ON THE POSSIBILITY OF LOCAL SR CONSTRUCTION

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Abstract

The violation of the invariance of the speed of light in Special Relativity has been made. The version of the theory has been constructed in which the possibility of the superluminal motions are permitted.

1 Introduction

In view of mathematical elegance, laconicalness and predictive power Special Relativity (SR) is the fundamental theory of modern physics. Owing to this the mathematical postulates of the theory, possibility of their modification and generalization as well as of experimental test attract attention constantly. As examples one can be presented the well known Pauli monograph[[1\]](#page-10-0), containing the elements of the Abraham and Ritz theories; academician Logunov's lectures on the foundations of Relativity Theory with the formulation of SR in the affine space[[2\]](#page-10-0); Fushchich's publication on the non-linear electrodynamics equations with the non-invariant speed of light[[3\]](#page-10-0); Glashow's work on the experimental consequences of the violation of the Lorentz-invariance in astrophysics[[4](#page-10-0)].

To the present time SR is one of the most experimentally-justified theories (for example, Pauli and Landsberg monographies [\[1, 5\]](#page-10-0); Strakhovsky and Uspensky [\[6](#page-10-0)], Basov and his coauthors[[7\]](#page-10-0), Møller[[8\]](#page-11-0) and Molchanov[[9\]](#page-11-0) reviews; the original publications of [\[10](#page-11-0), [11](#page-11-0), [12\]](#page-11-0)). Here one can mention the experiments on detection of the ether wind in the experiments of the Michelson type[[1](#page-10-0), [5\]](#page-10-0); determination of the angular light aberrations[[1, 5](#page-10-0)]; transversal Dopplereffect measurement [[10](#page-11-0)]; experiments on the proof of independence of the speed of light from the velocity of the source of light [\[9, 10](#page-11-0)]; experiments on determination of the relativistic mass dependence of the velocity of a particle motion [\[10](#page-11-0)]; the relativistic retardation of time [\[10\]](#page-11-0); the g-2 experiments [\[11, 12](#page-11-0), [10](#page-11-0)]. The results of these experiments indicate the absence of the ether wind to closer and closer limits of accuracy, and argue for SR.

This raises the natural question, whether do exist at all any experiments different from SR predictions, even though they are ambiguously interpreted. It appears that there are a number of the publications on this theme. Let us consider those concerning the second postulate - the postulate of the constancy of the speed of light.

Giannetto, Maccarrone, Mignani and Recami [\[13\]](#page-11-0) have been considered the possibility of the negative sign interpretation of the square of the neutrino 4 - momentum $P^2 = E^2 - \mathbf{p}^2 c^2 =$ $M_0^2 c^4 = (-0, 166 \pm 0, 091) \; MeV^2$ in the experiments on π - decay $\pi^+ \to \mu^+ + \nu$ as the fact of observationof a superluminal particle with imaging mass $M_0 = im$ (tachyon). Khalfin [[14](#page-11-0)] has established that negative sign of the square of the neutrino 4-momentum may be due to incorrectness of the observational data processing near upper bound of β - spectrum (in our own case near a upper bound of μ - spectrum). Thus, the possibility of the interpretation

of π - neutrino as a particle of the tachyon nature is eliminated practically in the light of the contemporary explanation for the negative sign of the 4-momentum square.

Mamaev[[15](#page-11-0)] has analyzed the time-flight spectra of π^- , μ^- , e^- particles from Joint Institute for Nuclear Research (Dubna) and concluded that the data from the article[[16](#page-11-0)] may be interpreted as the result of superluminal motion of mesons and electrons. However, taking into account the presence in the signal processing electronic circuit of a threshold device (discriminator) with 2543 channels of the analyzer, it is possible to conclude that the velocities of these particles were $0, 92c, 0, 94c$ and $0, 96c$ respectively, where c is the speed of light. The phenomenon of superluminal motion disappears, and mutual arrangement of the spectral lines from [\[16](#page-11-0)] may be explained in the framework of SR[[26\]](#page-12-0).

Nevertheless numerous examples are known in which the elimination of superluminal motion turns out to be more difficult and less convincing than in the considered cases. These are observations of superluminal motion of particles in broad atmospheric showers and the acts of antiproton birth, as well as on expansion of the shells of some extragalactic radiosources, for example[[17](#page-11-0), [12](#page-11-0), [19](#page-11-0)].

Clay and Crouch has observed [\[17\]](#page-11-0) impulses, preceding the signal induced by a broad atmospheric shower. Let us suppose that particles from the shower had the velocity equal to the speed of light (that is natural). Then it is not clear, what has preceded these particles. "We conclude that we have observed non-random events preceding the arrival of an extensive air shower. Being unable to explain this result in a more conventional manner, we suggest that is the result of a particle traveling with an apparent velocity greater than of light " [\[17](#page-11-0)]. Further the authors[[17\]](#page-11-0) have assumed that the impulses were stipulated by the particles with imaginary masses (tachyons) traveling at the velocities exceeding the speed of light.

