On the Condition of Non-Quantum Teleportation on the Surface of a Spherical Body

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Here we consider the degeneration of the four-dimensional fundamental metric tensor and the physically observable three-dimensional metric tensor as geometric conditions for non-quantum teleportation. It is shown that non-quantum teleportation can be implemented under any physical conditions at the North and South Poles of a rotating spherical body and, in general, everywhere along the axis of its rotation. But even at a very small distance from the poles along the geographical latitudes, non-quantum teleportation requires exotic conditions, such as a very strong electromagnetic field, etc.

In the late 1980s, we began an extensive theoretical study, the task of which was to find out whether instant transmission of signals (*long-range action*) and instant displacement of physical bodies in general (*non-quantum teleportation*) is possible according to Einstein's theory of relativity.

The reason why we started this research was the need to explain some unique experiments in biophysics, which were performed in the late 1980s by one of our close colleagues, an outstanding experimental biophysicist with a broad erudition in the field of bionics (he passed away in 2001). His experiments had no theoretical explanation in the framework of modern science. Only with a theory of these experiments could we determine the key physical factors that produced the discovered effect and, accordingly, determine methods for enhancing these factors in order to create a new industrial technology of communication and transport.

As always in our theoretical studies, we used the *mathematical apparatus of chronometric invariants*, introduced in 1944 by Abraham Zelmanov [1–3]. Chronometric invariants are invariant projections of four-dimensional quantities onto the three-dimensional space (spatial section) and the line of time belonging to an observer. Such projections are dependent on the geometric and physical characteristics of the observer's physical space and are physically observable quantities registered by him in his reference frame. For this reason, Zelmanov's mathematical apparatus of chronomertic invariants is also known as the *theory of physically observable quantities* in the four-dimensional space-time.

Since Zelmanov's original publications [1–3] were very concise, at the request of our close colleague Pierre Millette, three decades later, in 2023, we published the most comprehensive survey of Zelmanov's chronometrically invariant formalism [4], wherein we collected almost everything that we know in this field personally from Zelmanov and based on our own research studies.

So, let us now return to our theoretical research that we began in the late 1980s.

First of all, we determined the *weak and strong conditions for non-quantum teleportation* in the four-dimensional space-time. According to the chronometrically invariant formalism, the physically observable time interval $d\tau$ and the physically observable three-dimensional interval $d\sigma$ registered by an observer are, respectively, chr.inv.-projections of the four-dimensional displacement vector dx^{α} ($\alpha = 0,1,2,3$) onto the time line of the observer and his three-dimensional space (spatial section of space-time). They are calculated as

$$d\tau = \sqrt{g_{00}}\,dt - \frac{1}{c^2}\,v_i\,dx^i, \tag{1}$$

$$d\sigma^2 = h_{ik}\,dx^i dx^k, \quad i = 1,2,3, \tag{2}$$

where dt is the interval of coordinate time, which is counted in the absence of disturbing factors. The three-dimensional chr.inv.-metric tensor

$$\left.\begin{aligned} h_{ik} &= -g_{ik} + \frac{g_{0i}\,g_{0k}}{g_{00}} = -g_{ik} + \frac{1}{c^2}\,v_i v_k \\ h^{ik} &= -g^{ik}, \qquad h^i_k = \delta^i_k \end{aligned}\right\} \tag{3}$$

is the chr.inv.-projection of the fundamental metric tensor $g_{\alpha\beta}$ onto the spatial section of the observer and possesses all properties of $g_{\alpha\beta}$ throughout the spatial section (the observer's three-dimensional space). The time (zero) component g_{00} of the fundamental metric tensor $g_{\alpha\beta}$ is expressed with the physically observable chr.inv.-potential w of the gravitational field that fills the space of the observer

$$\sqrt{g_{00}} = 1 - \frac{\mathrm{w}}{c^2}\,, \qquad \mathrm{w} = c^2\left(1 - \sqrt{g_{00}}\right), \tag{4}$$

and v_i is the three-dimensional vector of the linear velocity of rotation of the observer's space

$$v_i = -\frac{c\,g_{0i}}{\sqrt{g_{00}}}\,, \quad v^i = -c\,g^{0i}\sqrt{g_{00}}\,, \quad v_i = h_{ik}v^k, \tag{5}$$

which is caused by the non-orthogonality of the observer's spatial section to his time line and therefore it cannot be eliminated by coordinate transformations along his spatial section. Therefore, the square of the four-dimensional (space-time) interval $ds^2 = g_{\alpha\beta}\, dx^\alpha dx^\beta$ is expressed with chronometrically invariant (physically observable) intervals by the formula

$$ds^2 = c^2 d\tau^2 - d\sigma^2, \tag{6}$$

from which we obtain the weak and strong conditions for non-quantum teleportation:

