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OPERATIONAL APPROACH TO RELATIVE KINEMATICS

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Though Poincare [1] underlined the convention of isotropy of light velocity even before the creation of Special Theory of Relativity (STR), it is often under discussion [2] in recent time. Under convention one understands a theoretical statement which may be replaced without contradiction with experiment by another inconsistent with the first one. If a light anisotropy convention is accepted, it leads to a different from that within STR synchronization convention. Therefore, a comparison of time and space coordinates in two reference frames (r.f.) will also include different from STR convention [2]. Thus the principal conceptions (simultaneity of events, time, velocity, length) within STR imply elements of convention. It is very difficult to distinguish them from theory statements. This may explain an endless discussion on principal problems of STR [3]. This situation is unsatisfactory, since in general sense the convention may be excluded at least from experimental predictions of the theory.

The aim of this paper is to give a systematical description of kinematics avoiding, if possible, convention conceptions and using postulates allowing an experimental test. Principal definitions and conceptions will be introduced according to operational principle, i.e., on consideration of experimental procedure with which the corresponding values may be measured. A "radiolocation" method [4] will be used for coordination of events (ev.). A variety of standard clocks and electromagnetic signals (γ) will be the only measuring apparatus.

The properties of γ-signals are postulated in item 3 (i.3). The characteristics of clocks are given by the definition of the standard clock (i.1) and by a postulate (i.3) of "equal rights" of clocks in the experiment on observation of Doppler effect for the two close clocks flying away from a point (p.). At first a conception of the relative motion of two points is introduced only for such clocks. Then after the introduction of the definition of a reference frame (i.5) and under assumption (i.4) of Euclide geometry a method is developed for the coordination of events in remoted arbitrarily moving points.

We shall try to formulate in an evident form the most important definitions, assumptions, and postulates. The definitions will be indicated with the number of the type [D1.1]; assumptions and postulates, [A2.3]; theorems referred to, [3.1]. References to them are made with numbers in round brackets.

1. Registration of coincidence of some event with a clock "strike", or its occurrence between the clock "strikes", is an elementary experimental procedure. Any kinematical measurement means to get such data for different clocks at different sites. First of all one should define the requirements for the standard clock to satisfy. For this purpose let us consider an aggregate $(0,1,2,\dots k \dots \ell \dots)$. of cycle processes in which any cycle leads to an event in some point O. Let there be registered in point O n_ℓ neighbour events of ℓ-th cycle between n_k neighbour events of k-th cycle. [D1.1] - This aggregate of processes can be used as a clock in point O if ratio n_k/n_ℓ should be invariable with a variation of physical conditions. In kinematics it is important to check up the constancy of these ratios under different clock replacements and, in particular, with a variation of clock motion.

We cannot make a definition for motion or acceleration without having defined the standard clock. Therefore we cannot speak about the constancy of n_k/n_ℓ for a clock, e.g., moving with an acceleration of 980 cm/sec^2. But we can state constancy of n_k/n_ℓ for the clock falling under Earth gravity. Experiments of this type can be performed only with an aggregate of processes /5/. So, only an aggregate of processes is called a clock.

Besides a comparison of different processes of one clock a comparison may be drawn of the corresponding processes of two clocks A and B, if point A and B coincide. [D1.2] - Then for the standard clock the following equation must hold $n_k(A)/n_k(B)=1$. Further we shall operate only with standard clocks.

A certain quantity M (scale coefficient) is usually assigned to the neighbouring events ("strikes") of a given process $(k=0)$ and the interval between them is said to be equal to M time units. The equality of scale coefficients of standard clocks A and B, if points A and B coincide, follows from a comparison of corresponding processes of these clocks $(n_k(A)/n_k(B)=1)$. If, then, the clocks are spaced, there is no experiment setting limits for the choice of a scale coefficient for them. The simplest way is to take the same coefficients, but it still remains a convention /6/. Frequency taken as a number of events per unit time implies the same convention. But the experiment operated only with the frequency ratios (of the type n_k/n_ℓ) which is naturally independent of scale coefficient convention.

