Fallacies regarding the principle of relativity, slow clock transport and Marinov's experiment

S.A. Belozerov
Arzamas, Nizhny Novgorod Region, Russia
E-mail: sbeloz@gmail.com

A number of common fallacies regarding various theories of relativity and methods of falsification thereof are considered in this paper. A "weak" principle of relativity implicitly applied in theories of relativity based on preferred reference frame has been formulated. Fallaciousness of the commonly accepted views on the relativistic effect of the phase shift in slow clock transport as well as of the resulting theories of experimental verification of the special theory of relativity (STR) is demonstrated. In particular, it is shown that there is at least one type of clock which produces the same time reading in both STR and in preferred reference frame theories of relativity. It is also shown that Marinov's "coupled shutters experiment" involves a unique technique that allows detection of the relativistic effect of the torsion of rotating bodies.

Keywords: *relativistic torsion effect; effect of self-synchronization of slowly transported clock; coupled shutters experiment, principle of relativity.*

1. Introduction

Poincaré was the first to formulate the fundamental law of physics which he referred to as the principle of relativity (PR): "…*The principle of relativity, according to which the laws of physical phenomena must be the same, whether for a fixed observer, as also for one dragged in a motion of uniform translation, so that we do not and cannot have any means to discern whether or not we are dragged in a such motion*" [1]. Since then, several different metaphysical models claiming to provide an explanation of that principle have been proposed. They laid foundations of various interpretations of the *relativity theory* (RT). The most well-known among them are the standard *special relativity theory* (SRT) based on a metaphysical model of the 4D spatial-temporal continuum by Minkovsky and the interpretation of RT based on a metaphysical model of immobile ether developed by Larmor, Lorentz and Poincaré.

All the possible interpretations of RT can be divided into two classes depending on whether or not they involve a preferred reference frame, and into two subclasses depending on fundamentality of the underlying PR, which in fact means the distinguishing between "*strong*" and "*weak*" variants of PR. If Whittaker's statement *It is impossible to detect a uniform motion which the system possesses as a whole, if observation of the phenomena is made entirely inside this system* [2] can be taken a formulation of a "strong" PR, then a "weak" PR should state: *It is impossible to detect a uniform motion which the system as a whole possesses, upon observation* ***of the overwhelming majority of phenomena****, if observation is made entirely inside the system*.

The difference between "strong" and "weak" RPs lies in the fact that, unlike "weak" variants, the "strong" ones defy the possibility of their being violated by any physical phenomena. For example, in the

Lorentz immobile ether theory, the RP will be violated upon observation of any fields of nonelectromagnetic origin which propagate in ether at a rate different from that of an electromagnetic field [3]. Many modern interpretations of RT based on “weak” RP assume that the latter can be violated due to superluminal quantum effects.

Based on these two criteria, all the possible RTs can be divided into three groups. The first group includes theories (interpretations) based on a “strong” RP and the absence of a preferred reference frame; the second group includes theories based on a “strong” RP and the presence of a preferred reference frame; and the third one includes theories involving a preferred reference frame and a “weak” RP.

Probably, only the currently prevailing Einstein-Minkowsky STR can be attributed to the first group. The second group includes the interpretation by Poincaré who shared Lorentz’s ideas but thought it was impossible to detect the effects of absolute motion. Most of the alternative interpretations of RT [4-7 and others] including the Lorentz-Poincaré incomplete relativistic theory of immobile ether, by our classification, belong to the third group. The explanatory spatial-temporal models underlying the first and second groups of RT interpretations are incompatible with each other, which explains the dramatic and long-standing confrontation between the competing theories.

In this paper, we analyze some of the common mistakes regarding two of the spatial-temporal relativistic effects. There are a total of four such effects, three of which directly follow from the Lorentz transformations, and the fourth one is due to the necessity to bring the Lorentz transformations into agreement with the RP. The first three relativistic effects are known as: *the effect of Lorentz-Fitzgerald contraction*, i.e. contraction of longitudinal sizes of moving bodies; *the effect of time dilation*, i.e. decrease in frequency of physical oscillators; and *the effect of phase shift in slowly transported clocks* (which will be considered in more detail further in this article as *the clock synchronization effect*).

