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Special and general relativity according to superfluid quantum space.

Fluid quantum relativity.

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Abstract

by starting from the mathematically demonstrated quantum fluid dynamic reformulation of Newton's law of universal gravitation [1], it is shown how the principle of equivalence can be likewise reformulated according to a hypothetical superfluid quantum space. From this, special and general relativity are incorporated in fluid quantum gravity, which can also explain GR's curved spacetime as a fluid dynamic phenomenon. The unification of gravity and Einstein's relativity with QFT would be easily completed without resorting to gravitons or string theory. Relativity would be moreover simplified, since only a primary relativistic effect would exist, mass increase, which in this work is shown as an increase of inertia due to a gravitational force acting in the opposite direction to motion, due to the fluid equivalence principle. Time dilation and length contraction would be respectively second and third-order effects. A minor correction in the classical formula of weight seems necessary and the nature of light is reconsidered according to superfluid quantum space. Indications are given for experimental verification.

1 Fluid principle of equivalence and relativistic mass increase.

This work starts from the mathematically proved mechanism of fluid quantum gravity [1], which entails that Newton's law of universal gravitation may be fluid dynamically reproduced by placing the hypothesis that fermions absorb space's quanta (SQ), as they would be superfluid vortices (topological defects) in

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superfluid quantum space (SQS), a theoretical framework, which seems moreover to show how to attain a complete unification of the fundamental interactions. From this point of view, a gravitational field is a flow of SQ directed toward the center of a massive body and the principle of equivalence (both in its weak and strong form) can be fluid dynamically reformulated (fig. 1). When the fluid in question is SQS, the principle assumes a quantum aspect and acts as entrance door to quantum gravity and quantum relativity.

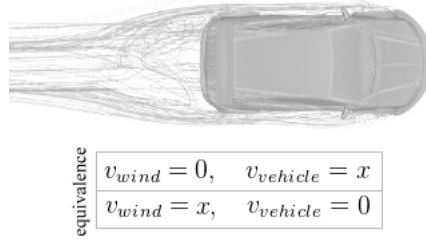


Figure 1: Fluid equivalence principle: it is impossible to distinguish between the two equivalent situations of a body moving through a fluid and a fluid moving toward the body at the same velocity. The same would occur regarding a body interacting with SQS.

The fluid explanation of the weak equivalence principle (gravitational mass = inertial mass) and of Einstein's equivalence principle is easily demonstrated in fig. 1. since the total velocity of the fluid relative to the vehicle is

$\mathbf{v}(x) = \mathbf{v}_{wind} + \mathbf{v}_{vehicle}$, which in fluid quantum gravity becomes:

$$\mathbf{v}_{\Phi} = \mathbf{v}_{sq} + \mathbf{v} \quad (1)$$

where \mathbf{v}_{Φ} is the velocity of the flow relative to the moving body, resulting from the vector sum of the velocity at which the SQ are absorbed (\mathbf{v}_{sq}) and the body's translational velocity (\mathbf{v}). For instance, an acceleration of 9.81m/s^2 for a body in a rocket, where all gravitational fields tend to zero, is therefore equivalent to being stationary in Earth's gravitational field, also from a quantum point of view. If (1) is valid, there must exist a formula which equates gravity to translational velocity. We can derive it by equating the formulas for time dilation of special and general relativity:

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

hence

$$\frac{v^2}{c^2} = \frac{R_S}{r} = \frac{2GM}{c^2 r} = v^2 \frac{1}{c^2} = \frac{2GM}{r} \frac{1}{c^2} \implies v^2 = \frac{2GM}{r} \quad (3)$$

and

$$v = \sqrt{2rg} = \sqrt{2V}. \quad (4)$$

where V is the gravitational potential and v corresponds to the SQ's drift velocity in the gravitational field (and, consequently, also to the escape velocity) while when $g \rightarrow 0$, we can only have translational velocity, which - according to the fluid equivalence principle (FEP)(1) -, produces the same relativistic effects. For instance, since SQ's drift velocity in Earth's gravitational field is ~ 11180 m/s (4), a body traveling at the same velocity where the field is irrelevant will undergo the same time dilation caused by Earth's gravitational field. It is thus demonstrated that the FEP applies to special and general relativity and attributes the cause of time dilation only to gravity, also in special relativity. This is a first simplification, thanks to the quantum approach of fluid space, which shows how Lorentz factor actually refers to an *increase of gravity opposite to motion*. As discussed below, this fact can also explain the increase of inertia in accelerated bodies, currently interpreted as relativistic mass increase. It is also interesting to notice that the speed of light cancels in the calculations, leading to an equation which simply relates velocity to gravity (4). From it, we have:

$$g = \frac{v^2}{2r} \quad (5)$$

which means that the intensity of a gravitational field quadratically depends on the velocity at which a mass absorbs SQ at a given distance, still according with the CFD simulations [1].

An additional reverse demonstration of Lorentz factor as increase of gravity opposite to motion, is obtained if we consider c as the distance traveled by light in one second, and in (5) we set $r = 4.5 \cdot 10^{16}$ m, as the notable distance d_N . We have $c = \sqrt{2d_N} \Rightarrow 2d_N = c^2$ and the identities:

$$g_N = \frac{\|\mathbf{v}_\Phi\|^2}{2d_N} = \frac{\|\mathbf{v}_\Phi\|^2}{c^2} \Leftarrow \frac{v^2}{c^2} = \beta^2 \quad (6)$$

where g_N is the value of g calculated by using d_N , v_Φ is the relative velocity of the flow (1) and β refers to $\frac{v^2}{c^2}$ in Lorentz factor. It is interesting to notice that β^2 , or g_N in its fluid reformulation, can be described as a dimensionless expansion parameter of compressible¹ SQS, identical to that described for other compressible superfluids by Malmi-Kakkada, Valls and Dasgupta [23](left):

$$\left(\frac{v}{v_s}\right)^2 \Rightarrow \left(\frac{\|\mathbf{v}_\Phi\|}{c}\right)^2 = g_N \quad (7)$$

where the speed of sound (v_s) in the superfluid can be equated by analogy to that of light, when considering photon as a phonon through SQS (§5). According to (6) Lorentz factor (9), conformed to the FEP, follows as:

¹primordial inflation and the expansion of the universe suggest that compressibility is a physical property of SQS.

$$\vec{\gamma}_\Phi \equiv -\hat{v}_\Phi \arcsin' \sqrt{g_N} = -\hat{v}_\Phi \frac{1}{\sqrt{1-g_N}} = -\hat{v}_\Phi \frac{1}{\sqrt{1-\frac{\|\mathbf{v}_\Phi\|^2}{2d_N}}} = -\hat{v}_\Phi \frac{1}{\sqrt{1-\frac{\|\mathbf{v}_\Phi\|^2}{c^2}}} \quad (8)$$

where

$$\|\vec{\gamma}_\Phi\| \Leftarrow \frac{1}{\sqrt{1-\frac{v^2}{c^2}}} \quad (9)$$

(*q.v.* also (47) for $\vec{\gamma}_\Phi$ as function of \vec{v}_Φ and SQS's density) where γ is derived as a mere function of gravity and is expressed as a vector, since it corresponds to an increase of gravity in the opposite direction to motion ($-\hat{v}_\Phi$), clarifying the cause of the so-called relativistic mass increase, which would be actually a *weight* increase opposite to motion (drag weight), detected as an increase of inertia and erroneously interpreted as a mass increase.

