Rudiments of Relativity Revisited

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Abstract

The Current framework of special relativity is shown to transform the unique time of a frame to many illusory times in the other frame that cannot be associated with any real clock. So, we revisit relativity as a problem of observing motion under finite signal speed. Kishori's axioms are developed for avoiding undesirable effects of finite signal speed from creeping into cross-frame measurements. The illusory transformed time and the relativity of simultaneity are shown as the undesirable effects of finite signal speed that creep into the current framework. A methodology is developed here to directly test the simultaneity of relativity experimentally, which is often deduced indirectly despite being directly testable. This study lays down the foundation of an alternative formulation of relativity that complies with Kishori's axioms besides the two famous postulates of relativity, reproduces the so far proven results, and also predicts new experimentally verifiable phenomena.

1. Introduction

Study of motion has been at the core of physics from the very beginning, which in turn revealed various physical mysteries uniting different branches of physics. Genius of Einstein associated the relativity of spacetime with motion so as to keep the speed of light constant [1]. He further extended special relativity to accelerated frames and gravity. Quantum physics associated even stranger aspects with motion such as the uncertainty principle. However, the theory of relativity and quantum physics do not inherently embrace and unify with each other despite being forcefully married at times. Are there some more mysteries associated with the motion still left unexplored? This paper explores and studies motion under finite signal speed (FSS), the relativity associated with it, in-frame and cross-frame observations of motion under FSS, the undesirable effects (UE) of FSS creeping into the in-frame and the cross-frame measurements, and the schemes to avoid these UE of FSS. It attempts to answer whether constancy and isotropicity of light-speed is achieved by the anisotropic odd order warping of time or of space, and whether we can find a trace of quantum physics in relativity or vice versa. Current framework of special relativity is shown to lead to illusory moving-frame time that cannot be associated with any real clock, and the relativity of simultaneity (RoS) is shown to be UE of FSS. Kishori's axioms are developed to avoid UE of FSS from creeping into in-frame and cross-frame measurements, thus laying down the foundation of an alternative formulation of relativity free from RoS, which also complies with Kishori's axioms besides the two famous postulates, reproduces so far proven results of relativity, and also predicts some new experimentally verifiable phenomena like anisotropic spatial warping (ASW), the relativity of spatial concurrence (RSC) and relativistic non-localization (RNL). Based on Kishori's first axiom, a scheme is developed to directly test RoS which is often deduced indirectly despite being directly testable. This scheme results in experimental setups to directly test RoS in subsequent papers.

2. Avoiding undesirable effects of finite signal speed

Suppose a game like volleyball is being watched from a distance. Because sound travels much slower than light, visual-hitting happens much before one listens to it. Though hitting and generation of sound are simultaneous, finite signal speed (FSS) gives rise to an irritating delay or gap between them for a distant observer. The fact that the speed of light is more than that of the sound, sound is heard after visuals of hitting. Now, suppose at the source if we encode or modulate the hitting sound on some EM wave and hitting visuals on some sound waves and again decode them to audio and visuals when they reach the distant observer, then she will listen to the hitting-sound much before she actually sees the player hitting the ball, thus even confusing the causality of the two events. However peculiar, serious and even experimentally verifiable these effects of FSS are, they are undesired ones distorting reality at a distance, and we do not wish them to enter into the framework of defining the physics of the game. Had the signal speed of both light and sound been infinite, such discrepancies would have not been observed even by a distant observer. But unfortunately no signal has got an infinite speed and also we do not wish such unnecessary reality-distorting effects of FSS to creep into the framework of physics. For example, they cannot be the basis of a theory stating that the time-gap between the timings of the action of hitting and the generation of sound are relative, depending on the observer's location because we know that such observational discrepancies are UE of FSS. How to avoid them? Lali puts this question to her friend and mentor Kishori more specifically, how to avoid the undesired effect of FSS from creeping into our definition of time and space? *Closer an observer is located to the event of hitting, lesser will be the undesirable discrepancy due to FSS and for an observer infinitesimally closer to the event such discrepancies disappear altogether,* replied Kishori thus laying down the foundation of Kishori's first axiom (KFA) on avoiding UE of FSS. Four tenets of this KFA are developed further, before we close this section.

