Non-Quantum Teleportation in a Rotating Space With a Strong Electromagnetic Field

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In 1991 we derived the physical conditions opening the gate to a fully degenerate space-time, where from the point of view of a regular observer the observable spatial and time intervals are equal to zero. The one of the conditions, under which the observable interval of time is zero, enables instant displacement (non-quantum teleportation) of physical bodies at any distance. In this article, we derive the teleportation condition for Schwarzschild's mass-point metric, Schwarzschild's metric inside a sphere filled with an incompressible liquid and de Sitter's metric of a space filled with the physical vacuum. We also introduce the modifications of the above three metrics, which contain rotation due to the space-time non-holonomity (non-orthogonality of the time lines to the three-dimensional spatial section) and derive the teleportation condition in each of these spaces. The obtained teleportation condition requires either a near-light-speed rotation or a super-strong gravitational field (depending on the particular space metric), which is very problematic if not impossible in a regular laboratory. On the other hand, the non-orthogonality of the time lines to the three-dimensional section can be implemented not only by a mechanical rotation of the laboratory space, but also using other physical factors. Thus, we are looking for how to do it using a strong electromagnetic field (the latter is not a problem for modern technologies). We introduce a space-time metric, which rotates due to its non-holonomity, and the gravitational field is neglected. Then, substituting the components of the obtained metric into Einstein's field equations with the electromagnetic energy-momentum tensor on the right hand side, we obtain the conditions under which the equations vanish and, therefore, the metric space is Riemannian and contains an electromagnetic field. As a result, we obtain how the electromagnetic field parameters can replace the rotation of space in the teleportation condition. The obtained result shows how to teleport physical bodies from an earth-bound laboratory to any remote point in the Universe using a super-strong electromagnetic field. Creating such devices is a very interesting task for engineers in the near future.

1 The background

In 1991, in the course of our extensive research on the application of the General Theory of Relativity to biophysics, we set ourselves the following primary task. We aimed to deduce such physical conditions, under which the four-dimensional preudo-Riemannian space, which is the basic space-time of the General Theory of Relativity, is fully degenerate from the point of view of a regular observer. In such a fully degenerate region, the four-dimensional space-time interval is equal to zero, as well as the three-dimensional spatial interval and the interval of time, which are observed by a regular observer outside this region (in a regular non-degenerate region of the space-time), are also equal to zero.

In particular, the condition that the interval of physically observable time between two events is equal to zero enables instant displacement (non-quantum teleportation) of a physical body from the observer's laboratory to any remote point in the Universe.

The source and logical basis of this idea was the fact that a partial degeneration of the space-time was already known. In this case the four-dimensional (space-time) interval is equal to zero, and the observable three-dimensional interval and the interval of observable time are not equal to zero, but are equal to each other. Such a partially degenerate region of the space-time is home to light-like trajectories and light-like (massless) particles moving along them, for example, photons (photons belong to the family of massless light-like particles).

In our mathematical search for physical conditions, under which the space-time fully degenerates, we used, as always in our theoretical work, the mathematical apparatus of chronometric invariants, which are physically observable quantities in the General Theory of Relativity. This mathematical apparatus was created in 1944 by our esteemed teacher A. L. Zelmanov (1913–1987), who published it first in 1944 in his PhD thesis [1] and then in two brief journal articles [2, 3]. It just so happened that after Zelmanov's death, we remain the only ones who professionally master this mathematical apparatus and apply it in scientific research. For this reason, before explaining our current study of the non-quantum teleportation condition, we give below a brief introduction to the theory of chronometric invariants.

2 A brief introduction to chronometric invariants

Briefly, *chronometric invariants* are the quantities that are invariant everywhere along a three-dimensional spatial section of the space-time and a line of time, which are linked to a real observer and his laboratory. Mathematically, chronometrically invariant quantities are projections of four-dimensional (general covariant) quantities onto the three-dimensional spatial section and the line of time of the observer. In the general case, such a real three-dimensional spatial section (local three-dimensional space) can be curved, inhomogeneous, anisotropic, deformed, rotating, be filled with a gravitational field and also have some other properties such as viscosity etc. The lines of real time can have different density of time coordinates depending on the gravitational potential, as well as be non-orthogonal to the three-dimensional spatial section (the latter property is called the space-time non-holonomity, which is manifested as a three-dimensional rotation of the spatial section). As a result, the reference frame of a real observer, consisting of a coordinate grid paved on his real three-dimensional spatial section, as well as a system of real clocks located at each point of the section, has all the geometric and physical properties of his local space. Therefore, chronometrically invariant quantities as projections of four-dimensional (general covariant) quantities onto the real spatial section and real time line in his reference frame take into account the influence of all the geometric and physical factors present in his local space. So, the chronometrically invariant projections of any four-dimensional (general covariant) quantity calculated in the real reference frame of an observer are truly *physically observable quantities* registered by the observer.

The operator of projection onto the time line of an observer is the unit-length four-dimensional vector tangential to the observer's world line at each of its points

$$b^{\alpha} = \frac{dx^{\alpha}}{ds}\,, \qquad b_{\alpha}b^{\alpha} = 1\,,$$

while the operator of projection onto his three-dimensional spatial section is the four-dimensional symmetric tensor

$$h_{\alpha\beta} = -\,g_{\alpha\beta} + b_{\alpha}b_{\beta}\,.$$

These operators are orthogonal to each other, i.e., their common contraction is always equal to zero

$$h_{\alpha\beta}b^{\alpha} = 0\,, \quad h^{\alpha\beta}b_{\alpha} = 0\,, \quad h^{\alpha}_{\beta}b_{\alpha} = 0\,, \quad h^{\beta}_{\alpha}b^{\alpha} = 0\,.$$

A regular observer rests with respect to his reference body ($b^i = 0$) and, thus, accompanies to his reference space. Thus, the components of the projection operator b^{α} are

$$b^0 = \frac{1}{\sqrt{g_{00}}}\,, \quad b^i = 0\,, \quad b_0 = \sqrt{g_{00}}\,, \quad b_i = \frac{g_{i0}}{\sqrt{g_{00}}}\,,$$

while the components of $h_{\alpha\beta}$ have the form

$$\begin{aligned}
&h_{00} = 0\,, && h^{00} = -g^{00} + \frac{1}{g_{00}}\,, && h^0_0 = 0\,,\\
&h_{0i} = 0\,, && h^{0i} = -g^{0i}, && h^i_0 = 0\,,\\
&h_{i0} = 0\,, && h^{i0} = -g^{i0}, && h^0_i = \frac{g_{i0}}{g_{00}}\,,\\
&h_{ik} = -g_{ik} + \frac{g_{0i}g_{0k}}{g_{00}}\,, && h^{ik} = -g^{ik}, && h^i_k = \delta^i_k\,.
\end{aligned}$$

According to Zelmanov's theorem on the chronometrically invariant (physically observable) projections, the chr.inv.-projections of a four-dimensional vector Q^{α} are

$$b^{\alpha}Q_{\alpha} = \frac{Q_0}{\sqrt{g_{00}}}\,, \qquad h^i_{\alpha}Q^{\alpha} = Q^i,$$

while for a symmetric 2nd rank tensor $Q^{\alpha\beta}$ these are

$$b^{\alpha}b^{\beta}Q_{\alpha\beta} = \frac{Q_{00}}{g_{00}}\,, \quad h^{i\alpha}b^{\beta}Q_{\alpha\beta} = \frac{Q^i_0}{\sqrt{g_{00}}}\,, \quad h^i_{\alpha}h^k_{\beta}\,Q^{\alpha\beta} = Q^{ik}.$$

Thus, the chr.inv.-projections of a four-dimensional interval dx^{α} are the physically observable time interval

$$d\tau = \sqrt{g_{00}}\,dt + \frac{g_{0i}}{c\,\sqrt{g_{00}}}\,dx^i$$

and the observable three-dimensional interval dx^i which coincides with the spatial coordinate interval. The physically observable velocity is the three-dimensional chr.inv.-vector

$$\mathrm{v}^i = \frac{dx^i}{d\tau}\,, \qquad \mathrm{v}_i\mathrm{v}^i = h_{ik}\mathrm{v}^i\mathrm{v}^k = \mathrm{v}^2,$$

which, on the trajectories of light, transforms to the three-dimensional chr.inv.-vector of the physically observable velocity of light c^i, the square of which is $c_ic^i = h_{ik}\,c^ic^k = c^2$.

Calculating the spatial chr.inv.-projections of the fundamental metric tensor $g_{\alpha\beta}$, we see that

$$h^{\alpha}_i h^{\beta}_k\,g_{\alpha\beta} = -\,h_{ik}\,, \qquad h^i_{\alpha}h^k_{\beta}\,g^{\alpha\beta} = -\,h^{ik},$$

i.e., h_{ik} is the physically observable chr.inv.-metric tensor. It has all properties of the fundamental metric tensor $g_{\alpha\beta}$ in the observer's three-dimensional spatial section

$$h^{\alpha}_i h^k_{\alpha} = \delta^k_i - b_ib^k = \delta^k_i\,,$$

where δ^k_i is the unit three-dimensional tensor, which is part of the four-dimensional unit tensor δ^{α}_{β}. Therefore, the chr.inv.-metric tensor h_{ik} can lift and lower indices in chronometrically invariant quantities.

The chr.inv.-operators of derivation

$$\frac{{}^*\partial}{\partial t} = \frac{1}{\sqrt{g_{00}}}\frac{\partial}{\partial t}\,, \qquad \frac{{}^*\partial}{\partial x^i} = \frac{\partial}{\partial x^i} - \frac{g_{0i}}{g_{00}}\frac{\partial}{\partial x^0}$$

are non-commutative

$$\frac{{}^*\partial^2}{\partial x^i\partial t} - \frac{{}^*\partial^2}{\partial t\,\partial x^i} = \frac{1}{c^2}\,F_i\,\frac{{}^*\partial}{\partial t}\,, \quad \frac{{}^*\partial^2}{\partial x^i\partial x^k} - \frac{{}^*\partial^2}{\partial x^k\partial x^i} = \frac{2}{c^2}\,A_{ik}\,\frac{{}^*\partial}{\partial t}\,,$$

where

$$F_i = \frac{1}{1-\frac{\mathrm{w}}{c^2}}\left(\frac{\partial\mathrm{w}}{\partial x^i} - \frac{\partial v_i}{\partial t}\right)$$

is the chr.inv.-vector of the gravitational inertial force,

$$A_{ik} = \frac{1}{2}\left(\frac{\partial v_k}{\partial x^i} - \frac{\partial v_i}{\partial x^k}\right) + \frac{1}{2c^2}\,(F_i\,v_k - F_k\,v_i)$$

is the antisymmetric chr.inv.-tensor of the three-dimensional angular velocity of rotation of the observer's space, w is the gravitational potential, and v_i is the three-dimensional linear velocity of rotation of the observer's space due to the space-time non-holonomity (non-orthogonality of the time lines to the three-dimensional spatial section)

$$\mathrm{w} = c^2\left(1-\sqrt{g_{00}}\right), \quad v_i = -c\,\frac{g_{0i}}{\sqrt{g_{00}}}, \quad v^i = -c\,g^{0i}\sqrt{g_{00}}\,.$$

In particular, v_i gives a detailed formula for the chr.inv.-metric tensor h_{ik}, which is

$$h_{ik} = -g_{ik} + \frac{1}{c^2}\,v_i v_k\,.$$

It should be noted that the quantities w and v_i do not have chronometric invariance, despite the fact that $v_i = h_{ik}v^k$ and $v^2 = v_k v^k = h_{ik}v^i v^k$ as for a chr.inv.-quantity.

The reference space can deform, changing its coordinate grids with time that is expressed with the three-dimensional symmetric chr.inv.-tensor of the space deformation

$$D_{ik} = \frac{1}{2}\frac{{}^*\partial h_{ik}}{\partial t}, \quad D^{ik} = -\frac{1}{2}\frac{{}^*\partial h^{ik}}{\partial t}, \quad D = h^{ik}D_{ik} = \frac{{}^*\partial \ln\sqrt{h}}{\partial t},$$

where $h = \det\|h_{ik}\|$.

The regular 2nd rank Christoffel symbols $\Gamma^{\alpha}_{\mu\nu}$ and the 1st rank Christoffel symbols $\Gamma_{\mu\nu,\sigma}$ are replaced with the respective chr.inv.-Christoffel symbols

$$\Delta^i_{jk} = h^{im}\Delta_{jk,m} = \frac{1}{2}\,h^{im}\left(\frac{{}^*\partial h_{jm}}{\partial x^k} + \frac{{}^*\partial h_{km}}{\partial x^j} - \frac{{}^*\partial h_{jk}}{\partial x^m}\right),$$

where the chr.inv.-metric tensor h_{ik} is used instead of the fundamental metric tensor $g_{\alpha\beta}$.