The peculiar mathematical increase of γ as the derivative of the arcsine of $\sqrt{g_N}$ can be understood along with the physical properties of SQS. In fact, this implies that SQS acts as a non-newtonian dilatant fluid, showing apparent viscosity as a reaction to shear stress brought to relativistic velocities. Indeed, no superfluid has exact zero viscosity. SQS's minimal viscosity would then play a decisive role, when shear stress is driven toward the speed of light by accelerating a body (such as a subatomic particle) through SQS until it reaches relativistic velocities. The reason why exactly c is the asymptote is discussed below (fig.5)(§5, *phonoton*).

There's however no physical limit (Lorentz factor doesn't apply) to the velocity of bodies which are falling in a gravitational field, as they fall *with* the SQ (fig. 3, case A) and don't undergo SQS's γ -increasing apparent viscosity.

Indeed, from (5) we see that the intensity of a gravitational field (in fig. 2 mass and radius are linked as density, similarly to Gauss's law for gravity) increases with the density of the attracting body, without any asymptote, allowing the absorption of SQ to occur at $v_{sq} \geq c$. It is assumed that this is the case of a black hole (BH).

1.1 Black holes.

A body could then have a velocity of fall into a BH $v \geq c$ but, according to the FEP, once on the surface - if there was one - it would be suddenly in the same situation of a body travelling at, or over, the speed of light. A case forbidden both by Einstein's relativity and by this quantum fluid reformulation of it (8)(fig.4, 5)(§5). Actually, the surface itself would be subject to an incoming flow of SQ moving at, or over, the speed of light.

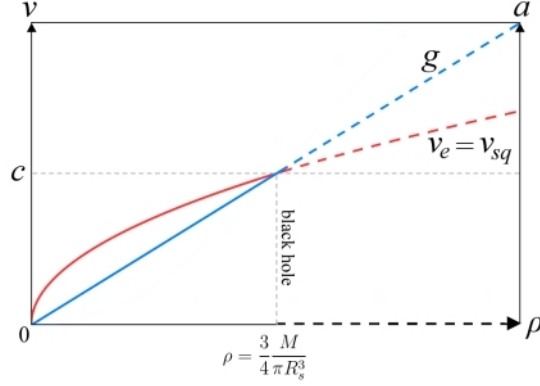


Figure 2: SQ-absorption velocity (= escape velocity) and intensity of a gravitational field according to density.

Either a BH has therefore no surface and is actually a singularity or the drift velocity of the SQ (v_{sq}) in a BH's gravitational field is more realistically $\lesssim c$. Light's speed and frequency would drop almost to zero and the celestial body would be, in any case, black. Fluid quantum gravity therefore agrees with Chapline [24] and Vachaspati, Stojkovic, Krauss [25], where they assert that BHs' horizons can't form. This would mean that, at a certain point, no further matter can be added to a BH's mass (to avoid $v_{sq} = \sqrt{2V} \geq c$). Thus, once attracted until the surface, matter would be probably annihilated, perhaps decomposed into SQ, according to [1], which describes fermions as superfluid vortices of SQ. Matter decomposition into SQ would solve the BH information paradox and BHs would appear as a sort of recycling plants of the universe. In such circumstance, BHs' density couldn't be $\geq 1.8517 \cdot 10^{19} \text{kg/m}^3$, calculated as:

$$\rho = \frac{3}{4} \frac{M}{\pi R_s^3} \quad (10)$$

BHs wouldn't be gravitational singularities but massive spheroids, whose density provokes the absorption of SQ *almost* at the speed of light and matter's decay into SQ. Of course, as far as supermassive black holes are concerned, a greater mass doesn't necessarily correspond to a greater density and it is impossible to theoretically vary the mass and the radius of a celestial body to obtain $v_{sq} \geq c$ (4) without falling in the case $r \leq R_s$.

The fact that neither an escape velocity $v_e \geq c$ nor, then, event horizons can be associated to BHs is already evident in (2) where

$$\frac{v^2}{c^2} < 1 \Leftrightarrow \frac{R_s}{r} < 1 \quad (11)$$

Also by putting $v = c$ in (4) we have that R_s is an asymptote as well as light's velocity:

$$c = \sqrt{\frac{2GM}{r}} \Rightarrow r = \frac{2GM}{c^2} = R_s \quad (12)$$

hence (10) represent the universal asymptote for density in fluid quantum relativity.

1.2 Weight in fluid quantum gravity.

When a gravitational field is described as a flow of SQ, and since SQS has a small (non zero) viscosity, like any superfluid, a difference occurs in the weight force acting on a body, depending on whether it is falling (along with SQ) in a gravitational field (fig. 3, case *a.*) or it is stationary in the field (case *b.*) and therefore undergoes SQ's apparent viscosity.

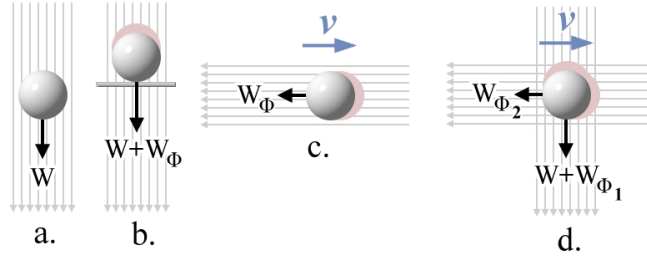


Figure 3: Weight in fluid quantum gravity: (a) normal weight (classical formula) for a body falling with SQ in a gravitational field; (b) if the body is in equilibrium in the field it undergoes SQ's apparent viscosity (pink halo) and, therefore, an additional force (\mathbf{W}_Φ) in the direction of the flow (of the order of $+10^{-10}$ kg per kilogram for a stationary body on Earth); (c) the same force acts on a body in motion outside of a gravitational field (FEP \Rightarrow apparent flow); (d) if a body is moving in a gravitational field all forces are combined.

As shown in fig. 3, when a body undergoes SQ's apparent viscosity (cases b, c, d), which increases with velocity, an additional force (\mathbf{W}_Φ), depending on the *fluid* Lorentz factor (8), acts on it, in the direction of the flow. Since near Earth's surface $v_{sq} = v_e \approx 11180$ m/s, this effect isn't noticed, as it would produce a difference of only $7 \cdot 10^{-10}$ kg per kilogram but it would become evident in synchrotrons for accelerated particles (as in fig. 3, case c, with \mathbf{W}_Φ diverging as $v \rightarrow c$). This means that the relativistic phenomenon of mass increase due to velocity is actually *a weight increase in the opposite direction to motion*. Observed as an increase of inertia opposite to motion and interpreted as mass increase.

This suggests to reconsider the formula of weight according to different situations:

| | fall, $g>0$ | eq., $g>0$ | $v>0, g\rightarrow 0$ | $v>0, g>0$ | eq., $a>0, g\rightarrow 0$ | $a>0, g>0$ |
|--|-------------|---------------------------|-----------------------|-------------------|----------------------------|----------------------------------|
| $\mathbf{W}_{\text{tot}} = \mathbf{W} + \mathbf{W}_{\Phi}$ | mg | $m(g + g_{\Phi}) \dagger$ | mg_{Φ} | $m(g + g_{\Phi})$ | $m(a + g_{\Phi}) \dagger$ | $m(a + g_{\Phi} + g + g_{\Phi})$ |
| $\mathbf{F} \neq \mathbf{W}$ | | | | | | |

where \mathbf{W}_{tot} is the vector sum of the gravitational forces acting on a body: normal weight, \mathbf{W} , and the relativistic *drag weight*² $\mathbf{W}_{\Phi} = m\mathbf{g}_{\Phi}$, concordant with the direction of the flow, where

$$\mathbf{g}_{\Phi} = \vec{\gamma}_{\Phi} - 1 \quad (13)$$

assessing the gamma-increase of gravity (8) in the direction of the flow and opposite to motion. The symbol \dagger indicates equivalent situations if $\mathbf{a} = \mathbf{g}$ (equivalence principle). The formula to express the total weight (also opposite to motion) in fluid quantum gravity is therefore:

$$\mathbf{W}_{\text{tot}} = m(\mathbf{g} + \mathbf{g}_{\Phi}) \quad (14)$$

in Earth's gravitational field, where $\mathbf{g}_{\Phi} \approx 0$, and at subrelativistic velocities, the classical formula applies. Fig. 4, shows the relativistic mass increase according to the reformulated Lorentz factor (8), which expresses the fluid properties of quantum space.

