



HAL
open science

Gravity as a fluid dynamic phenomenon in a superfluid quantum space. Fluid quantum gravity and relativity.

Marco Fedi

► **To cite this version:**

Marco Fedi. Gravity as a fluid dynamic phenomenon in a superfluid quantum space. Fluid quantum gravity and relativity.. 2015. hal-01248015v4

HAL Id: hal-01248015

<https://hal.science/hal-01248015v4>

Preprint submitted on 20 Apr 2016 (v4), last revised 5 May 2017 (v6)

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives 4.0 International License

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

Fluid quantum gravity and relativity.

April 20, 2016

MARCO FEDI

Ministero dell'Istruzione, dell'Università e della Ricerca (MIUR), Italy

marco.fedi@istruzione.it

Abstract

We know that a real vacuum doesn't exist [1, 2]. By describing it as a superfluid quantum space (SQS) it's shown how gravity can arise as absorption of space's quanta effected by fermions, when they are described as topological defects of SQS (superfluid vortices similar to those observed in superfluid helium-4 nanodroplets). By applying this hypothesis, Newton's law of universal gravitation has been obtained through CFD simulations. In this case, a gravitational field is an incoming flow of space's quanta, mathematically analogous to the virtual flow described in Gauss's law for gravity, and this leads to the formulation of a fluid equivalence principle, able to show how gravity is the origin of all relativistic effects, also in special relativity, producing a considerable simplification in the theory of relativity. It is shown how the fluid dynamics of a SQS is able to describe curved space and gravitational waves. Not less important when discussing fluid space, this hypothesis would not conflict with the MM-experiment and would open a new scenario on the nature of light and Hubble's law. A simple experiment is suggested to verify fluid quantum gravity and relativity on the ISS.

A hypothesis has been formulated, according to which, space is a quantum superfluid and fermions absorb space's quanta (SQ) [3], generating an attractive force, which corresponds to gravity (fig. 1). The mechanism of absorption is based on the description of fermions as point vortices in a superfluid quantum space (SQS), similarly to nanovortices occurring in superfluid helium-4 [7, 8, 9], *i.e.* as dynamic topological defects of SQS [3, 4, 5]. To compensate this absorption, emission of virtual photons would occur, capable of explaining the

existence of charged particles and, when no emission occurs, the β -decay. The exchange of SQ occurring between adjacent vortices would moreover justify the strong interaction leading to the complete unification of the four fundamental interactions [3]. In this work only the exofermionic consequences of SQ absorption are however analyzed, to describe fluid quantum gravity and relativity.

Within the hypothesis of absorption, it is convenient to consider Gauss's law for gravity, $\oint_{\partial V} \mathbf{g} \cdot d\mathbf{A}$, since it describes a radial field as an incoming flow. The following set of simulations has been performed. Navier-Stokes equations representing mass, momentum and energy have been used:

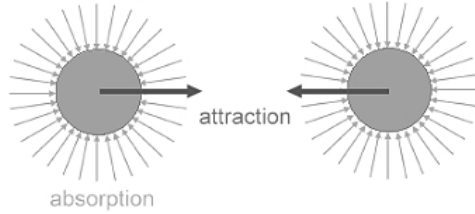


Figure 1: Two particles move the one toward the other, since they're absorbing the fluid (SQS) which they're immersed in.

$$\frac{\partial(u_j)}{\partial x_j} = 0 \quad (1)$$

$$\frac{\partial(u_i u_j)}{\partial x_j} = -\frac{1}{\rho} \frac{\partial p}{\partial x_i} + \frac{\mu}{\rho} \frac{\partial}{\partial x_j} \left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i} \right) \quad (2)$$

$$\frac{\partial((\rho E + p)u_j)}{\partial x_j} = -k \frac{\partial}{\partial x_j} \left(\frac{\partial T}{\partial x_j} \right) \quad (3)$$

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. 2.

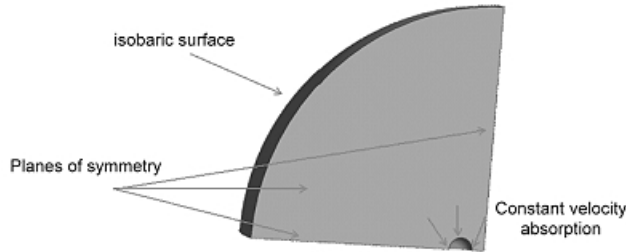


Figure 2: Simulation settings

The attractive force produced by pressure forces and momentum, where A corresponds to the surface of the inner sphere and \vec{d} is the unit vector for the distance between the spheres, is represented by the following equation:

$$F_a = \int_A (p + \rho(\vec{u} \cdot \vec{n})(\vec{u} \cdot \vec{d})) d\vec{A} \cdot \vec{d} \quad (4)$$

The analysis of velocity and pressure, with respect to the distance (radius) from the absorbing sphere is illustrated in fig. 3 and the diagrams in fig. 5, 6, 7 and 8 show an inverse quadratic dependence on distance and a quadratic dependence on the flow velocity.

