# Advances of relativity theory

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**Abstract:** Advances of relativity theory are in the replacement of the space-time model with time-invariant universal space that has a variable energy density. Every physical object with mass *m* and energy *E* is diminishing the energy density of space exactly for the amount of its energy. Lorentz factor has its origin in the variable density of universal space, we call it "superfluid quantum space"—SQS that is the primordial energy of the universe. Universal SQS is the absolute frame of reference for all observers as confirmed experimentally by the general positioning system, which demonstrates that the relative rate of clocks is valid for all observers. A planet's perihelion precession and the Sagnac effect are the results of the SQS dragging effect. © *2021 Physics Essays Publication*. [http://dx.doi.org/10.4006/0836-1398-34.2.201]

**Résumé:** Les progrès de la théorie de la relativité résident dans le remplacement du modèle spatio-temporel par un espace universel invariant dans le temps et à densité d'énergie variable. Tout objet physique de masse m et d'énergie E diminue la densité d'énergie de l'espace exactement pour la quantité de son énergie. Le facteur de Lorentz a son origine dans la densité variable de l'espace universel, nous l'appelons "espace quantique superfluide "- SQS qui est l'énergie primordiale de l'univers. Universal SQS est le cadre de référence absolu pour tous les observateurs comme confirmé expérimentalement par le système GPS, ce qui démontre que le taux relatif d'horloges est valable pour tous les observateurs. La précession du périhélie d'une planète et l'effet Sagnac sont les résultats de l'effet de traînée SQS.

Key words: Superfluid Quantum Space; Lorentz Factor; Planet's Precession; Sagnac Effect; GPS; Dragging Effect.

## I. INTRODUCTION

In special relativity (SR), time *t* is the duration of photon motion along the fourth coordinate: $X_4 = ict$. This confirms that fourth coordinate is not time, fourth coordinate too is spatial distance. Duration *t* multiplied by light speed *c* is spatial distance $X_4$. Minkowski manifold $X_1, X_2, X_3, X_4$ has four spatial coordinates and thinking that time is its fourth coordinate is an utter mistake. Experimental data confirm that time *t* is a duration of motion in universal space that is time-invariant in the sense that time is not its fourth dimension. Development of relativity theory is based on three significant scientific discoveries:

- Space-time is not a fundamental arena of the universe; time is not the fourth dimension of space. Time is merely the duration of motion in time-invariant universal space. Linear time "past-present-future" is phycological time based on the neuronal activity and exists only in the human brain. Irreversible universal changes run in time-invariant space. Time as the duration enters the existence when measured by the observer.[1,2]
- Entanglement happens in time-invariant space only and not in time. Time-invariant universal space is the immediate medium of quantum entanglement.[3]
- Universal space is not "empty," space is the fundamental energy of the universe, in today physics called "superfluid quantum vacuum" or "superfluid quantum space."[1,4] We will call it in this article time-invariant superfluid quantum space—SQS.

General positioning system (GPS) proves that the relative rate of clocks on satellites relative to the Earth's surface is valid for all observers, including observers in airplanes, trains, ships, and cars.[5,6] This experimental fact, along with everyday experience, suggests a revision to our understanding of the famous *Gedankenexperiment* of one observer at a train station and another observer on a passing train. Standard physics textbooks describe that a clock at the station runs faster for the observer on the train, and the clock on the train runs slower for the observer at the station. In classic relativity, both observers have their own "internal time" inside the reference system in which they exist and both have an "external time" that exists in the other observer reference system. This interpretation features four distinct times: The proper time of the observer at the station, the proper time of the observer in the train, the external time of the observer at the station, and the external time of the observer on the train. On the other hand, GPS proves that the relative velocities of clocks at the station and on the train are equally related to the rate of clocks on orbiting satellites, so are valid for both observers. If this were not so, then GPS could not work properly. In this article,

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we will develop a model where the relative rate of clocks in all inertial systems depends only on the variable energy density of SQS and is valid for all observers.

We have to acknowledge that time is merely the duration of change. No change in SQS would mean no time. This model is in perfect accord with experimental physics, where we measure with clocks the duration of material change that is time. In this sense, SQS is timeless, or we say, "time-invariant."[1] Rovelli is right in saying that time is an illusion: "According to theoretical physicist Carlo Rovelli, time is an illusion: our naive perception of its flow doesn't correspond to physical reality. Indeed, as Rovelli argues in *The Order of Time*, much more is illusory, including Isaac Newton's picture of a universally ticking clock. Even Albert Einstein's relativistic space-time—an elastic manifold that contorts so that local times differ depending on one's relative speed or proximity to a mass—is just an effective simplification."[7]

## II. MATHEMATICAL MODEL OF SQS

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

$$z_i = x_i + iy_i, \tag{1}$$

$(x_i, y_i)$ $(i = 1, \ldots, n)$ is an ordered $n$-tuple 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 $z_i$.[1] $\mathbb{C}^4$SQS is time-invariant in the sense that time is not its fourth dimension. Material changes run in time-invariant $\mathbb{C}^4$SQS, and time is their duration. We do not have 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 $\mathbb{C}^4$SQS.

Einstein did mistake keeping time as the fourth dimension of space: "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." In the above citation, Einstein suggestion that we can choose the time variable $t$ as the imaginary variable can be written as follows:

$$t = \sqrt{-1}\ ct. \tag{2}$$

Equation (2) 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. (2) with equation well know equation $X_4 = ict$ we get

$$X_4 = itc^2\sqrt{-1}. \tag{3}$$

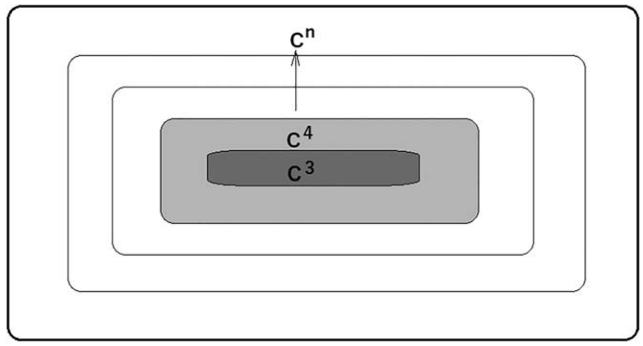


FIG. 1. Structure of the $\mathbb{C}^n$-SQS universe.

Equation (3) confirms that Einstein did a mistake keeping and interpreting time as the dimension of a four-dimensional continuum.[1]

$\mathbb{C}^n$SQS model is the reintroduction of the ether in physics; this is necessary because material objects are made out of energy and energy cannot exist in a space devoid of physical properties. $\mathbb{C}^4$SQS is the physical origin of the universal 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 3D Euclidean geometry. Because of that we cannot fully grasp the complex subatomic level of reality $\mathbb{C}^4$SQS with 3D apparatuses (Fig. 1).