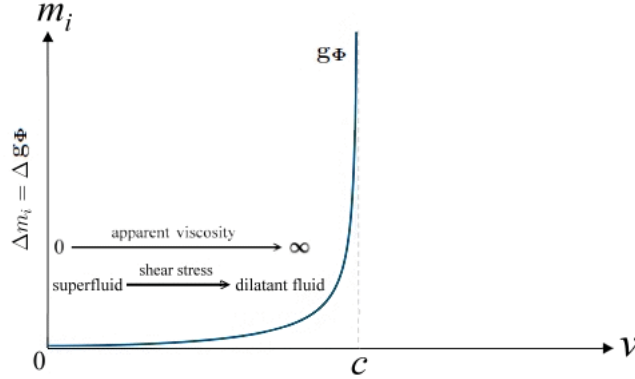


Figure 4: relativistic mass increase as drag weight increase, where $\Delta\mathbf{g}_{\Phi}$ is currently interpreted as Δm_i . This graph can also be interpreted as a rheogram of quantum space. As shear rates and flow velocities move toward relativistic values, collisions among SQ intensify and viscosities, albeit initially near-zero, critically increase, until fluid space's dilatant behavior produces an asymptote (see also fig. 5).

This quantum fluid reformulation of gravity and relativity shows how mass increase (we say now *drag weight increase*) can be considered the only fundamental relativistic effect, as discussed below (§2,3).

²in reference to the aerodynamic drag.

Before concluding this section, it is important to point out the difference between SQ's drift velocity (\mathbf{v}_{sq}) and the speed of action of gravity. The difference is analogous to that occurring between electrons' drift velocity along an electric wire (very slow, max ~ 6 m/s in superconductors) and the speed of action of electricity (pulse). This theory assesses the velocity of action of gravity at $\lesssim c$, for two reasons:

1. the absorption of SQ (drift velocity) can't occur at $v_{sq} \geq c$ if a density limit for BHs applies (10).
2. the propagation speed of a pulse through SQS exactly corresponds to the speed of light when a photon is described as a phonon of SQ traveling through SQS (see §5). A similar reasoning can explain why also gravitational waves travel at c (§ 4.1).

2 Relativistic time dilation.

Time dilation can be explained as a direct consequence of drag weight increase (14), in other words it would be a *secondary* relativistic effect. First of all, we know that time is never slowed down: only clocks are. In physics time is always linked to clocks and any clock works thanks to its mechanics, by means of energy and forces. For instance, when considering the case of a mechanical clock, a given amount of energy (from its battery, spiral mainspring *etc.*) produces a given force, which corresponds to a given movement, *e.g.* a tick of the second hand. When the same clock is situated in a stronger gravitational field, the weight of all its components increases and this means that a greater amount of energy would be necessary to produce greater forces and to keep the tempo. However, since the supplied energy remains the same and becomes insufficient, the clock slows down. This occurs also for caesium clocks since, once the atoms have been launched upwards by laser beams, they fall back down under gravity: they therefore mark time differently in different gravitational fields. The same happens for a pendulum: $T_0 = 2\pi\sqrt{\frac{\ell}{g}}$. Practically, every dynamic system, also biological, based on movement (in which the weight increase of its components can slow its mechanical processes) can be considered a clock and is subject to time dilation. Moreover, also cosmic muons are influenced by gravity, thus, their relativistic velocity (which provokes a greater gravity acting on them, in agreement with the FEP) is able to lengthen their life, by slowing their quantum mechanical processes. In the formula

$$T_c = \frac{F_f + W}{F_c} = 1 \quad (15)$$

a clock is calibrated to have a period $T_c = 1$ s, by counteracting internal friction (F_f) and gravitational force (W) by means of an equal force (F_c). By cancelling mass, we express the accelerations acting on the clock:

$$T_c = \frac{\cancel{m}a_f}{\cancel{m}a_c} + \frac{\cancel{m}g}{\cancel{m}a_c} = \frac{a_f + g}{a_c} = 1 \quad (16)$$

However, when a clock moves through SQS, another gravitational acceleration, oriented in the opposite direction to motion and due to the FEP, starts to act according to (8, fig.4). Therefore, in (16) we have to add drag acceleration g_Φ , which remains unbalanced and slows down the clock, by increasing the weight of its components (13):

$$T' = \frac{a_f + g}{a_c} + g_\Phi \geq 1 \quad (17)$$

(17) corresponds to (16) only if $g_\Phi = 0$ (stationary clock), otherwise T' refers to the travelling clock's dilated period. Thus, time dilation reduces to the quantum relativistic increase of gravity g_Φ . Below it's shown how the main hypothesis (15) actually corresponds to Lorentz factor, *i.e.* time dilation in SR. From (13) we know that: $\gamma_\Phi = 1 + g_\Phi$. Hence

$$T' = T_c + g_\Phi = 1 + g_\Phi = \gamma_\Phi = \frac{1}{\sqrt{1 - \frac{v_\Phi^2}{c^2}}}. \quad (18)$$

We have obtained SR's formula for time dilation (Lorentz factor), now conformed to the FEP (use of v_Φ), which can be therefore used also for gravitational time dilation.

The use of the further GR's formula $t' = \frac{1}{\sqrt{1 - \frac{R_S}{r}}}$ is then not necessary.

Here time dilation is thence a *secondary* relativistic effect, depending on the drag weight increase of clocks' components (Q.E.D.).

It is interesting to see that, in fluid quantum relativity, the well-known twin paradox is easily solved by (18), as it resorts to SQ's relative velocity (v_Φ) from the FEP instead of the relative translational velocity used in the standard Lorentz factor (equal for both brothers \Rightarrow paradox).

This means that the SQ's velocity relative to the traveling twin is equal to his translational velocity, $v_{sq} = v_{rocket}$ (since $g \rightarrow 0$) while for the twin on Earth we know from (4) that $v'_{sq} = \sqrt{2rg}$, which means he's only subject to the flow of SQ of Earth's gravitational field. Thus, at the end of the travel, the younger twin will be that who has been subject to a higher value of v_{sq} (\Rightarrow greater gravity \Rightarrow greater time dilation): if the rocket has traveled at $v > 11180$ m/s (*i.e.* greater than v_{sq} on Earth), the brother who was inside it will be the younger one. In fluid quantum gravity, time dilation depends on the (direct or equivalent) gravitational flows acting onto clocks, whose velocity has to be specified for both twins (as v_Φ) and the paradox vanishes. The issue of acceleration is therefore not necessary and we bypass Von Laue's and Halsbury's reasonings. On the contrary, in non-quantum relativity we have only one value for velocity (the relative translational velocity of a twin compared to the other) and the paradox arises.

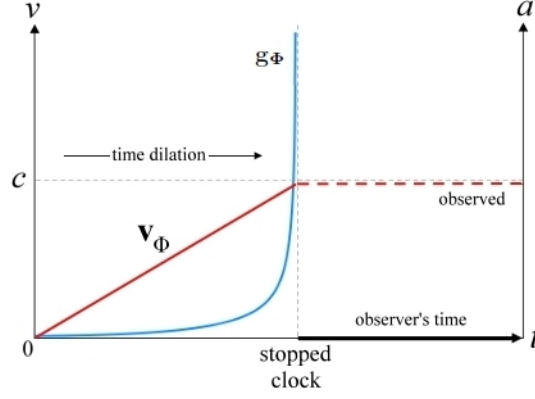


Figure 5: Gravitational drag weight increase opposite to motion (increase of \mathbf{g}_Φ , currently interpreted as mass increase) for a moving body, conforming to the FEP and time dilation.