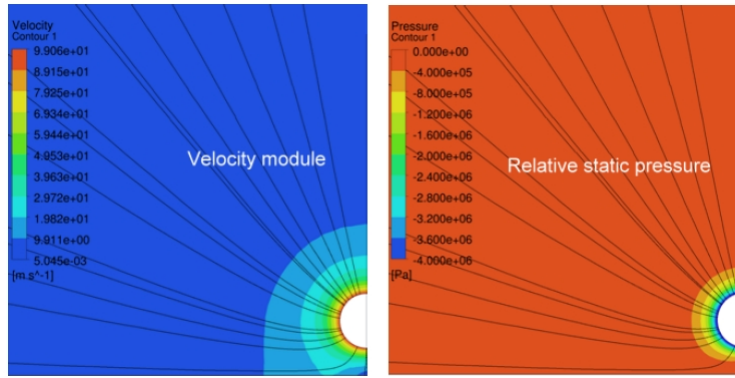


Figure 3: some results of the simulations.

Refinement of computational grid and domain enlargement helped to reduce the curvature of the flow lines, up to a virtually radial flow (fig. 4).

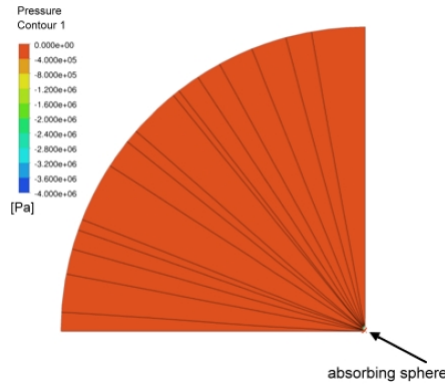


Figure 4: radial flow obtained in the simulations

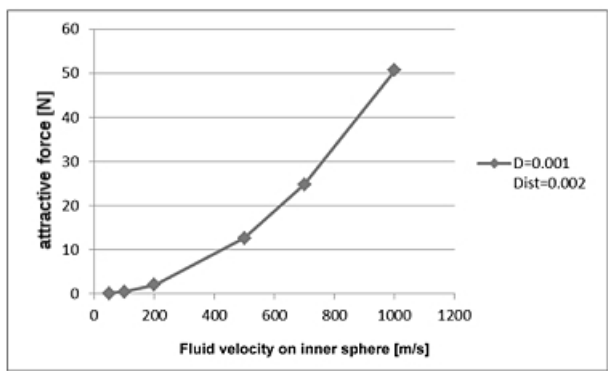


Figure 5: Test for force dependence on absorption velocity: sphere diameter 1mm, distance 2mm. Tested velocities: 50, 100, 200, 500, 700, 1000 m/s. Other tested conditions (50, 100, 200, 500 m/s) are shown in fig. 6 and 7.

Figure 6:

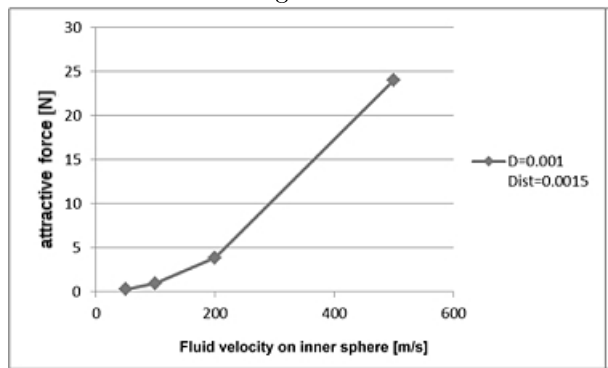


Figure 7:

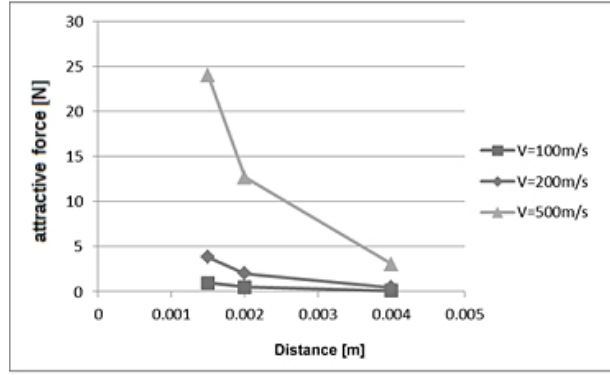
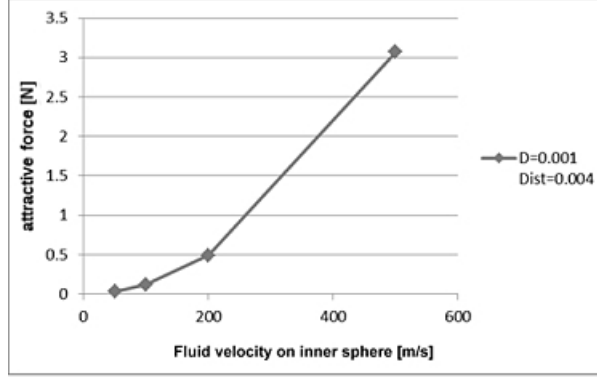


Figure 8: Test for force dependence according to the distance between the spheres.

