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Quantum gravity as dark energy inflow.

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Abstract

It is assumed that dark energy (68.3% of what constitutes our Universe) is quantized and behaves as a superfluid. We hypothesize that the flux described in Gauss's law for gravity is real and corresponds to dark energy absorption into massive particles. 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, since the ether wind would correspond to the gravitational field and would be independent of Earth's motion. An interferometric test has confirmed this new assumption. In SQG the Lense-Thirring precession can occur, along with any other effect described in special and general relativity. It is therefore suggested to replace Einstein's curved space-time with a superfluid space evolving in time through its fluid dynamics. Time dilation and gravitational waves are allowed in this approach and the consequences on light propagation and Hubble's law are analyzed.

1 From classical gravity to quantum gravity, without gravitons.

The mainstream believes that dark energy fills up the Universe, constituting the 68.3% 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

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acts as a superfluid, producing fluid dynamic phenomena. 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 is real and caused by the absorption of superfluid dark energy. Indeed if a body radially absorbs the fluid in which it is immersed (e.g. massive particles if they were superfluid vortices [1][12][13] 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 [2].

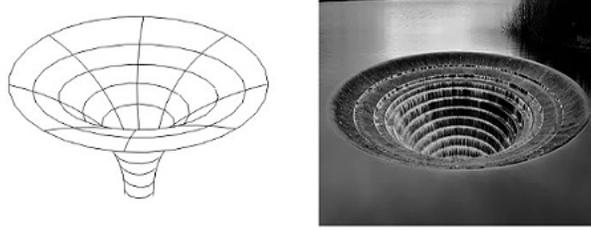


Figure 1: Analogy between curved space-time and inflow of superfluid space (here represented as a bell-mouth spillway).

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

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

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.

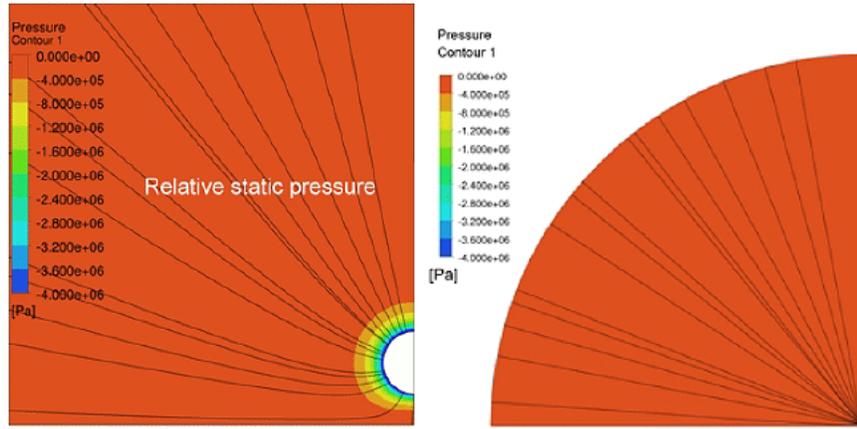


Figure 2: Pressure gradient around a particle absorbing the fluid in which it is immersed. As verified, the consequent attractive force mathematically equals Gauss's and Newton's laws for gravity and is compatible with the Schwarzschild solution. Refining the grid (right) leads to a perfectly radial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

$$Q_\varphi = \frac{p}{\rho} \quad (7)$$

where p is dark energy's pressure and ρ its density. Around a spherical body it assumes the form of a pressure 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 gravitational potential:

$$\varphi_{(r)} = G \frac{M}{r} \left[\frac{\text{m}^{\cancel{3}2} \cancel{\text{kg}}}{\text{s}^2 \cancel{\text{kg}} \cancel{\text{m}}} = \frac{\text{m}^2}{\text{s}^2} \right] \iff Q_\varphi = \frac{p}{\rho} \left[\frac{\cancel{\text{kg}} \text{m}^{\cancel{3}2}}{\cancel{\text{m}} \text{s}^2 \cancel{\text{kg}}} = \frac{\text{m}^2}{\text{s}^2} \right] \quad (8)$$

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 $\mathbf{g} = -\nabla\varphi$, we have the gravitational field expressed as the negative gradient of the gravitational quantum potential:

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

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

$$F_{g_Q} = -m\nabla Q_\varphi \quad (10)$$

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

$$-\nabla^2 Q_\varphi = -4\pi p r M^{-1} \quad (11)$$

It is immediate to understand that, as far as the produced effect is concerned, the case of an absorbing spherical body is compatible with 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.