The chr.inv.-curvature tensor is derived similarly to the Riemann-Christoffel tensor from the non-commutativity of the 2nd chr.inv.-derivatives of an arbitrary vector

$${}^*\nabla_i{}^*\nabla_k Q_l - {}^*\nabla_k{}^*\nabla_i Q_l = \frac{2A_{ik}}{c^2}\frac{{}^*\partial Q_l}{\partial t} + H_{lki\cdot}^{\cdots j}Q_j\,,$$

where the 4th rank chr.inv.-tensor

$$H_{lki\cdot}^{\cdots j} = \frac{{}^*\partial\Delta^j_{il}}{\partial x^k} - \frac{{}^*\partial\Delta^j_{kl}}{\partial x^i} + \Delta^m_{il}\Delta^j_{km} - \Delta^m_{kl}\Delta^j_{im}\,,$$

is the basis for the chr.inv.-curvature tensor C_{lkij},

$$C_{lkij} = \frac{1}{4}\left(H_{lkij} - H_{jkil} + H_{klji} - H_{iljk}\right),$$

$$C_{lk} = C_{lki\cdot}^{\cdots i}\,, \qquad C = h^{lk}C_{lk}\,,$$

which has all properties of the Riemann-Christoffel tensor in the observer's three-dimensional spatial section, and its contraction gives the observable chr.inv.-curvature C. Also

$$H_{lkij} = C_{lkij} + \frac{1}{2}\Big(2A_{ki}D_{jl} + A_{ij}D_{kl} + A_{jk}D_{il} + A_{kl}D_{ij} + A_{li}D_{jk}\Big),$$

$$H_{lk} = C_{lk} + \frac{1}{2}\left(A_{kj}D^j_l + A_{lj}D^j_k + A_{kl}D\right),$$

$$H = h^{lk}H_{lk} = C\,.$$

Please note that, as was found by Zelmanov, the physically observable chr.inv.-curvature of a space is depended on not only the gravitational inertial force acting in the space, but also the space rotation and deformation, and, therefore, does not vanish in the absence of the gravitational field.

The general covariant Einstein equations

$$R_{\alpha\beta} - \frac{1}{2}\,g_{\alpha\beta}R = -\varkappa\,T_{\alpha\beta} + \lambda\,g_{\alpha\beta}$$

with taking all possible factors into account have the chr.inv.-projections called the chr.inv.-Einstein equations

$$\left.\begin{aligned}
&\frac{{}^*\partial D}{\partial t} + D_{jl}D^{jl} + A_{jl}A^{lj} + {}^*\nabla_j F^j - \frac{1}{c^2}F_jF^j = \\
&\qquad\qquad = -\frac{\varkappa}{2}\left(\varrho c^2 + U\right) + \lambda c^2 \\
&{}^*\nabla_j\left(h^{ij}D - D^{ij} - A^{ij}\right) + \frac{2}{c^2}F_jA^{ij} = \varkappa J^i \\
&\frac{{}^*\partial D_{ik}}{\partial t} - \left(D_{ij} + A_{ij}\right)\left(D^j_k + A_{k\cdot}^{\cdot j}\right) + DD_{ik} + 3A_{ij}A_{k\cdot}^{\cdot j} - \\
&\quad - \frac{1}{c^2}F_iF_k + \frac{1}{2}\left({}^*\nabla_iF_k + {}^*\nabla_kF_i\right) - c^2C_{ik} = \\
&\qquad = \frac{\varkappa}{2}\left(\varrho c^2h_{ik} + 2U_{ik} - Uh_{ik}\right) + \lambda c^2h_{ik}
\end{aligned}\right\},$$

where the chr.inv.-derivative of the A^{ij} by x^j

$${}^*\nabla_jA^{ij} = \frac{{}^*\partial A^{ij}}{\partial x^j} + \Delta^i_{jl}A^{jl} + \Delta^l_{lj}A^{ij}, \quad \Delta^l_{lj} = \frac{{}^*\partial\ln\sqrt{h}}{\partial x^j}$$

is determined, as well as all other chr.inv.-derivatives

$$\begin{aligned}
&{}^*\nabla_i Q_k = \frac{{}^*\partial Q_k}{dx^i} - \Delta^l_{ik}Q_l\,,\\
&{}^*\nabla_i Q^k = \frac{{}^*\partial Q^k}{dx^i} + \Delta^k_{il}Q^l,\\
&{}^*\nabla_i Q_{jk} = \frac{{}^*\partial Q_{jk}}{dx^i} - \Delta^l_{ij}Q_{lk} - \Delta^l_{ik}Q_{jl}\,,\\
&{}^*\nabla_i Q^k_j = \frac{{}^*\partial Q^k_j}{dx^i} - \Delta^l_{ij}Q^k_l + \Delta^k_{il}Q^l_j\,,\\
&{}^*\nabla_i Q^{jk} = \frac{{}^*\partial Q^{jk}}{dx^i} + \Delta^j_{il}Q^{lk} + \Delta^k_{il}Q^{jl},\\
&{}^*\nabla_i Q^i = \frac{{}^*\partial Q^i}{\partial x^i} + \Delta^j_{ji}Q^i, \qquad \Delta^j_{ji} = \frac{{}^*\partial\ln\sqrt{h}}{\partial x^i}\,,\\
&{}^*\nabla_i Q^{ji} = \frac{{}^*\partial Q^{ji}}{\partial x^i} + \Delta^j_{il}Q^{il} + \Delta^l_{li}Q^{ji}, \quad \Delta^l_{li} = \frac{{}^*\partial\ln\sqrt{h}}{\partial x^i}\,,
\end{aligned}$$

by analogy with the respective absolute derivative, and

$$\varrho = \frac{T_{00}}{g_{00}}\,, \qquad J^i = \frac{cT^i_0}{\sqrt{g_{00}}}\,, \qquad U^{ik} = c^2T^{ik}$$

are the chr.inv.-projections of the energy-momentum tensor $T_{\alpha\beta}$ of the distributed matter that fills the space, e.g., an electromagnetic field: ϱ is the physically observable density of the field energy, J^i is the physically observable density of the field momentum, and U^{ik} is the physically observable stress-tensor of the field (its trace is $U = h^{mn}U_{mn}$).

The electromagnetic field tensor is the curl of the four-dimensional electromagnetic field potential A^α, i.e.,

$$F_{\mu\nu} = \nabla_\mu A_\nu - \nabla_\nu A_\mu = \frac{\partial A_\nu}{\partial x^\mu} - \frac{\partial A_\mu}{\partial x^\nu}\,,$$

where

$$\nabla_\mu A_\nu = \frac{\partial A_\nu}{\partial x^\mu} - \Gamma^\sigma_{\nu\mu} A_\sigma$$

is the absolute derivative of the A_ν by x^μ. The electromagnetic field tensor has the physically observable projections

$$E^i = \frac{F_{0\cdot}^{\cdot i}}{\sqrt{g_{00}}} = \frac{g^{i\alpha}F_{0\alpha}}{\sqrt{g_{00}}}\,, \qquad H^{ik} = F^{ik} = g^{i\alpha}g^{k\beta}F_{\alpha\beta}\,,$$

called the chr.inv.-electric strength E^i and chr.inv.-magnetic strength H^{ik} of the field. The respective chr.inv.-pseudovector H^{*i} and chr.inv.-pseudotensor E^{*ik}

$$H_{*i} = \frac{1}{2}\,\varepsilon_{ikm}H^{km}, \quad H^{*i} = \frac{1}{2}\,\varepsilon^{ikm}H_{km}\,,$$

$$E^{*ik} = -\varepsilon^{ikm}E_m\,, \quad \varepsilon^{ipq}H_{*i} = \frac{1}{2}\,\varepsilon^{ipq}\varepsilon_{imn}H^{mn} = H^{pq}$$

are created in accordance with the transposition of indices in the antisymmetric "discriminant" chr.inv.-tensor

$$\varepsilon^{ikm} = \frac{e^{ikm}}{\sqrt{h}}\,, \qquad \varepsilon_{ikm} = e_{ikm}\sqrt{h}\,,$$

which was introduced by Zelmanov by analogy with the Levi-Civita antisymmetric unit tensor e^{ikm}. Using ε^{ikm} and ε_{ikm}, we can transform chr.inv.-tensors into chr.inv.-pseudotensors (see §2.3 in our monograph [5]).

Thus, the general covariant energy-momentum tensor of an electromagnetic field

$$T_{\alpha\beta} = \frac{1}{4\pi}\left(-F_{\alpha\sigma}F_{\beta\cdot}^{\cdot\sigma} + \frac{1}{4}\,g_{\alpha\beta}F_{\mu\nu}F^{\mu\nu}\right)$$

has the following chr.inv.-projections

$$\varrho = \frac{T_{00}}{g_{00}} = \frac{1}{8\pi}\left(E_iE^i + H_{*i}H^{*i}\right),$$

$$J^i = \frac{cT_0^i}{\sqrt{g_{00}}} = \frac{c}{4\pi}\,\varepsilon^{ikm}E_kH_{*m}\,,$$

$$U^{ik} = c^2T^{ik} = \varrho c^2h^{ik} - \frac{c^2}{4\pi}\left(E^iE^k + H^{*i}H^{*k}\right).$$

Generally speaking, the mathematical apparatus of chronometric invariants is extensive. We have given above only that part of it that is necessary for understanding this article. For a deeper study of this mathematics, we recommend the respective chapters of our monographs [4, 5], especially — the chapter Tensor Algebra and the Analysis in [5]. You can also study Zelmanov's publications [1–3], of which his 1957 presentation [3] is the most useful and complete.

3 The physical conditions under which the space-time is fully degenerate

To deduce the physical conditions, under which the space-time is fully degenerate, we considered the square of the four-dimensional space-time interval $ds^2 = g_{\alpha\beta}\,dx^\alpha dx^\beta$ in the form, expressed in terms of chr.inv.-quantities, i.e.

$$ds^2 = c^2d\tau^2 - d\sigma^2,$$

where $d\tau$ is the interval of physically observable time, $d\sigma$ is the physically observable three-dimensional interval

$$d\tau = \left(1 - \frac{\mathrm{w}}{c^2}\right)dt - \frac{1}{c^2}\,v_i\,dx^i, \quad d\sigma^2 = h_{ik}\,dx^idx^k,$$

while w is the gravitational potential, and v_i is the linear velocity of rotation of the observer's space due to the space-time non-holonomity. Thus, considering the space-time interval the path travelled by a particle, we have

$$ds^2 = c^2d\tau^2\left(1 - \frac{\mathrm{v}^2}{c^2}\right), \qquad \mathrm{v}^i = \frac{dx^i}{d\tau}\,,$$

where v^i is the physically observable chr.inv.-velocity of the particle registered by the observer (see above).

Prior to our study, two types of trajectories and, respectively, two types of particles were known in the General Theory of Relativity. First, these are the so-called non-isotropic trajectories, along which, in terms of chr.inv.-quantities,

$$ds^2 = c^2d\tau^2 - d\sigma^2 \neq 0\,, \qquad c^2d\tau^2 \neq d\sigma^2 \neq 0\,.$$

They lie in the so-called non-isotropic region of the space-time, which is home to mass-bearing particles, and "mass-bearing" means that the rest-mass of such a particle is non-zero ($m_0 \neq 0$). The relativistic mass (mass of motion) of such a particle is non-zero too ($m \neq 0$). Such particles make up substances.

Trajectories of the second type are the so-called isotropic trajectories, along which, in terms of chr.inv.-quantities,

$$ds^2 = c^2d\tau^2 - d\sigma^2 = 0\,, \qquad c^2d\tau^2 = d\sigma^2 \neq 0\,.$$

They lie in the so-called isotropic region of the space-time, which is home to massless particles, for which "massless" means that the rest-mass of such a particle is equal to zero ($m_0 = 0$), while its relativistic mass (mass of motion) is non-zero ($m \neq 0$). Re-writting $ds^2 = 0$ in the form

$$ds^2 = c^2d\tau^2\left(1 - \frac{\mathrm{v}^2}{c^2}\right) = 0\,, \qquad c^2d\tau^2 \neq 0\,,$$

we see that massless particles travel at the velocity of light ($\mathrm{v}^2 = h_{ik}\,\mathrm{v}^i \mathrm{v}^k = c^2$). The latter mean that massless particles are related to the light-like family of particles.

The fact that $ds^2 = c^2 d\tau^2 - d\sigma^2 = 0$ and $c^2 d\tau^2 = d\sigma^2 \neq 0$ along the isotropic trajectories means that this is a partially degenerate region of the space-time.

Taking the above into account, we logically supposed that the space-time becomes fully degenerate, if

$$ds^2 = c^2 d\tau^2 - d\sigma^2 = 0\,, \quad c^2 d\tau^2 = 0\,, \quad d\sigma^2 = 0\,.$$

Our expectations found full justification. Below we will explain why.

As it is known from the geometry of metric spaces, a metric space is fully degenerate if the determinant of its metric tensor is equal to zero. In the four-dimensional pseudo-Riemannian space, which is the basic space-time of the General Theory of Relativity, the determinant of the fundamental metric tensor is $g < 0$. This means that the basic space-time of the General Theory of Relativity is non-degenerate.

The condition $d\tau = 0$ means that the physically observable time interval between any two events in this space-time region, when registered by an observer, whose home is the regular (non-degenerate) space-time region, is equal to zero. We re-write $d\tau = 0$ in the form

$$d\tau = \left[1 - \frac{1}{c^2}\left(\mathrm{w} + v_i u^i\right)\right] dt = 0\,, \qquad u^i = \frac{dx^i}{dt}\,,$$

where u^i is the three-dimensional coordinate velocity of motion with respect to the observer, which is not a physically observable chr.inv.-quantity; the u^i is based on the time coordinate increment dt, which is not equal to zero between the events ($dt \neq 0$).

