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Gravity as a fluid dynamic phenomenon in a superfluid quantum space.

Fluid quantum gravity and relativity.

September 29, 2016

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Abstract

This hypothesis starts from considering the physical vacuum as a superfluid quantum medium, that we call superfluid quantum space (SQS), close to the previous concepts of quantum vacuum, quantum foam, superfluid vacuum *etc.*[1, 2, 3] We usually believe that quantum vacuum is populated by an enormous amount of particles pairs (*e.g.* couples e^- , e^+) whose life is extremely short, in a continuous foaming of formation and annihilation. Here we move further and we hypothesize that these particles are superfluid symmetric vortices of space's quanta (SQ, for which we use the symbol ς), probably arising as perturbations of the SQS through a process similar to that of a Kármán vortex street, where dark matter probably acts as perturbing element. Because of superfluidity these vortices can have an indeterminately long life. Vorticity is interpreted as spin (particles' internal motion) and when two vortex-particles possess conflicting vorticity they destroy each other, justifying matter-antimatter annihilation. SQS would be an ubiquitous superfluid sea of SQ, before being a foam of particles pairs. Due to its non-zero viscosity, these vortices attract the surrounding quanta, pressure decreases and the consequent incoming flow of quanta, radially directed toward the center of the massive particle lets arise a gravitational potential. This is called fluid quantum gravity, whose *passive* quantum is the SQ and the quantum potential is triggered by the spin of any massive particles. We don't need gravitons in this model. We immediately notice that such a fluid model perfectly matches Gauss's law for gravity and this has been indeed proven through CFD simulations. Once comparing fluid quantum gravity with general relativity, it is evident how a hydrodynamic gravity can fully account for

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the relativistic effects due to spacetime distortion, where the space curvature is substituted by flows of space's quanta through the SQS. Also special relativity can be merged in the hydrodynamic of a SQS and we obtain a simplification of Einstein's relativity under the single effect of fluid quantum gravity.

1 Introduction: massive particles as vortices of space's quanta in a superfluid quantum space (SQS)

The particles of the Standard Model could form as dynamic topological defects (superfluid vortices) or pulses in a SQS [4]. In this view, the superfluid vacuum is a fundamental scalar field with quasi-zero viscosity which gives mass to particles through the kinetic energy of its quanta, once perturbations occur. There are therefore several analogies with the Higgs field, while Higgs boson would be a 0-spin vortex of SQ (a single vortex, then an elementary particle) whose remarkable mass, given the low density and viscosity of SQS, would make it unstable and would compel it to a quick decay into smaller vortices (lighter particles) and pulses. Sbitnev [5, 6] considers quantum vacuum as a superfluid and applies quantum considerations to Navier Stokes equations to describe vortex objects (vortex balls) which, unlike Hill's spherical vortices, show intersected streamlines and seem to satisfactorily reproduce fermions' spin by varying their orientation at each revolution. Also Volovik [7] accurately discusses the possible topology of quantum vacuum and the appearance of vortices. Huang [19] affirms that quantum turbulence (chaotic vorticity) in the early universe was able to create all the matter in the universe.

We know that quantum vortices occur in other superfluids such as those observed in helium-4 nanodroplets [8, 9]. It may be interesting to start from the analysis of vortices in Bose-Einstein condensates, for which the most simple model is the Gross-Pitaevskii equation [10]:

$$i\hbar \frac{\partial \psi(\mathbf{r}, t)}{\partial t} = -\frac{\hbar^2}{2m} \nabla^2 \psi(\mathbf{r}, t) + \frac{4\pi\hbar^2 a_s}{m} |\psi(\mathbf{r}, t)|^2 \psi(\mathbf{r}, t) + V_{ext}(\mathbf{r}, t) \psi(\mathbf{r}, t) \quad (1)$$

From (1) Proment, Onorato and Barenghi [11], elaborate the continuity and linear momentum conservation equations for an inviscid, barotropic, compressible and irrotational fluid:

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \mathbf{v}) = 0, \quad (2)$$

$$\frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v} \cdot \nabla) \mathbf{v} = -\frac{\nabla \rho}{2} + \nabla \left(\frac{\nabla^2 \sqrt{\rho}}{2\sqrt{\rho}} \right) \quad (3)$$

where the last term in (3) is the quantum stress tensor, which represents an important difference from the classical Euler equation. Albeit the superfluid is

irrotational, quantized vortices can appear, with a quantized circulation which is analogous to that described in the Bohr model, as the wavefunction must return to its same value after an integral number of turns

$$\oint_{C(t)} \mathbf{v} \cdot d\mathbf{l} \equiv \frac{2\pi\hbar}{m} n. \quad (4)$$

where m is the mass of the superfluid particle and $2\pi n$ the phase difference around the vortex. Eq. (4) is also the additional condition to impose to the Madelung equations

$$\partial_t \rho + \nabla \cdot (\rho \mathbf{v}) = 0, \quad (5)$$

$$\partial_t \mathbf{v} + \mathbf{v} \cdot \nabla \mathbf{v} = -\frac{1}{m} \nabla \left(\frac{1}{\sqrt{\rho}} \hat{H} \sqrt{\rho} \right) = -\frac{1}{\rho} \nabla \cdot \mathbf{P}_Q - \frac{1}{m} \nabla U \quad (6)$$

to describe a fundamental particle as a superfluid vortex. In eq. 6 \hat{H} corresponds to the quantum pressure tensor

$$\mathbf{P}_Q = - \left(\frac{\hbar}{2m} \right)^2 \rho \nabla \otimes \nabla \ln \rho \quad (7)$$

related to the Bohmian quantum potential discussed below (§3).

These vortices behave as gaps in the medium where superfluidity breaks down and the presence of a topological structure where pressure and density go to zero, would suggest the non-necessity of renormalization, since no ultraviolet divergence would occur. The use of hydrodynamic equations of vortices applied to SQS to describe the fundamental particles and their force fields would be advantageous under different aspects. We could for instance explain the appearance of particle-antiparticle pairs from quantum vacuum² as a perturbative phenomenon similar to that described in a Kármán vortex street (Fig. 1)

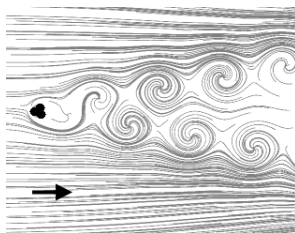


Figure 1: a computer simulation of a Kármán vortex street. Clumps of space's quanta (dark matter) in a SQS might be responsible for the appearance of particle-antiparticle pairs as superfluid vortices of space's quanta.

where pairs formed by a right- and a left-handed vortex occur due to a perturbation of the flow. In our case the flow may be represented by hydrodynamic

²Referring, for instance, to electron-positron pairs in the Casimir effect

gravitational fields in the SQS produced by other bodies and the perturbation elements by other particles [12] or clumps of space's quanta (a possible explanation for dark matter and its role in creating/aggregating ordinary matter?) or any stochastic perturbation of the SQS (do we interpret this originary disturbance as the Big Bang? Has it been a cascading perturbation of a pre-existing SQS?). The self-sustainability of the vortices would be possible thanks to superfluidity. The wave functions of particle-antiparticle pairs might then emerge from the perturbation of SQS. Avdeenkov and Zloshchastiev discuss self-sustainability and emergence of spatial extenta in quantum Bose liquids [13].

The trigger to the formation of vortex-antivortex pairs in fluid quantum space, corresponding to matter-antimatter within our analogy, might besides be a phase transition similar to the Kosterlitz-Thouless transition, where bound vortex-antivortex pairs get unpaired at some critical temperature, what could have occurred at a certain point in the history of the universe. Also the mathematics of Lamb-Chaplygin dipoles is interesting for describing the dynamics of symmetric vortices. We suggest however a different geometry for a vortex-particle in SQS, compatible with the fermionic spin- $\frac{1}{2}$, and described in §3.

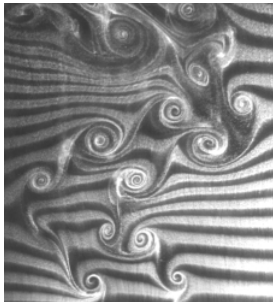


Figure 2: a possible analogy between Kármán vortex street phenomena [14] and perturbations in SQS might help us to understand how particles and interactions arise from a superfluid *false vacuum*.

