Measurement of the absolute speed is possible?

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Abstract One of popular problems, which are experimentally studied in physics in a long time, is the testing of the special relativity theory, first of all – measurements of isotropy and constancy of light speed; as well as attempts to determine so called "absolute speed", i.e. the Earth speed in the absolute spacetime (absolute reference frame), if this spacetime (ARF) exists. Corresponding experiments aimed at the measuring of proper speed of some reference frame in other one, including [the absolute speed] in the ARF, are considered in the paper.

Key words: informational physics, special relativity theory, spacetime, experimental testing

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1 Introduction

In [1 - 3] it was rigorously shown that Matter in our Universe – and Universe as a whole - are some informational systems (structures), which exist as uninterruptedly transforming [practically] infinitesimal sub-sets in absolutely infinite and absolutely fundamental "Information" Set. This informational conception allows to propose the physical model (more see [4], [5]), which, when basing practically only on Uncertainty principle, adequately depicts the motion and interactions of particles in the spacetime. In the model [subatomic] particles are some closed-loop algorithms that run on a "Matter's computer [6] hardware", which consists, in turn, of a closed chains of elementary logical gates – fundamental logical elements (FLE), which are some (distinct, though) analogues of C. F. von Weizsäcker's "Urs" [7 - 9]. The FLE's sizes in both – in the space and in the "coordinate" time (see below) – directions are equal to Planck length, l_P, $l_P = (\frac{\hbar G}{c^3})^{1/2}$ ($\hbar$ is reduced Planck constant - the elementary physical action, G - gravitational constant, c- speed of light in the vacuum); the time of the FLE's "flip" is equal to Planck time, $\tau_P, \tau_P = \frac{l_P}{c}$. Relating to the mechanics of fast particles/ bodies motion and interactions, the model allows to obtain basic kinematical and dynamical equation that were obtained in the Lorentz theory and the special relativity, but, at that, these equations are obtained basing on different principal suggestions and from the model a number of new inferences follow, including – that the real Matter's spacetime is absolute 4D Euclidian manifold and all material objects move in the 3D spacetime with absolute 3D speeds. The last is principally prohibited in the special relativity. In this paper a couple of experimental methods aimed at the testing this suggestion (as well, of course the testing of the SRT) is presented.

Spacetime. The introducing of the Space and the Time notions in the model [10] is quite natural – they are fundamental [that act on whole Set] logical rules/ possibilities that allow (and define or "implicitly govern" how to single out) to single out specific informational patterns / structures, for example, particles, in the main informational structure (i.e., Matter); at that taking into account both - fixed and dynamical – characteristics of the structures.
(We don't consider here the main problem of the Time notion definition, which follows from the logical inconsistence of any change in any, including material, system, including, for example, its spatial motion – that is discussed in a first approximation in [3]; and adopt here the existence of dynamical systems and of motions of objects at least as the experimental fact.)

As possibilities Space and Time realize themselves as some 4D-Emptiness (5D-?) where a dense 4D FLE lattice ("4D Aether") is placed – some analogue of "spin-network" [11], "causal set" [12], "Space-time points in causal space" [13], etc. the Space and Time possibilities are universal and "absolute", they exist "forever", since they exist also ("virtually") before a beginning and after an end of any specific informational structure, including – of Matter in our Universe. As the rules Space and Time establish that between informational fixed patterns (including material objects –particles, bodies, etc.) must be non-zero "space interval", between different states of a changing pattern must be non-zero "time interval" ("non-zero duration"). The time intervals always accompany every change of every changing pattern, so the constant increase of the time interval at the Matter's evolution sometimes is called as some self-independent "time flow"; tough this flow only accompanies changes of material objects and Matter as a whole. On the other hand since "Matter as computer" and every "automaton" in this computer, i.e. every material object and every system of objects "operate" with a stable "operation rate", measured concrete space and time intervals are useful at a description of processes that go in material systems as "the time" and " the space" variables that indicate changes of the objects in the 4D Euclidian spacetime spacetime, when any element of Matter – a particle, a molecule, a star, etc. – have its own space and time coordinates.