The condition $d\sigma^2 = 0$ in the extended form is

$$d\sigma^2 = h_{ik}\,dx^i dx^k = 0\,, \qquad dx^i \neq 0$$

and means that in this space-time region the physically observable three-dimensional distance $d\sigma$ between any two different points ($dx^i \neq 0$) when registered by an observer, whose home is a regular non-degenerate space-time region, is equal to zero. This condition satisfies only if the determinant of the chr.inv.-metric tensor h_{ik} is equal to zero

$$h = \det \| h_{ik} \| = h_{11}h_{22}h_{33} + h_{31}h_{12}h_{23} + h_{21}h_{13}h_{32} - \\ - h_{31}h_{22}h_{13} - h_{21}h_{12}h_{33} - h_{11}h_{23}h_{32} = 0\,.$$

Zelmanov proved that the determinant of the fundamental metric tensor $g = \det \| g_{\alpha\beta} \|$ is connected with that of the chr.inv.-metric tensor $h = \det \| h_{ik} \|$ by the formula

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

i.e., once the chr.inv.-metric tensor h_{ik} is degenerate, the fundamental metric tensor $g_{\alpha\beta}$ is degenerate too.

The above is an exact proof to why the entire space of the Universe or a local space region in it, wherein $c^2 d\tau^2 = 0$ and $d\sigma^2 = 0$, is fully degenerate. We therefore called such a space-time *zero-space*, while the trajectories that lie in it — *zero-trajectories*.

Using the formulae for $d\tau$ and h_{ik}, we obtained the *physical conditions for full degeneracy*, i.e., the physical conditions in a fully degenerate space-time (zero-space)

$$\mathrm{w} + v_i u^i = c^2, \qquad \left(1 - \frac{\mathrm{w}}{c^2}\right)^2 c^2 dt^2 = g_{ik}\,dx^i dx^k.$$

From a geometric point of view, the conditions for full degeneracy mean the following.

Within the infinitesimal vicinity of any point in a Rimeannian space, we can introduce a flat space, which is tangential to the Riemannian space in this point. The latter means that the basis vectors $\vec{e}_{(\alpha)}$ of the tangential flat space are tangential to the curved coordinate lines of the Riemannian space. But, since the coordinate lines in a Riemannian space are curved and non-orthogonal to each other (if the space is non-holonomic), the lengths of the basis vectors $\vec{e}_{(\alpha)}$ in the tangential flat space are different from the unit length. The vector of an infinitesimal displacement in the Riemannian space is expressed through the tangential basis vectors as

$$d\vec{r} = \vec{e}_{(\alpha)} dx^\alpha,$$

and, since the scalar product of the vector $d\vec{r}$ with itself gives $d\vec{r}d\vec{r} = ds^2$ and also it is $ds^2 = g_{\alpha\beta}\,dx^\alpha dx^\beta$, we obtain

$$g_{\alpha\beta} = \vec{e}_{(\alpha)}\vec{e}_{(\beta)} = e_{(\alpha)}e_{(\beta)}\cos\left(x^\alpha; x^\beta\right),$$

i.e., $g_{00} = e^2_{(0)}$, $g_{0i} = e_{(0)}e_{(i)}\cos\left(x^0; x^i\right)$, $g_{ik} = e_{(i)}e_{(k)}\cos\left(x^i; x^k\right)$. Thus, according to the definitions of v_i and h_{ik}, we have

$$v_i = -\,c\,e_{(i)}\cos\left(x^0; x^i\right),$$

$$h_{ik} = e_{(i)}e_{(k)}\Big[\cos\left(x^0; x^i\right)\cos\left(x^0; x^k\right) - \cos\left(x^i; x^k\right)\Big].$$

Taking into account that $d\tau = 0$ and $d\sigma^2 = 0$ in the zero-space (the latter, as was shown above, means $h = 0$), we obtain the *geometric conditions for full degeneracy*

$$e_{(0)} = -\frac{1}{c}\,e_{(i)}u^i\cos\left(x^0; x^i\right),$$

$$\cos\left(x^0; x^i\right)\cos\left(x^0; x^k\right) = \cos\left(x^i; x^k\right).$$

So, once the rotation of the observer's space reaches the light speed, $\cos\left(x^0; x^i\right) = 1$ and, thus, $\cos\left(x^i; x^k\right) = 1$: the lines of time become "fallen" into the three-dimensional spatial section (time becomes "fallen" into space), wherein all three spatial axes become coinciding with each other.

As for the particles located is the zero-space, their physical sense is derived based on Levi-Civita's rule, according to which, in a Riemannian space of n dimensions the length of any n-dimensional vector Q^α transferred in parallel to itself remains unchanged ($Q_\alpha Q^\alpha = const$).

As it is known, any mass-bearing particle is characterized by the four-dimensional momentum vector P^α, and any massless (i.e., having the zero rest-mass) particle is characterized by the four-dimensional wave vector K^α,

$$P^\alpha = m_0 \frac{dx^\alpha}{ds}, \qquad K^\alpha = \frac{\omega_0}{c}\frac{dx^\alpha}{ds},$$

each of which is transferred in parallel to itself along the particle's trajectory in the space-time. The chr.inv.-projections of the P^α and K^α onto the time line and the three-dimensional spatial section of a regular observer are equal to

$$\frac{P_0}{\sqrt{g_{00}}} = m, \qquad P^i = \frac{m}{c}\,\mathrm{v}^i,$$

$$\frac{K_0}{\sqrt{g_{00}}} = \frac{\omega}{c}, \qquad K^i = \frac{\omega}{c}\,c^i.$$

To adapt the P^α and K^α to the zero-space condition, we are looking for the condition in their structure. Based on the interval of physically observable time $d\tau$ (page 32), we obtain how the physically observable velocity depends on the condition for full degeneracy $\mathrm{w} + v_i u^i = c^2$, i.e.,

$$\mathrm{v}^i = \frac{u^i}{1 - \frac{1}{c^2}\left(\mathrm{w} + v_k u^k\right)},$$

and then express ds^2 in the form

$$ds^2 = c^2 d\tau^2 \left(1 - \frac{\mathrm{v}^2}{c^2}\right) = c^2 dt^2 \left\{\left[1 - \frac{1}{c^2}\left(\mathrm{w} + v_k u^k\right)\right]^2 - \frac{u^2}{c^2}\right\},$$

which gives

$$P^\alpha = m_0 \frac{dx^\alpha}{ds} = \frac{M}{c}\frac{dx^\alpha}{dt}, \quad K^\alpha = \frac{\omega_0}{c}\frac{dx^\alpha}{ds} = \frac{\omega}{c^2}\frac{dx^\alpha}{dt},$$

where $dt \neq 0$, and

$$M = \frac{m}{1 - \frac{1}{c^2}\left(\mathrm{w} + v_k u^k\right)}, \quad \omega = \frac{\omega}{1 - \frac{1}{c^2}\left(\mathrm{w} + v_k u^k\right)}$$

take the condition for full degeneracy $\mathrm{w} + v_i u^i = c^2$ into account and are not equal to zero in the zero-space.

For zero-space particles, the chr.inv.-projections of their momentum vector P^α and wave vector K^α onto the time line and the three-dimensional space of a regular observer outside the zero-space are equal to

$$\frac{P_0}{\sqrt{g_{00}}} = M\left[1 - \frac{1}{c^2}\left(\mathrm{w} + v_i u^i\right)\right] = 0, \qquad P^i = \frac{1}{c}\,M u^i \neq 0,$$

$$\frac{K_0}{\sqrt{g_{00}}} = \frac{\omega}{c}\left[1 - \frac{1}{c^2}\left(\mathrm{w} + v_i u^i\right)\right] = 0, \qquad K^i = \frac{1}{c^2}\,\omega u^i \neq 0.$$

The above result means that all zero-space particles have zero rest-masses $m_0 = 0$, zero relativistic masses $m = 0$ and zero relativistic frequencies $\omega = 0$. We therefore called the particles, whose home is the zero-space, *zero-particles*.

This is the third, new type of particles in addition to mass-bearing and massless (light-like) particles, already known in the General Theory of Relativity.

As it is known, for any regular mass-bearing and massless particle (their home is the regular non-degenerate space-time), the relation between its energy and momentum remains unchanged along its trajectory

$$E^2 - c^2 p^2 = const.$$

This follows from Levi-Civita's rule $P_\alpha P^\alpha = const$ and $K_\alpha K^\alpha \neq const$ having the form for mass-bearing particles and massless particles, respectively,

$$E^2 - c^2 p^2 = E_0^2, \qquad E^2 - c^2 p^2 = 0,$$

where $E = mc^2$, $p^2 = m^2 \mathrm{v}^2$, $E_0 = m_0 c^2$. For massless particles this relation, taking into account that $p^2 = m^2 \mathrm{v}^2 = m^2 h_{ik} \mathrm{v}^i \mathrm{v}^k$, transforms into the banal formula $h_{ik} \mathrm{v}^i \mathrm{v}^k = c^2$ meaning that they travel at the velocity of light.

On the other hand, $P_\alpha P^\alpha \neq const$ and $K_\alpha K^\alpha \neq const$ for zero-particles: anyone can verify this fact by his own calculations based on the above. This fact means that Levi-Civita's rule is violated along the trajectories of zero-particles, and, hence, the observed geometry along their trajectories is not Riemannian.

The said does not necessarily mean that the zero-space geometry is non-Riemannian itself, but only that it looks like that from the point of view of a regular observer.

Of all the types of particles known in modern physics, only virtual particles have $E^2 - c^2 p^2 \neq const$. Feynman diagrams show that virtual particles are carriers of the interaction between elementary particles, i.e., between each two branching points on the diagrams. According to Quantum Electrodynamics, all physical processes in our world are based on the emission and absorption of virtual particles by real mass and massless (light-like) particles.

That is, the interaction between particles in our regular space-time is transmitted through an "exchange buffer" that is the zero-space, while zero-particles transmitting the interaction through this "buffer space" (zero-space) are *virtual particles* known in Quantum Electrodynamics.

The above is the solely interpretation of virtual particles and Feynman diagrams in the framework of the space-time geometry, and is a "bridge" connecting Quantum Electrodynamics with the General Theory of Relativity.

To understand how zero-particles could be registered in an experiment conducted by a regular observer, consider them as waves travelling along their space-time trajectories.

As it is known, any massless particle in the framework of the geometric optics approximation is characterized by the four-dimensional wave vector determined in the lower-index form K_α through the wave phase ψ called eikonal. In analogy to it, we introduce the four-dimensional momentum vector characteristic of any mass-bearing particle, respectively,

$$K_\alpha = \frac{\partial\psi}{\partial x^\alpha}\,, \qquad P_\alpha = \frac{\hbar}{c}\,\frac{\partial\psi}{\partial x^\alpha}\,,$$

where $\hbar$ is Planck's constant. Their physically observable chr.inv.-projections onto the observer's line of time are

$$\frac{K_0}{\sqrt{g_{00}}} = \frac{1}{c}\frac{{}^*\partial\psi}{\partial t}\,, \qquad \frac{P_0}{\sqrt{g_{00}}} = \frac{\hbar}{c^2}\frac{{}^*\partial\psi}{\partial t}\,,$$

and, since these chr.inv.-projections are also equal to ω/c and m (see above), we obtain that, in the framework of the geometric optics approximation,

$$\omega = \frac{{}^*\partial\psi}{\partial t}\,, \qquad m = \frac{\hbar}{c^2}\frac{{}^*\partial\psi}{\partial t}\,.$$

Therefore, on the transition to the zero-space, i.e., under the condition for full degeneracy $\mathrm{w} + v_i u^i = c^2$, since $\omega = 0$ and $m = 0$ (see above), we obtain

$$\frac{{}^*\partial\psi}{\partial t} = 0\,.$$

The eikonal equation $K_\alpha K^\alpha = const$ means that the length of the four-dimensional wave vector transferred in parallel to itself remains unchanged. The chr.inv.-eikonal equation for regular massless (light-like) particles and mass-bearing particles, taking the main property $g_{\alpha\sigma}\, g^{\beta\sigma} = \delta_\alpha^\beta$ of the fundamental metric tensor $g_{\alpha\beta}$ into account, has the form, respectively,

$$\frac{1}{c^2}\left(\frac{{}^*\partial\psi}{\partial t}\right)^2 - h^{ik}\,\frac{{}^*\partial\psi}{\partial x^i}\,\frac{{}^*\partial\psi}{\partial x^k} = 0\,,$$

$$\frac{1}{c^2}\left(\frac{{}^*\partial\psi}{\partial t}\right)^2 - h^{ik}\,\frac{{}^*\partial\psi}{\partial x^i}\,\frac{{}^*\partial\psi}{\partial x^k} = \frac{m_0^2 c^2}{\hbar^2}\,,$$

and is a travelling wave equation. On the transition to the zero-space, the above eikonal equations take the same form

$$h^{ik}\,\frac{{}^*\partial\psi}{\partial x^i}\,\frac{{}^*\partial\psi}{\partial x^k} = 0\,,$$

which is a standing wave equation.

To understand the result we have obtained, we should take into account the fact that a regular observer does not register zero-space objects themselves, but only what he sees on the transition to or from the zero-space (we assume that Levi-Civita's rule is satisfied on this boundary), and the zero-space itself is the fully degenerate case of the isotropic space (home to massless light-like particles).

Therefore, zero-particles, i.e., all particles, whose home is the zero-space, should appear to a regular observer outside the zero-space as *standing light waves*, while the zero-space should appear as a point containing a system of standing light waves (a *light-like hologram*) inside itself.

4 Non-quantum teleportation

Teleportation is the instant displacement of particles from one point in the three-dimensional space to another.

Initially, scientists considered only quantum teleportation. In fact, quantum teleportation is not a real instant displacement, but a "probabilistic trick" based on the laws of Quantum Mechanics [7]. This is despite the fact that, using quantum teleportation, photons were first "teleported" in 1998 [8], and atoms were "teleported" in 2004 [9, 10].

