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Time-Invariant Superfluid Quantum Space as the Unified Field Theory

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The novelty of 21st-century physics is the development of the "superfluid quantum vacuum" model, also named "superfluid quantum space" that is replacing space-time as the fundamental arena of the universe. It also represents the model that has the potential of unifying four fundamental forces of the universe. Superfluid quantum space is represented as the time-invariant fundamental field of the universe where time is merely the duration of material changes.

Keywords: Unified field model; superfluid quantum space; gravity; entanglement; time.

1. Introduction

Valeriy Sbitnev suggests that superfluid quantum vacuum also named superfluid quantum space is the physical origin of the universal space.[1,2] In this article we developed a model of the time-invariant n-dimensional complex superfluid quantum space which offers the new solution for Einstein's dream of a "Unified Field Model". In Einstein's Relativity the universal space is understood as a 4-D reality with tree spatial dimensions and one temporal dimension. Bezuglav also suggested that the superfluid quantum vacuum, which is the physical origin of the universal space, is four-dimensional.[3] In experimental physics, time is duration of material change, i.e.,

motion in space. Taking this in account we developed the model of time-invariant n-dimensional complex superfluid quantum space, shortly "SQS".

The measured value of cosmological constant $\Lambda = 5.96 \cdot 10^{-27}\,\mathrm{kg/m^3}$ [4] is different from its calculated value following the Planck metrics for the magnitude of 10^{123}; this discrepancy is an unsolved subject of physics for decades.[5] Regarding the suggested energy density of space proposed in this article, we are defending our proposal by the fact that the gravitational constant G is obtained by measurement and is expressed by the Planck energy density ρ_{EP} and the Planck time t_P as[6]:

$$G = \frac{c^2}{P_{EP} t_P^2} \tag{1}$$

This means that the Planck energy density ρ_{EP} reflects the real energy density of a 4-D universal space. In the absence of stellar objects, the energy density of the universal space has a value of Planck energy density which is $\rho_{EP} = 4.64 \cdot 10^{113} Jm^{-3}$.[6] Meis has developed another formula for calculating the gravitational constant G:

$$G = \frac{l_P^2 c^2}{4\pi e \xi} \tag{2}$$

where e is the elementary charge constant and ξ is the vector potential amplitude of the electromagnetic field to a single photon state ($\xi = 1.747 \cdot 10^{-25}\,\mathrm{V\,m^{-1}\,s^2}$).[7] We can replace in Eq. (2) the term c^2 with the electric permittivity ε_0 and the magnetic permeability μ_0 obtaining:

$$G = \frac{l_P^2}{4\pi e \xi \varepsilon_0 \mu_0} \tag{3}$$

Equation (3) confirms that the 4-D SQS electromagnetic properties are defining the gravitational constant.

2. SQS as the Unified Field Model

Time-invariant superfluid quantum space (SQS) has a general n-dimensional complex structure $\mathbb{C}^n$; every point of it has complex coordinates:

$$z_i = x_i + iy_i. \tag{4}$$

$(x_i, y_i)(i = 1, \ldots, n)$ is an ordered n-uple of real numbers ($(x_i, y_i) \in \mathbb{R}^n$); for the purpose of this article, we consider its subset $\mathbb{C}^4$ where all elementary particles are different structures of $\mathbb{C}^4$-SQS and have four complex dimensions z_i. In $\mathbb{C}^n$-SQS the elapsed time of a given material change, i.e., motion is the sum of Planck times t_P[8]:

$$t = t_{P1} + t_{P2} + \cdots + t_{PN} = \sum_{i=1}^{N} t_{Pi} \tag{5}$$

$\mathbb{C}^n$-SQS is time-invariant in the sense that time is not its fourth dimension. Material changes run in time-invariant $\mathbb{C}^n$-SQS and time is their duration. We do not have

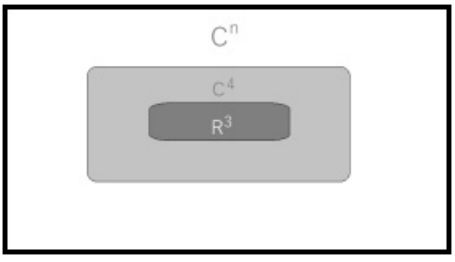

Fig. 1. Structure of the $\mathbb{C}^n$-SQS universe.

any experimental data that time is the fourth dimension of space and we suggest in this article a novel model where time is only the duration of change in time-invariant complex space $\mathbb{C}^n$-SQS. Its subset $\mathbb{C}^4$-SQS is the physical origin of the universal space: we call it "four-dimensional complex superfluid quantum space". Subatomic particles are different structures of $\mathbb{C}^4$-SQS; atoms, made out of subatomic particles, are three-dimensional physical objects, described by real geometry $\mathbb{R}^3$ and therefore follow the 3-D Euclidean geometry. Because of that we cannot fully grasp the complex subatomic level with 3-D apparatuses (Fig. 1).