The space is 3D Euclidian manifold, when the time is "two-faced" – in Matter simultaneously two rules/possibilities "Time" act - "absolute (or "true") time" and "coordinate time". Absolute time defines that for any change in Matter (e.g., for a FLE's flip in any - "space" or "coordinate time" – direction) is necessary to spend same "true time interval". Since all material objects always move with identical speed in the 4D spacetime, the absolute time interval, which accompanies these processes, changes ("true time flows") for all Matter only in one ("positive", as that is accepted in physics now) direction by definition. The "coordinate time" is necessary because of to do reversible operations, which are logically incorrect, if only the true time acts, it is necessary to have corresponding rule that allows and defines such operations. This rule/possibility exists in our Matter and material objects can move in the coordinate time in both (direct and reversal, ±) directions – like along of a space direction, so this time constitute, with the space, Matter's "space-[coordinate]time", or further in the text - the "spacetime" (as well as below "time" as a rule is "coordinate time").

The time axis in the spacetime is orthogonal to any spatial line, including, naturally, to 3 [e.g., Cartesian] spatial axes (so the 4D spacetime is in reality "Cartesian"); what follows from the model's premise that FLEs have 4 independent degrees of freedom and from the experimentally measured the "rest mass" and "relativistic mass" relation, the equality of "transverse" and "relativistic" masses, etc. The absolute time isn't a coordinate in the model, though it can be fifth coordinate in a 5D spacetime, where all Matter's objects, since they uninterruptedly move, after Matter obtained at Beginning a portion of something, what in the physics is called "the energy", with 4D speeds that have identical absolute values, which are equal to the speed of light in the 4D spacetime, so move simultaneously (simultaneously being in one true time interval) with the speed of light along "true time coordinate" in positive direction.

2 Comparing of the SRT and the model

In this informational model Lorentz transformations can be obtained quite naturally, [4] if it is [rather reasonably] postulated that:

(1) The Matter exists and evolves in the [at least] 4D lattice of FLEs, at that every particle and every system of particles (material body) moves – as some disturbance of the lattice - through the lattice, and, because of the FLEs' sizes are identical, through 4D spacetime, with identical (by absolute value = the light speed in the vacuum, *c*) 4D speeds. At that in Matter there exist two main types of particles (and bodies that are systems of particles) – "T-particles" that were/ are created after an impacts with [on the lattice] the 4D momentums, which were/are directed along the *t*-axis (electrons, protons, etc.) and "S-particles", when the impacts momentums were/are spatially directed (e.g. photons); thus T-particles can move in the 1D [coordinate] time and in the 3D space simultaneously, when X-particles move in the 3D space only;

(2) The lattice – and the spacetime – don't depend on any Matter's bodies motion, they are absolute and constitute by this way for Matter absolute coordinate system(s) (ACS).

Insofar as the lattice is highly standardized for steps in any – time or space – direction (there is "equal footing"), there can be established "absolute reference frame" (ARF) which is at rest relating to an ACS and so it is inertial reference frame. There can be infinite number of equivalent ARFs and ACSs, as results of translations and/ or (*spatial only*) rotations of some ARF (ACS).

However such ARF cannot be realized in practice since every material object, including clocks, rules, observers [in certain sense], etc., are some material objects that always move in the spacetime/the lattice (excluding some exotic cases when some particles can be, in certain sense, at rest in the ACS if they are built from particles and antiparticles, e.g. – the mesons). Thus there is a sense to say only about "absolute" reference frames that are at rest only relating to one of the two main dimensions of the Matter's spacetime – at rest in the 1D time and at rest in the 3D space. The first version can be realized only if all constituents of s reference frame – clocks, rules, observer – are made, for example, from photons; what is evidently non-applicable in the physics; and there is a sense to seek for the ARFs that are at 3D spatial rest. Just these ARFs, which are at rest in the 3D Aether, were sought for in last decades of 19 century, including the Michelson and Morley experiment [14] and were claimed as principally non-existent in the special relativity theory – as well in this theory the absolute "Newtonian" spacetime is postulated as being non-existent, though.