On the contrary, we considered instant displacement in accordance with the geometric structure of the space-time of the General Theory of Relativity, which is real teleportation without any "probabilistic tricks". This is why we called this regular non-quantum method of particle teleportation *non-quantum teleportation*.

In terms of physically observable chr.inv.-quantities, teleportation is a process of displacement in which the interval of physically observable time between its beginning and end is equal to zero ($d\tau = 0$). If a mass-bearing particle is teleported (mass-bearing particles make up substances), the teleportation condition $d\tau = 0$ is added with the physically observable three-dimensional interval between the point of departure and the point of arrival, which is not equal to zero, i.e. $d\sigma \neq 0$. Therefore, the space-time metric along the trajectories of non-quantum teleportation of mass-bearing particles is

$$ds^2 = c^2 d\tau^2 - d\sigma^2 = -d\sigma^2, \quad c^2 d\tau^2 = 0\,, \quad d\sigma^2 \neq 0\,.$$

Since $d\sigma^2 = h_{ik}\, dx^i dx^k$ and taking into account the condition $\mathrm{w} + v_i u^i = c^2$ under which $d\tau = 0$, the space-time metric takes the form, which we called the *non-quantum teleportation metric*

$$ds^2 = -d\sigma^2 = -\left(1 - \frac{\mathrm{w}}{c^2}\right)^2 c^2 dt^2 + g_{ik}\, dx^i dx^k = \\ = -\frac{1}{c^2}\, v_i u^i v_k u^k dt^2 + g_{ik}\, dx^i dx^k.$$

As you can see, in the non-quantum teleportation metric, the regular signature $(+---)$ of space-time is replaced with the inverted signature $(-+++)$. That is, from the point of view of a regular observer, "time" and "space" are replaced with each other on the teleportation trajectories: "time" of a teleporting particle is "space" of a regular observer, and "space" of the teleporting particle is "time" of the regular observer.

The same is true for the non-quantum teleportation metric, derived for massless (light-like) particles. If a massless (light-like) particle is teleported, the teleportation condition $d\tau = 0$ is added with $c^2 d\tau^2 = d\sigma^2$, since the latter is characteristic of the isotropic region of the space-time, which is home to such particles. Therefore, the space-time metric along the trajectories of non-quantum teleportation of massless (light-like) particles is fully degenerate

$$ds^2 = c^2 d\tau^2 - d\sigma^2 = 0, \qquad c^2 d\tau^2 = d\sigma^2 = 0\,,$$

which means that the trajectories along which massless particles are teleported lie in the fully degenerate space-time (zero-space). The equation of such trajectories is derived from the non-quantum teleportation metric (see above) equalized to zero, and is the fully degenerate light hypercone equation

$$\left(1-\frac{\mathrm{w}}{c^2}\right)^2 c^2 dt^2 = g_{ik}\, dx^i dx^k .$$

So, according to the General Theory of Relativity, as soon as we realize the physical condition

$$\mathrm{w} + v_i\, u^i = c^2$$

in the local space inside a device in our laboratory (under this condition, $d\tau = 0$), a mass-bearing or massless (light-like) particle that is inside this device enters a teleportation trajectory and, thus, can be instantly teleported to any other place in our Universe. For this reason, we call $\mathrm{w} + v_i\, u^i = c^2$ also the *physical condition for non-quantum teleportation*.

5 Finding the teleportation condition accessible in a real laboratory. Problem statement

The above results, which we obtained in the early 1990s, were presented in our two monographs in 2001 [4, 5], and then in the brief article [6]. The reason for such a long overview of these results in the present article is that without a detailed acquaintance with the above results, it would be impossible to understand everything that follows, including the engineering implementation of non-quantum teleportation at any distance in our Universe.

So, the physical condition $\mathrm{w} + v_i\, u^i = c^2$ under which the interval of physically observable time is degenerate ($d\tau = 0$) is also the physical condition for non-quantum teleportation. To implement this physical condition, a super-strong gravitational potential and a near-light-speed rotation of the observer's space are required. Obviously, in a real laboratory, this is extremely difficult, if not impossible.

On the other hand, when deriving the teleportation condition $\mathrm{w} + v_i\, u^i = c^2$ from $d\tau = 0$, we did not indicate the formulas for the individual components of the fundamental metric tensor $g_{\alpha\beta}$ and the chr.inv.-metric tensor h_{ik}. That is, we did not specify the specific local space of the real laboratory in which we are going to teleport particles.

It is obvious that, as soon as we specify the metric of the local space in a real laboratory, the teleportation condition derived from this metric will be different from its general form $\mathrm{w} + v_i\, u^i = c^2$. Say, we have an electromagnetic field generator installed and running in our laboratory. If so, then the local space in our laboratory has an electromagnetic field. Accordingly, we expect that the characteristics of the electromagnetic field will appear in the teleportation condition derived from $d\tau = 0$. In particular, if the generated electromagnetic field is super-strong (this is not a big problem when using modern technologies), then the numerical values of the electromagnetic field terms in the teleportation condition can be so significant that "replace" the gravitational potential and rotation of the laboratory space. In such a case, the teleportation condition, i.e., the condition under which particles enter teleportation trajectories and, thus, can be instantly teleported to any other place in our Universe, can be implemented in a real laboratory.

Which specific space metric is suitable for a real laboratory? Such a local space is connected either with the Earth, or with another planet, or with another star system, and, at first glance, is described by Schwarzschild's mass-point metric. On the other hand, the mass-point metric does not take into account the rotation of space, which is one of the two "core" factors in the teleportation condition $\mathrm{w} + v_i\, u^i = c^2$. Another drawback is that the space described by the mass-point metric is filled only with a gravitational field, and does not have an electromagnetic field. The third drawback is that the gravitational field is so weak in a real earth-bound laboratory that this factor can be neglected in the teleportation condition.

We therefore have drafted the following research plan for the next Sections of this article.

At our first step we will derive and analyze the teleportation condition for each of the three most popular space metrics. These are Schwarzschild's mass-point metric, Schwarzschild's metric inside a sphere filled with an incompressible liquid and de Sitter's metric of a space filled with the physical vacuum. Then, based on the above metrics, we will introduce three similar metrics containing a three-dimensional rotation due to the space-time non-holonomity (expressed by $g_{0i} \neq 0$). After that we will derive and analyze the teleportation condition in each of these three types of rotating space.

At our second step, we will introduce the metric of a space that rotates due to the space-time non-holonomity, but free from the gravitational field. This metric will be our "working metric" in this research.

It is not a fact that the introduced metric containing rotation describes a Riemannian space. As it is known, a Riemannian space metric must not only have the Riemann square form $ds^2 = g_{\alpha\beta}\, dx^\alpha dx^\beta$, determined by the Riemann fundamental metric tensor $g_{\alpha\beta}$, and be invariant $ds^2 = inv$ everywhere in the space. It must also satisfy Einstein's field equations — the relation between the Ricci curvature tensor, the fundamental metric tensor multiplied by the curvature scalar, and the energy-momentum tensor of the "space filler", which is satisfied in any Riemannian space. The latter means that as soon as we substitute the components of the fundamental metric tensor $g_{\alpha\beta}$ (taken from the formula of a particular Riemannian space metric) and the components of the energy-momentum tensor of the medium filling the space into the component notation of the field equations, this must turn the field equations into the zero identity. This is why not many space metrics are proven to be Riemannian and, thus, are used in the General Theory of Relativity.

So, most likely, the introduced metric containing rotation will turn out to be non-Riemannian due to the term taking the three-dimensional space rotation into account.

To correct this situation, at our second step, we will take the $g_{\alpha\beta}$ components from the introduced metric, then substitute them into the chr.inv.-Einstein equations, the right hand side of which is non-zero and contains the energy-momentum tensor of an electromagnetic field. The relations that vanish the resulting chr.inv.-Einstein equations (we call them the *Riemannian conditions*), are the conditions under which the metric is Riemannian and describes a non-holonomic (rotating) space-time filled with an electromagnetic field.

Please note that, as was found by Zelmanov (see page 33), the physically observable chr.inv.-curvature of a space is depended on not only the acting gravitational inertial force, but also the space rotation and deformation, and, therefore, does not vanish in the absence of the gravitational field.

At our third step, we will consider the teleportation condition, derived for the introduced metric containing rotation, and the Riemannian conditions for this metric in the presence of an electromagnetic field (the latter follow from the Einstein equations, see above).

The obtained system of equations will show how strong the electromagnetic field should be and what additional conditions are required to launch particles on teleportation trajectories in a slow rotating laboratory space. Super-strong electromagnetic fields are not a big problem when using modern technologies. For this reason, the obtained electromagnetic field parameters and additional conditions will show how, under the conditions of a real earth-bound laboratory, real physical bodies and photons can be instantly teleported to any other place in our Universe.

6 The teleportation condition in the space of a mass-point body

Schwarzschild's mass-point metric describes a spherically symmetric space filled with the gravitational field created in emptiness by a spherically symmetrical massive island, which is considered as a point-like mass. The metric has the form

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

where r is the distance from the centre of the island, while $r_g = 2GM/c^2$ is its gravitational radius.

Here and below, in terms of the spherical coordinates, r is the radial coordinate, θ is the polar angle, φ is the geographical longitude, dr is the elementary segment length along the r-axis, $r\,d\theta$ is the elementary arc length along the θ-axis, and $r \sin\theta \, d\varphi$ is the elementary arc length along the φ-axis.

Therefore, the non-zero components of the fundamental metric tensor $g_{\alpha\beta}$ of the mass-point metric expressed in terms of the spherical coordinates are equal to

$$g_{00} = 1 - \frac{r_g}{r}, \quad g_{11} = -\frac{1}{1 - \frac{r_g}{r}}, \quad g_{22} = -r^2, \quad g_{33} = -r^2 \sin^2\theta .$$

With the above $g_{\alpha\beta}$ components, we obtain that the interval of physically observable time in the space of the mass-point metric has the form

$$d\tau = \sqrt{g_{00}}\, dt + \frac{g_{0i}}{c\sqrt{g_{00}}}\, dx^i = \sqrt{1 - \frac{r_g}{r}}\, dt ,$$

and the teleportation condition, which is $d\tau = 0$ with $dt \neq 0$, has the following form

$$1 - \frac{r_g}{r} = 0 \quad \Longrightarrow \quad r = r_g .$$

In addition to the above, because g_{00} is expressed through the gravitational potential w in the form

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

the obtained teleportation condition can be re-written as

$$1 - \frac{\mathrm{w}}{c^2} = 0 \quad \Longrightarrow \quad \mathrm{w} = c^2 .$$

The obtained result means that, in the space of the mass-point metric, i.e., in the field of a spherically symmetric non-rotating mass, a particle enters a teleportation trajectory under the condition of gravitational collapse, i.e., on the surface of a gravitational collapsar.

In other words, if you are in the field of a spherically symmetric non-rotating mass, in order to launch a particle on a teleportation trajectory, you need to simulate a mini black hole in your laboratory.

7 The teleportation condition in the space of a rotating mass-point body

Introduce a mass-point metric, where a gravitational field is created in emptiness by a spherically symmetrical massive island, which rotates due to the space-time non-holonomity. We use Schwarzschild's mass-point metric as a basis. Assume that the space rotates along the φ-axis (along the geographical longitudes) with the linear velocity $v_3 = \omega r^2 \sin^2\theta$, where $\omega = const$ is the angular velocity of this rotation. Since, according to the definition of v_i,

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

we obtain

$$g_{03} = -\frac{1}{c}\, v_3 \sqrt{g_{00}} = -\frac{\omega r^2 \sin^2\theta}{c} \sqrt{1 - \frac{r_g}{r}} ,$$

and, thus, we obtain a Schwarzschild-like mass-point metric containing the above rotation, i.e.,

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

Accordingly, the interval of physically observable time in the rotating space of the Schwarzschild-like metric we have introduced is

$$d\tau = \sqrt{g_{00}}\,dt + \frac{g_{0i}}{c\sqrt{g_{00}}}\,dx^i = \\ = \left(\sqrt{1-\frac{r_g}{r}} - \frac{\omega r^2 \sin^2\theta}{c^2}\frac{d\varphi}{dt}\right) dt\,,$$

and the teleportation condition, i.e., $d\tau = 0$ with $dt \neq 0$, written in the spherical coordinates has the form

$$\sqrt{1-\frac{r_g}{r}} - \frac{\omega r^2 \sin^2\theta}{c^2}\frac{d\varphi}{dt} = 0\,,$$

or, that is the same

$$\mathrm{w} + \omega r^2 \sin^2\theta\,\frac{d\varphi}{dt} = c^2,$$

where $\sin\theta = 1$ for the observer's laboratory located at the equator, and the last multiplier is the coordinate velocity of the teleporting particle along the φ-direction, which is the geographical longitude (we assume that the particle travels either in the same or in the opposite direction in which the space rotates).

This condition is different from that in the space of the Schwarzschild mass-point metric in only the second term depending on the rotation of space due to the space-time non-holonomity: the faster the rotation of space and the faster the teleporting particle, the farther the teleportation trajectory from the surface of gravitational collapse.

