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PRESENT

An introduction to the new book of
The Celebrated Italian Physicist Franco Selleri

Weak Relativity

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Introduction

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Around 1913 the situation of French physics was particularly interesting. It is difficult to imagine a more favorable moment for the reception of the Sagnac results. The most authoritative personality for a problem concerning Einstein's relativistic theory was Paul Langevin, who had studied in England, at Cambridge University under J.J. Thomson, then in Paris at the Sorbonne where he had obtained his Ph.D. under Pierre Curie. Langevin had shown an active interest in relativistic matters already in the years 1905 - 1909, crowning it with an incredible paper in 1911, year in which he published an article [1] on the journal *Scientia*. The title was L'EVOLUTION DE L'ESPACE ET DU TEMPS and the article provided a critical examination of the new theory. The level is exceptional as in 24 pages there is not even one equation, not even one mathematical symbol. Nevertheless, the words are clear, the meanings always transparent. The reader is taken by hand and accompanied in a guided tour of relativistic space. In this way he can appreciate the role of the simultaneity of events in the very definition of space, the definition of proper time, the importance of causality and the necessary absence of superluminal propagations. Two astonishing coups-de-théatre were left for the final part of the paper. First, about ether there is an opening and a critical remark addressed to Einstein: "A uniform translation in the ether does not have experimental meaning, but one should not conclude, as it has been done sometimes prematurely, that the notion of ether must be abandoned and that ether is non existing, not accessible to experience.” Langevin goes on by saying that of course, a uniform velocity with respect to the ether cannot be detected, but a change of velocity, yes, it can. In the electromagnetic theory of matter every accelerated particle, being electrified, radiates a spherical wave. Therefore the acceleration has an absolute meaning, in determining the production of spherical waves centered on that piece of matter which underwent a change of velocity. The ether shows its reality by supporting the energy of the waves. Second, about the twin paradox. Langevin starts by noticing that if one of two identical radioactive samples of radium is sent out of the laboratory (where the other remains constantly), carries out a high speed travel in space and finally comes back to the same laboratory, this wandering sample will show a higher activity as if it were younger. After this example the article closes “humanizing” the paradox with a space traveler.

When the Sagnac experimental results were published [2] Langevin was considered one of the best physicists in France. Langevin in his way liked very much the new theory of relativity and was interested in deepening its understanding and spreading its teachings. This was the situation when the Sagnac effect was discovered. The Sagnac papers, written in French with provocative titles, practically demanded that he expressed his opinion about the new effect. Therefore Langevin started to work at the problem, presumably with the purpose of showing that the two relativistic theories had no difficulty in the interpretation of the new effect. Proving that the results of the rotating disk experiment were in agreement with the predictions of the relativistic theory could convince people that ether existed, at least in Langevin’s opinion. But the outcome of his research was very different, so much that a paper describing it was published only in 1921, eight years after the first Sagnac article [3]. This paper did not contain what one expected, a direct calculation of the measured quantities in the framework of the relativistic theory. Rather, it relied on indirect defensive arguments, stressing that Sagnac’s was a first order experiment on which all theories (whether classical or relativistic) had to agree, given that the experimental precision did not allow to detect the differences.

But Langevin was not satisfied with his treatment of the rotating disk, and in 1937 he published a second article on the same subject. Here he proposed two different “relativistic” treatments, giving birth to a proliferation of wrong proofs, which in recent times has become spectacular. Possessing the resolution of the Sagnac problem, today we can better understand the arguments of the past. Langevin was struggling against a theory whose real consequences do not agree with Sagnac’s experimental findings.

As stated before, the first published discussion of the Sagnac effect by Langevin came only in 1921 and was as much formally self-assured as substantially weak. One of the opening statements is this: “I will show how the theory of general relativity explains the results of Sagnac’s experiment in a quantitative way.” Langevin argues that Sagnac’s is a first order experiment, on which all theories (relativistic or pre-relativistic) must agree qualitatively and quantitatively, given that the experimental precision does not allow one to detect second order effects: therefore it cannot produce evidence for or against any theory. Then he goes on to show that an application of Galilean kinematics explains the empirical observations! In fact his approach is only slightly veiled in relativistic form by some words and symbols, but is essentially 100% Galilean.