The weak condition of non-quantum teleportation

$$d\tau = 0\,, \qquad d\sigma \neq 0 \tag{7}$$

means that the interval of physically observable time $d\tau$ between the moments of departure and arrival of a signal (or a physical body) registered by the observer is equal to zero ($d\tau = 0$), while the three-dimensional physically observable distance $d\sigma$ between the points of departure and arrival is not equal to zero ($d\sigma \neq 0$). Therefore, the space-time metric ds^2 along the trajectories of weak non-quantum teleportation is

$$\left.\begin{aligned} & ds^2 = c^2 d\tau^2 - d\sigma^2 = -d\sigma^2 \\ & c^2 d\tau^2 = 0\,, \quad d\sigma^2 \neq 0 \end{aligned}\right\}, \tag{8}$$

thus these are the trajectories of mass-bearing particles (since along the trajectories of massless light-like particles $ds^2 = c^2 d\tau^2 - d\sigma^2 = 0$ and $c^2 d\tau^2 = d\sigma^2 \neq 0$).

The strong condition of non-quantum teleportation

$$d\tau = 0\,, \qquad d\sigma = 0 \tag{9}$$

means that not only the physically observable time interval $d\tau$ between departure and arrival registered by the observer, but also the three-dimensional physically observable distance $d\sigma$ between these points is equal to zero. Therefore, the space-time metric ds^2 along the trajectories of strong non-quantum teleportation is

$$\left.\begin{aligned} & ds^2 = c^2 d\tau^2 - d\sigma^2 = 0 \\ & c^2 d\tau^2 = d\sigma^2 = 0 \end{aligned}\right\}, \tag{10}$$

i.e., the space-time metric along the trajectories is *fully degenerate*: for a regular observer, all four-dimensional space-time intervals ds, three-dimensional observable intervals $d\sigma$ and observable time intervals $d\tau$ are zero along such fully degenerate trajectories. We therefore called them *zero-trajectories*, and the fully degenerate space-time region that hosts such trajectories — *zero-space*. The zero-space is the fully degenerate case of the light-like space (since along light-like trajectories $ds^2 = c^2 d\tau^2 - d\sigma^2 = 0$, but $c^2 d\tau^2 = d\sigma^2 \neq 0$). We showed that all particles in the zero-space appear to a regular observer as having zero rest-mass $m_0 = 0$ similar to light-like particles, but they also have zero relativistic mass $m = 0$ and frequency $\omega = 0$ (unlike light-like particles, since for them $m \neq 0$ and $\omega \neq 0$). Therefore, we called them *zero-particles*. Deducing the eikonal equation (wave phase equation) for zero-particles, we found that it has the form of a standing wave equation. This means that, for a regular observer, all particles located in the zero-space (zero-particles) appear as *standing light-like waves*, and the entire zero-space appears filled with a system of light-like standing waves — a *light-like hologram*. We also showed that the relation between energy and impulse is not conserved for zero-particles: $E^2 - c^2 p^2 \neq const$. This is characteristic only of virtual particles. According to Feynman diagrams, virtual particles are carriers of interactions between elementary particles. This means that all interactions between particles of our regular space-time are transmitted by zero-particles through an "exchange buffer" that is the zero-space.