8 The teleportation condition in the space inside a liquid sphere

Consider the metric of the space inside a liquid sphere, which was introduced by Schwarzschild. It describes the space inside a sphere, which is not empty, but filled with an incompressible liquid. The gravitational field inside such a sphere is created by a spherically symmetrical imcompressible liquid that fills it. As it is known, this metric has the form

$$ds^2 = \frac{1}{4}\left(3\sqrt{1-\frac{r_g}{a}} - \sqrt{1-\frac{r^2 r_g}{a^3}}\right)^2 c^2 dt^2 - \\ - \frac{dr^2}{1-\frac{r^2 r_g}{a^3}} - r^2\left(d\theta^2 + \sin^2\theta\,d\varphi^2\right),$$

where $r_g = 2GM/c^2$ is the gravitational radius calculated for the entire mass M of the liquid (source of the gravitational field) inside the sphere, and $a = const$ is the radius of the sphere. Respectively, the non-zero components of the fundamental metric tensor $g_{\alpha\beta}$ of this metric are

$$g_{00} = \frac{1}{4}\left(3\sqrt{1-\frac{r_g}{a}} - \sqrt{1-\frac{r^2 r_g}{a^3}}\right)^2,$$

$$g_{11} = -\frac{1}{1-\frac{r^2 r_g}{a^3}}\,, \quad g_{22} = -r^2, \quad g_{33} = -r^2\sin^2\theta\,.$$

As a result, we obtain that the interval of physically observable time inside such a sphere has the form

$$d\tau = \sqrt{g_{00}}\,dt + \frac{g_{0i}}{c\sqrt{g_{00}}}\,dx^i = \\ = \frac{1}{2}\left(3\sqrt{1-\frac{r_g}{a}} - \sqrt{1-\frac{r^2 r_g}{a^3}}\right) dt\,,$$

and the teleportation condition, i.e., $d\tau = 0$ with $dt \neq 0$, has the following form

$$3\sqrt{1-\frac{r_g}{a}} - \sqrt{1-\frac{r^2 r_g}{a^3}} = 0\,.$$

The obtained formula is a condition under which a particle enters a teleportation trajectory inside a sphere filled with an incompressible liquid.

It is obvious that the obtained teleportation condition is satisfied if

$$r = r_g = a\,,$$

which means that a particle enters a teleportation trajectory on only the surface of the liquid sphere (where the particle's radial coordinate is $r = a$), and the liquid sphere is a gravitational collapsar ($a = r_g$).

9 The teleportation condition in the space inside a rotating liquid sphere

Introduce the metric of the space inside a sphere filled with an incompressible liquid, which rotates due to the space-time non-holonomity.

We use the metric of a liquid sphere as a basis. Assume that the liquid sphere has a radius $a = const$, a mass M and rotates along the φ-axis (along the geographical longitudes) with the linear velocity $v_3 = \omega r^2 \sin^2\theta$, where $\omega = const$ is the angular velocity of this rotation. With these characteristic parameters, according to the definition of v_i, we obtain

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

$$g_{03} = -\frac{1}{c}\,v_3\sqrt{g_{00}} = -\frac{\omega r^2 \sin^2\theta}{2c}\left(3\sqrt{1-\frac{r_g}{a}} - \sqrt{1-\frac{r^2 r_g}{a^3}}\right).$$

Thus, the metric inside such a rotating liquid sphere is

$$ds^2 = \frac{1}{4}\left(3\sqrt{1-\frac{r_g}{a}} - \sqrt{1-\frac{r^2 r_g}{a^3}}\right)^2 c^2 dt^2 - \\ - \omega r^2 \sin^2\theta\left(3\sqrt{1-\frac{r_g}{a}} - \sqrt{1-\frac{r^2 r_g}{a^3}}\right) dt\,d\varphi - \\ - \frac{dr^2}{1-\frac{r^2 r_g}{a^3}} - r^2\left(d\theta^2 + \sin^2\theta\,d\varphi^2\right).$$

Therefore, the interval of physically observable time inside such a rotating sphere has the form

$$d\tau = \sqrt{g_{00}}\, dt + \frac{g_{0i}}{c\sqrt{g_{00}}}\, dx^i =$$

$$= \left\{ \frac{1}{2}\left(3\sqrt{1-\frac{r_g}{a}} - \sqrt{1-\frac{r^2 r_g}{a^3}}\right) - \frac{\omega r^2 \sin^2\theta}{c^2}\frac{d\varphi}{dt} \right\} dt\,.$$

where $\sin\theta = 1$ for the observer's laboratory located at the equator, and the last multiplier is the coordinate velocity of the teleporting particle along the φ-direction, which is the geographical longitude (we assume that the particle travels either in the same or in the opposite direction in which the space rotates).

As a result, the teleportation condition ($d\tau = 0$ with $dt \neq 0$) inside such a rotating liquid sphere has the form

$$\frac{1}{2}\left(3\sqrt{1-\frac{r_g}{a}} - \sqrt{1-\frac{r^2 r_g}{a^3}}\right) - \frac{\omega r^2 \sin^2\theta}{c^2}\frac{d\varphi}{dt} = 0\,.$$

This is a condition under which a particle enters a teleportation trajectory inside the space of a rotating sphere filled with an incompressible liquid. It is different from that in the space inside a non-rotating liquid sphere in only the second term depending on the rotation of space due to the space-time non-holonomity. The smaller the gravitational radius r_g of the rotating liquid sphere and the smaller the distance r from the centre of the sphere, the faster the sphere should rotate and a particle should travel in order for this particle to enter a teleportation trajectory.

According to the obtained teleportation condition, two ultimate cases of particle teleportation are conceivable in the space inside a rotating liquid sphere.

1. In the first ultimate case of particle teleportation, the gravitational radius r_g of the liquid sphere is much smaller than the distance r of the teleporting particle from the centre of the sphere, and this distance r is much smaller than the radius a of the sphere

$$r_g \ll r\,, \qquad r \ll a\,,$$

which is possible if the liquid sphere has a small mass, the liquid itself is very rarefied, and the teleporting particle is close to the centre of the sphere.

In this case, the obtained teleportation condition takes the simplified form

$$\omega r^2 \sin^2\theta \frac{d\varphi}{dt} = c^2,$$

i.e., the liquid sphere should rotate at the velocity of light and the particle should travel at the velocity of light in order for this particle to enter a teleportation trajectory.

2. In the second ultimate case of particle teleportation,

$$r r_g = a^2 \quad \Longrightarrow \quad r = r_g = a\,,$$

and g_{00} of the metric is equal to zero

$$g_{00} = \frac{1}{4}\left(3\sqrt{1-\frac{r_g}{a}} - \sqrt{1-\frac{r^2 r_g}{a^3}}\right)^2 = 0\,,$$

which means gravitational collapse. In this case, the teleporting particle is on the surface of the liquid sphere, which is a gravitational collapsar. In this case, the obtained teleportation condition takes the form

$$\omega r^2 \sin^2\theta \frac{d\varphi}{dt} = 0 \quad \Longrightarrow \quad \frac{d\varphi}{dt} = 0\,,$$

which means that the teleporting particle rests with respect to the liquid sphere, since the sphere rotates ($\upsilon_3 \neq 0$) according to the initial formulation of the problem.

In other words, in order for a particle to enter a teleportation trajectory on the surface of a liquid sphere, which is a gravitational collapsar, the particle should be at rest with respect to the sphere.

10 The teleportation condition in the space filled with the physical vacuum

De Sitter's metric describes a space filled with the physical vacuum (λ-field) and does not include any island of mass or a distributed matter. The curvature is the same everywhere in such a space, so it is a constant curvature space. The physical vacuum (λ-field) produces a non-Newtonian gravitational force, which is proportional to the distance in the space, i.e., the force of non-Newtonian gravitation (λ-force) grows with distance. If $\lambda < 0$, it is an attraction force. If $\lambda > 0$, it is a repulsion force.

For details about the physical vacuum, its physically observable properties, and also the non-Newtonian gravitational force, see Chapter 5 in our monograph [5].

As it is known, de Sitter's metric has the form

$$ds^2 = \left(1 - \frac{\lambda r^2}{3}\right)c^2 dt^2 - \frac{dr^2}{1-\frac{\lambda r^2}{3}} - r^2\left(d\theta^2 + \sin^2\theta\, d\varphi^2\right),$$

and, hence, the non-zero components of the fundamental metric tensor $g_{\alpha\beta}$ of this metric are

$$g_{00} = 1 - \frac{\lambda r^2}{3}\,, \quad g_{11} = -\frac{1}{1-\frac{\lambda r^2}{3}}\,, \quad g_{22} = -r^2, \quad g_{33} = -r^2\sin^2\theta\,.$$

Using these components, we obtain that the interval of physically observable time in a de Sitter space is

$$d\tau = \sqrt{g_{00}}\, dt + \frac{g_{0i}}{c\sqrt{g_{00}}}\, dx^i = \sqrt{1 - \frac{\lambda r^2}{3}}\, dt\,,$$

and the teleportation condition, i.e., $d\tau = 0$ with $dt \neq 0$, has the following form

$$1 - \frac{\lambda r^2}{3} = 0 \quad \Longrightarrow \quad r = \sqrt{\frac{3}{\lambda}}\,,$$

where, since $\lambda = const$, the r means the maximum distance in the space. As it is known, $\lambda \leqslant 10^{-56}$ cm^{-2} with today's measurement accuracy. So, if our Universe is a de Sitter space, the maximum distance in it is $r \geqslant 10^{28}$ cm.

In addition, the teleportation condition we have obtained above means that the space is in the state of collapse, i.e.,

$$g_{00} = 1 - \frac{\lambda r^2}{3} = 0\,.$$

The above means that a particle in a de Sitter space, i.e., in a space filled with the physical vacuum in the absence of any other matter, enters a teleportation trajectory at the maximum distance from the observer, which is conceivable in the space. Besides that, since the state of collapse occurs at the same distance from the observer, we conclude that the entire space should be in the state of collapse, i.e., the entire space filled with the physical vacuum should be a collapsar.

11 The teleportation condition in the rotating space filled with the physical vacuum

Introduce the metric of a space filled with the physical vacuum in the absence of other matter, which rotates due to the space-time non-holonomity.

We derive the metric based on de Sitter's metric. Assume that the space rotates along the φ-axis (along the geographical longitudes) with the linear velocity $v_3 = \omega r^2 \sin^2\theta$, where $\omega = const$ is the angular velocity of this rotation. Thus, according to the definition of v_i, we obtain

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

$$g_{03} = -\frac{1}{c}\, v_3 \sqrt{g_{00}} = -\frac{\omega r^2 \sin^2\theta}{c} \sqrt{1 - \frac{\lambda r^2}{3}}\,.$$

As a result, we obtain the metric of a rotating space filled with the physical vacuum

$$ds^2 = \left(1 - \frac{\lambda r^2}{3}\right) c^2 dt^2 - 2\,\omega r^2 \sin^2\theta \sqrt{1 - \frac{\lambda r^2}{3}}\, dt\, d\varphi - \\ - \frac{dr^2}{1 - \frac{\lambda r^2}{3}} - r^2 \left(d\theta^2 + \sin^2\theta\, d\varphi^2\right),$$

and, hence, the interval of physically observable time in such a space has the form

$$d\tau = \sqrt{g_{00}}\, dt + \frac{g_{0i}}{c\sqrt{g_{00}}}\, dx^i = \\ = \left(\sqrt{1 - \frac{\lambda r^2}{3}} - \frac{\omega r^2 \sin^2\theta}{c^2}\, \frac{d\varphi}{dt}\right) dt\,,$$

and the teleportation condition ($d\tau = 0$ with $dt \neq 0$) has the following form

$$\sqrt{1 - \frac{\lambda r^2}{3}} - \frac{\omega r^2 \sin^2\theta}{c^2}\, \frac{d\varphi}{dt} = 0\,,$$

where r is the distance between the teleporting particle and the observer, $\sin\theta = 1$ for the observer's laboratory located at the equator, and the last multiplier is the coordinate velocity of the teleporting particle along the φ-direction, which is the geographical longitude (assuming that the particle travels either in the same or in the opposite direction in which the space rotates).

The above formula we have obtained is the condition under which a particle enters a teleportation trajectory in a rotating de Sitter space, which is a rotating space filled with the physical vacuum in the absence of any other matter.

According to the obtained teleportation condition, two ultimate cases are conceivable for particle teleportation in a rotating de Sitter space.

1. In the first ultimate case of particle teleportation,

$$\lambda r^2 \ll 1\,,$$

and the obtained teleportation condition takes the following simplified form

$$\omega r^2 \sin^2\theta\, \frac{d\varphi}{dt} = c^2.$$

Since $\lambda \leqslant 10^{-56}$ cm^{-2} (according to modern astronomy), in this ultimate case of particle teleportation in a rotating de Sitter space, the teleporting particle should be at the distance $r \ll 10^{28}$ cm from the observer. In addition, the space should rotate at the velocity of light and the particle should travel at the velocity of light.

2. In the second ultimate case of particle teleportation, the teleporting particle should be very far from the observer

$$r = \sqrt{\frac{3}{\lambda}} \geqslant 10^{28} \text{ cm},$$

i.e., at the edge of the observable Universe or even beyond that observable edge.

In this case, g_{00} of the metric is equal to zero

$$g_{00} = 1 - \frac{\lambda r^2}{3} = 0\,,$$

which means that the space is in the state of collapse (i.e., the entire space is a huge collapsar), and the obtained teleportation condition takes the form

$$\omega r^2 \sin^2\theta\, \frac{d\varphi}{dt} = 0 \quad \Longrightarrow \quad \frac{d\varphi}{dt} = 0\,,$$

which, since the space rotates ($v_3 \neq 0$), means that the teleporting particle is at rest.

In other words, in the second ultimate case of particle teleportation in a rotating de Sitter space, the teleporting particle should be resting with respect to the space, be at the maximum distance from the observer, which is conceivable in the space, while the entire space should be in the state of collapse (it should be a huge collapsar).

