precession of the perihelion of Mercury, the Shapiro delay, the determination of the precise angle of deflection of light by the Sun's gravitational field, gravitational redshift, gravitational lensing, frame dragging, black holes, and gravitational waves.

At large scales, GR faces difficulties in explaining the physical origins of dark matter (DM) and dark energy (DE). DM and DE are necessary to account for the large-scale cosmic structures and cosmic acceleration. In this context, the adjective 'Dark' is synonymous with the unknown. Strong evidence of these unknowns comes from the Planck 2013 [1, 2] and data from other sources such as the cosmic microwave background (CMB) radiation anisotropies [3–5], optical observations on supernovae Type Ia [6, 7], galaxy rotational curve observations [8, 9], and observations of galactic cluster dynamics [10, 11]. Understanding the nature of DM and DE is a key challenge in modern astrophysics and is further compounded by the lack of direct detection of the material constituents of these phenomena by both space-based and ground-based experiments [12, 13]. The challenge of understanding the nature of DE has led to a plethora of models of which the leading ones as compiled by Capozziello et al. [14] is as follows:

(1) The ΛCDM (Λ cold dark matter) model

(2) DE models with a constant equation of state (ωCDM or quintessence), derived from a scalar field coupling with curvature

(3) DE models in which the equation of state is parametrized in terms of the power of $a(t)$ as in for example the CPL parametrization

(4) DE models that in which DE interacts with CDM as in the Chaplygin gas model

(5) DE arising from quantum effects as in the Dvali–Gabadadze–Porrati (DGP) model and its phenomenological extension

(6) $f(R)$-gravity theories

(7) $f(T)$-gravity theories

Models (1), (6), and (7) are also used to describe DM.

The challenges facing GR in explaining the dark sector stem from the fact that GR explains gravity in terms of the geometry of space-time and excludes in its description of gravity, an essential component, which is the quantum vacuum.

Happily, a promising new approach in describing gravity as a quantum field has been presented in [15–18]. Here, we have a paradigm in which the geometric language of GR is translated into the wave function language of quantum field theory. In the Nexus paradigm of quantum gravity, GR has been extended to include the quantum vacuum. The success of this paradigm lies in that it naturally explains DE and DM and derives the equations of galactic and cosmic evolution from first principles. The Nexus paradigm includes the quantum vacuum in its description of gravity, and at large scales, the second quantized vacuum electromagnetic fields dominate the quantum vacuum. As the length and time scales shrink to subatomic scales, other quantum fields of the standard model begins to dominate the high-energy quantum vacuum interactions characterizing these microcosmic scales.

In this paper, we apply the semiclassical version of the Nexus paradigm to investigate the effect of vacuum electromagnetic fields on Einstein manifolds and how this effect can explain the enigmas of jet genesis in black holes and the nature of DE and DM. This study is an extension of the studies undertaken in [17]. Preliminaries has been written for the reader who is not familiar with the Nexus paradigm of quantum gravity as well as includes some improvements and clarifications from previous publications.

1.1. Preliminaries. Since the fundamental concept in GR is the description of gravity using the language of geometry of space-time and that of quantum field theory (QFT) is the esoteric wave function, then, the problem of quantum gravity is therefore to seek a description of gravity in terms of the principles of QFT. To seek a geometric description of the microworld using GR is impossible since at these levels GR yields infinities, which are a sure signal that the theory has reached its limits. On the other hand, QFT can provide insights into the properties of space-time at infinitesimal space-time intervals. A direct attempt to apply the rules of QFT to the problem of quantum gravity at small scales yields infinities upon infinities, a situation which is much absurd than applying GR. Gravity therefore seems nonquantizable and only accepting a classical geometric description.

The path to reconciling GR with QFT as suggested by the author requires considering the following aspects:

(1) GR is preferably interpreted as a theory of straight lines in curved space-time and yet Einstein's equations can also be interpreted as curved lines in flat space-time. By adopting the latter interpretation, one can start embarking on an alternative path to quantum gravity since QFT is a theory built on flat space-time and has curved lines that appear as a sum over histories in the Feynman interpretation of QFT. Moreover, the Ricci tensor in GR is the average of the possible paths a test particle can take in a gravitational field

(2) Secondly the nonlocalizability of gravitational energy hints at the uncertainty principle providing an important role in formulating a self-consistent quantum theory of gravity

In the Nexus paradigm of quantum gravity, we begin the quantization process by considering the local coordinates in Minkowski space as quantized wave packets of space-time and expressing them as Fourier integrals as follows:

$$\Delta x_n^\mu = \frac{2r_{\mathrm{HS}}}{n\pi}\gamma^\mu \int_{-\infty}^{\infty} \operatorname{sinc}(kx) e^{ikx} dk = \gamma^\mu \int_{-\infty}^{\infty} a_{nk}\psi_{(nk\mu)} dk, \quad (1)$$

where

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

Here, $\gamma^\mu$are the Dirac matrices, r_{HS} is the Hubble radius, $\psi_{(nk\mu)} = \operatorname{sinc}(kx)e^{ikx}$ are Bloch energy eigenstate functions in which the four wave vectors assume the following quantized values:

$$k^\mu = \frac{n\pi}{r_{\mathrm{HS}}^\mu}, \quad (3)$$

where $n = \pm 1, \pm 2 \cdots 10^{60}$.