Fig. 5 shows how the asymptote at c can be explained through time dilation, which for its part depends on the increase of gravity opposite to motion, \mathbf{g}_Φ : when the weight of a clock's parts is critically high and the clock stops, further acceleration is impossible:

$$\mathbf{a} = \frac{d\mathbf{v}}{dt}, \text{ if } T \rightarrow \infty \Rightarrow dt \rightarrow \infty \Rightarrow \mathbf{a} \rightarrow 0.$$

Near the point of time freezing, clock's period (T) diverges to infinity, as well as \mathbf{g}_Φ , acceleration stops and the translational velocity undergoes an asymptote.

To conclude this section, also the relativistic phenomenon of gravitational redshift is explainable according to SQS within the effect of time dilation, since an observer's clock located in a weaker gravitational field ticks faster. This means that the observer will measure a longer period for light waves (\Rightarrow redshift). Therefore, the current formula

$$\omega_1 = \omega_0 \frac{\sqrt{1 - \frac{R_S}{r}}}{\sqrt{1 - \frac{R_S}{r'}}}$$

where ω_1 is the observed frequency, is still valid in fluid quantum relativity but its quantum aspect emerges when it is expressed according to the FEP:

$$\omega_1 = \omega_0 \frac{\sqrt{1 - \left(\frac{v_\Phi}{c}\right)^2}}{\sqrt{1 - \left(\frac{v'_\Phi}{c}\right)^2}} \quad (19)$$

in which v_Φ is the SQ's drift velocity (calculated from (4)) where the light beam is emitted and v'_Φ where the observer is situated.

3 Lorentz-FitzGerald contraction.

Relativistic length contraction is here treated as a *third-order* relativistic effect, in that it depends on time dilation which, for its part, depends on drag weight increase. It affects *measurements* taken in two different frames of reference in relative motion, when compared. Also length contraction is therefore explainable within the theoretical framework of fluid quantum gravity. Let's consider fig. 6:

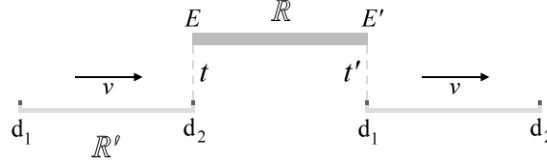


Figure 6: Relativistic length contraction. According to an inertial frame of reference (\mathbb{R}), the length $\overline{EE'}$, detected in the frame \mathbb{R}' , is shorter when measured in that frame, since in a moving frame of reference Lorentz factor has to be considered: $l_{\mathbb{R}'} = v \frac{\Delta t}{\sqrt{1 - \frac{v^2}{c^2}}}$.

Be \mathbb{R} an inertial frame of reference and \mathbb{R}' a frame moving with velocity v . The length $\overline{EE'}$ is measured in both frames by considering Δt as the difference $t' - t$, between the instants in which the detectors d_2 , d_1 respectively align with E , E' . The two measurements are determined by:

$$l_{\mathbb{R}} = v\Delta t \quad \text{and} \quad l_{\mathbb{R}'} = v \frac{\Delta t}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\text{and since } \frac{\Delta t}{\sqrt{1 - \frac{v^2}{c^2}}} > \Delta t \quad \implies l_{\mathbb{R}} > l_{\mathbb{R}'}$$

Clocks tick slower in \mathbb{R}' then Δt is shorter in that frame, as well as the measured length $\overline{EE'}$.

From (8), we can now replace the standard form with the corresponding quantum formula:

$$\vec{l}_{\mathbb{R}'} = \mathbf{v}_{\Phi} \frac{\Delta t}{\sqrt{1 - \frac{\|\mathbf{v}_{\Phi}\|^2}{c^2}}} \quad (20)$$

which indicates the contraction of the measured length in the direction of motion:

$$\vec{l}_{\mathbb{R}'} = \hat{v}_{\Phi} l_{\mathbb{R}'}.$$

4 How superfluid quantum space can replace Einstein's curved spacetime.

It is discussed how the fluid dynamics of SQS (gravitational flows due to fermionic absorption of SQ [1], corresponding to the tidal forces of GR) is able to reproduce and justify GR's curved spacetime as a fluid space and to reproduce any relativistic effect Einstein's theory predicts. This means that tensors in GR have to correspond to the mathematical description of what occurs under the effect of such flows.

For instance, the Schwarzschild solution

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

may correspond to a sphere absorbing the fluid space in which it is immersed: the geodesic of a body situated in the attraction field of such sphere would be indeed identical. This is the simplest case but since both Ricci tensor, which expresses how riemannian metric differs from euclidean space, and the Christoffel symbols depend on a metric tensor g_{ij} ,

$$\begin{pmatrix} g_{00} & g_{01} & g_{02} & g_{03} \\ g_{10} & g_{11} & g_{12} & g_{13} \\ g_{20} & g_{21} & g_{22} & g_{23} \\ g_{30} & g_{31} & g_{32} & g_{33} \end{pmatrix}$$

which refers to how to compute the distance between any two points in a given space, Einstein's field equations can be thought as an elegant tool by which the geometrical characteristics of space can be *arithmetized* by way of introducing a sort of generalized coordinate system [3], which describes space and time, depending on how mass-energy (the source of gravity) is distributed in it, as indicated by the energy-momentum tensor $T_{\mu\nu}$. Cauchy's tensor

$$\begin{pmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} \\ \sigma_{21} & \sigma_{22} & \sigma_{23} \\ \sigma_{31} & \sigma_{32} & \sigma_{33} \end{pmatrix}$$

used in fluid dynamics to describe small deformations occurring in fluids, wouldn't be so different from the metric tensor g_{ij} if we added time. Below, we see that Einstein's tensor is defined as the interaction between the metric tensor and the scalar curvature expressed by Ricci tensor ($R_{\mu\nu}$):

$$G_{\mu\nu} \equiv R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} \quad (22)$$

and the Christoffel symbols can be directly derived from the metric tensor:

$$\Gamma_{cab} = \frac{1}{2} \left(\frac{\partial g_{ca}}{\partial x^b} + \frac{\partial g_{cb}}{\partial x^a} - \frac{\partial g_{ab}}{\partial x^c} \right). \quad (23)$$

Also in fluid quantum gravity, the source of the attraction, discretized in GR by Christoffel symbols, is mass but it doesn't curve space, it absorbs it, producing tidal forces analogous to those described by GR. A discretization of space which, after all, is necessary also when performing CFD simulations. But, albeit geometrically useful as a calculation tool, space deformation is not theoretically necessary in the present approach: neither of Einstein's spacetime nor of superfluid quantum space, inasmuch what is rather able to replace spacetime's curvature is fluid dynamics itself: flows occurring in SQS, vortices *etc.* In this work, gravity is only a flow of space quanta which transports what is immersed in the SQS, as a floating object would be sucked into the spillway of fig. 7.b.

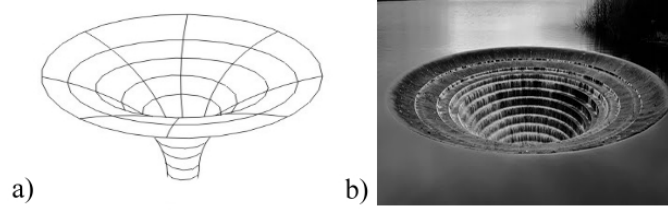


Figure 7: how the presence of a massive body curves spacetime (a) or absorbs it (b), here in analogy with a bell-mouth spillway.