The condition $d\tau = 0$ gives a formula for *physical conditions of non-quantum teleportation*

$$\mathrm{w} + v_i u^i = c^2, \qquad u^i = \frac{dx^i}{dt}\,, \tag{11}$$

which is a specific combination of the gravitational potential w, the linear velocity of rotation of the observer's space v_i, and also the coordinate velocity u^i of the teleported particle. This condition is true for both weak and strong non-quantum teleportation (since $d\tau = 0$ in both cases). In both cases, the physically observed velocity v^i of the teleported signal (or teleported body) registered by the observer is

$$\mathrm{v}^i = \frac{dx^i}{d\tau} = \infty, \tag{12}$$

which means that, from the observer's point of view, the observed signal (or body) *instantly displaces* over the distance from the point of departure to the point of arrival.

Note that non-quantum teleportation is really instant displacement of signals (or bodies) over a distance in accordance with the geometric structure of the four-dimensional space-time. It has nothing common with quantum teleportation [5], which does not transfer energy or matter over a distance, but is merely a probabilistic effect based on the laws of Quantum Mechanics.

We published the above results in 2001, in our first monograph [6], many years after obtaining them. Then a short summary of the results was published in 2005 [7].

In our monograph [6] we related the physical conditions of non-quantum teleportation $\mathrm{w} + v_i u^i = c^2$ (11) to the surface of gravitational collapsars (black holes). We proceeded from the fact that according to the definition of the gravitational potential $\mathrm{w} = c^2 (1 - \sqrt{g_{00}})$ (4) the gravitational collapse condition $g_{00} = 0$ means $\mathrm{w} = c^2$, which coincides with the teleportation conditions $\mathrm{w} + v_i u^i = c^2$ in the particular case where space does not rotate ($v_i = 0$). This means that the surfaces of all black holes in the Universe are physically connected to each other and are gateways to non-quantum teleportation in the Universe.

The question remained open: how to achieve the physical conditions for non-quantum teleportation in a regular laboratory on the Earth? In our monograph [6] and paper [8] we considered the stopped (frozen) light experiment performed in 2000 by Lene Hau [9]. In her famous experiments, the physically observable time of photons was stopped for up to 1.5 seconds in 2009 [10] in her Harvard laboratory without the state of gravitational collapse, thereby implementing the non-quantum teleportation conditions for photons during this period of time.

However, we are interested in non-quantum teleportation of physical bodies, and physical bodies consist of substance (i.e., mass-bearing particles).

At first glance, to realize the physical conditions of non-quantum teleportation $\mathrm{w} + v_i u^i = c^2$ (11) for real physical bodies, we need either to increase the gravitational potential in our laboratory to the numerical value characteristic of gravitational collapse or to rotate the local space of our laboratory at a speed close to the speed of light and also move the teleported test-body at a similar speed. Both are beyond the capabilities available in a regular laboratory.

Therefore, in 2022 we took a different approach to solving this problem [11], where the exotic physical conditions required for non-quantum teleportation can be achieved using a very strong electromagnetic field (such strong electromagnetic fields are able to be generated using modern technologies since the 1930s). The basis was considered to be the space of a low-speed rotating spherical body (like the planet Earth), the gravitational field of which is so weak that it can be neglected, which corresponds to the physical conditions in a regular Earth-bound laboratory. Having solved Einstein's field equations for the metric of such a space (their right-hand side is non-zero due to the electromagnetic field), we obtained specific characteristics of the magnetic and electric strengths under which physical bodies can be teleported.

Now we would like to answer the following question: are there natural, not man-made, conditions on the Earth (and on any other planet or star) under which non-quantum teleportation of physical bodies can be implemented?

To answer this question, let us now consider geometric conditions of non-quantum teleportation in the field of each of the three following space metrics:

- the space of a rotating spherical body, the gravitational field of which is so weak that can be neglected (its metric was introduced and proved in [11]);
- the space of a non-rotating spherical massive body, approximated by a material point (Schwarzschild's mass-point metric);
- the space of a rotating spherical massive body, approximated by a material point (its metric was introduced and proved in [12]).

The key point in our consideration is the *degeneration of space*. Under the weak non-quantum teleportation condition (8), only the physically observable time is degenerate ($d\tau = 0$). However, under the strong non-quantum teleportation condition (10), both the physically observable time, the physically observable three-dimensional space and the four-dimensional space-time are degenerate.