Back in 2014, NASA has measured that universal space has Euclidean shape: "Recent measurements (c. 2001) by a number of ground-based and balloon-based 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. This suggests that the Universe is infinite in extent; however, since the Universe has a finite age, we can only observe a finite volume of the Universe. All we can truly conclude is that the Universe is much larger than the volume we can directly observe."[8] NASA results are confirming that universal space is not "curved" as suggested by Einstein. In our model, we replaced the Einstein tensor with the variable energy density of $\mathbb{C}^4$SQS. Einstein tensor has three elements, curvature tensor on the left, Einstein constant and stress-energy tensor on the right side of the equation

$$G_{\mu\nu} = \kappa T_{\mu\nu}. \tag{4}$$

Curvature tensor $G_{\mu\nu}$ describes curvature of space due to the presence of a given mass that is expressed by the stress-energy tensor $T_{\mu\nu}$. Curvature tensor is useful only on the macro scale, it cannot be applied on microscale, for example, proton. In this article, curvature tensor will be replaced by the minimal energy density of $\mathbb{C}^4$SQS in the center of the given physical object with the rest mass $m_0$. This formula is valid from the proton to the supermassive black holes (SMBH). Every physical object with energy $E$ and mass $m$ is

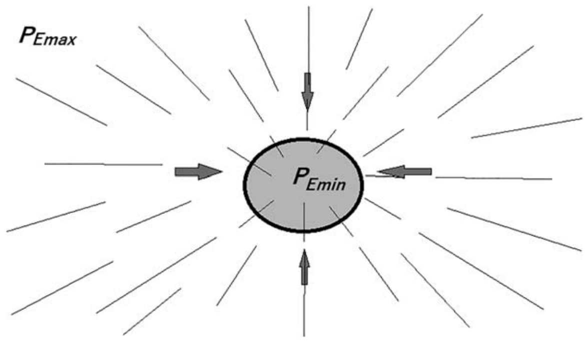


FIG. 2. Inertial mass $m_1$ and gravitational mass $m_g$ have the same origin in $\mathbb{C}^4$SQS pressure in the direction from $\rho_{\text{Emax}}$ toward the direction $\rho_{\text{Emin}}$.

diminishing energy density of $\mathbb{C}^4$SQS in its center exactly for the amount of its energy and correspondent mass[1]

$$E = mc^2 = (\rho_{\text{Emax}} - \rho_{\text{Emin}}) \cdot V, \quad \text{in units}: J = kg \cdot \frac{m^2}{s^2} = \left(\frac{J}{m^3}\right) \cdot m^3, \tag{5}$$

where $\rho_{\text{Emax}}$ is density of $\mathbb{C}^4$SQS in interstellar space, $\rho_{\text{Emin}}$ is density of $\mathbb{C}^4$SQS in the center of a given physical object, and $V$ is the volume of physical object.

$\mathbb{C}^4$SQS model distinguishes between rest mass and inertial mass. A given physical object with the rest mass $m_0$ is diminishing the energy density of $\mathbb{C}^4$SQS in its center exactly for the amount of its energy $E$. The diminished energy density of $\mathbb{C}^4$SQS is creating the $\mathbb{C}^4$SQS pressure in the direction toward the center of the physical object. This pressure is the common origin of the inertial mass $m_i$ and of the gravitational mass $m_g$ of a given physical object. Einstein has proved inertial mass and gravitational mass are equal, and we confirm in this article they are equal because they have the same origin (Fig. 2).

We can calculate the energy density $\rho_{\text{ER}}$ of $\mathbb{C}^4$SQS at a given point on the distance $R$ from the center of a given stellar object as follows:[4]

$$\rho_{ER} = \rho_{\text{Emax}} - \frac{3m}{4\pi(r+R)^3}, \tag{6}$$

where $m$ is mass of the stellar object, $r$ is radius of the stellar object, and $R$ is the distance from the center of the stellar object to the point where we calculate $\rho_{\text{ER}}$ density of $\mathbb{C}^4$SQS (Fig. 3).

In advanced relativity, curvature of space is replaced with variable energy density of $\mathbb{C}^4$SQS. More space is curved in general relativity (GR), less is its energy density in advanced relativity. When $R$ is zero, we have minimal energy density of $\mathbb{C}^4$SQS in the center of a given stellar object and maximum curvature of space in GR. When $R$ is equal to the radius $r$ of the stellar object, we have energy density of $\mathbb{C}^4$SQS on the surface of the stellar object. When $R$ is close to infinity, we have the maximum energy density of $\mathbb{C}^4$SQS in interstellar space, where the curvature of space in GR is at the minimum.

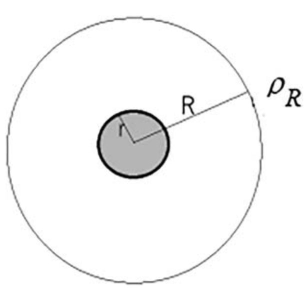


FIG. 3. Energy density of SQS at the distance $R$ from the center.

## III. THE LORENTZ FACTOR AND VARIABLE ENERGY DENSITY OF THE SQS

Lorentz factor $\gamma$ expresses a diminished rate of clocks and a diminished velocity of material changes due to the motion. In the famous example of a train passing a station, $t'$ is the elapsed time on the train and $t$ is the elapsed time at the station, such that

$$t' = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}\left(t - \frac{vx}{c^2}\right), \tag{7}$$

where $1/\sqrt{1-\frac{v^2}{c^2}}$ is the Lorentz factor $\gamma$, $v$ is velocity of the train, and $x$ is the distance along the motion from the station clock to the clock in the train.[9] This diminished rate of clocks on the train has its origin in the decreased energy density of the $\mathbb{C}^4$SQS inside the train. In general, a moving system interacts with the $\mathbb{C}^4$SQS energy so that the higher the velocity $v$, the stronger the interaction and more $\mathbb{C}^4$SQS energy is integrated into the moving object, which in turn increases its mass $m$ of a moving object according to

$$m = \gamma m_0 = m_0 + \frac{EK}{c^2}, \tag{8}$$

where $m_0$ is the object's rest mass, EK is moving object kinetic energy in the form of integrated energy of $\mathbb{C}^4$SQS, and $\gamma$ is the Lorentz factor.