Yes, but what about relativity? Langevin would answer: "The relativistic curve is very near the Galilean curve." But this is not correct because the difference between the two sets of transformations is of first order in v/c. Thus in reality the success of the Galilean curve casts by itself serious doubts about the effectiveness of the relativistic theory in dealing zitrh the Sagnac effect.

Of the two proofs of 1937 [4], the first one is still that of 1921, this time deduced from the unjustified idea that the time to be adopted everywhere on the disk is that of the rotational centre (motionless in the laboratory). The second one is to define "time" in such a way as to enforce a velocity of light constant and equal to c, falling so flatly in a problem of discontinuity for a tour around the disk, which is well known to exist.

Meanwhile in Holland Hendrik Lorentz worked on a line of thought very favorable to ether, arguing that of all frames of reference, the one should be preferred in which ether is at rest. Clocks at rest in this frame show the real physical time, and simultaneity, as shown by them, is not relative but holds true in nature. The conditions of the ether are described by the electric field E and by the magnetic field H: they represent the "states" of the ether. For Lorentz the electromagnetic field of the ether makes possible the interactions, and changes in this field can propagate with a speed not higher than the speed of light $S_0(S)$.

Concerning the Lorentz-FitzGerald contraction hypothesis of moving bodies, Lorentz wrote: "Surprising as this hypothesis may appear at first sight, yet we shall have to admit that it is by no means farfetched, as soon as we assume that molecular forces are also transmitted through the ether, like the electric and the magnetic forces of which we are able at the present time to make the assumption definitely. If they are so transmitted, the translation will very probably affect their action between two molecules or atoms, in a manner resembling the attraction or repulsion between charged particles".

In 1916 Lorentz published the final edition of a book [5] in which his different formulation of the relativistic theory was developed. It was based on three assumptions:

1. A rod in motion with respect to the ether with a velocity v parallel to its length becomes shortened by a factor $\sqrt{1-v^2/c^2}$;

2. A clock in motion with respect to the ether with velocity v has the time measuring periodic process slowed down by a factor $\sqrt{1-v^2/c^2}$.

3. Einstein's convention for synchronizing clocks is valid, that is the velocity of light can be assumed equal to *c* in all directions and in all inertial frames.

Even though the effects of length contraction and clock retardation were initially introduced relatively to a privileged frame only, the Lorentz transformations were nevertheless deduced in later developments from the postulates of the theory for any pair of reference frames.

An excellent reconstruction of the realistic approach to relativistic physics was published by H. Erlichson in 1973 [6]. In this paper the Lorentz theory is called "rod contraction - clock retardation ether theory" (the RC-CR ether theory). This historical research closes with the following words: "We conclude that as of this date there do not seem to have been any experimental proposals offered which would clearly distinguish between the STR and the RC - CR ether theory. On the other hand, we have also not been able to find any theoretical proof showing the impossibility of such a distinction." With the advantage of being 36 years in the future of Erlichson's paper we can comment that from the empirical point of view the difference between the two theories was practically zero, given that the RC - CR ether theory had repeated the relativistic choice about the velocity of light. In other words Lorentz had defended the Lorentz transformations. For such a man we must say: *errare humanum est.*

Thus, it is not possible to distinguish experimentally Lorentz's theory and Special Relativity. The conceptual differences are very important, however, as in Lorentz's theory the ether has a fundamental role, while the relativity principle seems to be only coincidental: it was not in the set of the assumptions, as we saw, but it could be deduced as a sort of qualitative theorem. In principle every physicist could have chosen the formulation he liked most; in practice the great diffusion of negative ideologies in the European culture of the twenties and thirties strongly favored the acceptance of Einstein's relativism. The diffusion of the Copenhagen formulation of quantum mechanics, after the mid twenties, brought the large majority of physicists to a philosophical unification on an idealistic basis. And in such a frame of ideas the relinquishment of ether and the acceptance of subjectivistic relativism became the great and stable fashion of the XXth century.