2 Light propagation through superfluid dark energy.

Light doesn't travel through a real vacuum. In fact, quantum physics knows that a real vacuum (as zero-energy R^3) doesn't exist and refers to a quantum vacuum [14][15]. After all, if all is immersed in dark energy, this is understandable. What we call quantum foam [16], quantum vacuum, with particle-antiparticle pairs which continuously form and annihilate in it, would correspond to stochastic fluid dynamic perturbations of dark energy, i.e. superfluid quantum vortices, named particles. Light therefore propagates through dark energy. Equations show that a photon could be actually a special spin-1 phonon. A pulse through dark energy as sound wave through air. Waves existing in nature would reduce to only one type.

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 have

$$a = \frac{1}{\sqrt{\beta_S \rho}} \quad (12)$$

If we consider $\beta_S = \beta_0$ as dark energy's isentropic compressibility, ρ_0 as its mass density and c as the speed of the pulse, we get

$$c = \frac{1}{\sqrt{\beta_0 \rho_0}} \quad (13)$$

expressing the speed of a photon as a phonon through dark energy, mathematically analogous to $c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$, 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 would explain why the physical vacuum possesses a given permittivity (ε_0) and permeability (μ_0). From (13), 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 have also to consider light propagation as a phenomenon of second sound through dark energy. After all, we know that phonons as well are bosons [3], have wave-particle duality [4, 5], 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 [6], can form squeezed coherent states and can interact via parametric down conversion [7]. 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:

$$E_n = \left(n + \frac{1}{2}\right) \hbar\omega_k \quad n = 1, 2, 3, \dots \quad (14)$$

If a photon is a pulse through the superfluid dark energy and the gravitational field is an incoming flow of such energy, 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, since the original premise of the Michelson-Morley test was in our case wrong, as the ether is not stationary but radially directed toward the center of the Earth. The only influence on it comes from Earth's rotation and corresponds to the Lense-Thirring precession described by general relativity, in which the rotation of the planet bends, in this case, the ether wind, as a rotating garden sprinkler bends its jet of water. A test with a vertical interferometer performed by Grusenick gave positive result [8]. Of course, this has nothing to deal with Einstein's redshift, since no clock is used in the measurement and the splitted beam merges in the same point of the gravitational field.

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 (as a star) because of the absorption. We

observe the same mechanism in classical fluid dynamics when the wind deflects a sound. This would be the reason why a gravitational field bends light beams. The inflow of dark energy would also keep a body orbitating about another one, again without resorting to curved space-time.

2.1 Gravitational waves.

Assuming gravity as absorption of superfluid dark energy, gravitational waves [9] 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 [10]). Gravitational waves would be negative pressure waves through dark energy. Actually, no curved space-time is needed to explain what experimentally observed. The amplitude of the wave can be explained as a periodic pressure variation in time, at a point of detection:

$$p_{obs}(r, t) = -p_{max}(\cos \theta) \sin \left(2\omega \left(t - \frac{r}{c} \right) \right) = -p_{max}(\cos \theta) \sin \left(2\sqrt{\frac{Q_\varphi}{r_q^2}} (t - r\sqrt{\beta_0\rho_0}) \right) \quad (15)$$

where r is the distance from the source, t the elapsed time, θ the angle between the perpendicular to the plane of the orbit and the line of sight of the observer, p_{max} the maximum pressure difference in dark energy generated by the quadrupole at the point of detection, ω the angular frequency of the quadrupole, i.e. $\sqrt{\frac{Q_\varphi}{r_q^2}}$ (with r_q as the radius of the orbit in the quadrupole) by using the identity (8) in the Newtonian formula for the constant angular velocity of a circular orbit $\sqrt{G(m_1 + m_2)}/r^3$, and $\sqrt{\beta_0\rho_0}$ corresponds to c^{-1} (13), which accounts for the speed of the gravitational wave as speed of light, since in both cases we would 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. (1-5), the pressure variation corresponds to an acceleration, acting in this case on LIGO's mirrors if we take into account the recent tests. We see the analogy with the accepted formula (here considered in the polarization h_\times):

$$h_\times = -\frac{1}{R} \frac{G^2}{c^4} \frac{4m_1m_2}{r} (\cos \theta) \sin \left(2\omega \left(t - \frac{R}{c} \right) \right) \quad (16)$$

where the wave amplitude expressed in $-\frac{1}{R} \frac{G^2}{c^4} \frac{4m_1m_2}{r}$ (with R as the distance of the observer from the center of mass of the quadrupole, equivalent to r in Eq. (15)) is determined in (15) by the pressure variation.

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

$$z = \frac{H_0 D}{c} \quad (17)$$

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 velocity. This phenomenon is different from the theorization of tired light provided by Zwicky [11]. 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 is 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

$$z_{obs} = z_a + z_\mu \quad (18)$$

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 one due to dark energy's viscosity.