The fourth spatial-temporal relativistic effect is *the torsion effect of rotating bodies*. Discovered by Cohn as early as in 1904 [8] but never mentioned in SRT textbooks, nor being known to the physics community at large, it consists in the following: from a stationary observer viewpoint, a solid body rotating at a frequency of ω and moving at a speed of $\upsilon<$c along the rotation axis experiences axial-torsional deformation [5]:

$$\Delta\varphi = l\upsilon\omega/c^2, \tag{1}$$

where c is the speed of light in vacuum, $\Delta\varphi$ is the angle of torsion between the cross-sections of the rotating body, and l is the distance between the cross-sections.

All the relativistic spatial-temporal effects have fundamentally different explanations in the SRT and RTs with a preferred reference frame. For the SRT, relativistic effects are equally realistic in any inertial reference frame where $\upsilon<c$, however the contents of the kinematical (*ostensible*) and dynamical (*veritable*) components upon observation of each of the effects are undetermined. For RTs with a preferred reference frame, including the immobile ether theory, any of the observed relativistic effects is *definitely* a result of both kinematical and dynamical factors. The only exception is two extreme cases. A stationary observer of a preferred reference frame system can only see the dynamical (veritable) components of relativistic effects. If a solid body or a clock is stationary with respect to a preferred reference frame, a moving observer is sure that all relativistic transformations of such a body or clock are illusionary. Accordingly, such an observer sees all the observed effects as having a “purely”

kinematical nature determined by the terminal velocity of information signals.

All four spatial-temporal relativistic effects were described by Cohn more than a century ago [8]. It would seem that by nowadays each of them should have been most thoroughly examined, which unfortunately has never happened. The situation with this aspect of the SRT verification is somewhat paradoxical. Two of the spatial-temporal relativistic effects (Fitzgerald contraction and time dilation) have been highly accurately verified in dozens, if not hundreds, of experiments. As far as verification of the relativistic law of the phase shift in slowly transported clocks is concerned, we have been able to locate only five reports of experiments [9-13], of which only three were interpreted by the authors as supporting the STR [9, 11, 12]. One of them – Cialdea's experiment [9] had a very low accuracy because of a short transportation distance. The null result interpretation [11] is questionable [14] as there was a systematic data error correlating with sidereal time.

The situation with the fourth spatial-temporal relativistic effect looks strange insofar as *it has never been experimentally tested*. The only experiment whose results can testify about the presence or absence of the torsion effect is Marinov's "*coupled shutters experiment*" [15]. In that experiment, Marinov allegedly detected anisotropy of the one-way speed of light which practically coincides with anisotropy of microwave background radiation. Marinov's experiment was rightly criticized for technical imperfection of the used equipment, but his unique method for detection of the torsion effect – that no one ever verified either prior or after Marinov's experiment – went unnoticed.

2. Methods for testing the phase shift effect in slow clock transport

According to the SRT, a clock at rest in a laboratory reference frame that is uniformly and rectilinearly moving with respect to a preferred reference frame at a speed of $\upsilon > c$ should change its reading when being transported along υ at an infinitesimal velocity, by the value of:

$$\Delta t' = -s\upsilon / c^2. \tag{2}$$

where s is the transportation distance, and υ is the velocity of motion of the laboratory reference frame with respect to the luminiferous medium. Transportation of a clock (not necessarily uniform and rectilinear) at an infinitesimal velocity at which the relativistic effect of time dilation can be neglected is called the *slow clock transport*. It follows from (2) that a slowly transported clock should remain synchronized with a clock at rest, which further means that a slowly transported clock should be capable of self-synchronization with a clock at rest.

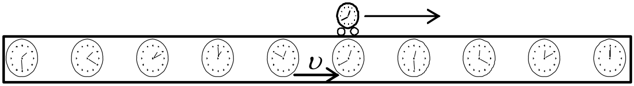

Fig. 1. A moving platform with clocks as viewed by a stationary observer.

