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# Quantum foundations of special relativity: three evidences on the existence of a dilatant vacuum and on light as its acoustic perturbation.

Marco Fedi \*

25 November 2017

## Abstract

Despite previous approaches which describe quantum vacuum as possibly endowed of superfluid features, we demonstrate by computing Mercury's perihelion precession and the Pioneer anomaly, that it rather behaves as a dilatant fluid. As a third further evidence, we obtain the complete range of cosmological redshift plotting the equation of light speed in a fluid quantum vacuum. Lorentz factor appears as the rheogram of quantum vacuum, whose acoustic perturbation corresponds to light and a complete analogy photon-phonon in quantum vacuum's quasi-lattice is presented.

**Keywords**— quantum vacuum, dilatant vacuum, Pioneer anomaly, anomalous perihelia precessions, Stokes's law, Lorentz factor, special relativity

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## Quantum vacuum as a dilatant fluid

Several authors have considered the possibility that quantum vacuum be a quantum fluid, i.e. a BEC with superfluid features [1, 2, 3, 4, 5, 6, 7, 8] and our previous works [9, 10, 21, 22] also referred to it as a dark superfluid, probably constituted by dark energy and dark matter possessing superfluid features but passing to a dilatant behavior in a relativistic regime. The present work definitively shows that what we call quantum vacuum is a non-Newtonian dilatant fluid and this is most likely due to its granular (quantum) nature [11]. As shown below, even considering velocities in the classical range, as the orbital velocities of planets in the solar system, evidences of quantum vacuum's dilatant behavior arise, which here lead to Einstein's formula for perihelia precessions (letting us reinterpret it as the interaction of a celestial body with a dilatant vacuum) and to the exact calculation of the Pioneer anomaly. Lorentz factor is here presented as the rheogram of quantum vacuum (Fig 1), i.e. as the mathematical behavior

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of quantum vacuum's apparent viscosity over the increase of shear stress. About relativistic time dilation in a flat spacetime due to velocity, its quantum justification would be then linked to the action of apparent viscous forces, even at Planck scale, onto the physical dynamic processes from which time emerges. Finally, as far as the Lorentz-FitzGerald contraction is concerned, it can be justified in the same way, since it is due to time dilation affecting measurements.

## 1 Relativistic mass increase: an erroneous interpretation in lieu of a dilatant quantum vacuum.

Special relativity claims that the mass of a body diverges as its speed approaches that of light, according to Lorentz factor. This seems demonstrated in synchrotrons where even a tiny charge cannot be accelerated up to the speed of light despite the huge energy supplied. However, we see that the reasons for the cancellation of positive acceleration can be two: the divergence of mass or the divergence of a braking force due to the diverging apparent viscosity of vacuum (passage to a transient solid state)

$$a = \frac{F}{m_{rel}} \xrightarrow{\text{actually}} a = \frac{F - F_v}{m} \quad (1)$$

where  $m_{rel}$  is the supposed diverging relativistic mass (or currently interpreted as diverging energy),  $m$  the rest mass and  $F_v$  is the braking viscous force exerted by the dilatant quantum vacuum which obeys (as in the case of the supposed diverging mass) Lorentz factor. In both cases the positive acceleration is canceled, so there can be two different interpretations for the same observed phenomenon. Below, we demonstrate that the correct interpretation is the diverging apparent viscosity of a dilatant quantum vacuum.

## 2 Reason for the insuperability of the speed of light

Below we show that a photon can be nothing but a transversal phonon in the quasi-lattice of a fluid quantum vacuum, being vacuum's permittivity and magnetic permeability actually its density and isentropic compressibility. The speed of sound can be surpassed in a Newtonian fluid (as in the case of a supersonic aircraft) but what does it happen in a dilatant fluid? As the speed (and shear stress) increase has led to a complete (transient) solidification of the medium, this becomes impenetrable to bodies bigger than its structural interstices.

Assuming that the texture of the quantum vacuum possesses the finest scale in nature, then even an electron would be too big to pass through a dilated vacuum. Only sound would still propagate through it. Since we show that the analogy between a photon and a transverse phonon in the quasi-lattice (transient lattice, existing within relaxation time in fluids) of vacuum is complete (see Sect. 5), we declare that light is the sound of a fluid quantum vacuum and that its insuperability is due to the dilatancy and to the finest texture of vacuum. The arcane value of 299792458 m/s indicating the speed of

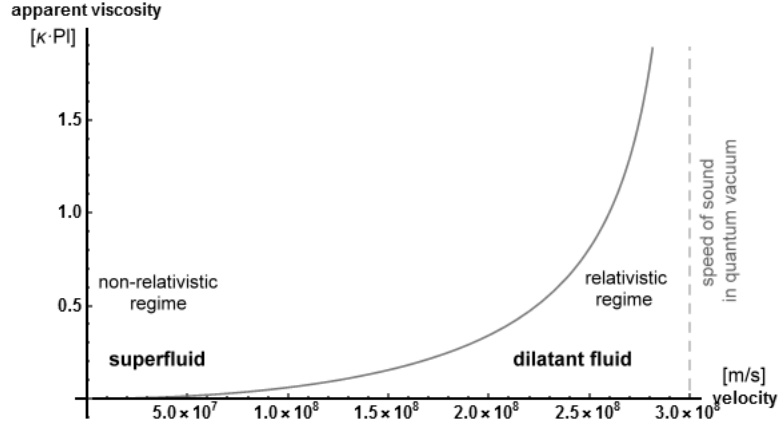


Figure 1: Lorentz factor reinterpreted as vacuum's rheogram. As shear stress approaches the speed of light, here explained as the speed of sound in the fluid quantum vacuum, apparent viscosity diverges up to making the physical vacuum an impenetrable wall even for a tiny electron.

light would be nothing but the speed of sound in the fluid quantum vacuum, a sound that we perceive with our eyes<sup>1</sup>.