Out of Eq. (5) follows, the equation for the minimal energy density of $\mathbb{C}^4$SQS $\rho_{\text{Emin}}$ in the rest wagon of the train is following:

$$\rho_{\text{Emin}} = \rho_{\text{Emax}} - \frac{m_0 c^2}{V}. \tag{9}$$

Formula for the energy density of $\mathbb{C}^4$SQS in the moving wagon $\rho_{\text{Emin.m}}$ is following:

$$\rho_{\text{Emin.m}} = \rho_{\text{Emax}} - \gamma \frac{m_0 c^2}{V}, \tag{10}$$

where $\rho_{\text{Emin.m}}$ is the additionally diminished energy density in the center of the wagon, because moving wagon matter is absorbing some of the $\mathbb{C}^4$SQS energy which increases wagon's relativistic mass accordingly to Eq. (10). This decreased energy density of the $\mathbb{C}^4$SQS $\rho_{\text{Emin.m}}$ causes the rate of the clock on the moving wagon to run slower. According to Eq. (10), we can express the Lorentz factor as follows:

$$\gamma = \frac{(\rho_{\text{Emax}} - \rho_{\text{Emin.m}})V}{m_0 c^2}. \tag{11}$$

The difference in the energy density of $\mathbb{C}^4$SQS we can write as $(\rho_{\text{Emax}} - \rho_{\text{Emin.m}}) = \Delta\rho_E$.

By replacing the $m_0c^2$ with energy $E$ of the rest object we get

$$\gamma = \frac{\Delta\rho_E V}{E}, \tag{12}$$

where $E$ is the energy of the object at rest, $V$ is the volume of the object, and $\Delta\rho_E$ is the difference between the energy density of $\mathbb{C}^4$SQS far away from the physical object and the center of the moving object. In Eq. (12), rest energy $E$ and volume $V$ of the object are not changing. The only parameter that changes the Lorentz factor is the diminished energy density of $\mathbb{C}^4$SQS in the center of the moving object which depends on the velocity $v$ of the object. So, the higher is the speed $v$, the stronger is the interaction of the object with the $\mathbb{C}^4$SQS, absorption of the $\mathbb{C}^4$SQS energy is greater, and the energy density of the $\mathbb{C}^4$SQS in the center of the moving object becomes smaller. With a smaller density of the $\mathbb{C}^4$SQS in the center of the wagon (and in any other moving object), the rate of the clock is slower:

increased velocity → increased absorption
of the $\mathbb{C}^4$SQS energy →decreased energy
density of the $\mathbb{C}^4$SQS→ decreased rate of a clock.

## IV. ADVANCES OF SPECIAL RELATIVITY

In the $\mathbb{C}^4$SQS model, the relative rate of clocks and the relative velocity of material changes depend on the variable energy density of the $\mathbb{C}^4$SQS. For example, muon decay when approaching the Earth's surface decreases. Coming closer to the Earth surface muons decay decreases. The official explanation is that muons' life-time is depending on the observer's reference frame. Official explanation says if you would be a potential observer moving along the muon, you would experience different muon decay as if you are on the Earth's surface.[10] This seems wrong because the velocity of given physical phenomena has nothing to do with the observation. It depends only on the variable energy density of $\mathbb{C}^4$SQS. Coming closer to the Earth's surface muons enter the lower energy density of $\mathbb{C}^4$SQS, and their decay decreases. A muon's relativistic decay is valid for all observers and is determined only by the variable energy density of the $\mathbb{C}^4$SQS.

In the areas of universal space where energy density of $\mathbb{C}^4$SQS is not changing, the speed of light is constant for all observers because all observers exist in the same $\mathbb{C}^4$SQS and light is the vibration of the $\mathbb{C}^4$SQS. The velocity of light in the intergalactic space is constant, the energy density of $\mathbb{C}^4$SQS there is at the maximum. In the areas where the energy density of $\mathbb{C}^4$SQS is lower gravity is stronger and light speed diminishes minimally. We call this effect in classic relativity wrongly "gravitational time dilation," see Section V B; what Shapiro has measured is that in stronger gravity light needs more time to travel on a given distance which means that its speed has a minimal diminishment.

The area of $\mathbb{C}^4$SQS around a given physical object is moving and rotating with it. We call this "dragging effect." $\mathbb{C}^4$SQS around the Earth is rotating, and so the light motion needs a shorter duration when travels in the direction of Earth's motion because $\mathbb{C}^4$SQS is also rotating with the Earth. When light is moving in the opposite direction of Earth motion from B to A needs a longer duration. In both cases, light speed is constant. By assuming constancy of light in stationary $\mathbb{C}^4$SQS and in moving $\mathbb{C}^4$SQS, we will develop an SR theory without contradictions as those that exist with the current SR in the thought experiment of two-photon clocks.

Here, we place two identical photon clocks on a moving train where one is positioned horizontally in the direction of motion, and the other is positioned vertically. According to the idea of "length contraction," the horizontal photon clock will shorten in length and tick faster compared with the vertically oriented clock that will not diminish in length. This scenario leads to a contradiction as SR does not predict that the two clocks in the same inertial system will have different rates. The solution is available through the development of an SR model in a three-dimensional Euclidean space with a Galilean transformation and Selleri's equation for the variable rate of clocks with no occurrence of length contraction: "Einstein's formalism of special relativity based on the standard Lorentz transformations may be derived from a more fundamental 3D Euclidean space, with Galilean transformations for the three spatial dimensions and Selleri's transformation for the rate of clocks"[11]

$$t' = \sqrt{1 - \frac{v^2}{c^2}}\, t. \tag{13}$$

Selleri's Eq. (13) confirms that rate of clocks is not related to the spatial dimensions. SR equipped with this formalism also describes successfully all phenomena previously described by classical SR such as aberration of light, Doppler effect, Jupiter's satellites occultation, and radar ranging of the planets.[10] By the use of algebra Eq. (13) can be derived from Eq. (7).[9]

A second contradiction occurs with the rate of the vertical photon clock on the moving train from the perspective of the observer at the station. The classical interpretation states that for the observer at the station, the vertical photon clock ticks slower, because they see the photon in the clock moves in a "zig-zag" direction, as illustrated in Fig. 4.[12]

This explanation may appear illogical, because the optical illusion of the stationary observer cannot slow the rate of the moving clock. Instead, in the moving train, the energy density of the $\mathbb{C}^4$SQS diminishes, causing a reduced velocity of the photon. With the diminishing of $\mathbb{C}^4$SQS energy density also the velocity of light diminishes a bit, see Section V B. Therefore, the moving vertical photon clock ticks slower in the moving train because of the diminished energy density of $\mathbb{C}^4$SQS and not because of the optical illusion of the stationary observer in the station.

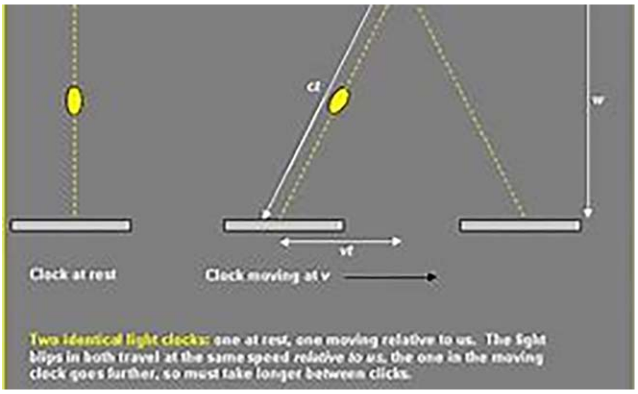


FIG. 4. (Color online) An observer at rest, seeing a moving clock photon.