It may be now interesting to analyze whether what we usually call vacuum fluctuations are vortices in SQS. Let's consider the relationship:

$$\Delta E \Delta t \geq \frac{\hbar}{2\pi} = \hbar \quad (8)$$

In natural units $\hbar = 1E_P t_P$ and we know that $E_P = m_P c^2$. Within the photon-phonon analogy described in §4.5, we see that $c^2 = \frac{\chi}{\rho_0}$, *i.e.* the ratio between the Young modulus (unidirectional compression) applied to SQS and its density. Hence $E_P = m_P \frac{\chi}{\rho_0}$. Planck energy therefore corresponds to the maximum mass a single vortex which emits virtual photons (m_P) can have, multiplied by the ratio compressibility/density of SQS. We see that

$$\Delta E \Delta t \geq \frac{m_P \frac{\mathcal{Y}}{\rho_0} t_P}{2\pi}. \quad (9)$$

Since 2π corresponds to a 360° turn, the reduced Planck constant is interpretable as the rotation a vortex with Planck mass can do within a Planck time, given a specific density and compressibility of the SQS. On the other hand, time arises as a chain of elementary hydrodynamic phenomena in SQS, where the rotation of the vortices is itself the generator of time. For this reason the hydrodynamics of the SQS can be sufficient for replacing Einstein's spacetime (§4). Once put (9) in (4) we have the circulation of SQ, Γ_ζ , directly related to spin (fig.4, §3), in a vortex-particle expressed as

$$\Gamma_\zeta = \oint_{C(t)} \mathbf{v} \cdot d\mathbf{l} \equiv \frac{m_P}{m} \frac{\mathcal{Y}}{\rho_0} n t_P \leq \frac{\Delta E \Delta t}{2\pi m} n, \quad (10)$$

which approximatively corresponds to n vacuum fluctuations each complete turn (2π), divided by the mass of the vortex-particle whose life corresponds to $n t_P$. Since vacuum fluctuations consist in annihilating particles pairs, we have to consider two symmetrical vortices which destroy each other when they come into contact in the way their circulations are not mechanically mutual. Also the phenomenon of annihilation would therefore occur on the basis of quantum hydrodynamics.

2 The engine of quantum gravity: spin, pressure and non-zero viscosity of SQS.

No superfluid has a real zero viscosity. Non-zero viscosity of SQS would cause the attraction of the space's quanta surrounding the vortices into the vortices themselves (absorption, Fig. 3). The result is a force gradient around the vortex which obeys the inverse-square law. Thus, we proclaim that quantum gravity can be described without resorting to gravitons, where space's quanta are the passive carriers of gravity as an apparent force mediated by a radial pressure decrease, due to absorption, around massive particles. CFD simulations using Navier-Stokes equations have been performed (considering for simplification a newtonian fluid like water), with a positive result, and details are collected in the annex. We see in the simulation that a spherical geometry of the attracting object would exactly correspond to Gauss's law for gravity, which is directly connected with Newton's law of universal gravitation. Below (§3) we suggest a horn-torus-vortex geometry, which seems able to justify fermions' spin- $\frac{1}{2}$ and the link gravity-electromagnetism. Also Consoli and Pappalardo investigated the possibility that gravity can emerge from a superfluid vacuum [15].

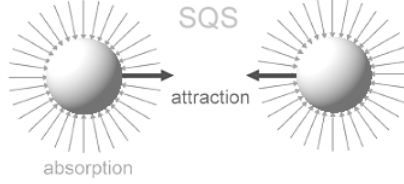


Figure 3: Two spherical vortex-particles move the one toward the other since they're absorbing the fluid (SQS) which they're immersed in. This phenomenon is in direct agreement with Gauss's law for gravity: $\iint_{\partial V} \mathbf{g} \cdot d\mathbf{A} = -4\pi GM$ and has been proven through CFD simulations. The result is an apparent attractive force due a pressure gradient (Fig. 6) that we interpret as gravity.

Navier-Stokes equations representing mass, momentum and energy have been used:

$$\frac{\partial(u_j)}{\partial x_j} = 0 \quad (11)$$

$$\frac{\partial(u_i u_j)}{\partial x_j} = -\frac{1}{\rho} \frac{\partial p}{\partial x_i} + \frac{\mu}{\rho} \frac{\partial}{\partial x_j} \left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i} \right) \quad (12)$$

$$\frac{\partial((\rho E + p)u_j)}{\partial x_j} = -k \frac{\partial}{\partial x_j} \left(\frac{\partial T}{\partial x_j} \right) \quad (13)$$

The condition of two stationary spheres immersed in an incompressible fluid was set and the pressure integral of the forces acting on them was calculated. The analysis took into account the response to absorption velocity and to distance between the spheres. To simplify the simulations, the system was reduced as showed in Fig. 12 (annex).

The attractive force produced by pressure forces and momentum is represented by:

$$F_a = \int_A (p + \rho(\vec{u} \cdot \vec{n})(\vec{u} \cdot \vec{d})) d\vec{A} \cdot \vec{d} \quad (14)$$

where A corresponds to the surface of the inner sphere, \vec{n} is the normal unit vector to the sphere's surface (if the absorption velocity is perfectly radially aligned we have $\vec{u} \cdot \vec{n} = |\vec{u}|$), and \vec{d} is the unit vector for the distance between the spheres. The analysis of velocity and pressure, with respect to the distance (radius) from the absorbing sphere is illustrated in Fig. 6 and the diagrams in Fig. 14, 15, 16 and 17 (annex) show an inverse quadratic dependence on distance and a quadratic dependence on the flow velocity.

Refinement of computational grid and domain enlargement helped to reduce the curvature of the flow lines, up to a virtually radial flow (Fig. 13).

The behavior of the attractive force shown by this analysis is concordant with Newton's law of universal gravitation, since the attractive force decreases with distance (radius) according to an inverse square law and quadratically grows according to the velocity of the flux. Two equal absorbing spheres have been considered, corresponding to equal masses in Newton's law.

3 Vortex geometry and emergence of quantum potential.

As far as the most appropriate vortex geometry is concerned, it is interesting to consider the evolution: vortex tube \rightarrow vortex torus \rightarrow horn torus (Fig.4). Also Villois, Krstulovic et al. analyze vortex tubes evolving into vortex tori in superfluids [16], demonstrating the emergence of a non-trivial topology. The suggested geometry could be able to account for the main mechanism suggested in this work, *i.e.* the absorption of SQ (gravity) and the consequent emission of virtual photons, which accounts for Coulomb's force and is necessary to maintain energy balance in spite of the absorption. Furthermore, referring to Fig.4, if a space's quantum (dot in the figure) in the toroidal vortex needed the same time the vortex needs to complete two turns in the toroidal direction (σ_1 spin component) to return in the same position, while the vortex completes a single turn in the poloidal direction (σ_2), then the vortex would have spin $\frac{1}{2}$ (the system returns in the same state after a toroidal rotation of 720° , *i.e.* after each quantum forming the vortex has moved along a Möbius strip path). It is interesting to notice that a two-components spin can explain in mechanical terms any other type of spin, as the ratio between the two different rotations in the torus. In fact, we would obviously have:

$$\frac{1\sigma_2}{2\sigma_1} \Rightarrow spin \frac{1}{2}; \frac{1\sigma_2}{1\sigma_1} \Rightarrow spin 1; \frac{0\sigma_2}{1\sigma_1} \Rightarrow spin 0 \quad (15)$$

The peculiar geometry of a toroidal vortex would also account for the charge of the particle: neutral if the vortex is a ring torus, as there cannot be genesis of virtual photons and charged in the case of a horn torus.

The theoretical mainstream describes the electrostatic field of charged fermions as the emission and reabsorption of virtual photons. In the hypothesis of gravity as absorption of SQ occurring in fermions (§2) we have first absorption and a subsequent emission to maintain energy balance. If we then hypothesize the emission of virtual photons as discrete packets of compressed SQ (Fig.4) we would start seeing how gravity can be related to electromagnetism. Unlike normal photons, virtual photons can have a mass, since they're packets of SQ not simple pulses (*i.e.* phonons through SQS [4]). The strenght of their momentum is for instance evident when trying to bring together two magnets that repel each other. Therefore, the vortex geometry (horn torus or ring torus) would be the deciding factor for having a charged or neutral particle. It is however presumable that the torus geometry of a charged particle will have $r \rightarrow R$, instead of being an exact horn torus.

