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A New Gravitational Paradigm for Relativity and Dynamics, and its Philosophical Scope

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Abstract. The present framework of dynamics and relativity is based on Albert Einstein's special and general theories of relativity. However, the empty featureless space and its time that are assumed in constructing these theories are in direct conflict with the reality of the vast universe with enormous quantity of matter-energy and its gravity. Gravitational interaction affects spatio-temporal intervals and dynamics in general. Since all the physical phenomena as well as the theories that attempt to describe them are operative in this single real universe, really existing as given, the factual gravitational background of cosmic matter should be the inseparable basis of our theories of relativity and dynamics. After proving the need for a new paradigm of relativity and dynamics based on cosmic gravity, I will outline the empirically consistent theory and its crucial experimental support. I will show that the factual results on the one-way propagation of light and relativistic motional corrections of clocks contradict the current theoretical framework. The gravitational paradigm, called Cosmic Relativity, is Galilean and Machian, and includes all relativistic physical effects, with the universe as the determining master frame. It accords a physical measure of real motion and also, a universal time. Most importantly, Cosmic Relativity is in perfect agreement with all known experimental results. These remarkable developments in physics support and vindicate Henri Bergson's criticism of Einstein's theory and his philosophical stand on the notions of universal time and absolute simultaneity.

1. Introduction

The special and general theories of relativity were completed more than a century ago. The theory of quantum mechanics as well as its extension to quantum field theories soon followed. Hence, the core physical theories of relativity and dynamics were considered complete before we acquired any significant knowledge about the real universe we live in, where we construct and test our theories and where all the physical phenomena happen. Therefore, these theories explicitly assume, as their basis, an empty and isotropic space and time marked by clocks within, called the Minkowski space-time [1]. Then, there is no privileged reference frame to define true motion and there is no physical sense in the notion of absolute rest. The reality of our factual existence in a vast universe with enormous amount of matter was realized well after our fundamental theories were matured, when observational cosmology extended its reach with the large telescopes after 1930. Space is not empty; there is no place in the universe we can find as empty space, devoid of matter and gravity. We know that gravity affects and modifies spatial and temporal intervals, and affects the general features of dynamics of particles. Yet, we explicitly assume a universe with empty space, devoid of gravity, in our fundamental theories. There is enormous conceptual and quantitative difference between physical phenomena in empty

space and those in the gravitational potentials of vast amounts of matter. Hence, it is obvious that we deemed our theories complete too early to incorporate in them the one decisive factor that controls and determines relativistic physics and dynamics – the gravity of the matter in the universe, or 'cosmic gravity'. Worse still, we neglected to reconsider the basis of these theories for a century, even after an accumulating body of empirical evidence with warning clues was available. How long are we going to pretend that all is well with the prevailing theories, given the serious logical lacuna as well as several unambiguous empirical indicators?

A reconsideration is obviously essential, demanded by both logical factors and empirical evidence. The gravitational background of a matter-filled universe that can affect relativistic physical phenomena and dynamics is an undeniable reality. Hence, a paradigm based on empty space cannot be maintained or defended logically. What needs to be examined is whether there is also clear empirical evidence that contradicts and falsifies the Einstein-Minkowski empty space paradigm. We will see that there are unambiguous and easily verifiable experimental evidence that falsify the prevailing paradigm [2, 3]. I will show that the matter in the universe and its gravity define relativity and dynamics. Then, the universe takes the role of the master determining frame, or what was traditionally called the 'absolute frame', with a universal time and valid notion of absolute simultaneity. The cardinal prediction of the Galilean nature of the propagation of light, instead of the Einsteinean propagation with invariant relative speed, is now verified well in laboratory experiments [2, 3, 4]. Several experimental results on the motional relativistic modifications of clocks support the reality of the master frame for relativity and they are in clear conflict with Einstein's theory. This resurrects, with ample supporting evidence, the physical and philosophical positions of an absolute physical reference for motion and simultaneity of events [5, 6]. The totality of empirical evidence is fully consistent with the gravitational paradigm with the matter-filled universe as the master determining frame, which I developed as the complete theory of 'Cosmic Relativity' [2, 7].

The paradigm of Cosmic Relativity rightfully replaces Einstein's Special Theory Relativity (STR) because of the simple reason that universe is not empty, contrary to the fundamental assumption of Special Relativity. Since the physical reason is the gravity of cosmic matter, Einstein's General Theory of Relativity (GTR) needs a major modification, being a theory of gravity. The unavoidable and perennial gravitational fields of cosmic matter should be the irreducible part of Einstein's equations themselves. The energy-momentum of the matter in the universe is included in the new 'Centenary Einstein's Equations' of modified GTR [3]. This modification takes away the feature of 'general coordinate invariance' from GTR, due to the physical reality of the unique master frame of the universe. The theory becomes fully 'Machian'; the well known enigma of inertial forces — pseudo-forces without sources — is solved and these forces naturally emerge as true gravitational forces with cosmic matter as their source [8].

I will survey the relevant points of this new gravitational paradigm for relativity and dynamics, citing and briefly explaining crucial empirical evidence as well as the robust logical evidence. What needs to be kept in mind throughout is the empirical and logical integrity of the paradigm and its theoretical consequences, without a single logical blemish or hint of disagreement. Further, there is no place for ambiguities or paradoxes, unlike the well-known ones in the prevailing theory.

Einstein's theories are interpreted as not only the theories of relativity and gravity, but also as the theories of space and time themselves [1]. This is because the physical effects due to motion and gravity are described in terms of the changes on spatial and temporal intervals, abstractly defined. While these are factually the spatial intervals between material particles and the duration marked by material clocks, the essential and crucial role of the 'material' markers is dropped at the level of abstraction, without logical rigour. The fact that motion through space changes rate of clocks and length of rods is interpreted as the natural amalgamation of space and time into a single geometrical entity called space-time. The unobservable space-time is elevated

to a full fledged dynamical entity in the General Theory of Relativity; the properties of the abstract space-time are said to be defined by matter, which in turn determines the gravitational dynamics of matter. In real physical terms, however, all observable experiences of gravity are limited to matter affecting spatial separation between material particles and the rate of material clocks.

The surprising fact of the history of physics is that, even with such tight relations between matter, gravity and the properties of space in the most studied theory, we have ignored, and continue to ignore, most of the matter in the universe and its gravity to such an extent that we claim that our space is truly empty far enough from our 'massive home' of the solar system. Few physicists realize that the gravitational potential of the Earth is a billion times weaker than the potential due to all the matter in the universe!

Einstein's Special Theory of Relativity has been scrutinized and criticized by some well known physicists and philosophers at various times in the past century. One issue that attracted much early attention is the asymmetrical behaviour of clocks in motion in the observer-symmetric theory. Much confusion prevails even today about the difference in the rates of two clocks in relative motion, called the twin paradox. While I do not discuss the paradox itself, I draw attention to the fact that most physicists are unaware of Einstein's singular paper on addressing the paradox, in 1918, and his clear statement that the issue couldn't be resolved within the special theory because the theory treated all inertial observers as equivalent [9]. Hence, Einstein's resolution invoked the gravitational time dilation deduced from the general relativistic equivalence of acceleration and a gravitational field. In that paper, he reached close to identifying the determinant role of the universe and the gravity of its matter content, but strayed away without holding on to a possible insight [10].

A less noticed, but even more important issue in the special theory is that of the synchronization of clocks. The notion of simultaneity is fundamental to the physics of relativity. It is central to the foundations of the theory as well as in applications like global navigation systems (like GPS) based on atomic clocks and the propagation of light. Empirical evidence supporting the Galilean nature of the propagation of light and the Galilean notion of simultaneity in a master 'absolute' frame, as well as the modification of the rate of clocks that depends on their 'absolute' speed (rather than their mutual relative speed), are now available in the operation of the global navigation systems. In fact, the focus of this article and also the strength behind its assertions are the overwhelming empirical evidence in favour of a new paradigm of relativity and dynamics that is entirely determined by the gravity of the matter and energy in the unique frame of the universe. I will explicitly demonstrate that Einstein's conclusion of simultaneity in his theory was in direct conflict with his postulate of the invariance of the speed of light [3]. This inconsistency was clearly pointed out by the French philosopher Henri Bergson already in 1922 [5], but physicists were dismissive, thereby missing an early chance to redeem [6].

Einstein's theories influenced philosophical discussions concerning space, time and the evolution of the universe like never before. Bergson's philosophy was anchored on the notion of universal time and absolute simultaneity, considered as simple and intuitive hypothesis, with no conflict with the notion of time and its synchronization in physics. Bergson studied Einstein's special theory of relativity and criticized its notions of simultaneity and the multitude of times, pointing out inconsistencies [5]. With his early mathematical training and proven competence, Bergson had no difficulty with the formal aspects of relativity. There is a general impression that Bergsonian world view is effaced by Einstein's theory [11, 12]. However, we will see that despite its many successes Einstein's theory is in conflict with verifiable and common empirical evidence, like the routine operation of GPS. With the matter-filled gravitational universe taking the role of the master frame, universal time and absolute simultaneity stressed by Bergson are naturally resurrected [6].

2. Empty Space of Einstein's Theories and its Time

Einstein's Special Theory of Relativity (STR) originated in the fertile soil of experimental results in optics and electrodynamics, and the Lorentz-Poincaré Theory of Relativity (LPTR), developed during 1895-1905 [13, 14].

The Galilean principle of relativity, according to which the state of uniform motion cannot be detected and distinguished from a state of rest, was at the basis of pre-STR dynamics. As for electrodynamics, it was assumed that the propagation of light required a universal medium, called the *ether*. The question naturally arose whether the hypothetical ether could be detected by measuring the relative velocity of light while the laboratory on the Earth was moving through the ether, just as one could detect the presence of the medium of air by measuring the velocity of sound relative to an observer moving and chasing the sound waves. A. A. Michelson and E. W. Morley announced in 1887 the failure to detect the motion of the Earth through the ether, in spite of sufficient sensitivity of their experiment that used a novel optical interferometer invented earlier by Michelson [15]. It was as if *the ether was as undetectable as the empty space*.

This null result implied an invariance property of Maxwell's equations of electrodynamics. H. A. Lorentz eventually arrived at the 'Lorentz transformations' of spatial coordinates and time that achieve this invariance, *while preserving the invisible ether and the Galilean notion of the variable relative speed of light* [13]. In Lorentz's theory, a measuring rod (scale) that moved relative to the ether contracted (length contraction) and the time measured by a moving clock progressed slower (time dilation). Henri Poincaré provided decisive mathematical completion to this theory, stressing the general principle relativity applicable to all physical phenomena [16].

That was when Einstein published his ideas of relativity in 1905, with the same principle of relativity as one of the postulates and a very different interpretation of the Lorentz transformations [17]. Einstein's generalization was to include all physical phenomena in its scope, just as Poincaré did.

