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Quantum gravity without gravitons as dark energy inflow.

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Abstract

It is assumed that dark energy (69.1% of what constitutes our Universe²) is quantized and behaves as a superfluid. We hypothesize that the flux described in Gauss's law for gravity be real and correspond to dark energy absorption into massive particles, driven by spin. Due to absorption, a quantum potential arises from the pressure gradient around any massive body and quantum gravity (as superfluid quantum gravity, SQG) is explained without resorting to gravitons. If dark energy exists, it is irrefutable that it is an ether which fills up the whole Universe and the Michelson-Morley test should be then revised starting from a different assumption, in which a radial ether wind corresponds to the gravitational field and is independent of Earth's motion. Interferometric tests seem to confirm this new assumption. In SQG the Lense-Thirring precession can occur, along with any other effect described in special and general relativity. Einstein field equations along with the Schwarzschild, Kerr, Reissner-Nordström and Kerr-Newman metrics are presented in their quantum versions, where the constants unveil their constituting quantities and vanish. It is therefore suggested to proceed with this approach to replace Einstein's curved space-time with a superfluid space evolving in time through its quantum fluid dynamics. Time dilation and gravitational waves are allowed in this approach and the consequences on light propagation and Hubble's law are analyzed. To balance the absorption of dark energy, massive particles (seen as superfluid vortices of dark energy) emit virtual photons, making clear the nexus between gravity and electromagnetism.

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²data from the ESA Planck space observatory.

1 From classical gravity to quantum gravity, without gravitons.

According to the mainstream dark energy fills up the Universe, constituting 69.1% of its mass-energy. Since any form of energy has to be quantized, we suppose that also dark energy is and that this ubiquitous sea of dark quanta acts as a superfluid medium, producing fluid dynamic phenomena in the Universe and in the world of elementary particles. The most important would be gravity. Gauss's law for gravity,

$$\oiint_{\partial V} \mathbf{g} \cdot d\mathbf{A} = -4\pi GM \quad (1)$$

describes the gravitational field as an incoming flux. We assume that this flux be real and caused by the absorption of superfluid dark energy into massive particles, driven by their spin³. Indeed, if a body radially absorbs the fluid in which it is immersed (e.g. massive particles, if they were superfluid vortices [3, 4, 5, 6] of dark energy), it consequently attracts other bodies around it which are immersed in the same fluid, due to a pressure gradient, in the same mathematical form of Gauss's law for gravity. A similar hypothesis (fluid dynamic gravity) was proposed by Cahill [7].

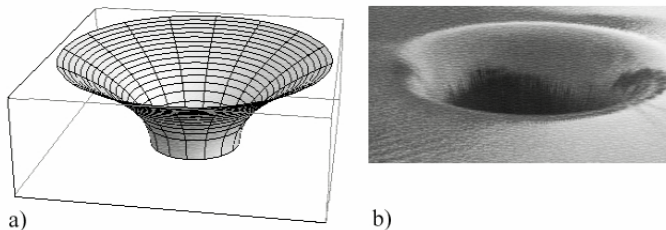


Figure 1: Analogy between curved space-time in a Flamm's paraboloid (a), corresponding to the Schwarzschild solution, and inflow of superfluid dark energy, represented as a bell-mouth spillway (b). An object floating in the area around the spillway would be attracted toward the site of absorption because of a force generated by a pressure gradient in a flat space-time.

We can describe the motion of dark energy's quanta (DEQ) in relationship with density:

$$d\rho = -\rho_0 \frac{\partial s}{\partial x} \quad (2)$$

³we believe that fundamental massive particles are superfluid vortices of dark energy's quanta and according to Salvatore Esposito [2], who cites Recami and Salesi [1], we think that the quantum potential $Q = -\frac{1}{2}m\vec{v}_S - \frac{1}{2}\nabla \cdot \vec{v}_S$ of a particle totally arises from its internal motion $\vec{v}_S \times \vec{s}$, where $\vec{v}_S = \frac{1}{2m} \frac{1}{\rho} \nabla \rho = \frac{1}{2m} \frac{\nabla R^2}{R^2}$ and \vec{s} is the direction of spin. Since viscosity cannot be exactly zero, the vortex would attract the surrounding quanta, causing a pressure variation. Mass conservation despite the absorption may occur thanks to emission of virtual photons, as discussed in §4, marking the nexus between gravity and electromagnetism.