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 it quadratically grows according to the velocity of the flux (fig. 5, 6, 7). Two equal spheres have been considered, corresponding to equal masses in Newton's law.

Moreover, a sphere absorbing the fluid in which it is immersed generates a radial attraction field equal to the Schwarzschild solution for Einstein's field equations

$$ds^2 = \left(1 - \frac{2Gm}{c^2 r}\right)^{-1} dr^2 + r^2(d\theta^2 + \sin^2 \theta d\phi^2) - c^2 \left(1 - \frac{2Gm}{c^2 r}\right) dt^2 \quad (5)$$

suggesting that the metric tensor of GR may be expressed through fluid

dynamic forces. Fluid quantum space which evolves in time instead of curved geometric spacetime (fig. 9, 10, 11).

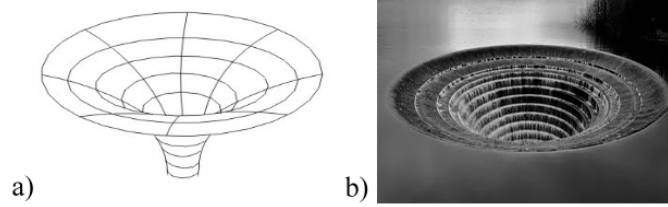


Figure 9: how the presence of a massive body curves spacetime (a) or absorbs fluid quantum space (b), here in analogy with a bell-mouth spillway.

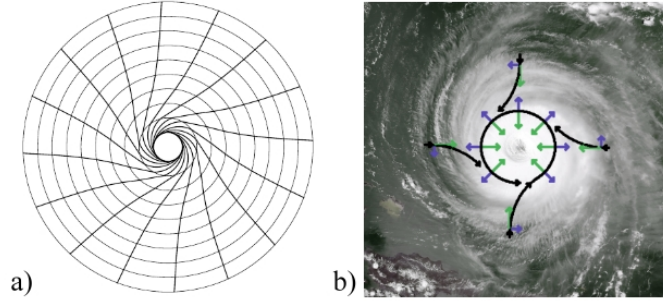


Figure 10: the Lense-Thirring effect according to Einstein's curved spacetime (a) and to fluid dynamics (b). Here as an analogy with the Coriolis effect in a cyclone.

Where the gravitomagnetic field related to the Lense-Thirring effect is expressed as

$$B = -\frac{4}{5} \frac{m\omega R^2}{r^3} \cos \theta \quad (6)$$

and the Coriolis force can be written as:

$$F_C = -2m\omega(\omega R)\mathbf{u}_R. \quad (7)$$

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

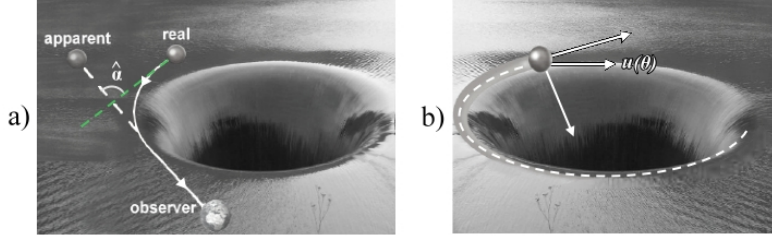


Figure 11: Gravitational lensing (a) and the motion of a satellite (b) according to SQS, here in analogy with a bell-mouth spillway representing the gravity of a star which curves space (in our case, which absorbs SQS).

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

$$\vec{\hat{\alpha}}(\vec{\xi}) = \frac{4G}{c^2} \int d^2\xi' \int dz \rho(\vec{\xi}', z) \frac{\vec{b}}{|\vec{b}|^2} \quad (8)$$

with $b \equiv \vec{\xi} - \vec{\xi}'$, where ξ, z are coordinates and $\hat{\alpha}$ is the deflection angle, which in fig. 11.a is determined by vector interaction between light's and space quanta's momenta, where their absorption is illustrated as water flowing into a spillway (acting as an interposed star).

While in fig. 11.b SQS's fluid dynamics describes orbital motion, since the angular velocity for any inverse square law, such as that found in the CFD simulations (4), is given as

$$u(\theta) = \frac{\mu}{h^2} - A \cos(\theta - \theta_0) \quad (9)$$

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 fluid dynamic solutions based on Navier Stokes equations.