The different interpretation of the Lorentz transformations came from the second and the characteristic postulate of Einstein's theory – that the relative velocity of light is always an invariant constant, relative to any observer, moving or at rest. Once this non-intuitive feature is assumed, Lorentz transformations follow as a consequence. But there was a special price to pay; without any universal reference, the theory became symmetrical and reciprocal between any two observers in uniform relative motion. Any observer 'A' can claim being in a state of rest and that the other one 'B' is moving, with the Lorentz modifications affecting the clocks and rulers of only the observer B. In turn, B can equally well claim that he is at rest and A is moving with exactly the same modifications happening only to A's clocks and rulers. The fastest clock and the longest ruler are always in the frame at rest. But, the frame at rest is equally A and B, from their own frame. This is the point of departure in Einstein's symmetrical theory regarding the notions of space and time postulated in physical theories until then.

One should note the important feature in Einstein's theory that there is no physical reason for the modifications of time and length. In fact, there is no reason, in the sense of a cause-effect relation, because the cause – presumably motion – is not real, but only a relative notion in Einstein's theory. Relative inertial motion is a totally symmetrical notion among two reference frames, with equal right to both to claim the state of rest. What is demanded is only consistency within each reference frame. This is perhaps the first instance in modern physics when one had to be content with observable physical changes without any identifiable cause, after Newtonian physics matured with its tight cause-effect relationship in physical phenomena in terms of the forces of interactions between matter. (There is another earlier instance, of the inertial pseudo-forces, that challenged Newton's wits and later, Einstein's. Only Ernst Mach had a viable proposal for their possible cause). This gap of 'missing cause' in measurable physical phenomena is a serious philosophical issue as well, though not much attention has been drawn to it. We will see later that the theory of Cosmic Relativity identifies cosmic gravity as the true cause and

fundamental interaction behind both inertial forces and relativistic changes in spatial intervals and time.

Einstein's Special Theory of Relativity, assumed to be valid in all inertial frames including freely falling frames in a gravitational field, is explicitly an empty-space theory. Quite naturally, that is what results when the undetectable ether is eliminated from the otherwise empty space. This is easily seen by noting that it is described in a space-time characterized by the 'Minkowski metric' in every inertial reference frame, which reflects static (time independent) isotropic and homogeneous space that remains invariant under uniform relative motion. This means that the Minkowski metric has only diagonal components

$$g_{ij} \equiv \eta_{ij} = diag\{-1, 1, 1, 1\} \tag{1}$$

in every inertial frame. The formal mathematical statement of the theory is that in all frames connected by the velocity transformations called the Lorentz transformations, this metric (its components) remains invariant. The physical equivalent is to say that the relative speed of light in an invariant constant in all inertial frames. Only empty space remains isotropic under motion; space with matter becomes anisotropic under motion because there would be a 'current' or flow of matter in a relatively moving frame, defining a direction of anisotropy. Therefore, STR, the Minkowski metric and the Lorentz transformations make sense only in empty space. The physical measures of spatial and temporal intervals are formally given by the product of the metric and the coordinate intervals. Since the metric remains invariant in STR, the entire motional modifications that happen to length and time – the well known length contraction and time dilation – are contained in the Lorentz transformations of the coordinates.

STR is used in all of physics and established as the correct fundamental theory for relativistic dynamics. After decades of familiarity and support, it has been presumed that the theory is consistent with all empirical evidence at hand. However, it might come as a shock to most when the fact is stated that *its fundamental distinguishing postulate of the invariance of the relative speed of light has never been tested directly in any experiment.* More deplorable is the widespread false impression even among experts that the Michelson-Morley experiment and its variants prove the constancy of the relative speed of light. Further, it is not recognized by most that there is not a single experimental evidence that contradicts the Lorentz-Poincaré ether relativity! Added to this factual situation is another undeniable realization that our universe is filled with matter and gravity, which renders the very 'empty-space' basis of the theory invalid. Instead of an undetectable ether we always had the observable and mighty presence of the matter-energy in the universe that defined an 'absolute' master frame, with its gravity controlling dynamics, including that of light. It is just that we did not know about this universe when the theory of relativity originated and gained acceptance in its first two decades. However, this awareness about the physical universe makes all the difference, as we will see after we discuss the true situation regarding the empirical support for the theory.

3. Michelson-Morley and Other 'Two-Way' Experiments

I stress the important statement that the hypothesis of the constancy of the speed of propagation of light relative to any inertial frame has remained untested experimentally to this day. People get upset or animated when this is stated. But the falsity of the general impression that the Michelson-Morley experiment or its variations are proof for the light hypothesis is easy to show. The proof of the inefficacy of such experiments to address the issue is elementary.

The Michelson-Morley experiment (or its important variation, the Kennedy-Thorndike experiment with one arm of the interferometer much shorter) are two-way experiments where light propagates in both 'up' and 'down' directions, parallel and anti-parallel to the direction of the motion of the interferometer. Such a scheme was necessary because the propagation of light in a one-way experiment is conceptually intertwined with the issue of synchronization and

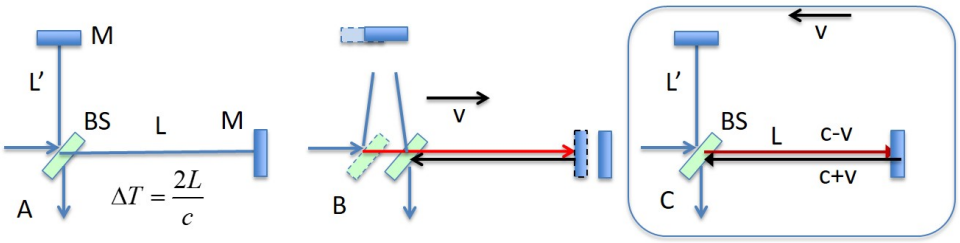

Figure 1. A: The Michelson Interferometer. Light waves travel from the beam splitter BS to the two mirrors M and back and exit overlapped, causing interference and 'fringes'. The duration of propagation at ideal rest is 2L/c. B: In the Michelson-Morley experiment, the interferometer is in motion with the Earth's velocity v while the light waves are on their two-way trip. As seen from a global frame, light traverses unequal up and down distances as indicated with the red and black arrows. C: In the rest frame of the interferometer, light travels with unequal Galilean relative speeds, $c - v$ and $c + v$ in 'absolute' theories and at the invariant speed c in Einstein's theory.

simultaneity of clocks in two different locations; the measurement of the velocity necessarily requires the measurement of duration that light takes to propagate from 'here' to 'there', and hence, between two clocks. Therefore, all measurements, direct and indirect, have been limited to the two-way speed in which light is brought back to the same point in space, to measure the duration of the two-way propagation, as in the Michelson-Morley experiment (figure 1).

It is very easy to see why the two-way experiments like the Michelson-Morley experiment cannot decide on the isotropy of the propagation of light. Referring to fig. 1, the time taken in propagation over a length L at speed s is L/s. So, if the speed is not isotropic, but instead $c - v$ while light is in one direction and $c + v$ in the return path after reflection in the two-way experiment, the total duration taken is

$$T = \frac{L}{c-v} + \frac{L}{c+v} = \frac{2L}{c(1-v^2/c^2)}$$

Hence, the total duration is different from the isotropic value $T_0 = 2L/c$ only by the small 'second order' term, $(1 - v^2/c^2)$. If both length and time (clocks) are modified due to the motion (through ether, say) by factors $\sqrt{1-v^2/c^2}$, this excess factor of $(1 - v^2/c^2)$ is exactly compensated. Thus, we get $2L/c$ as the duration even when the propagation of light is not isotropic! (The excess duration along the perpendicular arm L' is $2L'/c\sqrt{1-v^2/c^2}$, which is compensated by just the time dilation term). On the other hand if one postulates that the speed of light is isotropic in any frame, then there cannot be any modification of length or time in such frames. *Either view is consistent with the Michelson-Morley experiment*, making such experiments indecisive on this issue. It is an elementary fact, and there is no justification for the continuing widespread erroneous belief.

3.1. One-Way Experiments

It is obvious that a measurement of the one-way relative speed of light needs to tackle the hard problem of synchronizing two separated clocks. Before discussing the solution to this problem, I will prove the *impossibility of testing the constancy of the one-way speed of light by schemes that use two spatially separated clocks*. The measurement needs fixing the spatial distance L between two points A and B, and measuring the duration of propagation ΔT of light from A to B, using synchronized clocks. Without synchronization, physical 'duration' remains arbitrary. Fixing L with a two-way measurement is easy and does not interfere with the measurement

of the relative one-way speed, first order in v/c, because any relativistic correction due to the unknowable inertial speed of the reference frame is second order in v/c. But, how do we synchronize the two clocks? Obviously, we cannot use a pulse of light from one point to another to synchronize clocks because the duration depends on what we assume for the propagation of light; if we assume constant relative speed, the duration of propagation is L/c whereas if we assume Galilean propagation, we get the duration $L/(c \pm v) \simeq (L/c) \mp (L/c)(v/c)$, with the first order correction. Since we cannot know the velocity of the frame (principle of relativity), our synchronization depends on our assumption and chosen convention. Our task of finding out the nature of propagation of light would become logically circular if we used light to synchronize the clocks.

The other possibility of synchronizing two clocks at the same location A and transporting one slowly to point B does not work either. For a clock transported at the small velocity v_c in the frame moving at the velocity v_f, the second order time dilation is

$$\Delta T_B \simeq -T_B \frac{(v_f + v_c)^2}{c^2 n} \simeq -T_B \left(\frac{v_f^2}{2c^2} + \frac{v_c^2}{2c^2} + \frac{v_f v_c}{c^2} \right) = -T_B \frac{v_f^2 + v_c^2}{2c^2} - \frac{L v_f}{c^2} \tag{2}$$

Therefore, there is an *unknowable* first order time dilation between the two clocks, of $(L/c)(v_f/c)$, making the clock B to run ahead of A, if synchronized with this protocol. If we use such a clock to measure the propagation duration of light, the synchronization mismatch $(L/c)(v_f/c)$ masks the Galilean propagation factor $-(L/c)(v_f/c)$, giving the false conclusion that the speed of light is an invariant! So, we have proved that *it is impossible to decide whether the relative speed of light is Galilean, or an invariant constant, in a one-way measurement that employs two spatially separated clocks.*

However, even seasoned experts do not always realize this crucial point. One can see a number of well-cited publications claiming the verification of the postulate in measurements involving one-way propagation and clocks at two different locations. The irony and embarrassment of the situation go deeper than one might imagine. The need for one-way measurements to demarcate Einstein's theory from the Lorentz-Poincaré theory was reiterated in a paper in the journal Physical Review Letters by M. Ruderfer in 1960 [18]. He suggested an experiment based on the newly discovered Mössbauer effect. Very soon Ruderfer published a vital erratum [19], when he understood the fundamental issue of the inseparability of the propagation delay and the duration measured with separated clocks. This fundamental 'catch' was already known and discussed by Poincaré, stressing the role of 'convention' in synchronization, but it is a subtle and deep issue that is easily missed, as history shows. Oblivious to the content of the erratum, researchers went ahead and "confirmed the light hypothesis", while citing both Ruderfer's proposal paper as well as the nullifying erratum [20]! And many are continuing in vain to refine these tests on the "isotropy of the speed of light" [21], still remaining in the dark about the inefficacy of such experiments due to the interdependence of synchronization and time dilation of separated clocks in moving frames. It is a lasting embarrassment in the recent history of physics.