where ρ is dark energy's density, ρ_0 its density if no absorption occurs and $s = s(x, t)$. The corresponding pressure variation is

$$dp = \frac{\beta}{\rho_0} \quad (3)$$

with $\beta = \rho \frac{dp}{d\rho}$ bulk modulus of dark energy. Substituting from (2) we have

$$p = p_0 - \beta \frac{\partial s}{\partial x} \quad (4)$$

The corresponding force is given as

$$-\frac{\partial p}{\partial x} dx = \beta \frac{\partial^2 s}{\partial x^2} dx \quad (5)$$

The acceleration is expressed as $\frac{\partial^2 s}{\partial t^2}$. In the form of Newton's second law, the force reads:

$$\beta \frac{\partial^2 s}{\partial x^2} dx = \rho_0 dx \frac{\partial^2 s}{\partial t^2}. \quad (6)$$

Since in the absorption process we consider quantized dark energy, we obtain quantum gravity without resorting to gravitons. Let's see what the quantum potential depends on.

From CFD simulations we verify that in the case of an absorbing spherical body a pressure gradient (Fig. 2) arises around it. The absorption provokes an attractive force which follows Gauss's law for gravity and the Schwarzschild solution. Refinement of the computational grid and domain enlargement helped to reduce the curvature of the flow lines up to a virtually radial flow.

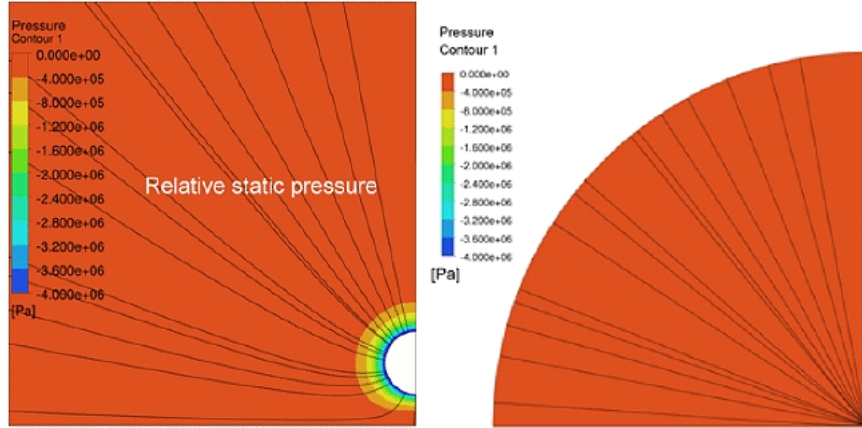


Figure 2: Pressure gradient around a particle absorbing the fluid in which it is immersed. As verified, the consequent attractive force mathematically equals Gauss's and Newton's laws for gravity and is compatible with the Schwarzschild solution. Refining the grid (on the right) leads to a perfectly radial symmetry.

In this view, a gravitational field corresponds to the absorption field. As we see in Fig. 2, pressure plays a major role and, in effect, the quantum potential of quantum gravity can be defined as:

$$Q_\varphi = \frac{P_d}{\rho_d} \quad (7)$$

where P_d is dark energy's pressure and ρ_d its density. Around a spherical body it is expressed as a gradient $-\nabla Q_\varphi$ (Fig. 2). This quantum potential has to coincide with the classical gravitational potential. The dimensional analysis permits the identity, where φ is the Newtonian gravitational potential:

$$\varphi_{(r)} = G \frac{M}{r} \left[\frac{\text{m}^2}{\text{s}^2} \right] \iff Q_\varphi = \frac{P_d}{\rho_d} \left[\frac{\text{m}^2}{\text{s}^2} \right] \quad (8)$$