As we know from the theory of metric spaces, a metric space is degenerate if the determinant of its metric tensor is equal to zero. Anyone familiar with Riemannian geometry and tensor calculus can verify that in the four-dimensional pseudo-Riemannian space, which is the basic space-time of General Relativity, the determinant of the fundamental metric tensor $g = \det \| g_{\alpha\beta} \|$ is equal to $g < 0$. This means that the basic space-time of General Relativity is non-degenerate, and the zero-space (fully degenerate space-time) is located outside of it.

Zelmanov had proved that the determinant of the fundamental metric tensor $g = \det \| g_{\alpha\beta} \|$ and the determinant of the chr.inv.-metric tensor $h = \det \| h_{ik} \|$ are related with each other by the formula

$$h = -\frac{g}{g_{00}}\,, \tag{13}$$

which means that, once the chr.inv.-metric tensor h_{ik} is degenerate ($h = 0$), the fundamental metric tensor $g_{\alpha\beta}$ is degenerate too ($g = 0$). Or, in another form

$$g = -g_{00}\, h\,, \tag{14}$$

i.e., non-quantum teleportation is possible either under the state of gravitational collapse ($g_{00} = 0$), or under the degeneracy of the observable three-dimensional metric ($h = 0$), or if both these conditions take place together.

Consider the above Zelmanov formula in the field of each of the three mentioned space metrics.

The metric of the space of a rotating spherical body, the gravitational field of which is so weak that it can be neglected, was introduced and proved using Einstein's field equations in [11]. It has the form

$$ds^2 = c^2 dt^2 - 2\,\omega r^2 \sin^2\theta\, dt\, d\varphi - dr^2 - r^2 \left(d\theta^2 + \sin^2\theta\, d\varphi^2\right), \tag{15}$$

where the non-zero components of the fundamental metric tensor $g_{\alpha\beta}$ are

$$\left. \begin{array}{lll} g_{00} = 1\,, & g_{03} = -\dfrac{\omega r^2 \sin^2\theta}{c} & \\ g_{11} = -1\,, & g_{22} = -r^2, & g_{33} = -r^2 \sin^2\theta \end{array} \right\}, \tag{16}$$

and the chr.inv.-metric tensor h_{ik} of such a space has the following non-zero components

$$\left. \begin{array}{ll} h_{11} = 1\,, & h_{22} = r^2 \\ h_{33} = r^2 \sin^2\theta \left(1 + \dfrac{\omega^2 r^2 \sin^2\theta}{c^2}\right) & \end{array} \right\}, \tag{17}$$

where, since the matrix h_{ik} is diagonal, the upper-index components of h_{ik} are $h^{ik} = (h_{ik})^{-1}$ just like the invertible components to any diagonal matrix. Such a space rotates in the equatorial plane along the φ-axis (along the geographical longitudes) with a constant angular velocity $\omega = const$ and, according to the definition of v_i (5), with a linear velocity

$$v_3 = -\frac{c\,g_{03}}{\sqrt{g_{00}}} = \omega\, r^2 \sin^2\theta\,, \tag{18}$$

for which, since $v^2 = v_i v^i = h_{ik} v^i v^k$ and $v^i = h^{ik} v_k$, we have

$$v^2 = v_i v^i = \frac{\omega^2 r^2 \sin^2\theta}{1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}}\,, \qquad v = \frac{\omega\, r \sin\theta}{\sqrt{1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}}}\,, \tag{19}$$

i.e., the dimension of v is [cm/sec]. At slow rotation the above formula transforms to the conventional $v = \omega\, r \sin\theta$.

Therefore, the determinant of the fundamental metric tensor $g = \det\| g_{\alpha\beta} \|$ and the determinant of the chr.inv.-metric tensor $h = \det\| h_{ik} \|$ of such a space have the form

$$g = -r^4 \sin^2\theta \left(1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}\right), \tag{20}$$

$$h = r^4 \sin^2\theta \left(1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}\right). \tag{21}$$

From these formulae for the determinants $g = \det\| g_{\alpha\beta} \|$ and $h = \det\| h_{ik} \|$ it is clear:

> The space of a rotating spherical body, the gravitational field of which is so weak that it can be neglected, is fully degenerate (the conditions of full degeneracy $h = 0$ and $g = -g_{00} h = 0$ are satisfied together) everywhere along the axis of its rotation, i.e., along its polar axis, in particular — at the North and South Poles on the surface of the body. This takes place simply because there $\sin\theta = 0$, since the polar angle θ is measured from the North Pole. But even at a very small distance from the North or South Poles along the geographical latitudes, the space of such a body is non-degenerate.