3.2. One-Way Experiments in Rotating Frames

In 1913, Georges Sagnac used a closed-loop optical interferometer at the Sorbonne in Paris to measure the effect of rotation through the 'stationary ether'. He presented the positive results, 'the proof of the reality of the luminiferous aether by the experiment with a rotating interferometer', in several publications [22, 23]. He considered his result as the decisive disproof of the etherless Special Theory of Relativity.

A. A. Michelson had published a similar idea in 1904, to detect Earth's rotational motion relative to the ether, but managed to do an experiment only in 1924, with H. G. Gale [24, 25]. Michelson concluded from their heroic experiment, with a partially evacuated kilometer-size

Figure 2. The equivalence of the relative durations the wave takes to propagate a relative distance L, while the frame is moving at the uniform speed v, for the linear case (left) and for the looped circular case (right). Here, $2\pi R = L$, and $R\Omega = v$. The experiment on the left is not feasible, because the waves would be far from the observer, at the end B, where another synchronized clock is required. The one on the right is the Sagnac experiment.

closed rectangular interferometer, that the slow rotation of the Earth relative to the stationary ether was detected.

The essence of Sagnac's experiment can be stated in a simple way (figure 2). If one moves in the direction of the light waves at velocity v, chasing light through the stationary ether, light waves will be moving at a lesser relative velocity, at $c - v$, just as the relative velocity of sound waves changes for an observer who moves through stationary air medium. Then the duration of propagation over the same distance will be longer. If we arrange to loop the path, by identifying the end points of the total path, the frame is moving in the same direction through the medium anywhere along the path. If light is sent opposite to the rotation, the relative velocity is $c + v$. The two can be combined using two identical waves going clockwise and counter-clockwise, while the rotation is only in one sense; then the time taken to cover the same loop distance L' (in the rest frame of the observer) by one wave is different from the time taken by the other,

$$\delta T' = \frac{L'}{c - v} - \frac{L'}{c + v} \simeq \frac{2L'v}{c^2} \tag{3}$$

The duration $\delta T'$ is exactly equal to $2Lv/c^2$ when the second order time dilation and length contraction are included. When the light beams are combined, this difference manifests as the phase difference and the shift of the interference fringes. The simple result can be written in a more general form, with the same content. Since $L = 2\pi R$ and $v = \Omega R$ for a path looped into a circle, $\delta T = 4A\Omega/c^2$, where $A = \pi R^2$ is the 'area' of the interferometer. In contrast, if the speed of light is assumed to be isotropic and invariant, the fringe shift is zero.

Therefore, the results of the experiments by Sagnac and Michelson clearly contradict the validity of the light hypothesis in uniformly rotating frames. However, most physicists do not take these results seriously in discussions of the validity of the light hypothesis because the postulate was introduced in the context of inertial frames. (Results in relativity like Thomas precession are analyzed in a rotating frame and the entire Einstein argument on gravitational redshift of light is done in an accelerating frame, both assuming the light hypothesis. But, one very often sees such selective defensive stance, devoid of any logic, in discussions on the foundations of relativity). Another twist of history is that all physicists who concluded that Sagnac's results were consistent with both special relativity and ether relativity only demonstrated the equality of the velocity-dependent duration ($\Delta T(\omega) \propto (1 + v/c)$) taken by the light beam to circulate around the interferometer in both theories. But, they did not pay attention to the crucial fact that the path length L of propagation in the rotating frame, as calculated in both theories, was independent of the rotational velocity! It is then elementary to conclude that the relative speed of light, which is the ratio $L/\Delta T$, varies linearly with the velocity

of rotation, to first order in v/c. The criticism, that the conclusion drawn from experiments done in noninertial rotating frames are flawed as tests of the light hypothesis, was overcome a century later in the experiments done in our laboratory, on the one-way propagation of light relative to inertial frames.

4. Proof of Galilean Relative Velocity of Light

I will now discuss the central experimental result that proves the Galilean nature of the relative speed of light, relative to inertial frames [2, 4]. To establish a relative velocity, we need to measure the duration for propagation from point A to B with a spatial distance L measured along the path. As we clarified already, it is immaterial whether there is a length contraction or not when the frame moves at different velocities, because the effect is second order in velocity. Since we are trying to assert whether relative one-way velocity is a constant c or the variable $c(1 \pm v/c)$, an effect of order v^2/c^2 is insignificant in the experiment (in terms of numbers, $v/c \sim 10^{-8}$ whereas $v^2/c^2 \sim 10^{-16}$).

Once the path length is fixed, the measurement involves only the duration $T(v)$ of propagation between A and B of fixed path length, as a function of the velocity v of the frame, which is a common synchronous velocity of A and B, or the emitter and the detector (fig. 3). The relative speed is $c(v) = L/T(v)$. We measure $T(v)$ either directly or interferometrically. With fixed oscillator frequency between the emitter and detector with no relative motion (no Doppler shift), phase measurement is the same as time (duration) measurement ($\delta T = \omega\delta\varphi$).

As stressed earlier, we need to adhere to two conditions: (a) the clock synchronization problem needs to be solved, (b) the reference frame should be in inertial motion. I succeeded in solving both issues, resulting in a decisive experiment that falsifies Einstein's light hypothesis.

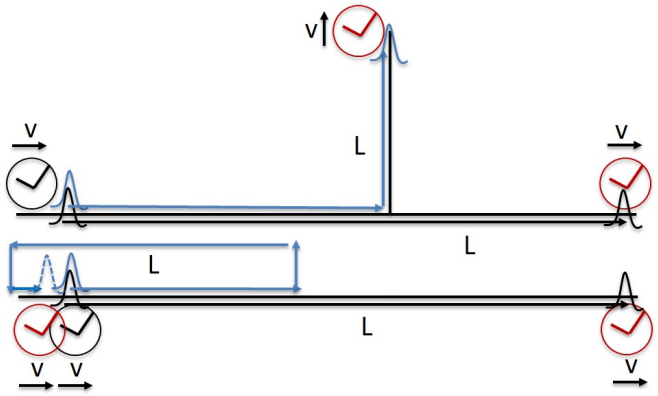

Figure 3. Upper panel: The equivalence of the duration of light propagation on a straight path and another path with bends, relative to a system of two clocks in motion with their separation fixed as L. Lower panel: When the path with bends completes a loop, the clocks with separation L approach each other, solving the synchronization problem. Then, the synchronized clocks can be in inertial motion while the light waves traverse the fixed distance L between the clocks along the one-dimensional path.

We note that light takes identical durations to travel identical path lengths irrespective of the shape of the path. That is, for the one-dimensional path with a bend, L-shaped, the time of propagation is the same as that for the straight path of the same length for the same inertial speeds of A and B, but for a possible small fixed bend-correction that is independent of the velocity of the observer (figure 3). A special one-way path with a finite number of bends is the closed 'stadium' path with long inertial sections over which the source and detector move,

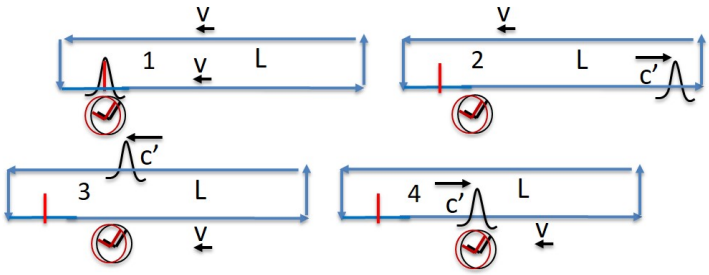

Figure 4. Four snapshots of the propagation of the light pulse in the reference frame of the clocks, which are in motion relative to a master frame at speed v. The looped 'stadium' path of fixed length L between the clocks moves at uniform velocity $-v$ relative to the clocks, while the light pulse propagates at the relative speed c'. The relative speed is $c'(v) = L/\Delta T(v)$. In the actual experiment, the two clocks are implicit in the emitter and detector of the light signals.

always inertially. The distance between the emitter and the wavepacket increases whereas the distance to the receiver decreases monotonically, verifiably, as in a linear path. So, we have established logically that the experimental results on the relative speed would be identical in the straight path and in the stadium path. We will verify this assertion experimentally as well, to avoid any residual misunderstanding.

By establishing the equivalence of the results in the linear path with separated clocks and the stadium path with clocks at the 'start' and 'finish' points, I have removed the crucial hurdle that prevented hitherto the direct measurement of true one-way relative speed of light, relative to inertial observers. Note that in the 'stadium' configuration we have a fixed separation L between the clocks and yet they are nearby due to the looping, allowing unambiguous synchronization that is free of conventions or postulates! Also, because they are nearby, it is easy to move them together *inertially* on the same short platform. In fact, the two clocks can be mathematically and physically identified and replaced by a single clock for reference. Waves travel the same fixed distance L from the source to the detector in a round trip, without retracing back their path (fig. 4). *We have indeed solved the crucial problem of clock synchronization, while preserving inertial motion* [4].

Relative to the moving frame, the path length is fixed as L. This is evident since the source and the detector that define the path of length L between them are then in the 'rest frame' and there is no relative motion between them. The duration depends on whether the relative velocity of light is Galilean or an invariant. If the relative velocity is an invariant (same c_0 in all inertial frames) then $\delta T = L/c_0$. On the other hand, if the relative velocity is Galilean $c_0 - v$, then the duration $\delta T'$ is *the same as in the lab-frame to first order in* v/c. (For Galilean physics $\delta T' = \delta T$ to first order in v/c).

$$\delta T = L/(c_0 - v) \simeq \frac{L(1 + v/c_0)}{c_0} \tag{4}$$

I have taken the important step of validating the logic and method of the experiment and its ability to test whether the one-way relative velocity is Galilean with *sound*, which is a known Galilean wave. As is well known, the velocity of sound is independent of the velocity of the source and depends only on the properties of the medium (this is true for other waves and established for light as well before the days of relativity theories). The measurement is done in the moving frame, with both the emitter and at the receiver comoving on the same mobile platform.

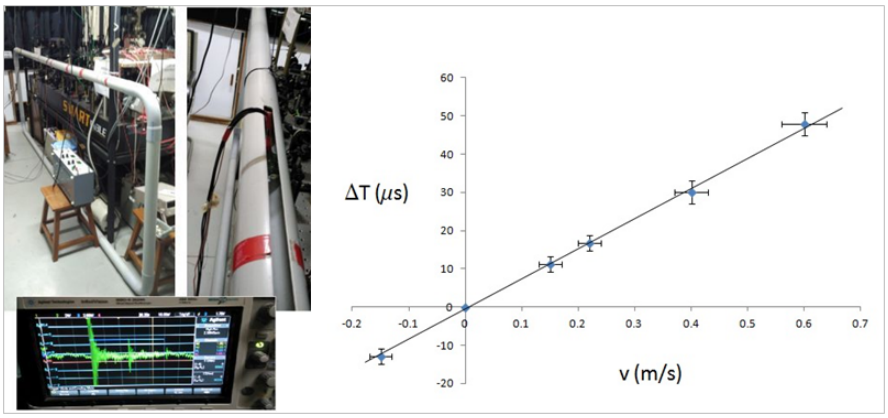

Figure 5. The scheme for the measurement of relative velocity of Galilean sound. Left: The experimental arrangement and the oscilloscope trace of the sound pulses at the source and after the round trip. Right: The measured duration of propagation as a function of the velocity of the 'observer' frame, confirming the expected Galilean nature.