In advanced relativity rate of clocks in all moving inertial systems depends on the diminished energy density of $\mathbb{C}^4$SQS in the system due to its motion. The relative rate of clocks does not depend on the position of a given observer and is valid for all observers. GPS is proving this without any doubt. Because of the GR effect clocks on the satellites are running faster than clocks on the Earth surface for 45 $\mu$s per day. Because of the SR effect clocks are running slower on the satellites than the clocks on the Earth surface for 7 $\mu$s per day.[5] This is valid for all observers.

If the clock would be taken out of the satellite it would keep the same rate. The mass of the satellite is too small to influence the rate of the clock because of the GR effect and SR effect. The only factor that determines diminished $\mathbb{C}^4$SQS energy density and so the Lorentz factor $\gamma$ and consequently the rate of clock related to the SR effect is the velocity $v$ of the clock. We have shown in our article the relation between the Lorentz factor and diminished energy density of $\mathbb{C}^4$SQS in Eq. (12).

In advanced relativity length contraction and "time dilation" where time is supposed to be the fourth dimension of space are abolished. We do not know a physical mechanism that would shorten the length of the objects that are moving in the direction of motion. The idea was created by Hendrik Lorentz in 1892 to save "ether." After Michelson–Morley's experiment has given a null result, Lorentz predicted that the beam in the interferometer that was pointed in the direction of Earth motion has shortened. In advanced relativity, time is the duration of material change, i.e., motion in time-invariant $\mathbb{C}^4$SQS and cannot dilate. Time as duration is the result of the measurement form the side of the observer and as such has no physical existence on its own.[1,2] What is "relative" in the universe is not time, it is the velocity of material changes that depends on the variable energy density of $\mathbb{C}^4$SQS.

## V. ADVANCES OF GENERAL RELATIVITY

In the model presented in this paper, the rotation of stellar objects also causes rotation of the surrounding $\mathbb{C}^4$SQS. For example, the rotation of the $\mathbb{C}^4$SQS around the Sun causes precession of the planets according to the following equation:

$$\sigma = \frac{24\pi^3 L^2}{Tc^2(1-e^2)}, \tag{14}$$

where the perihelion shift $\sigma$ is expressed in radians per revolution, $L$ is the semimajor axis, $T$ is the orbital period, $c$ is the speed of light, and $e$ is the orbital eccentricity.[13] The mass of the Sun is not included as there is also no mass of a planet, so these masses do not affect the precession of the planets. In the model of $\mathbb{C}^4$SQS, the perihelion shift $\sigma$ depends on the rotation of the $\mathbb{C}^4$SQS caused by the rotation of the Sun, which in turn pushing the planets and causes a perihelion precession. With increasing distance from the Sun, the impact of the rotating $\mathbb{C}^4$SQS (dragging effect) on planets diminishes along with the precession of the perihelion.

Irregular and spiral galaxies comprise approximately 60% of all galaxies in the universe. In the center of most spiral galaxies exist a rotating black hole.[14] We suggest in this article that rotating black holes are rotating the surrounding $\mathbb{C}^4$SQS. This might be one of the physical causes of their spiral shape; dragging effects between the rotating black hole and rotating $\mathbb{C}^4$SQS diminishes with the distance from the black hole leading to the spiral geometry. The development of the mathematical model of this effect is one of the goals of our further research.

In 2019 NASA has reported: "as if black holes weren't mysterious enough, astronomers using NASA's Hubble Space Telescope have found an unexpected thin disk of material furiously whirling around a supermassive black hole at the heart of the magnificent spiral galaxy NGC 3147, located 130 million light-years away. The conundrum is that the disk shouldn't be there, based on current astronomical theories."[15] Our proposal to solve this conundrum is that in current astronomical theories, supermassive black holes rotate in an "empty space." In $\mathbb{C}^4$SQS model presented in this article, supermassive black holes rotate in the medium of $\mathbb{C}^4$SQS, and their rotation, in turn, rotates the $\mathbb{C}^4$SQS. Therefore, this dragging effect of $\mathbb{C}^4$SQS might be a physical cause of thin disc that is furiously whirling around a supermassive black hole of the spiral galaxy NGC 3147.

In GPS, Sagnac effect corrections make the system work.[16] Rotation of the Earth causes the dragging effect of $\mathbb{C}^4$SQS. Essentially, a signal when moving from A to B in the direction of Earth's rotation needs less time compared with when moving from B to A in the direction opposing Earth's rotation. In a $\mathbb{C}^4$SQS model presented in this article, light has a constant speed regardless of the $\mathbb{C}^4$SQS's motion. So, when moving from A to B, light is moving in the same direction as its medium $\mathbb{C}^4$SQS and needs a shorter duration (time). When light is moving from B to A, the duration of motion is longer because light moves in the opposite direction of its medium motion (Fig. 5).

Sagnac's experiment with the rotating interferometer is indisputable proof that photon does not move in the empty space deprived of physical properties.[17,18] On the contrary, it proves that the photon is the excitation of the $\mathbb{C}^4$SQS that is dragged by the rotating interferometer.

The Michelson–Morley experiment demonstrated a null result, because the area of the $\mathbb{C}^4$SQS around the Earth is not

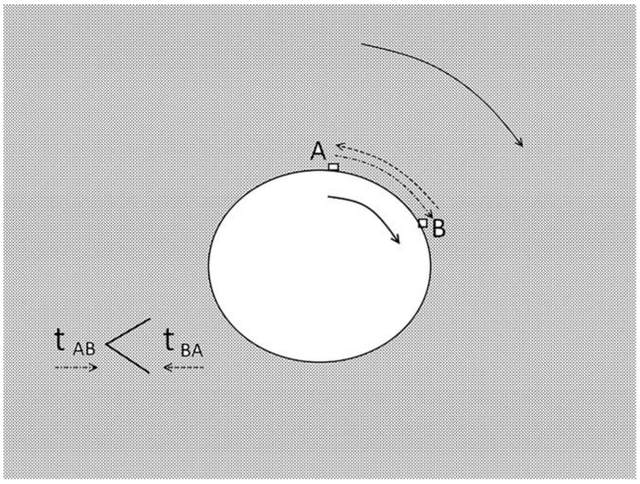


FIG. 5. A light signal's duration due to the rotation of the quantum $\mathbb{C}^4$SQS.

only rotating with the Earth but is also moving with the Earth, as shown in Fig. 6.