Having this in mind one may easily in the very beginning exclude from theory the discussed convention. [D1.3] - For this purpose let us define the time interval by clock of p. 0 $\tau_{12}(0)$ between the events 1 and 2 in point O as a number of "strikes" of a given standard clock process $(k = 0)$ between the events 1 and 2, or as a ratio n_0/m, if events 1 and 2 are periodical and one counts m such events between n_0"strikes". The time interval is expressed (either exactly or approximately) through a rational number. Since according to the above statement the definition of the time characterizes the relationship between the measured events and clock processes, then the question of self-congruence of clock readings (scale coefficient constancy) with clock replacement has no sense, as well as that of the congruence of readings of the two spaced clocks. So, this conception of time differs from that widely accepted [6,7].

If events a and b occur at different sites, then the experimental connection between them and a given clock can be established only with the help of signals (e.g., γ-signals). This connection is characterized by two events of γ-signal departures from the clock of point O towards the points of events a and b and two events of γ-signal arrivals at clock site being reflected from points in which events a and b occur. Let us introduce the following denotions: $\tau^-_{ab}(0)$ is the time interval of the clock at O between the departures; and $\tau^+_{ab}(0)$, between the arrivals of γ-signals. [D1.4] - We shall call them signal coordinates of events a and b. These denotions though cumbersome appear to be convenient, since reflect the experimental procedure and help to avoid confusion. We shall also use these denotions in the case if only one event occurres out of clock point (see fig.1a, $\tau^-_{14}(0) \equiv \tau_{12}(0)$, $\tau^+_{14}(0) \equiv \tau_{13}(0)$).

2. Let us define the relative motion of two close points A and O for the case of point A moving through and away from point O. There (fig.1a) by the clocks at A and O only $\tau^-_{14}(0)$, $\tau^+_{14}(0)$, $\tau_{14}(A)$ may be measured. [D2.1] - We shall call $\ell_4(0) = (\tau^+_{14}(0) - \tau^-_{14}(0))/2$ the location coordinate of event 4 (in point A) with respect to point O. [D2.2] - Limits $\mu^-_A(0)$, $\mu^+_A(0)$, $\mu_A(0)$, to which ratios $\ell_4/\tau^-_{14}(0)$, $\ell_4/\tau^+_{14}(0)$, $\ell_4/\tau_{14}(A)$ tend to with decreasing τ^-_{14}, are the quantitative characteristics of motion of point A and γ-signals with respect to point O. But to avoid complicated terminology we shall speak about the motion of point A with respect to point O.

$$\ell_4(0) = \mu^-_A(0)\,\tau^-_{14}(0) = \mu^+_A(0)\,\tau^+_{14}(0) = \mu_A(0)\,\tau_{14}(A) \tag{1}$$

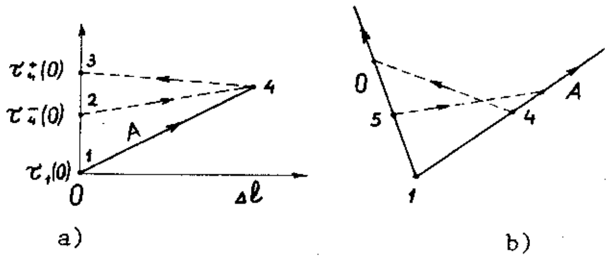

Fig.1

3. Let us postulate the following features of the experiment on γ-signal exchange between moving points. [A3.1] - The motion of a source of γ-signal does not affect the propagation of γ-signal. Therefore, it is convenient to use γ as a signal. [A3.2] - If clocks in points A and O in a relative motion exchange γ-signals in a short enough time after coincidence (ev.1) (fig.1b), then

$$\tau_{14}(A)/\tau^{+}_{14}(0) = \tau_{15}(0)/\tau^{+}_{15}(A).$$

That is, the clocks have "equal rights" in such experiment. In particular, we insist on satisfying (A3.2) either for clocks of points A and O moving uniformly or with acceleration relative to other points.