If the source and the detector are moved slowly through the medium, air, the duration that sound takes to propagate a fixed distance L changes linearly in v. For $v \simeq 1\, m/s$, and $L \simeq 8.6m$, the change in propagation duration is $73\, \mu s$, which is measurable directly in a careful experiment (there are no synchronization problems with sound; therefore the experiment is feasible in a straight path as well as in a 'stadium' configuration).

The source is a buzzer operated by a periodic short pulse (1 ms) at 4-5 kHz base frequency. The detector is a miniature microphone, fixed facing the opposite direction to receive sound that comes to it after round trips. The folded round trip path is defined with 50 cm diameter PVC pipes with smooth bends. The source-detector assembly can be smoothly moved over a distance of about 50 cm through a small long slot in the pipe (figure 5).

The result of the experiment is plotted in fig. 5, which confirms that the round trip duration changes linearly with the velocity of the frame [3, 26]. As expected, the result confirms that sound is a Galilean wave and the result for the round trip path is identical to the one expected in a linear path. *This validates the experimental method, freeing it from conventions, postulates and theories of relativity.*

What do we expect for light? *It is not Galilean according to STR. So, the experimental results should be different from that for sound, in the moving frame.* In the lab frame, since the path length from the source to the detector changes with velocity, as $L(v) \simeq L(1 + v/c)$ the duration also should change in a similar way, such that velocity is the invariant c. In the moving frame, the path length remains constant at L'. This is easy to see, since the L' is the distance to the detector D from the source S measured along the round trip path, in the rest frame of the source. Since there is no relative motion between S and D, L' remains fixed. So, if the relative velocity of light, $L'/\delta T'$, is an invariant constant, then the duration $\delta T'$ also should remain fixed.

However, it is a simple exercise to show that the duration according to the Lorentz transformations is identical to that in the Galilean transformations for this closed and piecewise inertial path, to first order in v/c; we get $\delta T'(v) \simeq \delta T_0(1 + v/c)$ (The proof does not need any elaborate calculation; for any closed path the integral of the Lorentz term vx/c^2 is zero. Therefore, both transformations are identical to first order in v/c). We can already see that the Lorentz transformations are inconsistent with the postulate that the physical speed of light is an invariant, when we go beyond the trivial scope of motion (inertial or noninertial) along a

linear piece of path with separated clocks. But, our focus here is what real direct experiment has to say on the relative speed of light.

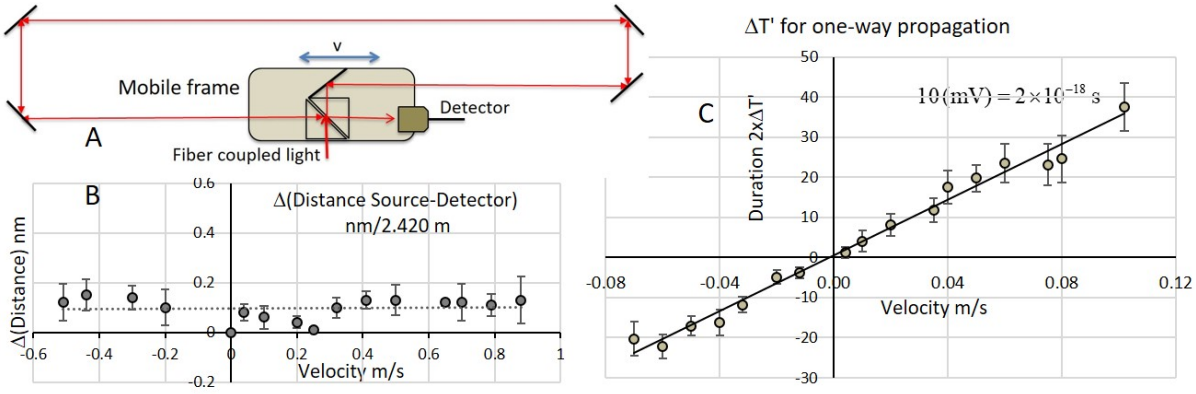

Figure 6. A: Measurement scheme of the dependence of the one-way velocity of light on the velocity of the reference frame. B: Data that establish the independence of the path length L' when the velocity of the platform (reference frame) is varied. C: Results showing the Galilean nature of the propagation of light. Compare with the results on the experiment with the Galilean sound.

Fig. 6A shows the scheme of the experiment with light, in an identical configuration as the one we discussed for sound. The measurement, as before, is in the moving frame. The quantity measured is the difference in the durations in the two directions, measured interferometrically, as a phase difference. This way, we are measuring $\delta T_R - \delta T_L$, or the anisotropy. For a Galilean wave,

$$\delta T_R - \delta T_L = \frac{L}{c(1-v/c)} - \frac{L}{c(1+v/c)} = \frac{2L}{c}\frac{v}{c} \tag{5}$$

precisely because the relative velocity in the moving frame is aniostropic. For the isotropic light of STR, with invariant velocity, the result should be very different.

Light from a CW laser (He-Ne or a diode laser at 780 nm) is fiber coupled onto a movable platform containing beam splitters, mirrors and a split photodiode detector. Two identical round trip paths are created with the beam splitter and mirrors (fig. 6A), with long straight sections such that the moving frame is inertial during the measurement (supplementary experiments clearly show that this restriction is not necessary, but we do not discuss those aspects here). The total path length is about 3 meters. The alignment is done by shifting the platform to various positions and making sure that the fringe pattern remains stable at all positions (with the speed of motion zero). For low velocity, 0.1 m/s, the expected additional one-way delay, if (and only if) light is Galilean, is $3.3 \times 10^{-18} s$. This corresponds to about 1/1000 of the wavelength and is not difficult to measure, once the alignment remains good and the noise due to the vibrations during the movement of the platform is controlled. (The sensitivity can be increased with longer path length. Use of optical fibers can enormously increase the signal, but if the propagation is not in free space, correction for Fresnel drag etc. brings in some theoretical overhead). It was not possible to do the measurements at velocities larger than about 10 cm/s, because of the blurring of the fringes due to vibrations in the platform. (This situation was improved later and a new interferometry experiment with femtosecond laser pulses is in preparation in our laboratory, employing pulse detection techniques feasible only with fast high power pulses. Direct measurement (without interferometry) of propagation delay is difficult for path length of the order of few meters, even with femtosecond pulses). The fact that the path length L'

remains constant (independent of the velocity of motion) to first order in v/c is verified by supplementary measurements of the two-way propagation of light, by retro-reflecting light and monitoring the stability of the interference fringes (fig. 6B).

The data from the experiment, plotted in fig. 6C, follow eq. 5 for Galilean waves and it goes against the expectation of STR. The duration for the one-way propagation of light, measured in the moving frame, varies linearly with the velocity of the frame, $\delta T \simeq Lv/c^2$, as for the Galilean sound! By comparing the behaviour of the two kinds of waves, expected to be widely different, we have eliminated uncertain theoretical and interpretational factors. The result unambiguously establishes that the relative velocity of light is Galilean, $c \pm v$, and not an invariant. *The fundamental postulate of the theory of Special Relativity stands falsified and with that, the theory itself.*

This result clearly demands another theoretical paradigm with a privileged frame that predicts and agrees with all known empirical evidence, but very different in foundations and content from STR. We will discuss the salient features of that paradigm and the theory of Cosmic Relativity after discussing another important supporting experimental evidence for the reality of a master (absolute) frame and the Galilean propagation of light.

5. More Empirical Support: Satellite Navigation Systems & GPS

Global Navigation Satellite Systems (GNSS) like the GPS or GLONASS have become indispensable technological tools in daily living. GNSS operates with the fundamental hypothesis that the speed of light in free space is an invariant constant, independent of the velocity of either the source or the observer (receiver). The proper operation with practical accuracy and stability requires relativistic corrections to be applied to the atomic clocks in the satellites and the reference atomic clocks in the laboratories on Earth. These corrections are for the general relativistic gravitational time dilation of the clocks, at different gravitational potentials at the satellite height and at the Earth's surface (called the geoid), as well as for the motional time dilation of the satellite clock as dictated by STR. Since the special relativistic time dilation depends only on the relative speed, what is relevant is only the speed of the satellite relative to the rest frame of the receiver. Hence, it is $\delta T/T = -v_{rel}^2/2c^2$. From the propagation time T_s of the GPS signal from the satellite to the receiver, the range (distance) is calculated as $D_s = cT_s$.

Let us examine the factual corrections in GPS [27]. The relative gravitational time dilation is

$$\Delta T/T = \sqrt{-g_{00}(r)} - 1 \simeq \frac{\Phi(r)}{c^2} = \frac{GM}{rc^2} \tag{6}$$

The gravitational correction in GPS takes into account the shape correction of Earth's gravitational potential due to quadrupole moment, for the stationary reference clock,

$$\Delta T/T = \frac{GM_e}{r_s c^2} - \frac{GM_e}{a_e c^2}(1 + J_2/2) \tag{7}$$

However, the correct physics of motional time dilation of clocks (as in GPS) is to be found outside Einstein's theory [27]. This is an unbelievable piece of information for most people, but nevertheless this is the fact. The factual motional correction has two terms, instead of the special relativistic correction $\delta T/T = -v_{rel}^2/2c^2$ with only the relative speed of the satellite. The full motional correction is

$$\Delta T/T = -\frac{v_s^2}{2c^2} - \frac{-v_o}{2c^2} \tag{8}$$

where v_s and v_o are the individual speeds of the satellite and the observer-receiver, referenced to a common reference frame, exactly as in theories with an absolute frame! The factual speed of the reference clock on Earth, though it is in the rest frame, appears explicitly. (The fallacy and flimsiness of the justification that Earth is noninertial, often brought up as an escape route,

can be realized if one imagines an inertial frame that is comoving with the Earth-based clock over the short duration δT).

The situation is much worse, as we see in the next correction, which is first order in the velocity of the receiver frame. The actual propagation time of the GPS signal is calculated using the formula

$$T_s = \frac{D_s}{c} + \frac{\vec{D_s} \cdot \vec{v_o}}{c^2} \tag{9}$$

instead of the core formula of Special Relativity, $T_s = D_s/c$. This is called, ironically, the 'Sagnac term' by GPS scientists, which they try to justify with multiple reasons and lengthy explanations [27]. v_o is the 'absolute' velocity of the GPS receiver (observer) referenced to a common master frame for the satellite and the receiver, and D_s is the distance to the GPS satellite (aligned to the propagation vector $\hat{c}$) along which the signal propagates. Again, the velocity of the receiver appears in the extra correction though we are in the rest frame of the receiver. Note that this expression is simply the extra delay in light propagation that happens when the relative speed of light is Galilean instead of a constant! Then, instead of the delay D_s/c we get

$$\Delta T = \frac{D_s}{|\vec{c} - \vec{v_o}|} = \frac{D_s}{(c^2 + v_o^2 - 2\vec{c} \cdot \vec{v_o})^{1/2}} \simeq \frac{D_s}{c(1 - \vec{c} \cdot \vec{v_o}/c^2)} \simeq \frac{D_s}{c} + \frac{\vec{D_s} \cdot \vec{v_o}}{c^2} \tag{10}$$

This is undeniable evidence, along with the second-order correction for the rate of observer's clock, that falsifies the light hypothesis and Einstein's theory. Thus, Global Navigation Satellite Systems are one's everyday "pocket proof" for the Galilean nature of the propagation of light and the existence of a master frame.