The 4-D complex superfluid quantum space $\mathbb{C}^4$-SQS is the theoretical frame for the unification of gravity and the other three fundamental forces which have already been unified by the Standard Model. In this complex superfluid quantum space, we have four spatial coordinates which have a real and imaginary component. The energy density of $\mathbb{C}^4$-SQS is calculated in the terms of $\mathbb{R}^3$ matter in units kg/m^3 and related to the mass m of a given physical object; every physical object with mass m is decreasing the energy density ρ_{Emin} of $\mathbb{C}^4$-SQS in its centre exactly for the amount of its energy:

$$E = mc^2 = (\rho_{EP} - \rho_{Emin})V \tag{6}$$

where ρ_{EP} is the energy density of SQS faraway of a stellar object in the interstellar space and V is its volume.[6] By developing Eq. (6), we can calculate the minimal energy density of space in the centre of a given physical object:

$$\rho_{Emin} = \rho_{EP} - \frac{mc^2}{V} \tag{7}$$

Equation (7) holds from the proton scale to black holes scale. Going away from the centre of a given physical object, the energy density of space is increasing by the following Eq. (8):

$$\rho_{Emin} = \rho_{EP} - \frac{3mc^2}{4\pi(r+d)^3} \tag{8}$$

where r is the radius of the physical object and d is the distance from its centre. When d tends to the infinite, ρ_{Emin} tends to ρ_{EP} (Fig. 2).

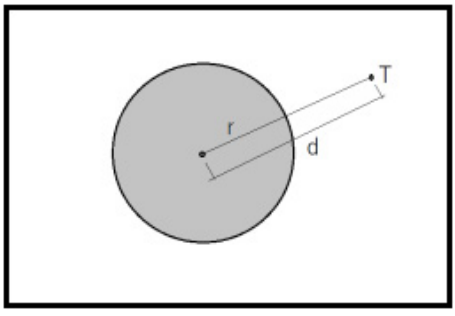

Fig. 2. Energy density of $\mathbb{C}^4$-SQS in the point T at the distance d from its centre.

Gravity is carried by external pressure of $\mathbb{C}^4$-SQS towards the centre of physical objects; it is the force of $\mathbb{C}^4$-SQS pressure from the maximum energy density of $\mathbb{C}^4$-SQS towards its decreased energy density in the centre of the given physical object. Two physical objects are creating decreased area of $\mathbb{C}^4$-SQS energy density, causing outer pressure of $\mathbb{C}^4$-SQS towards its lower inner pressure. This outer pressure is gravity (Fig. 3).[6]

That gravity is generated by the pressure force of the medium in which physical objects exist is also proposed by Arminjon back in 1997: "The theory starts from a tentative interpretation of gravity as Archimedes' thrust exerted on matter at the scale of elementary particles by an imagined perfect fluid ("ether"): the gravity acceleration is expressed by a formula in which the "ether pressure" ρe plays the role of the Newtonian potential. The instantaneous propagation of Newtonian gravity is obtained with an incompressible ether, giving a field equation for ρe".[9] In our model, the medium is not filling universal space in the sense as ether should fill the universal space. Universal space itself is the physical medium in which physical objects exist. NASA has measured back in 2014 that universal space has a Euclidean shape: "Recent measurements (c. 2001) by a number of ground-based and balloon-based

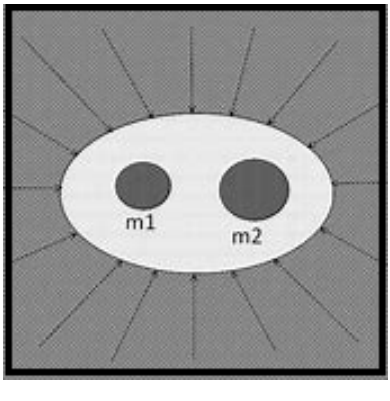

Fig. 3. Gravity is the space pressure towards the physical objects.