Fig. 1 illustrates the relativistic effect of self-synchronization of a slowly transported clock. A rigid platform with identical clocks synchronized *in the standard way by a light signal* and attached to the platform is moving from left to right, relative to the observer, at a constant velocity of $\upsilon < c$. To the observer, the platform clocks seem to be desynchronized (the effect of relative synchronism). If a portable clock, synchronized with the platform clocks, is placed on the platform and then slowly moved along the platform, it will be "adjusting" itself to keep synchrony with the stationary clocks at any given point of its location. This is a truly unusual effect – slowly transported clocks not only changing their readings but self-synchronizing with each other and with the stationary clocks. In our opinion, it would be more correct to refer to the third relativistic effect as *the effect of self-synchronization of a slowly transported clock.*

There are two known methods of verification of the relativistic effect of clock self-synchronization. One is based on comparison between the readings of a slowly transported clock and each of the several stationary clocks, synchronized to each other, at the time when the portable clock appears next to a respective stationary clock. However, conducting this experiment on Earth is complicated by such factors as non-inertiality of the reference frame due to the terrestrial environment, and the gravitational potential difference at different sections of the clock route. In 1990, Nelson attempted verification of the effect of self-synchronization by this method using high-stability hydrogen maser atomic clocks [13]. One of the clocks was located at the NASA research facility in Greenbelt, Maryland, and another clock was slowly transported to the United States Naval Observatory in Washington, DC. Notwithstanding an extremely high stability of the clocks (hydrogen maser clocks are twice as accurate as the cesium atomic frequency standard), the experiment did not meet the expectations. The cause of the abnormal phase difference between the stationary and portable masers has not been explained.

Anther method for verification of self-synchronization effect of a clock is used in experiments for measurement of the one-way speed of light. It consists in the following: *two distant and relatively stationary observers at spatially different locations compare the readings of each other's clocks while the angle between the ether wind and the radius vector projected from one of the observers onto another is changing.* This method was first applied by Michelson and Morley [16] in a device for measurement of the one-way speed of light (Fig.2), where the rotating mirrors served as a transported clock. The Michelson-Morley technique is feasible if the Lorentz transformations are valid. The joint action of the two relativistic effects (size reduction and self-synchronization of rotation phases of the mirrors when the system is turning relative to the ether wind direction) should fully compensate the effect of anisotropy of the true speed of light in the luminiferous medium.

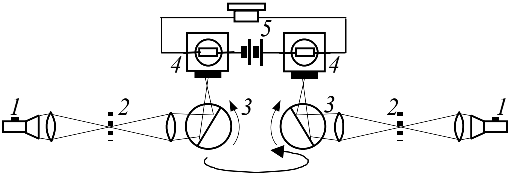

Fig. 2. Schematic diagram of experiment by Michelson and Morley for measurement of the one-way speed of light. 1 - light source; 2 – optical lattices; 3 – rotating mirrors; 4 – photodetectors; 5 – speaker. In case of anisotropy of observable one-way speed of light upon rotation of the system, the intensity of the sound signal in the phone should vary.

There are numerous systems designed for measuring the one-way speed of light [e.g. 15-19]. All of them, with the exception of Marinov's device [15], are based on various modifications of the above-described method of Michelson-Morley which, if the Lorentz transformations or other similar transformations are valid, cannot detect the anisotropy of the one-way speed of light.

The Michelson-Morley method was first applied by Cialdea [9] for verification of constancy of the beam phases of two oppositely directed masers fixed at the opposite ends of a rigid platform slowly rotating around its vertical axis.

A similar technique is used for comparison of signals of two remote clocks fixed on the Earth surface [10, 12]. The angle between the line connecting the clocks and the ether wind direction changes due to the Earth's daily rotation. These experiments, as well as

Cialdea's experiment, involve a slow clock transport, and therefore the joint action of the relativistic effects of slow clock transport and longitudinal size reduction should ensure the maintaining the RP in this group of experiments.

3. Relativistic effect of torsion

As was noted above, the only experiment that theoretically can allow verification of the relativistic effect of torsion of rotating bodies is Marinov's "coupled shutters experiment" [15]. Interestingly, Marinov considered his experiment to be a realization of the Michelson-Morley method [16]. As demonstrated below, that is not correct.