[3.1] - From eqs. (1) and (A3.2) one gets a particular case of the Doppler effect and the relationship of the characteristics of motion.

$$\tau_{14}(A) = \tau^{+}_{14}(0)\sqrt{\mu^{+}/\mu^{-}} = \tau^{-}_{14}(0)\sqrt{\mu^{-}/\mu^{+}}, \tag{2}$$

$$\mu_{A}(0) = \mu_{0}(A), \quad \mu^{2} = \mu^{+}\mu^{-}, \quad 1/\mu^{+} - 1/\mu^{-} = 2. \tag{3}$$

If a point moves slower than γ-signal, then possible μ^{-}, μ^{+}, μ corresponding to it lie in the intervals $(0,\infty)$, $(0,½)$, $(0,\infty)$, respectively. Following this and relation (1) it is clear that particle A living the shortest possible time ($\tau_{14}(A) \to 0$) may have finite $\ell_{14}(0)$. This explains the observation near the Earth's surface of μ-mesons born in the upper atmospheric layers without refering to the "slowing of the time".

4. [D 4.1] -Points A and B are at rest with respect to each other, if the time interval between the departures of two γ-

signals from one point (τ_{12}(A) or τ_{34} (B)) is equal to that between the arrivals of these signals to the other point (τ^{+}_{12}(B) or τ^{+}_{34}(A)). As a result the location coordinate of any event in one point relative to the other does not change with time. [D 4.2] - Then the location coordinate is called the distance between the points. Further we shall use the term "distance" only speaking about this location coordinate. [A 4.1] - Suppose that some set of points at rest can be imaged as a set of mathematical points in the three-dimensional space. [D 4.3] - A straight line is defined as an image of points of the trajectory of γ-signal. [D 4.4] - A metric is introduced by assigning the distance between the points at rest to the corresponding mathematical points. Having this in mind we shall speak about the space of resting points. After the introduction of definitions for a straight line and distance the question about the geometry of space is decided by the experiment. [A 4.2] - We propose the Euclide geometry.

5. [D 5.1] - If in the system of points at rest the times of γ-signal flight along the closed trajectory in both directions are equal, then a points of this system used for the measurement (and the clock placed in it) will be called the system of reference (s.r.). Going a little ahead (i.8) let me note that for the points rotating uniformly along the circumference the above is not true and thus they, though at rest relative to each other, cannot be used as a system of reference. Speaking about s.r. we shall mark it with some point A of this system, i.e., (s.r.p.A).

[5.1] - From such definition of the system of reference it directly follows that: a) The time of γ-signal flight along a closed trajectory in a given s.r. is equal to the length of the trajectory; b) Two γ-signals sent from one point but along different paths come to the other point in times which difference is equal to the difference of paths covered by them; c) For three events 1,2,4 (points 1 and 2 belong to s.r.), one may write down the following relationship of the "triangle" for the measured coordinates of γ-signal (D1.4)

$$\tau^{+}_{14}(1) + \tau^{-}_{14}(1) - \tau^{+}_{12}(1) - \tau^{-}_{12}(1) = \tau^{+}_{24}(2) - \tau^{-}_{24}(2) . \qquad (4)$$

To coordinate K events in the points of s.r. it is quite enough to know the relative coordinates of γ-signal $\tau^{+}_{12}(1)$, $\tau^{+}_{21}(2)$ (or $\tau^{-}_{12}(1)$, $\tau^{-}_{21}(2)$, see D4.1) for each pair of events 1 and 2, i.e., on the whole K(K-1) values. But for each three events one has the relationship of the type (4) for the coordinates of γ-signal. So, to coordinate three events (let's call them basis events, if they are not lying on one straight line) one needs to know 5, but not 6 quantities.