So, the negative outcome of Michelson–Morley abolished the ether model. According to bijective research methodology, where every element in the model has exactly one correspondent element in physical reality, universal space is neither filled with ether, nor is it empty. Instead, universal space contains material objects that contain energy. Energy and matter cannot exist in an empty space deprived of all physical properties, so in this article universal space, we name it $\mathbb{C}^4$SQS, is understood as the primordial energy of the universe. A photon is a wave of the $\mathbb{C}^4$SQS, and the velocity of this photon wave is the speed of light, $c$. The photon velocity $c$ is invariant with respect to the $\mathbb{C}^4$SQS's motion as it appears through the Sagnac effect. The photon velocity diminishes minimally when a photon moves through a stronger gravity where the density of the $\mathbb{C}^4$SQS is lower, as is the case with the Shapiro experiment, as will be described in Section V B.

Motion and rotation of the universal space with physical objects is referred to as the "$\mathbb{C}^4$SQS dragging effect" in this article. Dragging effect was measured by Josef Lense and Hans Thirring in 1918 and was called "frame-dragging" due to the belief that space-time being distorted by rotating objects, reference.[19] Recent research confirms that this "space-time" model has no physical reality, so it cannot be dragged by rotating or moving objects.[1] According to bijective research methodology, an adequate term would be the $\mathbb{C}^4$SQS dragging effect.

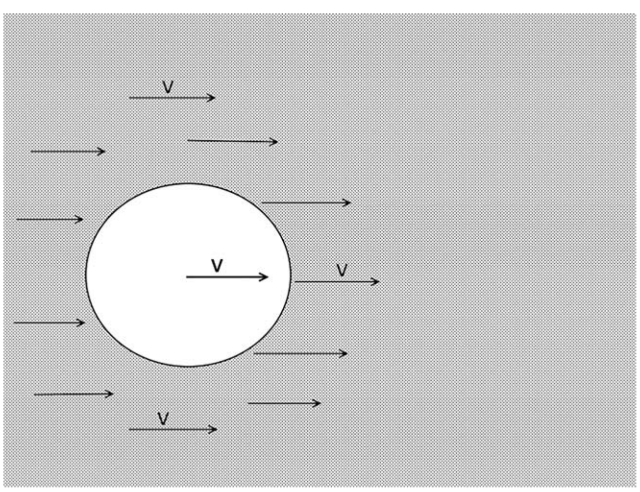


FIG. 6. The SQS moves with the Earth.

In this article, the model of "length contraction" and "time dilation" (dilation of time as the fourth dimension of $\mathbb{R}^4$) do not exist. Length contraction in SR is only a mathematical tool with no physical reality. Also, time, being in Special Relativity the fourth dimension of space, does not "dilate"; what we observe is that the relative velocity of material changes (the rate of clocks included) depends on the variable density of the $\mathbb{C}^4$SQS. On the other hand, all observers measure the same value for the velocity of light, because the light is the vibration of the $\mathbb{C}^4$SQS in which all observers move.

In 2011, Croatian mathematician and theoretical physicist Vladimir Varičak asserted that one sees the length contraction in an objective way, according to Lorentz, while it is "only an apparent, subjective phenomenon, caused by the manner of our clock-regulation and length-measurement," according to Einstein.[20] Einstein has commented: "The author unjustifiably stated a difference of Lorentz's view and that of mine *concerning the physical facts*. The question as to whether length contraction *really* exists or not is misleading. It doesn't 'really' exist, in so far as it doesn't exist for a comoving observer; though it 'really' exists, *i.e.* in such a way that it could be demonstrated in principle by physical means by a non-comoving observer."[21] It seems Einstein did not want to accept that if the stick on the train is not contracting for the observer on the train but it contracts only for the observer on the station this does not make sense. The equation for length contraction will not contract the stick. Physical reality does not obey models invented by humans. He also did not clearly point out that the relative rate of clocks in the train and on the station is valid for both observers and has nothing to do with their act of observation. In classical relativity, the observer in the inertial system at rest experiences the rate of clocks in moving inertial system is slower. In advanced relativity, relative rate of clocks in all inertial systems depends only on the variable energy density of $\mathbb{C}^4$SQS and is valid for all observers. The rate of clocks is not related to the act of observation. If observers would be not there, clocks would have the same rate.

### A. Gravitational redshift

Theory of vector gravity is a model that allows the reinterpretation of gravitational redshift: "Similarly to general relativity, vector gravity postulates that the gravitational field is coupled to matter through a metric tensor $f_{ik}$ which is, however, not an independent variable but rather a functional of the vector gravitational field. In particular, action for a point particle with mass m moving in the gravitational field reads

$$S_{\text{matter}} = -mc \int \sqrt{f_{ik}\, dx^i dx^k}, \qquad (15)$$

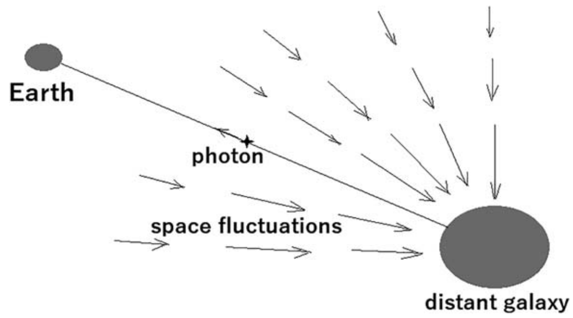


FIG. 7. The redshift of light arriving from galaxies caused by SQS fluctuations.

where $c$ is the speed of light. Action (12) has the same form as in general relativity, however, the tensor gravitational field $g_{ik}$ of general relativity is now replaced with the equivalent metric $f_{ik}$ ($f_{ik}$ is a tensor under general coordinate transformations)."[22] Our model provides the physical origin of vector gravity that is in the $\mathbb{C}^4$SQS quantum fluctuations that are directed from the higher energy density of $\mathbb{C}^4$SQS toward the lover density of $\mathbb{C}^4$SQS. These fluctuations interact with photons to diminish their frequency, which is referred to as "gravitational redshift." When light from distant galaxies reaches the Earth, its frequency is lower. On its path to Earth, light loses some of its energy because it is moving against the $\mathbb{C}^4$SQS fluctuations that points toward the direction of galaxies, so that

$$E_{\text{photon.Earth}} = E_{\text{photon.galaxy}} - \Delta E, \tag{16}$$

where $E_{\text{photon.galaxy}}$ is the energy of the photon at the galaxy, $E_{\text{photon.Earth}}$ is the energy of the arrived photon at the Earth, and $\Delta E$ is the loss of energy due to the fluctuations of the $\mathbb{C}^4$SQS

$$\Delta E = h\Delta\nu, \tag{17}$$

where $h$ is Planck's constant and $\Delta\nu$ is the decrease in the photon frequency due to $\mathbb{C}^4$SQS fluctuations (Fig. 7).