12 The metric of the space, which rotates, but is free from the gravitational field

Introduce the metric of a space, where the three-dimensional space rotates due to the space-time non-holonomity, but there is no field of gravitation. This space metric most accurately describes the local space of an observer, who is located in an earth-bound laboratory, since the gravitational potential on the Earth's surface is so weak that its factor under the teleportation condition can be neglected. Only the factors of rotation of space and the teleporting particle's speed affect teleportation in this case. An addition, in the space of this metric, the effect of rotation of space due to the space-time non-holonomity is most clearly manifested.

For the above reasons, we will deduce the characteristics of such a simplest rotating space in more detail.

Assuming that the space rotates along the φ-axis (along the geographical longitudes) with the velocity $v_3 = \omega r^2 \sin^2\theta$, where $\omega = const$ is the angular velocity of this rotation, and, according to the definition of v_i,

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

we obtain the metric of such a space. It has the form

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

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

$$g_{00} = 1\,, \quad g_{11} = -1\,, \quad g_{22} = -r^2, \quad g_{33} = -r^2 \sin^2\theta\,.$$

So forth, using the general formula for the chr.inv.-metric tensor, which is

$$h_{ik} = -g_{ik} + \frac{g_{0i}\, g_{0k}}{g_{00}} = -g_{ik} + \frac{1}{c^2}\, v_i v_k\,,$$

we obtain that its non-zero components in the specific space we are considering are equal to

$$h_{11} = 1\,, \quad h_{22} = r^2, \quad h_{33} = r^2 \sin^2\theta\left(1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}\right),$$

$$h^{11} = 1\,, \quad h^{22} = \frac{1}{r^2}\,, \quad h^{33} = \frac{1}{r^2 \sin^2\theta\left(1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)}\,,$$

where, since the matrix h_{ik} is diagonal, the upper-index components of h_{ik} are obtained as $h^{ik} = (h_{ik})^{-1}$ just like the invertible matrix components to any diagonal matrix.

To check the correctness of the above construction of the space metric, we calculate $v^2 = v_i v^i = h_{ik} v^i v^k$. Since $v^i = h^{ik} v_k$, we obtain the following

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

hence, the dimension of v is [cm/sec]. If the space rotates slowly, the above formula transforms to $v = \omega r \sin\theta$ [cm/sec] that is completely "comme il faut".

Based on the above formula for v_3 and using the corresponding h^{ik} components, we obtain that the antisymmetric chr.inv.-tensor of the angular velocity of rotation of space, A_{ik} (see page 32), has the following non-zero components

$$A_{13} = \omega r \sin^2\theta\,, \qquad A_{31} = -A_{13}\,,$$

$$A_{23} = \omega r^2 \sin\theta \cos\theta\,, \qquad A_{32} = -A_{23}\,,$$

$$A^{13} = \frac{\omega}{r\left(1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)}\,, \qquad A^{31} = -A^{13},$$

$$A^{23} = \frac{\omega \cot\theta}{r^2\left(1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)}\,, \qquad A^{32} = -A^{23}.$$

To check the correctness of the above, we calculate the square of the chr.inv.-pseudovector of the angular velocity of rotation of space, $\Omega^2 = \Omega_{*i}\Omega^{*i} = h_{ik}\,\Omega^{*i}\Omega^{*i}$. Since

$$\Omega^{*i} = \frac{1}{2}\,\varepsilon^{ikm} A_{km}\,, \quad \varepsilon^{ikm} = \frac{e^{ikm}}{\sqrt{h}}\,, \quad \Omega_{*i} = h_{ik}\,\Omega^{*k}$$

as for any pseudovector (see page 34 in this paper; for more details on pseudovectors and pseudotensors see §2.3 of our monograph [5]), after some algebra we obtain

$$\Omega^2 = \Omega_{*i}\Omega^{*i} = \frac{\omega^2}{1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}}\,, \quad \Omega = \frac{\omega}{\sqrt{1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}}}\,,$$

so, the dimension of Ω is [sec^{-1}]. If the space rotates slowly, the obtained formula transforms to $\Omega = \omega$ [sec^{-1}] that is completely "comme il faut".

Using the non-zero h_{ik} components, we obtain the determinant of the chr.inv.-metric tensor h_{ik} (see page 35)

$$h = \det\|\, h_{ik} \|= r^4 \sin^2\theta\left(1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}\right).$$

So forth, we obtain nonzero chr.inv.-derivatives of $\ln\sqrt{h}$. According to the mathematical apparatus of chronometric invariants, they are equal to the respective chr.inv.-Christoffel symbols, in which two indices have been contracted, i.e., Δ^i_{ik}. Such Christoffel symbols are used in our further calculation of the chr.inv.-divergence of A^{ik}, as well as the chr.inv.-Ricci curvature tensor C_{ik}, which are the left hand side terms of the chr.inv.-Einstein equations. After some algebra, we obtain

$$\Delta^i_{i1} = \frac{{}^*\partial \ln\sqrt{h}}{\partial r} = \frac{2}{r\left(1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)}\left(1 + \frac{3\,\omega^2 r^2 \sin^2\theta}{2\,c^2}\right),$$

$$\Delta^i_{i2} = \frac{{}^*\partial \ln\sqrt{h}}{\partial\theta} = \frac{\cot\theta}{1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}}\left(1 + \frac{2\,\omega^2 r^2 \sin^2\theta}{c^2}\right),$$

as well as their chr.inv.-derivatives

$$\frac{{}^*\partial\Delta^i_{i1}}{\partial r} = -\frac{2}{r^2\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)^2} - \frac{3\,\omega^2\sin^2\theta}{c^2\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)^2} - \frac{3\,\omega^4r^2\sin^4\theta}{c^4\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)^2}\,,$$

$$\frac{{}^*\partial\Delta^i_{i1}}{\partial\theta} = \frac{2\,\omega^2r\sin\theta\cos\theta}{c^2\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)^2}\,,$$

$$\frac{{}^*\partial\Delta^i_{i2}}{\partial r} = \frac{2\,\omega^2r\sin\theta\cos\theta}{c^2\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)^2} = \frac{{}^*\partial\Delta^i_{i1}}{\partial\theta}\,,$$

$$\frac{{}^*\partial\Delta^i_{i2}}{\partial\theta} = -\frac{1}{\sin^2\theta\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)} - \frac{2\,\omega^2r^2\sin^2\theta}{c^2\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)^2} - \frac{2\,\omega^4r^4\sin^2\theta}{c^4\left(1+\frac{\omega^2r^2\sin^4\theta}{c^2}\right)^2}\,.$$

The chr.inv.-Ricci curvature tensor C_{lk} is one of the terms contained in the tensorial equation of the chr.inv.-Einstein equations (see page 33). Its formula (page 33) is based on the chr.inv.-Christoffel symbols Δ^i_{jk} and their chr.inv.-derivatives. Therefore, to calculate the chr.inv.-Ricci curvature tensor C_{lk} in the specific space we are considering, we need to calculate the chr.inv.-Christoffel symbols. They are re-combinations of the chr.inv.-derivatives of the chr.inv.-metric tensor h_{ik} (see page 33). Thus, first, we obtain non-zero chr.inv.-derivatives of the chr.inv.-metric tensor h_{ik} for the space we are considering. They have the form

$$\frac{{}^*\partial h_{22}}{\partial r} = 2\,r\,,$$

$$\frac{{}^*\partial h_{33}}{\partial r} = 2\,r\sin^2\theta\left(1+\frac{2\,\omega^2r^2\sin^2\theta}{c^2}\right),$$

$$\frac{{}^*\partial h_{33}}{\partial\theta} = 2\,r^2\sin\theta\cos\theta\left(1+\frac{2\,\omega^2r^2\sin^2\theta}{c^2}\right).$$

So forth, according to the general formula for the chr.inv.-Christoffel symbols (see page 33), we calculate all them one by one in the specific space we are considering. After some algebra, we obtain formulae for those of them that are different from zero, i.e.,

$$\Delta^1_{22} = -\,r\,,$$

$$\Delta^1_{33} = -\,r\sin^2\theta\left(1+\frac{2\,\omega^2r^2\sin^2\theta}{c^2}\right),$$

$$\Delta^2_{12} = \Delta^2_{21} = \frac{1}{r}\,,$$

$$\Delta^2_{33} = -\sin\theta\cos\theta\left(1+\frac{2\,\omega^2r^2\sin^2\theta}{c^2}\right),$$

$$\Delta^3_{13} = \Delta^3_{13} = \frac{1}{r\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)}\left(1+\frac{2\,\omega^2r^2\sin^2\theta}{c^2}\right),$$

$$\Delta^3_{23} = \Delta^3_{32} = \frac{\cot\theta}{1+\frac{\omega^2r^2\sin^2\theta}{c^2}}\left(1+\frac{2\,\omega^2r^2\sin^2\theta}{c^2}\right).$$

Then, we look for non-zero components of the contracted 4th rank chr.inv.-tensor $H_{lki\cdot}^{\cdots i}$, which, since the space we are considering is free from deformations ($D_{ik}=0$), is equal to the chr.inv.-Ricci curvature tensor C_{lk} (for the full formulae of the chr.inv.-curvature tensors see page 33)

$$C_{lk} = C_{lki\cdot}^{\cdots i} = H_{lki\cdot}^{\cdots i} = \frac{{}^*\partial\Delta^i_{il}}{\partial x^k} - \frac{{}^*\partial\Delta^i_{kl}}{\partial x^i} + \Delta^m_{il}\Delta^i_{km} - \Delta^m_{kl}\Delta^i_{im}\,,$$

where, according to the mathematical apparatus of chronometric invariants (see page 33), we have

$$\Delta^i_{ik} = \frac{{}^*\partial\ln\sqrt{h}}{\partial x^k}\,.$$

As a result, we obtain that the chr.inv.-Ricci tensor in the specific space we are considering has the following non-zero components

$$C_{11} = H_{11i\cdot}^{\cdots i} = \frac{{}^*\partial\Delta^i_{i1}}{\partial r} + \Delta^2_{21}\Delta^2_{12} + \Delta^3_{31}\Delta^3_{13}\,,$$

$$C_{12} = H_{12i\cdot}^{\cdots i} = \frac{{}^*\partial\Delta^i_{i1}}{\partial\theta} + \Delta^3_{31}\Delta^3_{23} - \Delta^2_{21}\Delta^i_{i2}\,,$$

$$C_{21} = H_{21i\cdot}^{\cdots i} = \frac{{}^*\partial\Delta^i_{i2}}{\partial r} + \Delta^3_{32}\Delta^3_{13} - \Delta^2_{12}\Delta^i_{i2}\,,$$

$$C_{22} = H_{22i\cdot}^{\cdots i} = \frac{{}^*\partial\Delta^i_{i2}}{\partial\theta} - \frac{{}^*\partial\Delta^1_{22}}{\partial r} + 2\,\Delta^2_{12}\Delta^1_{22} + \Delta^3_{32}\Delta^3_{23} - \Delta^1_{22}\Delta^i_{i1}\,,$$

$$C_{33} = H_{33i\cdot}^{\cdots i} = -\frac{{}^*\partial\Delta^1_{33}}{\partial r} - \frac{{}^*\partial\Delta^2_{33}}{\partial\theta} + 2\,\Delta^3_{13}\Delta^1_{33} + 2\,\Delta^3_{23}\Delta^2_{33} - \Delta^1_{33}\Delta^i_{i1} - \Delta^2_{33}\Delta^i_{i2}\,,$$

where

$$\Delta^i_{i1} = \frac{{}^*\partial\ln\sqrt{h}}{\partial r}\,, \qquad \Delta^i_{i2} = \frac{{}^*\partial\ln\sqrt{h}}{\partial\theta}\,.$$

To calculate the components of the chr.inv.-Ricci tensor, we already have the specific formulae for Δ^i_{i1} and Δ^i_{i2} in the metric we are considering (see page 43). In addition, we need formulae for the chr.inv.-derivatives of Δ^1_{33} with respect to r and Δ^2_{33} with respect to θ, which are contained in the chr.inv.-Ricci tensor. We obtain that they are equal to

$$\frac{{}^*\partial\Delta^1_{33}}{\partial r} = -\sin^2\theta\left(1+\frac{6\,\omega^2r^2\sin^2\theta}{c^2}\right),$$

$$\frac{{}^*\partial\Delta^2_{33}}{\partial\theta} = \sin^2\theta + \frac{2\,\omega^2r^2\sin^4\theta}{c^2} - \cos^2\theta - \frac{6\,\omega^2r^2\sin^2\theta\cos^2\theta}{c^2}\,.$$

So forth, after some algebra, we obtain formulae for the non-zero components of the chr.inv.-Ricci tensor

$$C_{11} = \frac{3\,\omega^2 \sin^2\theta}{c^2\left(1+\frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)} - \frac{\omega^4 r^2 \sin^4\theta}{c^4\left(1+\frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)^2}\,,$$

$$C_{12} = \frac{3\,\omega^2 r \sin\theta\cos\theta}{c^2\left(1+\frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)} - \frac{\omega^4 r^3 \sin^3\theta\cos\theta}{c^4\left(1+\frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)^2}\,,$$

$$C_{21} = \frac{3\,\omega^2 r \sin\theta\cos\theta}{c^2\left(1+\frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)} - \frac{\omega^4 r^3 \sin^3\theta\cos\theta}{c^4\left(1+\frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)^2}\,,$$

$$C_{22} = \frac{3\,\omega^2 r^2 \cos^2\theta}{c^2\left(1+\frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)} - \frac{\omega^4 r^4 \sin^2\theta\cos^2\theta}{c^4\left(1+\frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)^2}\,,$$

$$C_{33} = \frac{3\,\omega^2 r^2 \sin^2\theta}{c^2} - \frac{\omega^4 r^4 \sin^4\theta}{c^4\left(1+\frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)}\,,$$

where, in particular, we see that $C_{12} = C_{21}$ that means a certain curvature symmetry in the space we are considering.

