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A superfluid Theory of Everything?

May 7, 2016

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Abstract

We know that a real vacuum (zero-energy space) doesn't exist [1, 2, 3, 4, 5]. By describing it as 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 in SQS (superfluid vortices). Gauss's law for gravity mathematically supports this hypothesis, since it defines an incoming radial flux, and the plausibility of this mechanism has been also confirmed through a set of CFD simulations. In this case, a gravitational field is an incoming flow of space's quanta and this leads to the formulation of a fluid equivalence principle, able to show how gravity may be the origin of all relativistic effects, also in special relativity, producing a simplification in the theory of relativity. It is discussed how the fluid dynamics of a SQS would be able to replace Einstein's curved space-time and to explain gravitational waves. Not less important when considering fluid space, this hypothesis would not conflict with the Michelson-Morley experiment and would open up a new scenario on the nature of light and on Hubble's law. A simple experiment is suggested to proof fluid quantum gravity and its consequences. Among these, the mechanism of SQ absorption would automatically lead to the unification of the four fundamental interactions, making us reinterpret the universe as a fluid phenomenon, from subatomic to cosmic scale.

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

1.1 Fluid quantum gravity and relativity.

A hypothesis has been formulated, according to which, space is a quantum superfluid and fermions absorb space's quanta (SQ), 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 (§2.3)[4, 5]. To compensate this absorption, emission of virtual photons would occur, capable of explaining the existence of charged particles (§2.1) and, when no emission occurs, the β -decay (§2.2). The exchange of SQ occurring between two adjacent vortices would moreover justify the strong interaction (§2.4) leading to the complete unification of the four fundamental forces (§2).

The hypothesis of gravity as absorption of SQ is mathematically supported by Gauss's law for gravity, since it describes the gravitational field as an incoming radial flux. Once applied to a SQS, we automatically obtain an effective, and the simplest, theory of quantum gravity and quantum relativity without resorting to strings, extra dimensions or gravitons. A set of CFD simulations (see also the annex) has been performed and it has confirmed that the situation shown in fig.1 agrees with Gauss's law for gravity and Newton's law of universal gravitation. Navier-Stokes equations representing mass, momentum and energy have been used:

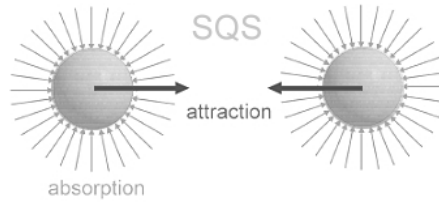


Figure 1: Two particles move the one toward the other since they're absorbing the fluid (SQS) which they're immersed in. This phenomenon is in direct agreement with Gauss's law for gravity $\iint_{\partial V} \mathbf{g} \cdot d\mathbf{A} = -4\pi GM$.

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

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

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

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. 21 (annex).

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. 22 in the annex and the diagrams in fig. 24, 25, 26 and 27 show an inverse quadratic dependence on distance and a quadratic dependence on the flow velocity.

Refinement of computational grid and domain enlargement helped to reduce the curvature of the flow lines, up to a virtually radial flow (fig. 23).

The behavior of the attractive force shown by this analysis is concordant with Newton's law of universal gravitation, since the attractive force decreases with distance (radius) according to an inverse square law and quadratically grows according to the velocity of the flux (fig. 24, 25, 26). 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,

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

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. 2, 3, 4). Here a 3D space plus time, not space-time as a single physical entity, is defined, since time may simply arise as a chain of events occurring in a 3D fluid quantum space; events which may be more or less close (\rightarrow time dilation) depending on the gravitational force acting in a given frame of reference, also when a flat Minkowski space is considered, as discussed below.

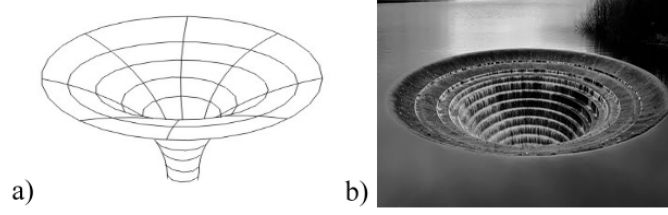


Figure 2: how the presence of a massive body curves spacetime (a) or absorbs fluid quantum space (b), here in analogy with a bell-mouth spillway.

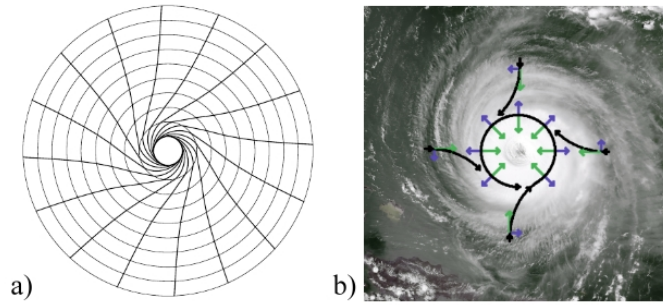


Figure 3: the Lense-Thirring effect according to Einstein's curved spacetime (a) and to fluid dynamics (b). Here as an analogy with the Coriolis effect in a cyclone.

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.

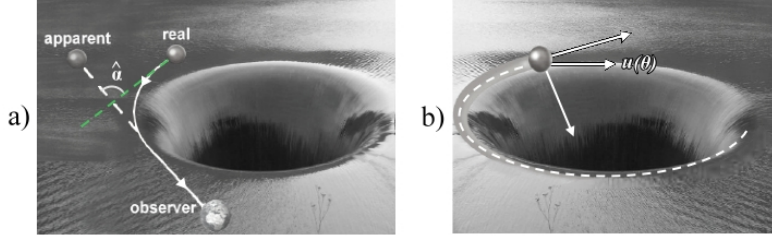


Figure 4: Gravitational lensing (a) and the motion of a satellite (b) according to SQS, still in analogy with a bell-mouth spillway representing the gravity of a star which curves space (in our case, which absorbs SQS).

Other effects which can be described by the 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. 4.a is determined by vector interaction between light's and space quanta's momenta (gravitational flow), where their absorption is illustrated as water flowing into a spillway (acting as an interposed star).

While in fig. 4.b SQS's fluid dynamics describes orbital motion, since the angular velocity for any inverse square law, such as Gauss's law for gravity and (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. 5):

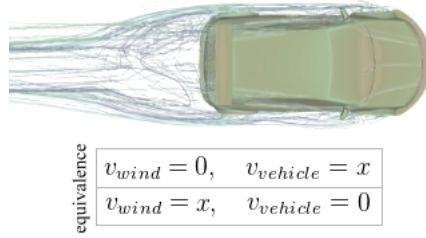


Figure 5: Fluid equivalence principle (FEP): it is impossible to distinguish between the two equivalent situations of a body moving at a given velocity through a stationary fluid and a fluid flowing toward a stationary body at the same velocity. This would also occur as far as a body interacting with 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, 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 therefore provokes an apparent gravitational field (g_Φ) acting on the accelerated body and detected as an increase of inertia but basically a weight force opposite to motion (\mathbf{W}_Φ) (fig.6).