When considering gravity as absorption of SQ, a gravitational field corresponds then to a *flow of SQ moving toward the center of the absorbing mass* and - because of the presence of SQS -, also translational motion puts 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):

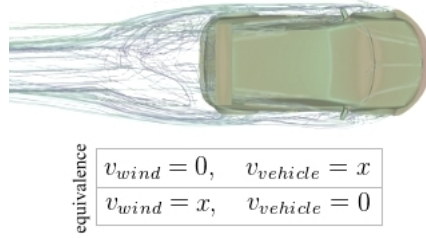


Figure 12: Fluid equivalence principle (FEP): it is impossible to distinguish between the two equivalent situations of a body moving at a given velocity through a stationary fluid and a fluid flowing toward a stationary body at the same velocity. This would also occur as far as a body interacting with SQS is concerned.

The equation is

$$\mathbf{v}_\Phi = \mathbf{v}_{sq} + \mathbf{v} \quad (10)$$

where \mathbf{v}_Φ is the velocity of the total resultant flow acting on the moving body and determined by the vector sum of the velocity at which SQ are absorbed (\mathbf{v}_{sq}) and/or of the body's translational velocity (\mathbf{v}) through fluid space. According to the FEP, any translational velocity provokes then an apparent gravitational field (g_Φ) acting on the accelerated body and detected as an increase of inertia (mass) but basically a weight force opposite to motion (\mathbf{W}_Φ)(fig. 13).

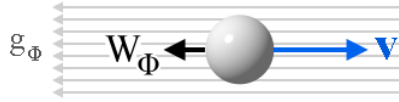


Figure 13: Weight acting in the opposite direction to motion (drag weight, \mathbf{W}_Φ) due to the apparent gravitational field caused by motion through SQS. At low, everyday speeds this effect wouldn't be noticed, since SQS's viscosity is minimal (quasi zero), as for every superfluid, but the effect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

This is in agreement with the so-called 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.

In synchrotrons, if this force is ignored, the only (and current) explanation for the evident obstacle to infinite acceleration is that mass increases:

$a = \frac{F - W_\Phi}{m}$. But if drag weight increased following Lorentz factor (20), then the effect detected in synchrotrons would be exactly the same. If SQS acted as a non-newtonian, dilatant fluid for extreme shear stress (bodies accelerated through SQS at relativistic velocities) this would justify the asymptote to translational velocity (c). Moreover, being a dilatant fluid would confirm the granular [6] (and quantum) nature of space. The reason why this asymptote is exactly the speed of light is discussed below, along with Lorentz factor.

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

$$\mathbf{W}_{\text{tot}} = m(\mathbf{g} + \mathbf{g}_{\Phi}) \quad (11)$$

where the accelerations g and g_{Φ} may point in different directions, according to the presence of a gravitational field and/or translational motion.

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

$$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{\Delta t}{\sqrt{1 - \frac{R_S}{r}}} \quad (12)$$

hence

$$\frac{v^2}{c^2} = \frac{R_S}{r} = \frac{2GM}{c^2 r} = v^2 \frac{1}{c^2} = \frac{2GM}{r} \frac{1}{c^2} \implies v^2 = \frac{2GM}{r} \quad (13)$$

and

$$v = \sqrt{2rg} = \sqrt{2\Phi}. \quad (14)$$

Where (14) 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. 3 (absorption of SQ \Rightarrow sink at origin) and, on the right, the equivalence between translational velocity and absorption velocity of a gravitational field, explaining the relativistic phenomenon of illusory mass increase (drag weight) and unifying the cause of time dilation in SR and GR (gravity in both cases).

- *All* relativistic effects, inasmuch (besides what described in fig. 9, 10, 11) 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) - may be therefore explained *through the sole action of gravity* (fig. 14), described as a fluid dynamic force.

Time dilation (12) would be therefore caused by gravity also in SR (a simplification of Einstein's relativity), as a force which interferes with clocks' motion. If the parts of a physical system become heavier their movements are affected, unless more energy is provided to the system. *Clocks* in the broadest sense, since any physical system, also a biological organism, is not immune from the action of gravity, which influences its dynamical aspects (macroscopic, molecular *etc.*) and consequently causes time dilation as a force which interferes with motion.

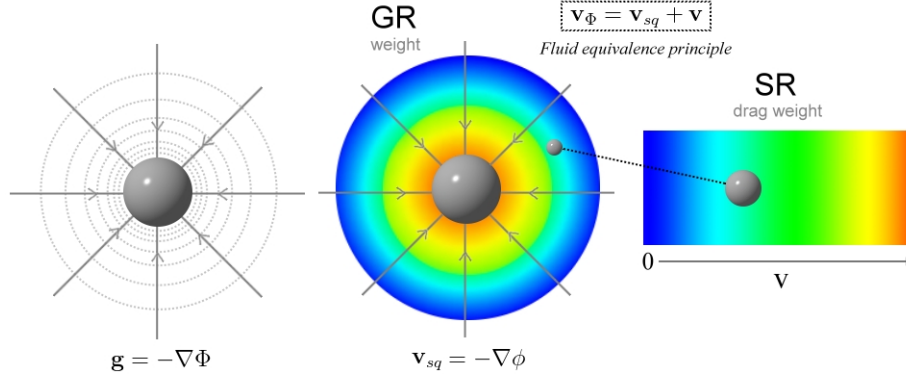


Figure 14: equivalence of a gravitational field and a velocity field, where the latter corresponds to the absorption velocity (v_{sq}). In both cases we have a sink at the origin and equipotential surfaces. On the right, a given translational velocity (SR) through SQS corresponds to being in a point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