Cooper [\[12\]](#page-11-0) has concluded that the time-flight experiments on observation of antiprotons admit the existence of superluminal particles (antimesons) connected with antiprotons. The calculated probability of the velocity of antimesons exceeding the speed of light, is equal 0.9972. The evaluation turn out to be tolerant to various experimental errors. The author writes: " A reexamination of the Nobel-prize-winning experiment in which the antiproton was discovered reveals that associated antimesons might be traveling faster than light " [\[12](#page-11-0)].

The numerous publications are known on the observation of superluminal expansion of extragalactic radiosources (for example[[19, 20,](#page-11-0) [26\]](#page-12-0)). It is an interesting phenomenon, and it is difficult to be explained in terms of modern astrophysics. The observation of the superluminal expansion became possible after the radio interferometers VLBI (Very Long Baseline Interferometry) for the centimetre spectral range were created. These possess a superlong trans-continental base L (thousands and tens of thousands kilometers). The angular resolution of such telescopes $\delta \sim \lambda/L$ is proportional to the ratio of a working wavelength λ to the value of the base L. It is much higher than the one of the best optical devices. In the optical range L/λ is equal ~ 6 · 10⁷, while in the radio range it is equal ∼ 18 · 10⁸. The radio interferometers allow one to study such thin structure of space objects (∼ $7 \cdot 10^{-4}$ angle seconds) as was inaccessible to be observed by optical means. The studies have shown that many extragalactic radio sources have a complicated, bi-component structure. Among of them the substructure of six radio sources run away from each other at calculated velocities that are some times more than the speed of light. It is the radio galaxy 3C120 $(z = 0.033)$, quasars 3C273 $(z = 0.158)$, 3C279 $(z = 0.538)$, 3C345 $(z = 0.595)$, 3C179 $(z = 0.846)$ and NRAO140 $(z = 1.258)$ [\[21\]](#page-11-0). (Here z is the parameter of redshift). The

transversal velocities calculated within the framework of the cosmological Friedmann model of the motion of the components are equal $V_{\perp} \sim (2-20)c$. It has been proposed over ten versions for interpretations of this phenomenon. It may be associated with more complicated multicomponent structure of the quasars; the random superposition of radio spots on the quasars; influence of intergalactic gravitational lens duplicating a visible image; Doppler effect; increase of Hubble's constant that is accompanied by decreasing the distances to the quasars, which results in disappearing the superluminal expansion. Also, it may be due to the influence of interstellar magnetic fields; existence of tachyon matter; introduction of 5-space with an additional fifth coordinate such as the speed of light running the values from 0to ∞ ; model of the light echo; optical illusion not contradicting to SR [[19, 20,](#page-11-0) [26](#page-12-0)]. It is evident that the conventional explanation for the superluminal expansion is not offered yet, and various hypothesizes on the nature of this phenomenon may be discussed.

Loiseau [\[22](#page-11-0)] has paid attention to the little difference between the galaxy NGC 5668 redshift z', measured by radioastronomical method at the frequency corresponding to the wavelength 21 cm, and the redshift z , measured in the optical range for this galaxy. This result, if it really is outside the limits of measurement errors, cannot be explained in the framework of SR, as $z' = z$ should be with $c' = c$. To explain this result, author [\[22\]](#page-11-0) introduced 3-dimensional non-Euclidean space, inserted into 4-dimensional Riemannian space with some common time. In this case it may be obtained that the galaxy speed of light c' and the speed of light c on the Earth are connected by the ratio $c' = c(1+z)/(1+z')$, where z is the redshift on a wave length in the optical range, and z' is the redshift on a wave frequency in the radio range. In accordance with the observed data on the galaxy NGC 5668 z is equal to 0.00580 in the optical range; z' is equal to 0.00526 in the radio range on the frequency corresponding to the wavelength 21 cm. It follows from here that $c'/c = (1+z)/(1+z') = 1.00580/1.00526 = 1.0005372$, and $c' = c + 182.04$ km / sec *i*, *c* [\[22\]](#page-11-0). The estimation has shown that the speed of light from quasar QSO PKS 2134 with the opticalredshift $z = 1.936$ is equal to $c' = 440.000 \text{ km } / \text{ sec } [22]$ $c' = 440.000 \text{ km } / \text{ sec } [22]$. The relationship between c' , c and the quasar velocity v relative to the Earth is described by the formula $c' = c\sqrt{1 + v^2/c^2}$ in the approximation of a weak gravitational field. The statistical significance of the hypothesis on the difference between the redshifts in the radio and optical ranges is naturally the deciding factor for the Loiseau work.

Thus, unambiguously interpreted experimental data distinct from SR predictions are apparently absent now. But there are vague indications that it is not improbable that they exist in particle physics and in astrophysics. Let us consider the hypothesis on the existence of the superluminal motion in terms of the violation of invariance of the speed of light in the expression for the second degree of 4-interval at the infinitesimal level.