2.3 Mass-energy relationship.

By calculating the speed of light as described in Eq. (7) the mass-energy formula $E = mc^2$ can be observed in a new form by substituting $c^2 = (\beta_0 \rho_0)^{-1}$ from (13):

$$E = \frac{m}{\beta_0 \rho_0} \quad (19)$$

where β_0 is the isentropic compressibility of dark energy and ρ_0 its density. We can now perhaps answer to an ancient question: what is energy? An excitation of dark energy's quanta, according to dark energy's features such as its density and compressibility. 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 through the superfluid sea of dark energy. Phonons as pressure waves transport quantum mechanical energy, as second sound in dark energy (§2).

2.4 Lorentz factor

Assuming an ubiquitous sea of quantized dark energy as the very fundamental scalar field in the Universe, DEQ would not interact with each other and dark energy would rather appear as a suspension. The non-zero viscosity would depend on the non-zero mass of DEQ. In this case dark energy would be actually a non-newtonian dilatant fluid. However, given the extremely low density of dark energy, its dilatant behavior would be detectable only for extreme shear stress. This would explain why particles which are accelerated towards the speed of light encounter an increasing nonlinear resistance, as indicated by Lorentz factor, where $\beta = \frac{v}{c}$ is the ratio between the velocity of an accelerated body and that of a pulse ($v_p = c$) through dark energy. The derivative of the arcsine indicates the impossibility to exceed the speed of a pulse through the medium because of its dilatant response as speed increases:

$$\gamma \equiv \arcsin' \frac{v}{v_p} = \frac{1}{\sqrt{1 - \left(\frac{v}{v_p}\right)^2}} \quad (20)$$

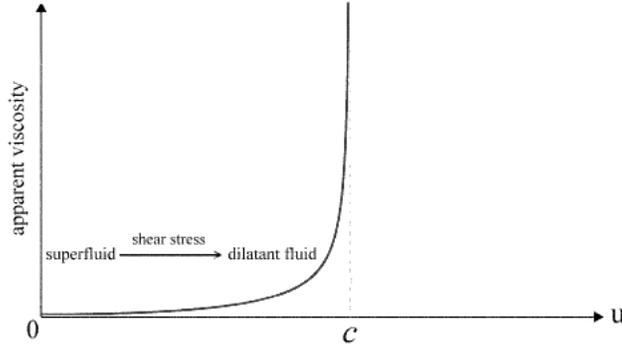


Figure 3: Lorentz factor as dark energy's rheogram.

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. After all, also in Newtonian physics, we can see the influence of the gravitational field g on the simplest clock, the pendulum: $T_0 = 2\pi\sqrt{\frac{\ell}{g}}$. The stronger the field the slower the clock. Now, something interesting happens when we remember that we have defined a gravitational field as an incoming flow of dark energy (§1). 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. Sitting still in a wind of 80 km/h or traveling by motorcycle at the same speed with no wind, we're subject to the same force. This would be the reason why both velocity (SR) and gravity (GR) slow down clocks. We can express a fluid equivalence principle as:

$$\mathbf{u}_{tot} = \mathbf{u}_\varphi + \mathbf{u} \quad (21)$$

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 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 velocity in SR corresponds to the gravitational quantum potential, thus demonstrating the quantum FEP in Einstein's relativity:

$$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{\Delta t}{\sqrt{1 - \frac{R_S}{r}}} \quad (22)$$

hence

$$\frac{v^2}{c^2} = \frac{R_S}{r} = \frac{2GM}{c^2 r} \implies v^2 \frac{1}{c^2} = \frac{2GM}{r} \frac{1}{c^2} \implies v^2 = \frac{2GM}{r} \quad (23)$$

and

$$v = \sqrt{2rg} = \sqrt{2\varphi} \quad (24)$$

eventually from (8)

$$v = (2Q_\varphi)^{\frac{1}{2}}. \quad (25)$$

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 [1] that massive particles of the Standard Model are superfluid vortices [12][13] in the superfluid quantum space of dark energy, according to Helmholtz's second theorem we consider an output for the absorbed energy and we believe it is packed 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 cause their 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 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, equating the effect of 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 relativistic effects of special and general relativity seem to be 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 gravity continues to influence clocks also in SQG. 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 Michelson interferometer. The non-zero viscosity of dark energy would cause energy loss in photons, explaining the empirical Hubble's law without expansion of the Universe and without the known objections against the 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 to mathematically investigate the whole framework of SQG, by reinterpreting for instance GR according to the equations of quantum fluid dynamics.

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