### 3 First evidence: Mercury's anomalous perihelion precession

Net of classical gravitational contributions, perihelia precessions show an anomalous positive contribution, which is particularly evident for the planet Mercury due to its small mass, high orbital velocity and vicinity to the Sun compared to the other planets of the solar system. In general relativity this anomalous (relativistic) contribution to the precession is given by a formula [19] which can be observed in three equivalent variants

$$\Delta\phi = \frac{24\pi^3 a^2}{T^2(1-e^2)c^2} = 6\pi \left(\frac{v}{c}\right)^2 \frac{1}{1-e^2} = 6\pi \frac{GM}{a(1-e^2)c^2} \quad (2)$$

where  $\Delta\phi$  expresses the relativistic contribution to perihelia precessions in radians per revolution corresponding, using the data of Mercury, to the known value of  $\sim 43''$  per century (or  $5.018 \times 10^{-7}$  rad/rev.),  $a$  is the semi-major axis,  $T$  the orbital period and  $e = 0.205$  the orbital eccentricity. In the expression in the center (2) we have considered the orbital velocity  $v = 2\pi a/T$  and in that on the right we have used the second cosmic velocity squared  $v^2 = GM/a$ , where  $GM/a$  is the classical gravitational potential, also putting  $a = r = p$  [20], where  $p$  is the semi-latus rectum (elliptic parameter).

We want to demonstrate that (2) is due to the interaction of a planet with a dilatant quantum vacuum. For doing this, we resort to Stokes's formula for friction in a viscous

<sup>1</sup>"What? Is it the light I hear?", R. Wagner, Tristan und Isolde, Act 3, Scene 2.

fluid

$$F_v = 6\pi r v \eta \quad (3)$$

where  $v$  is the translational velocity,  $r$  the radius of the object (the law considers a spherical object) and  $\eta$  is a coefficient of dynamic viscosity expressed in  $\text{Pa} \cdot \text{s}$ . Since we assume to use Lorentz factor as the expression of vacuum's apparent viscosity, we insert it into the formula in place of the linear (for a Newtonian fluid) viscosity coefficient  $\eta$ . Treating Mercury as a point mass, we do not consider here the direct proportionality to the radius. Now, using Lorentz factor in the form  $\gamma - 1$ , (3) becomes the following adimensional expression

$$6\pi \left( \frac{1}{\sqrt{1 - \frac{GM}{ac^2}}} - 1 \right) = 6\pi(\gamma - 1). \quad (4)$$

Resorting to Taylor we use the approximation

$$2(\gamma - 1) \approx \left(\frac{v}{c}\right)^2 \quad (5)$$

and (4) reads

$$3\pi \left(\frac{v}{c}\right)^2 = 3\pi \frac{GM}{ac^2}. \quad (6)$$

where, on the right,  $v$  is expressed as second cosmic velocity as in the rightmost expression in (2). As we refer to motion in elliptic orbit, we have to use the elliptic parameter, correcting  $a$  into  $a(1 - e^2)$  and we obtain a formula which exactly gives 1/2 the result of general relativity (2)

$$\Delta\phi = 3\pi \frac{GM}{a(1 - e^2)c^2}. \quad (7)$$

The 1/2 discrepancy with the formula of general relativity (also Vayenas and colleagues have come to half the value of general relativity by calculating the perihelion precession in the limit of special relativity, [20], and indeed also a fluid quantum vacuum is flat) is explained by the use of the *mean* orbital velocity in Lorentz factor. Actually, what determines the perihelion precession is the variable orbital velocity in the elliptic orbit: along the semi-orbit from aphelion to perihelion the positive acceleration of the planet causes a relativistic mass increase (using the current language of special relativity) and a consequent slight increase of the centripetal acceleration due to the increased gravitational attraction. While in the semi-orbit from perihelion to aphelion, the orbital velocity decreases, along with the relativistic mass and the centripetal force, letting the planet move further in the direction of the precession, since the planet is now in the opposite side of the orbit. By translating this reasoning into the language of a dilatant quantum vacuum, it's enough to substitute the concept of relativistic mass with vacuum's apparent viscosity (1). Because of the relativistic contribution (quantum vacuum's contribution) occurring in each semi-orbit, the value of (7) has to be multiplied by two, correcting the result obtained from the use of mean orbital velocity and matching that of general relativity.

$$\Delta\phi = 6\pi \frac{GM}{a(1 - e^2)c^2} \quad (8)$$

Vayenas and Fokas come to the same consideration about the use of mean orbital velocity, correcting the 1/2 result in a second paper of theirs [23]. Here we have resorted to a fluid quantum vacuum while in [20] and [23] the authors use the current concept of relativistic mass increase through different calculations. This demonstrates that Mercury's perihelion precession is actually not due to a curved spacetime but to the interaction with a flat dilatant quantum vacuum, suggesting that Einstein's reasoning is correct from a quantitative but not from a qualitative point of view, being curved spacetime actually a fluid quantum vacuum in which pressure forces manifest and this is after all in agreement with the stress-energy tensor, in which  $T^{00}$  is vacuum's density.