experiments, including MAT/TOCO, Boomerang, Maxima, and DASI, have shown that the brightest spots are about 1 degree across. Thus, the universe was known to be flat to within about 15% accuracy prior to the WMAP results. WMAP has confirmed this result with very high accuracy and precision. We now know (as of 2013) that the universe is flat with only a 0.4% margin of error".[10] This puts in question the curvature of the universal space as suggested in General Relativity. We suggested in our previous research that the curvature of space in General Relativity (GR) is the mathematical description of some fundamental physical property of the universal space that is its variable energy density. With the increasing of space curvature in GR, the energy density of space is decreasing in our model.[11]

We will use this Eq. (7) to calculate the energy density of space in the centre of different stellar objects, considering that these objects are non-rotating. In Table 1 there is the comparation of the energy densities of space in the centre of the black hole with the mass of the Sun, in the centre of the proton, in the centre of the Moon, Earth, and Sun:

Hawking has proposed that proton could be a min black hole.[12] Voyager did not find these primordial black holes.[13] Our research confirms, in the centre of a proton, the minimal energy density of SQS is not low enough for a proton to become a black hole. The energy density of space in the proton centre is for the order of 10^2 higher than in the black hole centre with mass of the Sun. In the centre of a proton, the minimal energy density of SQS is for the order of 10^{14} lower than in the centre of Sun, Earth and Moon, because these stellar objects are made out of atoms where there is a vast empty space between the nucleus and electrons orbits. Proton's mass is very small compared with the mass of the Sun, but it diminishes the energy density of an extremely small area of space compared with that of Sun, that diminishes the energy density of an extremely big area of universal space; that is why the gravity force of the Sun has such a long-range.

Proton has much lower energy density of $\mathbb{C}^4$-SQS in its centre than the Earth (Fig. 4); however, it has almost no attraction force because of its extremely small mass. The calculation of attraction force because of lower energy density of $\mathbb{C}^4$-SQS in the centre of proton and neutron in deuterium nucleus is as follows:

$$F_g = \frac{1.67 \cdot 10^{-27}\,\mathrm{kg} \cdot 1.67 \cdot 10^{-27}\,\mathrm{kg} \cdot 6.67 \cdot 10^{-11}\,\mathrm{m^3\,kg^{-1}\,s^{-2}}}{(2 \cdot 0.87 \cdot 10^{-15}\,\mathrm{m})^2} = 6.144 \cdot 10^{-35} N,$$

Table 1. Comparation values of the minimal energy density of space with respect to the centre of indicated objects.

Centre of objects	$\rho_P = 4.64 \cdot 10^{113} Jm^{-3}$
Black hole with mass of the Sun	$\rho_P - 1.58 \cdot 10^{36} Jm^{-3}$
Proton	$\rho_P - 5.43 \cdot 10^{34} Jm^{-3}$
Earth	$\rho_P - 4.94 \cdot 10^{20} Jm^{-3}$
Moon	$\rho_P - 3.00 \cdot 10^{20} Jm^{-3}$
Sun	$\rho_P - 1.26 \cdot 10^{20} Jm^{-3}$

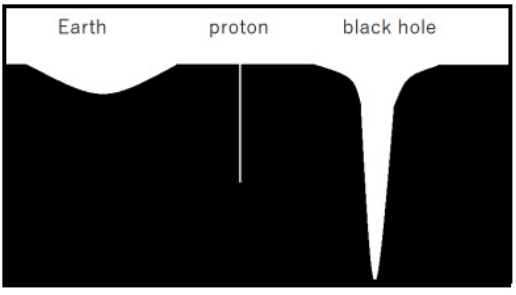

Fig. 4. Energy density of $\mathbb{C}^4$-SQS in the centre of Earth, proton and black hole (figure is an approximation)

where $1.67 \cdot 10^{-27}$ kg is the mass of proton and neutron, and $0.87 \cdot 10^{-15}$ m is their radius. This calculation confirms that gravity force and strong nuclear force are not the same force as suggested by Vayenas and Souentie.[14] The binding energy between a proton and neutron in deuterium nucleus is 2224575 ± 9 eV which is $3.564 \cdot 10^{-13}$ J.[15] The error of their proposal is of rate 10^{22}.

From the macro to the microscale, it holds that a given physical object is interacting with the $\mathbb{C}^4$-SQS in which it exists, and the result of this interaction are the inertial mass m_i and the gravitational mass m_g:

$$m_i = m_g = \frac{(\rho_{EP} - \rho_{Emin})V}{c^2}. \tag{9}$$

The rest mass m_0 of the proton is not its inertial mass m_i, but is related to the amount of $\mathbb{C}^4$-SQS energy E which is incorporated in the proton, as per Eq. (10):

$$m_0 = \frac{E}{c^2}. \tag{10}$$

The inertial mass m_i of the proton is the result of proton interaction with the $\mathbb{C}^4$-SQS energy and the decrease in energy density of $\mathbb{C}^4$-SQS in proton's centre is exactly for the amount of its mass and volume V as we can see in Eq. (9). This decreased energy density of $\mathbb{C}^4$-SQS is the physical origin of proton's inertial mass. Einstein has proved that inertial mass and gravitational mass of a given physical object are equal. We have shown that they have the same origin in the decreased energy density of $\mathbb{C}^4$-SQS accordingly to the Eq. (9).