2 Space - Time Metric, Differentials Coordinates Transformation Law

Let us start from the condition for the invariance of the 4 - interval differential in Minkowski

space with the metric:

$$
ds^{2} = -(dx_{1}')^{2} - (dx_{2}')^{2} - (dx_{3}')^{2} - (dx_{4}')^{2} = -(dx_{1})^{2} - (dx_{2})^{2} - (dx_{3})^{2} - (dx_{4})^{2} - inv.
$$
\n(1)

Here $dx_{1,2,3} = (dx, dy, dz)$, $dx_4 = icdt$, it is not necessary for the speed of light c' to be equal c. Corresponding infinitesimal space - time transformations, saving the invariance of the form (1), obviously contain the group locally isomorphic to the Lorentz group [\[23\]](#page-12-0):

$$
dx'_a = dx_a, \ dx'_a = L_{ab}dx_b, \ a, b = 1, 2, 3, 4,
$$
\n(2)

where L_{ab} is the matrix of the six-dimensional Lorentz group L_6 [\[23\]](#page-12-0) with local kinematics parameter β . The one-dimensional infinitesimal transformations corresponding to the given matrix, take the well known form:

$$
dx_1' = \frac{dx_1 + i\beta dx_4}{\sqrt{1 - \beta^2}}; \ dx_4' = \frac{dx_4 - i\beta dx_1}{\sqrt{1 - \beta^2}}; \ dx_2' = dx_2; \ dx_3' = dx_3
$$
 (3)

The reciprocal transformations may be obtained by the prime permutation. The group parameters are connected by the ratio $\beta' = -\beta$ [\[23](#page-12-0)]. But contrary to the global Lorentz transformations[[23](#page-12-0)], here the parameters β and β' can depend explicitly or implicitly on a space - time point $\beta = \beta(f(\mathbf{x}, t)), \ \beta' = \beta'(f'(\mathbf{x}', t'))$. This is the important circumstance which will allow one to construct the theoretical model in which the existence of superluminal motion is possible. The integral space - time transformations induced by (3) are:

$$
x_1' = \int \frac{dx_1 + i\beta dx_4}{\sqrt{1 - \beta^2}} + d_1; x_4' = \int \frac{dx_4 - i\beta dx_1}{\sqrt{1 - \beta^2}} + d_4; x_2' = x_2 + d_2; x_3' = x_3 + d_3,
$$
\n(4)

where $d_1 - d_4$ are the translation parameters; the reciprocal transformations may be obtained by the prime permutation; $d'_a = -d_a$, $a = 1, 2, 3, 4$. The transformations (4) go into the Poincaré ones if $c = \text{cost}, c' = c$ be put into them and our consideration be restricted to inertial motions (β = const). In this case on integration they go into the standard transformations from Poincar´e group (inhomogeneous Lorentz group). Thus, Lorentz transformations are contained here as the particular case. The group properties of the integral transformations (4) are realized due to the group properties of the differential transformations (3) and due to the relativistic velocity addition theorem $\beta'' = (\beta + \beta')/(1 + \beta \beta')$.

3 Integral of Operation, Energy, Momentum

Let us turn to the integral of operation in SR [\[23](#page-12-0)]. It is not invariant with respect to the transformations with broken invariance of the speed of light. However this property may be corrected if we start from the invariant integral of operation[[26\]](#page-12-0):

$$
S^* = cS = -mc^2 \int ds + e \int A_a dx_a + \frac{i}{16\pi} \int F_{ab}^2 d^4x = -mc^2 \int ds - i \int A_a j_a d^4x + \frac{i}{16\pi} \int F_{ab}^2 d^4x =
$$
\n
$$
\int (-mc^2 \sqrt{1 - \beta^2} + e\mathbf{A} \cdot \beta e\phi)(c dt) + \frac{1}{8\pi} \int (E^2 - H^2) d^3x (c dt).
$$
\n(5)

Here S^* is the new integral of operation, which we name the generalized one; mc^2 is the invariant combination corresponding to the rest energy of a particle $(m$ is the rest-mass, c is the speed of light); e is the invariant electrical charge of a particle; $A_a = (A_1, A_2, A_3, A_4)$ $(A, i\phi)$ is the 4-potential [\[23\]](#page-12-0); $j_a = (j_1, j_2, j_3, j_4) = (\rho \mathbf{v}/c, i\rho)$ is the 4-vector of current density [\[1\]](#page-10-0) instead of $j_a = (\rho \mathbf{v}, i c \rho)$ [\[23](#page-12-0)], ρ is the charge density, **v** is the velocity of a charge; $F_{ab} = \partial A_b/\partial x_a - \partial A_a/\partial x_b$ is the tensor of electromagnetic field; $\mathbf{E} = -(1/c)\partial \mathbf{A}/\partial t - \nabla \phi$ is the electrical field; $\mathbf{H} = \nabla \mathbf{X} \mathbf{A}$ is the magnetic field; $F_{ab}^2 = 2(H^2 - E^2)$; $d^4x = dx_1 dx_2 dx_3 dx_4$ is the element of the invariant 4-volume[[23\]](#page-12-0).