## 4 Second evidence: the Pioneer anomaly

Being the anomalous negative acceleration of the Pioneer spacecrafts 10 and 11 well-known (concrete investigations of the anomaly started in 1994 [13]), we do not summarize here this issue. However, before introducing our explanation from the point of view of a dilatant quantum vacuum, we note that the commonly accepted explanation, i.e. an excessive deceleration due to anisotropic recoil of thermal photons [12, 13, 14, 15, 16], is not reliable due to too many approximations and assumptions involved in the calculations. Even at the end of mission, the heat radiated by the probe was in excess of 2 kW. Since the power needed to produce the reported acceleration is only  $\sim 65$ W, the anisotropy is only  $\sim 3\%$  and a small error in computing the total radiated heat produces an unacceptable discrepancy in the recoil force [17]. Moreover, every revolution of the spinning spacecraft adds further discrepancies to measurements. Third, the largest amount of heat was radiated from the radioisotope thermoelectric generators, not from the louver, being useless as regards the computation of the anomalous deceleration. Finally, without accurately knowing the dynamics of heat diffusion inside the probe [16], we cannot be sure that the anisotropic recoil of thermal photons from the louver be the reason of the Pioneer anomaly. Scheffer [15] analyzes in detail four sources of anisotropic heat radiation and their possible contribution to the anomaly. The author assumes (a) a uniform internal temperature with closed louvers, while the modeling of the internal heat is considered difficult due to a lack of precise information and, on the other hand, other studies indicate the radiation from the louvers as a possible valid source of anisotropic contribution to the anomaly [18]; (b) the contribution from the not reflected photons coming from the radio antenna (at about 45 degree angle to the spin axis) is actually balanced by the symmetrical contribution in the direction of the Sun; (c) the radiation from the radioisotope heater units and from the radio-thermal generators are considered by the author difficult to calculate and are hypothesized; (d) the same uncertainties, assumptions and hypothetical modeling concern the antenna's solar reflectivity and are common features to all studies done about the thermal hypothesis. In a last analysis, we can therefore conclude that the thermal cause of the anomaly is possible by opting for suitable values in the calculations among many different scenarios of thermal diffusion, so it is not demonstrated yet, since an accurate thermal modeling is difficult [12, 15].

On the contrary, here we calculate the deceleration by resorting again to the modified Stokes's law (4) for friction in a dilatant vacuum, in which Lorentz factor, here dimen-

sionally corrected by the unitary constant  $\kappa$ , is used as quantum vacuum's rheogram, exactly as for the case of perihelia precessions (Sect. 3).

We calculate the Pioneer probe's anomalous deceleration as  $a_P = -F_V/m$ , where  $m$  is the mass of the spacecraft and the sign minus is due to the frictional (braking) force.

$$a_P = -\frac{F_V}{m} = -\frac{6\pi r \left( \frac{1}{\sqrt{1-(\frac{v}{c})^2}} - 1 \right) \kappa}{m} = -\frac{6\pi \cdot 1.37 \text{ m} \cdot \left( \frac{1}{\sqrt{1-\left(\frac{36657 \text{ m}\cdot\text{s}^{-1}}{299792458 \text{ m}\cdot\text{s}^{-1}}\right)^2} - 1 \right) \cdot 1 \text{ Kg}\cdot\text{s}^{-2}}{222 \text{ Kg}} \quad (9)$$

$$= -8.7 \times 10^{-10} \text{ m}\cdot\text{s}^{-2}$$

In the calculations we consider: the mass of the spacecraft (258 kg) minus the mass of the burned fuel (36 kg), the radius of the antenna and the maximum speed of the probe after the swing-by caused by Jupiter. As we see the result is in absolute agreement with the measured value expressing the anomalous negative acceleration

$$a_P = -(8.74 \pm 1.33) \times 10^{-10} \text{ m}\cdot\text{s}^{-2} \quad (10)$$

## 5 Light as the acoustic perturbation of a fluid quantum vacuum

Before introducing a third evidence concerning the cosmological redshift, we want to discuss the reasons for considering light as the sound of quantum vacuum, i.e. the grounds for treating a photon as a transverse phonon propagating in quantum vacuum's quasi-lattice.