These quantized wave packets of space-time have a minimum four radius equal to the Planck length and a maximum equal to the Hubble four radius. The 10^{60} states arise from the ratio of Hubble four radius to the Planck four length. The Bloch functions in each eigenstate of space-time generate an infinite Bravais four lattice.

Each displacement vector is a graviton and is associated with a pulse of four momentum which can also be expressed as a Fourier integral as

$$\Delta p_n^\mu = \frac{2np_1^\mu}{\pi}\gamma^\mu \int_{-\infty}^{\infty} \psi_{(nk\mu)} dk = \gamma^\mu \int_{-\infty}^{\infty} c_{nk}\psi_{nk\mu} dk, \quad (4)$$

where p_1^μ is the four momentum of the ground state.

The wave packet is essentially a particle of four-space and can be envisioned as enveloping a spherically symmetric lump of energy from the quantum vacuum. This vacuum energy can be in any form of the fields described by the standard model of particle physics. At large scales, the electromagnetic field dominates the quantum vacuum since it is a long-range field while the other fields are mainly confined to extremely short space-time intervals. The displacement vectors obey the rules of Clifford algebra because of the gamma matrices implying an intrinsic quantized spin. Each component vector is created in the vacuum according to the off-shell Heisenberg uncertainty principle, which implies an angular momentum constraint of $\Delta p.\Delta x \leq \hbar/2$ or half-integral spin. Also, the components undergo a Lorentz transformation according to the law:

$$\Delta x'^{\mu}_{n} = \exp\left(\frac{1}{8}\omega_{\mu\upsilon}\left[\gamma_{\mu}, \gamma_{\upsilon}\right]\right)\Delta x^{\mu}_{n}, \tag{5}$$

where $\omega_{\mu\upsilon}$ is an antisymmetric 4×4 matrix parameterizing the transformation.

Since each component of the 4-vector has a spin-half. A summation of all four half-integral spins yields a total spin of 2 for the composite graviton. Thus, bosons are created in the vacuum according to the angular momentum constraint $\Delta x^{\mu}_{n}\Delta p_{n\mu} \leq 2\hbar$. This constraint allows bosons of only spin 0,1 and 2 to be created.

The norm squared of the four momentum of the nth state graviton can be computed by multiplying the inner product of Equation (3)by the square of the reduced Planck constant:

$$(\hbar)^2 k^{\mu}k_{\mu} = \frac{E_n^2}{c^2} - \frac{3(nhH_0)^2}{c^2} = 0, \tag{6}$$

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

$$\Lambda_n = \frac{E_n^2}{(hc)^2} = \frac{3k_n^2}{(2\pi)^2} = n^2\Lambda. \tag{7}$$

From Equation (7), the Nexus graviton can be considered a compact Einstein manifold or a trivial Ricci soliton of the positive Ricci curvature expressed in the form:

$$G_{(nk)\mu\upsilon} = n^2\Lambda g_{(n,k)\mu\upsilon} = n^2 k\rho_{\Lambda} g_{(n,k)\mu\upsilon}, \tag{8}$$

where $G_{(nk)\mu\upsilon}$ is the Einstein tensor of space-time in the nth state and k is the Einstein constant. Equation (8) depicts a contracting Ricci soliton, and as explained in Refs. [16–18], this is DM which is a localized packet of vacuum energy $n^2 \rho_{\Lambda}$ in the nth quantum state. Thus, DM is a Ricci soliton and should exhibit the following soliton characteristics:

(1) It is a localized lump of (vacuum) energy

(2) It preserves its form while growing or diminishing in size

(3) It preserves its speed and form after collision with another soliton

The second feature might explain the existence of DM less galaxies [19] as a result of a rapid decay in a Ricci soliton which once enveloped a galaxy. The third feature explains the observations of the dynamics of the Bullet Cluster [20].