Correspondingly in this paper only the absolute reference frames that are at 3D spatial rest are considered. The existence of such frames in the informational model is evident – that are the frames, where AFS' clocks, rules and observers (not only, of course) move in the [coordinate] time only with the speed of light.

(3) Since all/ every particles/ bodies always move in the 4D spacetime with the sped of light, the particle's/ body's motion is characterized by the 4D momentum, which is an analogue of the classical momentum, $\vec{P} = m\vec{V}$, $\vec{P} = mc\vec{k}$, where *m* is some coefficient (the mass), $\vec{k}$ is 4D unit vector, at that particle is always oriented relating to the $\vec{k}$.

If a number of particles constitute a rigid body, this body becomes be oriented relating to its movement direction. An example – moving rod having the length L - is shown in the Fig.1.

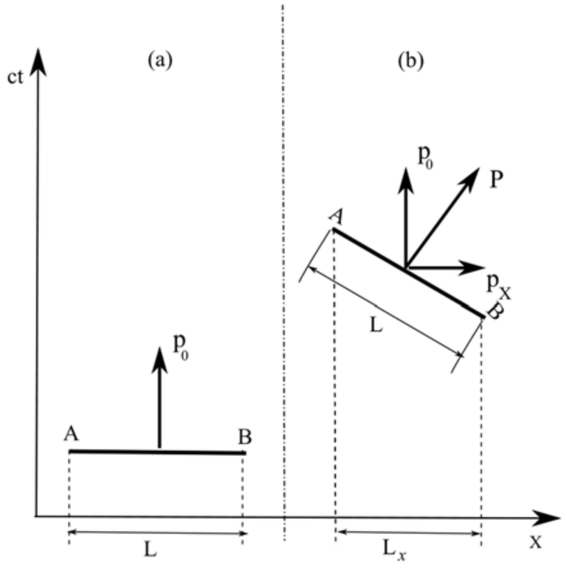

Fig.1. A rod having the length *L* moves in the spacetime: (a) – the rod is at rest (moves in the time only) in the ARF, (b) the rod moves also along X-axis with a speed *V*.

At rest (Fig. 1 (a)) the rod moves along temporal axis [with the speed of light] having the momentum $\vec{p}_0 = m_0 c\vec{i}_t$ that is perpendicular to the rod. If the rod was impacted with transmission to the rod a spatial momentum $\vec{p}_X = m\vec{V}$, it moves in the spacetime with the total momentum $\vec{P} = \vec{p}_0 + \vec{p}_X$, $\vec{P}$ is perpendicular to the rod.

From the Fig. 1 immediately follow the main equations of the special relativity theory (as well as of the Lorentz theory, though). Lorentz transformations:

- the first equation

$$x = vt + x'(1-\beta^2)^{1/2}, \qquad (1)$$

- and the second one:

$$t' = (1-\beta^2)^{1/2} t - \frac{Vx'}{c^2}, \qquad (2)$$

but with essential difference from the SRT – these equation aren't valid in whole [in the SRT - pseudoEuclidian] Matter's spacetime but are true for rigid mechanical systems (e.g., a system Earth + a satellite is rigid system also because of the gravity force) only, nothing happens at a motion of a body with the spacetime. Simultaneously, the variables, x', t', are measured lengths (here - from the back of the rod) to some (here – the rod's) matter points, and clocks' readings in these points; thus for some rigid system of bodies it is possible to set some local inertial reference frame.

As well as from the postulates above follow main equations of the SRT dynamics.