I assert from Cosmic Relativity that the correct and the most accurate expressions for the relative time (difference of elapsed durations) of two clocks is

$$\Delta T/T = \sqrt{1 - v^2/c^2} - \sqrt{1 - u^2/c^2} \simeq -(v^2/2c^2 - u^2/2c^2) \tag{11}$$

$$= -\frac{(v-u)(v+u)}{2c^2} = \frac{(u-v)(v+u)}{2c^2}$$

$$= -\frac{(v-u)(v-u+2u)}{2c^2} = \frac{(u-v)(u-v+2v)}{2c^2}$$

$$= -\frac{v_{rel}^2}{2c^2} - \frac{v_{rel}u}{c^2} = \frac{v_{rel}^2}{2c^2} - \frac{v_{rel}v}{c^2} \tag{12}$$

Here, the velocities v and u are relative to the cosmic frame, and $v_{rel} = (v - u) = -(u - v)$. The asymmetry in the time dilation between the frames is explicit. When the velocities are not uniform, the infinitesimal durations can be accumulated (integrated) to get the total duration.

We note that eq. 11, written in terms of the 'absolute' speeds of the two clocks, is exactly the equation used for the factual relativistic motional correction of GPS clocks, and not the special relativistic expression with mere relative speed,

$$\Delta T/T \simeq -v_{rel}^2/2c^2 \tag{13}$$

GPS in a light smartphone signifies the heavy burden of carrying the wrong theory.

6. Simultaneity: Einstein's Assertion and Bergson's Criticism

The concept of simultaneity is of central importance in theories of relativity, being an essential prerequisite for defining synchronization of clocks and the measurement of time. As stressed by Einstein, the time of an event can be reliably attributed only by consulting a clock adjacent to

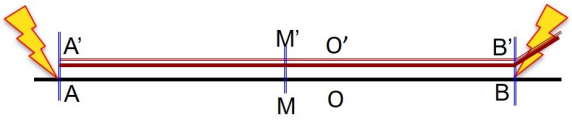

Figure 7. Einstein's example reference systems for discussing the relativity of simultaneity. The train A'B' and the railway platform AB are in relative motion, with 'midpoint' observers at M' and M.

the event. Then, one has to specify a method to synchronize such clocks at different locations, to build a consistent physical theory. That was how the constancy of the velocity of light in all inertial frames became the pivotal point of relativity. After postulating the invariance of the velocity of light, Einstein asserted that if all clocks are synchronized in the rest frame of the clocks using light, they are all properly synchronized, independent of any common uniform velocity they may have. In other words, they are synchronized as if they are all at rest.

6.1. Einstein's Train and Platform Scenario

Einstein has discussed and clarified the notion of simultaneity in STR in his popular monograph 'Relativity: The Special and General Theory' [28].

> We suppose a very long train travelling along the rails with the constant velocity v... Then every event which takes place along the line also takes place at a particular point of the train. ... As a natural consequence, however, the following question arises: Are two events (e.g. the two strokes of lightning A and B) which are simultaneous with reference to the railway embankment also simultaneous relatively to the train?

The problem is clearly stated (figure 7). We will answer this in steps, first assuming Galilean propagation of waves. Consider two observers O and O' in relative motion. O is stationary and at the midpoint M relative to the sources of the Galilean waves, say sound from two alarm bells (figure 8). Therefore, O hears the bells simultaneously, say at time $t = T_0$. Conversely, if O hears the bells simultaneously, then it is deduced that they were sounded at the same time $(t = T_0 - d/c_s)$ at A and B.

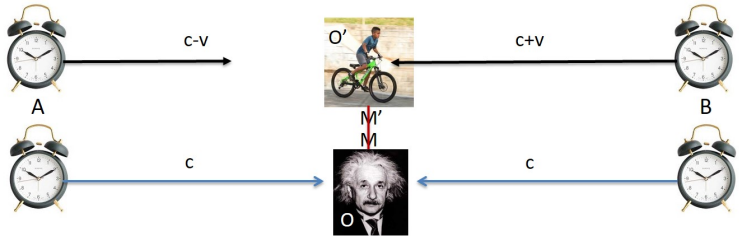

Figure 8. The situation regarding apparent simultaneity with Galilean waves as the messenger of events that are spatially separated.

The observer O', who coincides with O at M'=M when the bells were sounded, is in motion towards B at the relative speed v. In his rest frame, the waves are arriving at relative speeds $c_s + v$ from B and $c_s - v$ from A. Therefore, O' will hear the bell from B first, at $t'_1 = L/(c_s + v)$ and that from A later, at $t'_2 = L/(c_s - v)$, and the events would be judged as not simultaneous. I remind the important fact that the motion of source points, at distance L when the signals were emitted, does not affect the velocity of the sound waves, just as for light. Thus, the unambiguous

answer to Einstein's query for the case of Galilean waves is that different observers perceive the order of events differently, depending on their state of motion. For Galilean messenger waves with velocity c, the lack of simultaneity is

$$\Delta t' = \frac{L'}{c-v} - \frac{L'}{c+v} = \frac{L'v}{c^2(1-v^2/c^2)} \tag{14}$$

For $v \ll c_s$ the second order term in brackets can be ignored. *Events that the stationary observer perceives as simultaneous will not be simultaneous for the observer in motion.* Identical conclusion is reached from the rest frame of the stationary person as well; the moving person moves away from the midpoint and therefore the sounds of bells reach him in succession from the locations B and A. There is consistency and there is no reciprocity.

We note an important additional point that is obvious in the case of sound. Not only that the observer O' perceives the bells in succession, he would also perceive them shifted relatively in pitch; the one from B at a higher pitch than the one from A, due to the Doppler effect. Hence, he has a measure of his real motion and velocity relative to air. Therefore, absolute simultaneity is recoverable when the messenger of the spatially separated events is Galilean.

Now we analyze Einstein's query on simultaneity with light as the signal, *under the assumption that the speed of light is the same in all inertial frames, independent of their velocity*, as Einstein had postulated in STR. Due to this cardinal difference from familiar Galilean waves like sound, we expect a different conclusion regarding simultaneity, when light is the messenger wave, instead of sound.

In the frame O' of the train (fig. 7), the observer at the midpoint M' is at rest. After lightning strikes A' and B', light travels at equal speed from the equidistant points A' and B' towards M' (the relative velocity of the source does not affect the relative velocity of light). Light from A' reaches at time $t'_1 = L'/c$ and light from B' reaches at $t'_2 = L'/c$. Evidently $t'_1 = t'_2$ and $\Delta t' = 0$. Then, the light flashes will arrive *simultaneously at M'* and the *observer will perceive the events as simultaneous*. Now, we consider the observer who is at rest in the frame O. Relative to O, the train O' is moving, but that is irrelevant for what the observer of O experiences in O. Light pulses travel at equal speed from equidistant points A and B towards the midpoint M. $t_1 = t_2 = L/c$. They will reach *simultaneously at the observer at M*, who perceives the lightning at A and B as simultaneous. So, we conclude that the *experiences of observers in O and O', in their own rest frames, are identical, assuming the universal speed of light.*

We note in contrast that if light propagated similar to sound and if its relative speed was *not a universal constant*, the events perceived as simultaneous in one frame would have been seen as one after the other, in succession, in another frame, relatively moving. The lack of simultaneity in the moving frame is given by equation 14, and in the 'stationary frame' by $\Delta t = Lv/c^2$. This is the situation in a theory of relativity with a master (absolute) frame.

What was Einstein's answer, which is also today's physicists' answer and belief? Continuing with what Einstein wrote,

> When we say that the lightning strokes A and B are simultaneous with respect to the embankment, we mean: the rays of light emitted at the places A and B, where the lightning occurs, meet each other at the mid-point M of the length A–B of the embankment. But the events A and B also correspond to positions A and B on the train. Let M' be the mid-point of the distance A–B on the travelling train. ... *Now in reality (considered with reference to the railway embankment) he is hastening towards the beam of light coming from B, whilst he is riding on ahead of the beam of light coming from A. Hence the observer will see the beam of light emitted from B earlier than he will see that emitted from A.* Observers who take the railway train as their reference-body must therefore come to the conclusion that the lightning flash B took place earlier than the lightning flash A. We thus arrive at the important result:

> *Events which are simultaneous with reference to the embankment are not simultaneous with respect to the train, and vice versa (relativity of simultaneity).*

His conclusion was identical to the one we arrived at in the case of Galilean waves (sound), though he assumed an invariant relative speed of light! I have italicized some sentences to emphasize the faulty logic in Einstein's analysis. Decades of reading these passages by generations have not spotted this logical misstep and why the conclusion with light (of invariant velocity) ended up in preferential simultaneity for the observer on the embankment and events in succession for the observer in the train, in a theory in which both observers are equivalent. They have the same speed of light, and either can consider himself as at rest and the other one as moving. The fatal gap of logic in Einstein's analysis is easily spotted with some guidance. There is no 'real motion' in STR; it is a theory in which only relative motion makes sense. Einstein errs within his own theory when he writes "in reality he is hastening towards the beam of light coming from B". *The observer is at rest in his frame and the source of light is coming towards him, but that does not affect the relative speed of light, or of any wave.* If Einstein had started his discussion with the train as the reference, he would have reached the conclusion that the events were simultaneous to the observer in the train, but not to the observer O on the embankment, because O moved away from M' and hastened towards point A', relative to the immobile train! It is clear that Einstein would have been saved from this fatal error of inadvertent preference for the embankment as 'really stationary' if he had considered two trains in relative motion. By spotting this error, we can see that Einstein's light hypothesis is in conflict with the notion of simultaneity and clock synchronization is STR. Einstein's Special Theory of Relativity is clearly inconsistent, as per the testimony of its author himself [3].

What Einstein describes is not what the observer in the train experiences, but what the person on the platform, who considers M' as moving, confers on the moving observer as his experience. However, he failed to notice that this assumed experience is inconsistent with the light hypothesis. The philosopher Henri Bergson had found the fallacy in Einstein's logic, while trying to reconcile the common sense notion of simultaneity and the role of the concept in the physical theory, and expressed his disagreement.

Bergson wrote in his monograph [5], published soon after he had expressed his reservations about Einstein theory in a discussion session during Einstein's eventful visit to Paris in April 1922 [29]

> This passage enables us to catch on the wing an ambiguity that has been the cause of a good many misunderstandings...we must not forget that the train and the track are in a state of reciprocal motion... Let us now emit our two flashes of lightning. The points from which they set out no more belong to the ground than to the train; the waves advance independently of the motion of their source.
> It then becomes evident at once the two systems are interchangeable, and that exactly the same thing will occur at M' as at the corresponding point M. If M is at the middle of AB and if it is at M we perceive a simultaneity on the track, it is at M', the middle of B'A', we shall perceive this same simultaneity in the train...what is simultaneity with respect to the track is simultaneity with respect to the train.