As a result, the physically observable chr.inv.-scalar curvature $C = h^{lk} C_{lk}$ (see page 33) of the rotating space we are considering is equal to

$$C = \frac{6\,\omega^2}{c^2\left(1+\frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)} - \frac{2\,\omega^4 r^2 \sin^2\theta}{c^4\left(1+\frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)^2}\,,$$

i.e., the origin of the physically observable chr.inv.-curvature of such a space is only its three-dimensional rotation due to the space-time non-holonomity (non-orthogonality of the time lines to the three-dimensional spatial section).

As you can see, the obtained formula for the scalar curvature and also every component of the obtained chr.inv.-Ricci curvature tensor (used in the chr.inv.-Einstein equations, see below) consists of two terms: the first order term, the goal of which is very significant, and the second order (additional) term, the influence of which is tiny. When Larissa first saw the above formulae, she immediately said: "You just made a fundamental theoretical discovery: if a space rotates due its space-time non-holonomity, its curvature produces the first order effect."

The above characteristics of the space we are considering will be used further to calculate the individual components of the chr.inv.-Einstein equations in this space.

So forth, we obtain that the interval of physically observable time in such a rotating space has the formula

$$d\tau = \sqrt{g_{00}}\,dt + \frac{g_{0i}}{c\,\sqrt{g_{00}}}\,dx^i = \left(1 - \frac{\omega\, r^2 \sin^2\theta}{c^2}\,\frac{d\varphi}{dt}\right) dt\,,$$

where $\sin\theta = 1$ (the polar angle θ is equal to $\frac{\pi}{2}$) for the observer's laboratory located at the equator, and the last multiplier is the coordinate velocity of the teleporting particle along the φ-direction, which is the geographical longitude (assuming that it travels either in the same or in the opposite direction in which the space rotates).

As a result, we obtain that the teleportation condition, i.e., $d\tau = 0$ with $dt \neq 0$, has the form

$$\omega\, r^2 \sin^2\theta\, \frac{d\varphi}{dt} = c^2.$$

The obtained formula is the teleportation condition in a rotating space that is free from the field of gravitation and a distributed matter. In this case, as you can see from the above formula, a particle enters a teleportation trajectory in such a space, if it travels at the velocity of light, and the space rotates at the velocity of light.

Next, we will look how this condition changes if the rotating space is not empty, but filled with an electromagnetic field. To do it we will consider Einstein's field equations for a space of the above metric, where the right hand side of the equations is non-zero, but contains the energy-momentum tensor of the electromagnetic field (such Einstein equations characterize a space filled with an electromagnetic field).

As it is known, Einstein's equations are one of the necessary conditions for a space metric to be Riemannian. Therefore, the considered rotating space filled with an electromagnetic field is Riemannian under some particular conditions by which the Einstein equations for this space metric vanish (for this reason we call them *Riemannian conditions*).

We hope, the derived Riemannian conditions will somehow replace the rotation of space (the main factor in the teleportation condition) with the electromagnetic field parameters, thereby giving us the opportunity to "strengthen" the space-time non-holonomity to the level necessary for particle teleportation without the need to mechanically rotate the observer's local space at the light speed.

13 Using Einstein's field equations to find conditions under which the introduced metric is Riemannian

In an empty rotating space of the metric we have introduced above, the gravitational inertial force, the space deformation and the λ-term are equal to zero, while the space curvature and rotation are non-zero

$$F_i = 0\,, \quad D_{ik} = 0\,, \quad \lambda = 0\,, \quad C_{ik} \neq 0\,, \quad A_{ik} \neq 0\,.$$

The chr.inv.-Einstein equations (for their full formulae see page 33) very simplify under the above conditions. If the rotating space is filled with a distributed matter, they have the non-zero right hand side and take the form

$$\left.\begin{aligned} & A_{ik}A^{ki} = -\frac{\varkappa}{2}\left(\varrho c^2 + U\right) \\ & {}^{*}\nabla_k A^{ik} = -\varkappa\, J^{i} \\ & 2A_{ij}A^{\cdot j}_{k\cdot} - c^2 C_{ik} = \frac{\varkappa}{2}\left(\varrho c^2 h_{ik} + 2U_{ik} - U h_{ik}\right) \end{aligned}\right\},$$

where the right hand side contains the physically observable projections of the energy-momentum tensor of the matter that fills the space: ϱ is the chr.inv.-density of the field energy, J^i is the chr.inv.-density of the field momentum, and U^{ik} is the chr.inv.-stress-tensor of the field.

Calculate $U = h_{mn}U^{mn}$, i.e., the trace of the electromagnetic field chr.inv.-stress-tensor U^{ik} (see page 34). Since the trace of the chr.inv.-metric tensor is $h_{mn}h^{mn} = 3$, we obtain $U = \varrho c^2$. Thus, the chr.inv.-Einstein equations in a rotating space filled with an electromagnetic field have the form

$$\left.\begin{aligned} & A_{ik}A^{ki} = -\varkappa\varrho c^2 \\ & {}^*\nabla_k A^{ik} = -\varkappa J^i \\ & 2A_{ij}A_{k\cdot}^{\cdot j} - c^2 C_{ik} = \varkappa U_{ik} \end{aligned}\right\},$$

or, extending the electromagnetic field characteristics,

$$\left.\begin{aligned} & A_{ik}A^{ki} = -\frac{\varkappa c^2}{8\pi}\left(E_i E^i + H_{*i}H^{*i}\right) \\ & {}^*\nabla_k A^{ik} = -\frac{\varkappa c}{4\pi}\,\varepsilon^{ikm}E_k H_{*m} \\ & 2A_{ij}A_{k\cdot}^{\cdot j} - c^2 C_{ik} = \\ & \quad = \frac{\varkappa c^2}{8\pi}\left(E_j E^j + H_{*j}H^{*j}\right)h_{ik} - \frac{\varkappa c^2}{4\pi}\left(E_i E_k + H_{*i}H_{*k}\right) \end{aligned}\right\}.$$

Taking into account the characteristics of the space metric we are considering (see above), after some algebra we obtain non-zero components of the left hand side terms

$$A_{ik}A^{ki} = -\frac{2\omega^2}{1+\frac{\omega^2 r^2\sin^2\theta}{c^2}},$$

$${}^*\nabla_k A^{3k} = \frac{\omega}{r^2\sin^2\theta\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)}\left\{1+\frac{2\omega^2 r^2\sin^2\theta}{c^2\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)}\right\},$$

$$2A_{1j}A_{1\cdot}^{\cdot j} - c^2 C_{11} = -\frac{\omega^2\sin^2\theta}{1+\frac{\omega^2 r^2\sin^2\theta}{c^2}} + \frac{\omega^4 r^2\sin^4\theta}{c^2\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)^2},$$

$$2A_{1j}A_{2\cdot}^{\cdot j} - c^2 C_{12} = -\frac{\omega^2 r\sin\theta\cos\theta}{1+\frac{\omega^2 r^2\sin^2\theta}{c^2}} + \frac{\omega^4 r^3\sin^3\theta\cos\theta}{c^2\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)^2},$$

$$2A_{2j}A_{1\cdot}^{\cdot j} - c^2 C_{21} = -\frac{\omega^2 r\sin\theta\cos\theta}{1+\frac{\omega^2 r^2\sin^2\theta}{c^2}} + \frac{\omega^4 r^3\sin^3\theta\cos\theta}{c^2\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)^2},$$

$$2A_{2j}A_{2\cdot}^{\cdot j} - c^2 C_{22} = -\frac{\omega^2 r^2\cos^2\theta}{1+\frac{\omega^2 r^2\sin^2\theta}{c^2}} + \frac{\omega^4 r^4\sin^2\theta\cos^2\theta}{c^2\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)^2},$$

$$2A_{3j}A_{3\cdot}^{\cdot j} - c^2 C_{33} = -\omega^2 r^2\sin^2\theta + \frac{\omega^4 r^4\sin^4\theta}{c^2\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)}.$$

We see that the left hand side of the chr.inv.-Einstein equations does not vanish. This means that a rotating space characterized by the considered metric is not Riemannian, if it is empty. To be Riemannian, such a space must be filled with a distributed matter so that the right hand side of the Einstein equations equalized the non-zero left hand side.

Using the obtained left hand side of the chr.inv.-Einstein equations, as well as the formulae for the electromagnetic field characteristics ϱ, J^i, U_{ik} (see page 34), we get the above chr.inv.-Einstein equations in the final form

$$\left.\begin{aligned} & \frac{\omega^2}{1+\frac{\omega^2 r^2\sin^2\theta}{c^2}} = \frac{\varkappa c^2}{16\pi}\left(E_i E^i + H_{*i}H^{*i}\right) \\ & \frac{\omega}{r^2\sin^2\theta\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)}\left\{1+\frac{2\omega^2 r^2\sin^2\theta}{c^2\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)}\right\} = \\ & \qquad = -\frac{\varkappa c}{4\pi}\,\varepsilon^{3km}E_k H_{*m} \\ & \frac{\omega^2(2+\sin^2\theta)}{1+\frac{\omega^2 r^2\sin^2\theta}{c^2}} - \frac{\omega^4 r^2\sin^4\theta}{c^2\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)^2} = \\ & \qquad = \frac{\varkappa c^2}{4\pi}\left(E_1 E_1 + H_{*1}H_{*1}\right) \\ & \frac{\omega^2 r\sin\theta\cos\theta}{1+\frac{\omega^2 r^2\sin^2\theta}{c^2}} - \frac{\omega^4 r^3\sin^3\theta\cos\theta}{c^2\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)^2} = \\ & \qquad = \frac{\varkappa c^2}{4\pi}\left(E_1 E_2 + H_{*1}H_{*2}\right) \\ & \frac{\omega^2 r\sin\theta\cos\theta}{1+\frac{\omega^2 r^2\sin^2\theta}{c^2}} - \frac{\omega^4 r^3\sin^3\theta\cos\theta}{c^2\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)^2} = \\ & \qquad = \frac{\varkappa c^2}{4\pi}\left(E_2 E_1 + H_{*2}H_{*1}\right) \\ & \frac{\omega^2 r^2(2+\cos^2\theta)}{1+\frac{\omega^2 r^2\sin^2\theta}{c^2}} - \frac{\omega^4 r^4\sin^2\theta\cos^2\theta}{c^2\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)^2} = \\ & \qquad = \frac{\varkappa c^2}{4\pi}\left(E_2 E_2 + H_{*2}H_{*2}\right) \\ & 3\omega^2 r^2\sin^2\theta - \frac{\omega^4 r^4\sin^4\theta}{c^2\left(1+\frac{\omega^2 r^2\sin^2\theta}{c^2}\right)} = \\ & \qquad = \frac{\varkappa c^2}{4\pi}\left(E_3 E_3 + H_{*3}H_{*3}\right) \end{aligned}\right\},$$

where the right hand side is expressed through the chr.inv.-electric strength vector E^i and the chr.inv.-magnetic strength pseudovector H^{*i} of the field (see page 34 for detail).

Note that the dimension of the electric and magnetic field strengths here is $[\text{gram}^{1/2}\,\text{cm}^{-3/2}]$ as well as everywhere in the relativistic electrodynamics. To avoid confusion, we note that in our earlier works for these quantities we used the "electromagnetic" dimension [gram$^{1/2}$ cm$^{-1/2}$ sec^{-1}], as is customary in Classical Electrodynamics and technology. It is different from the above by a unit coefficient, the dimension of which is the same as that of the velocity of light.

Mathematically, the obtained chr.inv.-Einstein equations mean that a rotating space filled with an electromagnetic field of the specific configuration, as indicated in the equations, is Riemannian. Therefore, the above Einstein equations are the *Riemannian conditions* for this space metric. That is, we can consider a rotating space in the General Theory of Relativity only if it is filled with an electromagnetic field of the specific structure determined by the Einstein equations.

14 The structure of the electromagnetic field

To obtain some information about the structure of the particular electromagnetic field determined by the obtained Einstein equations, we analyze the equations in detail.

The scalar and tensorial equations give trivial relations between E and H.