From a strictly logical point of view the abolishment of ether should not be considered a necessary consequence of Einstein's relativism: this philosophy demands only that the description of the physical reality be the same in all inertial reference frames and this can be achieved also with an ether endowed with certain unusual physical properties. The new line of thought of Albert Einstein started from the realization that the word ether says nothing more than that space has to be viewed as a carrier of physical properties.

However: "Extended physical objects can be imagined to which the idea of motion cannot be applied. They are not to be thought of as consisting of particles that allow themselves to be separately tracked through time. In Minkowski's idiom this is expressed as follows: Not every extended conformation in the four-dimensional world can be regarded as composed of lines of Universe." In this way the ether is postulated to be devoid of motion.

In his 1916 paper on general relativity [7], Einstein repeated Newton's reasoning of the rotating bucket with an even better example, that of two deformable spheres, *A* and *B*, placed in interstellar space. One of them (say, *A*) is set in rapid rotation around the straight line joining the geometrical centers of *A* and *B*. From the point of view of kinematics one could say that motion is relative, since the observer on *B* says: "*A* rotates" , but also the observer on *A* can say: "*B* rotates". If one, however, considers the deformation due to the centrifugal force both observers must conclude that only *A* rotates and that rotation is not a matter of subjective points of view, is not relative, but is an absolute property of bodies. Concerning the immediate cause of the deformation, it can only come from space, from the region of space surrounding the rotating sphere, as the stars are so far away that an *immediate* action coming from them is not reasonable. Rather we can say that the matter of the universe has created everywhere a property of space generating the deformations of rotating bodies. Of course, Einstein showed that the situation is still compatible with the principle of relativity, but such a conclusion does not eliminate the physical meaning of the example of the rotating spheres.

Thinkers of all times worried about the distinction between the past, the present, and the future. In particular they were puzzled about the nature of the past and the future, which seem unreal: the past has ceased to exist and the future does not yet exist. The tentative answers given to this problem show that scientific thinkers tend to divide into two groups. On one side there are those who regard the passage of time as an objective feature of reality, and interpret the present moment as the marker of this advance. Some members of this group take the view that the past is real in a way that the future is not, so that the present consists in something like the coming into being of a well defined reality. Philosophers of the second group regard the present as a subjective notion and claim that just as "here" means "this place," so "now" means "this time". In either case what is picked up depends on where the speaker stands. On this view there is no more an objective division of the world into the past, the present and the future than there is an objective division of a region of space into here and there. In other words, the division is purely subjective. Considering the notion of time from an objective point of view no division exists and the universe looks like a monolithic entity extending its compact reality very far in the past and in the future. In this way the notion of *block universe* was born.

A powerful objection to the view that there is a real present came from Einstein's theory of relativity. The theory had weapons to use against the idea of an objective reality of the present: It was in very good agreement with experiments and its mathematical foundations fully supported the idea of a multiplicity of presents crossing the universe with different inclinations. In this book we are going to see how this happened, and look for an alternative based on a more reasonable description of reality that we will detect in the notion of absolute simultaneity.

In interstellar space there is a very good vacuum, which can reach an atomic density as low as 0.1 atom/cm3. One can make a safe guess: if even the few atoms left were taken away, none of the fundamental properties of space would disappear.

The property which here interests us mostly, is that space in some sense is a container of distances. We see in space bright objects and our science has been able to measure their distances. Three examples: the moon is 1,2 light seconds away; the nearest star (Proxima Centauri) is at about 4.3 light years; the great spiral galaxy of Andromeda at about 2.2 million light years.

For a positivist the vacuum is pure emptiness: take away those few atoms and nothing remains. The vacuum is the physical zero. The vacuum is nothing, it does not exist.

But a good answer can be given to the positivistic rejection of space. If the vacuum is nothing how is it possible that the distances separating cosmic objects be so different from case to case? These distances are made of vacuum. If the vacuum is the physical zero, one would expect that 0+0=0, or a unicity of distances, even the vanishing of all distances. In the real world, instead, there are small distances, large distances, immense distances, ... Correspondingly one can have small, large, huge quantities of space. We can measure space on a line, in a surface, and in a volume. It is not possible that something so easily quantified be nonexistent.