The DE arises from the emission of a ground state graviton such that Equation (8) becomes

$$G_{(nk)\mu\upsilon} = \left(n^2 - 1\right)\Lambda g_{(n,k)\mu\upsilon} = \left(n^2 - 1\right)k\rho_{\Lambda} g_{(n,k)\mu\upsilon}. \tag{9}$$

These are Einstein's vacuum field equations in the quantized space-time. The above equation depicts a high-energy graviton emitting a ground state graviton. Thus, the Ricci soliton decays to a low quantum state by the emission of the ground state graviton. To find the force exerted by the emission of a ground state graviton, we apply the uncertainty principle and consider the ground state graviton as having a temporal interval Δt equal to the Hubble time and a spatial interval Δx equal to the Hubble radius.

Thus,

$$\Delta t\Delta E = \Delta t\Delta x.F = \frac{cF}{H^2} \sim \frac{h}{2\pi}, \tag{10}$$

Therefore,

$$F \sim \frac{hH}{c^2}\bullet\frac{Hc}{2\pi} = m\bullet a. \tag{11}$$

This implies that the mass of the ground state graviton $m = hH/c^2$ and the graviton-induced acceleration is $a = Hc/2\pi$. This acceleration was first empirically observed by Milgrom from data on galaxy rotation curves [21]. Milgrom noted that non-Newtonian dynamics began to manifest at this critical acceleration. This critical acceleration therefore marks a transition from the classical to the quantum gravity regime.

If the graviton field is perturbed by the presence of baryonic matter then Equation (9) becomes

$$G_{(nk)\mu\upsilon} = kT_{\mu\upsilon} + \left(n^2 - 1\right)\Lambda g_{(n,k)\mu\upsilon}. \tag{12}$$

From Ref. [16], the solution to Equation (8) is computed as

$$\begin{aligned} ds^2 = &-\left(1 - \left(\frac{2}{n^2}\right)\right)c^2dt^2 + \left(1 - \left(\frac{2}{n^2}\right)\right)^{-1} dr^2 \\ &+ r^2\left(d\theta^2 + \sin^2\theta d\varphi^2\right). \end{aligned} \tag{13}$$

The above metric equation describes curved worldlines in flat space-time. One remarkable feature of this metric is that there are no singularities. At high energies which are characterized by microcosmic scale wavelengths of the Nexus graviton and high values of n, the worldline is straight and the local coordinates are highly compact or localized. This aspect also reveals asymptotic freedom in quantum gravity since for high values of n, gravity (world line curvature) vanishes asymptotically. Thus, at high energies, graviton-graviton interactions are nonexistent due to the absence of curvature. The worldline begins to deviate substantially from a rectilinear trajectory at low energies where the uncertainties in its location are large and the associated graviton wavelengths are at macrocosmic scales. In the ground state of space-time ($n = \pm 1$), we notice that the metric signature of Equation (13) becomes negative and that the worldline is straight.

If we compare the quantized metric of Equation (13) with the Schwarzschild metric, we notice that

$$\frac{2}{n^2} = \frac{2GM(r)}{c^2 r}. \tag{14}$$

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

$$n^2 = \frac{c^2 r}{GM(r)}. \tag{15}$$

Equation (15) shows a family of concentric black hole like spherical surfaces of radii $r_n = n^2 GM/c^2$ with corresponding orbital speeds $v_n = c/n$. The innermost stable circular orbit occurs at $n = 1$ or at half the Schwarzschild radius implying that in the Nexus paradigm the event horizon is half the size predicted in GR. This distinguishing feature should be readily observed by the event horizon telescope.

Energy transitions from higher energy levels to the ground state orbital by a mass m can be computed from Equation (15) as

$$\Delta E_{n\to 1} = mc^2\left[1 - \frac{1}{n^2}\right]. \tag{16}$$

This implies that a free falling mass from infinity will lose its total energy, including its rest energy as it falls towards the event horizon leaving behind a Ricci soliton in the ground state. The soliton is the final object that merges with the black hole. The mass of a black hole is therefore a measure of missing mass just as an electron hole is a measure of a missing electron. Gravitational mass can therefore be considered the amount of vacuum energy that has been displaced from a locality by inertial mass. This insight may explain the results by [22] in which the strong equivalence principle appears violated. That is, if some vacuum energy is fed back into the locality from which it was displaced by some other means, then the gravitational mass becomes less than the inertial mass within that locality. Thus, increasing the vacuum energy density of a locality is a means of attenuating the local gravitational field.