Bergson was impeccable in his logic concerning simultaneity in Einstein's theory. Bergson showed that the asymmetrical conclusion on simultaneity that Einstein arrived at was merely a result of the preferential choice of the frame of the platform as 'stationary' and that of the train as 'moving'. If we had started with the train as the rest frame and platform as moving, we would come to the opposite conclusion. Since both the frames are equivalent, their experiences of simultaneity are identical.

7. The Factual Universe and its 'Space' and Time

After Hubble's discovery of the recessing galaxies [30], the universe that emerged was really vast, with enough matter and its gravity to define space and time for physics. Though gravity was a well understood interaction, neither Einstein nor anybody else reconsidered the course already taken by the theories of relativity, in the light of this crucial knowledge of cosmology. The theories of relativity continue to assume that our physical space is the non-existent empty space, and our time has no relation to the gravity of cosmic matter. It is as if the standard physics of today considers the universe we see as a huge make-believe film set with virtual reality galaxies and matter devoid of gravity; the theories continue in their course set definitely in the 1920s. In reality, there is one master frame with its material reference markers as the galaxies, and one universal time, given by the expanding universe and its evolutionary clock (also termed 'absolute time', but only in the sense of being defined by the single master reference frame of the material universe. 'Universal time' is the appropriate term. This is distinctly different from Newton's ideal and metaphysical absolute time).

The old ether was stationary and without evolution, whereas the real universe is evolving, as evident in its expansion. Thus, the evolving universe defines a universal time, which the ether was devoid of. Empty space is homogeneous and isotropic for all inertial observers and the measures of spatial and temporal intervals or the 'metric' remain homogeneous and isotropic in every moving frame. The invariant isotropy is a property specific to the Lorentz transformations (LT) wherein the metric $\eta_{ij} = diag\{-1, 1, 1, 1\}$ remains invariant under motion and LT. This is the very basis of the Special Theory of Relativity. The matter distribution in the universe is more or less homogeneous and isotropic on very large scales, but only for an observer who is 'at rest' relative to the average matter distribution. It is clear that moving in matter-filled universe generates a relative flow of matter opposite to the motion of the observer and this *current of gravitational charge* should generate physical effects akin to magnetic effects in electromagnetism. Space becomes anisotropic with this flow and a physical vector potential proportional to the velocity (which is in fact a part of the full 10-component symmetric metric tensor), $A_i/c = g_{0i} = v_i/c$ is generated, but LT cannot accommodate this anisotropy. It is a straightforward logical and mathematical deduction, given the factual universe with matter at the observed critical density, that the Lorentz transformations and the invariant Minkowski space-time structure should be abandoned. The real universe is maximally Lorentz violating, contrary to general belief (the truth is not visible to two-way experiments, as we already discussed). In fact, the unjustified and widely held belief of 'faith' is the only factor that delays the opportunity to correct the misguided course of the physics of relativity and dynamics.

The Doppler dipole anisotropy of the temperature of the cosmic microwave background (CMB) enables fairly precise determination of one's motion relative to the cosmic frame. Conceptually very significant is the fact that the monotonically decreasing temperature of the CMB provides us with a universal absolute clock and time, synchronized everywhere in the universe to a precision better than a part in 10^6. This demolishes the arguments for the lack of universal simultaneity of spatially separated events. However, it is the physical fact that the matter-energy in the universe is the source of dominant gravity that determines the physics of relativity and dynamics. This fact defined and guided my theory of Cosmic Relativity, which theoretically complemented the decisive experimental results and completed the gravitational paradigm of relativity and dynamics.

8. Cosmic Relativity

The anchoring realization of my theory Cosmic Relativity is that all physical phenomena, their experience and tests, as well as their understanding through the theoretical frameworks that we construct happen in this single factual universe, in the perennial and irreducible presence of all the matter and its gravity. We do not have the freedom to assume postulates that are in

conflict with this factual situation. The physical consequence of nearly uniformly distributed matter is the highly homogeneous gravitational potentials, which remain so for every observer who is in uniform motion. All relativistic effects and the laws of dynamics themselves are then gravitational consequences. The fact that there are no locally measurable physical effects of a constant potential field is then the statement of the principle of relativity and it is strongly tied to the observed homogeneity of the matter-energy distribution. Surprisingly, the Galilean transformations (GT) correctly give us, along with the observed anisotropy, the most important relativistic feature of motion – time dilation! To show this I use a limited version of the actual Friedmann-Robertson-Walker metric, ignoring the very slow time evolution. GT specifies the coordinate transformations $x' = x - vt$ and $t' = t$. Physical spatial and temporal intervals can be deduced by including the metric in the moving frame. GT to a frame with velocity v transforms the metric as

$$\begin{bmatrix} g_{00} = -c^2 & g_{01} = 0 \\ g_{10} = 0 & g_{11} = 1 \end{bmatrix} \quad \overrightarrow{GT(v)} \quad \begin{bmatrix} -c^2(1 - v^2/c^2) & -v/c \\ -v/c & 1 \end{bmatrix} \tag{15}$$

Nonzero g_{i0}, a gravito-magnetic potential, gives the observed anisotropy. The temporal duration in the moving frame is now $\sqrt{-g_{00}}dt' = (1 - v^2/c^2)^{1/2}dt$. GT indeed contains the physics of time dilation with v as the absolute velocity, or the velocity relative to the cosmic frame. Of course, the relative velocity of light is now Galilean, $c' = c \pm v$. Therefore, we also get the length contraction correctly.

This can also be treated in the language of gravitational potentials. In moving frames, the relativistic potential will have velocity dependent 'vector potential' component

$$A_i = \frac{v_i \Phi_u}{c} \left(1 - v^2/c^2\right)^{-1/2} = \gamma \frac{v_i \Phi_u}{c} \tag{16}$$

leading to several large gravito-magnetic effects. Though g_{i0} is homogeneous in a uniformly moving frame, which implies the principle of relativity, g_{i0} becomes time dependent if there is an acceleration. Then the physical effect is a reactive force on the accelerated system,

$$F_i = -m_g \frac{dA_i}{cdt} = -\frac{m_g \Phi_u}{c^2} \left(\gamma a_i + \gamma^3 v_i (\vec{v} \cdot \vec{a}\right) \tag{17}$$

We see that accelerating a body requires overcoming this cosmic gravito-magnetic reaction and hence a force F_i which is *the full relativistic form of Newton's law of dynamics*. The conventional inertial mass is just $m_i = m_g \Phi_u / c^2$. Hence the ratio m_i/m_g is universal [2, 8].

Therefore, Newton's law of dynamics, the analogue of Lenz's law in electrodynamics, and the equivalence principle all have the same physical content and one implies the other [2, 3, 8]. The curl of g_{0i} (or A_i) is 2Ω, which is the cosmic gravito-magnetic field B_{cg} in any rotating frame; therefore, an object moving at velocity v will feel a gravito-magnetic force $F_{gm}(v) = m_g v \times 2\Omega$. Thus, the Coriolis force is just the gravitational Lorentz force. The particular pseudo-force that Mach addressed [31], the centrifugal force, is from the time dependence of the direction of A_i; $F_c = m_g A_i \frac{d\hat{A}}{dt} = mv^2/r$. We have solved the long-standing problem of the inertial pseudo-forces that troubled Newton, Mach and Einstein. They are true gravitational forces with the cosmic matter as sources. But, I must stress the profound difference between the gravitational force that we feel from the Earth and gravitational force we feel in an accelerating mobile. The latter is inductive, from the time varying gravito-magnetic potential, analogous to the 'induced electric force' $F_i = -\partial A_i/\partial t$. It is not the same as the gravitational force of attraction $F_g = \nabla \phi_g$ between two masses that makes apples fall and keeps the moon in its orbit. Put compactly, 'inertia' is the response to the gravitational action by 'mass'; they are distinct in character. This difference between gravity and acceleration suggests that Einstein's Equivalence Principle

is violated in the case of the gravitational time dilation of clocks: there will not be any relative time dilation of clocks in an accelerating frame, and such a test is yet to be done. However, there is the gravitational shift of the frequency of light in an accelerated frame because of the Doppler shift and the Galilean nature of the propagation of light.

A hypothetical situation in familiar electrodynamics can help to dissolve away any residual doubt as to the verity of this gravitational paradigm. Imagine a situation where there is a slight charge asymmetry of less than 1 part in 10^{40} between the proton and electron and that atoms are slightly charged. In the pre-cosmology era, while Maxwell was completing his theory, no knowledge about the matter content of the universe was known and such a tiny charge asymmetry in matter known then (solar system, Milky way, and a few nebulae around us) would not have made any difference to observed features of electrodynamics. However, the true reality would have been the enormously charged universe with a huge electric potential generated by all the unseen charged matter, but *undetectable in all inertial experiments* because constant four-vector potentials cannot be locally detected. However, in situations of accelerated motion of a charge, some extra forces would appear without any identifiable sources because the potentials became time dependent. Charges in rotation would experience pseudo-magnetic forces. A magnetic moment in a rotating frame would feel an anomalous torque, without any identifiable source. The situation would have required postulating pseudo-forces in electrodynamics, proportional to the electric charge. One would be faced with a new electromagnetic inertia, in addition to the usual inertia proportional to mass, forcing one to ascribe it to special motion relative to 'absolute' space, as Newton did to discuss his 'water in a rotating pail' experiment. The vexing puzzle would not be solved until somebody realized, from wisdom or actual observations, that there indeed was enormous amount of matter in the universe with a slight charge asymmetry. We do not see such forces and the entire electrodynamics is accounted for with local sources only because the matter in the universe is essentially neutral. *In contrast, the universe is gravitationally charged, with the mass and energy as the charge of gravity.*

This reiterates that we are grossly wrong in ignoring the gravity of the matter around us in our fundamental theories of dynamics. The gravitational potential of just the visible matter in the universe adds up to about 10^8 times the gravitational potential of the Earth in a terrestrial laboratory. It is also well-known that the Newtonian potential of a near critical-density universe is equal to the square of the velocity of light $\left(\Phi_u \simeq c^2\right)$. The simple phenomenological claim that the Lorentz factor $\left(1 - v^2/c^2\right)^{1/2}$ is in fact $\left(1 - v^2/\Phi_u\right)^{1/2}$ and has nothing to do with the velocity of light is empirically fully defendable [7]. That the conventional pseudo-forces are indeed gravitational had been argued by D. Sciama [32]. However, stopping there gives an incomplete and inconsistent story, rejected several times in the past by the physics community. One has to realize that such a framework also demands a preferred frame and notion of absolute rest, and hence, compatible Galilean notions of space and time and propagation of light. Even a partial implementation of the Machian paradigm necessarily rejects Einstein's Special Relativity. We are at once faced with a natural paradigm, with the universe as the master frame (instead of the old ether) and universal gravitation as the determining interaction (instead of electromagnetism with its limited scope). Cosmic Relativity demands and predicts that the relative velocity of light and gravitational waves are Galilean, and all relativistic effects are factually gravitational effects. Dynamics and its laws are then dictated by gravity.