It is important to observe that, when we describe the classical gravitational potential as a quantum potential induced by pressure, the gravitational constant G vanishes. Furthermore, the units $\frac{\text{m}^2}{\text{s}^2}$ correspond to Gray (Gy), i.e. the unit of measure used for energy absorption (J/kg). In this case, absorption of dark energy. Another clue to the validity of the present hypothesis. Since $g = -\nabla\varphi$, we have the gravitational field expressed as the negative gradient of the gravitational quantum potential:

$$g = -\nabla Q_\varphi \quad (9)$$

By substituting (9) in Newton's law of universal gravitation we obtain the formula of quantum gravity:

$$F_{g_Q} = -m \nabla \left(\frac{P_d}{\rho_d} \right) = -m \nabla Q_\varphi \quad (10)$$

The differential form of Gauss's law for gravity (i.e. Poisson's equation) loses the gravitational constant⁴ and becomes a quantum formula:

$$-\nabla^2 Q_\varphi = -4\pi Q_\varphi \frac{r}{M} \rho_m = -\frac{3Q_\varphi}{r^2} \quad (11)$$

where $\rho_m = \frac{3}{4} \frac{M}{\pi r^3}$ is mass density. It is immediate to understand that, as far as the resulting forces are concerned, the case of an absorbing spherical body is analogous to the Schwarzschild solution and, if the body rotates about its axis, compatibility with the Lense-Thirring precession arises, without resorting to a curved space-time.

We can write a quantum form of Einstein's field equations (EFE), where gravity is due to dark energy absorption, by replacing the constants c , G , κ , Λ with the physical quantities from which they actually arise

$$G_{\mu\nu} + 8\pi Q_\varphi \frac{r}{M} \beta_d \rho_{d_0}^2 g_{\mu\nu} = 8\pi Q_\varphi \frac{r}{M} \beta_d \rho_{d_0} T_{\mu\nu}, \quad (12)$$

⁴as we know, introduced by Newton to simply balance the calculations in a non-quantum formula.

where we consider the identities

$$G = Q_\varphi \frac{r}{M}, \quad (13)$$

from (8) and

$$\Lambda = \kappa \rho_{vac} = 8\pi \frac{G}{c^2} \rho_{vac} = 8\pi Q_\varphi \frac{r}{M} \beta_d \rho_{d_0}^2, \quad (14)$$

putting $\rho_{vac} = \rho_{d_0}$, with ρ_{d_0} density of dark energy when $g \rightarrow 0$. Finally from §2 (21) we know that $c = \frac{1}{\sqrt{\beta_d \rho_{d_0}}}$, with β_d as isentropic compressibility of dark energy. Consequently, Einstein's constant, κ , reads

$$\kappa = 8\pi \frac{G}{c^2} = 8\pi Q_\varphi \frac{r}{M} \beta_d \rho_{d_0}. \quad (15)$$

We can note that the meaning of the stress-energy tensor is fully compatible with a quantum fluid dynamic interpretation which considers dark energy, being T^{00} its density, $\rho_{d_0} = \rho_{vac}$, T^{ii} , its pressure, P_d , $T^{0i} = T^{i0}$ the momentum density and being shear stress (cf. §2.4) and momentum flux the remaining components. As far as the metric tensor, $g_{\mu\nu}$, of EFE is concerned, though space-time would not be distorted but it would be simply expressed by dark energy's fluid dynamics, it maintains its computational usefulness *as if space were distorted*. Einstein's description of gravity and space would therefore remain relevant from a quantitative point of view (differential geometry) but not about the explanation it provides. The same can be said for the other tensors in EFE, since both Ricci tensor, $R_{ij} = R^k_{ikj} = \partial_l \Gamma^l_{ji} - \partial \Gamma^l_{li} + \Gamma^l_{l\lambda} \Gamma^\lambda_{ji} - \Gamma^l_{j\lambda} \Gamma^\lambda_{li}$ and Ricci scalar, $S = 2g^{ab}(\Gamma^c_{a[b,c]} + \Gamma^d_{a[b} \Gamma^c_{c]d})$, forming Einstein tensor, $G_{\mu\nu}$, are defined through Christoffel symbols, which are themselves expressed by the metric tensor, e.g. $\Gamma_{cab} = \frac{1}{2}(\partial_b g_{ca} + \partial_a g_{cb} - \partial_c g_{ab})$.