Our conclusion about the reality of space allows us to move another step forward. In fact space is not only real, but is homogeneous. We do not know how far this property can be extrapolated, but for our concrete physics, limited to the interior of the solar system, homogeneity is certainly at least an excellent approximation.

In deducing the Lorentz transformations a certain use is made of the space and time homogeneity conditions. This does not mean, however, that the Lorentz transformations satisfy “fully“ the homogeneity conditions. In fact they do not. For example, Lévy-Leblond arrived at transformations [8], which he wrote in differential form

$$dx' = H(a)dx - K(a)dt$$
$$dt' = L(a)dt - M(a)dx$$

The symbol a represents some kinematical variable, but here it is not of interest and can be safely neglected. The presence of the diagonal coefficients $H(a)$, $L(a)$ is easy to justify physically:

$H(a) \neq 0$, because generally speaking, two events seen from S to have different position ($dx \neq 0$) at the same time ($dt = 0$) must be seen also from S' in different positions $(dx' \neq 0)$;

$L(a) \neq 0$, because, generally speaking, two events seen from S in the same position $(dx = 0)$ at different times $(dt \neq 0)$ must be seen also from S' at different times $(dt' \neq 0)$.

Also the presence of $K(a)$ is no mystery. One has
$K(a) \neq 0$, because two events seen from S in the same position $(dx = 0)$ at different times $(dt \neq 0)$ must be seen from S' in different positions x'. This is like saying that a particle at rest in S must be seen in motion relative to S'.

No justification of the same quality can be found for $M(a)$. One can say, of course, that $M(a) \neq 0$ makes it possible that two events seen from S to have different position ($dx \neq 0$) at the same time ($dt = 0$) can be seen from S' to be at different times $(dt' \neq 0)$. It is a standard relativistic conclusion against a unique simultaneity, but one cannot see any direct physical justification, a priori. For sure, it violates the standard formulation of the homogeneity of space. Homogeneous means "equal in all parts." How can one make time depend on a variable specifying in which part one is of a medium equal in all parts? Then such medium would not be homogeneous, because its different parts would have different effects on time. $M(a) \neq 0$ implies a space dependence of the transformation of time. It is exactly in this way that the lack of homogeneity of space has been introduced in relativistic physics. Let us try to dig deeper into the idea.

Cartesian axes are very useful for the resolution of physical problems. They are conventional, but nevertheless most important components of elementary mathematical and physical description. They are the backbone of the inertial reference frames. Consider two such frames, S_0 and S, and suppose that S translates rigidly with respect to S_0 with velocity v pointing in the +x0 direction. The usual situation. But now let us try to obtain some consequences from the little universe we have built. One could say that it is a simplistic situation. Indeed, we have introduced three entities and nothing else:

1 The Cartesian axes of S_0, ideally extended to infinity;
2 The Cartesian axes of S , also ideally extended to infinity;
3 The velocity v present with constant density in the whole universe.

There is nothing else in the universe we are building, but this does not make it simplistic, because this is exactly the situation starting from which the famous transformations are deduced: Galilei and Lorentz in the first place, of course.
What is it the velocity v ? Well, we said it above, it is the velocity of rigid translation of S with respect to S_0. This means that v can be thought of as applied

to all points of S. But “to all points“ is not a useful indication, as it would give rise to a huge black spot if applied graphically. We can help reality with a drop of human creativity. Doing so is useful, provided we are respectful of the properties of the real world. If we are arrogant, instead, we are likely to produce disastrous theories. We can decide to represent graphically “only” N velocity vectors per cubic meter of S and to distribute them uniformly in all space.