One can easily show that there are only 3 independent equations for four events (tetrahedron, 4 triangles). Having this in mind let us consider K points. So, we have $(K-1)(K-2)/2$ triangles with a summit in the K-th point. An independent equation corresponds to each of them since each has a variable not belonging to others. Any triangle without the K-th point forms a tetrahedron with the K-th point. Thus to this triangle there corresponds an equation dependent on other three equations for triangles forming the tetrahedron. [5.2] - Thus owing to equations of the type (4) for K events only $5+4(K-3)+$ $+(K-3)(K-4)/2$ quantities from $K(K-1)$ possible coordinates remain independent. [5.3] - The fact that the space of the points at rest is three-dimensional (the assignment of the location of points 4 and 5 relative to basis points leads to the knowledge of r_{45} and consequently to equation $2r_{45} = \tau^{+}_{45}(4) - \tau^{-}_{45}(4)$) leaves only $5+4(K-3)$ independent quantities: 5 - to coordinate the basis events, while to each of the rest $(K-3)$ events there correspond 4 quantities which are enough to coordinate them with respect to basis points.

The signal coordinates are in relation with the basis, since they change on passing to other basis points belonging to the same s.r. But the distance between the points 4 and 5 is invariant. [5.4] - One more quantity invariant to the change of basis points may be composed of the signal coordinates of events 4 and 5 (equations of the type (4) is used for the events 1,2,4 and 1,2,5): $2T_{45} = \tau^{+}_{\alpha 5}(A) - \tau^{+}_{\alpha 4}(A) + \tau^{-}_{\alpha 5}(A) - \tau^{-}_{\alpha 4}(A)$.
This quantity depends neither on the choice of point A in the system in which $\tau^{+}_{\alpha 5}$, $\tau^{+}_{\alpha 4}$, $\tau^{-}_{\alpha 5}$, $\tau^{-}_{\alpha 4}$ are measured, nor on the event α in point A to which the times are refered.

To indicate other invariants let us introduce some quantity $T_{45}(\eta) = T_{45} - (\bar{r}_{45}\bar{\eta})$, where $\bar{\eta}$ is the arbitrary vector with $|\eta| \leq 1$, ($\eta = 0$ is usually omitted in the denotions). [5.5] - $T(\eta)$ has the following properties: a) If interaction propagates from ev.4 to ev.5 slower than γ-signal, then $T_{45}(\eta) > 0$; b) Equation $T_{45}(\eta) + T_{56}(\eta) = T_{46}(\eta)$ holds for any event 4,5,6; c) if events 4 and 5 occur in the same point A, then $T_{45}(\eta)$ equals to the time interval $\tau_{45}(A)$. Therefore $T(\eta)$ is a convenient time coordinate. $T(\eta)$ is conventional because one may take different $\bar{\eta}$ with one and the same experimental data about events 4 and 5, defined by signal coordinates.

In i.i.2 and 3 we considered the relative motion of two points in the vicinity of these points. Now in the system of reference we may describe the motion of any point with the help only of readings of three clocks placed in the basis points. But this will be possible after investigating with the help of a set of points at rest belonging to any s.r. the geometry of the part of the world where we make experiments.

Let us note that here differently from STR we defined s.r. consequently and with kinematical methods only.

6. One may easily show that the measurement of the time coordinate t_{45} in STR is a particular case of the procedure of measuring T_{45}. Therefore, the procedure of time coordination in STR may be simplified by measuring T_{45} with any clock of s.r. (instead of t_{45} measured by two clocks in points 4 and 5). Then the role of γ-signal transmission in all kinematical measurements is much emphasized. Usual two-step procedure of measuring t_{45} in STR (clock synchronization, taking time) separates γ-signal transmission and time measurement. Therefore the time coordinate T_{45} being invariant (5.4) is imperceptible in STR, but an emphasis is made on clock synchronization which is not unnecessary.