We can rewrite the solutions to EFE without the Newtonian gravitational constant (13) and by putting from (21) $c = \sqrt{F^{-1}}$, where $F = \frac{1}{c^2} = \beta_d \rho_{d_0}$, i.e. by using quantum parameters which refer to dark energy (§2). The line element for Schwarzschild metric will then read

$$ds^2 = g_{\mu\nu} dx^\mu dx^\nu = (1 - 2Q_\varphi F)^{-1} dr^2 + r^2 (d\theta^2 + \sin^2 \theta d\phi^2) - F^{-1} + 2Q_\varphi dt^2, \quad (16)$$

where Q_φ is the quantum potential from (8) and θ, ϕ coordinates of colatitude and longitude.

Let us now consider the quantum form of Kerr metric

$$F^{-1} d\tau^2 = \left(F^{-1} - \frac{2Q_\varphi r^2}{\varrho^2} \right) dt^2 - \frac{\varrho^2}{\Delta} dr^2 - \varrho^2 d\theta^2 - \left(r^2 + \frac{\gamma^2}{F} + \frac{2Q_\varphi r^2}{\varrho^2} \gamma^2 \sin^2 \theta \right) \sin^2 \theta d\phi^2 + \frac{4Q_\varphi r^2}{\varrho^2} \gamma \sin^2 \theta dt d\phi, \quad (17)$$

by defining for brevity $\gamma = \frac{J}{Mc^2} = \frac{JF}{M}$, being J the angular momentum; $\varrho^2 = r^2 + \frac{\gamma^2}{F} \cos^2 \theta$ and $\Delta = r^2 + \frac{\gamma^2}{F} - 2Q_\varphi r^2 F$. We note that, by using quantum parameters, Schwarzschild radius reads $2Q_\varphi r F$.

Switching to Reissner-Nordström metric in spherical coordinates (t, r, θ, ϕ) , we see that

$$F^{-1} d\tau^2 = \left(F^{-1} - 2Q_\varphi + \frac{Q^2 F Q_\varphi}{4\pi\epsilon_0 r M} \right) dt^2 - \left(\frac{1}{F^{-1} - 2Q_\varphi + \frac{Q^2 F Q_\varphi}{4\pi\epsilon_0 r M}} \right) F^{-1} dr^2 - r^2 d\Omega^2, \quad (18)$$

where Q is the charge, Q_φ the gravitational quantum potential, ϵ_0 vacuum (dark energy) permittivity and $d\Omega^2 = d\theta^2 + \sin^2 \theta d\phi^2$.

Finally, we see the line element of Kerr-Newman metric in Boyer-Lindquist coordinates as follows

$$F^{-1} d\tau^2 = - \left(\frac{dr^2}{\Delta} + d\theta^2 \right) \varrho \cos^2 \theta + \left(\sqrt{F^{-1}} dt - \xi \sqrt{F} \sin^2 \theta d\phi \right)^2 \frac{\Delta}{\varrho \cos^2 \theta} - (\varrho d\phi - \xi dt)^2 \frac{\sin^2 \theta}{\varrho \cos^2 \theta} \quad (19)$$

where the following length-scales are introduced for brevity: $\xi = \frac{J}{M}$; $\varrho = r^2 + F \xi^2$ and $\Delta = \varrho - 2Q_\varphi r^2 F + \frac{Q^2 Q_\varphi r F^2}{4\pi\epsilon_0 M}$.

2 Light propagation through superfluid dark energy.

Light doesn't travel through a real vacuum. We don't refer to quantum vacuum⁵ [8, 9] or quantum foam [10] but to the fact that dark energy permeates the Universe. Light therefore propagates through dark energy. Equations show that a photon could actually be a special spin-1 phonon. A pulse propagating through dark energy. Waves existing in nature would reduce to only one type and photon's electromagnetic field could be interpreted as a periodic excitation of dark energy's quanta.

Let's consider the formula indicating the speed of a mechanical wave through a fluid, $a = \sqrt{\frac{K}{\rho}}$, in which K is the bulk modulus, referring in our case to dark energy compressibility. By putting $\beta_S = \frac{1}{K}$ as isentropic compressibility, we see

$$a = \frac{1}{\sqrt{\beta_S \rho}} \quad (20)$$

⁵where particle-antiparticle pairs continuously form and annihilate probably corresponding to stochastic fluid dynamic perturbations of dark energy, i.e. superfluid quantum vortices, whose angular velocity is expressed by spin.