Now we decide to explore this simple three dimensional universe. We take a small spaceship and travel, for example in the +y0 direction. Everywhere is the same view, a constant density of vectors, all parallel to one another, all perpendicular to our direction of motion, all flowing in the +x0 direction. The universe is everywhere equal to itself, all values of y0 are perfectly equivalent because all points have exactly the same situation. Choosing a value of y0 means going in a particular region of the universe, but why should we go there if we know a priori that what we meet there is identical to what we have here? In these conditions it is clear that no physical property, no phenomenon, no useful parametrization can depend on the y0 coordinate. In particular, the relationship between the time of S_0 and the time of the spaceship cannot depend on y0. The TSR respects this conclusion. In fact, nothing in the Lorentz transformations depends on y0.

Something could depend on y0 only if different values of y0 indicated a property, a reality which is variable. But in our universe there are only three things (listed above) and none is variable (the Cartesian variables, represented numerically on the axes, do not count as they are purely conventional).

Now we decide to move differently. We travel, say, in the +x0 direction. Everywhere is the same view, a constant density of vectors, all parallel to one another and to our direction of motion, all flowing in the +x0 direction. The universe is everywhere equal to itself, all values of x0 are perfectly equivalent, all regions have exactly the same structure. Introducing a dependence on x0 means establishing a hierarchy of the points of the universe, but why should we do this if we know a priori that all points are perfectly equivalent? In these conditions it is clear t co hat no physical property, no phenomenon, no useful parametrization can depend on the x0 ordinate. *The TSR does not respect this conclusion*. It contains something which depends on x0, the relationship between the time of S_0 and the time of the spaceship. It has been introduced something external, something useless, something likely to complicate the theory without real practical advantage. This is what can be called the original sin of the TSR.

Next comes a surprise concerning the behavior of traveling clocks. Two identical clocks, C_A and C_B are at rest on the x_0 axis of the isotropic reference frame S_0 at a distance D_0 from one another. Like the other clocks of S_0, C_A and C_B have been synchronized on the basis of the velocity of light (Einstein’s method). Therefore a new flash of light propagating in the $+x_0$ direction and touching C_A and C_B at times t_A and t_B, respectively, satisfies the relationship $D_0 / (t_B - t_A) = c$, meaning that the new measurement of the velocity of light is bound to give the result "*c*".

What happens if one modifies the times shown by the two clocks with two equal resettings? For example, one subtracts 33'45'' from the time of C_A and 33'45'' from the time of C_B. What happens if after doing this, one uses C_A and C_B for a new determination of the velocity of light? Of course, nothing happens, and the result "*c*" is found again, because the equal corrections of the two clocks cancel in the time difference.

We can also try to implement the resetting of time by physical means, that is by using the time retardation of moving clocks. We can do it, because C_A and C_B are on board of two spaceships, A and B, respectively. At a certain common time marked by the two clocks, A and B ignite their engines and actuate a pre-established program of acceleration such that at every instant of S_0 time the velocity is the same for A and B. But then, also the usual velocity dependent square root factor of time retardation is the same. Integrating over time, the retardation of the two clocks at the end of the acceleration period is the same. Incidentally, C_A and C_B at the end of the acceleration period, are at rest in a different inertial system *S*. Anyway, if they are used for a new measurement of the velocity of light they do not produce "*c*", but the value predicted by the inertial transformations (based, as you will remember, on $e_1 = 0$).

Clearly during the parallel trip of the two spaceships there seems to be a change in the reciprocal synchronization of C_A and C_B. Before departure the two clocks were *synchronized à la Einstein*, at the end of acceleration they had adopted the absolute synchronization.

Actually there was no synchronization change. That would be logically impossible, given the identical physical actions performed by the two spaceships. Our surprise is due to the fact that we are mmisled by a century-long acceptance of the theory of relativity: C_A and C_B had exactly the same velocity at every instant of S_0 time. From the point of view of an observer at rest in S_0, their equal motion can only imply equal changes of any physical quantity. There is absolutely no logical space for different changes. We must face the truth: the inertial transformations provide the only possible physical connections of moving frames to an isotropic inertial system.

A thought experiment very similar to the one discussed above was published in 1989 by S. P. Boughn [9]. The basic phenomenology examined was essentially the same as ours: twins undergo the same acceleration for the same length of time. The difference is all in the theoretic treatment, as Boughn relies on the Lorentz transformations, while for obtaining our results we use only the basic kinematics of rectilinear motion and the Lorentz contraction of moving objects, which as we saw is a consequence of all ET, not only of the LT.