Consider two sources, at fixed points *A* and *B* in Lali's inertial frame, which are flashing signal-pulses simultaneously at periodic intervals. Let us for a while also assume that the limiting signal speed in the new world of Kishori and Lali is unknown to Lali but known to Kishori and further Lali is unaware of the simultaneity of these flashes in her frame. Lali has got a signal-detector with an inbuilt clock and facility to record and display the time of receipt of any signal-pulse. If she puts the detector at *A* or *B*, it fails to receive the two flashes simultaneously and if it is equidistant from both the sources then it shows them flashing simultaneously but at a delayed time. What configuration must she use to decide on both the simultaneity and the exact time of emission of the two flashes, devoid of any UE of FSS? Kishori advises Lali inline with KFA to take up two such signal detectors, one for each event, place them at *A* and *B* and then synchronize their inbuilt clocks before using them to detect the flashing pulses. Lali is amazed to see that synchronized detectors placed close to the events not only grab the actual time of the emission for each emitter but also by comparing them she can tell if the emissions are simultaneous or not in her frame. Lali learns and summarizes the KFA: 1. *To avoid any undesirable effect of FSS from creeping into measured distances and times of one or more events, we must rely on a set of well synchronized detectors/clocks positioned infinitesimally closer to the event-locations.* If we add one more simultaneous event *C* located on the line joining *A* and *B* then we will not get even a single position for a single observer to whom all three events can appear simultaneous, but the KFA scheme works well by using three such detectors put infinitesimally closer to their events. In all the above cases, the location of the events in the frame are priorly known. How to measure the timings of events whose locations and numbers are not known prior to the experiment? Thus we get the second tenet of KFA: 2. *Use a dense matrix of synchronized detectors spread all over the frame of reference for detecting time and location of a number of priorly-unknown events in that frame. Virtually every point of the frame is assumed to be a tiny synchronized detector.* Here synchronized detectors means that their inbuilt clocks which are used to record the time of detection are well synchronized among themselves in the frame of the observer, not bothering how they appear to the observer of the other frame. In addition to the facilities of signal-detection, time recording and retrieval facilities, such a detector can optionally have an inbuilt tiny imager that can sense the direction and relative distance of the sources of the signal, which may help to figure out quickly which detector-location is in immediate proximity to the event. 3. *The location of the detector in infinitesimal proximity of the event is taken as the location of the event and the time stamped by it is taken as the time of the event for the frame of the detection.* This third tenet of KFA states the definition of time and position of an event under KFA in a given frame. Only assumption here is that clocks stationed in a frame can be synchronized with each other, which is quite a fair assumption under the constancy of the signal speed and is supported by the experience. In the KFA-scheme of measurement, an observer in her respective frame has to rely just on her own matrix of synchronized detectors spread across her own frame irrespective of if clocks of any other frame appear to her synchronized or not or vice versa. At last, the final tenet of KFA is stated exclusively: 4. *As a litmus test, if any apparent effect of FSS or concept disappears when examined under KFA, i.e. under the axiom of infinitesimal proximity of the detectors to the respective events, then it is an undesirable effect of FSS which is unnecessarily distorting the reality rather than being a law of nature and it need not form the part of the theoretical framework of relativistic physics*.

Lali having learnt the numerical value of the FSS in her world argues: In all the above cases, instead of using detectors for every event or harnessing the frame of detection with a dense matrix of identical synchronized detectors in compliance with KFA, a single detector can be used at any location of the frame to record the time of all events and retrieve the time of event at its very source by back estimation, provided we know their respective distances from the detector's location and exact signal speed. Kishori bewares, for such 'back-estimation' method to work, the phrase 'if distances are known unambiguously' is of key importance and therefore it may succeed to resolve in-frame FSS discrepancies for the detections done in the frame of the events where space is well behaved (Euclidean) for the signal, but it is prone to fail for cross-frame measurements. So far we have discussed such in-frame detection cases only and methods of back estimation may succeed here. But such methods fail to prevent undesirable cross-frame FSS discrepancies from leaking in the measurements of space-time made across the frames i.e. when the source of the event is located in one frame and the detector in the other, because distances are not unambiguously known. due to the relativistic warping of space. However, KFA-scheme based on infinitesimal proximity of detectors works equally for all cases to expose and avoid both in-frame and cross-frame FSS discrepancies. Consider an example of a cross-frame observation first before we systematically learn how conventional relativity (CR), unaware of KFA, eventually succumbs to cross-frame FSS discrepancies creeping into its framework and how KFA is capable of exposing and eliminating them.

