About causality principle in relativity theory

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Abstract

The paper reveals a contradiction between the causality principle and relativity theory in the processes dealing with emission/absorption of light within non-inertial frames of references.

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1. Introduction

The causality principle (CP) means two fundamental requirements:

1. A cause-consequence order of events is absolute.

2. The events, which can cause essential inferences (for example, collision of particles), are absolute.

It is known that a finiteness of light velocity provides conformity of the relativity theory with the first requirement of CP. The second requirement of CP is taken into account by a choice of homogeneous admissible space-time transformations for increments of space-time four-vectors. Indeed, the event of collision of two particles (or intersection of two light rays) corresponds to the equality Δt, Δr=0, and for homogeneous transformations we get $\Delta t'$, $\Delta r'$=0, too. Here t, r and t', r' belong to two different reference frames. At the same time, when the space-time coordinates of two particles (or any other point objects) are close to each other, a possibility of intersection (or non-intersection) of their world lines can be expressed in terms of relationships between magnitudes and time derivatives of the functions, describing these world lines. It is clear that in physically correct theory the conditions of intersection/non-intersection of the world lines should be the same for observers in any frame of references.

Section 2 considers two near world lines in an empty space-time and derives the conditions for their intersection simultaneously for different inertial and non-inertial observers. It has been found that for the processes of emission/absorption of light the relativity theory is failed to correctly describe these conditions.

Section 3 presents a special physical problem, where a violation of CP in the relativity theory is demonstrated without complex calculations.

2. Conditions of intersection of two world lines in inertial and non-inertial reference frames

Let us consider some inertial and non-inertial reference frames related by the transformation

$$X^i = X^i(x^k), \tag{1}$$

(i, k= 0…3), where X^i are the pseudo-Euclidean coordinates in an inertial frame, and x^k are the space-time coordinates in a flat curvilinear geometry of non-inertial frame. Transformation (1) defines the metric coefficients g_{ik} in a non-inertial frame, which can be used for determination of physical four-vectors $x_{\mathrm{ph}}{}^i$ in this frame:

$$dx_{\mathrm{ph}0} = \sqrt{g_{00}}dx^0 + \frac{g_{0\alpha}dx^\alpha}{\sqrt{g_{00}}},$$

$$\Sigma dx^2_{\mathrm{ph}\alpha} = \left(-g_{\alpha\beta} + \frac{g_{0\alpha}g_{0\beta}}{g_{00}} \right) dx^\alpha dx^\beta, \quad (\alpha=1\ldots3). \tag{2}$$

Further, let us consider a class of kinematical problems in non-inertial frames of references with known relationship between space $x_{\mathrm{ph}}{}^\alpha$ and time $x_{\mathrm{ph}}{}^0$ components of a four-vector $x_{\mathrm{ph}}{}^i$, corresponding to some point object in physical space-time. In this case we can find from (2) a correlation between space x^α and time x^0 components in coordinates x^i of our non-inertial frame. In means that we determine a world line of the point object $x^{\alpha}(x^0)$ in x^i coordinates. Now let there are two point objects (particles or short light pulses), for which we determine the world lines $x^{(1)\alpha}(x^0)$ and $x^{(2)\alpha}(x^0)$. Using (1), we find the shapes of two world lines $X^{(1)\alpha}(X^0)$ and $X^{(2)\alpha}(X^0)$ for an inertial observer. The functions $x^{(1)\alpha}(x^0)$, $X^{(1)\alpha}(X^0)$, and $x^{(2)\alpha}(x^0)$, $X^{(2)\alpha}(X^0)$ can be quite different. However, due to homogeneity of the transformation (1), an intersection of the world lines $x^{(1)\alpha}(x^0)$ and $x^{(2)\alpha}(x^0)$ is accompanied by corresponding intersection of the $X^{(1)\alpha}(X^0)$, $X^{(2)\alpha}(X^0)$ lines. On the other hand, one may express the conditions of such intersection in terms of magnitudes and time derivatives of the functions $x^{(1)\alpha}(x^0)$, $x^{(2)\alpha}(x^0)$, $X^{(1)\alpha}(X^0)$, $X^{(2)\alpha}(X^0)$ near intersection points. It is clear that in physically correct theory these conditions should be the same for observers in all reference frames under consideration.