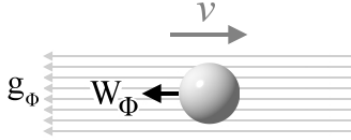


Figure 6: Weight acting in the opposite direction to motion (drag weight, \mathbf{W}_Φ) due to the apparent gravitational field caused by motion through SQS. At low, everyday speeds this effect wouldn't be noticed, since SQS's viscosity is quasi zero, as for every superfluid, but the effect of apparent viscosity would play a key role at relativistic velocities (extreme shear stress), increasingly opposing acceleration.

This is in agreement with the 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. This issue is clear if we suppose that, when dealing with accelerated particles in synchrotrons, we make a dimensional mistake, swapping kgf with kg, *i.e.* interpreting a weight force (\mathbf{W}_Φ) pointing in the opposite direction to acceleration as the increased inertia of a mass. If drag weight grew according to Lorentz factor (§1.2.1)(22), it would be the cause of relativistic mass increase:

$$a = \frac{F}{m + W_\Phi}. \quad (11)$$

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

$$\mathbf{W}_{\text{tot}} = m(\mathbf{g} + \mathbf{g}_{\Phi}) \quad (12)$$

where the accelerations g and g_{Φ} may point in different directions, according to the presence of a gravitational field and/or translational motion. Still according to the FEP, a slight difference in weight, corresponding to a γ factor, should moreover occur when comparing the gravitational force acting on a free falling body and on the same body when it is in equilibrium in the gravitational field, due to the minimal viscosity of SQS (no superfluid has real zero-viscosity): in the second case the weight of the object should be slightly greater, corresponding to:

$$W' = \frac{mg}{\sqrt{1 - \left(\frac{v_{sq}}{c}\right)^2}} \quad (13)$$

where $v_{sq} < v_e$ (fig.7)(§1.4), thus on Earth: $\Delta W < 7 \cdot 10^{-10}$ kg per kilogram.

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

$$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{\Delta t}{\sqrt{1 - \frac{R_S}{r}}} \quad (14)$$

hence

$$\frac{v^2}{c^2} = \frac{R_S}{r} = \frac{2GM}{c^2 r} = v^2 \frac{1}{c^2} = \frac{2GM}{r} \frac{1}{c^2} \implies v^2 = \frac{2GM}{r} \quad (15)$$

and

$$v = \sqrt{2rg} = \sqrt{2\Phi}. \quad (16)$$

Where (16) 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.7 indeed shows how a gravitational field corresponds to an absorption velocity field (velocity potential) analogous to that of fig.22 in the CFD simulations (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. 2, 3, 4) also mass increase - or better, what would be the current interpretation of drag weight -, time dilation and, consequently, Lorentz-Fitzgerald contraction (which depends on time dilation and does not need to be discussed here)

- might be therefore explained *through the sole action of gravity* (fig.7), described as a fluid dynamic force in SQS.

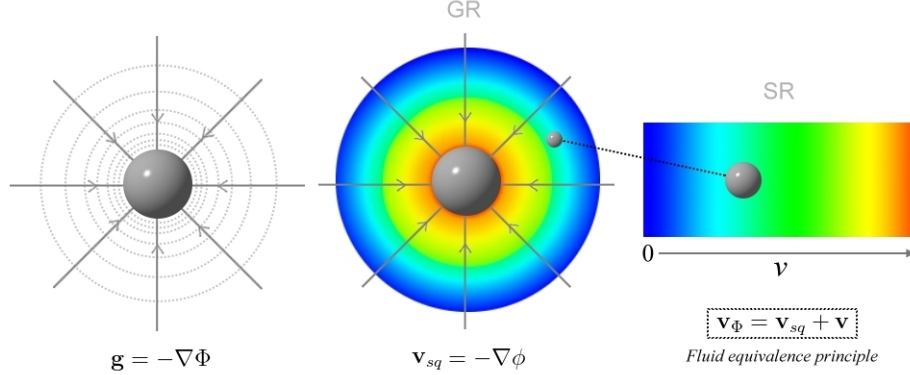


Figure 7: equivalence of a gravitational field and a velocity field, where the latter corresponds to the absorption velocity (v_{sq}). In both cases we have sink at the origin and equipotential surfaces. On the right, a given translational velocity (SR) through SQS corresponds to being in a point of a gravitational field (GR) where space's quanta are absorbed at the same velocity.

Time dilation (14) 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 to the action of gravity, which influences its dynamical aspects (macroscopic, molecular *etc.*) and consequently causes time dilation as a force which interferes with motion. If we had, for instance, a clock with period $T_c = T_0 \frac{F_f + F_g}{F_c} = 1s$, calibrated by balancing friction and gravity ($F_f + F_g = F_c$), where $T_0 = 1s$ is the period where $g \rightarrow 0$, when we put out the accelerations acting on it, $T_c = T_0 \frac{\mu(a_f + g)}{\mu a_c}$, it would be clear that any additional positive acceleration in the numerator would unbalance the mechanism, producing time dilation, both when the clock is in a stronger gravitational field, $T' = T_0 \frac{a_f + g + \Delta g}{a_c} > 1s$, and when it is subject to drag weight, $T' = T_0 \frac{a_f + g + g_\Phi}{a_c} > 1s$. And of course, if g_Φ increases according to Lorentz factor (22, 24)(fig. 9), time dilation too obeys γ , until the clock is stopped.

To understand now why Lorentz factor is built on the ratio (β) between the translational velocity of a body and the speed of light, we need to discuss the nature of light in relation to the possible existence of a SQS. Let us hypothesize that a photon is a pulse through a superfluid medium, *i.e.* a phonon through SQS. As shown below, all equations and facts seem to confirm that. But firstly, it is necessary to point out that

- the Michelson-Morley experiment [14] is in our case meaningless, since the

hypothesis of SQ absorption (4) entails that *the ether wind corresponds to the gravitational field*, as an incoming flow of SQ. No relative motion Earth-luminiferous aether occurs and can be considered in this theory. On the contrary, experimental evidences are respected, since light traveling upward or downward in a gravitational field would be respectively subject to red/blueshift (29) and would be curved by the field when it travels not parallel to it (as sound is bent by wind), phenomena whose effects are described also in GR (gravitational redshift and curvature of light in a gravitational field). Hence the MM-experiment is not an obstacle to fluid quantum gravity and to a superfluid ToE. This issue is further discussed below.

1.2 Photon as phonon through a superfluid quantum space.

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

$$a = \frac{1}{\sqrt{\epsilon_0\rho_0}} \quad (17)$$

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

$$c = \frac{1}{\sqrt{\epsilon_0\mu_0}}. \quad (18)$$

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 after all that also sound waves can spin [16, 19]), as illustrated in fig. 8.