The other important physical effects arise in the coupling of cosmic gravity to spin, both classical and quantum. Spin is the closed current of the charge of gravity and all spin dependent physical effects should be traced to the gravitational interaction. The coupling is $s \cdot B_{cg}/2$. Cosmic Relativity addresses this and derives a whole lot of observed and observable physical effects, with the scope ranging from geometric phases and spin valve effects on particles in chiral motion to purely quantum effects like the quantum Hall effects and the mysterious spin-statistics connection of Bosons and Fermions [33, 34].

General Relativity itself has to be reconstructed in a way that retains the agreement with all its impressive precision tests done during a century and yet compatible and *consistent with the prior and unique background universe* with so much matter and its gravity. A major prediction of General Relativity is gravitational waves. Because of its anchor on Special Relativity, gravitational waves are supposed to propagate like light in GTR. However, since light is already shown to be Galilean, from direct experiment, gravitational waves also are Galilean, as evident from the recent simultaneous detection of both [35].

Einstein's equations for gravity are modified by including the cosmic gravity and the master frame as part of the equation itself. The resulting Centenary Einstein's equation is

$$R_{ik} - \frac{1}{2}g_{ik}R - \frac{8\pi G}{c^4}T_{ik(U)} = \frac{8\pi G}{c^4}T_{ik} \tag{18}$$

The extra piece on the left is the energy momentum tensor of the universe, included as the non-removable integral part of the equation itself [3]. Adding this term incorporates universe as a preferred frame for Einstein's equations, which do not have general coordinate invariance in reality, and makes the theory maximally Machian. Then, Mach is naturally integrated with Galileo, Newton, Lorentz and Poincaré, and Einstein, retaining only the consistent elements that constitute a satisfactory completion.

9. Resurrection of Bergson's Philosophy of Time

The theories of relativity have been both a source and a cradle for many philosophical views and assertions on space, time and physical reality in general. As a consequence, our conclusions on the correct paradigm for relativity and dynamics based on the robust empirical and logical evidence have multi-faceted philosophical implications. Cosmic Relativity will seriously affect and change certain philosophical positions. Here, I comment on an important implication for Bergson's philosophy of time, with its basis on the notion of a universal time and the implied absolute simultaneity. The reason Bergson ventured to study the theories of relativity was to understand the conflict between his philosophy and the physical theories, with their multitude of times and the relativity of simultaneity [5, 6]. In Lorentz's theory with the insensible ether, there was the direct and irreconcilable conflict; each observer had his own real time that depended on the speed relative to the ether, but there was no way to sense the state of motion. Bergson's hope was to find harmony with Einstein's theory, with its equivalence of all observers in motion and at rest, allowing the interpretation that the multitude of times was merely in the mathematical content of the theory without real physical manifestations. The empirical situation eventually proved otherwise, showing the observable reality of the velocity-dependent multitude of durations. But, we have seen that the real reason for the motional modification of duration could be found in the gravity of the matter-energy in the universe. This is *consistent with both the Galilean nature of light and the existence of a privileged master frame.* In this frame, identified as the matter-filled universe, *both the universal time and the physical multitude of times, coexist consistently.* This is because unlike the situation in invisible and static ether, those who move have the correct measure of their motion with the cosmic matter and radiation as the markers of real rest.

We can now assess the compatibility of Bergson's views on time, duration and simultaneity, with the factual relativity and its correct theory that I completed, based on cosmic gravity (Cosmic Relativity). The modification of durations marked by a clock in motion is real, and therefore there are a multitude of real times. Similarly, simultaneity changes to succession for observers in motion, being linked to the Galilean nature of the relative velocity of light. However, since factual relativity is entirely based on the gravity of matter-energy in the universe, there is a *tangible privileged frame*, relative to which all motions are felt and measured. In new relativity, the modification of the duration is related to the real measurable velocity relative to the cosmic matter. Therefore, an observer always has access to both his proper time, measured

by his clocks, and the universal absolute time measured by the clocks at relative rest to the cosmic matter! This universal time, the same time everywhere in the universe, is operationally equivalent to the slowly decreasing temperature of the cosmic microwave background radiation in the expanding universe. Now we can see that the notion of simultaneity of spatially separated events is also absolute, because these events are tagged to their local time which in turn is the single universal cosmic time. The perception of succession is mere appearance, exactly as the change of simultaneity of the sound of bells for one at rest into succession for another who is moving. Since the velocity is known, simultaneity is regained, just as the universal time is regained.

With the universal time regained, Bergson's philosophy remains intact. The time of the physicist and the time of the philosopher, and indeed the time of common intuition coexist in harmony, without any logical or conceptual conflicts.

10. Concluding Assertions

I have presented direct experimental evidence that the relative speed of light, relative to inertial reference systems, is Galilean ($c \pm v$) to first order in v/c. This falsifies Einstein's light hypothesis and his Special Theory of Relativity. I have presented supplementary empirical evidence from global navigational satellite systems like the GPS for relativistic motional corrections that go beyond Einstein's Special Relativity; they support new relativity with a master 'absolute' frame. Further, GPS corrections explicitly include a clock correction that clearly implies Galilean propagation of light, instead of propagation that is independent of the speed of the observer. These demand a drastic change of the physical paradigm for relativity and dynamics. From the theoretical and logical point of view, I had already arrived at a new paradigm that recognizes the plain physical fact that all physical phenomena occur in the presence of the matter-energy and its gravity in the universe. This realization which was not available when our fundamental theories were formulated and completed, before 1930, leads to a concrete and consistent theoretical framework in which cosmic gravity determines all motional relativistic effects as well as dynamics (the laws of motion). My theory of Cosmic Relativity is in perfect agreement with all known relativity experiments and it predicted Galilean propagation of light, with the physical universe as the master determinant frame.

Since the correct theory of relativity has the matter-filled cosmos as the 'absolute' frame, and since its gravity is the determining factor for dynamics and motional relativistic effects, Einstein's theory of gravity – the General Theory of Relativity – necessarily needs a fundamental modification. Einstein's equations are modified to incorporate the perennial and irreducible presence of cosmic matter; this is achieved by adding the energy-momentum tensor of the factual universe in the equations permanently. This makes the Einstein's equations consistent with the observed Galilean nature of the propagation of light and gravitational waves. In addition, the theory becomes Machian, with the physical universe as the master frame, yielding the familiar inertial forces as true gravitational forces with the cosmic matter as the sources.

Thus, a century after we started our exploration of relativistic modifications of space, time, and matter, we have a complete and consistent theory in Cosmic Relativity. It is in complete agreement with all empirical knowledge from the laboratory as well as with the logical and factual premise that we practise physics and philosophy, and conduct all our activities, in this one universe, in its total gravitational presence.

Acknowledgments

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Appendix: Commentary

Reviewer A. Comment 1.
The expansion of space means a continuous decrease of the mass density, reduction of the negative gravitational potential due to the increasing Hubble radius, and continuous reduction of the velocity of light. Does this invalidate the postulated constancy of the velocity of light?

Reply.
I stated the well known relation that the Newtonian gravitational potential is nearly equal to the square of the speed of light, $\Phi_u \simeq c^2$, to highlight the significance of cosmic gravity. However, this is not the basis of Cosmic Relativity. All rigorous calculations are based on the observationally verified Friedmann-Robertson-Walker $k = 0$ metric. Also, the potential does not diminish due to the expansion of the universe! The density decreases as the universe expands, $\rho \propto 1/t^2$, but since the radius R_u of the causally connected universe with matter increases linearly with time the potential $\Phi \propto R_u^2$ remains invariant. This is also a well known result.

Reviewer A. Comment 2.
Replacement of c^2 with Φ_u in the T_{00} component of the General Relativity (GR) stress-energy tensor conveys the gravitational potential of whole space to the stress tensor. Why do we need "a fundamental modification" of GR for including the effect of cosmic gravity?

Reply.
I am not replacing c^2 with Φ_u in the T_{00} component of the GR stress-energy tensor. I am adding the energy-momentum components of the universe, known from precision observations as of today, to the Einstein's equations as a *permanent and irreducible element*. This changes the equations to one with a privileged frame, which is the universe itself and makes the equations and the theory consistent with the gravity of the universe. The original Einstein's equations do not contain cosmic gravity; the equations without any terms representing the matter-energy of the universe are not consistent with the gravity of the universe in which the theory is operative. Once the matter-energy of the universe is included in the equations, as it should be, there is a privileged frame that defines all dynamics. This drastically alters the character of Einstein's equations and the General Theory of Relativity.

Reviewer A. Comment 3.
In SR and GR, the modifications (spatial and temporal intervals) are linked to relative velocity, in CR to the absolute velocity in cosmic frame. What are the physical reasons of the modifications in CR?

Reply.
The sole physical reason is in the gravitational potentials of the matter-energy in the universe. It may be verified that these potentials are different (similar to electrodynamics) in a moving frame. Hence, *both physical length and time are affected by the modified potentials.*

Reviewer A. Comment 4.
Unnikrishnan is looking for experimental evidence for the cosmic frame from several novel laboratory experiments and, e.g., from the GPS system. Satellite clocks, like the GPS clocks, are studied in the "Earth-Centered Inertial frame, ECI-frame" with a hypothetical reference clock at rest outside the gravitational interaction of the Earth. The ECI frame honors the rotational velocity of the Earth but ignores the orbital velocity around the Sun as well as the orbital velocity of the solar system in the Milky Way. The ECI frame is not a "cosmic frame"

described in Cosmic Relativity, but a subsystem in the Sun Centered Inertial frame with a hypothetical reference clock at rest outside the gravitational interaction of the Sun. Further, the Sun Centered Inertial frame is not an absolute frame but a subframe in the Milky Way Inertial frame, etc.

Reply.
A distinction between the cosmic frame and ECI frame is irrelevant for the Earth-based experimental results discussed in the article and for comparing two frames with different velocities relative to the cosmic frame. This is because all *common velocities*, like that of the Sun, galaxy etc. cancel out in the comparison of clocks and signals in the satellites with those in the Earth-based laboratory, leaving only the velocities that are different. For example, the satellite clocks as well as the Earth clocks have the same time dilation due to the absolute velocity of the galaxy, sun, and the earth around the sun etc. through the cosmic frame. Only their velocities after subtracting the common velocities are relevant for the experimental comparison. One such velocity is due to the rotational motion (about 460 m/s at the equator). If we use GPS in a fast mobile, its velocity should be included in the computation, if accurate navigation is desired. However, this is not the relative velocity of the two frames as in Special Relativity, and that is why the results in GPS as well as in the data of Hafele-Keating experiment are in conflict with Special Relativity. In the H-K experiment, a transported clock had its rate faster than a reference clock in the rest frame of the laboratory! In GPS, the velocity of the inertial receiver clock is required for the accurate relativistic correction, in the rest frame of the clock. Both these facts falsify the Special Theory of Relativity.