In the following images, we see how fluid space can produce the same relativistic effects of general relativity.

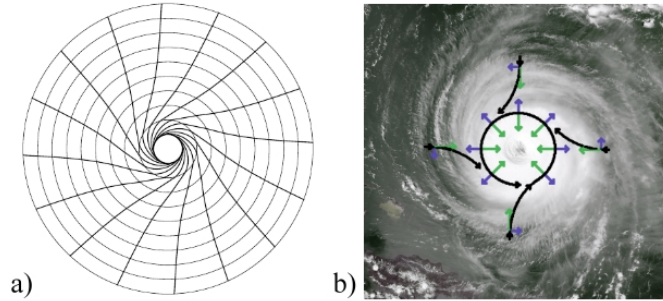


Figure 8: The Lense-Thirring effect according to Einstein's curved spacetime (a) and to fluid dynamics (b). Here as an analogy with the Coriolis effect in a cyclone.

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

$$B = -\frac{4}{5} \frac{m\omega R^2}{r^3} \cos \theta \quad (24)$$

and the Coriolis force can be written, in some respects, in a not so dissimilar form:

$$F_C = -2m\omega(\omega R)\mathbf{u}_R. \quad (25)$$

Other effects which can be described by fluid dynamics are, for instance, the gravitational lensing:

$$\vec{\alpha}(\vec{\xi}) = \frac{4G}{c^2} \int d^2\xi' \int dz \rho(\vec{\xi}', z) \frac{\vec{b}}{|\vec{b}|^2} \quad (26)$$

with $b \equiv \vec{\xi} - \vec{\xi}'$, where ξ, z are coordinates and $\hat{\alpha}$ is the deflection angle, which in fig. 9.a is determined by vector interaction between light's and SQ's momenta. The absorption of SQ is here illustrated as water flowing into a spillway. By considering a photon as a special spin-1 phonon, as discussed in §5, SQS interestingly curves light beams as wind curves sound waves. In this case, gravitational lensing would rather mean that light is moving in a superfluid medium (SQS), where flows occur, not that space is statically curved by a mass. Equations in (§5) seem to confirm that.

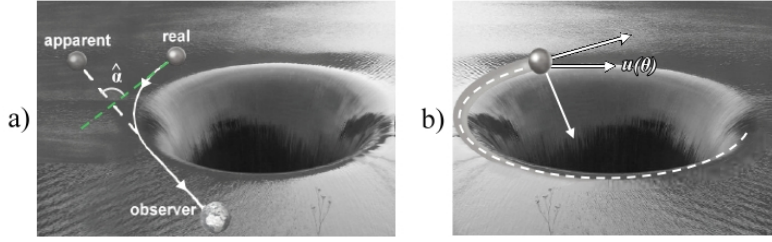


Figure 9: Gravitational lensing (a) and the motion of a satellite (b) according to SQS, here in analogy with a bell-mouth spillway.

Also orbital motion (fig. 9.b) is fluid dynamically explainable, when the description of angular velocity for *any* inverse square law, such as that found in the CFD simulations [1] is given as

$$u(\theta) = \frac{\mu}{h^2} - A \cos(\theta - \theta_0) \quad (27)$$

where A and θ_0 are arbitrary constants, h the angular momentum and μ the standard gravitational parameter GM . Beyond this newtonian formula (27), relativistic effects which may occur along with orbital motion, as the aforementioned Lense-Thirring effect, can be likewise described by fluid dynamics, without resorting to curved spacetime.

4.1 Gravitational waves in SQS.

In fluid quantum gravity and relativity, gravitational waves are explainable through the fluid dynamics of SQS.

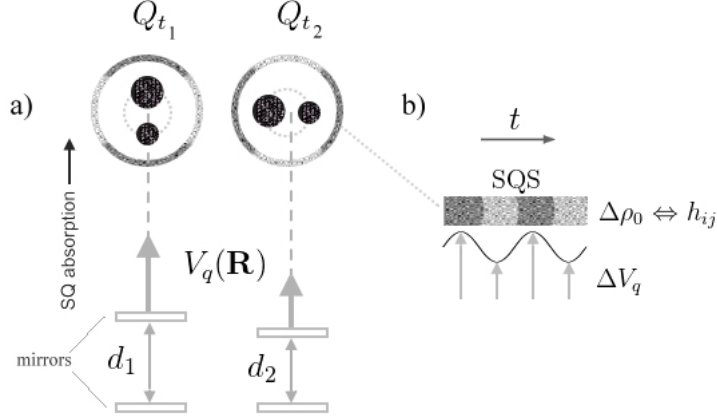


Figure 10: Gravitational waves according to fluid quantum gravity.

In fig. 10.a, a binary system of black holes (Q) in circular orbit, seen in two different mass distributions at the instants t_1 , t_2 , determines an oscillating gravitational potential ($V_q(\mathbf{R})$), here considered in the direction of the mirrors of an interferometer. A small variation in the distance between the mirrors occurs and, according to GR, Δd is interpreted as a perturbation (h_{ij}) of spacetime's metric.

From the point of view of fluid quantum gravity, the evolving system of masses represented by the quadrupole moment tensor

$$Q_{ij} = \int \rho(3r_i r_j - \|\vec{r}\|^2 \delta_{ij}) d^3 \mathbf{r} \quad (28)$$

generates over time a changing rate of SQ absorption in the direction of the mirrors, expressed as a variable gravitational potential

$$V_q(\mathbf{R}) = -\frac{1}{2} \frac{G}{|\mathbf{R}|^3} \sum_{i,j} Q_{ij} n_i n_j. \quad (29)$$

From (4) we obtain the quadrupole potential for fluid quantum gravity:

$$V_q(\mathbf{R}) = -\frac{1}{2} \frac{|\mathbf{v}_\Phi|^2}{|\mathbf{R}|^2} \quad (30)$$

where \mathbf{v}_Φ expresses the absorption velocity. This means that the changing rate in the absorption of SQ (twice the orbital frequency) causes periodic decompressions in SQS (fig. 10.b), locally (at the detection point) determining the gravitational wave as

$$\Delta \rho_0 2\omega_q. \quad (31)$$

There would be thence a mutual dependence between $\Delta \rho_0$ and the perturbation of the metric (gravitational wave amplitude):

$$\Delta\rho_0 \Leftrightarrow h_{ij} \quad (32)$$

formulated in linear gravity as:

$$g_{ij} = \eta_{ij} + h_{ij} \quad (33)$$

When we consider orbital motion in SQS, it is conceivable that its viscosity (extremely small but non-zero) would provoke, over time, energy loss and orbital decay. In fact, we know that this actually occurs and the power (luminosity) radiated from the source is expressed as:

$$P_{gw} = \frac{dE_{gw}}{dt} = \frac{G}{c^5} \frac{1}{5} \left\langle \ddot{\mathcal{I}}_{jk} \ddot{\mathcal{I}}^{jk} \right\rangle. \quad (34)$$

An analogous explanation may also be adduced as far as synchrotron radiation for accelerated charges in circular orbits is concerned (interaction with SQS's apparent viscosity and energy loss).

If gravitational waves actually arise from $\Delta\rho_0$, due to SQ absorption effected by matter, they behave then as sound waves (pressure oscillations through a medium). Considering this, it is very interesting to reflect on the similar nature of light in relation with SQS (§5). No wonder then, that gravitational and electromagnetic waves travel at the same speed $c = \lambda f$. Both would be pulses of SQ through SQS, with some differences though: negative pulses (SQ subtraction, causing negative pressure in SQS) produced by cosmic mass-quadrupoles (macroscopic origin) on the one hand and positive pulses of SQ (on a quantum scale) as far as a photon is concerned.