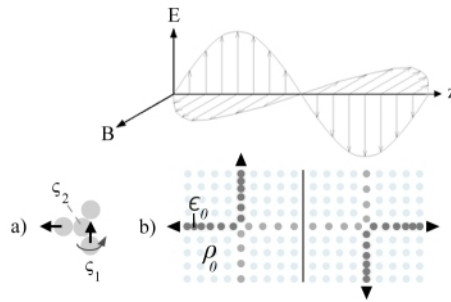


Figure 8: Density (ρ) and deformability (ϵ) of SQS at the origin of photon-phonon's transverse EM field (b), whose oscillations are due to harmonic, orthogonal compressions of space's quanta, while the main pulse propagates along the z -axis. On the left (a), the probable quantum mechanism at the origin 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 $\epsilon_0\rho_0 = \epsilon_0\mu_0$ (17, 18) - to SQS's deformability(ϵ_0):

$$\mathbf{J} = \epsilon_0 \int \mathbf{r} \times (\mathbf{E} \times \mathbf{B}) d^3\mathbf{r} \quad (19)$$

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

$$E_n = (n + \frac{1}{2})\hbar\omega \quad (20)$$

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

$$E_n = (n + \frac{1}{2})\hbar\omega_k \quad n = 0, 1, 2, 3, \dots \quad (21)$$

Both photons and phonons:

- are bosons [5]
- possess wave-particle duality [17, 18]
- 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 [16, 19]
- can form squeezed coherent states [15]
- can interact via parametric down conversion [15]

1.2.1 Reinterpretation of Lorentz factor and Hubble's law.

If SQS acted as a non-newtonian, dilatant fluid under extreme shear stress (bodies accelerated through SQS at relativistic velocities) this would justify the tested asymptote to translational velocity (c). Moreover, being a dilatant fluid would confirm the granular [8] (and quantum) nature of space.

When a photon is a phonon (pulse) of space's quanta through SQS, the parameter β in Lorentz factor is intelligible as the ratio between the speed of

a body through SQS and that of a pulse through it, which is higher than any translational velocity since it doesn't imply shear stress (furthermore photons are massless) and doesn't induce dilatancy. The ratio $\left(\frac{v}{c}\right)$ is expressed as an adimensional parameter analogous to the ratio between the speed of a body and of sound (v_s) through other superfluids [20]: $\left(\frac{v}{v_s}\right)^2 \implies \left(\frac{v}{c}\right)^2 \equiv \beta^2$.

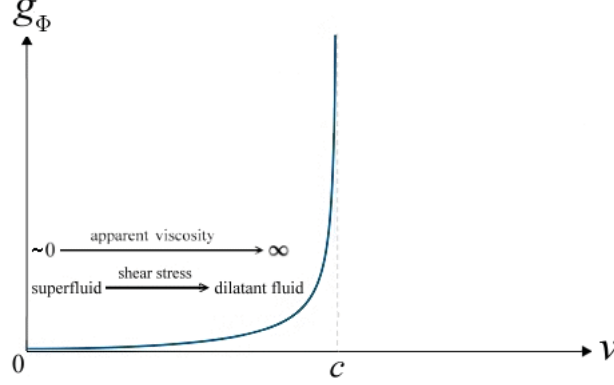


Figure 9: motion induced gravitational acceleration (g_Φ) causing drag weight ($W_\Phi = mg_\Phi$) increase, currently interpreted as relativistic mass increase. This graph can also be read as a rheogram of fluid quantum space. As shear rate and the velocity of the relative flow of SQ shift toward relativistic 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, $v_p = c$, in SQS. Thus, as sound has a given speed through a given fluid, light would have one through SQS, corresponding to ~ 299792458 m/s.

According to a SQS

- Lorentz factor is then interpretable as $\arcsin' \frac{v_\Phi}{v_p}$, indicating the asymptote at $v_p = c$:

$$\gamma \equiv \frac{1}{\sqrt{1 - \left(\frac{v_\Phi}{v_p}\right)^2}} \quad (22)$$

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 (17), c^2 corresponds then to the square of the pulse velocity $c^2 = v_p^2 = \frac{1P_a}{\rho_0 \epsilon_0}$. The similarity with $v_s^2 \equiv \frac{1}{\rho_a \kappa}$ in [20] is interesting, where v_s is the speed of sound through a compressible superfluid. If this is true, we could state that light is *the sound of space*, inasmuch it would be a pulse (phonon) through a fluid space.

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 $\sigma_0 = 1 \text{ Pa}$:

$$E = mc^2 = \frac{m \sigma_0}{\rho_0 \epsilon_0} = \frac{m}{\rho_0} \Upsilon. \quad (23)$$

Lorentz factor can be now written in the (still adimensional) form:

$$\gamma_{\Phi} \equiv \frac{1}{\sqrt{1 - v_{\Phi}^2 \rho_0 \Upsilon^{-1}}} \quad (24)$$

where v_{Φ} expresses the FEP. It means that (24) could be used also in place of $\frac{1}{\sqrt{1 - \frac{R_s}{r}}}$ if we knew the velocity of the SQ flow in a given point of a gravitational field (fig. 7).

- Valid the analogy photon-phonon, Hubble's law would be compatible with an energy loss (\Rightarrow redshift) of photons due to the minimal viscosity of SQS, after they've traveled enormous distances, instead of being a mysterious acceleration of distant galaxies. The further a galaxy, the greater the detected redshift.

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

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

there is in this case no dependence on surface (A) or shape (C_D) for a body traveling through SQS. According to the FEP, the same dynamics valid for standard weight has indeed to be valid also for drag weight, *i.e.* dependence only on mass and field intensity. Hence it has to be true: $\mathbf{F}_{\mathbf{D}_{\text{qs}}} = \mathbf{W}_{\Phi} = m \mathbf{g}_{\Phi}$. Where the meaning of $C_D A$ in (25) is represented by mass, *i.e.* the quantity of matter exposed to the flow, regardless of shape and surface. Thus, we just need to define the formula of g_{Φ} . We know that it has to increase according to Lorentz factor, whose reformulation (24) precisely contains the dependence on velocity and medium's density as in (25). The formula for drag weight can be therefore written as:

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

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

¹Obvious, after all, if fermions are superfluid vortices of space's quanta

$$\mathbf{g} = -\hat{\mathbf{r}} \frac{1}{2} \frac{v_e^2}{r} = -\hat{\mathbf{r}} \frac{GM}{r^2} \quad (27)$$

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

$$\mathbf{g}_\Phi = -\hat{\mathbf{v}} \frac{a}{\sqrt{1 - v_\Phi^2 \rho_0 \Upsilon^{-1}}} - 1 = -\hat{\mathbf{v}} a \gamma_\Phi - 1 \quad (28)$$

when it is induced by motion through SQS.