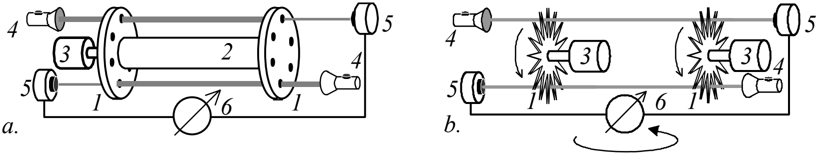

Fig. 3. Marinov's (*a*) and Schweitzer's (*b*) devices for measuring the one-way speed of light. 1– obturators; 2 – rigid shafts; 3 – electric motors (a reverse motor in Marinov's experiment); 4 – sources of light; 5 – photodetectors; 6 – signal phase shift measurers (a bridge circuit in Marinov's experiment).

Marinov's device (Fig. 3*a*) is very similar to the system proposed by Schweitzer [17] in 1904 as an improvement of Michelson-Morley's idea (Fig. 3*b*). However, there is an important difference between the two. Schweitzer's system uses two independent electric drives synchronously rotating Fizo's cogwheels that intercept the light beams directed onto the photodetectors. Verification of anisotropy of the one-way light speed consists in measurement of the phase shift between the signals of the photodetector upon the system's rotation around its vertical axis. Schweitzer's measurement procedure is analogous to the Michelson-Morley technique. Therefore, the joint action of the relativistic effects of longitudinal size contraction and the phase shift of a slowly transported clock should fully compensate for the effects of absolute motion in the RT with a preferred reference frame.

Marinov's experiment employs a fundamentally different technique based on the relativistic effect of torsion, rather than the clock self-synchronization effect as used in all other cases. This is because Marinov synchronized the obturators by means of a rigid shaft. In addition, Marinov's system was not rotated around its vertical axis as was provided by the Michelson-Morley procedure and intended by Schweitzer. Instead, Marinov was changing the direction of the rigid shaft rotation.

In our opinion, Marinov's experiment should be interpreted as an attempt of verification of the joint action of the relativistic effects of size contraction and torsion of a rotating shaft. As the effect of size contraction has been verified at a very high accuracy in many experiments, positive or negative results of experiments based on Marinov's technique would be able to indicate whether or not the relativistic effect of torsion exists. It is premature to speak of an experimental support of even a "weak" variant of RP for long as one of the four spatial-temporal relativistic effects has not been verified.

4. The effect of clock self-synchronization

There are a number of common fallacies about the clock self-synchronization effect. In many publications, it is stated or implied that in the classical SRT, clock synchronization by means of slow transportation is *equivalent* to standard signal synchronization [20-22]. Conversely, it is often stated that in the RT with a preferred reference frame (including the Lorentz-Poincaré relativistic theory), self-synchronization of a slowly transported clock with stationary clocks is *impossible* [24, 25]. In this section, we will show that both of these views are incorrect.

Let us accept as a *clock* any physical object equipped *a localized oscillator* and *an oscillation counter* – for example, a clock that has an oscillator in the form of a mirror box with a light wave circulating in it. Let us combine the clock oscillator with a counter whose reading is changed by a unit per one circulation of the beam. Assume that the mirror box dimensions are in agreement with relativistic transformations. The existence of such a clock oscillator would contradict neither the SRT nor the Lorentz theory. A similar type of clock is used in quantum generators.

Such a light clock (we will refer to it as a *photon clock*) will allow us to easily uncover falsity of the aforesaid statements. For clarity purposes, let us consider a variant where the light beam in the clock oscillator circulates between two mirrors whose planes are parallel to the directions of their motion. Calculation of the readings of the moving clock will require only two parameters: the distance between the mirrors, and the speed of the light beam. According to relativistic transformations, the distance between the mirrors in this case does not depend on the velocity of the clock movement. This is true for both RT interpretations with a preferred reference frame (including the Lorentz-Poincaré theory) and for the SRT.