If we consider $\beta_S = \beta_d$ as dark energy's isentropic compressibility, ρ_{d_0} as its mass density and c as the speed of the pulse, we get

$$c = \frac{1}{\sqrt{\beta_d \rho_{d_0}}} \quad (21)$$

expressing the speed of a photon as a phonon through dark energy, mathematically analogous to $c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$, as resulting from Maxwell's equations. This means that light's EM field would quantum mechanically arise from the periodic excitation of DEQ during the propagation of the phonon. This explains why the physical vacuum possesses a given permittivity (ϵ_0) and permeability (μ_0). From (21), we see that the speed of light would simply be the speed of sound through dark energy, a *sound* that we perceive through our eyes. We also have to consider light propagation as a phenomenon of second sound through dark energy. After all, we know that phonons as well are bosons [11], have wave-particle duality [12, 13], obey the doppler effect, are symmetric under exchange, $|\alpha, \beta\rangle = |\beta, \alpha\rangle$, can be created by repeatedly applying the creation operator, b^\dagger , share the same momentum of photons, $p_{ph} \equiv \hbar k = \frac{h}{\lambda}$, with $k = \frac{2\pi}{\lambda}$, can produce photoelectric effect and Compton scattering thanks to their momentum, can possess spin [14], can form squeezed coherent states and can interact via parametric down conversion [15]. Both for photons and phonons, $\frac{1}{2}\hbar\omega$ is vacuum's (we say dark energy's) contribution, where the harmonic oscillator eigenvalues for the mode ω_k (k is the wave number) are:

$$E_n = \left(n + \frac{1}{2}\right) \hbar\omega_k \quad n = 1, 2, 3, \dots \quad (22)$$

If a photon is a pulse through superfluid dark energy and the gravitational field is an incoming flow of such medium, then light cannot have the same speed when travelling upward or downward parallel to the gravitational field. We need to vertically place a Michelson interferometer to verify that. Indeed, the original premise of the Michelson-Morley test was in this case wrong, since the ether is not stationary but radially directed toward the center of the Earth, independently of its motion about the Sun. The only influence on this flow comes from Earth's rotation and corresponds to the Lense-Thirring precession described in general relativity, in which the rotation of the planet bends the gravitational field (in this case the flow of dark energy), as a rotating garden sprinkler bends its jet of water. Tests with a vertically placed Michelson interferometer give positive result [16].

We can verify that any other effect described in special and general relativity is explainable through the laws of fluid dynamics within a superfluid sea of dark energy, instead of a curved space-time. The word *dynamics* already contains time in itself.

For instance, the gravitational lensing would not be caused by curved space-time but by the fact that light travels through a flowing medium, since dark energy flows toward massive bodies (6), (7) as stars. We observe the same mechanism in classical fluid dynamics when the wind deflects a sound. The inflow of

dark energy would also keep a body orbitating about another one, again without resorting to curved space-time. In quantum gravity, differential geometry gives way to quantum fluid dynamics in explaining Einstein's relativistic effects.

2.1 Gravitational waves.

Assuming gravity as absorption of superfluid dark energy, gravitational waves [17] arise as negative pressure waves generated by periodic (\Rightarrow quadrupole) variations in the absorption intensity oriented towards a given point (e.g. towards LIGO's mirrors [18]). Gravitational waves would be negative pressure waves propagating through dark energy. Again, no curved space-time is needed to explain what experimentally observed. Let us consider a supposed space-time deformation as a wave with polarization \times :

$$h_{\times} = -\frac{1}{R} \frac{G^2}{c^4} \frac{4m_1 m_2}{r} (\cos \theta) \sin \left(2\omega \left(t - \frac{R}{c} \right) \right). \quad (23)$$