Boughn uses the LT and reaches the conclusion that once arrived in the final inertial system after equal acceleration the twins discover having different ages. Actually in the case of equally accelerating spaceships the LT are excluded by elementary kinematics, as we saw above. In this way a brand new problem emerges for the TSR. If one insists on classical kinematics and on space homogeneity, gets our results. If instead one insists on the Lorentz transformations, the Boughn result appears. But the two outcomes are incompatible! They can be recovered only by resynchronizing clocks in the final state, but this is only an artificial procedure which cannot be given priority over an evolution dictated directly by nature's inner tendencies.

Boughn's conclusion is terrible: "Of course there is no paradox. The situations of the twins are not exactly the same. Jane started the trip a distance x_0 from Dick in the direction of the subsequent acceleration. Had the two accelerated to the left it would have been Dick who aged more." A never heard of breakdown of space homogeneity is introduced without a word of specific comment. The original sin of the TSR hits again!

The incompatibility between elementary kinematics and the Lorentz transformations in the case of twins undergoing the same acceleration for the same length of time has not been noticed by S.K. Ghosal and collaborators [10] who in a recent paper state: "Although the outcome is counter-intuitive (since in spite of the twin's accelerations being symmetric in every respect they age differently), the effect is an undeniable fact since it follows from SR." It is deniable instead, in particular because SR clearly does not apply to concretely produced inertial systems, but only to those coming from infinity.

If the reader has accepted what was written up to this point, he will not be surprised to know that this book contains six different proofs of absolute simultaneity, that is of the absence of space coordinates in the transformation of time. To make the point as clear as possible six chapters have the little formula $e_1 = 0$ already in the title. This is to signify that each one of those chapters contains one of the six proofs. On this we say nothing else here.

It is better to review other two original proofs of $e_1 = 0$ coming from independent researches. Very interesting results have been obtained by the Californian physicist, Ron Hatch [11] who is familiar with the point of view of observers placed in satellites. His papers produce the impression that the game between different approaches to relativistic phenomena is being played anew, with results converging with what has been found on the ground. Atomic clocks distributed around the world in scientific institutes communicate with one another by means of radio signals. The synchronization signals sent by a transmitting station always reach the receiving station 'on time,' at any hour of the day and in any season, despite the motion of the Earth. For some authors this means that these signals propagate isotropically (with one way velocity c), even with respect to the Earth surface. In fact in chapter 8 we will show that this may not be so: the proper working of the network says nothing about the one way velocity, as it is consistent with another theory, based on the inertial transformations, empirically (sometimes) equivalent to special relativity, in which the one way speed of light has a directional dependence in moving frames. But Hatch says much more by disclosing the mechanism by which an irregular timing system can be seen as perfectly smooth and regular.

From the GPS there is very strong evidence that clocks run faster when the gravitational potential is increased. But a clock on the earth at noon is closer to the sun than a clock on the earth at midnight. Therefore the clock at noon has a lower gravitational potential from the sun. Experimentally it has been found, however, that there is no apparent clock rate difference between noon and midnight. This is "the noon/midnight problem."

Different explanations have been attempted, but those based on the orthodoxy failed to resolve the problem. One idea was that the earth, the satellites, the clocks are all freely falling in the gravitational field of the sun and cannot therefore feel the action of that field. But this cannot be correct, because when a satellite passes from a first position at noon to a second position at midnight it covers a long distance and certainly it must feel the variation of the gravitational potential of the sun, which is to a very good approximation linear in the space separation between the two positions.

The key for resolving the problem came from a simple fact: data taken from clocks external to the solar system (millisecond pulsars), show that earth-based clocks actually do run at different rates at midnight and at noon!