Since $P = mc$ and since *t*-axis is normal to any spatial direction (so the momentum of a particle at 3D rest remains be constant (as the temporal component of the momentum) at any spatial motion) it can be easily obtained that

$$p_X = mV = \frac{m_0 V}{(1-\beta^2)^{1/2}} \ , \tag{3}$$

and, for example, calculating the work of some force *F* at the spatial (an temporal impact results in the creation of new particles) acceleration of a body with rest mass m_0 on a way S (in the Eq. (4) below $p \equiv p_X$ for convenience),we obtain:

$$A = \int_{S_1}^{S_2} F(S)dS = \int_{p_0}^{p} \frac{p(1-\beta^2)^{1/2}}{m_0} dp = c\int_{p_0}^{p} \frac{pdp}{(p^2 + m_0{}^2c^2)} dp = c\Delta P \, . \tag{4}$$

Since at motion of a body the work of the force results in the change of the body's kinetic energy, from (4) we obtain

$$\Delta E = E - E_0 = cP - cp_0 , \tag{5a}$$

or

$$E = cP = \frac{m_0 c^2}{(1-\beta^2)^{1/2}} \ , \tag{5b}$$

and for a body at rest in an 3D ARF

$$E_0 = cp_0 = m_0 c^2 \, . \tag{5c}$$

3 Kinematical relations in moving rigid mechanical systems

The Voigt-Lorentz *t*- decrement [in (2)] for the rod's matter (including clocks) along the rod's length (the maximum is $-\frac{VL}{c^2}$), appears at the acceleration of the rod up to the speed V and further remains be constant for any fragment of the rod at the uniform motion. So if (i) - one synchronizes a number of clocks along the rod before the acceleration, (ii) - after the acceleration up to some speed, e.g., the back end clock is transported slowly along the rod to the front end, so, that this clock constituted with the rod rigid system, - then the moving clock and stationary clocks along the rod readings will be identical, including the (moved) back end and front end clocks eventually. But if one accelerates also a pair of synchronized clocks, which were placed initially on the distance *L* (Fig.2 (a)), let to the same speed *V* (Fig.2 (b), independently, then the free front clock reading will be identical to the both back ones, but will show later time then front end rod's clock; though all clocks are evidently in the same inertial reference frame.

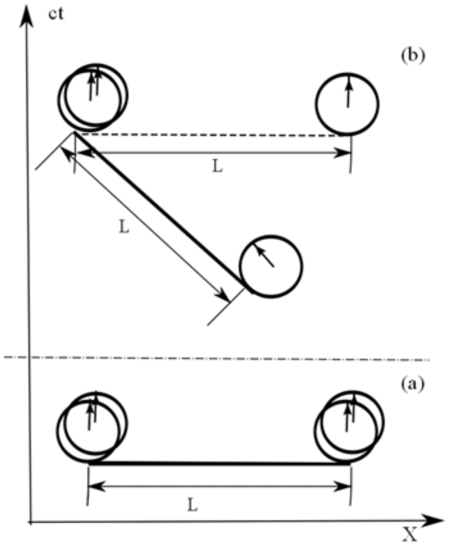

Fig. 2. Two pairs of synchronized clocks in the same reference frames. (a) at rest in an ARF, and (b) all clocks move with the same speed in the ARF, one pair constitutes the rigid body with accelerated rod; other pair moves independently on the rod.

This "desynchronization" of clocks, which were equally impacted at the acceleration, dependently on are the clocks free or they constitute a rigid system, occurs not only in the case above.

Besides consider a simple kinematical problem.

Let in the middle point of moving rod a short light flash occurs. The rod's clocks readings at the flush are, if corresponding clock readings in an ARF is t: on back end clock: $t_A = t(1-\beta^2)^{1/2}$; on the middle point clock; $t_M = t_A - \dfrac{VL}{2c^2}$; on front end clock: $t_B = t_A - \dfrac{VL}{c^2}$.

Since photons move only in the space [4], the flash will be registered with some time increment, for example on back end clock, it is $\Delta t_A = \dfrac{L(1-\beta^2)}{2(V+c)}$. So observed in the rod's reference frame elapsed time is $\Delta t_{MA} = \dfrac{L}{2c}(1-\beta) + \dfrac{L}{2c}\beta = \dfrac{L}{2c}$, so measured by this way speed of light in the rod's IRF is equal to c.