Let us formulate such conditions for a one-dimensional case, using in this section the units with c=1. Let there are two world lines $x^{(1)}{}_{\mathrm{ph}}(t_{\mathrm{ph}})$ and $x^{(2)}{}_{\mathrm{ph}}(t_{\mathrm{ph}})$ in physical space time of a non-inertial reference frame. Within some short time interval $\{t_{\mathrm{ph0}}, t_{\mathrm{ph0}}+\Delta t_{\mathrm{ph}}\}$ the values $x^{(1)}{}_{\mathrm{ph}}$ and $x^{(2)}{}_{\mathrm{ph}}$ are close to each other, and, for example, $x^{(2)}{}_{\mathrm{ph}}(t_{\mathrm{ph0}}) > x^{(1)}{}_{\mathrm{ph}}(t_{\mathrm{ph0}})$. The same is true for corresponding coordinates $x(t)$: $x^{(2)}(t_0) > x^{(1)}(t_0)$. Then we may definitely assert that the functions $x^{(1)}(t)$ and $x^{(2)}(t)$ will not have a point of intersection within the time interval Δt, if in this time range

$$x^{(1)}(t_0) + \frac{dx^{(1)}}{dt}\Delta t < x^{(2)}(t_0) + \frac{dx^{(2)}}{dt}\Delta t \text{, or}$$

$$\frac{dx^{(1)}}{dt} - \frac{dx^{(2)}}{dt} < \frac{\Delta x}{\Delta t}, \tag{3}$$

where we designated $\Delta x = x^{(2)}(t_0) - x^{(1)}(t_0)$. Correspondingly, a condition of intersection of the world lines considered is

$$\frac{dx^{(1)}}{dt} - \frac{dx^{(2)}}{dt} \ge \frac{\Delta x}{\Delta t}. \tag{4}$$

Due to homogeneity of the functions (1), (2) for increments of space and time intervals, the corresponding space coordinates $X^{(1)}(T)$, $X^{(2)}(T)$ are also close to each other within corresponding time interval ΔT. Under $X^{(2)}(T_0)>X^{(1)}(T_0)$, two world lines do not have a point of intersection for inertial observer, if

$$\frac{dX^{(1)}}{dT} - \frac{dX^{(2)}}{dT} < \frac{\Delta X}{\Delta T}. \tag{5}$$

Here we designated $\Delta X = X^{(2)}(T_0) - X^{(1)}(T_0)$. Conversely, the world line intersect, if

$$\frac{dX^{(1)}}{dT} - \frac{dX^{(2)}}{dT} \ge \frac{\Delta X}{\Delta T}. \tag{6}$$

Simultaneous implementation of either inequalities (3, 5) or inequalities (4, 6) is a strong requirement of CP.

Now let us investigate a possibility of simultaneous realization of the inequalities (3, 5) or (4, 6) in more detail. Proceeding from eq. (1), we can write

$$dX = \frac{\partial X}{\partial t}dt + \frac{\partial X}{\partial x}dx\,,\ dT = \frac{\partial T}{\partial t}dt + \frac{\partial T}{\partial x}dx,\ \frac{dX}{dT} = \frac{\frac{\partial X}{\partial t}dt + \frac{\partial X}{\partial x}dx}{\frac{\partial T}{\partial t}dt + \frac{\partial T}{\partial x}dx}\,. \tag{7}$$

In a one-dimensional case eqs. (2) transform into

$$dt_{\text{ph}} = \sqrt{g_{00}}dt + \frac{g_{01}}{\sqrt{g_{00}}}dx,\ dx_{\text{ph}} = \sqrt{\frac{-g}{g_{00}}}dx \tag{8}$$

where g=det**g**. From there

$$dx = \sqrt{\frac{g_{00}}{-g}}dx_{\text{ph}}\,,\ dt = \frac{dt_{\text{ph}}}{\sqrt{g_{00}}} - \frac{g_{01}}{\sqrt{g_{00}}\sqrt{-g}}dx_{\text{ph}}\,. \tag{9}$$

Substituting the differentials *dx* and *dt* from (9) into (7), we obtain:

$$\frac{dX}{dT} = \frac{\frac{1}{\sqrt{g_{00}}}\frac{\partial X}{\partial t} + \frac{dx_{\text{ph}}}{dt_{\text{ph}}}\left(\sqrt{\frac{g_{00}}{-g}}\frac{\partial X}{\partial x} - \frac{g_{01}}{\sqrt{g_{00}}\sqrt{-g}}\frac{\partial X}{\partial t}\right)}{\frac{1}{\sqrt{g_{00}}}\frac{\partial T}{\partial t} + \frac{dx_{\text{ph}}}{dt_{\text{ph}}}\left(\sqrt{\frac{\text{g}_{00}}{\text{-g}}}\frac{\partial T}{\partial x} - \frac{g_{01}}{\sqrt{g_{00}}\sqrt{-g}}\frac{\partial T}{\partial t}\right)}\,. \tag{10}$$

Let the value of Δt_{ph} is so small, that we may take all metric coefficients and all derivatives as constant within this time interval. Let us designate

$$\frac{1}{\sqrt{g_{00}}}\frac{\partial T}{\partial t} = A_0;\sqrt{\frac{g_{00}}{-g}}\frac{\partial X}{\partial x} = A_1\,, \tag{11}$$

where A_0 and A_1 are some constant numbers in our approximation. Then we can write

$$\frac{1}{\sqrt{g_{00}}}\frac{\partial X}{\partial t} = k_1 A_0;\sqrt{\frac{g_{00}}{-g}}\frac{\partial T}{\partial x} = k_2 A_1\,, \tag{12}$$

where k_1, k_2 are some constant numbers.