Readings of photon clocks transported at any speed in any direction can be easily computed if the clocks are transported within a plane that is parallel to the mirrors and the computations are done in a reference frame where one-way speed of light is isotropic in all the directions. In the SRT, the one-way speed of light is isotropic in any inertial reference frame. In RT with a preferred reference frame there is at least one reference frame that provides for isotropy of the one-way speed of light is isotropic. For instance, in Lorentz's theory, there is a reference frame associated with the luminiferous medium. *A* *fundamentally important property of the photon clock lies in the fact that its readings are computed in the same way in both STR and TR with a preferred reference frame (including the Lorentz-Poincaré theory).*

The very fact of the existence of such a clock proves falsity of the commonly accepted belief that in the SRT the clock synchronization by slow transport may be in any way different from the same type of synchronization in Lorentz's theory or any other RT with a preferred reference frame. Evidently, that is not true for at least one type of clock.

Can the above statement be applied to all and any possible types of physical clocks in the SRT? We believe it can. The principle of relativity requires that different types of clocks located next to each other run identically, for any observer. In the SRT, this requirement is automatically met for any type of clock. In the Lorentz-Poincaré immobile ether theory or any other RT with a preferred reference frame, the said requirement can be met by limiting the allowable types of physical oscillators – in the same way as the relativistic theory of immobile ether was developing by drastically narrowing the fundamental physical essences [3].

Now we need to verify that synchronization of a slowly transported photon clock is indeed *equivalent* to the standard signal synchronization. First, we need to check if upon completion of slow transportation a portable photon clock will remain strictly synchronized with the stationary clocks. To establish that, we will use a rigid platform whose plane coincides with the xy coordinate plane. We will have a photon clock fixed at point A being the origin of the coordinates, and four identical photon clocks fixed, equidistantly to point A, at points $B – E$ on x and y coordinate axes (Fig. 4). Each clock will be denoted by the same letter as a respective point. We will have clocks $B – E$ synchronized by a standard light signal procedure.

Then, all four clocks at a same point of time as per each respective clock's reading will be transported uniformly and rectilinearly to point *A* so that they all simultaneously reach point *A*.

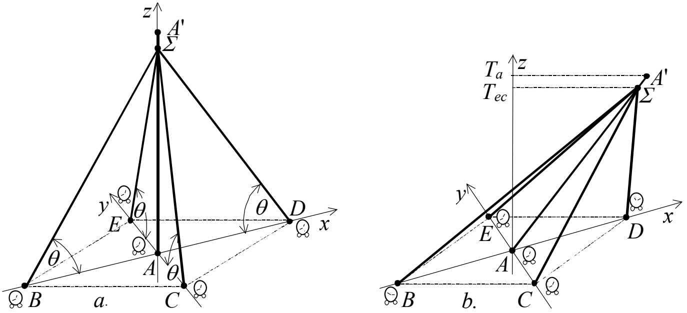

Fig. 4. The diagram for calculation of the effect of slow clocks transport. *a* – the platform is stationary relative to the observer; *b* – the platform is uniformly and rectilinearly moving in the x direction relative to the luminiferous medium.

To demonstrate nonequivalence of the two methods for clock synchronization, let us consider the simplest case when the platform is stationary relative to the observer. Fig. 4*a* shows the simplest graphical method for determining discrepancies in readings of the photon clocks. Segments $|AA'|$ for the stationary clock and $|B\Sigma|$ through $|E\Sigma|$ for the portable clocks represent the way passed by the light beam in each clock's oscillator. The stationary clock *A* has counted, within the transportation time, a *T* number of circulations represented by the length of the $|AA'|$ segment. The light beam circulating in the oscillators of portable clocks *B* – *E* during the clocks transportation was propagating at a non-right angle θ $(\theta\neq\pi/2)$ to the plane *xy*, same for all transported clocks, which slowed down the propagation of the light wave along the axis *z* and thus reduced the number of circulations of the light waves in the transported clocks as compared to the stationary clock.

Since the speed of light is constant, the lengths (T) of segments $|AA'|$ and $|B\Sigma|$ - $|E\Sigma|$ are equal. To determine the reading of clock B at the moment of its arriving at point A, it suffices to determine the segment $|B\Sigma|$ projection onto axis z:

$$T' = |A\Sigma| = |B\Sigma| \sin\theta . \tag{3}$$

The difference between the readings of the transported clocks and the stationary clocks is:

$$\Delta T = |AA'| - \left(|B\Sigma| \sin\theta\right) = T - \sqrt{T - L^2 / c^2} . \tag{4}$$

The maximum discrepancy in the readings occurs when the clocks are transported at the speed of light ($\theta = 0$). The longer the time of the clock uniform transportation to point A, the closer is angle θ to the right angle and the less is the discrepancy in the readings of the portable clocks and the stationary clock. In an extreme case, i.e. at an indefinitely long transportation time, ΔT tends to zero.