The transformational rest-mass properties is changed as the result from the introduction of the generalized integral [\(5](#page-3-0)). The mass is not any more scalar. The mass is transformed according to the law $m' = (c^2/c^2)m = \gamma^{-2}m$. The rest energy mc^2 has a scalar property. The transformational property of Plank constant \hbar is changed as well. The invariant is not the constant \hbar , but the product $\hbar c$. Due to the electrical charge property of invariance e , the thin structure constant remains invariant $\alpha = e^2/\hbar c$ - inv.

The generalized Lagrangian, energy and 4 - momentum of a particle correspond to the generalized integral of operation. We will label the generalized values with the symbol *. We have:

$$
L^* = cL = -mc^2\sqrt{1 - \beta^2} + e\mathbf{A} \cdot \beta - e\phi;
$$
 (6)

$$
\mathbf{P}^* = \frac{\partial L^*}{\partial \beta} = \frac{cm\mathbf{v}}{\sqrt{1 - \beta^2}} + e\mathbf{A} = c\mathbf{p} + e\mathbf{A};\tag{7}
$$

$$
E^* = \mathbf{P}^* \cdot \beta - cL = \frac{mc^2}{\sqrt{1 - \beta^2}} + e\phi = E.
$$
 (8)

It follows from here that the motion integrals are the energy E and the product of the speed of light by the momentum from SR: $c\mathbf{P} = c\mathbf{p} + e\mathbf{A}$. The parameter β has meaning as generalized velocity. The differential $dx^0 = cdt$ plays a role of the time differential. It is essential that owing to the differentiation with respect to the parameter β , the results obtained do not depend on the particular assumptions concerning the properties of the speed of light, as the value c enters into the parameter $\beta = v/c$.

Owing to the well known property of 4 - speed $U^2 = -1$, we have the following expression for the generalized 4 - momentum $p_a^* = mc^2 u_a$ of a free particle:

$$
p_a^{*2} = c^2 p^2 - E^2 = -m^2 c^4 - inv.
$$
\n(9)

As in [\[23\]](#page-12-0), in case of a particle in electromagnetic field we find:

$$
P_a^* = mc^2 u_a + eA_a; \tag{10}
$$

$$
(P_a^* - eA_a)^2 = (cP_a - eA_a)^2 = -m^2c^4 - inv.
$$
\n(11)

4 Equations of Motion for Charged Particle

Keeping in the mind expression (6), we shall start from Lagrange equations $d(\partial L^*/\partial \beta)/dx^0$ $\partial L^*/\partial \mathbf{x} = 0$ taking into account the vector equality $\nabla (\mathbf{a} \cdot \mathbf{b}) = (\mathbf{a} \cdot \nabla)\mathbf{b} + (\mathbf{b} \cdot \nabla)\mathbf{a} + \mathbf{a}\mathbf{x}(\nabla \mathbf{x}\mathbf{b}) +$ $bx(\nabla xa)$ $bx(\nabla xa)$ $bx(\nabla xa)$ [[23](#page-12-0)]. We obtain the following equations for the motion of a charged particle in electromagnetic field:

$$
\frac{d\mathbf{p}^*}{dt} = \frac{d(c\mathbf{p})}{dt} = ce\mathbf{E} + e\mathbf{v}\mathbf{x}\mathbf{H};
$$
\n(12)

$$
\frac{dE^*}{dt} = \frac{dE}{dt} = e\mathbf{E} \cdot \mathbf{v};\tag{13}
$$

5 Maxwell Equations

Let us start from the permutational ratios of the electromagnetic field tensor and the field Lagrange equations $\partial(\partial \mathcal{L}^*/\partial A_{a,b})/\partial x_b - \partial \mathcal{L}^*/\partial A_a = 0$ [\[23, 24](#page-12-0)] taking into account the expression $\partial F_{ab}^2/\partial A_{a,b} = 4F_{ab}$ [[23\]](#page-12-0) and the density of the Lagrange function \mathcal{L}^* $c\mathcal{L} = iA_a j_a + (i/16\pi)F_{ab}^2$. Here $A_a(x)$ is 4-potential; $A_{a,b} = \partial A_a/\partial x_b$; $a, b = 1, 2, 3, 4$; $g_{ab} = diag(-, -, -, -)$. In sum we have:

$$
\nabla \mathbf{X} \mathbf{E} + \frac{1}{c} \frac{\partial \mathbf{H}}{\partial t} = 0; \qquad \nabla \cdot \mathbf{E} = 4\pi \rho; \n\nabla \mathbf{X} \mathbf{H} - \frac{1}{c} \frac{\partial \mathbf{E}}{\partial t} = 4\pi \frac{\mathbf{j}}{c}; \quad \nabla \cdot \mathbf{H} = 0.
$$
\n(14)

Out of them the equation of motion (13) and the equations of electromagnetic field (14) coincide with the equations which are known from SR.