Reviewer B.
I received the reviewer's comments marked directly on my article with "questionable portions" (QP) highlighted. There are no specific questions asked and the reviewer has in fact avoided any mention of the definite experimental evidence, logical arguments and proofs, as well as the mathematical proofs in the article. The reviewer's comments have remained at a peripheral level, mostly citing standard text books and some compilations available in the internet as proofs of certain beliefs. I am familiar with these cited sources, and also know that they all repeat the same fallacious statements of faith, already proved as incorrect in my article, with the steps of the proofs spelt out. However, the reviewer has not commented on any of the transparent proofs. The reviewer seems to have no arguments or critical comments of his own. Nevertheless, I will answer or comment on all doubts implied by the highlighted 'QP'.

Reviewer B. Comment 1.
Countering my assertion in the abstract that the factual results on the one-way propagation of light and relativistic motional corrections of clocks contradict the current theoretical framework, the reviewer states such conflict is not there, and cites as support the documents on one-way tests in relativity from the website http://math.ucr.edu/home/baez/physics/.

Reply.
Unfortunately, the reviewer seems to have missed the discussion of these very experiments in section 3.1 of my article (and references [17-20]), exposing the embarrassing history of these conceptually flawed 'one-way experiments' (Champeney et al. [20] and Krisher et al. [21]). These experiments were based on a proposal-paper by M. Ruderfer in 1960 [18], but the experimenters did not notice the erratum published by Ruderfer in the following year [19], admitting that the idea for the experiment was faulty! Ruderfer showed that the experiment couldn't distinguish between special relativity and ether (absolute frame) relativity. Either not reading the erratum

or not understanding its contents, while citing it nevertheless, the experimenters went ahead and did the experiment and claimed a decisive test in favour of Einstein's theory! Now the reviewer has repeated the same self-defeating act of citing something without checking or knowing the contents. By citing these blatantly flawed collection as a counter point to my results, the reviewer has fallen into a blunder-trap. The fundamental fact that the nature of one-way propagation of light cannot be determined in experiments with spatially separated clocks that need synchronization was stated already by Poincaré, and reading his writings carefully might help.

Reviewer B. Comment 2.
Another portion highlighted as questionable is my assertion that my theory of Cosmic Relativity (CR) is in perfect agreement with all known experimental results. The reviewer comments that there is an enormous amount of experimental results that are in agreement with STR (which is true) and CR has to match that.

Reply.
First of all, the fact that STR is in agreement with many experiments does not contradict the fact that CR agrees with all known experiments. My article highlights the important fact that *there are several experimental results which do not agree with STR.* It is significant that *nowhere in his comments and citations the reviewer is able to point out a single experiment that contradicts CR or a theory of relativity with an absolute frame.*

Reviewer B. Comment 3.
The reviewer cites Einstein's opinions about ether and its conceptual equivalents (Leiden lecture, for example), presumably to establish that space need not be empty in STR, if ether is appropriately redefined.

Reply.
My article concerns physics based on evidence, and not on Einstein's or anybody else's beliefs and opinions. It is not a paper on history of evolving opinions. So, my statement that the theory of Special Relativity is set in "empty space without matter" has a very precise meaning in terms of its mathematical structure, that of the Minkowski metric. Any amount of discussion on what Einstein believed and professed cannot change that structure and its physical meaning. Therefore, I will skip commenting on such remarks about the opinions of famous physicists. Yet, one technical comment is essential. The fundamental metric of STR is the Minkowski metric that remains invariant in any relatively moving inertial frame, effected by the Lorentz transformations. This cannot happen if there is matter distributed in space because relative motion implies relative matter currents and anisotropy in the metric. Einstein's general statements on the history and place of insensible 'ether' and its equivalents in relativity are irrelevant for the results discussed in the article. General Relativity is constructed with STR as the basis. That is why GR has the 'vacuum Einstein's equations' in the limit, in empty space. General Relativity is not Machian because a Machian theory necessarily has the privileged frame of the matter distribution.

Reviewer B. Comment 4.
The next 'QP' highlighted is my statement, "The cardinal prediction of the Galilean nature of the propagation of light, instead of the Einsteinean propagation with invariant relative speed, is now verified well in laboratory experiments [2, 3, 4]".

Reply.
The experiment that compares the propagation of light with the Galilean sound is described in detail in the article, results are shown, and the straightforward conclusion is discussed. Saying that it is questionable without stating any reason is barking up the wrong tree. The truth is in the verifiable experimental results. We must face it.

Reviewer B. Comment 5.
Next we come to an issue that has been debated many times, with the adherents of STR wriggling out every time, laboriously and without waiting to complete their arguments. This is the issue of twin paradox, which is mentioned in my article in the context of Einstein's own paper on its resolution. In that 1918 paper, Einstein admitted that that the paradox could not be cleared within STR and that one needed to use the gravitational time dilation of GTR. The reviewer has the strange illogical comment, "Even if so there are many textbooks (e.g., Smith, French, and Bondi) show just how the paradox occurs within STR."

Reply.
Either Einstein was right in his paper, or he was wrong. Both Einstein and the textbooks that defend the resolution within STR cannot be right. But, the reviewer does not want to take any stand, as though both are authorities that should not be assessed or criticized. My article has the relevant details and references that clearly show the inadequacy of STR for dealing with the paradox. The experimenter's choice of briefly freezing the running clock for the brief duration of acceleration rules out GTR's pseudo-gravitational field solution as well, leaving my resolution in Cosmic Relativity (CR) as the only one that is valid and consistent [10]. The asymmetric time dilation is due to the different (increased) gravitational gravitational potential experienced by the clock that moves relative to the cosmic frame. The clock that moves more relative to the cosmic matter-energy is the one that has more time dilation. Whether the motion is with acceleration or not is irrelevant. The verity of the CR solution may be checked in the GPS data and in any clock comparison experiments.

Reviewer B. Comment 6.
Commenting on my short discussion of the development relativity theories, first by Lorentz and Poincaré and then by Einstein, the reviewer cites some later writings of Lorentz to say that Lorentz's views on his 'local time' evolved and changed.

Reply.
Local time of a spatially separated clock is not experimentally accessible without a signal that depends on convention, as Poincaré had highlighted. Individual opinion and its evolution, even if it is Lorentz's, are not relevant for the experimental and logical facts.

Reviewer B. Comment 7.
My statement that there is no physical reason, in the sense of an interaction or causal influence, for the modifications of time and length in Einstein's theory is highlighted as questionable. Reviewer asserts, "Yes there is if one uses the invariance of the speed of light along with Einstein's definition of synchronicity, etc.; this procedure involves causal influences. Example: If a meter stick has one length in inertial system, K, then the cause of the two ends of a meter stick being simultaneously recorded in another inertial system, K', comes from the nature of the meter stick, synchronization procedure, relative motion of K' with respect to K, and the speed of light".

Reply.
The reviewer's example implies that a rod changes length due to real act of measuring both ends simultaneously. Nobody tries to measure the length of a Michelson interferometer, yet its null signal needs length contraction! So, metrological intervention cannot be the reason for length contraction. The reviewer avoids giving any such reason for the change in the rate of a clock.

Reviewer B. Comment 8.
After these qualitative comments, when we come to the serious content of the article containing the actual mathematical and logical proofs and the description of the experimental evidence, results, and discussion, there is complete silence with no 'QP' highlights and only one comment, all the way till the concluding section of the article. That is about 16 pages (3/4 of the article) of intense physics and logic, skipped by the reviewer. There no comments at all about the experiment or its robust result that falsify the fundamental hypothesis of special relativity. The only comment is about my result that the propagation of light is Galilean, with relative velocity $c \pm v$, relative to a frame moving with the velocity v. The reviewer asks and states, "You seem to be arguing for the classical addition of velocities. But that has been contradicted by experiments, e.g., by pi mesons travelling near the speed of light and then emitting photons — where the photons do not travel at a speed determined by that "additional of velocities" idea."

Reply.
It is very important to answer this precisely and clearly. I will now prove that my claim on Galilean propagation of light and the addition of velocities is not contradicted by any experiment or any known result. The reviewer is also confused between 'relative velocity' and 'resultant velocity'.

The experiment and its result are about the 'relative velocity' of light, relative to an observing frame at velocity v. I am not discussing the 'resultant velocity' of a particle or light emitted by another one moving at the velocity v in the laboratory. I suppose everybody knows the elementary result that even the velocity of sound does not depend on the velocity of its source! Not only photons from pions have their speed independent of the speed of the pions, even the speed of sound from a speeding source like a bird is independent of the speed of the bird. However, in another example of a particle like the muon that emits an electron when it decays, we can ask whether the resultant velocity of the electron is obtained by Galilean velocity addition. We know the velocity of the muon in the laboratory. What is the other velocity to add, to get the resultant velocity of the electron in the laboratory?!

This is where there is lot of confusion among physicists, physics teachers, and students. We can only ask how the speed of the electron changes when the speed of the parent particle varies. Then the law of addition of velocities becomes relevant. But *the two velocities to be added should both be referred to the same single frame*, shouldn't so? If v is one velocity and u is another, both relative to the laboratory, then the law of addition is indeed Galilean! However, if u' is specified relative to the frame of the parent particle, then it has to be first transformed and written in the lab frame before the addition operation. Let us do that, assuming the absolute frame theory like my theory of Cosmic Relativity.

The spatial and temporal intervals in the parent frame is dx' and dt', and the speed is $u' = dx'/dt'$. There is absolute length contraction $dx = dx'\sqrt{1 - v^2/c^2}$ and time dilation $dt = dt'/\sqrt{1 - v^2/c^2}$ in the parent frame moving at speed v. Besides, the time at two points separated by dx' differs by the amount vdx'/c^2 due to first order synchronization defect. Thus the time interval in the parent frame is different from the lab frame as $dt = (dt' + vdx')/\sqrt{1 - v^2/c^2}$

So, the speed $u' = dx'/dt'$ transformed to the lab frame is

$$u = \frac{dx}{dt} = dx = \frac{dx'\sqrt{1 - v^2/c^2}}{dt = (dt' + vdx'/c^2)/\sqrt{1 - v^2/c^2}} = \frac{u'(1 - v^2/c^2)}{1 + vu'/c^2} \tag{19}$$

Now that we have both velocities in the same frame, we can do a Galilean addition $v + u$ to get the final resultant velocity w,

$$w = v + u = v + \frac{u'(1 - v^2/c^2)}{1 + vu'/c^2} = \frac{v + u'}{1 + vu'/c^2} \tag{20}$$

This is the correct expression for the resultant velocity, derived in the theory of relativity with the privileged absolute frame and Galilean relative velocity of light. Thus, *I have shown that the velocity addition relative to a single reference frame is indeed Galilean.* I mention with pleasure and a certain satisfaction that the first person to point this out in writing, with full mathematical proof, was none other than Henri Bergson, in his treatise 'Duration and Simultaneity'. But those who undermine Bergson have not read any of these, yet blindly disregard, or even ridicule, the tightly argued truths! As Popper lamented, one ought to feel sorry for them.

In summary, I emphasize that there is ample evidence from experiments to replace the current theories of relativity and dynamics with a comprehensive theory that recognizes the gravity of the matter-energy in the universe as the source of all relativistic physical phenomena. The theory of Cosmic Relativity will eventually prevail, as truth supported by rigorous logic and empirical evidence.

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