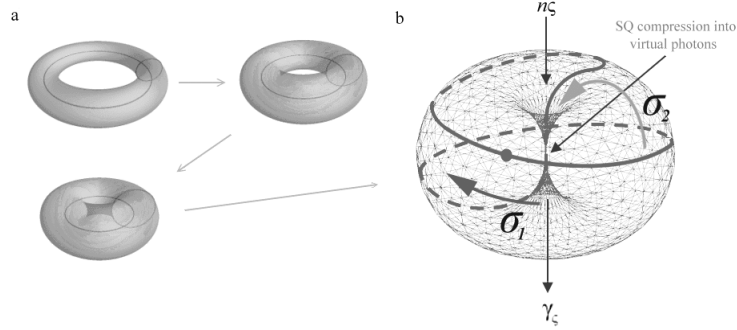


Figure 4: evolution from a ring vortex tube, into a horn torus. This might justify the compression of space's quanta (ς) into virtual photons (γ_ς) within the absorption-emission mechanism. On the right the possible mechanism corresponding to $spin\frac{1}{2}$, where the system returns in the same state after a rotation of 720° in the toroidal direction σ_1 , while each space's quantum in the vortex flows along a Möbius strip. Such two-components model (σ_1, σ_2) may mechanically explain any other kind of spin as the ratio between the two rotations (15). In this case we have $\frac{1\sigma_2}{2\sigma_1} = spin\frac{1}{2}$.

Since the vortex

1. is a closed path with constant strenght along its filaments.
2. may be triggered by the perturbation (clumps of space's quanta \Rightarrow dark matter?) of the flows occurring in SQS, as for instance gravitational flows or flows produced by the motion of other bodies

all three Helmholtz's theorems are respected.

Considering \vec{v}_θ as the poloidal tangential velocity associated with σ_2 and \vec{v}_φ as the toroidal tangential velocity of σ_1 , we can think of the continuity equation for the horn torus vortex:

$$\frac{\partial \rho}{\partial t} + \iint_S \rho \mathbf{v} \cdot d\mathbf{S} = 0 \quad (16)$$

where $\mathbf{v} = \vec{v}_\theta + \vec{v}_\varphi$, S denotes the surface of the torus as $S = 4\pi^2 \varrho$, with $\varrho = Rr$ to impose the horn torus geometry and 0 on the right side accounts for having neither sources nor sinks of mass-energy or, to be more precise in our case, it accounts for an equilibrium between absorbed ($n\varsigma$) and emitted (γ_ς) quanta, which occurs through a quick sawtooth energy oscillation of the vortex-particle (Fig.5), which reads

$$m_{eff(t)} = (t - [t])k_a + m_0, \quad (17)$$

where $m_{eff(t)}$ is the time-depending effective mass of the particle, which would rapidly oscillate between two values (m_0, m_{max}), and k_a is a constant of

mass-energy absorption expressed in kg/s, whose value is $k_a = m_{\gamma_\zeta}/t_{emission}$, *i.e.* the ratio between the mass of a virtual photon and the necessary time to emit it from the vortex. The proper mass of a charged fermion would therefore minimally oscillate and this fact would agree with the indeterminacy of quantum mechanics. The oscillatory behavior of superfluid vortices shown in Fig.5, might also account for the phenomenon of *zitterbewegung* (trembling motion).

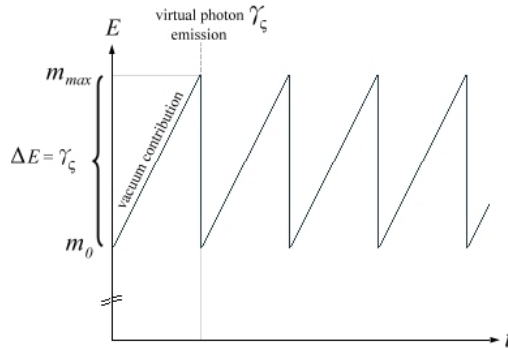


Figure 5: sawtooth electrogravitational oscillator for a charged particle expressing its rest mass variation while producing gravitational pull and electrostatic field. Vacuum contribution corresponds to the absorption of SQ in the vortex.

It may be inferred that if no emission of virtual photons occurs (charge neutrality) a particle would be compelled to decay, because of the increase of its internal energy due to absorption of SQ. But this only has to occur in unbound neutral particles, *i.e.* where no exchange of SQ with adjacent vortices occurs. We indeed observe decay in unbound neutral particles such as isolated neutrons, whose mean lifetime is 881s. A prediction of this theory would be a greater mass of isolated neutrons before they decay, if compared with the mass of bound neutrons in a nucleus and, for instance, also that of a faster decay of neutral pions (indeed $8.4 \cdot 10^{-17}$ s) if compared with charged pions ($2.6 \cdot 10^{-8}$ s), as it actually occurs. Moreover if neutrinos have a mass, since they're not bound to charged particles, they are due to decay.

As far as a suitable quantum Hamilton-Jacobi equation for the vortex geometry in Fig.4 is concerned, it is first of all useful to cite Recami, Salesi, Esposito and Bogan, who underline how the internal kinetic energy of a particle associated with spin can be identified as the quantum potential of Bohmian mechanics.

Recami and Salesi [17] reflect on the fact that fermions' spin can be the source of quantum potential. Salvatore Esposito [18], citing Recami and Salesi, defines two velocity fields related to a quantum particle, one external, $\vec{v}_B = \frac{1}{m} \nabla S$, with S as the phase of the function ψ of the Schrödinger equation ($i \frac{\partial \psi}{\partial t} = \psi H$), and $\vec{v}_S = \frac{1}{2m} \frac{1}{\rho} \nabla \rho = \frac{1}{2m} \frac{\nabla R^2}{R^2}$ as the internal velocity. Since we can know the external initial conditions but not the initial conditions of internal motion, and since quantum mechanics is based on a probabilistic formulation which comes

into play exactly when we deal with incognizable parameters, he asserts that the quantum potential of the particle is totally determined by its internal motion $\vec{v}_S \times \vec{s}$, where \vec{s} is the direction of spin. From [18] we have

$$Q = -\frac{1}{2}m\vec{v}_S - \frac{1}{2}\nabla \cdot \vec{v}_S \quad (18)$$

and we see here that the quantum potential of a fermion may be determined by the rotation itself of the vortex. Also Bogan [19], citing Esposito, indicates the internal kinetic energy of a fermion as the spin itself (18). The Bohmian term Q in the quantum Hamilton-Jacobi equation can be then justified by the spin, where in our case: $\vec{v}_S \times \hat{s} = \vec{v}_\theta + \vec{v}_\varphi$.

$$\frac{\partial S}{\partial t} = - \left[\frac{|\nabla S|^2}{2m} + V + \left(-\frac{1}{2} (m\vec{v}_S - \hbar\nabla \cdot \vec{v}_S) \right) \right]$$

Spin alone would not be however sufficient to justify the absorption mechanism, thus the non-zero viscosity of the medium in which the vortex takes shape is fundamental. The other main element in the mechanism of fluid quantum gravity is SQS pressure. Because of the SQ absorbed into the vortex-particle, pressure decreases around the object and this generates a flow directed toward the point of lower pressure, exactly as it happens in the atmosphere for wind. But in the SQS this flow is the gravitational field.

Indeed, we see (Fig 6) from the performed CFD simulations, that gravity is an apparent force mediated by a pressure gradient in the sea of space's quanta, produced by the absorption process. On the left we have a velocity potential, causally linked to a pressure potential (right). Since we are talking about pressure in SQS, also a quantum potential is again part of the play.

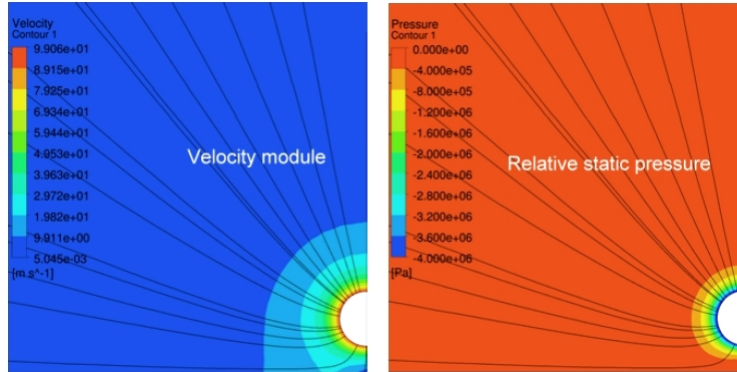


Figure 6: absorption velocity and pressure gradient from the performed CFD simulations.