Let us note that according to the given scheme Maxwell equations turn out to be invariant not only in inertial frames (it is well known), but also in non-inertial frames in the flat pseudo - Euclidean space with the metric $ds^2 = c^2 dt^2 - d\mathbf{x}^2$. This property of Maxwell equations seems to be unusual, but it is known and has been noted by academician Logunov: "... in the framework of SR it is possible to describe a physical phenomena in non-inertial frames as well. Fock understood this deeply ... "[[2\]](#page-10-0). The statement follows also from the general covariant formulation of Maxwell equations[[2,](#page-10-0) [23, 26](#page-12-0)].

6 Local SR

Up to this point any constraint did not placed on the transformation properties of the speed of light in the theory. It turns out that it is possible to realize various theoretical considerations by appropriate postulation. In particular, if we postulate that $c' = c$, all the obtained equations will go into SR equations. If we state that the speed of light is constant and $c' \neq c$, $c't' = ct$ - inv, the model may be realized which we name SR with non-invariant speed of light [\[26\]](#page-12-0). It describes the same physical reality as SR and also contains additional classification capabilities due to the symmetry with respect to more general group of transformations. Besides Poincaré group, this group includes the group induced by the generators $X_{-1} = \partial_t - t\partial_t/c$, $X_0 = c\partial_c - t\partial_t$, $X_{+1} = c^2\partial_c - ct\partial_t$ [\[26\]](#page-12-0). At last, the postulation is possible which permits one to construct a version of the theory compatible with the principle of relativity and the concept of superluminal motion. Let us consider this possibility at length.

Accordingto Ritz [[1\]](#page-10-0) we assume that the speed of light is equal to $c_o = 3 \cdot 10^{10}$ cm/sec not in global meaning, but only relatively to an emitter. Let us add a new physical element to the infinitesimal transformations([2\)](#page-3-0) and the model based on them with equations of motion [\(12](#page-5-0)),([13](#page-5-0)), ([14](#page-5-0)). We assume that the state of motion (inertial, or non-inertial) does not influences on the proper value of the speed of light c_0 , Plank constant \hbar_0 , the thin structure constant α and other physical proper values, for example, the proper length l_0 , proper time t_0 , proper frequency of oscillations ω_0 , rest-mass m_0 , electrical charge e. (A proper value is the physical value in the frame K_0 relatively to which the object is immobile). These remain invariant in the process of motion:

$$
c'_0 = c_0 = c_o = 3 \cdot 10^{10} cm/sec;
$$

\n
$$
\hbar'_0 = \hbar_0 = 1, 0 \cdot 10^{-27} g \cdot cm^2/sec;
$$

\n
$$
l'_0 = l_0; t'_0 = t_0; \omega'_0 = \omega; m'_0 = m_0; e' = e.
$$
\n(15)

The hypothesis on the independence of proper values of physical quantities from the state of a physical object motion we agree to name the local relativity principle.

Let us assume further that the time intervals measured by means of differently-placed clocks in any frames K, K', \cdots coincide with the local time in a proper frame K_o on the trajectory of the motion of the object:

$$
dt_o = dt = dt'.\tag{16}
$$

We agree to name the theoretical model, realizing the local relativity principle in the flat space - time with the metric [\(1](#page-3-0)) in combination with the hypothetical property of time (16), as Local Special Relativity Theory (LSR) as distinct from the classical SR. We find the following expressions for infinitesimal space - time transformations in this case:

$$
dx = \frac{dx_o - v_o dt_o}{\sqrt{1 - v_o^2/c_o^2}}; dy = dy_o; dz = dz_o; dt = dt_o - \frac{v_o dx_o}{c_o^2};
$$

\n
$$
c = \frac{c_o}{\sqrt{1 - v_o^2/c_o^2}};
$$

\n
$$
dx_o = \frac{dx - vdt}{\sqrt{1 - v^2/c^2}}; dy_o = dy; dz_o = dz; dt_o = \frac{dt - vdx/c}{1 - v^2/c^2};
$$

\n
$$
c_o = c\sqrt{1 - v^2/c^2},
$$
\n(17)

where $v/c = -v_o/c_o$; $(1 - v^2/c^2) \cdot (1 + v^2/c_o^2) = 1$. In this case the following relationship between the speed of light c and the velocity of emitter v is hold true as the result from the transformation properties of the speed of light in the formulae (17):

$$
c = c_o \sqrt{1 + \frac{v^2}{c_o^2}}.
$$
\n(18)