1.3 Gravitational waves.

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

- The known dissipation of energy occurring in the orbits of celestial bodies, which would be caused by SQS's minimal viscosity.
- Gravitational waves, which would be defined as a periodic variation in SQS's density caused by the variable position of a quadrupole in time (fig. 10), corresponding to a variable rate in the absorption of SQ.

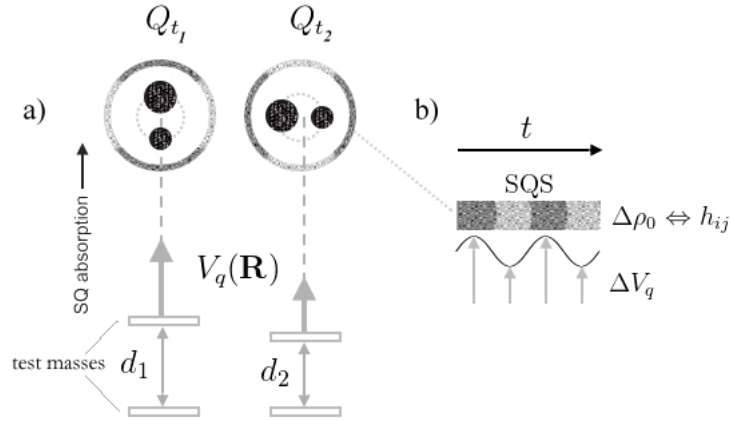


Figure 10: Gravitational waves according to fluid quantum gravity. A cyclical variation in SQS's density, due to a likewise cyclical variation of the absorption velocity (changing position of the quadrupole) may explain them without the concept of space-time deformation.

The changing rate in the absorption of space's quanta, occurring twice the orbital frequency ($2\omega_q$), causes periodic decompressions ($\Delta\rho_0$) in SQS (fig. 10. b), interpreted as space-time deformation (h_{ij}). In linear gravity we have: $g_{ij} = \eta_{ij} + h_{ij}$.

1.4 Verification.

In fluid quantum gravity, within the photon-phonon analogy, we should be able to measure different velocities for light traveling up/downward with respect to a gravitational field, since the drift velocity of SQ (v_{sq} , not to be confused with the speed of action of gravity which, according to this theory, corresponds to c , *i.e.* to a pulse through SQS) should be subtracted or added to c , determining a detectable blue/redshift as:

$$f_{obs} = \frac{c + (v_{\phi_{obs}} - v_{\phi_{source}})}{\lambda_{source}} \quad (29)$$

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 (fig. 7).

Also Einstein's relativity predicts this effect (gravitational blue/redshift), where the cause is however (only) time dilation but we should detect that the shorter the distance between source and detector is, the higher the deviation from Einstein's predictions, especially near the surface of the absorbing body, where v_{sq} has the highest value. Tests should be improved in this direction, under 30 cm height difference between source and detector [25]. As far as the verification of fluid quantum gravity is concerned, the fact that it seems able to describe all relativistic effects predicted by Einstein, although desirable, since any new theory has to respect experimental evidences, makes it difficult to think of tests which underline differences when compared with GR.

Surely, if the MM-experiment were performed again by measuring the frequency shift of laser beams traveling up/downward with respect to a gravitational field (by using however a different interferometer, a 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 would be detected for light traveling downward and, vice versa, a redshift and this would be congruent with both theories. The test suggested below should however determine whether light has different speeds while traveling up/downward with respect to a gravitational field, instead of not being affected by gravity (we know that, according to the relativistic effect of gravitational redshift, the variation of the detected frequency is merely caused by the different speed of the observer's clock).

One could object that c is then relative and unreliable but this value is simply the speed of light *when not modified by a gravitational field*. In a round trip, the speed of light is for instance unmodified when detected. Thus, in an Earth-Moon round-trip test for measuring the speed of light, or in satellite communications, the slower velocity during the outward trip of EM waves, would be compensated by their faster velocity during the return trip (fig. 11.b), nothing would be noticed and the detected average speed would be exactly c . Therefore, a difference could be only detected in a one way trip of light (fig. 11.a). GPS would only have to correct frequency, as they actually do. Moreover, this theory also predicts the bending of light rays (fig. 11.c) as a fluid dynamic effect similar to the bending of sound caused by wind, since the ether wind corresponds here

to the gravitational field.

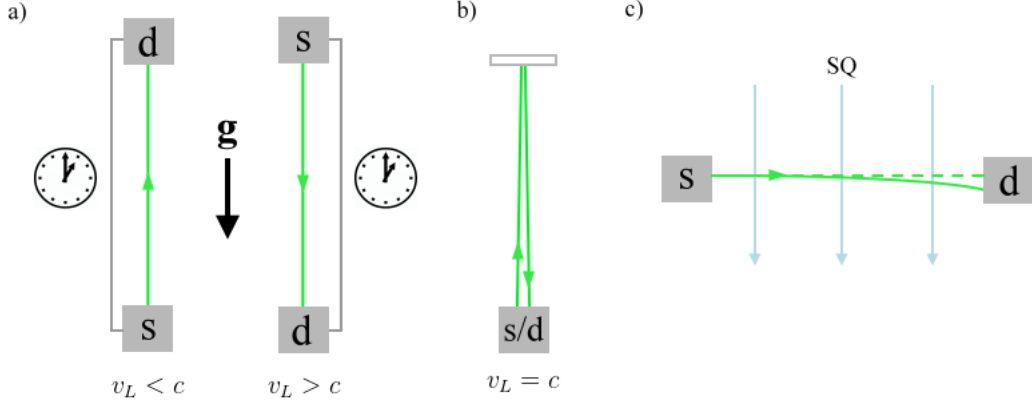


Figure 11: possible test for verifying fluid quantum gravity and photon as a phonon through SQS. Clocks at source and at detector are synchronized to exclude gravitational time dilation and the speed of light is measured after it has traveled up/downward with respect to the gravitational field (a). A slightly lower speed should be detected while light travels upward and, vice versa, light should be faster. The two opposite effects would be balanced in a round trip of light (b) giving $v_L = c$. On the right (c) fluid quantum gravity predicts the bending of light due to the gravitational field as a flow of SQ and photon as a phonon of SQ, without resorting to curved space-time.

- In the suggested test, a laser beam travels from a source till a detector, whose clock is synchronized with that at the source to exclude gravitational time dilation and the speed of light (as time needed to reach the detector) is measured. While propagating upward light should have a slightly lower speed and higher speed when traveling downward. The use of optical clocks based on $^{27}\text{Al}^+$ ions or even preciser clocks is recommended.