By substituting from (13) and (21) we see that the amplitude of the gravitational wave is a pressure oscillation propagating through dark energy

$$\begin{aligned} h_{\times} = & -\frac{1}{R} \left(2 \frac{P_d}{\rho_d} \beta_d \rho_{d_0} \right)^2 r \frac{m_2}{m_1} (\cos \theta) \sin \left(2 \sqrt{\frac{P_d}{\rho_d r^2} \left(1 + \frac{m_2}{m_1} \right)} (t - R \sqrt{\beta_d \rho_{d_0}}) \right) = \\ & -\frac{1}{R} (2Q_{\varphi} F)^2 r \frac{m_2}{m_1} (\cos \theta) \sin \left(2 \sqrt{\frac{Q_{\varphi}}{r^2} \left(1 + \frac{m_2}{m_1} \right)} (t - R\sqrt{F}) \right), \quad (24) \end{aligned}$$

while the polarization h_{+} of the wave reads

$$h_{+} = -\frac{1}{R} (Q_{\varphi} F)^2 2r \frac{m_2}{m_1} (1 + \cos^2 \theta) \cos \left(2 \sqrt{\frac{Q_{\varphi}}{r^2} \left(1 + \frac{m_2}{m_1} \right)} (t - R\sqrt{F}) \right), \quad (25)$$

where R is the distance from the observer, t the elapsed time, θ the angle between the perpendicular to the plane of the orbit and the line of sight of the observer, r the radius of the quadrupole, $\sqrt{\frac{Q_{\varphi}}{r^2} \left(1 + \frac{m_2}{m_1} \right)} = \omega$ the angular frequency of the quadrupole obtained by using the identity (8) in the Newtonian formula for constant angular velocity of a circular orbit $\sqrt{G(m_1 + m_2)/r^3}$, and $\sqrt{\beta_d \rho_{d_0}} = \sqrt{F}$ corresponds to c^{-1} (21), which accounts for the speed of the gravitational wave as speed of light, since in both cases we observe a pressure wave through dark energy though, in the case of gravitational waves, with the distinction of a negative pulse whose frequency depends on the quadrupole. As shown in Eq. (2-6), the pressure variation corresponds to an acceleration, acting in this case on LIGO's test masses if we take into account the recent tests.

2.2 Hubble's law.

Valid the analogy photon-phonon and taken into account that no superfluid has actually zero viscosity, Hubble's law in the form

$$z = \frac{H_0 D}{c} \quad (26)$$

or by highlighting dark energy's role $z = H_0 D \sqrt{F}$, would be compatible with an energy loss (\Rightarrow redshift) of photons, due to the minimal viscosity of dark energy and proportional to distance: the further a galaxy, the greater the detected redshift, without accelerated expansion of the Universe. According to $E = \frac{hc}{\lambda}$, the energy decrease would cause a greater wavelength, hence a redshift, while the speed of light remains unaffected. Lemaître's hypothesis, $v \propto D$, used to interpret the empirical Hubble's law, would not be, therefore, correct in attributing the cause of the observed redshift to the recessional velocity of galaxies. This phenomenon is different from the theorization of tired light provided by Zwicky [19]. The known objections to tired light would vanish in this approach, since a redshift due to a quasi-zero, uniform viscosity of dark energy throughout the cosmos: a) would not exhibit blurring, since no Compton scattering occurs in this hypothesis, b) for the same reason, it would admit the same measurement in any wavelength-band and c) it would follow the empirical Hubble's law. Moreover, we don't need to explain cosmological time-dilation, since it was introduced to justify the cosmological redshift within a competing hypothesis (the expansion of the Universe). We have to add, that the observed redshift (z_{obs}) might arise as

$$z_{obs} = z_a + z_\mu \quad (27)$$

i.e. due to concomitant causes, where z_a is the redshift due to the expansion (in this case weaker as we think) of the Universe and z_μ the redshift due to dark energy's non-zero viscosity.

2.3 Mass-energy relationship.

By calculating the speed of light as described in Eq. (21) the mass-energy formula $E = mc^2$ can be observed in a new form by substituting $c^2 = (\beta_d \rho_{d_0})^{-1}$

$$E = \frac{m}{\beta_d \rho_{d_0}} = \frac{m}{F} \quad (28)$$

where we know that β_d is the isentropic compressibility of dark energy, ρ_{d_0} its density and F their product. Here, dark energy appears as the *Urenergie* in the Universe. If a certain mass were annihilated by a corresponding anti-mass, the total excitation of DEQ would correspond to a given number of photons, i.e. of phonons (§2) propagating through the superfluid sea of dark energy and occurring as result of the destruction of superfluid vortices which possess

conflicting spin (a particle-antiparticle pair). Phonons transport quantum mechanical energy, which can be interpreted as second sound through dark energy.