We have

$$F_q = \nabla Q = \nabla \frac{P}{\rho} \quad (19)$$

as the quantum force in relation with quantum potential and pressure, where the gradient is positive since we consider the decrease of pressure and of its repulsive quantum force by approaching the massive particle. This determines what we call a gravitational potential. We can therefore reflect on the following relations (cascading gradients occurring in SQS and involved in quantum gravity):

$$v_{sq} = -\nabla\phi \Rightarrow \nabla P \Rightarrow F_q = \nabla Q \Rightarrow g = -\nabla V \quad (20)$$

where v_{sq} is the velocity of the space's quanta directed toward the attracting vortex-particle and ϕ is the velocity field or velocity potential (Fig. 6 left), P is pressure of SQS, F_q the corresponding quantum force, Q the quantum potential, g the gravitational field and V the gravitational potential. With a different reasoning, also Volovik [20] discusses osmotic relationships between pressure of the superfluid vacuum and pressure in matter.

3.1 Dark energy as internal pressure of SQS.

We assume that the SQS is a compressible quantum superfluid, whose internal pressure may act as a repulsive force in the universe, having a role in its expansion. This would be what we call *dark energy*. We agree with Huang [21] who states that dark energy is the energy density of the cosmic superfluid, and dark matter arises from local fluctuations of the superfluid density. In points of space where gravitational fields are irrelevant, SQS internal pressure shifts toward its maximal value. On the contrary, within a gravitational field, pressure decreases because of the absorption of SQ and may assume negative values. In this case the quantum force acts in the direction of the center of the massive body, causing the reciprocal attraction (gravity) of the bodies immersed in the SQS.

In Fig. 7 we see the relationships (not in scale) among the four gradients involved in fluid quantum gravity. At the axis origin we have to imagine a massive particle. As a simplification the spherical gradients are depicted as 2D Gaussians. The velocity field and the gravitational potential decrease with distance from the particle, while pressure potential increases toward the value of SQS internal pressure at infinity. If we consider the repulsive quantum force due to SQS internal pressure, we see in the figure that also the quantum potential, which is proportional to pressure, increases with distance and becomes negative (\Rightarrow attraction) by approaching the axis of the vortex-particle.

Where the curve of the quantum potential intersects the x-axis (points Λ , Λ' in Fig. 7) the total quantum force acting on a body at that distance from the mass centered at the axis origin is zero, similarly to a Lagrange point. Here the gravitational quantum force is balanced by the quantum force of SQS internal pressure and a lighter body would be stationary with respect to the considered

massive particle. Outward past the lambda boundary (Fig. 7 right) the repulsive force of dark energy (SQS pressure) becomes dominant.

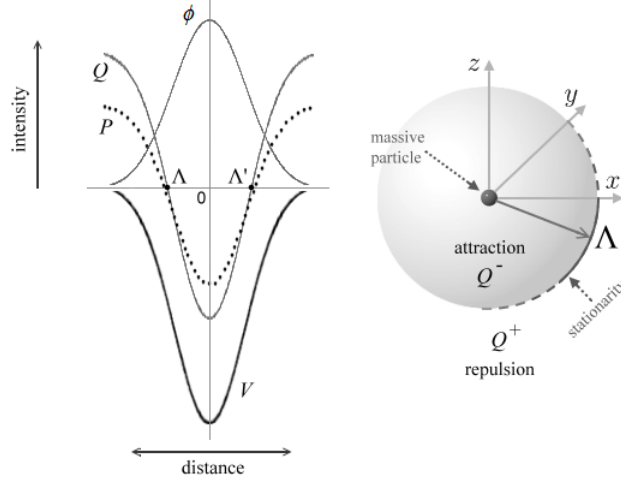


Figure 7: with a massive particle centered at the axis origin the four Gaussians (not in scale) represent in 2D, in causal order: the spherical gradient of absorption velocity (ϕ), of pressure (P), the quantum potential (Q) and the gravitational potential (V). Pressure and repulsive quantum potential (which are proportional) reach their maximal values with distance at infinity.

4 Fluid quantum gravity in general relativity.

We immediately notice that a sphere absorbing the fluid in which it is immersed generates a radial attraction field (as that generated by a vortex-particle in our hypothesis) equal to the Schwarzschild solution,

$$ds^2 = \left(1 - \frac{2Gm}{c^2 r}\right)^{-1} dr^2 + r^2(d\theta^2 + \sin^2 \theta d\phi^2) - c^2 \left(1 - \frac{2Gm}{c^2 r}\right) dt^2 \quad (21)$$

suggesting that the metric tensor of GR may be expressed through fluid dynamic forces. Fluid quantum space whose hydrodynamics produces time and influences clocks through gravity (weight force), likewise described as a fluid phenomenon, instead of a deformable geometric spacetime (Fig. 8, 9, 10).

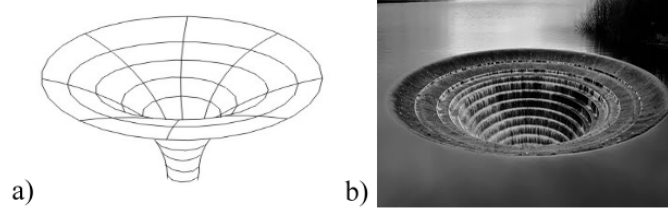


Figure 8: how the presence of a massive body curves spacetime (a) or absorbs fluid quantum space (b), here in analogy with a bell-mouth spillway.

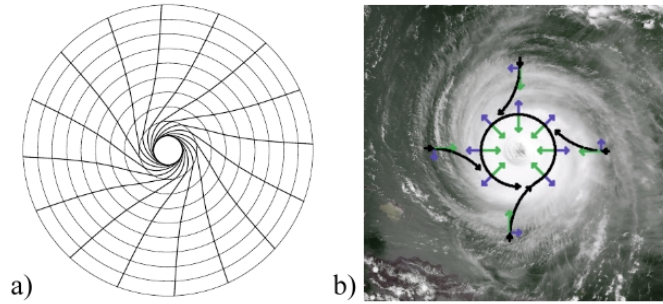


Figure 9: the Lense-Thirring effect according to Einstein's curved spacetime (a) and to fluid dynamics (b). Here as an analogy with the Coriolis effect in a cyclone.

Fig.9 describes the strong hydrodynamic analogy with a cyclone (\Rightarrow Coriolis effect), where the gravitomagnetic field related to the Lense-Thirring effect is expressed as

$$B = -\frac{4}{5} \frac{m\omega R^2}{r^3} \cos \theta \quad (22)$$

and the Coriolis force can be written as:

$$F_C = -2m\omega(\omega R)\mathbf{u}_R. \quad (23)$$

where the difference between a 3D (gravitomagnetic field) and a 2D (Coriolis) model has to be however considered.

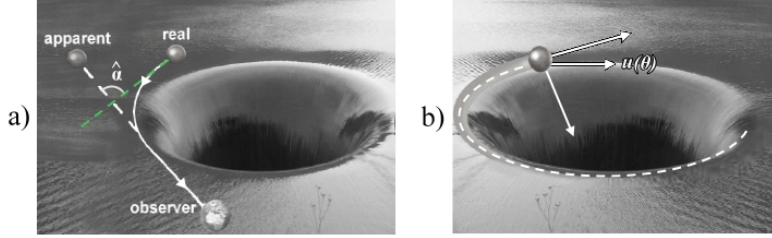


Figure 10: Gravitational lensing (a) and the motion of a satellite (b) according to SQS, still in analogy with a bell-mouth spillway representing the gravity of a star which curves space (in our case, which absorbs SQS).