Analogously the same result (measured speed of light is equal to c) can be easily obtained for the pair "middle point – front end" clocks; for the case, when the light moves from back end to front end (a mirror) and back, etc.

And on the contrary – if on the rod's ends there are two clocks and the time moments, when flashes hit the clocks, are set in the clocks as equal clocks showings, the clocks become be synchronized in accordance with the Lorentz transformations – that is "Einstein synchronization" in the SRT.

However from the Lorenz transformations for rigid systems evidently follows another synchronization method – the "slow clocks transport", when clocks are set in equal showings at some spatial point an further clocks are slowly moved to the points where it is necessary to measure time intervals.

But if the clocks are free, the Lorentz transformations aren't valid completely and both synchronization methods above become be incorrect also, besides – the results of a synchronization are different. Just this fact allows to observe the absolute motion of a system of clocks and to measure the absolute 3D speed of this system – what is principally impossible in the SRT

4 Measurement of proper speed of an IRF

4.1. The use of the rigid and free systems of two clocks

From above follows the possibility of measurement at least of the proper speed of concrete reference frame [15], if in this frame an observer uses simultaneously a set of rigidly connected and independent clocks, see Fig.3.

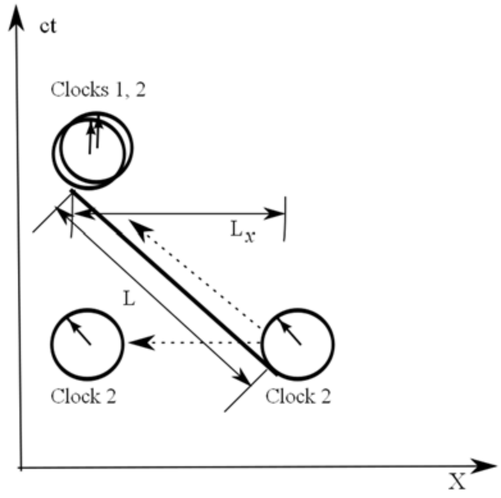

FIG. 3. A plot of clocks movements at measurement of the proper speed of a reference frame.

So, if there is a pair of synchronized clocks, and further one clock, let – the clock-2 telescopes slowly back and forth in any direction, the clocks' readings at the clocks rendezvous will be identical, independently on – the moved clock-2 was rigidly mechanically connected by some rod with the fixed one (with clock-1) or the clock moves independently.

But the moved clocks' readings at the motion are different. When the independently moved clock readings are always identical to the fixed clock-1's ones, the connected [to the rod] clock obtains additional decrement (if the clock is moved along the speed $\vec{V}$ of the reference frame), $-\frac{Vx}{c^2}$, where x is the distance between the clocks, measured by the observer's rule.

Thus, if on some moving object, for example – on an Earth satellite, an observer can implement the scheme that is shown on the Fig. 3, then it can measure his proper speed. To do that, the observer should use two clocks and some rigid rod, let – with the length L.

Let one clock (clock-1) is fixed in the satellite and other clock (clock-2) is rigidly fixed on the rod's end, both clocks are synchronized. Then, if the rod is pushed along the satellite speed forward and back, after returning both clocks will have identical readings. However, if the clock-2 is pushed forward being rigidly coupled with the rod, but returns back independently, for example, by using own engine, the time decrement, which this clock obtained at pushing forward conserves and so the clocks' readings are different at their rendezvous on the decrement $-\frac{VL}{c^2}$ (at pushing back - $+\frac{VL}{c^2}$ correspondingly). For example, if the experiment would be made at the International Space Station (V ~7600 m/s) and for the rod's length L=30 m, the decrement is $\sim 2.5 \cdot 10^{-12}$s.

Correspondingly from measured in this case the clock readings difference Δt_{12} and known rod's length the observer can determine the proper speed of his RF; in the case above – the orbital speed of the satellite, $V \approx \frac{\Delta t_{12} c^2}{L}$.