The metric coefficients in the accelerated frame, being determined from eq. (1), are as follows:

$$g_{00} = \left(\frac{\partial T}{\partial t}\right)^2 - \left(\frac{\partial X}{\partial t}\right)^2;\ g_{01} = g_{10} = \frac{\partial T}{\partial x}\frac{\partial T}{\partial t} - \frac{\partial X}{\partial x}\frac{\partial X}{\partial t};\ g_{11} = \left(\frac{\partial T}{\partial x}\right)^2 - \left(\frac{\partial X}{\partial x}\right)^2. \tag{13}$$

Substituting eqs. (11-12) into expression for g_{01}, we get in our designations:

$$g_{01} = \sqrt{-g}A_1 A_0\left(k_2 - k_{10}\right). \tag{14}$$

Now we notice that for admissible space-time transformations $g_{00}>0$, $g_{11}<0$. It means that [see (13)]

$$\left|\frac{\partial T}{\partial t}\right| > \left|\frac{\partial X}{\partial t}\right|; \ \left|\frac{\partial X}{\partial x}\right| > \left|\frac{\partial T}{\partial x}\right|. \tag{15}$$

Inequalities (15) with account of definitions (11-12) produce

$$|k_1|, |k_2| < 1. \tag{16}$$

Further, substituting eqs. (11-12, 14) into eq. (10), we get:

$$\frac{dX}{dT} = \frac{k_1 A_0 + \frac{dx_{\text{ph}}}{dt_{\text{ph}}} A_1 \left(1 - k_1 k_2 A_0 + k_1{}^2 A_0{}^2\right)}{A_0 + \frac{dx_{\text{ph}}}{dt_{\text{ph}}} A_1 k_2 \left(1 + \frac{k_1}{k_2} A_0{}^2 - A_0{}^2\right)}. \tag{17}$$

Now we restrict our research by the condition $g_{01}=0$, which is valid, for example, for uniform motion with constant (in relativistic meaning) acceleration. It means that $k_1=k_2=k$ [see (14)]. Then eq. (17) transforms into

$$\frac{dX}{dT} = \frac{kA_0 + A_1 \frac{dx_{\text{ph}}}{dt_{\text{ph}}}}{A_0 + kA_1 \frac{dx_{\text{ph}}}{dt_{\text{ph}}}}. \tag{18}$$

In order to find a relationship between A_0 and A_1, we use a requirement that for light signal $\frac{dx_{\text{ph}}}{dt_{\text{ph}}} = \frac{dX}{dT} = 1$. Hence, we obtain

$$1 = \left(kA_0 + A_1\right) / \left(A_0 + kA_1\right).$$

From there $A_0=A_1=A$, with account of inequality $|k|<1$. This condition allows further simplification of (18):

$$\frac{dX}{dT} = \frac{k + dx_{\text{ph}}/dt_{\text{ph}}}{1 + k\, dx_{\text{ph}}/dt_{\text{ph}}}. \tag{19}$$

In the case under consideration ($g_{01}=0$), $\frac{dx_{\text{ph}}}{dt_{\text{ph}}} = \frac{\sqrt{-g}}{g_{00}} \frac{dx}{dt}$. Substituting this equality into (19), we get a relationship between dX/dT and dx/dt:

$$\frac{dX}{dT} = \frac{k + \frac{\sqrt{-g}}{g_{00}} \frac{dx}{dt}}{1 + \frac{\sqrt{-g}}{g_{00}} \frac{dx}{dt}}. \tag{20}$$

Now let us suppose that two world lines $x^{(1)}(t)$ and $x^{(2)}(t)$ have a point of intersection in the time interval $\{t_0, t_0+\Delta t\}$ of a non-inertial frame. To simplify an analysis further, without a loss in generality we may consider a case, where

$$\frac{dx^{(2)}}{dt}=0, \frac{dx^{(1)}}{dt}=\frac{\Delta x}{\Delta t}, \qquad (21)$$

so that the two world lines intersect at the time moment $t_0+\Delta t$ (see (4)). At that the object, being described by the world line $x^{(2)}(t)$, rests within the time interval considered (Fig. 1 (a)). Now let us ask a question: is it possible in these conditions to implement the inequality (5) for inertial observer? Namely, we suppose that at the time moment $T_0+\Delta T$, $X^{(2)}(T_0+\Delta T)-X^{(1)}(T_0+\Delta T)=\delta$ (Fig. 1 (b)). In such a case inequality (5) means the same as