### 5.1 Photon-phonon identity in a quantum vacuum.

To state that a photon is a transverse phonon in the quasi-lattice of quantum vacuum, we begin by listing all current analogies between photons and phonons (which can also manifest in fluids and superfluids [26, 35] by propagating through the quasi-lattice which forms during Frenkel's relaxation time). Both are bosons [27], as their spin number confirms, and identical excitations can be created by repeatedly applying the creation operator,  $b^\dagger$ ; both possess wave-particle duality [28, 29], indeed in a lattice, or quasi-lattice we expect that waves appear that behave like particles; they obey the doppler effect,  $z = (f_{emit} - f_{obs})/f_{obs}$ ; are symmetric under exchange,  $|\alpha, \beta\rangle = |\beta, \alpha\rangle$ ; possess a momentum, where that of a phonon<sup>2</sup> is  $p_{ph} \equiv \hbar k = h/\lambda$ , with  $k = 2\pi/\lambda$  (hence the parallelism: radiation pressure  $\Leftrightarrow$  sound pressure); are involved in photoelectric effect and Compton scattering; they can spin [30, 31]. As far as spin as a quantum number is concerned, it would be realistic in our opinion that the higher degree of freedom of a phonon in the quasi-lattice of a fluid medium, may allow it to possess spin 1. For this reason we consider the photon as a special spin-1 phonon and anyway we actually know that photon's spin can have three different values (-1, 0, 1),

<sup>2</sup>it is said that a phonon possesses a pseudo-momentum but following our reasoning this can be true also for a photon, here described as a quasi-particle (phonon), in agreement with its wave-particle behavior.

so, at most, magnitude 1. Photon and phonon can form squeezed coherent states [32] and can interact via parametric down conversion [33]. For both,  $\hbar\omega/2$  is vacuum's contribution, since the harmonic oscillator eigenvalues for the mode  $\omega_k$  ( $k$  is the wave number) are  $E_n = (n + 1/2)\hbar\omega_k$ , with  $n = 1, 2, 3, \dots$  and (to confirm the presence of a “false vacuum”) also for  $n = 0$  the energy is not zero. Also as far as the relativistic effect of gravitational lensing is concerned, light would be deflected by currents in a fluid quantum vacuum exactly as sound is deflected by wind, these currents would correspond to the gravitational fields, in agreement with Gauss's law for gravity where the flux is real [21].

## 5.2 The formula for the speed of light.

It is worth recalling the fact that Maxwell derived the dielectric constant ( $\epsilon_0$ ) and the magnetic permeability ( $\mu_0$ ) of “vacuum”, from which the formula  $c = 1/\sqrt{\epsilon_0\mu_0}$  follows, in terms of density and transverse elasticity of the ether (see Sect. 5.4 and [34]). The existence of the ether was excluded (see Sect. 7) but we still need a “quantum” vacuum endowed with non-zero energy density. Thus, if we equate  $\epsilon_0\mu_0 = \beta_{qv}\rho_{qv}$ , where  $\rho_{qv}$  is the mass density of quantum vacuum and  $\beta_{qv}$  its isentropic compressibility (expressed in  $\text{Pa}^{-1}$ ), we can state that the speed of light is given as

$$c = \frac{1}{\sqrt{\beta_{qv}\rho_{qv}}}. \quad (11)$$

Indeed, starting from the equation which defines the speed of sound in a fluid,

$$v_s = \sqrt{K/\rho} \quad (12)$$

where  $K$  is the bulk modulus, and putting  $\beta_S = \frac{1}{K}$  as isentropic compressibility (in the specific case of quantum vacuum we say  $\beta_{qv}$ ), we obtain (11). This acoustic analogy for the speed of light is also considered possible by Gremaud in [34], as discussed in Sect. 5.4. Using (11) it is interesting to see what happens to the famous formula  $E = mc^2$ , as it acquires a much clearer meaning where the energy inside a mass directly arises from quantum vacuum's density and compressibility

$$E = \frac{m}{\beta_{qv}\rho_{qv}} \quad (13)$$

## 5.3 Photon-driven heat radiation as phonon-driven energy propagation through quantum vacuum's quasi-lattice.

We discuss now the possibility that photon-driven energy radiation be a phonon-driven energy propagation in the fluid quantum vacuum. Phonons, which are typically associated to a solid state, also manifest in fluids and superfluids [24, 25, 26]. Particularly relevant for our case is the paper by Bolmatov, Brazhkin and Trachenko [24], about a phonon theory of heat diffusion in classical and quantum fluids where longitudinal and transverse phonons are described following Frenkel [25], who first noticed that the density of liquids is much different from that of gases but only slightly different from the



density of solids and who also defined the existence of transversal waves in liquids, as previously observed in solids, for frequencies larger than  $1/\tau$ , where  $\tau$  is the relaxation time of the fluid. During this time, the structure of the liquid remains unaltered, similar to a solid lattice (a quasi-lattice). After many years this has been observed and also for low-viscosity fluids [26]. The importance of what investigated in [24] is linked to the fact that we need to describe phonons through the quantum vacuum as transverse waves (such as light) and to the evidence that photons too transmit energy (radiation). The analogy photon-phonon also as far as heat/energy transmission is concerned is then noteworthy and we believe it may end up into the full identity photon-phonon if the propagation is considered in the fundamental scalar field of quantum vacuum, which could even coincide with the Higgs field. In fact, from the Bose-Einstein distribution function for the grand canonical ensemble  $\rho \sim \exp \left[ -(k_B T)^{-1} (\epsilon - \mu N) \right]$  in the harmonic regime and with chemical potential  $\mu = 0$  considering the lowest energy state at 0K the probability of finding an average number of phonons *or photons* in a given state reads