Since just one component ${}^*\nabla_k A^{3k}$ of the vectorial Einstein equation is non-zero, ${}^*\nabla_k A^{1k}=0$ and ${}^*\nabla_k A^{2k}=0$ give

$$\varepsilon^{1km}E_k H_{*m} = \varepsilon^{123}E_2 H_{*3} + \varepsilon^{132}E_3 H_{*2} = 0\,,$$
$$\varepsilon^{2km}E_k H_{*m} = \varepsilon^{213}E_1 H_{*3} + \varepsilon^{231}E_3 H_{*1} = 0\,,$$

from which, since $\varepsilon^{123}=-\varepsilon^{132}=\varepsilon^{312}$ and so on, we obtain

$$E_2 H_{*3} - E_3 H_{*2} = 0\,,$$
$$E_1 H_{*3} - E_3 H_{*1} = 0\,.$$

The non-zero vectorial Einstein equation means

$$\varepsilon^{3km}E_k H_{*m} = \varepsilon^{312}E_1 H_{*2} + \varepsilon^{321}E_2 H_{*1} = = -\frac{4\pi\omega}{\varkappa c\, r^2\sin^2\theta\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)}\left\{1+\frac{2\,\omega^2r^2\sin^2\theta}{c^2\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)}\right\},$$

which, taking into account that (see page 34)

$$\varepsilon^{ikm}=\frac{e^{ikm}}{\sqrt{h}}\,,\quad e^{123}=+1\,,\quad e^{312}=-e^{132}=e^{123}=+1\,,$$

gives the following

$$E_1 H_{*2} - E_2 H_{*1} = = -\frac{4\pi\omega}{\varkappa c\sin\theta\sqrt{1+\frac{\omega^2r^2\sin^2\theta}{c^2}}}\left\{1+\frac{2\,\omega^2r^2\sin^2\theta}{c^2\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)}\right\}.$$

Taking the above into account, we conclude that the electromagnetic field determined by the obtained Einstein equations is characterized by the system of relations

$$\left.\begin{aligned}
&E^2+H^2=\frac{16\pi\omega^2}{\varkappa c^2\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)}\\
&E_2 H_{*3}-E_3 H_{*2}=0\\
&E_1 H_{*3}-E_3 H_{*1}=0\\
&E_1 H_{*2}-E_2 H_{*1}=\\
&\quad=-\frac{4\pi\omega}{\varkappa c\sin\theta\sqrt{1+\frac{\omega^2r^2\sin^2\theta}{c^2}}}\left\{1+\frac{2\,\omega^2r^2\sin^2\theta}{c^2\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)}\right\}\\
&E_1E_1+H_{*1}H_{*1}=\\
&\quad=\frac{4\pi}{\varkappa c^2}\left\{\frac{\omega^2(2+\sin^2\theta)}{1+\frac{\omega^2r^2\sin^2\theta}{c^2}}-\frac{\omega^4r^2\sin^4\theta}{c^2\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)^2}\right\}\\
&E_1E_2+H_{*1}H_{*2}=\\
&\quad=\frac{4\pi}{\varkappa c^2}\left\{\frac{\omega^2r\sin\theta\cos\theta}{1+\frac{\omega^2r^2\sin^2\theta}{c^2}}-\frac{\omega^4r^3\sin^3\theta\cos\theta}{c^2\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)^2}\right\}\\
&E_2E_2+H_{*2}H_{*2}=\\
&\quad=\frac{4\pi}{\varkappa c^2}\left\{\frac{\omega^2r^2(2+\cos^2\theta)}{1+\frac{\omega^2r^2\sin^2\theta}{c^2}}-\frac{\omega^4r^4\sin^2\theta\cos^2\theta}{c^2\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)^2}\right\}\\
&E_3E_3+H_{*3}H_{*3}=\\
&\quad=\frac{4\pi}{\varkappa c^2}\left\{3\,\omega^2r^2\sin^2\theta-\frac{\omega^4r^4\sin^4\theta}{c^2\left(1+\frac{\omega^2r^2\sin^2\theta}{c^2}\right)}\right\}
\end{aligned}\right\},$$

which at small ω simplifies to

$$\left.\begin{aligned}
&E^2+H^2=\frac{16\pi\omega^2}{\varkappa c^2}\\
&E_2 H_{*3}-E_3 H_{*2}=0\\
&E_1 H_{*3}-E_3 H_{*1}=0\\
&E_1 H_{*2}-E_2 H_{*1}=-\frac{4\pi\omega}{\varkappa c\sin\theta}\\
&E_1E_1+H_{*1}H_{*1}=\frac{4\pi\omega^2(2+\sin^2\theta)}{\varkappa c^2}\\
&E_1E_2+H_{*1}H_{*2}=\frac{4\pi\omega^2r\sin\theta\cos\theta}{\varkappa c^2}\\
&E_2E_2+H_{*2}H_{*2}=\frac{4\pi\omega^2r^2(2+\cos^2\theta)}{\varkappa c^2}\\
&E_3E_3+H_{*3}H_{*3}=\frac{12\pi\omega^2r^2\sin^2\theta}{\varkappa c^2}
\end{aligned}\right\}.$$

Please note that $E^2 = E_i E^i = h_{ik} E^i E^k$ and $H^2 = H_{*i} H^{*i} = h_{ik} H^{*i} H^{*k}$. The θ denotes the polar angle, i.e., $\sin\theta = 1$ and $\cos\theta = 0$ in the laboratory located at the equator.

What do the above relations between the electric and magnetic strength of the field mean and how to implement them in a real laboratory is rather better to ask engineers.

15 Non-quantum teleportation in the condition of a real laboratory using a strong electromagnetic field

Looking at the obtained Einstein equations (see page 46), you can see that the mechanical rotation of space, which appears due to the non-holonomity of the space-time, can be replaced by the magnetic or electric strength of the electromagnetic field that fills the space. Two natural questions arise in this regard: 1) Why is this even possible? 2) Is it possible to increase the space-time non-holonomity by an electromagnetic field in a real laboratory to such a level as to realize the non-quantum teleportation condition?

1. To understand why this is possible, you need to understand what is the three-dimensional rotation of space due to the non-holonomity of the space-time. An ordinary three-dimensional rotation is expressed in terms of $g_{ik} \neq 0$ in the space metric and, therefore, can be removed by a coordinate transformation (moving to another, non-rotating coordinate system on the observer's reference body). On the contrary, a rotation resulting from the non-orthogonality of the time lines to the three-dimensional spatial section originates from $g_{0i} \neq 0$ in the metric, and, therefore is not removable by a coordinate transformation; this is one of the fundamental properties of the observer's reference space.

For example, consider an observer in a laboratory located on the surface of the Earth. For him, the ordinary rotation expressed in terms of $g_{ik} \neq 0$, which can be removed by a coordinate transformation, is the rotation of an observed external body, say, the Moon. On the contrary, the non-removable rotation expressed in terms of $g_{0i} \neq 0$ is the rotation of his reference body, the Earth, around its own axis.

In terms of the basis vectors $\vec{e}_{(\alpha)}$ tangential to the curved coordinate lines of the Riemannian space (see page 35),

$$g_{0i} = e_{(0)} e_{(i)} \cos(x^0; x^i), \quad v_i = -c\, e_{(i)} \cos(x^0; x^i),$$

which means that the linear velocity v_i of such rotation is merely a manifestation of the inclination of the time coordinate lines to the three-dimensional spatial section. Cosine takes numeric values from +1 to −1. The length of the tangential basis vectors is equal to 1 in the absence of perturbing factors and decreases with increasing curvature of the coordinate lines. Therefore, such rotation of space cannot be mechanically increased to superluminal speed.

On the other hand, according to the obtained Einstein equations, the stronger the electromagnetic field, the faster the rotation of space: the limit for increasing the rotation of space is only the power of the electromagnetic field generator installed in your laboratory. This is because the angular velocity ω of rotation of space contained in them (and in the teleportation condition) has the same origin as the angular velocity ω in the definition of v_i.

As a result, we arrive at the conclusion that there are two types of rotation of space, which cannot be removed by a coordinate transformation. The source of the first type of rotation is a mechanical rotation of the observer's reference body, say, the planet Earth. Such rotation cannot exceed the speed of light. The second type is a "virtual rotation" that appears in a space filled with a distributed matter, due to the non-zero right hand side of the Einstein equations. Such "virtual rotation" is formally added to the first type of rotation of space, despite the fact that the observer's reference body still mechanically rotates at its own rotation speed, as before. This summation occurs because the angular velocity ω of both types of rotation has the same mathematical origin. For example, the Einstein equations showed that such "virtual rotation" can be as fast as the electromagnetic field strong.

This situation is similar to that with the equations of motion of particles. A free particle travels along a geodesic (i.e., shortest) trajectory. The equation of its motion is the equation of geodesic line: the right hand side of the equation is equal to zero. If an external factor perturbs the particle's motion, it deviates from the geodesic line. In this case, its motion is non-geodesic, and the equation of its motion contains the deviating force on the right hand side.

2. Now a second question arises: can we increase ω with an electromagnetic field to the level necessary to implement the teleportation condition in a real laboratory? To answer this question, let us consider the scalar chr.inv.-Einstein equation we have obtained (see page 46)

$$E^2 + H^2 = \frac{16\pi\omega^2}{\varkappa c^2 \left(1 + \frac{\omega^2 r^2 \sin^2\theta}{c^2}\right)}.$$

If the electric component of the electromagnetic field is much weaker than its magnetic component ($E \ll H$), then in the first order approximation we obtain the relation

$$\omega \approx \sqrt{\frac{\varkappa c^2}{16\pi}}\, H$$

connecting the angular velocity of the "virtual rotation" of space with the magnetic strength of the electromagnetic field (which is the source of this "virtual rotation").

On the other hand, the non-quantum teleportation condition is a rotating space filled with an electromagnetic field has the form (see page 45)

$$\omega r^2 \sin^2\theta \, \frac{d\varphi}{dt} = c^2,$$

where we assume that the space rotates with the linear velocity $v_3 = \omega r^2 \sin^2\theta$ along the φ-axis (geographical latitude),

$\omega = const$ is the angular velocity of this rotation, and the last multiplier is the coordinate velocity $\widetilde{\omega}$ of the teleporting particle along the φ-direction (we assume that the particle travels either in the same or in the opposite direction in which the space rotates).

Assume that the observer's laboratory is located on the Earth's equator. In this case, $\sin\theta = 1$. Then the ω necessary to launch a particle onto a teleportation trajectory in the observer's laboratory has the form

$$\omega = \frac{c^2}{\widetilde{\omega}\, r^2}\,.$$

Substituting here the formula for ω obtained above from the scalar chr.inv.-Einstein equation, we obtain the magnetic strength required for non-quantum teleportation in the condition of the earth-bound laboratory

$$H \approx \sqrt{\frac{16\pi}{\varkappa}}\,\frac{c}{\widetilde{\omega}\, r^2}\,.$$

That is, as soon as the magnetic strength inside the experimental setup reaches a numerical value according to this formula (and with the configuration of the electromagnetic field according to the obtained Einstein equations), a teleportation channel opens between this experimental setup and another remote experimental setup located anywhere else in the Universe. Synchronization of these two experimental setups is implemented using the same fine tuning of the magnetic field configuration and other characteristics, which allows physical bodies to be teleported only between these two setups, and not to some other place in the Universe.

Regarding the specific numerical value of H, necessary to implement the teleportation condition in the earth-bound laboratory, it depends on the understanding of the physical sense of the $\widetilde{\omega}$ and r in the above formula, as well as on the system of dimensions of electromagnetic quantities. Meanwhile, even on the basis of draft calculations and other information (that cannot be made public), we are sure that such an experimental setup is quite possible using a super-powerful pulsed magnetic field generator. These specific calculations, as well as the creation of such an experimental setup, are a task for engineers rather than for a theoretical physicist who is far from technology.

A century ago, Nikola Tesla claimed that the use of superstrong electromagnetic fields will allow us to travel instantly to any point in the Universe. We have no idea where he got this information from. Nevertheless, we are very glad that the words he uttered a century ago have now received a solid mathematical foundation in Einstein's theory.

Submitted on January 24, 2022

References

1. Zelmanov A. L. Chronometric Invariants. Translated from the 1944 PhD thesis, American Research Press, Rehoboth, New Mexico, 2006.
2. Zelmanov A. L. Chronometric invariants and accompanying frames of reference in the General Theory of Relativity. *Soviet Physics Doklady*, 1956, v. 1, 227–230 (translated from *Doklady Academii Nauk USSR*, 1956, v. 107, issue 6, 815–818).
3. Zelmanov A. L. On the relativistic theory of an anisotropic inhomogeneous universe. *The Abraham Zelmanov Journal*, 2008, vol. 1, 33–63 (translated from the thesis of the *6th Soviet Conference on the Problems of Cosmogony*, USSR Academy of Sciences Publishers, Moscow, 1957, 144–174).
4. Rabounski D and Borissova L. Particles Here and Beyond the Mirror. The 3rd expanded edition, American Research Press, Rehoboth, New Mexico, 2012 (the 1st edition was issued in 2001).
   Rabounski D. et Borissova L. Particules de l'Univers et au delà du Miroir. American Research Press, Rehoboth, New Mexico, 2012 (French translation).
5. Rabounski D. and Borissova L. Fields, Vacuum, and the Mirror Universe. The 2nd expanded edition, Svenska fysikarkivet, Stockholm, 2009 (the 1st edition was issued in 2001).
   Rabounski D. et Borissova L. Champs, Vide, et Univers miroir. American Research Press, Rehoboth, New Mexico, 2010 (French translation).
6. Rabounski D. and Borissova L. On the possibility of instant displacements in the space-time of General Relativity. *Progress in Physics*, 2005, v. 1, issue 1, 17–19.
7. Bennett C. H., Brassard G., Crepeau C., Jozsa R., Peres A., and Wootters W. K. Teleporting an unknown quantum state via dual classical and Einstein-Podolsky-Rosen channels. *Physical Review Letters*, 1993, v. 70, 1895–1899.
8. Boschi D., Branca S., De Martini F., Hardy L., and Popescu S. Experimental realization of teleporting an unknown pure quantum state via dual classical and Einstein-Podolsky-Rosen Channels. *Physical Review Letters*, 1998, v. 80, 1121–1125.
9. Riebe M., Häffner H., Roos C. F., Hänsel W., Benhelm J., Lancaster G. P. T., Korber T. W., Becher C., Schmidt-Kaler F., James D. F. V., and Blatt R. Deterministic quantum teleportation with atoms. *Nature*, 2004, v. 429, 734–736.
10. Barrett M. D., Chiaverini J., Schaetz T., Britton J., Itano W. M., Jost J. D., Knill E., Langer C., Leibfried D., Ozeri R., and Wineland D. J. Deterministic quantum teleportation of atomic qubits. *Nature*, 2004, v. 429, 737–739.