Other effects which can be described by the hydrodynamics of SQS are the gravitational lensing:

$$\vec{\alpha}(\vec{\xi}) = \frac{4G}{c^2} \int d^2\xi' \int dz \rho(\vec{\xi}', z) \frac{\vec{b}}{|\vec{b}|^2} \quad (24)$$

with $b \equiv \vec{\xi} - \vec{\xi}'$, where ξ, z are coordinates and $\hat{\alpha}$ is the deflection angle, which in Fig. 10.a is determined by vector interaction between light's and space quanta's momenta (gravitational flow), and their absorption is illustrated as water flowing into a spillway (acting here as an interposed star).

While in Fig. 10.b SQS's hydrodynamics describes orbital motion, since the angular velocity for any inverse square law, such as Gauss's law for gravity and (14), is given as

$$u(\theta) = \frac{\mu}{h^2} - A \cos(\theta - \theta_0) \quad (25)$$

where A and θ_0 are arbitrary constants, h the angular momentum and μ the standard gravitational parameter.

All this suggests that the found solutions to Einstein's field equations could be fully replaced by hydrodynamic solutions based on modified quantum Navier Stokes equations. Einstein's spacetime as a single interwoven continuum is here described by the interdependence space \leftrightarrow time, since time would arise from the hydrodynamics of SQS (10) and, also in our case, it wouldn't be absolute but influenced by gravity, which is *per se* a fluid phenomenon.

4.1 The Michelson-Morley test: does the ether wind correspond to the gravitational field?

When considering gravity as absorption of SQ (§2), a gravitational field corresponds then to a flow of SQ moving toward the center of the absorbing mass.

This fact motivates us to reconsider what the Michelson-Morley experiment [22] has actually demonstrated and to conclude that:

- the MM-test has only demonstrated the nonexistence of relative motion Earth-ether but not the absolute nonexistence of an ether, if we assume, within the hypothesis of fluid quantum gravity, that the ether wind corresponds to the gravitational field.

In this case the ether wind wouldn't be dependent on Earth's orbital motion, while Earth's rotation would cause the Lense-Thirring effect by bending the incoming ether wind (Fig.9), *i.e.* the gravitational field. Another effect caused by this kind of ether wind would be the gravitational lensing (Fig.10). Several hints matching the predictions of general relativity which suggest to proceed with the hypothesis of a fluid space and of quantum gravity as absorption of SQ into vortex-particles. The consequences of a fluid space as far as the propagation of light is concerned are likewise interesting and have been discussed in [4], suggesting the analogy photon = spinning phonon through the SQS.

In the MM-experiment the ether wind would have therefore been investigated in an erroneous way. Moreover, the Michelson interferometer, though vertically positioned, would be inappropriate to prove this hypothesis because of the round trip of light occurring in it, while a Hanbury-Brown-Twiss interferometer could be suitable.

Furthermore, the existence of a fluid medium would compel us to reconsider the meaning of Hubble's law, since the fact that the redshift is greater for more distant galaxies could simply mean that light loses energy by traveling through the SQS because of its non-zero viscosity and that we are observing a sort of tired light. In this case the universe wouldn't be accelerating its expansion.

4.2 Gravitational waves as periodic pressure variations propagating through a SQS.

Other consequences of a SQS and of fluid quantum gravity would be:

- Quantum vacuum friction, which has for instance been considered in pulsars [23, 24, 25]: when energy loss is indeed only related to magnetic dipole radiation, we have $n = 3$ from the braking index $n = \frac{\omega\ddot{\omega}}{\dot{\omega}^2}$, in disagreement with observations which show that $n < 3$.
- Vacuum friction could also have played a role in the Pioneer anomaly [26].
- Gravitational waves, which would be defined as a periodic variation in SQS pressure caused by the variable position of a quadrupole in time (Fig. 11) and corresponding to a variable rate in the absorption of SQ. In this case gravitational waves arise as negative pulses propagating through SQS. Since, as said, we think that also photons can be described as pulses

(phonons) through the SQS [4], it is obvious that gravitational waves travel at the speed of light. And, not surprisingly, also photons (§4.5), as positive pulses that carry energy (like sound), can provide kinetic energy to a target (radiation pressure), exactly as for gravitational waves acting on LIGO’s test masses where the pressure is however negative. Also in this case it would be a hydrodynamic quantum phenomenon and no deformation of a geometric spacetime would be necessary to explain gravitational waves.

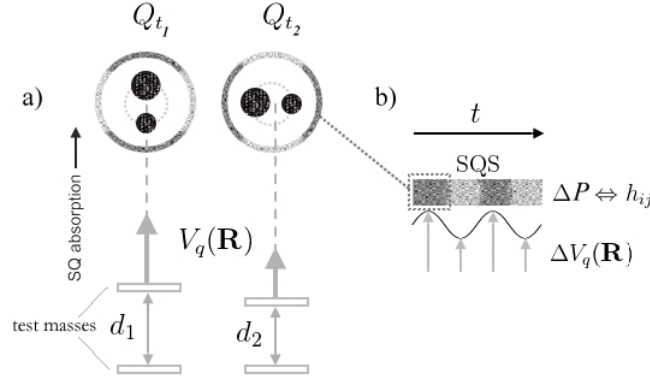


Figure 11: Gravitational waves according to fluid quantum gravity. Periodic variations in SQS pressure due to a likewise periodic variation of the absorption velocity (\Rightarrow changing position of the quadrupole) may explain them as a hydrodynamic quantum phenomenon, without resorting to the concept of spacetime deformation. Depending on the alternating position of the quadrupole (Q_{t_1}, Q_{t_2}) we have greater absorption (pressure decrease) or weaker absorption which correspond to a variation in the resulting gravitational potential (V_q). On the right, the periodicity of pressure variations is interpreted in time as a wave.

The changing rate in the absorption of space’s quanta, occurring twice the orbital frequency ($2\omega_q$), causes periodic decompressions (ΔP) in SQS (Fig.11.b), currently interpreted as a deformation of spacetime (h_{ij} , in linear gravity: $g_{ij} = \eta_{ij} + h_{ij}$). Also in this case the quantum potential arises from pressure variations. Quantum-like gravity waves but in a classical fluid have been investigated by Nottale [27].

Simplifying the theory of relativity. Special relativity according to a superfluid quantum space: gravity as the sole cause of all relativistic effects.

4.3 Fluid principle of equivalence: is relativistic mass increase rather a matter of *drag weight*?

Because of the presence of SQS, also translational motion would put a moving body in the condition of being subject to a gravitational field, as an apparent flow, which in this case acts in the opposite direction to motion. We can express that as a fluid equivalence principle (FEP) (Fig. 12).

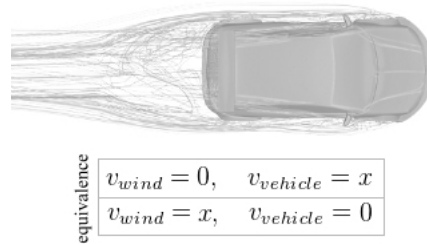


Figure 12: Fluid equivalence principle: it is impossible to distinguish between the two equivalent situations of a body moving at a given velocity through a stationary fluid and a fluid flowing toward a stationary body at the same velocity. This would also occur as far as a body interacting with SQS is concerned, where the equivalence is between being stationary in a gravitational field (being subject to an ether wind having a given velocity) or moving through SQS at the same velocity, *i.e.* being subject to a gravitational field induced by motion which would increase according to Lorentz factor.

Which obtains as:

$$\mathbf{v}_{\Phi} = \mathbf{v}_{sq} + \mathbf{v} \quad (26)$$

where \mathbf{v}_{Φ} is the velocity of the total resultant flow acting on the moving body, determined by the vector sum of the velocity at which SQ are absorbed (\mathbf{v}_{sq} , drift velocity of SQ) in the point of the gravitational field where the body is located at a given instant and of the body's translational velocity (\mathbf{v}) through the fluid space. According to the FEP, any translational velocity therefore provokes an apparent gravitational field (g_{Φ}) acting on the accelerated body and detected as a weight force opposite to motion (drag weight, \mathbf{W}_{Φ}) (Fig.13). Other cases of quantum vacuum friction have been discussed by several authors [28, 29, 30] and also Higgs field is said to possess a certain viscosity: potential relationships between these fields, or a possible correspondence, should be then investigated.