Here c_o is the speed of light in the proper frame associated with the emitter. (In the models admitting the existence of ether c_o is the speed of light relatively to ether). The expressions for the speed of light in the form of (17) or (18) were obtained by Abraham (1910) [\[1](#page-10-0)] and Rapier (1961)[[25\]](#page-12-0) respectively in the framework of ether models; next they were obtained by

the author of the present publication (1968) [\[26\]](#page-12-0) and Loiseau (1968) [\[22\]](#page-11-0) in the framework of the relativity principle. These formulae were reproduced further by many authors from variouspoints of view, in particular by Marinov (1975) [\[27](#page-12-0)], by Hsu (1976) [[28\]](#page-12-0), by Sjödin (1977)[[29](#page-12-0)], by Mamaev (1985) [\[15\]](#page-11-0), by Nimbuev (1996)[[30\]](#page-12-0), by Klimez (1997) [\[31](#page-12-0)], by Russo (1998) [\[32](#page-12-0)].

6.1 Generalized Momentum and Energy

Letus put the expression for the speed of light ([18](#page-6-0)) into the formulae for momentum [\(7](#page-4-0)) and energy([8](#page-4-0)) of a free particle. We have:

$$
\mathbf{p}^* = c\mathbf{p} = \frac{cm\mathbf{v}}{\sqrt{1 - v^2/c^2}} = m_0 c_0 \mathbf{v};
$$

\n
$$
E = \frac{mc^2}{\sqrt{1 - v^2/c^2}} = m_0 c_0^2 \sqrt{1 + v^2/c_0^2} = m_0 c_0 c.
$$
\n(19)

The relation has a view between the generalized momentum and energy by this:

$$
E^{2} - \mathbf{P}^{*2} = E^{2} - c^{2} \mathbf{p}^{2} = m_{0}^{2} c_{0}^{4} (1 + v^{2} / c_{0}^{2}) - m_{0}^{2} c_{0}^{2} \mathbf{v}^{2} = m_{0}^{2} c_{0}^{4}.
$$
 (20)

6.2 Energy and Superluminal Motion

Let us begin with the expression $v = \sqrt{E^2 - m_0^2 c_0^4} / m_0 c_0 \ge c_0$. It follows from here that in the framework of LSR a particle will move with superluminal velocity, if the particle energy will satisfy the equality:

$$
E_{tr} \ge \sqrt{2}E_0 = \sqrt{2}m_0c_0^2. \tag{21}
$$

This energy is equal $\sim 720 \,\text{keV}$ for electron and $\sim 1330 \,\text{Mev}$ for proton and neutron. We may conclude from here that neutron physics of nuclear reactors may be formulated in the nonrelativistic approximation in LSR (as in SR). The electrons with the energy $E > 720 \, keV$ (for example, from radioactive decay) should be superluminal particles in LSR. Particle physics on modern accelerators such as Serpukhov one with the energy of protons 66 GeV (1 Gev $=$ 1000 MeV) should be physics of superluminal motion in the framework of LSR, if it would be realized in reality.

6.3 Equations of Motion for Charged Particle in LSR

After putting the expression for the speed of light([18\)](#page-6-0) into the equations of motion [\(12\)](#page-5-0), we obtain [\[26](#page-12-0)]:

$$
\frac{d(c\mathbf{p})}{dt} = ce\mathbf{E} + e\mathbf{v}\mathbf{x}\mathbf{H} \rightarrow m_o \frac{d\mathbf{v}}{dt} = \frac{c}{c_o}e\mathbf{E} + \frac{e}{c_o}\mathbf{v}\mathbf{x}\mathbf{H};
$$
\n
$$
\frac{dE}{dt} = e\mathbf{v} \cdot \mathbf{E} \rightarrow m_o \frac{dc}{dt} = \frac{e}{c_o}\mathbf{v} \cdot \mathbf{E}.
$$
\n(22)

From here it can be seen that the integrals of motion are either the generalized momentum cp and energy E , or the associated velocity of a particle v and the speed of light c in the absence of external forces.

6.4 Maxwell Equations in LSR

Taking into account the expression for the speed of light [\(18](#page-6-0)), we obtain the following form of Maxwell equations [\[26](#page-12-0)]:

$$
\nabla \mathbf{X} \mathbf{E} + \frac{1}{c_0 \sqrt{1 + \frac{v^2}{c_0^2}}} \frac{\partial \mathbf{H}}{\partial t} = 0; \qquad \nabla \cdot \mathbf{E} = 4\pi \rho;
$$

$$
\nabla \mathbf{X} \mathbf{H} - \frac{1}{c_0 \sqrt{1 + \frac{v^2}{c_0^2}}} \frac{\partial \mathbf{E}}{\partial t} = 4\pi \rho \frac{\mathbf{v}}{c_0 \sqrt{1 + \frac{v^2}{c_0^2}}}; \quad \nabla \cdot \mathbf{H} = 0.
$$
 (23)

Here **v** is the electrical charge velocity; $c = c_0 \sqrt{1 + v^2/c_0^2}$ is the charge coordinate on the axis c (c is the speed of light in the laboratory frame K); c_0 is the proper value of the speed of light in the frame K.