This is a purely mathematical fact that does not depend on the physical properties of the spherical body (since they are negligible) or the speed of its rotation, but takes place only due to the geometric structure of its space.

Another case is a spherical body that does not rotate but has a significant mass, so that its gravitational field cannot be neglected. The metric of the space of a non-rotating spherical massive body, approximated by a material point, is known as Schwarzschild's mass-point metric. It has the form

$$ds^2 = \left(1 - \frac{r_g}{r}\right) c^2 dt^2 - \frac{dr^2}{1 - \frac{r_g}{r}} - r^2 \left(d\theta^2 + \sin^2\theta\, d\varphi^2\right), \tag{22}$$

where $r_g = 2GM/c^2$ is the gravitational radius characteristic of the body, which is calculated for its mass M, and

$$\left.\begin{aligned} g_{00} &= 1 - \frac{r_g}{r}\,, & g_{11} &= -\frac{1}{1 - \frac{r_g}{r}} \\ g_{22} &= -r^2, & g_{33} &= -r^2 \sin^2\theta \end{aligned}\right\} \tag{23}$$

and, respectively,

$$h_{11} = \frac{1}{1 - \frac{r_g}{r}}\,, \quad h_{22} = r^2, \quad h_{33} = r^2 \sin^2\theta\,, \tag{24}$$

on the basis of which we obtain formulae for the determinants $g = \det\| g_{\alpha\beta} \|$ and $h = \det\| h_{ik} \|$

$$g = -r^4 \sin^2\theta\,, \qquad h = \frac{r^4 \sin^2\theta}{1 - \frac{r_g}{r}}\,. \tag{25}$$

In such a space, we see a situation different from the previous one:

> The space of a non-rotating spherical massive body is fully degenerate (i.e., the conditions of full degeneracy $h = 0$ and $g = -g_{00} h = 0$ are satisfied together) at the North and South Poles of the body and, in general, along the entire axis of rotation of the space (since there $\sin\theta = 0$) only at distances $r \neq r_g$ from the centre of the body. On a spherical surface with a radius equal to the gravitational radius of the body r_g (on which $g_{00} = 0$), the four-dimensional space-time metric remains degenerate at the poles ($g = 0$), and the physically observable three-dimensional space has a breaking $h = \infty$ everywhere on the surface except at the poles, where it has an uncertainty $h = \frac{0}{0}$.

It should be noted that this is a coordinate effect, because a non-rotating spherical body does not have a physical polar axis: its polar axis can be chosen arbitrarily. Therefore, the effect of degeneration of the space of a non-rotating body can always be eliminated by coordinate transformations (shifting the "polar" axis to another place on the surface of the body). This is in contrast to rotating physical bodies, because each of them has its own physical polar axis (its own axis of rotation) and, therefore, the effect of degeneration of its space cannot be eliminated by coordinate transformations.

Finally, consider the space of a rotating spherical massive body, approximated by a material point. Its metric was introduced and proved in [12] and has the form

$$ds^2 = \left(1 - \frac{r_g}{r}\right) c^2 dt^2 - 2\,\omega r^2 \sin^2\theta \sqrt{1 - \frac{r_g}{r}}\, dt\, d\varphi - \\ - \frac{dr^2}{1 - \frac{r_g}{r}} - r^2 \left(d\theta^2 + \sin^2\theta\, d\varphi^2\right), \tag{26}$$

where, respectively,

$$\left.\begin{array}{ll} g_{00} = 1 - \dfrac{r_g}{r}\,, & g_{03} = -\dfrac{\omega\, r^2 \sin^2\theta}{c}\sqrt{1 - \dfrac{r_g}{r}} \\ g_{11} = -\dfrac{1}{1 - \frac{r_g}{r}}\,, & g_{22} = -r^2, \quad g_{33} = -r^2\sin^2\theta \end{array}\right\}, \tag{27}$$