5 Photon as phonon through superfluid quantum space.

The value of c is due to photon's interaction with vacuum. It is indeed derivable as:

$$c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}. \quad (35)$$

By replacing the concept of vacuum with that of SQS, ε_0 and μ_0 can be considered physical properties of the latter. Moreover, in the energy eigenvalue of any eigenstate ψ_n , expressed as

$$E_n = (n + \frac{1}{2})\hbar\omega \quad (36)$$

$\frac{1}{2}\hbar\omega$ (vacuum's energy contribution) may correspond to the energy from SQS. If quantum vacuum *is* SQS, then photons move through a superfluid. It is then interesting to make a comparison with the speed of sound in a fluid:

$$a = \sqrt{\frac{E}{\rho}} \quad (37)$$

where, by setting $\sigma = 1$ in Young's modulus ($E = \frac{\sigma}{\epsilon}$), we obtain $a = \frac{1}{\sqrt{\epsilon\rho}}$. When ϵ is seen as quantum space's deformability and ρ as its density, we have

$$a = \frac{1}{\sqrt{\epsilon_0\rho_0}} \quad (38)$$

which is mathematically analogous to (35): this suggests that light can really move through a superfluid, whose quanta, like air's molecules, possess specific properties. Superfluidity would, for instance, account for photon's indefinite propagation, more extensively discussed below.

When travelling through a specific medium and at specific temperature, sound has constant speed just as light and the motion of a sound source only determines frequency shift, according to the Doppler-Fizeau effect which, for light, corresponds to redshift's formula:

$$z = \frac{f_{emit} - f_{obs}}{f_{obs}}.$$

The photon-phonon analogy might, however, be questioned by pointing out that there are at least a couple of fundamental differences between sound and light. The latter doesn't move through a medium and the photon is also a particle. But there are actually no differences when the medium is, in our case, SQS (currently corresponding to quantum vacuum, zero-point field³) and the dual nature of photon actually matches that of phonon, which also has both wave and particles characteristics. Analogies with photons have also been encountered in plasmons [16]. Moreover, and this is of central importance, the disproof concerning the existence of a *luminiferous aether*, due to the Michelson-Morley experiment [4], doesn't confute the photon-phonon analogy since, in that case, the hypothesis was that of a stationary aether⁴ and - as a result of Earth's motion - of an aether wind which would have influenced light's speed in the experiment. While the present case is very different, as it assumes that Earth - since made up of fermions - absorbs SQ, whose flow shapes Earth's gravitational field. So, in our case, the aether and its motion simply correspond to the gravitational field. Thus, when traveling parallel to Earth's surface, light should slightly curve downward and this actually occurs according to general relativity⁵, albeit this effect becomes evident only on astronomical distances and for much greater

³Superfluid quantum space corresponds, in my opinion, to dark energy. This would mean that ~68% of universe's energy is SQS itself.

⁴proposed by A.Fresnel in 1818

⁵where the angle of deflection is: $\theta = \frac{4GM}{rc^2}$

gravitational fields. Since they started from the wrong hypothesis, Michelson and Morley concluded that light doesn't need any medium to propagate. Now, SQS - along with the fact that fermions absorb it, producing gravity - might be, in a way, a plot twist. It is now clear that SQS doesn't need gravitons or other force carriers to explain gravity, since quantum gravity is reduced to SQ's dynamics, as well as ocean currents don't need anything else than water and fluid-thermodynamics to be described and understood.

Therefore, we could actually think of light as a collective, excited state of space quanta (phonon in SQS). By considering phonons in a quantum mechanical harmonic chain of N identical atoms (as they were space's quanta) whose positions are x_1, x_2, \dots , the potential energy is expressed as:

$$\frac{1}{2}m\omega^2 \sum_j (x_j - x_{j+1})^2 = \frac{1}{2} \sum_k m\omega_k^2 Q_k Q_{-k} \quad (39)$$

where Q_k is a set of N normal coordinates defined as discrete Fourier transforms of the conjugate momenta Π of x and N , corresponding to the Fourier transforms of the momentum operator p

$$Q_k = \frac{1}{\sqrt{N}} \sum_l e^{ikal} x_l$$

$$\Pi_k = \frac{1}{\sqrt{N}} \sum_l e^{-ikal} p_l$$

k_n is the wave number of the phonon and

$$\omega_k = \sqrt{2\omega^2 [1 - \cos(ka)]}.$$

The harmonic oscillator eigenvalues for the mode ω_k are

$$E_n = (n + \frac{1}{2})\hbar\omega_k \quad n = 0, 1, 2, 3, \dots \quad (40)$$

with quantized levels at

$$\frac{1}{2}\hbar\omega, \quad \frac{3}{2}\hbar\omega, \quad \frac{5}{2}\hbar\omega \quad \dots$$

exactly matching (36), where $\frac{1}{2}\hbar\omega$ is the zero-point energy for phonon and photon, *i.e.* SQS's energy. We know that phonons are bosons [13], just like photons, since they are symmetric under exchange $|\alpha, \beta\rangle = |\beta, \alpha\rangle$ and any number of identical excitations can be created by repeatedly applying the creation operator b^\dagger . Phonon's hamiltonian (renormalized on the right by putting $\frac{1}{2}\hbar\omega_{q_k} = 0$) is:

$$\hat{H}_{ph} = \sum_k \hbar\omega_k \left(b_k^\dagger b_k + \frac{1}{2} \right), \quad \hat{H}_{ph} = \sum_k \hbar\omega_k b_k^\dagger b_k \quad (41)$$

and again a photon can be described as a phonon occurring in SQS, where the necessary collective excitation is satisfied by SQ: a discretized amount of these (as pulse), would form a photon. Other clues are that, as well as photons, phonons possess wave-particle duality [7, 8], can form squeezed coherent states and they can interact via parametric down conversion [14]. Moreover, it would be now evident that light moves at the maximum, possible speed, since a phonon, as a pulse, doesn't entail shear stress, while a body moving through SQS provokes, as velocity increases to relativistic values, intensifying collisions among SQ and apparent viscosity consequently increases according to (8). While in a newtonian fluid, such as air, supersonic velocities are possible, they wouldn't occur in a dilatant space. Here the speed of light can be considered as the speed of *sound* in SQS and the maximum, possible velocity. Although SQ are not matter (required for phonons), they would transport discretized energy in form of photons, so they can theoretically replace atoms and justify the existence of phonons in SQS. Light is *the sound of space*. Thus, for any object moving through SQS, we always have $v < c$. Because of superfluidity, a *phonoton* (a photon described as a special spin-1 phonon occurring in SQS) could indefinitely propagate - overcoming the limitations of a liquid space which would cause dissipation of light [17] - until it scatters, for instance, with an electron. The photoelectric effect and Compton scattering would be indeed still allowed, thanks to a phonoton's momentum $\frac{h}{\lambda}$, which for analogy is also derivable from standard phonons' crystal momentum $p_{crystal} \equiv \hbar k = \frac{h}{\lambda}$, where $k = \frac{2\pi}{\lambda}$. Anyway a phonoton doesn't possess crystal momentum, since it doesn't pertain to solid-state physics, thus photon's momentum $\frac{h}{\lambda}$ directly applies. Pair production is furthermore allowed and intelligible when electrons are described as vortices of space quanta [1], triggerable by scattering of discrete SQ's pulses such as phonotons. But how would the latters carry an electromagnetic field? In an ideal isotropic medium such as SQS, it is plausible that phonons may have spin= 1, as the angular momentum transmitted by the emitting particles. Theoretically, since it has been demonstrated how sound waves may spin [19, 20], also phonons moving through a superfluid medium might accordingly spin. This fact could trigger secondary compressive, elastic, harmonic phenomena - in addition to the main one occurring along the z-axis (fig. 11.b) - which might generate the field.