After synchronization in the case of remoted events only these two events are considered in taking time (as it is with events in the clock point). Then one by mistake may think that there is no essential difference between taking time t by one or two clocks. But as it was shown earlier (5.4) in the measurement of $T(\eta)$ for remoted events there appear four events (differently from the measurement of the time interval between the events in the clock point) and the convention for η is used (similar to synchronization convention [2]).

A velocity $V(\eta) = r_{45}/T_{45}(\eta)$ as a characteristic of motion differs from μ^+, μ^-, μ by the fact that it reflects the time coordinate choice convention. For example, if some points have μ different only in direction, then their $V(\eta \neq 0)$ differ in value (describable not observable anisotropy [2]). At $\eta=0$ $V(\eta)$ coincides with that in STR, if the velocity of light is accepted to be unity.

7. Let us underline the advisability of defining (D1.3) the time interval as a difference of readings of one and the same clock and compare it with other possible definitions. Under assumption of infinitely fast signal within absolute time conception the time interval $\tau^+_{45}(B) = \tau^+_{45}(C)$ is independent of the choice of point and of its motion and is rigidly correspondent to two events (even remoted) 4 and 5. In this case it is advisable to define the time interval as a difference of times of signal arrivals from these events (unlike D 1.3).

The employment of γ-signals to establish the correspondence between the events and distant clock makes the matter different. If events 4 and 5 take place in the point A of s.r. (of points A,B,C), then according to the properties of points at rest $\tau_{45}(A) = \tau^{+}_{45}(B) = \tau^{-}_{45}(B) = \tau^{+}_{45}(C)$. In this particular case the time interval will be the same according to both definitions. But for remoted events (in the s.r.) both definitions are unacceptable: the former, due to the fact that $\tau^{+}_{45}(B) \neq \tau^{+}_{45}(C)$; the latter (D 1.3), due to the absence of clocks (in this s.r.) in which point both events occur.

Is it reasonable in this situation to call the time coordinate $T_{45}(\eta)$ the time interval and consider events 4 and 5 simultaneous (if $T_{45}(\eta)=0$)? Then to avoid a set of "times" in one s.r. (different η) sometimes the preference of case $\eta=0$ is tried, because in Minkowsky space an orthogonal coordinate system corresponds to it. Under this definition of $T(\eta=0)$ is prefered to many time coordinates and the time coordinate T is not different from clock readings τ.

The condition $\eta=0$ (or any other) is introduced for convenience only (orthogonal coordinates) and is a convention. Main objection to unification within one conception of the time interval τ (D1.3) and time coordinate T (5.4) is the essential difference in measuring procedure. Besides τ is free of convention on $T(\eta)$. So, it seems reasonable to refuse from conception of time for remoted events and distinguish the time coordinate from the time interval.

8. The expression (2) describes the experiment on transmission of γ-signal between the clocks, flying away from the point. A system of reference allows one to describe the general case of γ-signal exchange between remoted clocks, if one knows the motion of the source $(\mu_A(0))$ and of the detector $(\mu_B(0))$ in some s.r. of any point O.

$$\tau_{12}(A)\sqrt{1+\mu_A^2(0)} + r_{24}(0) = \tau_{34}(B)\sqrt{1+\mu_B^2(0)} + r_{13}(0), \quad (5)$$

where events 1 and 2 are the γ-signal departures from p.A; and events 3 and 4, γ-signal arrivals at point B.

A relationship for the Doppler effect is obtained from (5) when r_{12}, $r_{34} \ll r_{24}$, r_{13} (e.g., r_{12} and r_{34} tend to 0):

$$\tau(A)\left(\sqrt{1+\mu_A^2(0)} - \mu_A(0)\cos\alpha(0)\right) = \tau^{+}(B)\left(\sqrt{1+\mu_B^2(0)} - \mu_B(0)\cos\beta(0)\right). \quad (6)$$

Here angles α and β are taken from trajectory of the signal to that of p.A and p.B, respectively; μ_A, α are taken between the events of γ -signal departures and μ_B, β - between γ -signal arrivals. [8.3] - Using (6) one may easily derive formulas for Mössbauer rotor experiments. In particular points rotating uniformly about circumferences satisfy the condition (D 4.1) for the points at rest with respect to each other.