Because of different densities of the $\mathbb{C}^4$SQS, the frequency of light also changes to red spectrum when moving from the source to the receiver above the Earth's surface. In a Harvard University experiment, a source on the Earth's

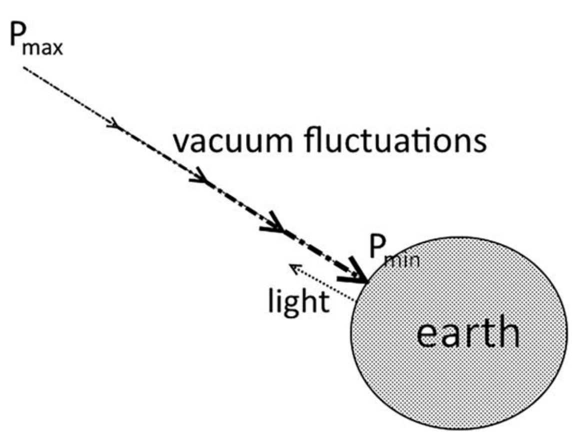


FIG. 8. The redshift of light moving from the Earth's surface upward.

surface and a receiver at the height of 22.5 m were positioned, as illustrated in Fig. 8.

The Mossbauer effect was used to measure the difference between y-ray emission and absorption frequencies at each end of the experiment. The measurement accuracy was $\Delta\omega/\omega \approx 10^{-15}$, which shows a change of light frequency as

$$\frac{\Delta\omega}{\omega} = \frac{GM}{R^2c^2}h, \tag{18}$$

where $h$ is the height of the receiver above the Earth surface, $M$ and $R$ are the mass and radius of the Earth, respectively.[23] We can substitute into Eq. (18) for the Earth mass $M$ with the $(\rho_{\text{Emax}} - \rho_{\text{Emin}})V/c^2$ from Eq. (5) as

$$\frac{\Delta\omega}{\omega} = \frac{G(\rho_{\text{Emax}} - \rho_{\text{Emin}})V}{R^2c^4}h, \tag{19}$$

which can be expressed as

$$\begin{aligned} \frac{\Delta\omega}{\omega} &= \frac{G(\rho_{\text{Emax}} - \rho_{\text{Emin}})4\pi R^3}{3R^2c^4}h \\ \frac{\Delta\omega}{\omega} &= \frac{4\pi RG(\rho_{\text{Emax}} - \rho_{\text{Emin}})}{3c^4}h. \end{aligned} \tag{20}$$

Equation (20) confirms that gravitational redshift depends on the minimal energy density of the $\mathbb{C}^4$SQS$\rho_{\text{Emin}}$ in the Earth's center. $\mathbb{C}^4$SQS fluctuations in the direction from $\rho_{\text{Emax}}$ toward $\rho_{\text{Emin}}$ are the physical cause of so called "tired light" model of astronomer Fritz Zwicky. Zwicky proposed that light is losing some of the frequency when traveling vast distances from the galaxies to the planet Earth.[24] The loss of frequency is due to the $\mathbb{C}^4$SQS gravity fluctuations that are in the opposite direction of the light motion. When light is moving in the direction of $\mathbb{C}^4$SQS gravitational fluctuations the gravitational blueshift occurs. Photons gain some energy, and their frequency increases.

In the model of relativity here presented $\mathbb{C}^4$SQS quantum fluctuations from $\rho_{\text{Emax}}$ toward $\rho_{\text{Emin}}$ we suggest could be the cause of the Pioneer anomaly which means the observed deviation from predicted accelerations of the Pioneer 10 and Pioneer 11 spacecraft after they passed on their trajectories out of the solar system.[25] Pioneer is in moving the opposite direction of $\mathbb{C}^4$SQS quantum fluctuations that cause the loss of photon energy. We suggest that $\mathbb{C}^4$SQS quantum fluctuations also cause Pioneer spacecraft to lose some of its kinetic energy and slow down its acceleration.

### B. Shapiro gravitational time delay

In 1964, Shapiro measured the decreased velocity of light in a gravitational field, as observed by the speed of a light signal diminishing when passing the gravitational field of the Sun.[26] Shapiro's result is understood by today's physics as a "gravitational time delay" caused by spacetime dilation, which increases the path length. According to bijective research methodology, where every element in the model has the exact correspondent element in physical reality, this interpretation appears not to be exact as Shapiro did not measure spacetime dilation. In SR, the element of "spacetime dilation" has no bijective correspondence in the physical world as it has never been observed in physics that spacetime or space are dilating. According to bijective research methodology, Shapiro's result should be termed the "gravitational diminishing of light-speed" caused by the diminished energy density of the $\mathbb{C}^4$SQS.

Speed of light is defined by the permittivity and permeability of the $\mathbb{C}^4$SQS

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}, \tag{21}$$

where $\mu_0$ is the magnetic permeability and $\varepsilon_0$ is electric permittivity of the $\mathbb{C}^4$SQS where there is no influence of gravity, and the density of the $\mathbb{C}^4$SQS is at its maximum $\rho_{\text{Emax}}$. In the $\mathbb{C}^4$SQS with a gravity field, the energy density of the $\mathbb{C}^4$SQS decreases and causes minimal diminishing of the permittivity and permeability, which in turn result in the minimal diminishing of the speed of light, as presented by Masanori, "it is known that the speed of light depends on the gravitational potential. In the gravitational fields, the speed of light becomes slow, and time dilation occurs. In this discussion, the permittivity and permeability of free space are assumed to depend on gravity and are variable."[27] Minimal variability of the speed of light caused by a gravity field maintains SR, because its first postulate is valid only in space where gravity is absent. The electric permittivity in flat space with no gravity is $\varepsilon_0$, and magnetic permeability in flat with no gravity $\mathbb{C}^4$SQS is $\mu_0$. Following Puthoff, on the surface of stellar object, permittivity and permeability are

$$\varepsilon = K\varepsilon_0 \tag{22}$$

$$\mu = K\mu_0 \tag{23}$$

where the space dielectric constant $K$ on the surface of a stellar object is

$$K \approx 1 + \frac{2Gm}{rc^2}, \tag{24}$$

with $G$ being the gravitational constant, $M$ is the mass, and $r$ is the distance from the origin located at the center of the mass $M$.[23]

Combining Eqs. (5) and (24), we can write

$$K \approx 1 + \frac{2G(\rho_{\text{Emax}} - \rho_{\text{Emin}})V}{rc^2}, \tag{25}$$

which shows the dielectric constant depends on the variable energy density of $\mathbb{C}^4$SQS. In this sense, a diminished energy density of the $\mathbb{C}^4$SQS on the surface of a given stellar object increases permittivity and permeability of the $\mathbb{C}^4$SQS which, in turn, minimally decreases the velocity of light as

$$c = \frac{1}{\sqrt{\varepsilon\mu}}, \tag{26}$$

where $\varepsilon$ is the electric permittivity and $\mu$ is its magnetic permeability of the $\mathbb{C}^4$ SQS with the gravitational field. From this, it follows that the Shapiro gravitational time dilation has its origin in the diminished energy density of the $\mathbb{C}^4$SQS near the stellar objects, which increases the dielectric constant $K$ of the $\mathbb{C}^4$SQS, and this minimally decreases the velocity of light. In other words: Diminishing $\mathbb{C}^4$SQS energy density $\rightarrow$ increases the dielectric constant $\rightarrow$ increases the electric permittivity of the $\mathbb{C}^4$SQS $\rightarrow$ increases the magnetic permeability of the $\mathbb{C}^4$SQS $\rightarrow$ decreases the velocity of light.