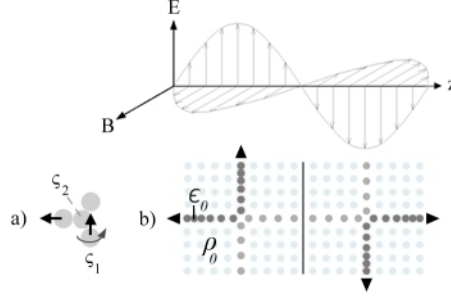


Figure 11: Density (ρ) and deformability (ϵ) of SQS at the origin of photon's/phonon's transverse EM field (b), whose oscillations are due to harmonic, orthogonal compressions of space's quanta, while the main pulse is moving along the z -axis. On the left (a), the probable quantum mechanism at the origin of transversality, due to compression and spin.

The EM field is generated according to vacuum's permittivity (ϵ_0) and permeability (μ_0), here represented as SQS's deformability (ϵ_0) and density (ρ_0) when a photon is described as a phonon.

As inferable from fig. 11, the dimensionless equivalence $\epsilon_0\rho_0 = \epsilon_0\mu_0$ is placed. Within this framework, SQS's density and deformability indeed determine phonon's speed (c) in vacuum (*i.e.* in SQS) and (38) is equivalent to (35). 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 equivalence - to SQS's deformability(ϵ_0):

$$\mathbf{J} = \epsilon_0 \int \mathbf{r} \times (\mathbf{E} \times \mathbf{B}) d^3\mathbf{r} \quad (42)$$

and deformability is inevitably pertaining to how (mass-)energy (\Rightarrow SQ) is locally distributed. Hence we observe the field's oscillation while a photon is travelling in the direction of propagation and its translational velocity is given as $c = \lambda\nu$. Light's EM field would be therefore created by superfluid scattering among the phonon and the adjacent SQ: this would be the underlying quantum mechanism to equation (35). A harmonic perturbation mechanism without energy loss. And it wouldn't be an isolated case: metamaterials have been investigated, in which light moves without energy loss [18]; energy is also conserved in Rayleigh scattering and *a fortiori* when the scattering pertains to the zero-point field (SQS). Fig. 11.a shows the possible quantum mechanism at the origin of the transversality ($E \perp B$). Space's quantum s_1 moves upward against the overlying SQ and elastic scattering occurs: because of both compression and its spin, received from the phonon⁶, an orthogonal pulse is generated in the opposite direction to spin, *i.e.* harmonically rightward and leftward, according to the varying orientation of the phonon along the direction of propagation.

⁶It's assumed that SQ have no intrinsic spin.

In some respects, a reference to the interaction among particles described in quantum billiards might be considered.

Phonotons as discrete pulses of SQ, along with gravity described as absorption of SQ, may also explain why photons, although massless, are subject to gravity. In both cases it's a matter of SQ's fluid dynamics. As a phonoton, it becomes also clear why a photon can't escape from a BH, as well as sound waves couldn't propagate if air was sucked more rapidly than sound's speed. Also equation (7) argues for photon as a phonon in SQS and, for its part, the concept of phonoton helps to justify the superfluid reformulation of Lorentz factor (8), by indicating c as the velocity of a pulse through SQS, obviously faster than any accelerated body, which would undergo increasing nonlinear dilatancy by approaching that velocity.

It is finally questionable whether the assumed accelerating expansion of the universe, *i.e.* distant galaxies' acceleration inferred from the distance-dependent increase of redshift (Hubble's law), is really caused by acceleration or rather by light's energy dissipation, after phonotons have propagated through SQS for extremely long time/distances. Does Hubble's law actually represent distant galaxies' acceleration?

5.1 Speed of light in fluid quantum gravity.

If photon is a phonon of SQ, it follows that, in a gravitational field, its velocity is not constant in some circumstances, inasmuch it would also depend on the drift velocity of SQ (corresponding to the escape velocity in that field, $v_{sq} = v_e$). Thus, when light travels upward in the field, its actual speed should be $c - v_e = 299781278$ m/s in Earth's gravitational field, since $v_e = 11180$ m/s, vice-versa $c + v_e = 299803638$ m/s, when the beam travels downward. This phenomenon would be confirmed in black holes, where light can't leave the celestial body since, in that case, $v_e = c \Rightarrow v_{light} = c - v_e = 0$. Or better $v_e \lesssim c$, according to what discussed in §1.1. In fact, we know that the speed of any wave traveling through a medium is relative. We would consequently observe a slight redshift when, in the field, the source is situated lower than the observer and a blueshift when light travels downward. This effect is already confirmed by Einstein's redshift (gravitational redshift) and it's then questionable whether it really depends on time dilation or on a different speed of light, or on both. It has to be pointed out that, when light travels round trip along the same path, the possible difference in velocity is cancelled. For this reason, a laser beam from Earth to Moon and back (or satellite communications) wouldn't show any aberration as far as light's speed is concerned and a vertically placed Michelson's interferometer wouldn't be useful to confirm different speeds of light. On the contrary, a Hanbury-Brown Twiss interferometer might be. The use of a specific interferometer to measure slight differences in light's speed on vertical paths would be then the simplest way to verify fluid quantum gravity, fluid quantum relativity and photon as phonoton.

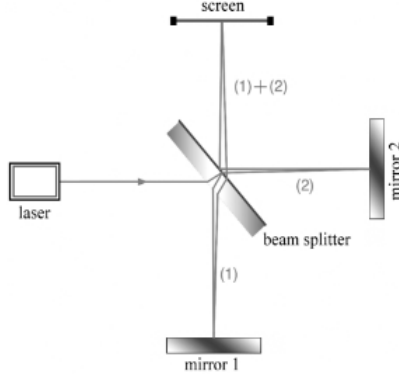


Figure 12: A vertically placed Michelson interferometer wouldn't be useful to detect fluctuations in light's speed when light travels in the same direction of the gravitational flow or in the opposite direction to it. Indeed, path (1) is round trip and would cancel the possible difference in velocity, nor a difference would arise from the joint path (1)+(2). A specific interferometer would be therefore necessary.

In this case, the value of the speed of light should be actually expressed as the scalar value of the vector

$$\vec{c} = \frac{\hat{c}}{\sqrt{\epsilon_0 \mu_0}} + \vec{v}_e = \frac{\hat{c}}{\sqrt{\epsilon_0 \rho_0}} + \vec{v}_{sq} \quad (43)$$

where \hat{c} is a versor indicating light's direction of propagation.

6 Physical properties of Superfluid Quantum Space.

SQS's physical properties so far examined in this work are:

- quantum nature \Rightarrow SQ
- superfluidity / quasi-zero viscosity
- compressibility
- capacity to propagate light as phonons of space's quanta, depending on SQS's density (ρ_0) and deformability (ϵ_0).
- dilatant behavior for extreme shear stress at velocities $\rightarrow c$, which determines drag weight (inertia) increase (currently interpreted as mass increase) and second-/third-order relativistic effects.

Compared to Einstein's spacetime, thought experiments which consider that spacetime can be bent to superimpose two distant points are not allowed in SQS. The only way to travel astronomical distances in a short time, would be

overcoming the speed of light by cancelling SQS's minimal viscosity to avoid dilatancy.

Let's now consider the possibility of knowing some further numerical data concerning SQS's density, deformability, energy per cubic meter *etc.*

If we set a value of 1 kg for mass in the mass-energy relationship $E = mc^2$, we obtain, for this case: $E = c^2$.