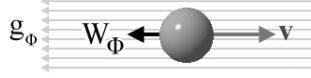


Figure 13: Weight acting in the opposite direction to motion (drag weight, \mathbf{W}_Φ) due to the apparent gravitational field caused by motion through SQS. At low, everyday speeds this effect wouldn't be noticed, since SQS's viscosity is quasi-zero, as for every superfluid, but the effect of apparent viscosity would play a key role at relativistic velocities (extreme shear stress), increasingly opposing acceleration.

This is in agreement with the relativistic effect of mass increase, which would actually be a resistance to acceleration due to an increasing gravitational force acting in the opposite direction to motion. This issue is clear if we suppose that, when dealing with accelerated particles in synchrotrons, we make a dimensional mistake, swapping kgf with kg, *i.e.* interpreting a weight force (\mathbf{W}_Φ) pointing in the opposite direction to the supplied acceleration as a mass increase. If drag weight grew according to Lorentz factor (§4.5.1)(40), it could be the cause of the so-called relativistic mass increase:

$$a = \frac{F}{m + W_\Phi}. \quad (27)$$

The new equation expressing the total weight of a body in fluid quantum gravity would be:

$$\mathbf{W}_{\text{tot}} = m(\mathbf{g} + \mathbf{g}_\Phi) \quad (28)$$

where the accelerations g and g_Φ may point in different directions, according to the presence of a gravitational field and/or translational motion. Because of the viscosity of SQS (we know that no superfluid has real zero-viscosity) a slight difference in the weight of a body should moreover occur when we compare the gravitational force acting on a free falling body with that acting when it is in equilibrium in the gravitational field: in the second case the weight should be slightly greater than $W = mg$ but in the Earth's gravitational field this difference would be probably too small to be detected.

It is possible to proof the FEP in Einstein's relativity by equating the cause of time dilation in special relativity (velocity) to that in general relativity (gravity):

$$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{\Delta t}{\sqrt{1 - \frac{R_S}{r}}} \quad (29)$$

hence

$$\frac{v^2}{c^2} = \frac{R_S}{r} = \frac{2GM}{c^2 r} \implies v^2 \frac{1}{c^2} = \frac{2GM}{r} \frac{1}{c^2} \implies v^2 = \frac{2GM}{r} \quad (30)$$

and

$$v = \sqrt{2rg} = \sqrt{2\Phi}, \quad (31)$$

where (31) relates velocity and gravity (as gravitational potential Φ) in the formula of the second cosmic velocity, also meaning that a given velocity in SR corresponds to a certain gravity (drag weight), equivalent to that of a gravitational field g in a point where the absorption of SQ occurs at the same velocity. Fig. 14 indeed shows how a gravitational field corresponds to an absorption velocity field (velocity potential) analogous to that of Fig. 6 from our CFD simulations (absorption of SQ \Rightarrow sink at the origin) and, on the right, the equivalence between translational velocity and absorption velocity of a gravitational field, which explains the relativistic phenomenon of illusory mass increase as drag weight and unifies the cause of time dilation of SR and GR (gravity in both cases).

- *All* relativistic effects could be therefore explained *through the sole action of gravity*, described as a hydrodynamic force occurring in SQS. Besides what described in Fig. 8, 9, 10, also mass increase (or better, what would be the current interpretation of drag weight), time dilation and consequently Lorentz-Fitzgerald contraction, which depends on time dilation and does not need to be discussed. What is *relative* in fluid quantum relativity is SQ's velocity with respect to a frame of reference (\mathbf{v}_Φ): it produces or varies the gravitational force acting in the frame, also modifying time, as discussed below.

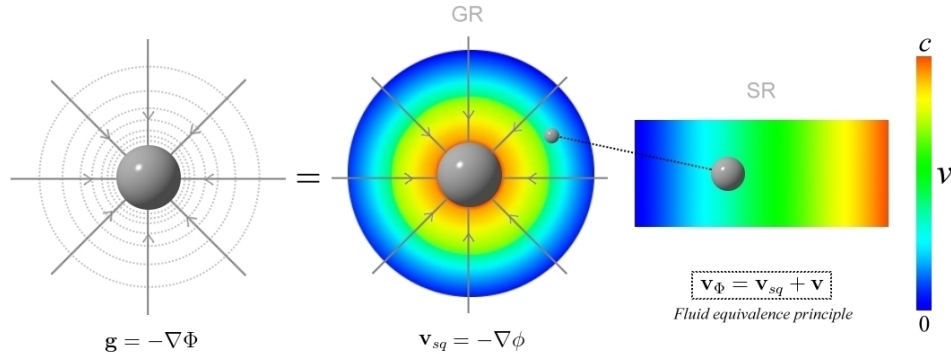


Figure 14: equivalence of a gravitational field (left) and a velocity field (center), where the latter corresponds to the absorption velocity (v_{sq}). In both cases we have sink at the origin and equipotential surfaces. On the right, a given translational velocity (SR) through SQS corresponds to being in a point of a gravitational field (GR) where space's quanta are absorbed at the same velocity.

4.4 Time dilation as the action of weight (in GR) and drag weight (in SR) on clocks.

Time can emerge from and can be influenced by the hydrodynamics of SQS. If the relativistic effect of drag weight (§4.3) caused in SR by translational velocity is explicable through the action of gravity, time dilation (29) would be therefore caused by gravity also in SR, since we know from GR that gravity interferes with clocks' motion. This would be a simplification of Einstein's relativity: the unification of all relativistic effects of both special and general relativity under the only action of gravity. Indeed, if the parts of a physical system (as a clock) become heavier, their movements are affected, unless more energy is provided to the system. We can say *clocks* in the broadest sense, since any physical system, also a biological organism, is not immune to the action of gravity, which influences its dynamical aspects (macroscopic, molecular *etc.*) and consequently causes time dilation. If we had, for instance, a clock with period

$$T_c = T_0 \frac{F_f + F_g}{F_c} = 1s \quad (32)$$

calibrated by balancing friction and gravity ($F_f + F_g = F_c$), where $T_0 = 1s$ is the period where $g \rightarrow 0$, when we put out the accelerations acting on it,

$$T_c = T_0 \frac{\mathcal{M}(a_f + g)}{\mathcal{M}a_c} \quad (33)$$

it would be clear that any additional positive acceleration in the numerator would unbalance the mechanism, producing time dilation, both when the clock is in a stronger gravitational field,

$$T' = T_0 \frac{a_f + g + \Delta g}{a_c} > 1s \quad (34)$$

and when it is subject to drag weight,

$$T' = T_0 \frac{a_f + g + g_\Phi}{a_c} > 1s. \quad (35)$$

This reasoning also tells us that the gravitational redshift described by Einstein is compatible with fluid quantum gravity, since the force (gravity) acting on the clocks' components increases by approaching a massive body (following the absorption gradient).

We see that if g_Φ increased according to Lorentz factor (40, 42)(Fig. 16), time dilation too would obey γ , until the clock is stopped by gravity.

This explanation also conforms to Einstein's redshift, where clocks run differently depending on the intensity of the gravitational field at the point where they are placed.

To understand now why Lorentz factor is built on the ratio (β) between the translational velocity of a body and the speed of light, we need to discuss the nature of light in relation to the possible existence of a SQS. Let us hypothesize

that a photon is a pulse (phonon) through a SQS. As shown below, equations and evidences seem to confirm that.

4.5 Photon as a phonon through a superfluid quantum space.

Once established that the MM-experiment didn't disprove the existence of a luminiferous ether (§4.1) and since light would propagate through a fluid medium if a SQS existed, we aim now to prove how a photon can be a pulse (a phonon) through a fluid quantum medium. In this case light would be *the sound of space*. Let's consider the formula of the speed of sound through a fluid. In the case of the propagation of a single photon as a phonon (unidirectional compression), we resort to Young's modulus ($E = \frac{\sigma}{\epsilon}$) instead of the bulk modulus. By setting $\sigma = 1$, we obtain $a = \frac{1}{\sqrt{\epsilon\rho}}$. When ϵ_0 is seen as SQS's compressibility and ρ_0 as its density, we have

$$a = \frac{1}{\sqrt{\epsilon_0\rho_0}}, \quad (36)$$

expressing the velocity of a pulse (then also of a phonon) through SQS, where the numerator has unit $\text{Pa}^{\frac{1}{2}}$. Mathematically analogous to

$$c = \frac{1}{\sqrt{\epsilon_0\mu_0}}, \quad (37)$$

resulting from Maxwell's equations. Hence, given the adimensional equivalence $\epsilon_0\rho_0 = \epsilon_0\mu_0$ (36, 37), photon's electromagnetic field might be described as a local density variation (\Rightarrow local energy variation) of SQS in time, due to the compression caused by the pulse, as illustrated in Fig. 15, whose spin (we know that also sound waves can spin [31, 32]) would play a role in the orthogonality of the magnetic field with respect to the electric field. The permeability and permittivity of free space would be therefore determined by SQS's properties such as its density and compressibility.