1.2. The Equations of Galactic and Cosmic Kinematics. The solution to Equation (12) in the weak field limit taking into consideration the graviton acceleration is

$$\frac{d^2 r}{dt^2} = \frac{GM(r)}{r^2} + H_0 v_n - \frac{H_0}{2\pi}c. \tag{17}$$

The first term on the right is the Newtonian gravitational acceleration; the second term is a radial acceleration induced by space-time in the nth quantum state, and the final term is acceleration due to DE. The dynamics become non-Newtonian when

$$\frac{GM(r)}{r^2} = \frac{H_0}{2\pi}c = \frac{v_n^2}{r}. \tag{18}$$

These are conditions in which the world line curvature due to baryonic matter is annulled by that due to the presence of DE. Under such conditions,

$$r = \frac{2\pi v_n^2}{H_0 c}. \tag{19}$$

Substituting for r in Equation (18) yields

$$v_n^4 = GM(r)\frac{H_0}{2\pi}c. \tag{20}$$

This is the baryonic Tully–Fisher relation. The conditions permitting the DE to cancel out the curvature due to baryonic matter leave the state of the quantum vacuum as the unique source of curvature. Thus, condition (18) reduces Equation (17) to

$$\frac{d^2 r}{dt^2} = \frac{dv_n}{dt} = H_0 v_n. \tag{21}$$

From which, we obtain the following equations of galactic and cosmic evolution:

$$r_n = \frac{1}{H_0} e^{(H_0 t)}\left(GM(r)\frac{H_0}{2\pi}c\right)^{1/4} = \frac{v_n}{H_0}, \tag{22}$$

$$v_n = e^{(H_0 t)}\left(GM(r)\frac{H_0}{2\pi}c\right)^{1/4} = H_0 r_n, \tag{23}$$

$$a_n = H_0 e^{(H_0 t)}\left(GM\frac{H_0}{2\pi}c\right)^{1/4} = H_0 v_n. \tag{24}$$

Here, r_n is the radius of curvature of space-time in the nth quantum state (which is also the radius of the nth state Nexus graviton), v_n is the radial velocity of objects embedded in that space-time, and a_n is their radial acceleration within it. The amplification of the radius of curvature with time explains the existence of ultradiffuse galaxies and the spiral shapes of most galaxies. The increase in radial velocity with time explains why early-type galaxies composed of population II stars are fast rotators. Equation (24) explains late-time cosmic acceleration which began once condition (18) was satisfied. Condition (18) also leads to the formation of ring galaxies such as Hoag's object (PGC 54559). The ring is a result of gas from the intergalactic medium accumulating at the Lagrange locus described by condition (18). Given the mass of the central object and the inner radius of the ring, one can compute the acceleration and find it to be $\sim (H_0/2\pi)c$.

Equation (15) reveals that the black hole-like surfaces generated by the presence of baryonic matter are Ricci solitons in the nth quantum state:

$$G_{(nk)\mu\nu} = kT_{\mu\nu} = n^2 \Lambda g_{(n,k)\mu\nu} = n^2 k\rho_\Lambda g_{(n,k)\mu\nu}. \tag{25}$$

Light grazing each black hole-like surface is deflected by an angle $\alpha = 4/n^2$.

Interestingly, the solitons of the vacuum state in which $n^2 = (r_{HS}/r_n)^2$ are of De Sitter topology while those formed in the presence of baryonic matter are anti-De Sitter where $n^2 = c^2 r/GM(r)$. This is apparent when one substitutes the term for n^2 for each soliton in the quantized metric of Equation (13). The De Sitter soliton assumes low-energy quantum states with an increase in radius whereas the anti-De Sitter soliton assumes high-energy quantum states with an increase in radius.

1.3. The Covariant Canonical Quantization of GR and a Speed of Entanglement. In the full quantum theory, GR is translated into QFT by expressing the metric coefficients in terms of the Bloch energy eigenstate functions as follows:

$$g_{(n,k)\mu\nu} = \gamma_\mu \Psi_{(nk)} \gamma_\nu \Psi_{(nk)}. \tag{26}$$

The Ricci flow for the vacuum equations is then expressed in following form:

$$\begin{aligned} -\partial_t g_{(nk)\mu\nu} &= \frac{1}{3} c r_{\mathrm{HS}} G_{(nk)\mu\nu} \\ &= \frac{1}{3} c r_{\mathrm{HS}} \left(n^2 - 1\right) \Lambda g_{(nk)\mu\nu} \\ &= \frac{1}{3} c r_{\mathrm{HS}} (n-1)(n+1) \Lambda g_{(nk)\mu\nu}. \end{aligned} \tag{27}$$

The term on the right suggests a covariant and contravariant derivative operating on the metric coefficient such that the Ricci flow when expressed in terms of the Bloch functions becomes

$$\partial_t \gamma_\mu \Psi_{(nk)} \gamma_\nu \Psi_{(nk)} = -\frac{c r_{\mathrm{HS}}}{3\pi^2} i\gamma_\mu \nabla^{(n-1)\mu} \Psi_{(nk)} i\gamma_\nu \nabla_{(n+1)\nu} \Psi_{(nk)}, \tag{28}$$

where

$$\begin{aligned} \nabla^{(n-1)\mu} &= \partial^{n\mu} - k^{1\mu}, \\ \nabla_{(n+1)\nu} &= \partial_{(n\nu)} + k_{1\nu}. \end{aligned} \tag{29}$$

The derivative operators on the RHS are entangled, and the coupling coefficient, $c r_{\mathrm{HS}}/3\pi^2$ is an areal speed which is the speed of entanglement with a numerical value of approximately 5.2 square parsecs per second.