The classic textbook explanation of the Shapiro experiment is that in stronger gravity, time, as the fourth physical dimension of space, dilates causing light to need more time to reach the point B from point A in a space-time that acts as the fundamental arena of the universe. This article shows that through a bijective interpretation of data, where data are not interpreted but read directly, requires an exact explanation where the velocity of light is minimally diminishing in a gravity field due to a diminished energy density of the $\mathbb{C}^4$SQS.

Doppler effect proves the second postulate of SR, which states that "the speed of light $c$ is a constant, independent of the relative motion of the source." The observer exists in $\mathbb{C}^4$SQS, and a photon is the vibration of the same $\mathbb{C}^4$SQS. When the observer moves toward or away from the source of light, they will experience the Doppler effect. With the understanding that the moving observer and the source both exist in the same $\mathbb{C}^4$SQS and that light is the vibration of the $\mathbb{C}^4$SQS, the second SR postulate becomes logical. The observer sees the light with a given frequency coming from the source. When the observer moves away from or closer to the source, the frequency of the light diminishes or increases, respectively.

### C. Gravitational lens

$\mathbb{C}^4$SQS fluctuations bend light, which we refer to as a "gravitational lens," and this bending of light as it passes the Sun is one proof of general relativity. The $\mathbb{C}^4$SQS fluctuations near the Sun's surface are strongest and push the photons, causing them to bend, as illustrated in Fig. 9.

$\mathbb{C}^4$SQS fluctuations bend the photon's trajectory, which we call gravitational lens. Einstein's formula for the bending of light as it passes the Sun is expressed as[28]

$$\delta = \frac{4GM_s}{c^2 b}, \tag{27}$$

where $\delta$ is the angle of deflection, $M_S$ is the mass of the Sun, $c$ is the speed of light, and $b$ is the minimum distance between the trajectory and the center of the Sun. The mass of

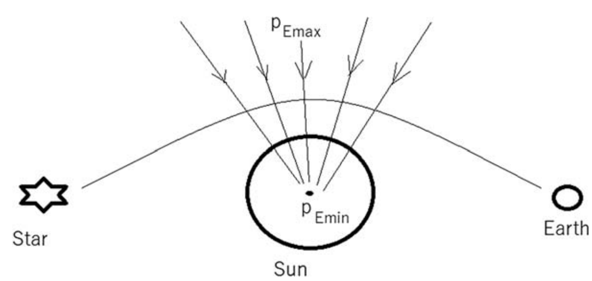


FIG. 9. $\mathbb{C}^4$SQS fluctuations bending light around the Sun.

the Sun, $M_S$, can be expressed according to Eq. (5), which we can combine with Eq. (27) and to obtain

$$\delta = \frac{4G\ (\rho_{\mathrm{Eman}} - \rho_{\mathrm{Emin}})V}{c^4 b}. \tag{28}$$

Equation (28) confirms that $\mathbb{C}^4$SQS fluctuations that carry gravity are directed from $\mathbb{C}^4$SQS, where the energy density of the $\mathbb{C}^4$SQS is $\rho_{\mathrm{Emax}}$, toward the energy density of the SQS is $\rho_{\mathrm{Emin}}$ in the center of the Sun, as in Fig. 9. These $\mathbb{C}^4$SQS fluctuations push the photons, causing light deflection. Light passing the Sun is not deflected as a result of the curvature of universal space; measurements by NASA have proven that the universe's space has a Euclidean shape.[8] Light is deflected around gravitational objects, such as the Sun, due to a push from $\mathbb{C}^4$SQS gravity fluctuations.

### D. Gravitational waves are waves of $\mathbb{C}^4$SQS

Gravitational waves are represented as "ripples in the fabric of space-time."[29] In this article, space-time as the fundamental physical arena of the universe is replaced with the time-invariant $\mathbb{C}^4$SQS. Gravitational waves are ripples of the $\mathbb{C}^4$SQS. Gravitational waves change the permittivity and permeability of $\mathbb{C}^4$SQS. As gravitational waves enter the LIGO interferometer, they changed permeability and permittivity of the $\mathbb{C}^4$SQS which minimally changes the speed of light moving in the beams of the interferometer. This minimal change in the speed of light is what is directly measured by LIGO. No direct data exist to confirm that the length of the beams of the interferometer change due to the gravitational waves. How the subtle phenomena of a gravitational wave could shrink or elongate the length of the interferometer beams, which have a solid iron-concrete core, is an unanswered question. The model here presented solves this question through the direct reading of the available data. What is measured by LIGO is the minimal change in light speed due to minimal variations of the permittivity and permeability of the $\mathbb{C}^4$SQS caused by the gravitational wave entering the interferometer. Would be better to say, that interferometer which is 3D is entering the gravitational wave that is the wave of the variable energy density of $\mathbb{C}^4$SQS. Our research suggests photons are excitations of $\mathbb{C}^4$SQS (also named superfluid quantum vacuum).[30]

Recent research confirms gravitational waves have a speed close to the speed of the photon, "since the recent major discovery in physics, the first measurement of gravitational waves, achieved by the LIGO/Virgo collaboration, several events have been registered. In particular, the merging of two neutron stars detected with its electromagnetic counterpart by the FERMI satellite has led to implications of paramount importance. One of them is the speed of gravitational waves now constrained to be extremely close to that of light, at the $10-15$ level, at low redshifts."[31] In the model presented in this article, the photon and gravitational wave are both excitations of the $\mathbb{C}^4$SQS.

In classical relativity, the time of the light passing the beams of the interferometer is defined by the quadrupole equation.[32] Quadrupole equation describes how gravitational wave is dilating and shrinking space-time and so the beams are also dilating or shrinking and so light need more or less time to pass them. In advanced relativity, a gravitational wave is changing the permittivity and permeability of $\mathbb{C}^4$SQS, and this causes the minimal variations of the light speed.