According to Hatch the data collected both by VLBI (Very Long Baseline Interferometry) and GPS (Global Positioning System) indicate that earth-based clocks are biased as function of their position in the direction of the orbital velocity of our planet. The existence of these biases is confirmed by comparison of earth-based clocks with millisecond pulsars. These clock biases are precisely such as to cause the speed of light to appear as if it has the isotropic value "c" in any earth centered inertial frame. This shows that the speed of light in reality is not isotropic in the earth centered inertial frames and that the Lorentz transformations are only an artificial structure built up by "inertial transformations combined with clock biases." Thus Hatch attributes to the inertial transformations a fundamental role, in agreement with what we have been preaching .

Distant pulsars, which have pulse rates of hundreds of pulses per second, in practice are extremely stable clocks with a slow but very precise change in frequency as they loose energy. Their stability equals that of the very best clocks on the earth. Therefore they can be compared to clocks of all types on the earth. This comparison easily allows one to detect local biases.

In fact, if the comparison of terrestrial clocks with pulsar emissions shows oscillating differences correlated with the earth motion it is unreasonable to assume that they are due to the pulsar which is far away in space. Moreover, there are several pulsars in different parts of the sky which can be used for reciprocal stability tests. The outcome is that the pulsar data reveal a diurnal variation in terrestrial clock rate. More exactly the noon second is about 300 ps shorter than the midnight second, a result obtained by combining effects due to velocity relative to the sun with solar gravitational effects. Hatch found that the clock bias Δt of the time t in the earth-based frame is

$$\Delta t = -\vec{V}.\vec{x} / c^2 \tag{1}$$

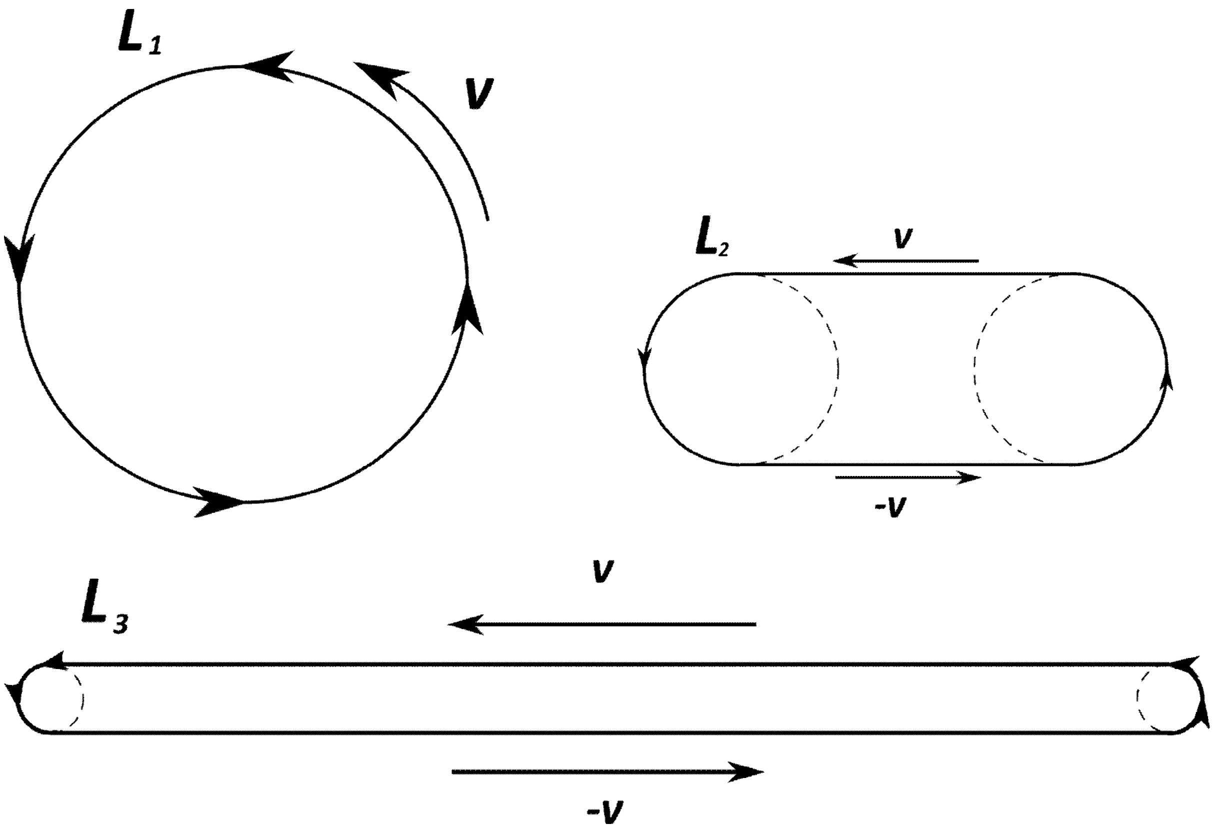
Equation (1) tells us that an inertial transformation which applies to a moving frame in an absolute ether can be converted into an apparent Lorentz transformation simply by biasing the clock settings. Thus, assuming an ether, the TSR can be made to appear as valid simply by biasing the clocks by the appropriate amount as a function of position .