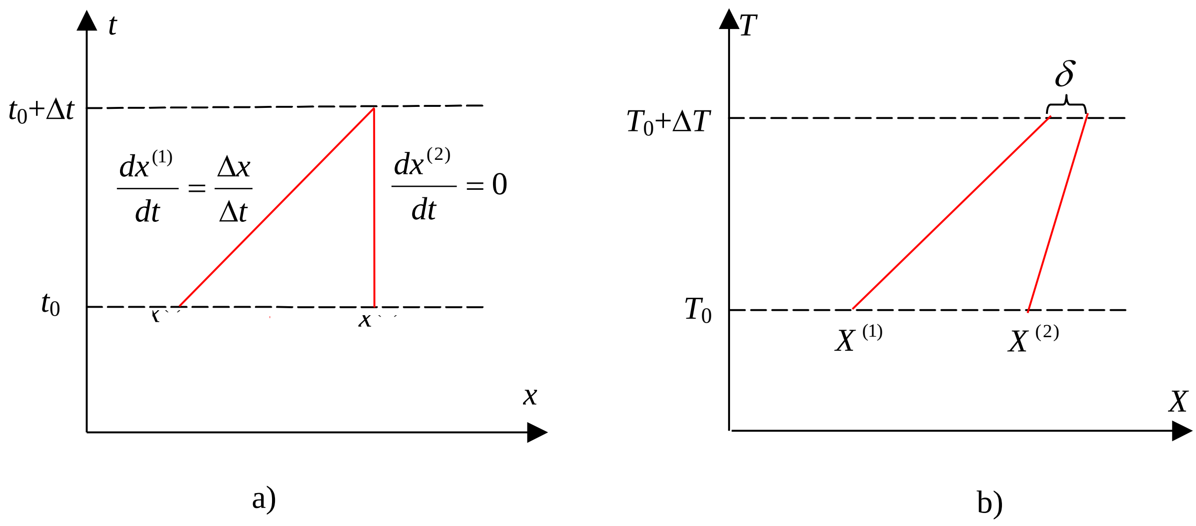

Fig. 1. Two world lines in non-inertial frame (a), being defined by (21), and the same world lines in an inertial reference frame (b). In case of non-vanishing δ we would get a violation of the causality principle.

$$\frac{dX^{(1)}}{dT}-\frac{dX^{(2)}}{dT}=\frac{\Delta X-\delta}{\Delta T}. \qquad (22)$$

If δ exceeds zero, we would get a violation of the second requirement of CP. Substituting into (22) the expression (20) for dX/dT, and taking into account the adopted conditions (21), we obtain:

$$\frac{\frac{\sqrt{-g}}{g_{00}}\frac{\Delta x}{\Delta t}\left(1-k^2\right)}{1+k\frac{\sqrt{-g}}{g_{00}}\frac{\Delta x}{\Delta t}}=\frac{\Delta X-\delta}{\Delta T}. \qquad (23)$$

Further, proceeding from transformation (7) with account of (11), (12) one can easy show that

$$\Delta X = A\frac{\sqrt{-g}}{\sqrt{g_{00}}}\left(1-k^2\right)\Delta x\,, \tag{24}$$

(scale contraction effect), and

$$\Delta T = A\left(\sqrt{g_{00}} + \frac{k\sqrt{-g}}{\sqrt{g_{00}}}\frac{\Delta x}{\Delta t}\right)\Delta t\,. \tag{25}$$

Substituting (24) and (25) into (23), we obtain that for smooth functions $x(t)$, $X(T)$, the parameter δ is always equal to zero.

This result seems quite trivial in a light of homogeneity of space-time transforms for increments of space and time intervals. At the same time, we stress that this proof is valid, in general, only for smooth world lines. From a formal mathematical viewpoint, if at least one of the functions $x^{(1)}(t), x^{(2)}(t), X^{(1)}(T), X^{(2)}(T)$ has a fracture in the considered time range, that the proof is broken. However, from a view of physics it seems that such fracture points cannot exist: in these points the derivatives dx/dt and dX/dT become infinite, that comes into contradiction with the fundamental requirement $dx_{\mathrm{ph}}/dt_{\mathrm{ph}}, dX/dT \le 1$. It is actually true, with the one exception: the cases of absorption (emission) of light. Indeed, let us imagine some absorber/remitter of light, which moves in some references frame. Let at some instant it absorbs a falling short light pulse, and after a fixed interval of its own time Δt_r it re-emits light pulse at the same direction. Since Δt_r is a definite value, we may imagine that during this time the remitter «keeps» information about the absorbed light pulse. Hence, we may join the world lines of absorbed and re-emitted light pulses by the world line of absorber/remitter (Fig. 2). In this case the events of absorption/emission of light can be formally treated in macroscopic scale as the “fracture” points of the common full world line in Fig. 2.