It is evident that such a procedure can be repeated any times with the accumulation of the decrements, so the requirements to the clocks' precision aren't too rigorous provided that they have adequate stability. If there were N repetitions, then $V \approx \frac{\Delta t_S c^2}{NL}$; where $\Delta t_S = \sum_{i=1}^{N} \Delta t_{12i}$.

The measurement error for a single measurement in first approximation depends practically on the clocks' readings internal long-term and short-term uncertainties. Let the sum of thee uncertainties is $\Delta_h \approx \Delta_{h12} 2^{1/2}$,where Δ_{h12} is the [equal here] individual clocks' error. Then for relative error for measured the $\beta = \frac{V}{c}$ value in first approximation obtain

$$\delta(\beta) \approx \frac{d\beta}{\beta} \approx \frac{\Delta_h c}{L\beta}, \tag{6}$$

and so

$$\beta \approx \frac{\Delta_h c}{L\delta(\beta)}. \tag{7}$$

For $\delta(\beta)$, for example be equal to 10%, $L = 30m$, $\Delta_h \approx 10^{-13}$, it is possible to measure the value β ~10^{-5}, i.e. the proper speed of the clocks' system ~ 3000 m/s; the proper speed of the ISS above can be measured with 5% precision.

Note, again, that on Earth orbit it is impossible to measure the "proper absolute" speed, since all clocks because of Earth gravity always constitute a rigid systems relating to the absolute Mater's spacetime.

4.2. The use of free two clocks system

Another way to measure the absolute [proper speed in near Earth systems] speed is using of two synchronized in one point clocks 1 and 2 after the clocks are slowly transported apart on a distance L and measuring one-way time intervals of light flushes hits in clocks at light motion between the clocks.

In this case measured one-way time intervals [in contrast to the case of a rigid system in the sec. 3 above], are $t_1 = \frac{L}{c-V}$ and $t_2 = \frac{L}{c+V}$, here t_1 and t_2 are possible clocks-1, 2 readings in an absolute reference frame. Though these values are unknown, we can obtain the actual clocks' readings - $t_1' = \frac{L(1-\beta^2)^{1/2}}{c(1-\beta)}$ and $t_2' = \frac{L(1-\beta^2)^{1/2}}{c(1+\beta)}$, where values L and β are unknown and the β value must be measured. Nonetheless we can use the equations $t_1' - t_2' = \frac{2L}{c}\frac{\beta}{(1-\beta^2)^{1/2}}$ and $t_1' + t_2' = \frac{2L}{c}\frac{1}{(1-\beta^2)^{1/2}}$ to obtain the equation that doesn't contain unknown [non-measurable] value of the distance between the clocks:

$$\beta = \frac{t_1' - t_2'}{t_1' + t_2'} \tag{8}$$

To estimate possible proper /absolute speed measurements errors in first approximation obtain (Δ_h - see the sec. 4.1 above):

$$\frac{d\beta}{\beta} \approx \frac{d(t_1'-t_2')}{t_1'-t'} + \frac{d(t_1'+t_2')}{t_1'+t'} \approx \frac{\Delta_h}{t_1'-t'} + \frac{\Delta_h}{t_1'+t'} \approx \frac{\Delta_h}{t_1'-t'},$$

and the relative uncertainty occurs twice lesser then in the case when the system of free and rigidly connected clocks are used that is considered in the sec.4.1. But the rest is the same:

$$\delta\beta = \frac{d\beta}{\beta} \approx [t_1'-t_2' \approx \frac{2L\beta}{c}] \approx \frac{\Delta_h c}{2L\beta} \tag{9}$$

and

$$\beta \approx \frac{\Delta_h c}{2L\delta\beta} \tag{10}$$

- i.e. this method allow to obtain twice better precision or twice lower measured speed at equal error.

However that is true only if the distance between the clocks is stable at the measurement (this problem is practically inessential in the experiment in the sec. 4.1 above), and the main contribution to the error is determined by the clocks precision limits. If that isn't so, then the rough analysis above isn't correct.