The Ricci flow in the presence of baryonic matter is expressed as

$$\begin{aligned} \partial_t \gamma_\mu \Psi_{(nk)} \gamma_\nu \Psi_{(nk)} = {} & \frac{c r_{\mathrm{HS}}}{3\pi^2} \gamma_\mu \nabla^{(n-1)\mu} \Psi_{(nk)} \gamma_\nu \nabla_{(n+1)\nu} \Psi_{(nk)} \\ & - n^2 H_0 \gamma_\mu \Psi_{(nk)} \gamma_\nu \Psi_{(nk)}, \end{aligned} \tag{30}$$

where

$$\begin{aligned} n^2 &= \frac{c^2 r_n}{GM} = \frac{c^2}{v^2}, \\ \frac{1}{3} c r_{\mathrm{HS}} \Lambda &= H_0, \end{aligned} \tag{31}$$

Thus, baryonic matter behaves as a heat sink and the vacuum state of space-time as a heat source. Gravitational attraction therefore occurs as a flow of space-time in much the same way as heat flows from a heat source to a heat sink. A test particle of baryonic matter flows along with the space-time to the gravitating mass.

1.4. Effects of Vacuum Electromagnetic Fields on Compact Einstein Manifolds. The presence of extravacuum excitations of the electromagnetic field elevates the energy state of the quantum vacuum or the vacuum expectation value of the second quantized electromagnetic field $\langle F^{\mu\nu} F_{\mu\nu} \rangle$ by introducing more virtual photons into the zone of impressed field. The quantum state of space-time will be elevated by an additional s state where

$$s^2 \Lambda = k \left\langle F^{\mu\nu} F_{\mu\nu} \right\rangle. \tag{32}$$

The Ricci soliton with impressed extravacuum electromagnetic field excitations can therefore be expressed as

$$G_{(nk)\mu\nu} = k \left\langle F^{\mu\nu} F_{\mu\nu} \right\rangle g_{(n,k)\mu\nu} + n^2 k \rho_\Lambda g_{(n,k)\mu\nu}. \tag{33}$$

The inner product $F^{\mu\nu} F_{\mu\nu}$ yields

$$F^{\mu\nu} F_{\mu\nu} = 2\left(B^2 - \frac{E^2}{c^2}\right). \tag{34}$$

For virtual photons, the electric and magnetic fields are out of phase suggesting that vacuum fluctuations can have the following conditions for the invariant term:

$$\begin{aligned} \left(B^2 - \frac{E^2}{c^2}\right) &> 0, \\ \left(B^2 - \frac{E^2}{c^2}\right) &= 0, \\ \left(B^2 - \frac{E^2}{c^2}\right) &< 0. \end{aligned} \tag{35}$$

These conditions can be referred to as magnetic, null, or electric. The electric mode has negative energy density just like the cosmological constant. This suggests that cosmological constant is a product of the electric mode of the vacuum electromagnetic field.

We can therefore express the semiclassical form of Einstein's field equations in the form:

$$\begin{aligned} G_{(nk)\mu\nu} &= k T_{\mu\nu} + k \left\langle F^{\mu\nu} F_{\mu\nu} \right\rangle g_{(n,k)\mu\nu} + \left(n^2 - 1\right) k \rho_\Lambda g_{(n,k)\mu\nu} \\ &= k T_{\mu\nu} + 2k \left\langle B^2 - \frac{E^2}{c^2} \right\rangle g_{(n,k)\mu\nu} + \left(n^2 - 1\right) k \rho_\Lambda g_{(n,k)\mu\nu}. \end{aligned} \tag{36}$$

The first and last terms of Equation (36) can be replaced by combining Equations (25) and (32) yielding

$$G_{(nk)\mu\nu} = s^2 k \left\langle F^{\mu\nu}_{(0)} F_{(0)\mu\nu} \right\rangle g_{(n,k)\mu\nu} + k \left\langle F^{\mu\nu} F_{\mu\nu} \right\rangle g_{(n,k)\mu\nu} + \left(n^2 - 1\right) k \left\langle \mathrm{F}^{\mu\nu}_{(0)} F_{(0)\mu\nu} \right\rangle g_{(n,k)\mu\nu} = k \left\langle F^{\mu\nu} F_{\mu\nu} \right\rangle g_{(n,k)\mu\nu} + \left(2n^2 - 1\right) k \left\langle F^{\mu\nu}_{(0)} F_{(0)\mu\nu} \right\rangle g_{(n,k)\mu\nu}, \quad (37)$$

where $T_{\mu\nu} = s^2 k \langle F^{\mu\nu}_{(0)} F_{(0)\mu\nu} \rangle g_{(n,k)\mu\nu}$, $s^2 = n^2 = c^2 r/GM(r)$, and $\rho_\Lambda = \langle F^{\mu\nu}_{(0)} F_{(0)\mu\nu.} \rangle$