6.5 LSR and Experiment

Let us consider the examples of experiments, the interpretation of which is close to or coincides with their interpretation in SR.

The Michelson Experiment $[1, 5]$ $[1, 5]$ $[1, 5]$ $[1, 5]$. For the case of a terrestrial light source the negative result of the experiment may be explained by space isotropy (the speed of light is the same in all directions). Owing to this circumstance the interference pattern will not be changed for a terrestrial observer at rotation of the interferometer. In the case of a extraterrestrial light source the negative result may be explained by two factors: the space isotropy and the square dependence of the speed of light from the velocity V of a light source $c = c_o\sqrt{1 + V^2/c_o^2}$ [\[26\]](#page-12-0).

The Fizeau Experiment [[1](#page-10-0), [5](#page-10-0)]. The explanation is similar to the one accepted in SR. The arising little correction is the the order of $V^2/c_0^2 \ll 1$ and does not influence on the experimentalresult in linear approximation $[26]$ $[26]$. (Here V is the velocity of fluid).

The Bonch-Bruevich and Molchanov Experiment [\[33\]](#page-12-0). The authors compared the speeds of the light radiated by the eastern and western equatorial edge of the solar disk. In the framework of LSR the speed of light $c = c_0 \sqrt{1 + V^2/c_0^2}$ does not depend on the direction of the light source motion V . Therefore the speed of light will be the same for both the western and eastern edges of the solar disk. As in SR it is in accord with the negative result of the experiment[[26\]](#page-12-0).

The Sadeh Experiment [\[34\]](#page-12-0). In the experiment the distinction between the speeds of the gamma - quanta, arising as a result of the electron - positron annihilation in flight, has been observed depending on the angle between the gamma - quanta. By virtue of the independence of the speed of light c from the direction of the velocity of the source V , the result of the experiment should be negative in LSR as well as in SR [\[26](#page-12-0)].

Let us consider also the experiments, which interpretation in LSR is different from their the interpretations in SR.

The Doppler Effect [\[1](#page-10-0), [23](#page-12-0)]. In LSR the change of a wavelength λ is described by the formula $\lambda = \lambda_0 (1 - V n_x/c) / \sqrt{1 - V^2/c^2} = \lambda_0 [\sqrt{1 + V^2/c_0^2} - V n_x/c_0].$ The change of

a frequency is described by the formula $\omega = \omega_0 (c/c_0) \sqrt{1 - V^2/c^2}/(1 - V n_x/c) = \omega_0/(1 V n_x/c_0$ [\[26](#page-12-0)]. Here $\theta = \arccos n_x$ is the angle of the observation; V is the emitter velocity. It is follows from here that in LSR there is no Doppler transversal frequent shift because with $n_x = 0, \omega = \omega_o$. For a wavelength the Doppler transversal shift is retained. Hence in LSR the parameters of redshifts z_{λ} and z_{ω} do not coincide with each other and are equal z_{λ} = $(\lambda-\lambda_0)/\lambda_0 \rightarrow 2V/c_0$ at $n_x = -1, V \rightarrow \infty$; $z_\omega = (\omega_0-\omega)/\omega_0 \rightarrow 1$ at $n_x = -1, V \rightarrow \infty$. In non - relativistic approximation they coincide with each other $z_{\lambda} \sim -V n_x/c_o$, $z_{\omega} \sim -V n_x/c_o$. When the emitters move with significant velocities, the distinction begins to show itself with the shifts $z_{\lambda} \geq 0.6$. The fulfillment of the inequality $z_{\lambda} \geq \sqrt{2} = 1.41$ is the criterion for longitudinal $(n_x = -1)$ superluminal motion. The fulfillment of the inequality $z_\lambda \geq \sqrt{2} - 1$ $= 0.41$ $= 0.41$ $= 0.41$ is the criterion for transversal $(n_x = 0)$ superluminal motion [[26\]](#page-12-0). The superluminal quasars 3C279 ($z_{\lambda} = 0.536$), 3C345 ($z_{\lambda} = 0.595$), 3C179 ($z_{\lambda} = 0.846$), NRAO 140 ($z_{\lambda} =$ 1.258)[[21\]](#page-11-0) satisfy the letter criterion. In particular, the calculated transversal velocity of the QSO NRAO 140 expansion is $V_{\perp} \sim 2c_o$. It is surprising that this velocity is close to the low bound of these velocities $3c_o$ within the Friedmann cosmological model [\[21](#page-11-0)]. It is important for LSR to determine the frequent redshifts z_{ω} of these superluminal objects and compare them with the lambda redshifts z_{λ} as well as to solve the problem of the existence of the limit $z_{\omega} \leq 1$. It will permit one to distinguish between LSR and SR because in SR the ratio $z_{\lambda} = z_{\omega}$ is true. The redshift of the radio emission from neutral hydrogen H_I on the frequency corresponding to the line 21 cm is attractive for this purpose. However in this frequency range the experimental data on superluminal quasars are not avallable. Therefore to reject LSR is not possible now.