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's hypothesize that a photon is a pulse through a fluid medium, *i.e.* a phonon through SQS. As shown below, many equations and facts would confirm that. But first of all, it is necessary to point out that

- the Michelson-Morley experiment [11] is in this case meaningless, inasmuch the hypothesis of SQ absorption (4) entails that *the ether wind corresponds to the gravitational field*, as an incoming flow of SQ. Light traveling upward or downward in a gravitational field would be then respectively subject to a red-/blueshift (24) and would be curved by the field when it travels not parallel to it (as sound is bent by wind), phenomena whose effects are also described in GR (gravitational redshift and curvature of light in a gravitational field). The MM-experiment is further discussed below.

By hypothesizing that a photon is a phonon through SQS, let's then consider the formula of the speed of sound through a fluid. By setting $\sigma = 1$ in Young's modulus ($E = \frac{\sigma}{\epsilon}$), we obtain $a = \frac{1}{\sqrt{\epsilon\rho}}$. When ϵ_0 is seen as quantum space's compressibility and ρ_0 as its density, we have

$$a = \frac{1}{\sqrt{\epsilon_0\rho_0}} \quad (15)$$

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

$$c = \frac{1}{\sqrt{\epsilon_0\mu_0}}. \quad (16)$$

Hence, photon's electromagnetic field might be described as a local variation in SQS's density (local energy variation) due to the compression caused by the pulse along with its spin (we know that also sound waves can spin [13, 17]), as illustrated in fig. 15.

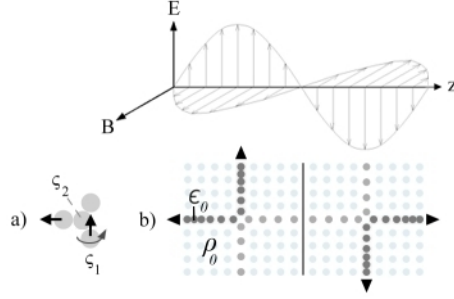


Figure 15: Density (ρ) and deformability (ϵ) of SQS at the origin of photon-phonon's transverse EM field (b), whose oscillations are due to harmonic, orthogonal compressions of space's quanta, while the main pulse is moving along the z -axis. On the left (a), the probable quantum mechanism at the origin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

To highlight the relationship between photon's electromagnetic field and its total angular momentum, we also see that the latter is related to ϵ_0 , that is - valid the adimensional equivalence $\epsilon_0\rho_0 = \epsilon_0\mu_0$ (15, 16) - to SQS's deformability (ϵ_0):

$$\mathbf{J} = \epsilon_0 \int \mathbf{r} \times (\mathbf{E} \times \mathbf{B}) d^3\mathbf{r} \quad (17)$$

and deformability is inevitably pertaining to a variation in how mass-energy (*i.e.* SQ) is locally distributed.

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

$$E_n = (n + \frac{1}{2})\hbar\omega \quad (18)$$

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

$$E_n = (n + \frac{1}{2})\hbar\omega_k \quad n = 0, 1, 2, 3, \dots \quad (19)$$

Both photons and phonons:

- are bosons [14]
- possess wave-particle duality [15, 16]
- 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 [13, 17]
- can form squeezed coherent states [12]
- can interact via parametric down conversion [12]

If a photon is a phonon (pulse) of space's quanta through SQS, the parameter β in Lorentz factor is then intelligible as the ratio between the speed of a body through the SQS and that of a pulse through it, which is faster than any translational velocity since it doesn't imply shear stress (furthermore photons are massless) and doesn't induce dilatancy. 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 [18]: $\left(\frac{v}{v_s}\right)^2 \implies \left(\frac{v}{c}\right)^2 \equiv \beta^2$.