2.4 Quantum Lorentz factor.

Dark energy's quanta which fill up the Universe as a suspension in space, would cause a non-newtonian, dilatant behavior of dark energy. However, given the extremely low density of dark energy, the dilatancy of this granular, dark substance would be detectable only for extremely high shear stress. This would explain why particles which are accelerated towards the speed of light encounter an increasing non-linear resistance, as indicated by Lorentz factor, where $\beta = \frac{v}{c}$ is here interpreted as the ratio between the total flow velocity of dark energy (u_{tot}) which a body is subject to, as expressed in the fluid equivalence principle (30), and that of a pulse through dark energy, $u_p = c = \sqrt{F^{-1}}$, (21). Of course we assume it is not possible to exceed the speed of sound through a dilatant fluid and particularly through dark energy.

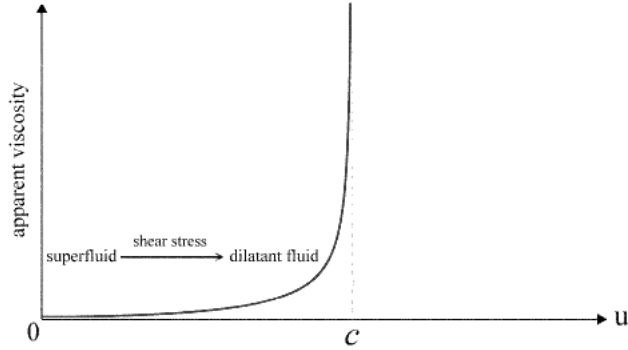


Figure 3: Lorentz factor as dark energy's rheogram.

The derivative of the arcsine indicates the impossibility of exceeding the speed of a pulse through dark energy because of its dilatant response as speed and shear stress increase

$$\gamma \equiv \arcsin' \frac{u_{tot}}{u_p} = \frac{1}{\sqrt{1 - \left(\frac{u_{tot}}{u_p}\right)^2}} = \frac{1}{\sqrt{1 - u_{tot}^2 F}} \quad (29)$$

where $F = \frac{1}{c^2} = \frac{1}{u_p^2} = \beta_d \rho_{d_0}$ (21) represents the role of dark energy, as a quantum fluid, in Lorentz factor.

Known the velocity field related to dark energy absorption, if we use the total flow velocity u_{tot} (30), instead of the simple translational velocity, Eq. (29), in

the form $\Delta t' = \frac{\Delta t}{\sqrt{1 - \left(\frac{u_{tot}}{u_p}\right)^2}}$, can also express gravitational time dilation, instead of resorting to $\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{R_S}{r}}}$, as discussed below.

3 Relativistic time dilation and fluid equivalence principle (FEP).

Special relativity (SR) tells us that velocity slows down clocks. General relativity (GR) asserts that also gravity slows them down. Now, something interesting happens when we remember that we have defined a gravitational field as an incoming flow of dark energy (§1). A body immersed in a gravitational field is therefore subject to that flow. Physics reminds us that a condition of equivalence arises when a body travels through a stationary fluid, since it is subject to an apparent flow. This is the reason why both velocity (SR) and gravity (GR) slow down clocks, i.e. being subject to a flow of dark energy which exerts a force (gravity). In SR we actually observe an apparent gravitational force opposite to the direction of motion, which increases as the speed of sound through dark energy (i.e. the speed of light) is approached, because of dark energy's dilatancy for extreme shear stress (Fig. 3). We can therefore express a fluid equivalence principle which considers both flows (gravitational and apparent) as:

$$\mathbf{u}_{tot} = \mathbf{u}_\varphi + \mathbf{u} \quad (30)$$

where the total flow velocity \mathbf{u}_{tot} of dark energy, which a body is subject to, arises from the sum of the flow velocity of dark energy due to the gravitational absorption (\mathbf{u}_φ) and from the translational velocity of the body (\mathbf{u}) through dark energy. In this way, relativistic time dilation is reduced to the action of gravity also in SR. Since Lorentz-Fitzgerald contraction depends on time dilation, we can therefore demonstrate that all relativistic effects of SR and GR are ascribable to the sole action of gravity.