That inertial mass and gravitational mass are one phenomenon ("to be identical thing") was also proposed by Rueda and Haisch back in 2005: "There are additional consequences that make this approach of assuming real interactions between the electromagnetic quantum vacuum and matter appear promising. It can be shown that the weak principle of equivalence — the equality of inertial and gravitational mass 1 — naturally follows. In the quantum vacuum inertia hypothesis, inertial and gravitational mass are not merely equal, they prove to be the identical thing".[16]

The strong nuclear force is carried by gluons which bind together quarks inside the proton and neutron. Residual nuclear force between quarks is acting also outside protons and neutrons and hold them together in nucleus of an atom. In the model here presented gluons are excitations of $\mathbb{C}^4$-SQS and they represent 99% of proton mass. In this perspective, the proton mass can be seen as the excitation of the $\mathbb{C}^4$-SQS in the form of gluons and quarks. In Meis model the mass of electron m_e and mass of proton M_P are expressed by the physical properties of the electromagnetic vacuum:

$$m_e = 2\pi ce^2 \left| \frac{\xi}{\mu_B} \right| = 9.109 \cdot 10^{-31}\,\text{kg} \tag{11}$$

$$M_P = 2\pi ce^2 \left| \frac{\xi}{\mu_B} \right| = 1.672 \cdot 10^{-27}\text{kg} \tag{12}$$

The mass m_i of any elementary particle i can be expressed using Eq. (11):

$$m_i = 2\pi ce^2 \left| \frac{\xi}{\mu_i} \right| \tag{13}$$

with $|\mu_i| = \mu_B$ for the electron and $|\mu_i| = (\frac{2\alpha}{n_i})\mu_B$ for other particles, with n_i an integer and α the fine structure constant, $\mu_B = 9,274 \cdot 10^{-27} JT^{-1}$.[7]

In Meis model, as well in $\mathbb{C}^4$-SQS model, elementary particles are different energy structures of the $\mathbb{C}^4$-SQS energy. This is also the view of Erwin Schrödinger who used to say: "What we observe as material bodies and forces are nothing but shapes and variations in the structure of space".[17] This is expressed in Einstein formula $E = mc^2$; E is the $\mathbb{C}^4$-SQS energy, which is incorporated in a given physical object, m is the mass of the object.

Relativistic particles are interacting with the $\mathbb{C}^4$-SQS and additionally integrating $\mathbb{C}^4$-SQS energy into its structure. Relativistic energy E of a given accelerated particle is the sum of the rest energy E_0 and kinetic energy E_K which is incorporated energy of $\mathbb{C}^4$-SQS due to the motion of the particle[18]:

$$E = E_0 + E_K = \gamma m_0 c^2 = (\rho_{EP} - \rho_{EminR})V, \tag{14}$$

where γ is Lorentz factor, m_0 is proton rest energy, ρ_P is Planck energy density, ρ_{EminR} is additionally diminished energy density of $\mathbb{C}^4$-SQS in the centre of the proton because the proton is additionally absorbing $\mathbb{C}^4$-SQS energy and so increasing its mass and energy, V is the volume of the proton at rest.

The unification of electromagnetism and weak nuclear force into electroweak force was independently proposed by Sheldon Glashow, Abdus Salam and Steven Weinberg in the sixties of the last century; we introduced here a model where all four fundamental forces are carried by $\mathbb{C}^4$-SQS. Gravity force is carried by variable density of $\mathbb{C}^4$-SQS, strong nuclear force and electroweak force are carried by the excitation of $\mathbb{C}^4$-SQS.

In the model of $\mathbb{C}^4$-SQS the electric field is the excitation of $\mathbb{C}^4$-SQS on the three real dimensions X_1, X_2, X_3, and the magnetic field is the excitation of C^4-SQS on the tree real dimension X_2, X_3, X_4. Both fields have in common dimensions X_2 and X_3.