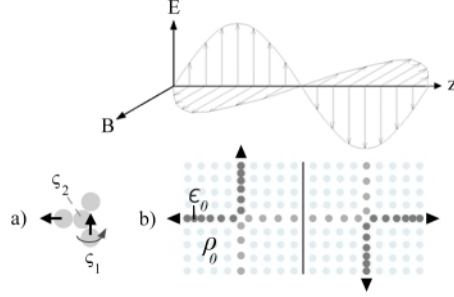


Figure 15: Density (ρ) and compressibility(ϵ) of SQS at the origin of photon-phonon's transverse EM field (b), whose oscillations are due to harmonic, orthogonal compressions of space's quanta, while the main pulse propagates along the z -axis. On the left (a), the probable quantum mechanism at the origin of transversality, due to compression and intrinsic angular momentum (spin) of SQ.

There are many analogies between photon and phonon. In the energy eigenvalue of any eigenstate ψ_n of photon, expressed as

$$E_n = (n + \frac{1}{2})\hbar\omega \quad (38)$$

$\frac{1}{2}\hbar\omega$ is vacuum (SQS) contribution, as well as for a phonon, where the harmonic oscillator eigenvalues for the mode ω_k (k , wave number) are

$$E_n = (n + \frac{1}{2})\hbar\omega_k \quad n = 0, 1, 2, 3, \dots \quad (39)$$

Both photons and phonons:

- are bosons [33]
- possess wave-particle duality [34, 35]
- obey the doppler effect $z = \frac{f_{emit} - f_{obs}}{f_{obs}}$
- are symmetric under exchange $|\alpha, \beta\rangle = |\beta, \alpha\rangle$
- can be created by repeatedly applying the creation operator b^\dagger
- share the formula of momentum: $p_{phonon} \equiv \hbar k = \frac{h}{\lambda}$, where $k = \frac{2\pi}{\lambda}$
- can produce photoelectric effect and Compton scattering thanks to their momentum $\frac{h}{\lambda}$
- can have a spin [31, 32]. In this case photon would be a special spin-1 phonon.
- can form squeezed coherent states [36]

- can interact via parametric down conversion [36]

When a photon is described as a phonon in SQS, the energy it carries would be justified within the quantum phenomenon of *second sound*, occurring in this case in SQS.

This would lead us to another simplification, since all waves in nature would be mechanical (quantum mechanical in the case of EM waves) and would need a medium to propagate.

4.5.1 Reinterpretation of Lorentz factor, mass-energy equivalence and Hubble's law.

If SQS acted as a non-newtonian, dilatant fluid under extreme shear stress (bodies accelerated through SQS at relativistic velocities), this fact would justify the asymptote at c to translational velocity. Being moreover a dilatant fluid would confirm the granular [37] (and quantum) nature of space.

When a photon is a phonon of space's quanta through SQS, the parameter β in Lorentz factor is intelligible as the ratio between the speed of a body and that of a pulse through SQS, where the accelerated body produces a greater shear stress and can't travel as fast as a pulse (photon): this because of the dilatancy it provokes in SQS when its speed approaches c . Indeed, the ratio $\left(\frac{v^2}{c^2}\right)$ is expressed as an adimensional parameter analogous to the ratio between the speed of a body and of sound (v_s) through other superfluids [38]: $\left(\frac{v}{v_s}\right)^2 \implies \left(\frac{v}{c}\right)^2 \equiv \beta^2$.

- Within a SQS, Lorentz factor is then hydrodynamically interpretable as

$$\gamma \equiv \arcsin' \frac{v_\Phi}{v_p} = \frac{1}{\sqrt{1 - \left(\frac{v_\Phi}{v_p}\right)^2}} \quad (40)$$

indicating the asymptote at $v_p = c$, where v_p , is the speed of a pulse through the fluid space and v_Φ (26) is the relative velocity of SQ in a given frame of reference. By approaching $v_\Phi = v_p$ (*i.e.* $v = c$, if in the FEP formula $v_{sq} = 0$), fluid space's dilatancy would play more and more a strategic role in preventing further acceleration.

Valid the analogy photon-phonon (36), c^2 corresponds then to the square of the pulse velocity $c^2 = v_p^2 = \frac{1 \text{Pa}}{\rho_0 \epsilon_0}$. The similarity with $v_s^2 \equiv \frac{1}{\rho_a \kappa}$ in [38] is interesting, where v_s is the speed of sound through a compressible superfluid. If this is true, we could state that light is *the sound of space*, inasmuch it would be a pulse (phonon) through a fluid space.

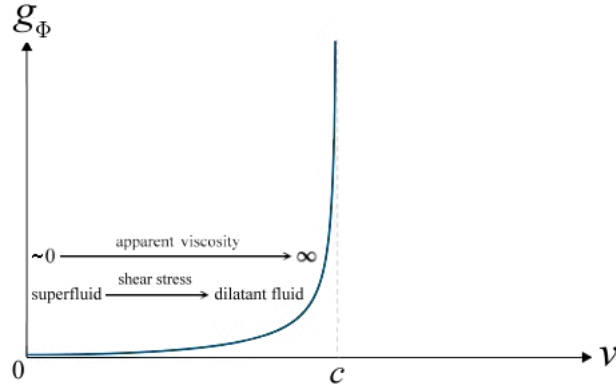


Figure 16: motion-induced gravitational acceleration (g_Φ) causing drag weight ($W_\Phi = mg_\Phi$) increase, currently interpreted as relativistic mass increase. This graph can also be read as a rheogram of SQS. As shear rate and velocity of the relative flow of SQ shift toward relativistic values, collisions among SQ intensify and viscosities, albeit initially near-zero, critically increase, until granular (quantum) fluid space's dilatant behavior leads to an asymptote, corresponding to the speed of a pulse ($v_p = c$) in SQS. Thus, exactly as sound has a given speed through a given fluid, light would have one through SQS, corresponding to ~ 299792458 m/s.

At this point $E = mc^2$ would be intelligible as the ratio between the rest mass-energy of a body and the energy of 1 m^3 of SQS³ (ρ_0) multiplied by the Young's modulus of SQS ($\frac{\sigma_0}{\epsilon_0} = \Upsilon$), where $\sigma_0 = 1\text{ Pa}$:

$$E = mc^2 = \frac{m}{\rho_0} \frac{\sigma_0}{\epsilon_0} = \frac{m}{\rho_0} \Upsilon. \quad (41)$$

In other words, Einstein's mass-energy equation would indicate how much energy from SQS is entrapped in a body of mass m , given a specific density and compressibility of SQS.

And Lorentz factor could be rewritten in the (still adimensional) form:

$$\gamma_\Phi \equiv \frac{1}{\sqrt{1 - v_\Phi^2 \rho_0 \Upsilon^{-1}}} \quad (42)$$

where v_Φ expresses the FEP in the considered frame of reference. It means that (42) could be used also in place of $\frac{1}{\sqrt{1 - \frac{v_s^2}{c^2}}}$ if we knew the velocity of the flow of SQ in a given point of a gravitational field (Fig. 14). Furthermore:

- Valid the analogy photon-phonon, Hubble's law would be compatible with an energy loss (\Rightarrow redshift) of photons due to the minimal viscosity of SQS,

³Obvious, after all, if fermions are superfluid vortices of space's quanta.

after they've traveled enormous distances, instead of representing a mysterious acceleration of distant galaxies driven by dark energy. The further a galaxy, the greater the detected redshift. This theory therefore indicates that dark energy is not necessary and that it doesn't probably exist (the $\sim 68\%$ of missing energy in the cosmo may be rather the SQS itself), in that the expansion of the universe would be *not* accelerating. When we therefore consider the role of an accelerated expansion in determining the age of our universe, astrophysicists should first reconsider their reasonings by taking into account the possible variation of SQS's density (ρ_0) in (36) in a younger and smaller universe, when that value was probably greater.