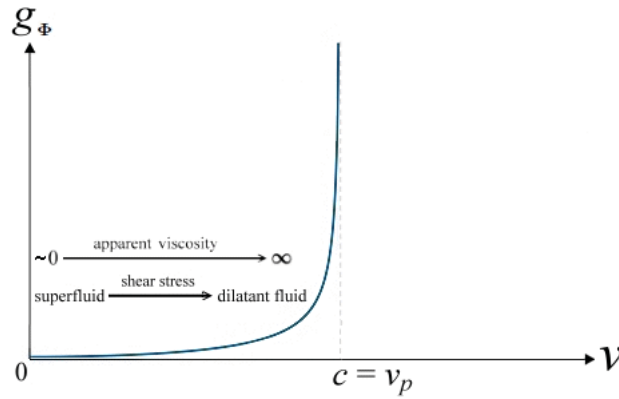


Figure 16: motion induced gravitational acceleration (g_Φ) causing drag weight ($W_\Phi = mg_\Phi$) increase, currently interpreted as relativistic mass increase. This graph can also be read as a rheogram of fluid quantum space. As shear rate and the velocity of the relative flow of SQ shift toward relativistic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

According to SQS:

- Lorentz factor is then interpretable as $\arcsin' \frac{v_\Phi}{v_p}$:

$$\gamma \equiv \frac{1}{\sqrt{1 - \left(\frac{|v_{\Phi}|}{v_p}\right)^2}} \quad (20)$$

where v_p , is the speed of a pulse through the fluid space and v_{Φ} is the relative velocity from the FEP. By approaching $v_p = c$, fluid space's dilatancy would play a key role in preventing further acceleration. Valid the analogy photon-phonon (15), 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 $v_s^2 \equiv \frac{1}{\rho_0 \kappa}$ in [18] 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 through a fluid space.

Moreover, $E = mc^2$ would be intelligible as the ratio between the rest mass-energy of a body and the energy of 1 m^3 of SQS¹ (ρ_0) multiplied by the Young's modulus for SQS ($\frac{\sigma_0}{\epsilon_0} = \Upsilon$), where $\sigma_0 = 1\text{Pa}$:

$$E = mc^2 = \frac{m \sigma_0}{\rho_0 \epsilon_0} = \frac{m}{\rho_0} \Upsilon. \quad (21)$$

And Lorentz factor can be now written in the form:

$$\gamma \equiv \frac{1}{\sqrt{1 - |v_{\Phi}|^2 \rho_0 \Upsilon^{-1}}} \quad (22)$$

where v_{Φ} expresses the FEP. It means that (22) could be used also in place of $\frac{1}{\sqrt{1 - \frac{R_s}{r}}}$ if we knew the velocity of the flow of SQ in a given point of a gravitational field (fig. 14).

- Valid the analogy photon-phonon, Hubble's law would be compatible with photons' energy loss (\Rightarrow redshift) after they've traveled great distances through SQS, instead of being a mysterious acceleration of distant galaxies.

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

- The known, infinitesimal but unstoppable dissipation of energy occurring in the orbits of celestial bodies, which would be caused by the minimal viscosity of SQS.
- Gravitational waves, which would be described as a periodic variation in SQS's density caused by the variable position of a quadrupole in time (fig. 17), corresponding to a variable rate in the absorption of SQ.

¹Indeed obvious if fermions are superfluid vortices of space's quanta [3]

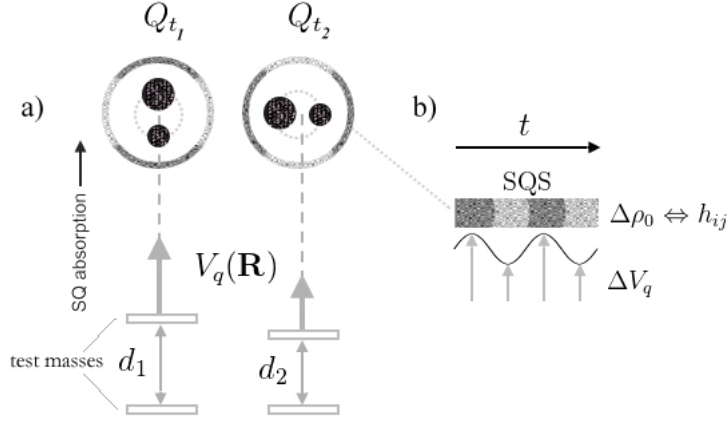


Figure 17: Gravitational waves according to fluid quantum gravity. A cyclical variation in SQS's density, due to a likewise cyclical variation of the absorption velocity (changing position of the quadrupole) may explain them without the concept of spacetime deformation.

The changing rate in the absorption of space's quanta, occurring twice the orbital frequency, causes periodic decompressions in SQS (fig.17.b), which determine the gravitational waves as

$$\Delta\rho_0 2\omega_q. \quad (23)$$

where $\Delta\rho_0$ is interpreted as h_{ij} . In linear gravity we have: $g_{ij} = \eta_{ij} + h_{ij}$.