To estimate a possible contribution of the distance fluctuation consider an optimal but easily executed variant when the light flashes happen practically simultaneously, for example – by a program that make flashes in given times in the cocks, for example – every exact second (or in any known times/ periods); after an measurement's cycle, the data about t_{1i} and t_{2i} are analyzed to make the β_i values by using the Eq.(8).

In this case fluctuations, dL, impact on the measurement results if they occur practically inside the intervals $(t_1 \pm t_2) \approx 2L/c$ (or L/c). For the corresponding error be near clocks errors, $\frac{dL}{c} \approx \Delta_h$, and suggesting that the fluctuations happen with constant acceleration, a, for the a obtain: $a \approx \frac{c^3}{L^2}\Delta_h$ and for L - $L \approx (\frac{c^3\Delta_h}{a})^{1/2}$.

It seems as rather reasonable that there cannot be iimpacts on, for example, a space probe with forces when corresponding acceleration would be greater, say, 100 m/s^2. Thus an acceptable distance when the errors because of the fluctuations are comparable with the errors that depend on the clocks' inaccuracy, for, for example, $\Delta_h \approx 10^{-12}$ the acceptable distance is $L \approx 500km$; returning to the Eq.(9) obtain that at such distance it is possible to measure the proper/ absolute speed lesser then 1 m/s.

5 Conclusion

From the consideration above follow a number of implications.
First of all from the informational model's approach, which is used here, follows, that if a system of measurement devices, i. e., rules and clocks constitute a rigid system (because of the Earth gravity it is possible to create rigid systems even between / with satellites, well known example is the GPS system), then outcomes of any experiment aimed at the measurement of the speed of light value or observation of some proper speed of this system will be in accordance with the special relativity; as well with the Lorentz theory, though, because of in this case the theories are experimentally indistinguishable. Measured values will be the [standard] speed of light and zero object's proper speed correspondingly. This inference is true independently of what experiment was executed – "tests of Lorentz invariance" at using interferometers, "round trip" or "one way" methods at measurements of the light speed value or its isotropy (see, e.g., [16]-[22] and refs therein); as well as of what clock synchronization is applied – "Einstein synchronization" or slow transport of synchronized clocks. If some deviations from the theories would be observed, than there will be, with a great probability, an artifact.

But if one creates at least partially free system, some possibilities occur. The described above experiment on Earth satellite seems as rather promising, since on stationary orbits Earth gravity gradient is small, and in this cases is inessential, so the measurement of a satellite orbital (proper in the Earth' reference frame) speed, rather probably, would be successful.

Nonetheless the Earth gravity makes impossible the measurement of the absolute speed, since the gravity always "has time" to correct the positions of clocks and rules in the 4D spacetime at the satellite orbital motion, so the instruments always constitute rigid systems relating to the ARF.

However principally the measurement of the absolute speed is possible. To do that is necessary to send corresponding cosmic probe in a point in space where resulting gravity force (not the gravity potential) is weak enough. Further an automaton could execute the set of measurements of the probe speed values in at least 2π directions by using the retractable rod and the pair of clocks, as that is described in the section 4 above.

But in the experiment in a [rather] deep Space it seems that the experiment with a pair free clocks (sec. 4.2) is more promising.

There are no principal technical constraints for such experiments yet now. The mass of the probe would be, rather probably, not bigger then those that were launched at other space missions. As well as seems that there aren't problems with the clocks – the measurement of time intervals with accuracy ~10^{-16} (see, e.g., [23], [24]) isn't now something exotic.

H. Poincaré wrote about the absolute motion in "Science and hypothesis" [25]:

"… Again, it would be necessary to have an ether in order that so-called absolute movements should not be their displacements with respect to empty space , but with respect to something concrete. Will this ever be accomplished? I don't think so and I shall explain why; and yet, it is not absurd, for others have entertained this view…I think that such a hope is illusory; it was none the less interesting to show that a success of this kind would, in certain sense, open to us a new world…"

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