From (6) it follows that the points belonging to one s.r. in another one keep the same value and direction of motion, and vice versa, if points experience the same motions in a s.r., then they may be used as the points belonging to another s.r.

9. Considering experiments in s.r.p.A and s.r.p.B one may obtain the relationship for γ -abberation using the fact that ratio $\tau(A)/\tau^{+}(B)$ in (6) is the same in both s.r.:

$$|\sqrt{1+\mu^2}-\mu\cos\phi(A)||\sqrt{1+\mu^2}-\mu\cos\phi(B)|=1 . \qquad (7)$$

This formula describes the relation of angle $\phi(B)$ between γ and $\mu_A(B)$ directions in s.r.p.B with $\phi(A)$ between the same γ and $\mu_B(A)$ directions in s.r.p.A ($\mu_A(B) = \mu_B(A) = \mu$; $\phi(A)$ and $\phi(B)$ are different angles and not one and the same angle in different s.r.).

10. Actually the principal postulate (A 3.2) considered to be stated the existence of pairs of "equal in rights" (symmetric) experiments in the exchange of γ-signals between close moving points. But this may be true for remote points also. From (6) (scheme for γ-exchange is shown in fig.2, in the bottom s.r.p.O, in the top s.r.p.A) it follows that, if there exist the events 1-8 that $\phi_{78}(0)=\phi_{34}(A)$, $\mu_{78}(0)=\mu_{34}(A)$ then

$$\tau_{12}(A)/\tau_{34}(0)=\tau_{56}(0)/\tau_{78}(A). \qquad (8)$$

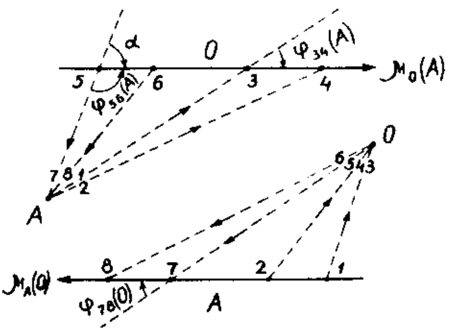

Fig.2

This condition may be satisfied, if p.A and p.O do not change their motion. If one chooses $\tau_{12}(A)=\tau_{56}(0)$, then experiments of exchange γ_{13}, γ_{24} from p.A to p.O and γ_{57}, γ_{68} from p.O to p.A will be symmetric. Relative to such experiments s.r. of p.O and p.A have "equal rights".

At $\phi_{12}(0)=\phi_{56}(A)=90°$ (transverse Doppler effect) both relations in (8) will be less than unity. These facts are "absolute" (both may take place in any s.r.). Each time interval in (8) is taken between their own pair of events, therefore, the transverse Doppler effect cannot be interpreted as a relative returdation of clocks.

If p.O moves with acceleration, e.g., between the events 6 and 3 (the time of existence of s.r.p.O is limited), then there is no symmetric experiment on sending γ_{57}, γ_{68} signals, i.e., "equal rights" of clocks of p.A and p.O are destroyed. The like case resulting in clock returdation will be considered in the following item.

11. A comparison (basing on 3.1 and D 5.1) of readings of clock O of some s.r. with those of a travelling clock of p.A passing through p.O (event 2) and back to p.O (event 3) gives the expression:

$$\tau_{23}(0) = \int_0^{\tau_{23}(A)} \sqrt{1+\mu_A^2(0)}\, d\tau(A)\,. \qquad (9)$$

From (9) it follows that at $\mu > 0$ the clock in p.A is slow $\tau_{23}(0) > \tau_{23}(A)$.