Here, $F^{\mu\nu}_{(0)}$ is the ground state of the second quantized electromagnetic field in which the vacuum energy density at large scales is considered to be purely electromagnetic nature. DE has been expressed in terms of the energy density of the ground state of the vacuum electromagnetic field. The middle term is the contribution of extra virtual photon fields within the Einstein manifold. If the virtual photon fields are magnetic in nature then the Einstein manifold will be of positive Ricci curvature resulting in contraction and giving rise to the attractive gravity of Ricci solitons. If the vacuum fields are strongly electric, the Ricci curvature is negative and Einstein manifold expands giving rise to dark voids—expanding patches of space-time which expel matter from their interior. This effect can also explain the relativistic jets from black holes and neutron stars as we shall explore in the next section.

1.5. Near Field Radiation at the Event Horizon. At the event horizon, the quantum state of space-time is $n = 1$ and Equation (33) is reduced to

$$G_{(1k)\mu\nu} = k \left\langle F^{\mu\nu} F_{\mu\nu} \right\rangle g_{(1,k)\mu\nu} + k \left\langle F^{\mu\nu}_{(0)} F_{(0)\mu\nu} \right\rangle g_{(1,k)\mu\nu} = k \left(\left\langle B^2 + B^2_{(0)} - \left(\frac{E^2_{(0)}}{c^2} + \frac{E^2}{c^2} \right) \right\rangle \right) g_{(1.k)\mu\nu}. \quad (38)$$

The extravirtual electromagnetic fields at the poles of the black hole are sourced from the near field region of an electrically excited accretion disc. These electrical excitations are a consequence of turbulence and disc oscillation modes. The disc is considered a radiating patch array antenna of uniform patch separation d_m. The discretization of the radiating accretion disc into radiating patches is consistent with numerical analysis of complex physical phenomena. The near fields generated by the N patch antenna at radius r are then expressed as follows in polar coordinates:

$$E_r = \sum_{m=1}^{N} - i\eta \frac{I_0 d_m cos\theta}{2\pi k r^3} e^{-ik_m r},$$

$$E_\theta = \sum_{m=1}^{N} - i\eta \frac{I_0 d_m sin\theta}{4\pi k r^3} e^{-ik_m r},$$

$$B_\phi = \sum_{m=1}^{N} \mu\eta \frac{I_0 d_m sin\theta}{4\pi k r^2} e^{-ik_m r}, E_\phi = B_r = B_\theta = 0. \quad (39)$$

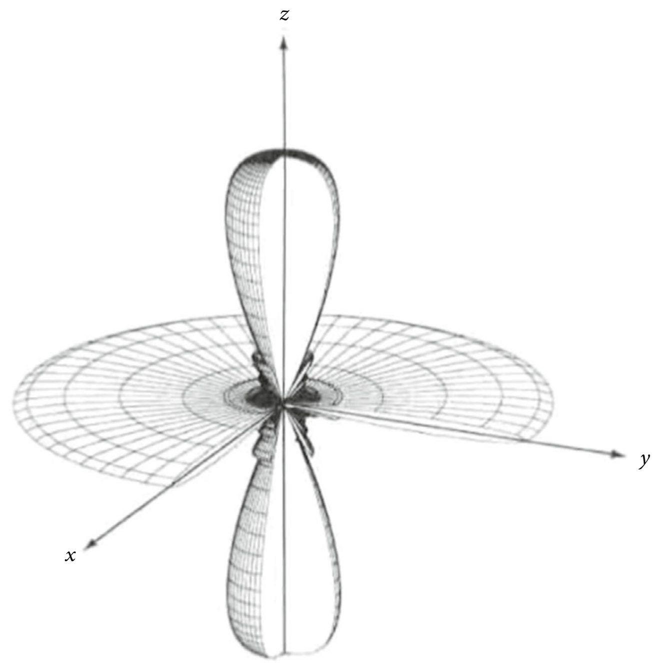

Figure 1: Three-dimensional amplitude patterns for broadside/end-fire arrays. Image source: Constantine A. Balanis Antenna Theory Analysis and Design. John Wiley and Sons ISBN0-471-59268-4.