$$\langle N(\omega_{k,s}) \rangle = \frac{1}{\exp \left( \frac{\hbar \omega_{k,s}}{k_B T} \right) - 1} \quad (14)$$

where  $k_B$  is Boltzmann's constant,  $T$  the absolute temperature,  $\hbar \omega_{k,s} = \epsilon$  the energy and  $\omega_{k,s}$  the frequency of phonons or photons in the given state. Resorting to ladder operators, the Hamiltonian reads

$$\mathcal{H} = \sum_k \sum_{s=1}^3 \hbar \omega_{k,s} \left( b_{k,s}^\dagger b_{k,s} + \frac{1}{2} \right) \quad (15)$$

in which we see again the contribution from quantum vacuum. It is also interesting to consider that an optical phonon (a phonon created via photon scattering) would represent the passage of a phonon from the quantum vacuum to a baryon lattice, i.e. the passage of an acoustic wave from a medium (dark) to another (baryonic). In superfluids, energy is dissipated as heat at small scales by phonon radiation [37]. So let us analyze the issue of phonons carrying heat in fluids, useful to describe photons as transversal phonons. Brazhkin and colleagues come to the result that there are two kinds of atomic motion in fluids: phonon motion, consisting in one longitudinal mode and two transverse modes with frequency  $\omega > \omega_F$ , where  $\omega_F = 2\pi/\tau$  is Frenkel frequency, and diffusive motion. Both kinds of motion possess a kinetic ( $K$ ) and a potential ( $P$ ) component, so the energy of the fluid is expressed as

$$E = K_l + P_l + K_s(\omega > \omega_F) + P_s(\omega > \omega_F) + K_d + P_d \quad (16)$$

where the subscripts  $l$  and  $s$  refers to longitudinal and shear waves (transversal phonons) and  $d$  to diffusion. By applying several steps, including the virial theorem, phonon free energy, Grüneisen approximation and Debye vibrational density of states, for the details of which we refer to [24], and neglecting the diffusive potential component since

$$P_d \ll P_s(\omega > \omega_F), \quad (17)$$

a final equation expressing a phonon theory of liquids is obtained in the form

$$E = NT \left( 1 + \frac{\alpha T}{2} \right) \left( 3D \left( \frac{\hbar\omega_D}{T} \right) - \left( \frac{\omega_F}{\omega_D} \right)^3 D \left( \frac{\hbar\omega_F}{T} \right) \right) \quad (18)$$

where

$$D(x) = \frac{3}{x^3} \int_0^x \frac{z^3 dz}{\exp(z) - 1} \quad (19)$$

is Debye function [36],  $\omega_D$  is Debye frequency,  $\alpha$  is the coefficient of thermal expansion of the fluid,  $\hbar$  the reduced Planck constant coming from phonon free energy

$$F_{ph} = E_0 + T \sum_i \ln \left( 1 - \exp \left( -\frac{\hbar\omega_i}{T} \right) \right), \quad (20)$$

where  $E_0$  is the temperature-dependent zero-point energy and  $N$  the number of modes. In (18) the zero-point energy has been omitted. The authors conclude that as we have a good understanding of thermodynamics in solids based on phonons, despite their structural complexity, the same can apply for liquids. The thermal (radiative) significance of a photon would then be comprised in phonon driven quasi-lattice vibrations of quantum vacuum.

Not only. Below, we discuss how Maxwell's equations describing photon's electromagnetic field can equally express the quasi-lattice dynamics of vacuum, theoretically completing the identity phonon-photon in all equations of electromagnetism.

#### 5.4 Maxwell's equations express the quasi-lattice dynamics of a fluid quantum vacuum.

Important for our photon-phonon identity in a fluid quantum vacuum is Gremaud's work at the Institute of Condensed Matter Physics of the Swiss Federal Institute of Technology, who discusses a complete analogy between the equations of a non-divergent deformation in an isotropic solid lattice in Euler's coordinates and Maxwell's equations of electromagnetism [34, 38, 39]. In his work he concludes that Maxwell's equations can be seen as a model for describing also different physical systems, not only electromagnetism.

Symmetrically speaking, we state that electromagnetism arises from the dynamics of a fluid quantum vacuum's quasi-lattice. Gremaud's analogy is complete since, along with Maxwell equations, it describes the dielectric polarization and magnetization of matter, as well as electrical charges and currents. The author introduces the concept of dislocation charges in the lattice [38], in analogy with electrical charges, associated to plastic distortions. It is shown that the transversal waves of rotation and shear strain are associated with a propagation velocity given by

$$c_t = \sqrt{\frac{K_2 + K_3}{nm}} \quad (21)$$

where the subscript on the left means transversal and  $K_2$  and  $K_3$  respectively repre-