The fact that the clock in p.A is slow is not connected with accelerated motion of p.A (action of forces). Similar fact takes place for the sum of readings of the set of clocks moving together with the clock of p.A, but each clock in the set moves uniformly accompanying p.A along the "straightened" infinitely short parts of the trajectory. Here we make use of the postulates reported in i.i.1,3 of equal properties of either accelerated (but not destroyed) or not accelerated clocks. Note, in STR one cannot predict the behaviour of an accelerated clock basing on the principle of relativity only.

If one considers a travelling twin (or meson) as a set of not desctroying clocks, then comes to the conclusion that the travelling brother having returned and outlived his twin brother (resting in s.r.) will not succeed to do more during his lifetime than the other did in his (relative frequencies of not destroying processes do not change (D 1.1) with motion).

12. Considering the measurement of signals coordinates τ^+, τ^- for event 4 and 5 using clocks of s.r.p.A and s.r.p.B moving relative to each other (μ) one obtains the following relationship

$$\tau_{45}^+(A)+\tau_{45}^-(A) \pm (\tau_{\alpha 4}^+(A)-\tau_{\alpha 4}^-(A)) = [\tau_{45}^+(B)+\tau_{45}^-(B) \pm (\tau_{\beta 4}^+(B)-\tau_{\beta 4}^-(B))]\sqrt{\frac{\mu^\pm}{\mu^\mp}},$$

$$\tau_{\alpha 5}^+(A) = \tau_{\beta 5}^+(B)\,. \qquad (10)$$

Here p.A and p.B (events α and β in them) are taken so that the direction of $\gamma_{\alpha 5}$ sent from p.A (ev. α) to ev. 5 forms with $\gamma_{\alpha 4}$ an angle of 90° in s.r.p.A (directions of $\gamma_{\alpha 4}$ and $\mu_B(A)$ coincide) and the direction of $\gamma_{\beta 5}$ sent from p.B (ev. β) to event 5 forms with $\gamma_{\beta 4}$ an angle of 90° in s.r.p.B. In order to obtain eq. (10) it is quite enough to assume the Euclide geometry for one s.r. only.

Let us take the Cartesian axes of X(A), Y(A), X(B), Y(B) along the directions $\gamma_{\alpha 4}$, $\gamma_{\alpha 5}$, $\gamma_{\beta 4}$, $\gamma_{\beta 5}$ respectively, and introduce the following denotions for the location coordinates of events 4 and 5 relative to points A and B – $2x_{45}(A) = r^{+}_{\alpha 4}(A) - r^{-}_{\alpha 4}(A)$, $2y_{45}(A) = r^{+}_{\alpha 5}(A) - r^{-}_{\alpha 5}(A)$. Then the relationship (10) is transformed into the expression which confirms the Lorentz transformations, if $\eta = \eta' = 0$

$$T_{45}(A,\eta) + \bar{r}_{45}(A)\,\bar{\eta} \pm x_{45}(A) = (T_{45}(B,\eta') + \bar{r}_{45}(B)\,\bar{\eta}' \pm x_{45}(B))\sqrt{\frac{\mu^{\pm}}{\mu^{\mp}}}\,, \tag{11}$$

$$y_{45}(A) = y_{45}(B)\,.$$

The relationship (10) shows the relativity of signal coordinates, i.e., their dependence on s.r. used. But the form of transformations (11) for T, x, y is dependent on both this relativity and choice convention for $\eta(A)$ and $\eta'(B)$. Speaking about the relativity of T, r^{+}, r^{-} (e.g., $T_{45}(A) = 5$ s, $T_{45}(B) = 6$ s) one should keep in mind that the term "second" in this paper does not mean a common scale for clocks in p.A and p.B. It indicates only the type of standard clocks we use in points (i.1).