The total near field electric radiation being $E_T = \sqrt{({E_r}^2 + {E_\theta}^2)}$.

For broadside/end fire patch antenna, the radiation pattern is concentrated at the poles as illustrated in Figure 1.

For radiation-emitting regions of the same separation distance, the half-power beam width is

$$\Theta_h = 2\cos^{-1}\left(1 - \frac{1.391\lambda}{\pi d N}\right). \quad (40)$$

The Ricci flow in the presence of these fields becomes

$$-\partial_t g_{(1.k)\mu\nu} = \frac{1}{3} c r_{\mathrm{HS}} k \left(\left\langle {B_\phi}^2 + B^2_{(0)} - \left(\frac{E^2_{(0)}}{c^2} + \frac{{E_T}^2}{c^2} \right) \right\rangle \right) g_{(1.k)\mu\nu}. \quad (41)$$

When the near field radiation is predominantly electric, the metric expands as follows:

$$g(t)_{\mu\nu} = g(0)_{\mu\nu} e^{(1/3) c r_{HS} \kappa \left(E^2(r)/c^2\right) t} \quad (42)$$

The increase in virtual photons density in the electric mode attenuates the gravitational field or the Ricci flow as follows:

$$-\partial_t g(t_n)_{\mu\nu} = \frac{1}{3} c r_{HS} G_{(nk)\mu\nu} = \frac{1}{3} c r_{\mathrm{HS}} \left(n^2 \Lambda - \frac{k E^2(r)}{c^2} \right) g_{(n,k)\mu\nu}, \tag{43}$$

where $n^2 = c^2 r_n / GM$ and M is the black hole mass.

The covariant and contravariant derivative terms for Equation (43) when expressed in the canonical form are

$$\nabla^{(n-1)\mu} = \partial^{n\mu} - \frac{\sqrt{k}.E^{\mu}(r)}{c}, \quad \nabla_{(n+1)\nu} = \partial_{(n\nu)} + \frac{\sqrt{k}E_{\mu}(r)}{c}. \tag{44}$$

This suggests a 4-momentum gap or gain of $2(\hbar\sqrt{k}E_{\mu}(r))/c$ attenuating the polar gravitational potential well. This attenuation will allow the lateral gravitational pressure to implode accretion material and releasing it through the polar regions where the gravitational pressure is weak. The implosion in turn concentrates the B_{ϕ} fields bringing the polar region into a strongly magnetic mode. The strong B_{ϕ} fields then contract the metric and increases gravitational pressure at the polar regions. As a consequence, an oscillation of the metric occurs which result in periodic jet outbursts as well as oscillations in the size of the event horizon. If the following condition $n^2\Lambda - (kE^2(r)/c^2) \leq 0$ from Equation (43) is satisfied then the jets can escape to infinity. Thus, for jet activation to occur, the virtual photon field must be in the electric mode and the magnetic mode in an attenuated state.

2. Discussion

By assuming that the energy of the quantum vacuum is electromagnetic at large scales, we have managed to express DM and DE as manifestations of the underlying quantized electromagnetic field and that space-time and gravity are emergent phenomena from this field. Thus, the detection of DE and DM requires the detection of the underlying electromagnetic field at large scales using highly sensitive synchroton radiation detection techniques. We have also shown that the enigmatic phenomenon of astrophysical jets can arise from the near field focus of virtual photons at black hole polar regions which leads to expansions or contractions of the space-time metric resulting in jet activation.

3. Conclusion

Understanding the nature of DM and DE is a key challenge in modern astrophysics. Almost all modified gravity theories attempt to explain the nature of the dark sector by modifying the geometric description of Einstein's equations. The hidden flaw in these attempts is the assumption that gravity at large scales can only be described in terms of geometry and that quantum gravity can only manifest at extremely small scales. DM and DE in the Nexus paradigm are a large-scale manifestation of quantum gravity. Thus, quantum gravity opens a new perspective on the nature of DE and DM and jet genesis which must be further pursued to reveal more hidden symmetries of nature.

Data Availability

No data is available.

Conflicts of Interest

The author declares no conflict of interest.

Acknowledgments

The author gratefully appreciates the funding and support from the Advanced Aerospacetime Concepts Project at Deep Time Technologies.

References

[1] P. A. Ade, N. Aghanim, M. I. Alves et al., "Planck 2013 results. I. Overview of products and scientific results," *Astronomy & Astrophysics*, vol. 571, p. A1, 2014, https://arxiv.org/abs/1303.5062.

[2] P. A. Ade, N. Aghanim, C. Armitage-Caplan et al., "Planck 2013 results. XVI. Cosmological parameters," *Astronomy & Astrophysics*, vol. 571, p. A16, 2014, https://arxiv.org/abs/1303.5076.