Let us also pay attention to the relationship between the speeds of light c and c_o and the parameters of redshifts $c = c_0(1 + z_\lambda)/(1 + z_\omega) \rightarrow c_0(1 + z_\lambda)/2$ in LSR. (The latter formula istrue with $z_{\omega} \sim 1$). We can conclude that it is the Loiseau formula [[22\]](#page-11-0). Its application to the observational interpretation was considered in Introduction. According to [\[22\]](#page-11-0), the speed of light from the galaxy NGC 5668 with the parameters of redshifts $z_{\lambda} = 0.00580$ and $z_{\omega} = 0.00526$, is equal $c = c_0 + 182.04$ km / sec. In the light of the present work this result, however, is not of statistical significance, as the redshift parameter $z_{\lambda} = 0.00580 \ll 1.41$. Therefore the conclusion that the NGC 5668 galaxy is superluminal fail. It also holds for the quasar PKS 2134 with parameter of redshift $z_{\lambda} = 1.935$. After putting this value and frequency shift $z_{\omega} = 1$ into above - mentioned formula we can conclude that the speed of light from the PKS 2134 quasar is $c = 300.000 \cdot 2.936/2 = 440.400 \sim 440.000 \text{ km/s}$ sec. Thus, the Loiseau estimation has theoretical character. This circumstance indicates once more that it is necessary to obtain experimental data concerning the redshifts for superluminal quasars in the radio-frequency and optical ranges [\[26](#page-12-0)].

Aberration of light [\[1](#page-10-0), [5\]](#page-10-0). By analogy with SR we have for one - half of the aberration angle: $sin\alpha = V/c; \alpha \sim (V/c_0)(c_0/c) = 10^{-4}(c_0/c) \sim 10^{-4}(2/(1+z_\lambda)) = (2/(1+z_\lambda)) \cdot 20,5$ seconds of arc. (The latter is true with large z_λ). It follows from here that, for example, $c = 2,86c_0, \ \alpha = 7.2$ seconds of arc for the Q 1158 + 4635 quasar with the redshift $z_{\lambda} = 4.73$ [\[35\]](#page-12-0). The 7.2 seconds of arc value should be checked in the experiment [[26\]](#page-12-0).

Superluminal motion of nuclear reaction products. Such phenomenon is impossible in SR. But it is possible in LSR, if the energy of a particle will be greater than $\sqrt{2}E_0$. It is 150 MeV for μ - mesons. Therefore in LSR (if it is realized in reality) the appearance of atmospheric μ - mesons near the surface of the Earth may be explained by superluminal motion of the mesons with the velocity of the order of $6 \cdot 10^6 / 2$, $2 \cdot 10^{-6} \sim 3 \cdot 10^{12}$ cm/sec, or 100 c_0 [[26\]](#page-12-0). The energy $E_\mu = m_{0,\mu}c_0c \sim 100 m_{0,\mu}c_0^2 \sim 10.6$ GeV corresponds to the given velocity in LSR. In virtue of the absence of the limitation on the upper value of the speed of light, faster particles explaining the results of Clay, Crouch [\[17](#page-11-0)] and Cooper experiments [\[18\]](#page-11-0), may be observed in front of the particles from nuclear reactions.

Motion of a charged particle in electromagnetic field. By integrating [\(12\)](#page-5-0), we find that in the case a particle moves in constant homogeneous electrical field, its velocity tends to infinity $v_x(t) = c_0 \sqrt{1 + v_y^2(0)/c_0^2} sh(eEt/m_0c_0) \rightarrow \infty$ [[26\]](#page-12-0). In SR the particle velocity is limitedby value c_o as is known [[23](#page-12-0)]. For the case of constant homogeneous magnetic field $H = (0, 0, H_z)$ the frequency of rotation of a particle is constant and does not depend on the energyof a particle $\omega = eH_z/m_0c_0 = \text{const}$ in LSR $(\omega \sim 1/E \text{ in SR } [23])$ $(\omega \sim 1/E \text{ in SR } [23])$ $(\omega \sim 1/E \text{ in SR } [23])$. However if the particle energy is great, the radius of particle rotation is connected with the particle energy by the ratio $r \sim E/eH_z$ as in SR. The differences in the radiuses of rotation is observed in the intermediate range of particle energies, when $M_0c_0^2 < E < m_0c_0v$ at $v > c_o$. The considered properties of particle motions in electrical and magnetic fields may be essential in the theory of linear and cyclical accelerators [\[26](#page-12-0)].

7 Conclusion

Summing we shall note that the validity of LSR or the proper field of its application are not clear yet now. In any case the problem arises which concerns the reason of the choice of preferable symmetry in the nature. Local SR transforms into SR, if $c' = c$.

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