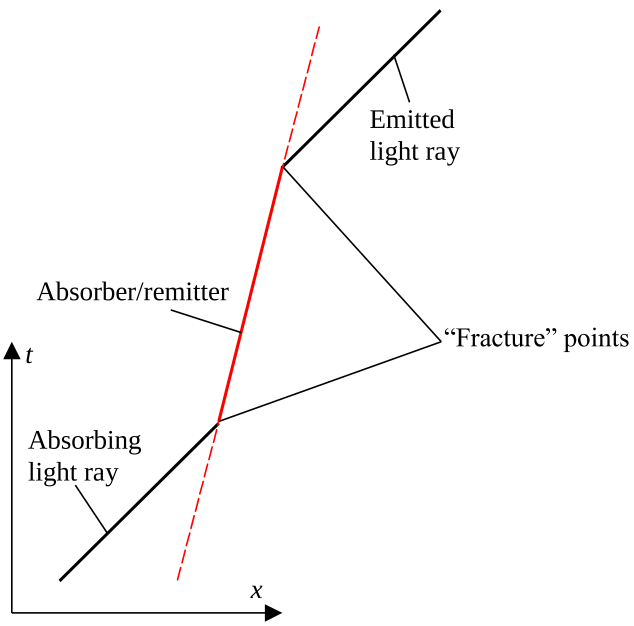

Fig. 2. Common “world line” of “absorbing light ray→absorber/remitter →emitted light ray”. The events of absorption/emission of light can formally be treated as the “fracture” points in macro-physics scale.

So, let us consider two near world lines $x^{(1)}(t)$ and $x^{(2)}(t)$ within two short successive time intervals $\{t_0, t_0+\Delta t'\}$ and $\{t_0+\Delta t', t_0+\Delta t'+\Delta t\}$of a non-inertial reference frame. Let again the world line $x^{(2)}(t)$ describes a resting in this frame point object, and let the time coordinate t is determined along this line. Further, we imagine that $x^{(1)}(t)$ represents a combined world line as follows: during its own time interval $\Delta t'^{(1)}$, corresponding to the time range $\{t_0, t_0+\Delta t'\}$ it describes a resting in the non-inertial frame emitter of light, and then it represents a short light pulse. Since within own time intervals $\{t_0, t_0+\Delta t'\}$ both worlds lines $x^{(1)}(t)$, $x^{(2)}(t)$ are parallel to the axis t, that along these lines

$$\Delta t'^{(1)} = \frac{\Delta T'^{(1)}}{A\sqrt{g_{00}(x^{(1)}(t_0))}}, \Delta t'^{(2)} = \Delta t' = \frac{\Delta T'^{(2)}}{A\sqrt{g_{00}(x^{(2)}(t_0))}}.$$

Taking

$$\Delta T'^{(1)} = \Delta T'^{(2)} = \Delta T', \tag{26}$$

we obtain the difference

$$\delta t' = \Delta t'^{(1)} - \Delta t'^{(2)} = \frac{\Delta T}{A}\left(\frac{1}{\sqrt{g_{00}\left(x^{(1)}(t_0)\right)}} - \frac{1}{\sqrt{g_{00}\left(x^{(1)}(t_0)\right)}}\right). \tag{27}$$

Now let us investigate the inequalities (3-6) in the corresponding time ranges $\{t_0+\Delta t', t_0+\Delta t'+\Delta t\}$ and $\{T_0+\Delta T', T_0+\Delta T'+\Delta T\}$. First of all, we reveal that the conditions (21), defining intersection of two world lines $x^{(2)}(t)$ and $x^{(1)}(t)$ at the edge of the time interval $\{t_0+\Delta t', t_0+\Delta t'+\Delta t\}$, should be rewritten as

$$\frac{dx^{(1)}}{dt} - \frac{dx^{(2)}}{dt} = \frac{\Delta x - \frac{\Delta x}{\Delta t}\delta t'}{\Delta t},$$

(see Fig. 3 (a)). At the same time, due to the adopted condition (26), the expressions (24) and (25) remains unchanged in the time interval $\{T_0+\Delta T', T_0+\Delta T'+\Delta T\}$. Then eq. (23) transforms into

$$\frac{\frac{\sqrt{-g}}{g_{00}}\frac{\Delta x}{\Delta t}\left(1-k^2\right)\left(1-\frac{\delta t'}{\Delta t}\right)}{1+k\frac{\sqrt{-g}}{g_{00}}\frac{\Delta x}{\Delta t}} = \frac{\Delta X - \delta'}{\Delta T}. \tag{28}$$

Substituting (24), (25) into (28), one obtains

$\delta' = \Delta x\frac{\delta t'}{\Delta t} > 0$ (see Fig. 3 (b)).

Thus, we reveal in our case that intersection of two world lines in a non-inertial reference frame is not accompanied by corresponding intersection of the world lines for inertial observer. It means that the relativity theory, in general, is not compatible with the CP. Next section considers a special physical problem, where without complex calculations a contradiction between relativity theory and CP is actually derived. It was already published in [1-3], but without analysis of physical reasons, leading to this contradiction.