The photon is then the excitation of $\mathbb{C}^4$-SQS on X_1, X_2, X_3, X_4 dimensions, it is a 4-D wave of $\mathbb{C}^4$-SQS; the light has a constant speed for all moving observers because it is a wave of $\mathbb{C}^4$-SQS. When the source of light is moving closer to the observer or moving away from the observer the frequency of light will respect the Doppler effect. The source of light and the moving observer are all moving in the $\mathbb{C}^4$-SQS. This model explains the physical meaning of the first postulate of Special Relativity, i.e., that the light has the same velocity for all observers; the light is a 4-D wave of $\mathbb{C}^4$-SQS in which the observer and the 3-D source of light are moving. The motion of the observer or the motion of the light source creates the Doppler effect but the light speed remains unchanged. In Special Relativity the photon is moving in a 4-D space of Minkowski, where time t is the element of the fourth dimension $X_4 = ict$. We have shown that time is just the numerical sequential order of material changes, i.e., motion in $\mathbb{C}^4$-SQS. When we measure the numerical order of photon motion from the point A to the point B in $\mathbb{C}^4$-SQS, we get duration. The photon is the wave of $\mathbb{C}^4$-SQS and does not move in some physical space-time, it moves in time-invariant universal space.[19]

3. Complex Time-Invariant $\mathbb{C}^4$-SQS is the Medium of Quantum Entanglement

Time-invariant superfluid quantum space is the medium of entanglement EPR-type.[19,20] In this perspective, time as duration of material change, i.e., motion in $\mathbb{C}^4$-SQS, can be seen as an emergent property of entangled universe. Time as duration enters existence when measured by the observer.[8,19] Moreva *et al.* came to the same conclusion, namely time is an emergent property of entanglement, starting their research from a different perspective.[21]

Einstein has interpreted the time t as the 4th coordinate X_4 of a Minkowski manifold. He wrote: "If we replace x, y, z, $\sqrt{-1}\,ct$ by x_1, x_2, x_3, x_4, we also obtain the result that $ds^2 = dx_1^2 + dx_2^2 + dx_3^2 + dx_4^2$ is independent of the choice of the body of reference. We call the magnitude ds the "distance" apart of two events or four-dimensional points. Thus, if we choose as time variable the imaginary variable $\sqrt{-1}$ ct instead of the real quantity t, we can regard the continuum space-time, in accordance with the special theory of relativity, as an "Euclidean" four-dimensional continuum, a result following by the consideration of the preceding section".[22] In the above citation, Einstein suggestion that we can choose the time variable t as the imaginary variable can be written as follows:

$$t = \sqrt{-1}\,ct \tag{15}$$

Equation (15) is false because on the left side of the equation we have t and on the right side we have $\sqrt{-1}\,ct$. Combining Eq. (6) with equation well know equation $X_4 = ict$ we get:

$$X_4 = itc^2\sqrt{-1} \tag{16}$$

Equation (16) confirms that Einstein did a mistake keeping and interpreting time as the dimension of a four-dimensional continuum. Physics is still today suffering this misinterpretation of time that is solved in this article: time is the duration of a given physical object motion in time-invariant space. There is no "distance in time" in the universe because there is no physical time in which events happen. The universal changes run in time-invariant space which means that the entire universe is existing simultaneously. This is so-called "absolute simultaneity" in which there is no physical past and there is no physical future.[19,20]

Several authors are proposing that entanglement is induced by gravity.[23–25] On the other hand, there is a proposal that entanglement influences gravity: "To summarize, we have shown that entanglement can affect the gravitational field. This suggests that entanglement "has a weight". The perturbations in the gravitational field depend on the amount of entanglement and vanish for vanishing quantum correlations".[26] We have shown in this article that gravity and entanglement are carried by the same medium which is $\mathbb{C}^4$-SQS. In the model presented in this article gravity force between two physical objects does not induce entanglement and entanglement has no impact on gravity. Two entangled physical objects are entangled via $\mathbb{C}^4$-SQS which variable energy density is also carrying gravity. Gravity does not influence entanglement and vice versa is also valid. In the model here presented gravity and entanglement are both induced by the superfluid quantum space that is time-invariant.[19,20]

4. Conclusions

The unified field theory of Albert Einstein is one of the main goals of modern physics. This goal can be achieved by the development of complex $\mathbb{C}^n$-SQS as the fundamental arena of the universe. Elementary particles and consequently strong nuclear force and electroweak force forces are different structures of $\mathbb{C}^4$-SQS. Gravity does not require the existence of some hypothetical particle graviton. It is carried directly by the variable energy density of time-invariant complex $\mathbb{C}^4$-SQS that is the medium of quantum entanglement EPR-type experiments.

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