sent shear stress modulus and rotation modulus. The dielectric permittivity of vacuum,  $\epsilon_0$ , is given as  $1/(2(K_2 + K_3))$ , and this corresponds to  $1/K = \beta_{qv}$ , to the isentropic compressibility of quantum vacuum of Eq.(11), while  $2nm$  corresponds to the mass density of the lattice, so in our case to  $\rho_{qv}$ . Below we summarize the analogy between alterations of lattice geometry presenting homogeneous expansion in a mobile frame  $O'x'y'z'$  and Maxwell's equations as argued in detail by Gremaud [34]. To do that, according to Frenkel [25] and Bolmatov [24], we treat the fluid medium as momentarily solid-like, assuming that electromagnetic waves have a frequency  $\nu > 1/\tau$ . This allows transversal waves propagation. Gremaud presents the following analogies with electromagnetism:

$$\begin{cases} -\frac{\partial \vec{\omega}}{\partial t} + \vec{rot} \frac{\vec{\phi}^{rot}}{2} = \vec{J} & \Leftrightarrow -\frac{\partial \vec{D}}{\partial t} + \vec{rot} \vec{H} = \vec{j} \\ \text{div } \vec{\omega} = \lambda & \Leftrightarrow \text{div } \vec{D} = \rho \end{cases} \quad (22)$$

where  $\vec{\omega}$  is the rotation field corresponding to the electric field of displacement,  $\vec{D}$ ;  $\vec{J}$  is the vector flow of rotation charges [38], equivalent to the density of electric current  $\vec{j}$ ;  $\lambda$  is the density of rotation charges analogous to the density of electric charges  $\rho$  and  $\vec{H}$  is the magnetic field.

$$\begin{cases} \frac{\partial n \vec{p}^{rot}}{\partial t} = -\vec{rot} \frac{\vec{m}'}{2} & \Leftrightarrow \frac{\partial \vec{B}}{\partial t} = \vec{rot} \vec{E} \\ \text{div } n \vec{p}^{rot} = 0 & \Leftrightarrow \text{div } \vec{B} = 0 \end{cases} \quad (23)$$

where  $\vec{B}$  is the magnetic induction field,  $\vec{E}$  the electric field,  $n \vec{p}^{rot}$  the volume linear momentum of lattice (mass flow of lattice) and  $\vec{m}'$  the generalized torque momentum.

$$\begin{cases} \vec{\omega} = \left( \frac{1}{2(K_2 + K_3)} \right) \frac{\vec{m}'}{2} + \vec{\omega}^{an} \\ n \vec{p}^{rot} = 2nm \left[ \frac{\vec{\phi}^{rot}}{2} + C \frac{\vec{\phi}^{rot}}{2} + \frac{(\vec{J}_I^{rot} - \vec{J}_L^{rot})}{2n} \right] \end{cases} \Leftrightarrow \quad (24)$$

$$\Leftrightarrow \begin{cases} \vec{D} = \epsilon_0 \vec{E} + \vec{P} \\ \vec{B} = \mu_0 \left[ \vec{H} + \chi \vec{H} + \vec{M} \right] \end{cases}$$

Being  $1/(2(K_2 + K_3)) \Leftrightarrow \epsilon_0$  and analogous to  $1/K = \beta_{qv}$  (11);  $\vec{\omega}^{an}$  the vector of anelastic shear and local rotation, analogous to the dielectric polarization of matter  $\vec{P}$ ;  $C = (C_I - C_L)$  the atomic concentrations of interstitials and vacancies, for which we take instead into consideration vacuum's quanta, corresponding to the paramagnetic and diamagnetic susceptibility of matter  $\chi = (\chi^{para} + \chi^{dia})$ ;  $(\vec{J}_I^{rot} - \vec{J}_L^{rot})$  is the surface flux of interstitials and vacancies;  $n$  the density of lattice sites and  $\vec{M}$  the magnetization of matter. Finally we also observe

$$\frac{\partial \lambda}{\partial t} = -\text{div } \vec{J} \Leftrightarrow \frac{\partial \rho}{\partial t} = -\text{div } \vec{j} \quad (25)$$

and

$$\begin{aligned} -\frac{\vec{m}'}{2} \vec{J} &= \frac{\vec{\phi}^{rot}}{2} \frac{\partial n \vec{p}^{rot}}{\partial t} + \frac{\vec{m}'}{2} \frac{\partial \vec{\omega}}{\partial t} - \text{div} \left( \frac{\vec{\phi}^{rot}}{2} \wedge \frac{\vec{m}'}{2} \right) \\ &\Downarrow \\ -\vec{E} \vec{j} &= \vec{H} \frac{\partial \vec{B}}{\partial t} + \vec{E} \frac{\partial \vec{D}}{\partial t} - \text{div} \left( \vec{H} \wedge \vec{E} \right) \end{aligned} \quad (26)$$

Electromagnetism as the quasi-lattice dynamics of a fluid quantum vacuum can be therefore possible.

Interestingly, a superfluid behavior of light has been observed in polaritons condensates from [40] up to recent experiences [41], even at room temperature [42]. Also these works suggest a fluid nature of light, along with Carusotto [43] and Leboeuf and Moulieras [44]. If light is an acoustic wave in a fluid quantum vacuum, a simplification would occur in theoretical Physics, since all waves existing in nature would be mechanical waves. The difference is only the medium. A *dark* medium has let us suppose that photons travel in a real (no structure, zero energy) vacuum but this is not the case, as also shown by vacuum's contribution to photon,  $\hbar\omega/2$ .