The location coordinates $x_{45}(A)$, $y_{45}(A)$ coincide in value with distances between point A and the points in s.r.p.A when there events 4 and 5 occur (points 4 and 5). To events 4 and 5 in each s.r. correspond their own pair of points. Therefore, from the point of view of the present work, the statements about coordinates T, x, y made in STR on the basis of Lorentz transformations cannot be interpreted as a relative retardation of clock and relative contraction of rods. Indeed $T_{45}(A,\eta)$ and $T_{45}(B,\eta')$ do not coincide in both systems with time intervals (D 1.3) and coordinates $x_{45}(A)$ and $x_{45}(B)$ with the distances (D 4.2) between the ends of the rod. In the case of a nonclosed trajectory of clock motion there is no experimental operation on comparison of readings of two clocks between two events. And for a rod moving in some s.r. one cannot speak about its length (distance between its ends) in this system, so one can speak only about the difference between the location coordinates of some events at the ends of the rod.

From eqs. (10,11) it follows that the quantity S $(4S_{45}^2 = (\tau_{45}^{+} + \tau_{45}^{-})^2 - (\tau_{\alpha 4}^{+} - \tau_{\alpha 4}^{-})^2 - (\tau_{\alpha 5}^{+} - \tau_{\alpha 5}^{-})^2 = T_{45}^2 - x_{45}^2 - y_{45}^2)$ is invariant to the transition to another s.r. For the clock C moving uniformly and rectilinearly from event 4 to event 5 one has $S_{45} = \tau_{45}(c)$. Having in mind this and definition of μ it is easily seen that μ can be transformed as $\bar{r}_{45}$ vector with coordinates x_{45}, y_{45}.

13. From the point of view of the present paper in STR there are mixed together the conceptions of time (D 1.3) and time coordinate (5.4). And the term "time" is used for the time coordinate of a particular type $(\eta = 0)$. Identification of time τ and time coordinate $T(\eta = 0)$ in STR produces an illusion of a common basis (relativity of time) in the explanation of clock returdation, if they move uniformly and rectilinearly, of transverse Doppler effect, and of clock returdation, if they move along a closed trajectory. But this statement about "relativity of time retardation" is to a greater extent connected with the conventionality of T. And it is difficult to distinguish convention and relativity in Lorentz transformations (misunderstandings and paradoxes are often due to this). While relationships (10) are free of this convention and thus it is much easier to analyse experiments using experimental values of τ^{+}, τ^{-}, τ (i.i.8,9,10,11).

The reported construction of kinematics and STR bases on different axioms (definitions, postulates, assumptions). Nevertheless it is easy to follow the "correspondence" of some positions,- e.g., of the principle of relativity and "equality of rights" postulate for the clocks flying away from a point (A 3.2). The principle of relativity assumes the existence of several laboratories so "screened" from the surrounding universe that the latter does not affect the experiments inside the laboratories. But since no "screening" of gravitational field is possible, then one demands that either large masses should be far away or the size of a laboratory should be limited. In other words the principle of relativity has a local character, as well as the postulate of the "equality of rights".

14. In conclusion let us summarize some results:

a) The properties of clocks were postulated in two cases: comparison of periodical processes of clocks in the point (i.1); arbitrary motion of two clocks in the point (i.3). The knowledge of these local properties of clocks was sufficient to study the geometry in the system of points at rest and on its basis to obtain kinematical relationships containing only clock readings (τ, τ^{+}, τ^{-}).

b) The conception of the time interval appeared to be local also (defined in the point of the clock). This conception needs neither convention about the values of scale coefficients of standard clocks remote in space (or in time) nor synchronization convention.

c) This definition for the time in the point is enough for the coordination of events using three basis clocks and γ-signals. For time coordination of any events it suffices to have one clock in any s.r.

d) With measured τ^{+}, τ^{-} the coordinates of different form may be made depending on convention.

e) The analysis of measuring procedures makes necessary to distinguish both time coordinate from time and location coordinate from distance (i.i.4,7).

f) Kinematical experiments can be analysed without the conventional conceptions and statements of STR, i.e., simultaneity of remoted events, relativity of simultaneity, relativity clock retardation and rod contraction.

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