1.5 Twin paradox.

If we now analyze the twin paradox according to fluid quantum relativity, we see that the paradox vanishes. After the trip, the younger twin 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 motion 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. We know that 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 of a frequency known at his brother's

location, by applying (29) the measured frequency shift, net of Einstein's redshift (fluid quantum redshift? (29)) and doppler effect, would unveil direction and velocity of his frame of reference, making it possible to understand which of the two brothers will be younger at the end of the travel. We can express how the period of a clock in the rocket's frame of reference varies with respect to a clock on Earth as

$$\Delta T_{rocket} = \frac{1}{\sqrt{1 - \frac{\Delta v_{\Phi}}{c^2}}} = \frac{1}{\sqrt{1 - \Delta v_{\Phi} \rho_0 \Upsilon^{-1}}} \quad (30)$$

where $\Delta v_{\Phi} = v_{\Phi_{rocket}} - v_{\Phi_{Earth}}$ is the delta of the FEP applied to both frames of reference.

1.6 Black holes.

Black holes can exist in fluid quantum gravity as celestial bodies which immensely absorb SQ and 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, as well as its absorption velocity. However, when we have $v_{sq} \approx c$, 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 (fig. 7, FEP). When approaching that limit, it is then plausible that the boundary layer of the star (*i.e.* the part of it exposed to the flow) is annihilated into photons or space's quanta themselves². Photons could remain trapped, since we can have $v_e > v_{sq} \lesssim c$, as v_e depends on $\Phi = \frac{GM}{r}$ and v_{sq} on $g = \frac{GM}{r^2}$. While the produced SQ would 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 situation $v_{sq} \geq c$.

²assumed that fermions are superfluid vortices of SQ

2 Unification of the fundamental interactions as a direct consequence of fluid quantum gravity.

We analyze below the *endofermionic* consequences of the SQ absorption. The first one seems to be the unification of gravity and electromagnetism, which makes us reflect on the fact that quantum gravity shouldn't be the last but the first piece of the unification puzzle, hence perhaps the long-standing difficulties in achieving a quantum theory of gravity and relativity.

2.1 Gravity-electromagnetism unification.

The theoretical mainstream describes the electrostatic field of charged fermions as the emission and reabsorption of virtual photons. Also in the hypothesis of gravity as absorption of space's quanta occurring in fermions we have absorption and we need a subsequent emission to maintain energy balance. If we then considered the absorption of SQ and their following emission as discrete packets (virtual photons) we would see how gravity may be related to electromagnetism and the only difference with the mainstream would be having *first* absorption and then emission. The Feynman diagram describing charged particles' self-energy might change as suggested in fig. 12.b:

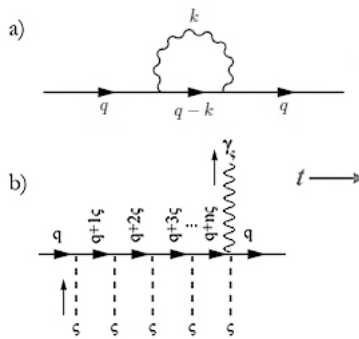


Figure 12: current (a) and suggested (b) Feynman diagram for describing a charged particle's self-energy, where ς indicates a space's quantum and γ_ς a virtual photon as a discrete packet of space's quanta.

The suggested absorption-emission mechanism could be possible if fermions were, for instance, superfluid vortices in SQS, as discussed below in §2.3.

It would be periodic, harmonic, and would be in agreement with the undulatory nature of particles (fig. 13).

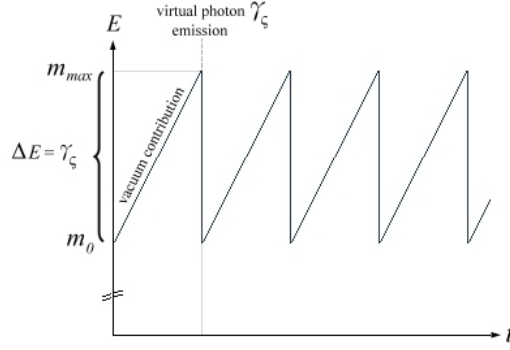


Figure 13: sawtooth electrogravitational oscillator for a charged particle expressing its rest mass variation while producing gravitational pull and electrostatic field. Vacuum contribution corresponds to the absorption of SQ.

The time-dependent equation for the electrostatic field of a charged particle (fig. 13) would be $m_{eff}(t) = (t - [t])k_a + m_0$, where m_{eff} is the effective mass of the particle, which would therefore rapidly oscillate between two values (m_0, m_{max}), and k_a is a constant of mass-energy absorption expressed in kg/s, whose value is $k_a = m_{\gamma_\zeta}/t_{emission}$, *i.e.* the ratio between the mass of a virtual photon and the necessary time to emit it from the vortex. An anisotropic interaction between superfluid vortices, instead of the exchange of virtual photons in isotropic conditions, could explain both attraction and repulsion between two charges as a mechanism driven by recoil (fig. 14), while within the current isotropic model based on virtual photons exchange justifying the attractive force is difficult.

The configuration of two same charges in fig. 14 shows Pauli exclusion principle (antisymmetric spin), which also accounts for the validity of the anisotropic hypothesis in the electrostatic interaction. The positioning of a charge with respect to another would generate the illusion of a radial electrostatic force. Such a positioning mechanism would be coherent with the interactions occurring also in more-particle systems. The confluence of the radially absorbed SQ toward a single emission point may explain why, for particles, the electrostatic interaction is 39 orders of magnitude stronger than the gravitational interaction.

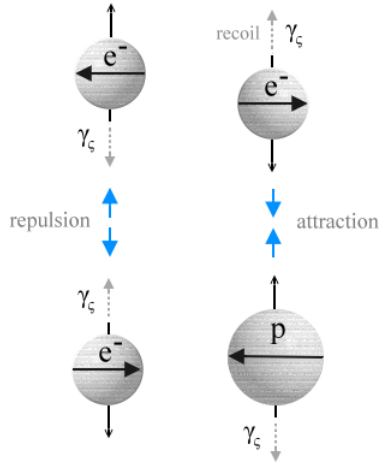


Figure 14: Electrostatic attraction and repulsion due to recoil caused by the emission of virtual photons (γ_5) from superfluid vortex-particles (charged fermions). A positioning of the particles according to their charge would occur (anisotropic interaction) and the emitted virtual photons are not exchanged but radially disperse obeying an inverse-square law, according to Gauss and Coulomb. The configuration of same charges (left) corresponds to Pauli exclusion principle (antisymmetric spin).

2.2 Weak interaction.

It may be inferred that in absence of virtual photons emission (charge neutrality) a particle would be compelled to decay, because of the increase of its internal energy due to absorption, as indeed observed in unbound neutral particles, such as neutrons (fig. 15), whose mean lifetime is 881s.