Still about the MM-experiment, that test should be performed again by measuring the frequency shift of laser beams traveling up-/downward in a gravitational field, by using however a different interferometer (Hanbury-Brown-Twiss) to avoid the cancellation of the sought effect due to the round trip of the beams in the Michelson interferometer. A blueshift should occur for light traveling downward and, vice versa, we should observe a redshift. A short distance between the source and the detector should exclude Einstein's redshift as a cause (*i.e.* if we have minimal difference in the intensity of the gravitational field between source and detector). Within the photon-phonon analogy, the frequency shift should be indeed due to different speeds of light, since the velocity of the gravitational field (SQ-flow velocity, not to be confused with its speed of action) should be subtracted or added to c , determining a blue-/redshift according to:

$$f_{obs} = \frac{c + (v_{\phi_{obs}} - v_{\phi_{source}})}{\lambda_{source}} \quad (24)$$

where f_{obs} is the observed frequency and $v_{\phi_{obs}} - v_{\phi_{source}}$ the difference between the velocity of the gravitational flow at the point of observation and that at the source. One could object that also c is then relative and unreliable but

it is simply the speed of light *when not modified by a gravitational field*. In a round trip travel of light, its speed is unmodified when detected. Thus, in an Earth-Moon round trip test for measuring the speed of light, the slower velocity of the outward trip would be indeed compensated by the faster velocity during the return trip: a difference could be noticed only in a one way trip of light.

- An experimental verification of this theory (fluid quantum gravity and relativity and light as phonons through a fluid quantum space) could be obtained by measuring on the ISS the frequency of a laser beam fired from Earth, by using a frequency meter whose internal clock has been synchronized with the clock on Earth at the source. If Einstein's redshift is correct, the device should detect the same frequency of the source (since time dilation has been compensated by the synchronization). On the contrary, if a slight redshift is in any case measured it will depend on the correctness of this theory.

If we now analyze the twin paradox according to fluid quantum relativity, we see that the paradox vanishes. The younger twin after the trip, will be that who has been subject to a faster flow of SQ for a longer time (by comparing the flow of the gravitational field on Earth, where his brother is, with that induced by velocity on board the rocket). What is important here is the motion of a body relative to SQS (\Rightarrow FEP), not that of a twin relative to the other. In this way we bypass Von Laue's and Halsbury's reasonings. The twin in the rocket is not supposed to travel in an inertial frame of reference, so the strong equivalence principle doesn't apply here: if he brought on board a frequency meter and a laser emitter which produces a beam with a known frequency at his brother's location, by applying (24), the measured frequency shift, net of Einstein's redshift and doppler effect, would unveil direction and velocity of his frame of reference, making possible to understand which of the two brothers will be younger at the end of the travel.

We could wonder now what the formula to calculate \mathbf{g}_Φ is, *i.e.* the gravitational field induced by velocity (fig. 13). The reasoning could start from the drag force formula used in fluid dynamics

$$\mathbf{F}_D = -\hat{\mathbf{v}} \frac{1}{2} \rho v^2 C_D A \quad (25)$$

by putting $\mathbf{F}_{D_{qs}} = \mathbf{W}_\Phi = m\mathbf{g}_\Phi$, where $F_{D_{qs}}$ is the drag force of a body traveling through SQS (corresponding to drag weight), the following form is suggested

$$\mathbf{W}_\Phi = m\mathbf{g}_\Phi = mK_C \frac{1}{2} \rho_0 |\mathbf{v}_\Phi|^2 \sqrt{1 - |v_\Phi|^2} \rho_0 \Upsilon^{-1}(-\hat{\mathbf{v}}_\Phi) \quad (26)$$

where $-\hat{\mathbf{v}}_\Phi$ is a unit vector indicating that the force acts in the opposite direction to translational velocity, \mathbf{v}_Φ is the relative velocity of the flow of SQ for the body in motion according to the FEP (10), ρ_0 is the density of SQS,

$\sqrt{1 - |v_{\Phi}|^2} \rho_0 \Upsilon^{-1}$ is the reciprocal of Lorentz factor (22), which expresses the asymptote of velocity due to the dilatant behavior of granular fluid space as shear stress increases and mK_C corresponds to AC_D in (25), since - by considering the gravitational field as the flow - the drag force depends in this case on mass (as in a mass-induced gravitational field, where weight can be considered a drag force pointing toward the center of the greater body), not on a surface (A) on which the flow acts, nor on the shape (C_D) of the body. However, since SQ would be much finer than a fermion and there are no vacuum regions in SQS, we can suppose that fermions have an impact surface, which is surely directly proportional to the body's mass (\Rightarrow number of fermions) and could be expressed through a conversion factor surface-mass (K_C), whose units are m^2/kg .

The gravitational field is therefore expressed as $\mathbf{g} = -\hat{\mathbf{r}} \frac{1}{2} \frac{v_e^2}{r} = -\hat{\mathbf{r}} \frac{GM}{r^2}$, when gravity is caused by the mass of a celestial body and as $\mathbf{g}_{\Phi} = -\hat{\mathbf{v}} \frac{1}{2} |v_{\Phi}|^2 \rho_0 K_C \alpha$ when the gravitational force (as drag weight) is produced by motion, where α is the reciprocal of Lorentz factor.