## 6 Third evidence: cosmological redshift explained via density-dependent speed of light in a fluid quantum vacuum

Once realized that it is plausible that light can be an acoustic wave through a fluid quantum vacuum (and photon a *quasi-particle* possessing wave-particle nature, i.e. a *phonon*), we show that the cosmological redshift, included that from distant supernovae, can be directly plotted from the equation for the speed of light in a fluid quantum vacuum (11) without the need for still unclear solutions which are at the moment included in the standard model of cosmology, as cosmic inflation and accelerated expansion.

Just using the formula for the speed of light in a fluid vacuum, the correct redshift curve is produced in a non-expanding universe immersed in a spherical gradient of fluid quantum vacuum whose density decreases with distance from the center [22].

This model works without big bang, where the CMB radiation is simply the intrinsic average temperature ( $\sim 2.725\text{K}$ ) of the fluid quantum vacuum and the latter if (once?) rotating could have produced fundamental fermions (without antimatter, justifying baryon asymmetry) as quantized vortices (see [9]), exactly as vortices observed in laboratory superfluids, which are all spinning in the same direction. This could also help justifying the observed asymmetry in spiral galaxies chirality [46] and the left-handed bias in the world of fundamental particles and of life molecules [47].

Let us plot (Fig. 3)

$$c = \sqrt{\frac{P_{qv}}{\rho_{qv}}} \quad (27)$$

which is equivalent to (11), putting

$$P_{qv} = P_{qv_0} + k\rho_{qv} \quad (28)$$

to underline the interdependence of density and pressure, where  $P_{qv_0}$  and  $k$  (with units  $\text{m}^2/\text{s}^2$ ) are arbitrary constants, to observe how the speed of light varies with the density of quantum vacuum. Since we assumed that density decreases moving away from the center of the universe, the speed of light will increase in distance equally in all directions from a central point of observation. The more distant a galaxy or a supernova,

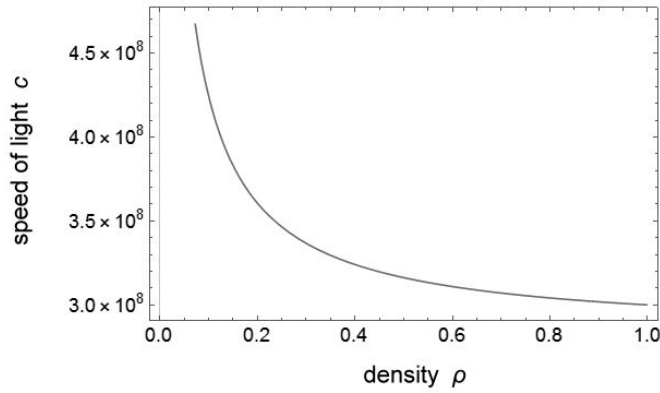


Figure 2: Speed of light-density plot. The scale has been set by way of example acting on the arbitrary constants  $P_{qv_0}$  and  $k$ , in the interval  $0 < \rho_{qv} \leq 1$ .

the more redshift its light will undergo at detection. In short, the curve of the observed redshift is nothing but the reciprocal of the speed of light, which varies with quantum vacuum's density fading out in cosmic distances.

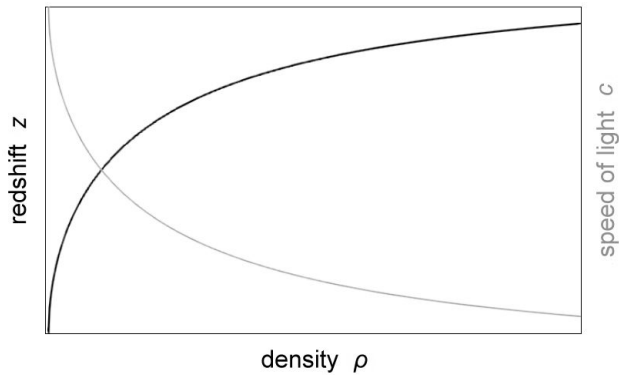


Figure 3:  $1/c$  redshift behavior caused by decreasing speed of light due to vacuum's density increase toward the center of the universe. As the curve suggests, the known value for  $c$  may be valid with good approximation only within relatively short cosmic distances.

Also in the empirical Hubble's law,  $z = H_0 D/c$ , the  $1/c$  dependence appears, albeit there  $c$  is a constant. And this is exactly the problem, since the law is in that case linear and does not fit the observations of distant supernovae, being not a suitable mathematical law for the cosmological redshift but just a historical step. Abandoning the expanding Big Bang universe, the use of FLRW metric becomes invalid/unnecessary and we explain the observations gaining a dramatic simplification in the mathematics and in the overall cosmological model.