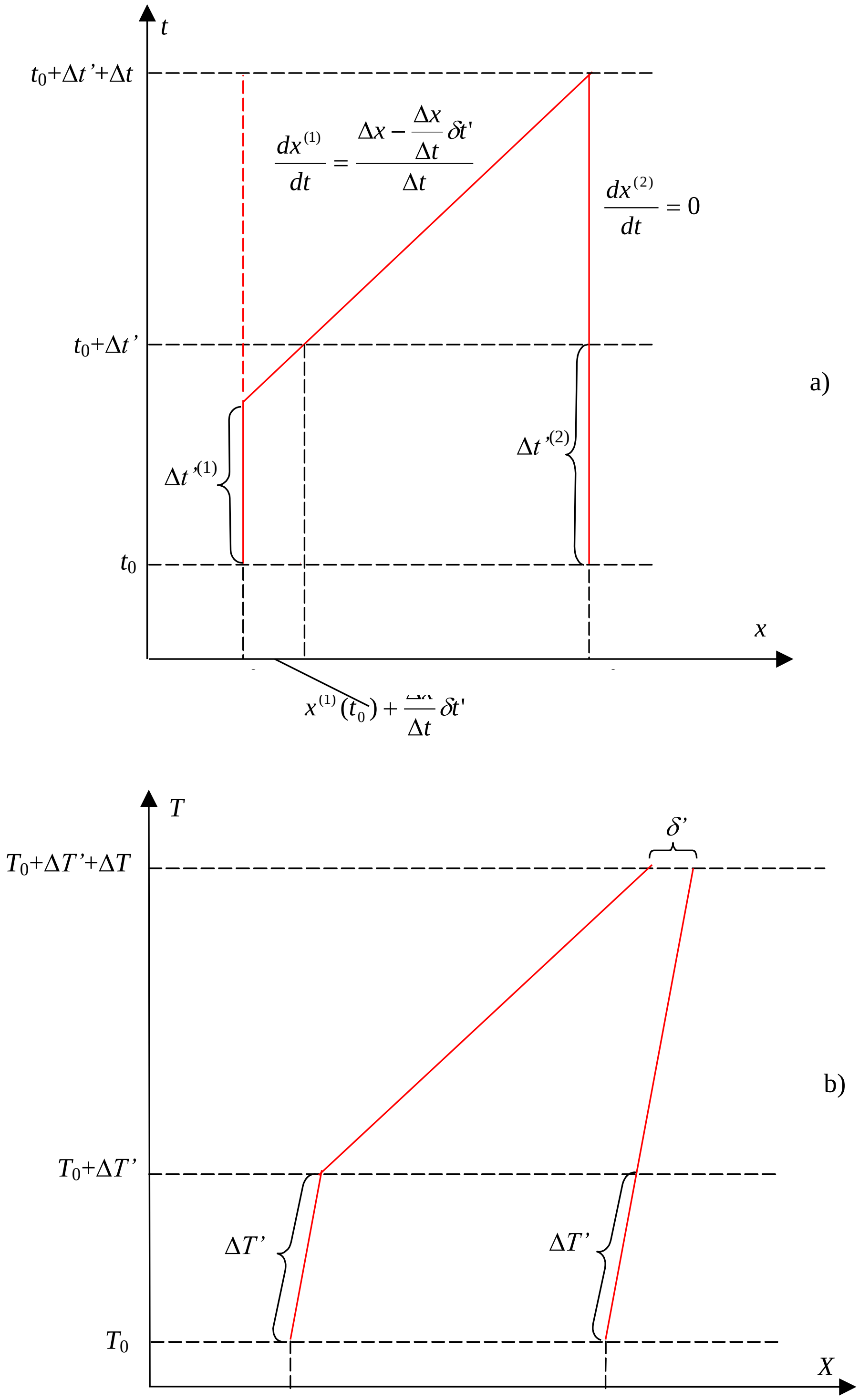

Fig. 3. The world lines $x^{(1)}(t), x^{(2)}(t)$ for non-inertial observer (a), and the same world lines $X^{(1)}(t), X^{(2)}(t)$ for inertial observer (b). The world line $x^{(1)}(t)$ has a "fracture" point, corresponding to event of emission of light.

3. Special example demonstrating a violation of the causality principle in relativity theory

Present Section will deal with a rigid non-inertial reference frame progressively moving at the constant (in relativistic meaning) acceleration *a*.

By definition, in a rigid frame the proper distance between two spatial points (measured by means of a scale being at rest in this frame) does not depend on time. Let us define such a rigid frame by the relationships [4]

$$x^\alpha = x'^\alpha; t' = 0; t = \tau, \tag{29}$$

where primer space and time coordinates belong to successive instantaneously co-moving inertial reference frames, while τ stands for the proper time at the origin of coordinates. In such definition, for the case of constant (in instantaneously co-moving inertial frames) acceleration *a* along the axis *x*, a relationship between space-time coordinates in a fixed inertial reference frame (*T*, *X*, *Y*, *Z*) and (*t*, *x*, *y*, *z*) takes the form [4]:

$$dT = dt(1+\frac{ax}{c^2})ch\frac{at}{c} + \frac{dx}{c}sh\frac{at}{c}, \tag{30}$$

$$dX = cdt(1+\frac{ax}{c^2})sh\frac{at}{c} + dxch\frac{at}{c}, \; dY = dy, \; dZ = dz. \tag{31}$$