The amazing fact is that such a time correction is exactly what is needed to force the inertial transformations to become the Lorentz transformations. Thanks to the work of Hatch, now we understand what happened: the clocks on the earth surface were synchronized with the Einstein method and biases were introduced. The Einstein synchronization on the earth is maintained as a result of the combined velocity relative to the sun and the solar gravitational effects.

Another independent confirmation for the inertial transformations came from Minnesota where a modified Sagnac experiment has been carried out recently by Ruyong Wang and collaborators [12]. The instrument was designed to decide whether the travel time difference only appears in rotational motion, or it also appears in rectilinear uniform motion. The results were sharply in favor of the latter possibility.

The Sagnac effect shows that two light pulses, sent clockwise and counterclockwise around a closed path on a rotating disk, take different times to travel the path. The time difference is often written as $\Delta t = 4A\omega / c^2$, where A is the area enclosed by the path and ω is the angular velocity of the disk rotation. For a circular path of radius R one can also write $\Delta t = 2v\, L / c^2$, where $v = \omega\, L$ is the speed of the circular motion and L is the path circumference length. The Sagnac effect has been studied in fiber optic gyroscopes (FOGs).

In a FOG, when a single mode fiber is wound to a coil with N turns the Sagnac effect increases to $\Delta t = 4A\omega\, N / c^2$ or $\Delta t = 2v\, L / c^2$ where L is now the total fiber length. Usually the two expressions of Δt are considered equivalent, but the experiment performed by R. Wang and coll. leads to the conclusion that only the second has general validity. Conceptually a FOG, shown in Fig. 10a, could be divided into two semicircular sections with extended fiber connecting the end sections as shown in Fig. 10b. The fiber moves when the wheels at the two ends rotate. This new device is called a fiber optic conveyor (FOC).



The conclusion of this experiment was that the time delay due to the uniform translation of a fiber segment with a speed of v and a length of ΔL contributes $\Delta t = 2v\,\Delta L / c^2$ exactly like a segment of circularly moving fiber does. Obviously this is in full agreement with our approach to relativistic physics, which attributes in all cases the same local velocity of light relative to an accelerating reference frame and to the locally comoving inertial frame. Both in the examined experiment and in our theory the physical difference between linear and curvilinear uniform motion tends to vanish.

In Chapter 16 the experiment is reviewed and is proposed another configuration in which the "wheels" of the FOC are small and the two rectilinear parts of the apparatus are parallel, very near and very long. Besides the isotropic frame S_0 in the game there are two inertial frames S' and S'', those in which the left-to-right and right-to-left going fibers are at rest, respectively. Clearly S' and S'' move with opposite velocities, but with the same speed wrt S_0. Also the speed of each light pulse is the same left-to-right and right-to-left, due to the isotropy of space. This must be so in all theories. Of course the speed can depend on the propagation being concordant or discordant with the motion of the fiber.

[1] M.G. Sagnac, *Compt. Rend.* **157**, 708, 1410 (1913).

[2] P. Langevin, *Compt. Rend.* **173**, 831 (1921).

[3] P. Langevin, *Compt. Rend.* **205**, 304 (1937).

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