We can now try to define the formula for drag weight. While the formula for classical drag force is

$$\mathbf{F}_D = -\hat{\mathbf{v}} \frac{1}{2} v^2 \rho C_D A \quad (43)$$

there is in this case no dependence on surface (A) or shape (C_D) for a body traveling through SQS. According to the FEP, the same dynamics which is valid for standard weight has indeed to be valid also for drag weight, *i.e.* dependence only on mass and field intensity. Hence it has to be true: $\mathbf{F}_{D_{qs}} = \mathbf{W}_\Phi = m \mathbf{g}_\Phi$. Where the meaning of $C_D A$ in (43) is represented by mass, *i.e.* the quantity of matter exposed to the flow, regardless of shape and surface. Thus, we just need to define the formula of g_Φ . We know that it has to increase according to Lorentz factor, whose reformulation (42) precisely contains the dependence on velocity and medium's density as in (43). The formula for drag weight could be therefore written as:

$$\mathbf{W}_\Phi = -\hat{\mathbf{v}} m \frac{a}{\sqrt{1 - v_\Phi^2 \rho_0 \Upsilon^{-1}}} - 1 \quad (44)$$

where $a = 1 \text{ m/s}^2$ and $\hat{\mathbf{v}}$ is a unit vector expressing the direction of motion. In conclusion, the gravitational field is expressed as

$$\mathbf{g} = -\hat{\mathbf{r}} \frac{1}{2} \frac{v_e^2}{r} = -\hat{\mathbf{r}} \frac{GM}{r^2} \quad (45)$$

when gravity is caused by the presence of a mass (celestial body), and as

$$\mathbf{g}_\Phi = -\hat{\mathbf{v}} \frac{a}{\sqrt{1 - v_\Phi^2 \rho_0 \Upsilon^{-1}}} - 1 = -\hat{\mathbf{v}} a \gamma_\Phi - 1 \quad (46)$$

when it is induced by motion through SQS.

Conclusion

If the single hypothesis of massive particles as vortices of space's quanta in a superfluid quantum vacuum, which obeys Gauss's law for gravity (incoming flux \Rightarrow attraction of space's quanta determining the relationship expressed in (20))

generates a series of consequences which range from describing and simplifying special and general relativity, letting us better understand what a fundamental particle can actually be, up to linking gravity to electromagnetism and explaining Hubble's law without resorting to accelerated expansion, it should be then considered for mathematical and experimental in-depth analysis. Furthermore, the hypothesis of SQ attraction into massive particle (thus also towards the center of the Earth) solves the incompatibility of a fluid space with the outcome of the Michelson-Morley experiment, since an ether wind corresponding to the gravitational field conforms to the known experimental evidences, such as light deflection and gravitational redshift. Finally, the description of photons as phonons propagating through a superfluid space would reduce waves which exist in nature to only one type (medium-dependent). We could therefore state that *entia non sunt multiplicanda praeter necessitatem*, as it seems that a superfluid approach may be able to explain nature without extra dimensions, strings, gravitons, cosmic inflation and other *dei ex machina*. Within this superfluid reconsideration of the universe, it is impossible to keep fundamental forces separated and to keep them separated from particles, since we see that everything is expression of the hydrodynamics of SQS. From vortices of SQ we have indeed mass, charge, fundamental forces *etc.* and nothing appears to be really fundamental but space's quanta.

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Annex.

Other images and charts from the performed CFD simulations.

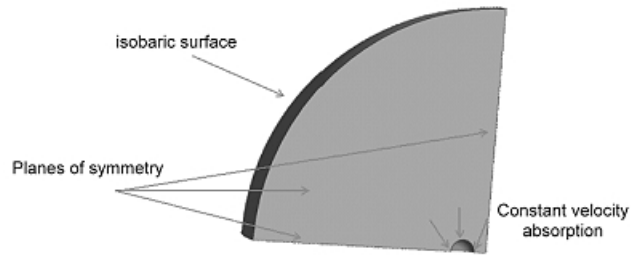


Figure 17: Simulation settings

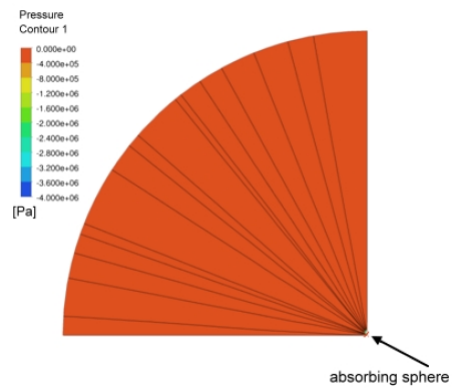


Figure 18: radial flow obtained in the simulations

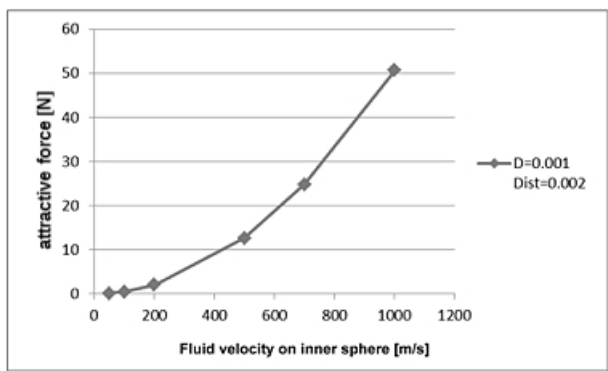


Figure 19: Test for force dependence on absorption velocity: sphere diameter 1mm, distance 2mm. Tested velocities: 50, 100, 200, 500, 700, 1000 m/s. Other tested conditions (50, 100, 200, 500 m/s) are shown in Fig. 6 and 7.

Figure 20:

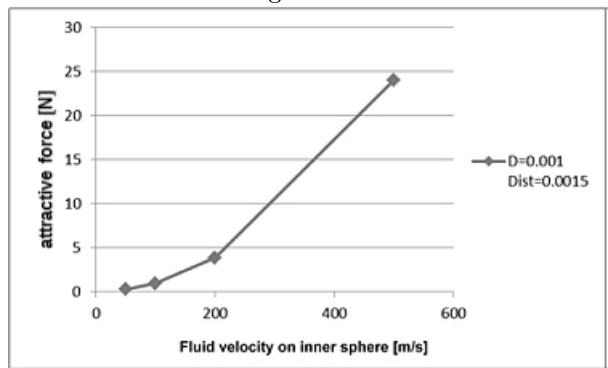


Figure 21:

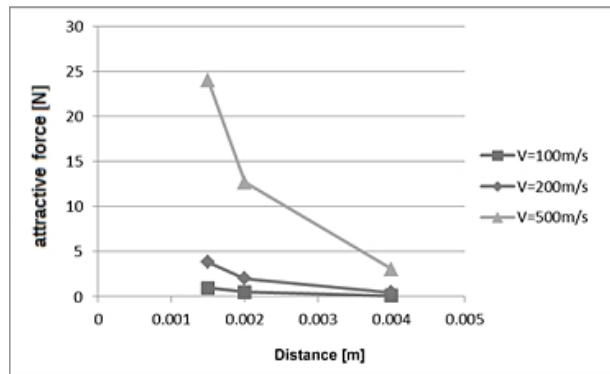
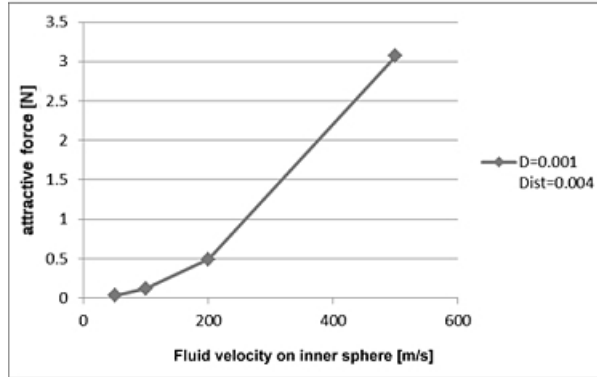


Figure 22: Test for force dependence according to the distance between the spheres.