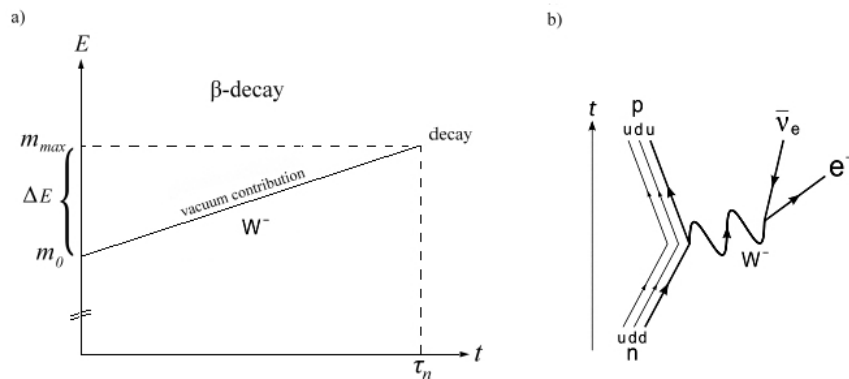


Figure 15: β -decay in unbound neutrons, (a) caused by vacuum energy absorption (SQ), being τ_n the neutron's mean lifetime. Here the W^- -boson corresponds to the sum of the absorbed SQ. (b) Feynman diagram for neutron's decay.

A prediction of this theory would be that of a greater mass of isolated neutrons before they decay, if compared with the mass of bound neutrons in a nucleus and, for instance, also that of a faster decay of neutral pions (indeed $8.4 \cdot 10^{-17}$ s) if compared with charged pions ($2.6 \cdot 10^{-8}$ s). Decay would also occur in unstable charged particles, where the equilibrium absorption-emission is imperfect (fig 18.d).

2.3 Appearance of fundamental particles as vortices of space's quanta in superfluid quantum space.

Before describing also quantum chromodynamics and the strong interaction, it is important to discuss how fundamental particles might emerge from a SQS, as dynamic topological defects (precisely, superfluid vortices), perhaps spherical or conical, similar to those observed in superfluid helium-4 nanodroplets [9, 12]. Circulation in a superfluid vortex is quantized and analogous to what described in the Bohr model, as the wavefunction must return to its same value after an integral number of turns

$$\oint_C \mathbf{v} \cdot d\mathbf{l} = \frac{2\pi\hbar}{m} n. \quad (31)$$

where \hbar is the reduced Planck constant, m is the mass of the superfluid particle and $2\pi n$ the phase difference around the vortex. These vortices behave as gaps in the medium where superfluidity breaks down and the presence of an axis inside them, would suggest the non-necessity of renormalization (since no ultraviolet divergence would occur), if fluid dynamic equations for vortices were used to describe the force fields of subatomic particles (gravity and electrostatic interaction, *i.e.* Newton's/Gauss's and Coulomb's laws). The reasons for considering fermions and other particles as superfluid vortices of SQ are several. We could, for instance, explain the appearance of particle-antiparticle pairs from quantum vacuum³ as a perturbative phenomenon analogous to that described in a Kármán vortex street (fig. 16)

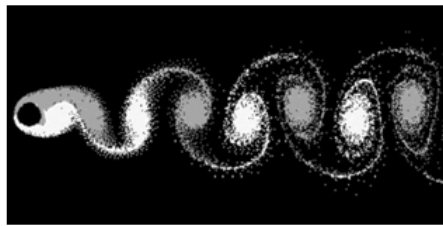


Figure 16: a computer simulation of a Kármán vortex street. Similar perturbations in a SQS might be responsible for the appearance of particle-antiparticle pairs as superfluid vortices of space's quanta.

³Referring, for instance, to the Casimir effect

where pairs formed by a right- and a left-handed vortice occur due to a perturbation of the flow. In our case the flow may be represented by the gravitational field and the disturbance by other particles [22] or stochastic perturbations of SQS. The trigger to the formation of vortex-antivortex pairs in fluid quantum space, corresponding to matter and antimatter within our analogy, might besides be a phase transition similar to the Kosterlitz-Thouless transition, where bound vortex-antivortex pairs get unpaired at some critical temperature. In the case described by Kosterlitz and Thouless, the vortices can exist above a critical temperature of

$$T_C = \frac{\kappa}{2k_B} \quad (32)$$

where κ is a parameter depending upon the system which the vortex is in and k_B is Boltzmann's constant. Also the mathematics of Lamb-Chaplygin dipoles is interesting for describing the dynamics of symmetric vortices. The stream function [10] of the flow is:

$$\psi = \begin{cases} -\frac{2U}{kJ_0(ka)}J_1(kr)\sin\theta & r < a \\ U\left(r - \frac{a^2}{r}\right)\sin\theta & r > a \end{cases} \quad (33)$$

where J_0 and J_1 are the zero- and first-order Bessel functions. When the first root of J_1 is ka the solution corresponds to a dipole. Single isolated point particles (here seen as point vortices [11]) could be therefore considered as vortex singlets or monopole vortices, whose origin would be linked to another, symmetric, particle. The equations of superfluid vortices might be then the new basis on which to describe the wave equations of fundamental fermions [21]. As far as the fluid dynamics of vacuum is concerned, also Sbitnev's work is noteworthy [6].

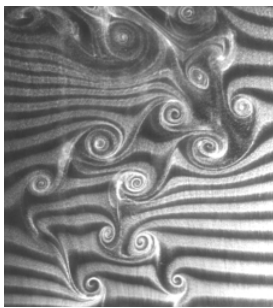


Figure 17: vortex street phenomena (here from [24]) may help understanding how particles and interactions might arise as perturbations in a SQS.

We can also point out that, when fermions are defined as superfluid vortices, Helmholtz's second theorem is respected, since vortex lines are extended to

infinity (SQ absorption and virtual photons emission are not confined in space indeed), reflecting the infinite radius of action of gravity in Gauss's and Newton's law and of electrostatic force in Coulomb's law.

2.4 Strong interaction and quantum chromodynamics.

When describing the elementary fermions as superfluid vortices of SQ, it is immediately clear that their spin can be conflicting or mutual. Two adjacent vortices with conflicting spins would annihilate each other. This fact could explain many known issues of atomic physics (fig. 18).

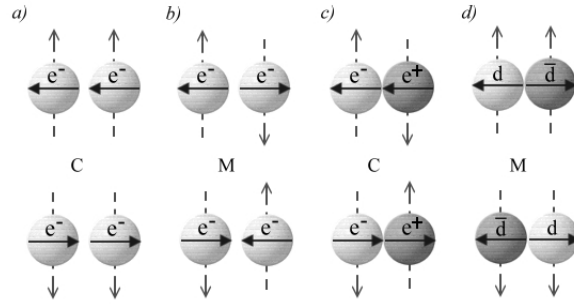


Figure 18: Conflicting (C) or mutual (M) spin would explain: Pauli exclusion principle (a, forbidden; b, allowed \rightarrow anti-parallel spin, according to fig.14.; particle-antiparticle annihilation (c); mesons, such as π^0 (d) or exotic atoms as ortho-positronium. Light grey vortices correspond to matter (left-handed) and dark grey ones to antimatter (right-handed). Without electrostatic repulsion, annihilation between two same charges with parallel spins would occur (a) even without involving antiparticles, due to conflicting rotations.