[3] J. C. Baker, K. Grainge, M. P. Hobson et al., "Detection of cosmic microwave background structure in a second field with the Cosmic Anisotropy Telescope," *Monthly Notices of the Royal Astronomical Society*, vol. 308, no. 4, pp. 1173–1178, 1999.

[4] M. Tegmark, M. A. Strauss, M. R. Blanton et al., "Cosmological parameters from SDSS and WMAP," *Physical review D*, vol. 69, article 103501, 2004.

[5] E. Komatsu, J. Dunkley, M. R. Nolta et al., "Five-year wilkinson microwave anisotropy probe observations: cosmological interpretation," *The Astrophysical Journal Supplement Series*, vol. 180, no. 2, pp. 330–376, 2009.

[6] A. G. Riess, A. V. Filippenko, P. Challis et al., "Observational evidence from supernovae for an accelerating universe and a cosmological constant," *Astronomy Journal*, vol. 116, no. 3, pp. 1009–1038, 1998.

[7] S. Perlmutter, G. Aldering, G. Goldhaber et al., "Measurements of Ω and Λ from 42 high-redshift supernovae," *The Astrophysical Journal*, vol. 517, no. 2, pp. 565–586, 1999.

[8] S. M. Faber and R. E. Jackson, "Velocity dispersions and mass-to-light ratios for elliptical galaxies," *The Astrophysical Journal*, vol. 204, pp. 668–683, 1976.

[9] B. Famaey and S. S. McGaugh, "Modified Newtonian dynamics (MOND): observational phenomenology and relativistic extensions," *Living Reviews in Relativity*, vol. 15, no. 1, p. 10, 2012.

[10] A. Vikhlinin, A. Kravtsov, W. Forman et al., "Chandra sample of nearby relaxed galaxy clusters: mass, gas fraction, and mass-temperature relation," *The Astrophysical Journal*, vol. 640, no. 2, pp. 691–709, 2006.

[11] R. Minchin, J. Davies, M. Disney et al., "A dark hydrogen cloud in the Virgo Cluster," *The Astrophysical Journal Letters*, vol. 622, no. 1, pp. L21–L24, 2005.

[12] C. E. Aalseth, P. S. Barbeau, N. S. Bowden et al., "Results 1 from a search for light-mass dark matter with a P-type point

contact germanium detector," *Physical Review Letters*, vol. 106, no. 13, article 131301, 2011.

[13] D. S. Akerib, H. M. Araújo, X. Bai et al., "First results from the LUX dark matter experiment at the Sanford Underground Research Facility," *Physical review letters*, vol. 112, no. 9, article 091303, 2014https://arxiv.org/abs/1310.8214v2.

[14] S. Capozziello, M. de Laurentis, O. Luongo, and A. Ruggeri, "Cosmographic constraints and cosmic fluids," *Galaxies*, vol. 1, no. 3, pp. 216–260, 2013.

[15] S. Marongwe, "The Nexus Graviton: a quantum of dark energy and dark matter," *International Journal of Geometric Methods in Modern Physics*, vol. 11, no. 6, article 1450059, 2014.

[16] S. Marongwe, "The Schwarzschild solution to the Nexus Graviton field," *International Journal of Geometric Methods in Modern Physics*, vol. 12, no. 4, article 1550042, 2015.

[17] S. Marongwe, "The electromagnetic signature of gravitational wave interaction with the quantum vacuum," *International Journal of Modern Physics D*, vol. 26, no. 3, p. 1750020, 2017.

[18] S. Marongwe, "A covariant canonical quantization of general relativity," *Advances in High Energy Physics*, vol. 2018, Article ID 4537058, 7 pages, 2018.

[19] S. Danieli, P. van Dokkum, C. Conroy, R. Abraham, and A. J. Romanowsky, "Still missing dark matter: KCWI high-resolution stellar kinematics of NGC 1052-DF2," *The Astrophysical Journal Letters*, vol. 874, no. 2, p. L12, 2019.

[20] D. Clowe, M. Bradač, A. H. Gonzalez et al., "A direct empirical proof of the existence of dark matter," *The Astrophysical Journal*, vol. 648, no. 2, pp. 109–113, 2006.

[21] M. Milgrom, "A modification of the Newtonian dynamics — implications for galaxies," *The Astrophysical Journal*, vol. 270, pp. 371–389, 1983.

[22] K. H. Chae, F. Lelli, H. Desmond, M. G. SS, P. Li, and J. M. Schombert, "Testing the strong equivalence principle: detection of the external field effect in rotationally supported galaxies," *The Astrophysical Journal*, vol. 904, no. 1, p. 51, 2020.