Now, c refers to a velocity but it also corresponds to a length: that traveled by light in one second. This consideration has been useful also about (6). We're then allowed to consider c^2 as the size of an area, which might correspond to a layer of SQ. In this case the energy of the layer would be:

$$E = c^2 \approx 8.987551 \cdot 10^{16} \text{J} \quad (44)$$

And the energy of a cubic portion of SQS with side equal to c would be: $\sim 2.6944 \cdot 10^{25} \text{J}$. We'd consequently have that:

1. the energy per cubic meter of SQS is exactly 1 J. The upper limit of Λ gives a lower value of 10^{-9}J but it's necessary to consider that, in fluid quantum gravity, the energy of SQS doesn't directly deal with the gravitational interaction: only when SQ are set in motion by fermionic absorption we have gravitational flows. Thus, a higher value wouldn't disturb the Lambda-CDM model. If anything, a higher density of SQS (*e.g.* as it might have been in the primordial universe) would imply expansion, *i.e.* apparent negative gravity. But not accelerating expansion, which wouldn't occur, since Hubble's law is most likely explainable as phonotons' energy loss in function of distance.
2. since the mass of the considered layer is 1 kg, the mass of 1m^3 is $1.11265 \cdot 10^{-17} \text{kg}$. Implying that SQ are not massless: this agrees with [1], where fermions are made up of SQ, and with SQS's dilatant behavior at relativistic shear.
3. density, ρ_0 , is $1.11265 \cdot 10^{-17} \text{kg/m}^3$
4. by considering only one space's quantum in a volume of ℓ_p^3 , the maximum number of SQ in one cubic meter is: $6.187154 \cdot 10^{104}$. But if SQ are, more likely, under the Planck scale, this number may be much higher.
5. the mass of a single quantum is $1.79404 \cdot 10^{-122} \text{kg}$, and its energy $1.79404 \cdot 10^{-105} \text{J}$ (however lower values under Planck scale).
6. SQS must be the elementary scalar field (how is it related to Higgs field? Is Higgs boson a cluster of SQ or a topological defect of SQS? In both cases it would agree with [1]).
7. the value of $\epsilon_0 = \frac{1}{\rho_0 c^2}$ is 1 (dimensionless, matching ϵ_0 in Young's modulus).

8. the velocity of light is, then, essentially function of SQS's density: $c = \frac{1}{\sqrt{\rho_0}}$, confirming light as phonons in fluid quantum space. But then, to be accurate (43), we have

$$\vec{c} = \frac{\hat{c}}{\sqrt{\rho_0}} + \vec{v}_{sq} \Rightarrow c = \|\vec{c}\| \quad (45)$$

9. the equation $E = mc^2$ corresponds to the relationship between the mass-energy of a body and the mass-energy (energy density) of quantum space. Indeed, from point 8. we have:

$$c^2 = \rho_0^{-1} \Rightarrow E = \frac{m}{\rho_0}. \quad (46)$$

and Lorentz factor (scalar form) appears as a function of the translational velocity through SQS and of its density:

$$\gamma_\Phi = \frac{1}{\sqrt{1 - \|\mathbf{v}_\Phi\|^2 \rho_0}} \quad (47)$$

where it's interesting to notice that, in absence of mass (6), only SQS's energy is able to cause an increase of gravitational interaction (g_Φ). That indeed occurs when considering a given energy corresponding to c^2 (44).

Conclusions and experimental verifications.

By hypothesizing the existence of a superfluid quantum space in place of what we call quantum vacuum or zero-point field, quantum gravity is obtained by starting from the Navier-Stokes equations without resorting to gravitons or string theory. In a previous work [1], it has been shown how this approach would be able to unify gravity with the other fundamental interactions and, in this paper, it has been shown how it also implies a fluid reformulation of the principle of equivalence, through which, special and general relativity can be merged with fluid quantum gravity.

GR's curved spacetime may be replaced by the fluid dynamics of SQS, without discarding Einstein's equations, which are simply reformulated according to the fluid equivalence principle. Also a correction to the equations of weight has been necessary.

Moreover, equations give evidences for considering a photon as a phonon of SQ moving through superfluid quantum space (*phonoton*), without violating the Michelson-Morley experiment. This would be, on its part, a confirmation to the existence of a superfluid quantum space. While gravitational waves can be described as negative pulses through SQS. In short, a virtuous circle that cannot be ignored and needs further investigations.

We can summarize as follows:

1. The fluid reformulation of the equivalence principle states that translational velocity produces gravitational interaction opposite to motion and this explains relativistic mass increase, which is actually an increase of inertia due to drag weight increase (a gravitational force acting in the opposite direction to motion).
2. Drag weight increase (currently mass increase) is the only fundamental relativistic effect.
3. Time dilation is a secondary relativistic effect which depends on drag weight increase and length contraction a third-order effect depending on time dilation.
4. All relativistic effects due in GR to curved spacetime are obtained and explained through the fluid dynamics of SQS, where the gravitational tidal forces of GR correspond to the flows of space's quanta occurring in SQS, due to fermionic absorption (fluid quantum gravity[1]).
5. SQS is compressible, as primordial inflation and universe's expansion suggest, and its quasi-zero viscosity (superfluidity) increases and becomes critical for shear stress driven toward c (*i.e.* when a body is accelerated through SQS to relativistic velocities), determining an apparent dilatant behavior.
6. A photon can be mathematically described as a phonon of space's quanta, implying that light needs SQS to propagate. In this case, c refers to the speed of light *through SQS* (not simply through vacuum) and indicates that light is *the sound of space*.

As far as the validity of the theory is concerned, it shows first of all theoretical concision, *i.e.* SQ absorption in fermions as the only starting condition, and has a mathematical foundation. Hence, *entia non sunt multiplicanda praeter necessitatem*. We probably don't need 26 dimensions⁷ in the universe, nor a supergravity with 11 dimensions as in M-theory. Space quanta's fluid dynamics seem to be enough to explain quantum gravity, quantum relativity, bosons, fermions and the fundamental interactions [1]. We shouldn't be surprised if one day the standard model will contain only one fundamental particle: the quantum of space(ς). Not *of space-time*, since it has been demonstrated (§2) that time (as physical time measured by clocks) is determined by motion, nor its quantization as Planck time refers to a quantum of time as a particle. Since fluid quantum relativity stands as the quantum reformulation of Einstein's relativity and is in agreement with it (except for describing gravity as a quantum fluid dynamic phenomenon rather than space-time's curvature, which is a pure mathematical tool to describe the *effects that we observe*), no wonder that almost all of its predictions correspond to those of SR and GR, making it difficult to realize experimental verifications. Which might be however carried out as follows:

⁷from Polyakov's equation.

1. Thanks to a specific interferometer which doesn't cancel possible discrepancies through round-trip trajectories (§5.1), it should be possible to demonstrate that light has a higher velocity (299803638 m/s, for instance by measuring a higher frequency) when traveling downward perpendicular to a gravitational field and, on the contrary, a lower velocity (299781278 m/s) when traveling upward in the field. The difference should exactly correspond to the escape velocity in that field. Since the observation of the interference fringes would occur on a very short distance where the gravitational field has practically a single, specific intensity, Einstein's redshift due to time dilation should be excluded and the effect ascribed to different velocities of light (43), confirming photon as a phonon in SQS (§5), the existence of a SQS, and the gravitational field as the fluid dynamic effect of the absorption of SQ effected by fermions [1].
2. when an object is in equilibrium in the Earth's gravitational field, its weight exceeds a γ factor that predicted by classical physics (14), where SQ's drift velocity ($v_{sq} = \sqrt{2rg}$) is considered in the calculation of γ . A specific ultra-sensitive balance would be however necessary.

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