Only electrons with antiparallel spin (fig. 18.b) can be in the same orbital: as vortices, they have in this circumstance mutual spins and this is precisely the configuration described in fig. 14 for same charges (antisymmetric spin). If they did not repel each other and came in contact, two electrons with parallel spin (fig 18.a) would annihilate like a pair electron-positron (fig. 18.c) because of their conflicting spins. Matter-antimatter annihilation would be then simply due to the conflicting spins of left- and right-handed vortices in antiparallel spin configuration, while, when they have parallel spin they can form unstable particles such as mesons (for instance a neutral pion π^0 , fig. 18.d) or ortho-positronium. Conflicting spins can also explain the decay occurring in nucleon resonances. Quantum chromodynamics and the strong interaction as exchange of gluons (seen as discrete amounts of space's quanta passing from a vortex to another) can be therefore described in terms of adjacent superfluid vortices in mutual-spin configuration, as shown in fig. 19.

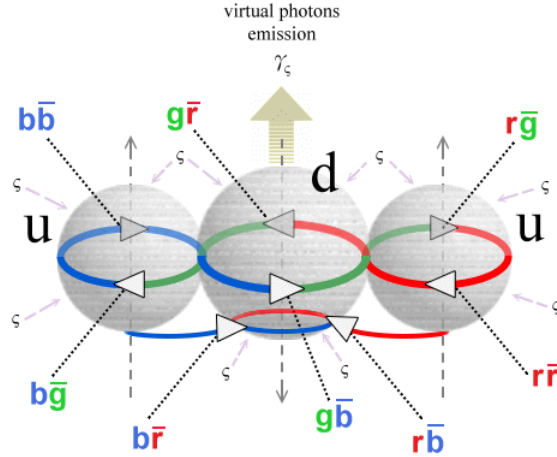


Figure 19: Quantum chromodynamics as superfluid vortices of SQ in mutual-spin configuration (here the hypothetical structure of a proton). The gluonic octet is represented as the exchange of discrete amounts of SQ among the vortices (a flow of SQ). The charge of the whole system is determined by emission of virtual photons from the central vortex (down quark), while the SQ expelled from the other quarks are absorbed by the central quark ($b\bar{r}$, $r\bar{b}$). This superfluid model would explain why most of the mass of the quarks in a proton is expressed as binding energy (gluonic flow): SQ, as gluons, continuously flow among the quarks (they exchange mass the one with the other) and this determines their continuous change of *color*.

The continuous exchange of discrete amounts of SQ (interpreted as gluons) among the three vortices would account for the fact that most of the mass-energy of bound quarks is in the form of force-field energy and that color migrates from a quark to another. A fluid dynamic, quantum explanation seems to be clear and necessary. The residual strong interaction can be likewise described as exchange of SQ between vortices which are close together, when a tube arises, whose break perturbs the fluid space (§2.3) and symmetrically generates a quark-antiquark pair (π^0 meson) as a vortex-antivortex pair: this, as we know, as a self-sustainable process.

2.5 Baryon asymmetry explained?

The decay of B mesons is predicted to favor the production of matter over antimatter, but not enough to explain the huge preponderance of matter in the present universe. Baryon asymmetry could be however explained by the fact that particles and antiparticles have more than one way to interact. By referring to fig.18, the different, possible configurations that the superfluid vortices can assume, might explain the origin of baryon asymmetry, starting from equal amounts of matter and antimatter in a quark-gluon-lepton plasma (fig. 20). The

statistically prevalent production of unstable and annihilation groupings would account for the large number of photons in the cosmic background radiation for each baryon. The dynamics illustrated in the figure could be extended up to having even 1 billion photons each baryon.

An asymmetry may then arise as a mere probability from all different combinations and spin configurations that vortex-particles can assume. In fig. 20, by starting from a perfect symmetry (S), particles (light grey) and antiparticles (dark grey) in a quark-gluon-lepton plasma (primordial universe) get stochastically mixed up and merge. Phenomena of annihilation and decay are statistically prevalent. The figure shows only one of the possible, infinite combinations, which produces in this case a single proton, two electrons and many photons and totally erases antimatter. This means that the Big Bang (or rather a cascade perturbation occurred in a calm, preexisting SQS?) may have produced equal amounts of matter and antimatter but the ways they have casually combined may have led to baryon asymmetry. This model also predicts, in every possible combination of particles, the existence in the universe of more leptons than baryons, in this case more electrons than protons, from the photon epoch.

It is finally questionable whether some heavy bosons detected in synchrotrons through photon counting couldn't be rather the outcome of unexpected annihilation configurations of fundamental particles.

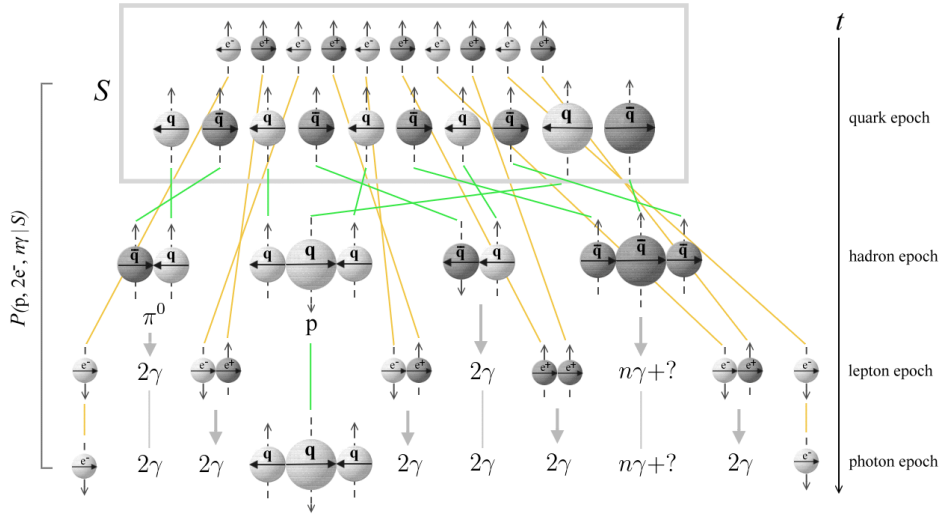


Figure 20: Baryon asymmetry as a mere probability which arises from all different combinations and spin configurations that fundamental vortex-particles might assume.