Eventually, to conclude our speculative reasoning it is interesting to see what happens

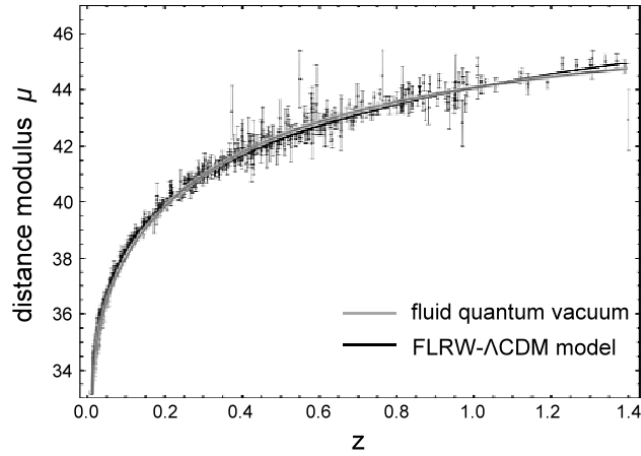


Figure 4: Distance modulus-redshift plot. Data including the supernova Union2 compilation [48]. When the models are compared the results substantially coincide

if the point of observation (Earth) is not exactly in the center of the bubble-universe. Fig. 5 shows that this fact would add deviations from the predicted redshift curve, since the measurement would not be anisotropic anymore, as regards the chosen direction of observation. For instance, observing along  $r$ , would yield different redshift data for some equidistant galaxies, e.g. those located at the equidistant points D and K. This can in part explain the deviation from the theoretical curve which, for some objects, is much higher than expected (Fig. 4). Finally, as we can see, this approach to cosmological redshift has nothing to do with the hypothesis of *tired light*. Here light does not lose its energy in scattering events but its velocity automatically changes according to vacuum's density.

## 7 Remark on the stability of planetary orbits and on the Michelson-Morley test

Planetary orbits can be stable despite planets are orbiting in a fluid viscous vacuum if the gravitational field is interpreted as a radial inflow of quantum vacuum ([21, 49, 50]). Being absorbed at a pace much faster than the orbital velocity, friction due to motion vanishes and orbits are stable. But for quick bodies with a weak gravitational field, as the Pioneer probes or Mercury, the lightest and faster planet in the solar system, the effect of vacuum's apparent viscosity is greater and remarkable in form of gravitational anomalies, as shown above in the calculations. Indeed, the inflow is in this case weaker and cannot completely neutralize the apparent wind of fluid quantum vacuum which exerts a braking pressure.

Secondly, a gravitational field as an inflow of fluid quantum vacuum, also means that no ether wind from relative motion between the Earth and a static ether could be detected

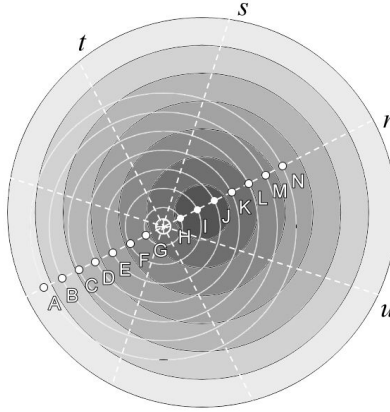


Figure 5: deviations of the observed redshift from the predicted curve due to the position of the point of observation in the universe (here an example). Concentric grey circles express a discretized variation of density in distance and white circles equidistant points from the Earth ( $\oplus$ ). We notice that equidistant galaxies (e.g. B and M) may show a different redshift. This could explain part of the observed deviations (Fig. 4). However, taking into account all the possible different directions (observing for instance along  $s$ ,  $t$  or  $u$ ) the predicted curve is on average respected, with more or less deviation, assuming the observer is not excessively decentralized toward the edge of the universe, where a blueshift would be mostly detected. This means that our galaxy is in a relatively central position in the spherical universe.

in the Michelson-Morley test [45]. As indeed happened. The ether (we say now the fluid quantum vacuum) is indeed not static but radially directed toward the center of any mass, according to Gauss's law for gravity, where the flux is real [21]. In this case the basic assumption of the MM-test, i.e. a static ether, was wrong and no ether could be detected. Here the so-called ether wind is the gravitational field itself.

Eventually, being the gravitational field an inflow of vacuum's quanta (attracted into vortex-particles due to Bernoulli pressure, [9]) and being light an acoustic wave in quantum vacuum, a gravitational redshift is predicted also in this approach. Curiously, in this framework, a black hole is able to travel faster than light, since it swallows the fluid quantum space at a pace faster than light, so no friction would occur till its speed is under that of the inflow.

## Conclusion

By considering quantum vacuum as a dilatant fluid whose apparent viscosity due to shear stress obeys Lorentz factor, we have explained the anomalous perihelia precessions and the anomalous deceleration of the Pioneer probes. This indicates Lorentz factor as the rheogram of a dilatant quantum vacuum. Light is its acoustic perturbation, the *sound of vacuum* (the photon-phonon identity in a fluid vacuum's quasi-lattice is complete and satisfactory), whose insuperability is due to quantum vacuum's dilatancy and finest texture. Special relativity is therefore presented here as a quantum

theory.

Furthermore, plotting the formula for the speed of light in a fluid vacuum and letting decrease vacuum's density in distance (with the radius of the universe), we also obtain the correct curve for the cosmological redshift, without inflation and accelerated expansion, suggesting that the universe is not expanding and is comprised in a spherical bubble of fluid quantum vacuum, whose density decreases from the center to a softened boundary. Further confirmations to the validity of this approach might be obtained still using the modified Stokes's formula, in which Lorentz factor has the role of a nonlinear viscosity factor, by applying it to other issues and anomalies where motion through a vacuum is taken into account.

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