### E. The rate of clocks is an indirect measure of $\mathbb{C}^4$SQS variable energy density

With rate of clocks, we can indirectly measure the variable energy density of the $\mathbb{C}^4$SQS due to the presence of stellar objects or the motion of the physical objects that change the energy density of $\mathbb{C}^4$SQS. National Institute of Standards and Technology (NIST) in Boulder, CO, registered differences in the passage of time between two high-precision optical atomic when one was elevated by just a third of a meter or when one was set in motion at speeds of less than 10 m/s.[33] In general relativity, the gravitational time dilation is calculated using the following equation:

$$t = \frac{t_0}{\sqrt{1 - \frac{2Gm}{c^2}}}, \tag{29}$$

where $t_0$ is the rate of the clock on the surface of the stellar object, $M$ is the mass of the stellar object, $G$ is the gravitational constant, $r$ is the radius of the stellar object, and $t$ is the rate of the clock at the point $T$ which is infinitely away in empty cosmic space. For example, when one second has passed on the Earth surface, at the point T in infinity 1.000000000695915 s has passed. We can calculate the rate of a clock at point T1, situated at the distance $h$ above the surface of the stellar object with the following equation:

$$t = t_0 \sqrt{\frac{1 - \frac{2GM}{(r+h)c^2}}{1 - \frac{2GM}{rc^2}}}. \tag{30}$$

Elapsed time $t$ at a point 20 km above the Earth's surface comparing with the 1 s elapsed time on the Earth's surface is 1.00000000000218 s. Elapsed time $t$ at a point 40 km above the Earth's surface comparing with the 1 s elapsed time on the Earth's surface is 1.00000000000434 s. The elapsed time $t$ at the surface of a black hole with the mass of the Sun and radius of 3000 m compared with the elapsed time of one second on the Earth surface is 0.12486696822 s. The rate of clocks is increasing with the increasing of the $\mathbb{C}^4$SQS energy density, and the rate of clocks is diminishing with the diminishing of the $\mathbb{C}^4$SQS energy density. The General Relativity effect causes clocks on the GPS satellites to run faster than on the Earth's surface by 45 $\mu$s per day. This is because on the satellite trajectory the $\mathbb{C}^4$SQS is denser than on the Earth's surface.

Considering that with the clocks run in time-invariant $\mathbb{C}^4$SQS in advanced relativity time travels are not allowed. Gödel development of Einstein field equations of general relativity shows that they lead to the contradiction, namely, one could move back in time and kill his grandfather and so he could not be born. By 1949, Gödel had produced a remarkable proof: "In any universe described by the Theory of Relativity, time cannot exist."[34] Gödel understood that his development of general relativity proves that time has no physical existence and nobody can travel in time. Still today he is misunderstood by thinking that his work is proving that time travel is possible.

The idea of time travel is in physics still alive, because we still believe the time is the fourth dimension of space and that one can move along this so-called "time dimension."[35]

In advanced relativity, time travels are categorically excluded. One can travel only in $\mathbb{C}^4$SQS and time is the duration of its motion. In classical relativity, we have a "twin paradox." A twin on the fast space-ship is aging slower than his twin-brother on the Earth. Or the twin on the Moon surface is aging faster than his twin-brother on the Earth surface. In advanced relativity, there is no twin paradox. Twins are aging in $\mathbb{C}^4$SQS, and the velocity of aging depends on the variable energy density of $\mathbb{C}^4$SQS.

## VI. CONCLUSIONS

Classical relativity's description of physical reality, in general, is mathematical with tools as space-time dilation, length contraction, space-time curvature, space-time dragging effect, quadrupole formula. Advances relativity's description of physical reality, in general, is physical. The tools of description are variable energy density of $C^4$SQS, consequently relative rate of clocks, variable permittivity and permeability of $C^4$SQS, and dragging effect of $C^4$SQS.

[1]A. Šorli and Š. Čelan, RAPS **4**, 2050007 (2021).
[2]D. Fiscaletti and A. Sorli, Found. Phys. **45**, 105 (2015).
[3]D. Fiscaletti and A. Sorli, Quantum Stud: Math. Found. **4**, 357 (2017).
[4]A. Šorli and Š. Čelan, Adv. Stud. Theor. Phys. **15**, 9 (2021).
[5]A. Neil, Phys. Today **55**(5), 41 (2002).
[6]D. C. Agnew and K. M. Larson, GPS Solutions **11**, 71 (2007).
[7]A. Jaffe, Nature **556**, 304 (2018).
[8]See https://wmap.gsfc.nasa.gov/universe/uni_shape.html for NASA (2014).
[9]A. Sorli, D. Klinar, and D. Fiscaletti, Phys Essays **24**, 113 (2011).
[10]L. Liu, preprint http://web.mit.edu/lululiu/Public/pixx/not-pixx/muons.pdf (2007).
[11]D. Fiscaletti and A. Sorli, Ann. Univ. Mariae Curie-Sklodowska, Sec. AAA–Phys. **68**, 39–62 (2015).
[12]P. Harris, preprint https://web.stanford.edu/~oas/SI/SRGR/notes/srHarris.pdf
[13]M. M. D'Eliseo, Am. J. Phys. **83**, 324 (2015).
[14]J. Loveday, MNRAS **278**, 1025 (1996).
[15]See https://www.nasa.gov/feature/goddard/2019/hubble-uncovers-black-hole-that-shouldnt-exist for NASA (2019).
[16]N. Ashby, *Fundamental Theories of Physics* (Springer, Dordrecht, The Netherlands, (2004), Vol. 135.
[17]G. Sagnac, C. R. Acad. Sci. **157**, 708 (1913).
[18]G. Sagnac, J. Phys. Theor. Appl. **4**, 177 (1914).
[19]B. Mashhoon, F. W. Hehl and D. S. Theiss, Gen. Relat. Gravit. **16**, 711 (1984).
[20]A. I. Miller, *Albert Einstein's Special Theory of Relativity: Emergence and Early Interpretation (1905–1911)* (Addison–Wesley, Reading, 1905), pp. 249–253.
[21]N. C. Andreasen, Science **275**, 1586 (1997).
[22]A. A. Svidzinsky, Phys. Dark Universe **25**, 100321 (2019).
[23]H. E. Puthoff, Found.Phys. **32**, 927 (2002).
[24]F. Zwicky, Proc. Natl. Acad. Sci. U.S.A. **15**, 773 (1929).
[25]M. M. Nieto and S. G. Turyshev, Class. Quantum Grav. **21**, 4005 (2004).
[26]I. I. Shapiro, Phys. Rev. Lett. **13**, 789 (1964).
[27]S. Masanori, preprint https://arxiv.org/vc/arxiv/papers/0704/0704.1942v3.pdf
[28]A. Einstein, Science **84**, 506 (1936).
[29]LIGO, preprint https://SQS.mit.edu/LIGO/more.html (2008).
[30]D. Fiscaletti and A. Sorli, Ukr. J. Phys. **65**, 106 (2020).
[31]L. Perenona, J. Bel, R. Maartens, and A. d.l. Cruz-Dombriz, JCAP **2019**, 020 (2019).
[32]S. M. Carroll, *Spacetime and Geometry* (Pearson/Addison Wesley, Boston, MA, 2004), pp. 300–307.
[33]C. W. Chou, D. B. Hume, J. C. J. Koelemeij, D. J. Wineland, and T. Rosenband, Phys. Rev. Lett. **104**, 070802 (2010).
[34]A. Sorli, D. Fiscaletti, and T. Gregl, Phys. Essays **26**, 113 (2013).
[35]S. Carroll, Phys. Today **55**(7), 60 (2002).