3 Conclusion

If the single hypothesis of fermions as vortices of space's quanta in a superfluid quantum space, which obeys Gauss's law for gravity (incoming flux \Rightarrow absorption of space's quanta), generates a series of consequences which range from describing and simplifying special and general relativity up to unifying the four fundamental interactions, explaining baryon asymmetry, Hubble's law without resorting to distant galaxies acceleration and producing a general simplification of various other issues, it should be then considered for mathematical and experimental in-depth analysis. Furthermore, the hypothesis of absorption (fig. 1) solves the incompatibility of a fluid space with the outcome of the Michelson-Morley experiment, since an ether wind corresponding to the gravitational field is possible and conforms to the known experimental evidences such as light deflection and gravitational redshift. Finally, the description of photons as phonons through a superfluid space would reduce waves existing in nature to only one type (propagation medium-dependent). We could therefore state that *entia non sunt multiplicanda praeter necessitatem*, as it seems that a superfluid approach may explain nature without extra dimensions, strings, gravitons or other complex reasonings. The suggested test concerning the speed of light (§1.4), is quite easy and might demonstrate the existence of a superfluid quantum space, of gravity as absorption of SQ and of light as a pulse (phonon) through a superfluid quantum medium. Unexpectedly, the new physics would in some respects have the flavor of pre-Einsteinian physics but the differences lie in the assumptions, as the reinterpretation of the MM-experiment demonstrates (§1.1), and what we now call *relativistic*, could be tomorrow described as a fluid quantum phenomenon.

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Annex.

Images from the performed CFD simulations.

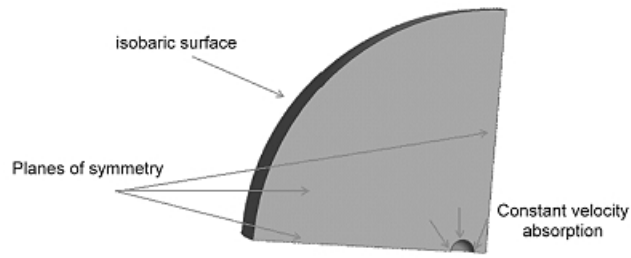


Figure 21: Simulation settings

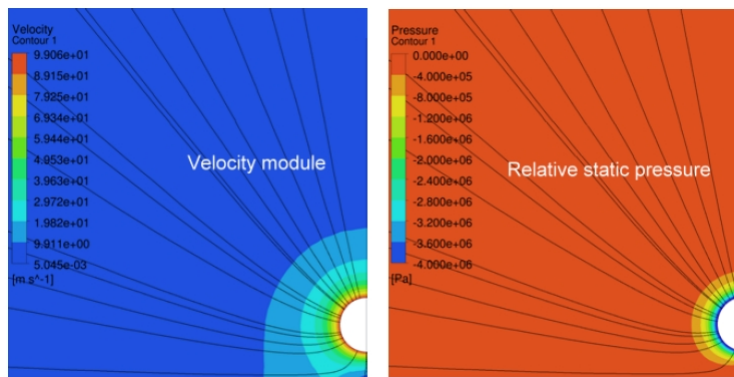


Figure 22: some results of the simulations.

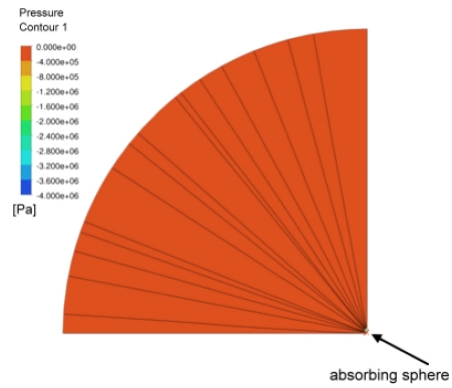


Figure 23: radial flow obtained in the simulations

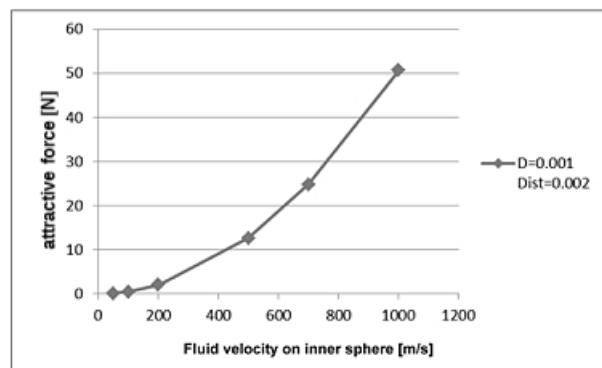


Figure 24: Test for force dependence on absorption velocity: sphere diameter 1mm, distance 2mm. Tested velocities: 50, 100, 200, 500, 700, 1000 m/s. Other tested conditions (50, 100, 200, 500 m/s) are shown in fig. 6 and 7.

Figure 25:

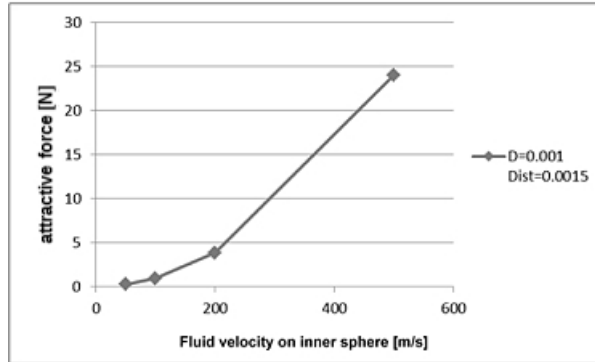
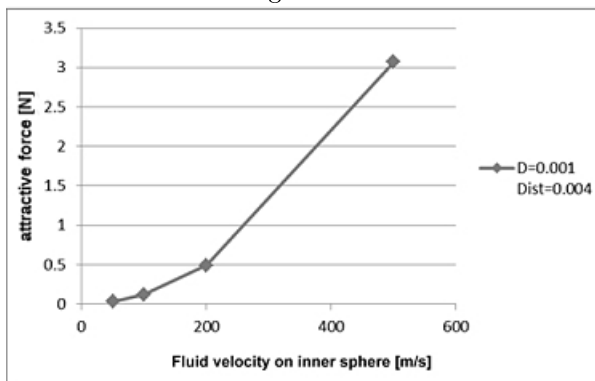


Figure 26:



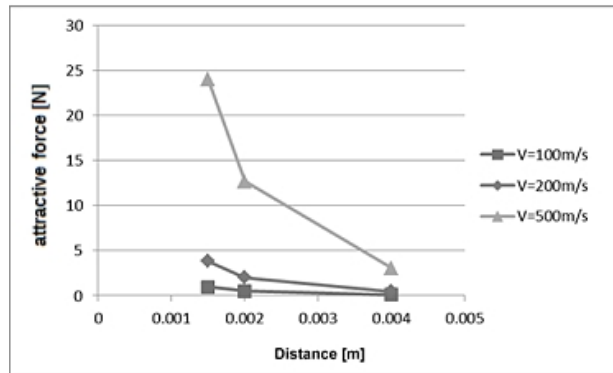


Figure 27: Test for force dependence according to the distance between the spheres.