Would it be true to state that in this simplest case the slow clock transport is equivalent to synchronization by a standard light signal? The answer is no. ‘*Equivalence*‘ implies not an approximate but *strict equality*, which is not observed in the above case. The fact that discrepancies in the clock readings can be reduced to ultimately low values by elongation of the transportation time is not sufficient for proving the equivalence. After all, the opposite can also be stated: for any however low velocity of clock transportation, it is possible to determine such a long transportation distance that will provide a certain discrepancy value however high it may be.

The nonequivalence of synchronization by a slow clock transport to synchronization by a standard light signal is due to the fact that resynchronization of transported *photon clocks* is caused not by the effect of time dilation, as it may be the case with clocks of other types, but by the difference of the paths passed by the light beams in the oscillators of the stationary and transported clocks. The difference of the paths cannot be eliminated in principle, and therefore *assertion of equivalence of the two methods of synchronization would mean non-strict compliance with the second postulate of the SRT*, which is logically unacceptable.

The same approach to comparison between the clock readings can be used in a case when the platform moves in the x direction uniformly and rectilinearly relative to the observer (Fig. 4*b*). In this case, too, projections of segments $|B\Sigma|-|E\Sigma|$ and $|AA'|$ onto axis z correspond to the readings of the stationary clock on the platform. As well as in the above case, trajectories of the light beams converge at point Σ which indicates both the absence of discrepancies in the readings of the transported clocks and the possibility of reducing the discrepancies to infinitesimal values. We do not provide the STR calculations of the readings of the slowly transported clocks illustrated in Fig. 4*b* as they are quite trivial. Calculations of the photon clock readings in Lorentz's theory in the reference frame with the isotropic one-way speed of light are identical to the calculations in the SRT.

A discrepancy between the transported and stationary clocks does not depend on the direction of transportation, which may seem paradoxical as the equivalence of the readings of transported clock on a moving platform is possible only at different lengths of segments $|B\Sigma|-|E\Sigma|$. Nonequivalence of the lengths of the segments is due to the fact that in the stationary observer's reference frame the four clocks begin to be transported *not simultaneously*. First, it is clock B that starts moving along the platform and, therefore, segment $|B\Sigma|$ is longer than the other segments. The last (from the observer's viewpoint) clock to start moving is clock D, so segment $|D\Sigma|$ is the shortest. It should be noted that several photon clocks transported at a same velocity in a laboratory reference frame remain *strictly* synchronized irrespective of the transportation direction.

5. Conclusion

Only two of the four spatial-temporal relativistic effects have been reliably verified in experiments. Verification of the effect of phase shift in a slowly transported clock does not seem to be reliable as there have been very few supporting experiments. The effect of torsion of rotating bodies has not been verified in any experiments other than the technically flawed Marinov experiment. All (or at least most) of the known interpretations of the RT with a preferred reference frame are implicitly based on the "weak" principle of relativity which allows for non-relativistic objects and absolute motion effects in certain situations. Some of those situations were pointed out as early as in Lorentz's work [3]: interaction between stable extended systems by means of non-electromagnetic fields propagating in the luminiferous medium at a speed (including superluminal speed) other than the speed of light; and motion of the charged particles in an electromagnetic field, provided that the mass of the particles is not of "purely" electromagnetic origin. We would like to add that an infringement of the "weak" principle of relativity can also be caused by the nonlinear properties of electromagnetic fields in the regions of high intensity or at supersmall distances.

One should distinguish between the experiments on verification of the relativistic effects *per s*e and those aimed at detection of violations of those effects under certain physical conditions. The results of experiments which discovered a correlation with sidereal time (Miller's interferometric experiments and the like [26, 27], observation of anisotropy of the sun spots [28], Shnoll's experiments

[29], and some others) may be the manifestation of violation of the "weak" PR and can probably be explained by the aforesaid factors.

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