The metrics of space-time determined by eqs. (30), (31), is the following:

$$ds^2 = c^2 dt^2 (1+\frac{ax}{c^2})^2 - (dx)^2 - (dy)^2 - (dz)^2. \tag{32}$$

The corresponding components of the metric tensor are:

$$g_{00} = (1+\frac{ax}{c^2})^2; g_{0\alpha} = 0; g_{11} = g_{22} = g_{33} = -1, \text{ all others } g_{\alpha\beta} = 0. \tag{33}$$

The physical values are defined by eq. (2). Substituting the components of metric tensor from (33) into (2), we obtain

$$dx_{\text{ph}} = dx, \; dy_{\text{ph}} = dy, \; dz_{\text{ph}} = dz; \tag{34}$$

$$dt_{\text{ph}} = dt(1+\frac{ax}{c^2}). \tag{35}$$

Now let us consider the following particular problem in such an accelerated frame.

Let a short light pulse be emitted from the point *x*=0 along the axis *x*. Let a number of remitters of light RL_m be located along the *x*-axis in some points x_m (RL_0 is located in the point *x*=0 and, for simplicity, all $\Delta x_m = x_{m+1} - x_m$ are equal to each other). When a light pulse arrives at each remitter, it is absorbed by it, and after a fixed interval of its own time $\Delta\tau_0$ is emitted by RL along the *x*-axis again.

Further, let the second light pulse be emitted from the point *x*=0 at such moment of time (taken as *t*=0), when the first light pulse has a co-ordinate

$$0 \langle \Delta x \le x_1. \tag{36}$$

One requires to find the times t_1 and t_2, where t_1 is the moment of time when the first (right) light pulse is emitted by RL_n, while t_2 is the moment of time when the second (left) pulse is reaching RL_n, and n is some number.

Due to the condition (36), the most general expression for t_1 can be written as

$$t_1 = t_{x_1-\Delta x} + \sum_{m=1}^{n-1} t_m + \sum_{m=1}^{n} \Delta t_m, \tag{37}$$

where $t_{x_1-\Delta x}$ is the propagation time of the first (right) light pulse from the point Δx to point x_1, t_m is the propagation time of the right pulse from RL_m to RL_{m+1}, and Δt_m is the time interval $\Delta\tau_0$ for RL_m, remitting the right pulse. The general expression for t_2 is:

$$t_2 = t'_{x_1-0} + \sum_{m=1}^{n-1} t'_m + \sum_{m=0}^{n-1} \Delta t'_m, \tag{38}$$

where t'_{x_1-0} is the propagation time of the second (left) light pulse from the point x=0 to point x_1, t'_m is the propagation time of the left pulse from the RL_m to RL_{m+1}, and $\Delta t'_m$ is the time interval $\Delta\tau_0$ for RL_m, emitting the left pulse. From (37) and (38)

$$t_2 - t_1 = \Delta t + \sum_{m=1}^{n-1} (t'_m - t_m) + (\sum_{m=0}^{n-1} \Delta t'_m - \sum_{m=1}^{n} \Delta t_m), \tag{39}$$

where $\Delta t = t'_{x_1-0} - t_{x_1-\Delta x}$.

Now let us ask the question: is it possible to implement the equality $t_2 - t_1 = 0$? It is obvious, such equality would mean an absolute event: a meeting of both light pulses considered in the spatial point x_n. Further, we will additionally solve the problem about possible equality of t_1 and t_2 in an external inertial reference frame and compare the obtained results for both non-inertial and inertial observers.

A solution of this problem for non-inertial observer attached with the chain of re-emitters can be obtained from eqs. (33-35). First of all, we get

$$\sum_{m=1}^{n-1} (t'_m - t_m) = 0 \tag{40}$$

due to independence of metric tensor on time (eq. (33)).

The intervals of physical time in different points are determined by (35). Hence, the physical values

$$\Delta\tau_0 = \int_0^{\Delta t_m} dt_{ph}(x_m) = \Delta t_m (1 + \frac{a x_m}{c^2}), \tag{41}$$

and

$$\Delta t_m = \frac{\Delta\tau_0}{1 + a x_m / c^2}. \tag{42}$$

Therefore, $\Delta t'_m$ and Δt_m are equal to each other, and the third term in the right part of (39) is equal to

$$\sum_{m=0}^{n-1}\Delta t_m - \sum_{m=1}^{n}\Delta t_m = (\Delta\tau_0 + \sum_{m=1}^{n-1}\Delta t_m) - (\sum_{m=1}^{n-1}\Delta t_m + \Delta t_n) = \Delta\tau_0 - \Delta t_n = \Delta\tau_0 \frac{ax_n}{c^2}\left(\frac{1}{1+ax_n/c^2}\right). \quad (43)$$

Substituting the obtained values (40), (43) into (39), one gets:

$$t_2 - t_1 = \Delta t + \Delta\tau_0 \frac{ax_n}{c^2}\left(\frac{1}{1+ax_n/c^2}\right). \quad (44)$$

Hence, the left and right light pulses will meet in the point

$$x_n = -\frac{\Delta t c^2}{a(\Delta\tau_0 + \Delta t)}. \quad (45)$$

Thus, an observer in the origin of coordinates of the accelerated frame will detect the absolute event: the left and right light pulses will meet in the point defined by eq. (45) (under negative sign of the acceleration *a*). As example, Fig. 4 shows a meeting of the right and left light pulses in the point x_n under n=4.