the space rotates along the φ-axis (along the geographical longitudes) with a constant angular velocity $\omega = const$ and, according to the definition of v_i (5), with a linear velocity

$$v_3 = -\frac{c\, g_{03}}{\sqrt{g_{00}}} = \omega\, r^2 \sin^2\theta\,, \tag{28}$$

and the chr.inv.-metric tensor h_{ik} of the space has the following non-zero components

$$\left.\begin{array}{l} h_{11} = \dfrac{1}{1 - \frac{r_g}{r}}\,, \qquad h_{22} = r^2 \\ h_{33} = r^2 \sin^2\theta \left(1 + \dfrac{\omega^2 r^2 \sin^2\theta}{c^2}\right) \end{array}\right\}, \tag{29}$$

so, the determinants $g = \det\| g_{\alpha\beta} \|$ and $h = \det\| h_{ik} \|$ have the form

$$g = -r^4 \sin^2\theta \left(1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}\right), \tag{30}$$

$$h = \frac{r^4 \sin^2\theta}{1 - \frac{r_g}{r}} \left(1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}\right). \tag{31}$$

In such a space, the situation with its degeneration is similar to the space of a massive spherical body that does not rotate (considered above):

> The space of a non-rotating spherical massive body is fully degenerate (i.e., both conditions of full degeneracy $h = 0$ and $g = -g_{00}\, h = 0$ are satisfied) if $\sin\theta = 0$, i.e., at the North and South Poles of the body and, in general, along the entire axis of rotation of the space, but only at distances $r \neq r_g$ from the centre of the body. At a distance equal to the gravitational radius of the body r_g (this is a spherical surface, on which $g_{00} = 0$) the four-dimensional space-time metric remains degenerate at the poles ($g = 0$), and the physically observable three-dimensional space has a breaking $h = \infty$ except at the poles, where it has an uncertainty $h = \frac{0}{0}$.

Note that there is one key difference between this situation and the situation in a space of Schwarzschild's mass-point metric. As we have noted above, the effect of degeneration of space has a coordinate origin in the case of the mass-point metric, because the polar axis of such a space can be chosen arbitrarily. On the contrary, any rotating body has its own physical polar axis (its axis of rotation) and, therefore, the effect of degeneration of its space cannot be eliminated by coordinate transformations. For this reason, the mass-point metric cannot be considered physically valid in the problems where the degeneracy of space plays a rôle: when solving such problems, the mass-point metric must be replaced with the space metric of a rotating spherical massive body.

Finally, based on the above analysis of the geometric conditions of degeneration of spherical spaces, we arrive at the following conclusion about preferred conditions under which non-quantum teleportation could be implemented in a regular laboratory located on the surface of the Earth:

Preferred conditions for non-quantum teleportation

> Non-quantum teleportation can be implemented under any physical conditions in a laboratory located at the North and South Poles of a rotating spherical body, say, the Earth. This is simply due to the geometric structure of its rotating space, which is fully degenerate at the poles and, in general, everywhere along its axis of rotation. But even at a very small distance from the poles along the geographical latitudes, non-quantum teleportation requires exotic conditions, such as a very strong electromagnetic field, etc.

Yes, non-quantum teleportation can be implemented in a laboratory located at any other geographical latitude, and not only at the North and South Poles, say, due to certain configurations of a very strong electromagnetic field generated in the laboratory [11], or under some other exotic physical conditions created in it (since they do not depend on the geographical location of the laboratory). On the other hand, as we found in this study, at the North and South Poles non-quantum teleportation can be implemented under any physical conditions simply due to the geometric structure of the rotating space of the planet, which significantly simplifies the technical implementation of non-quantum teleportation in practice.

Therefore, to paraphrase the legendary saying of Baron Nathan Mayer Rothschild, who in 1815 said "He who owns the information, owns the world" (this phrase is sometimes misattributed to Winston Churchill, who often repeated it), we say: "He who owns the land at the poles of the Earth, owns the technical possibility for non-quantum teleportation to any point in the Universe". To be more precise, we mean land at the South Pole (in Antarctica), since there, unlike the North Pole of the Earth, which is covered by the waters of the Arctic Ocean, it is possible to install a laboratory and a stationary device for non-quantum teleportation.

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