Lastly, black holes can exist in fluid quantum gravity, as celestial bodies on which the escape velocity is $v_e \geq c$, but lacking singularity. While an event horizon can form. If a star's collapsing is not instantaneous, its density will gradually increase. However, when the absorption velocity will be $v_{sq} \approx c$, the FEP predicts that an asymptote appears at $v_{sq} = c$. As a matter of fact, because of quantum space's dilatancy, the incoming flow of SQ acting on the surface of the star can't have velocity $v = c$, or the star would be in the same (impossible) situation of a body traveling at the speed of light (10, fig. 14). When approaching that limit, it is plausible that the boundary layer of the star (*i.e.* the part of it most exposed to the flow) is annihilated into photons or space's quanta themselves². Photons could remain trapped, since $v_e > v_{sq}$, so we can have $v_e > c$ although $v_{sq} < c$ (as they respectively depend on $V = \frac{GM}{r}$ and $g = \frac{GM}{r^2}$), while SQ could be absorbed, reducing the gravitational flow and keeping $v_{sq} < c$. Boundary layer annihilation (might it have a correlation with Hawking radiation?) would therefore maintain the equilibrium. Since $v_e > v_{sq}$, an event horizon could form when $v_{sq} \approx c$. But not singularities, since

$$r \rightarrow 0 \Rightarrow \rho \rightarrow \infty \Rightarrow v_{sq} \rightarrow \infty$$

which implies the forbidden condition $v_{sq} \geq c$.

References

- [1] H. B. G. Casimir, Proc. K. Ned. Akad. Wet. 51, 793 (1948)
- [2] P. W. Milonni, The Quantum Vacuum (Academic Press, San Diego, 1994); V. M. Mostepanenko and N. N. Trunov, The Casimir Effect and its Applications (Clarendon, Oxford, 1997); K. A. Milton, The Casimir Effect (World Scientific, Singapore, 2001).

²assumed that fermions are superfluid vortices of SQ [3]

- [3] Fedi M., Hypothetical role of quantum space superfluid dynamics in the physics of particles and fundamental interactions. <https://hal.archives-ouvertes.fr/hal-01223102>
- [4] V.I.Sbitnev, Hydrodynamics of the physical vacuum: II. Vorticity dynamics, arxiv.org/abs/1603.03069
- [5] A. V. Avdeenkov and K. G. Zlochastiev, Quantum Bose liquids with logarithmic nonlinearity: Self-sustainability and emergence of spatial extent, *J. Phys. B: At. Mol. Opt. Phys.* 44 (2011) 195303
- [6] D.Eichler, Searching for granularity of the vacuum, [arXiv:astro-ph/9811020v3](https://arxiv.org/abs/astro-ph/9811020v3) 22 Mar 1999
- [7] L.F.Gomez, K.R.Ferguson, J.P. Cryan et al., Shapes and vorticities of superfluid helium nanodroplets, *Science*, Vol. 345 n. 6199 pp. 906-909
- [8] H.Marmanis, The kinetic theory of point vortices, *The Royal Society*, vol. 454, 1998
- [9] G. E. Volovik, The Universe in a helium droplet, *Int. Ser. Monogr. Phys.* 117 (2003) 1-507.
- [10] Sean M. Carroll, Lecture notes on General Relativity, arxiv.org/pdf/gr-qc/9712019v1.pdf
- [11] Michelson, Albert A.; Morley, Edward W. (1887). "On the Relative Motion of the Earth and the Luminiferous Ether". *American Journal of Science* 34: 333–345
- [12] Reiter, D E; et al. (2009). "Generation of squeezed phonon states by optical excitation of a quantum dot", *J.Phys.: Conf. Ser.* 193 012121, Institute of Physics.
- [13] Santillán, A.O.; Volke-Sepúlveda, K. (2009), "A demonstration of rotating sound waves in free space and the transfer of their angular momentum to matter", *Am. J. Phys.* 77, 209
- [14] Feynman, Richard P. (1982). *Statistical Mechanics, A Set of Lectures*. Reading, Massachusetts: The Benjamin/Cummings Publishing Company, Inc. p. 159
- [15] Einstein, A. (1909). "Über die Entwicklung unserer Anschauungen über das Wesen und die Konstitution der Strahlung". *Physikalische Zeitschrift*, 10: 817–825
- [16] Saleh, B. E. A. and Teich, M. C. (2007). *Fundamentals of Photonics*. Wiley
- [17] Jiang, X.; Liang, B. *et al.* (2014), "Broadband field rotator based on acoustic metamaterials", *Appl. Phys. Lett.* 104, 083510

- [18] Malmi-Kakkada, A.N.; Valls, O.T.; Dasgupta, C., (2014) “Hydrodynamics of compressible superfluids in confined geometries”, *Journal of Physics. B, Atomic, Molecular and Optical Physics*; v. 47(5)