Now let the process of light pulses propagation in the accelerated frame be observed from some external inertial reference frame. Furthermore, let us choose for observing the light pulses propagation process an inertial frame K, such that at the time moment when an observer sees the appearance of the left light pulse in the point x=0, he simultaneously sees an arriving right pulse to RL_1 (such a choice is always possible due to condition (36)). For this time moment, let us introduce into consideration the second inertial frame K_s shifted along the axis *x* at such a distance (with respect to K) which is equal to the distance between RL_0 and RL_1. (The relative velocity of K and K_s is equal to zero). Due to the space homogeneity in inertial frames, such a shift is equivalent to re-numeration of the remitters in K_s: the RL_m (in K) be RL_{m-1} (in K_s). Hence, the propagation time from RL_0 to RL_{n-1} for the left pulse is exactly equal to the propagation time from RL_1 to RL_n for the right pulse in both K and K_s frames (since the RL_1, RL_n in K are the RL_0, RL_{n-1} in K_s). Hence, at the moment of time (in K) when the right pulse is emitted by RL_n, the left one is emitted by RL_{n-1} for any *n*. Therefore, these light pulses will never meet in the inertial frame K.

Conclusion

Thus, the invented special problem about two light pulses propagation in a rigid uniformly moving non-inertial reference frame confirms the obtained in Section 2 general conclusion about violation of the causality principle in the processes dealing with emission/absorption of light. Therefore, the relativity theory cannot be accepted as physically correct.

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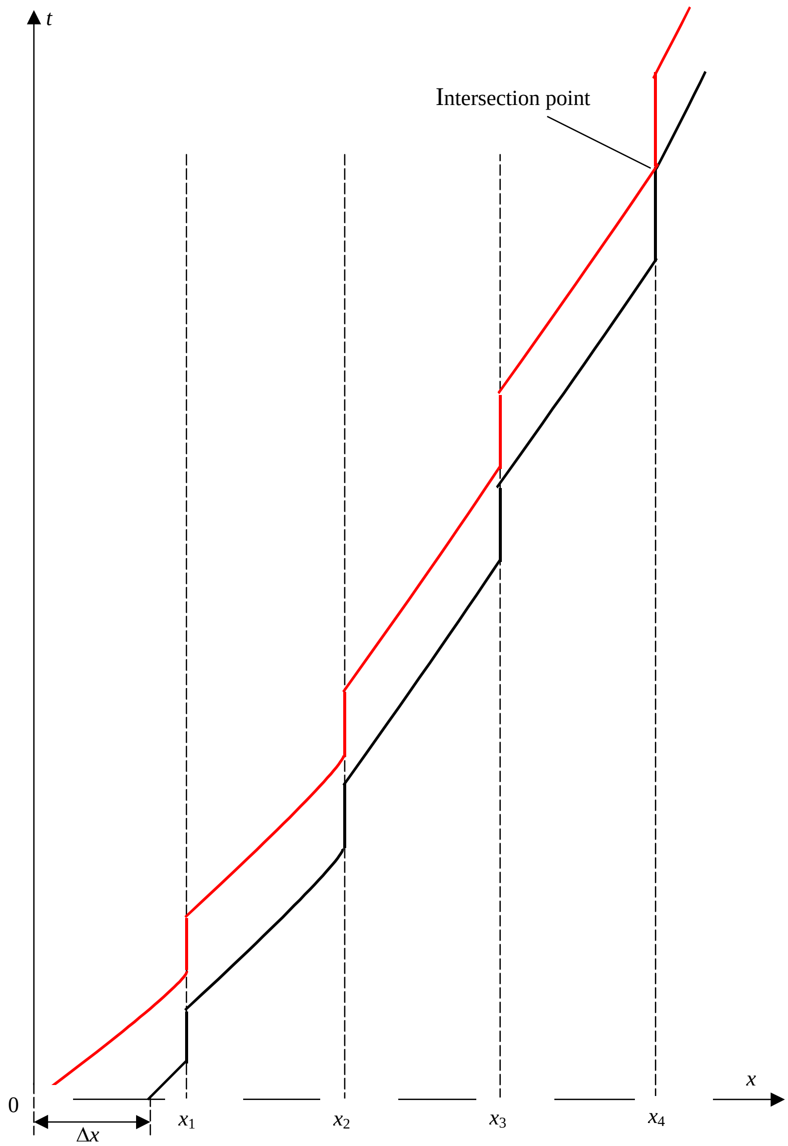

Fig. 4. Example, demonstrating an intersection of the right and left light pulses in the point x_n under n=4.