By equating the time dilation formulas of SR and GR we see that translational velocity in SR corresponds to a function of the gravitational quantum potential, as second cosmic velocity, which has to equal the absorption velocity, demonstrating the FEP in Einstein's relativity:

$$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{\Delta t}{\sqrt{1 - \frac{R_S}{r}}} \quad (31)$$

hence

$$\frac{v^2}{c^2} = \frac{R_S}{r} = \frac{2GM}{c^2 r} \implies v^2 = \frac{2GM}{r} \quad (32)$$

and

$$v = \sqrt{2rg} = \sqrt{2\varphi} \quad (33)$$

eventually from (8)

$$v = \sqrt{2Q\varphi}. \tag{34}$$

4 Mass conservation in SQG and prospect of fundamental interactions unification.

The absorption of dark energy into massive particles would cause their mass to increase. This doesn't occur. Since we assumed that the massive particles of the Standard Model are superfluid vortices in the superfluid sea of dark energy, according to Helmholtz's second theorem we consider an output for the absorbed energy and we believe it is packed, and emitted, into amounts known as virtual photons, which generate the electrostatic field of charged particles. This mechanism would connect gravity with electromagnetism. In the case of unbound neutral particles, as neutrons, the absorption process would push them to decay and, indeed, we know that unbound neutrons' mean lifetime is 881 s. Dark energy absorption, i.e. SQG, explains in this way the β -decay. On the contrary, bound neutrons in the nucleus can transfer the exceeding DEQ to protons and be stable: this transfer corresponds to the gluonic flow, explaining the strong interaction. A prediction of SQG, for instance, would be that of a greater mass of isolated neutrons before they decay, if compared with the mass of bound neutrons in a nucleus, as well as a faster decay of neutral pions ($8.4 \cdot 10^{-17}$ s) if compared with charged pions ($2.6 \cdot 10^{-8}$ s), as it actually occurs.

Since the emission of virtual photons is quantized and we assume that each of them is made up of several DEQ, charged particles would briefly increase their mass before the emission of the following virtual photon obeying a sawtooth function. This energy loop would explain the hypothesized phenomenon of Zitterbewegung. Not by chance, stochastic electrodynamics explains Zitterbewegung as the interaction of a charged particle with the zero-point field (dark energy, in our case).

5 Conclusion

Assuming that the ubiquitous dark energy is quantized and absorbed into massive particles, we can interpret the flux in Gauss's law for gravity as absorption of dark energy which generates a pressure gradient and therefore attraction, compatibly with the Schwarzschild solution. In this case, a gravitational field would be an incoming flow of dark energy and gravity would be described as a quantum fluid dynamic phenomenon without gravitons. The quantum potential arises as the ratio pressure/density and a quantum formula for universal gravitation is suggested. All the experimentally observed relativistic effects of special and general relativity are compatible with this approach, where instead of a curved space-time, space behaves as a superfluid whose fluid dynamics determines time, which also in this case is not absolute, since also in SQG gravity

influences clocks. The cause of all relativistic phenomena is reduced to gravity, as dark energy absorption, through a fluid equivalence principle. Recently detected gravitational waves would be negative pressure waves traveling through dark energy. Photons too, may be pulses traveling through dark energy. Mathematically and according to current observations, the photon-phonon analogy seems sufficiently strong. Light traveling parallel to a gravitational field should change its speed, as indeed observed in a test run by M. Grusenick using a vertically placed Michelson interferometer. The non-zero viscosity of dark energy would cause energy loss in photons, explaining the empirical Hubble's law without accelerated expansion of the Universe and solving the known objections against the classical hypothesis of tired light. Eventually, the issue of mass conservation in SQG suggests how to complete the unification of the fundamental interactions. It seems therefore worthwhile to perform further tests and to continue with the approach of a superfluid Universe.

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