3. Saving a moving clock from being illusory

The lightless sonic world of Kishori & Krishna, wherein Kishori is always mesmerized listening to Krishna's flute, is a perfect love world for them. One day they decide to observe their sonic world in motion. The sonic signal, which plays the same role in their world as light in ours, travels with a known finite, constant and limiting speed '*s*' and is capable of traversing their sonic space without the need of any medium. The idea behind simulating an altogether new world for experiment is just to keep our brain free of any presumptions and think afresh to closely witness how FSS and its effects help to creep attributes of one aspect (time) into the definition of the other aspect (space) in cross-frame observations. Out of three identical clocks that emit sonic bursts at an equal interval of time *t* at rest, Kishori gives one to Krishna.

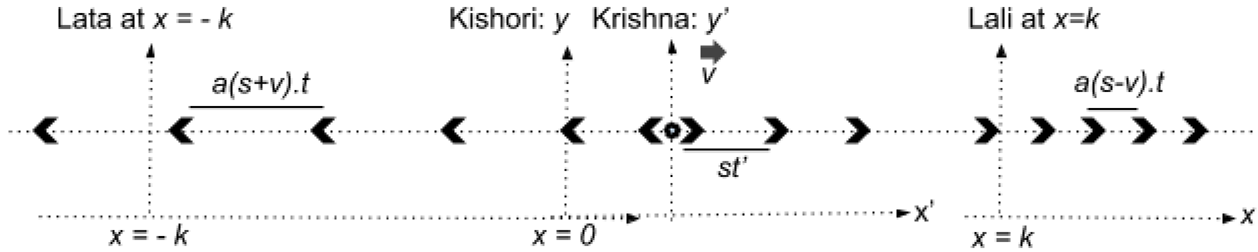

Fig 1. Lata and Lali in the rest frame of Kishori receive the periodically emitted sonic bursts from Krishna's moving frame's clock and compare its rate with their identical perfectly synchronized clocks. At emission of first burst, y and y' coincided and t=t'=0

The other two clocks she hands over to two of her friends Lali and Lata, stationed in Kishori's rest frame at $x=k$ and $x=-k$ respectively with Krishna moving with a velocity v in between them, see figure 1. Let the y coordinates of both the frames coincide at a time set to zero. Before Krishna's chariot is set in motion at a velocity v in $+x$, both Kishori and Lali confirm that his clock is emitting sonic bursts at every t when at rest. But as soon as Krishna moves at a speed v, Lata receives a sonic burst at a slower rate as if for her Krishna's clock has slowed down in the moving frame by a factor v/s. Let's assume the velocity v of Krishna's chariot is small enough to discard any second or higher order effects but is sufficient to observe any linear order effects of relativity. Commensurating with the slow rate of receipts of periodically emitted sonic bursts, Lata with the help of Kishori estimates the emission interval of the moving clock apparent to her, to a first order approximation, based on the constancy of signal speed 's' in all the frames, is given by t'_{lata} as :

$$t'_{lata} = \frac{(s+v)}{s} \cdot t \qquad (1)$$

So, for Lata Krishna's moving clock seems to have slowed down based on equation (1). But Kishori is astonished to find that for Lali the same moving clock of Krishna seems to be moving faster such that Lali estimates for her the same to be:

$$t'_{lali} = \frac{(s-v)}{s} \cdot t \qquad (2)$$

In such a formulation of relativistic physics though it reproduces the (apparent) experience of receiving the sonic bursts at different rates, Kishori smells some UE of FSS leaking in defining the time of the moving-frame-clock by the rest frame observers. Kishori knows that the rest-frame-clocks of Lali and Lata are well synchronised giving an identical time for the rest-frame. Equation (1) and (2) require that Krishna's moving clock is simultaneously going both slower and faster w.r.t the identical rest frame clock of Lali and Lata. Is it not illusory? No real clock can go both slow and fast simultaneously without being illusory. Further, reversing the direction of Krishna's motion just exchanges the situation for Lata and Lali but the fundamental contradiction of moving clock (or moving frame's time) going both slow and fast with respect to the rest-frame-time still remains. Kishori examines this situation very carefully. Spatially rarified or densified signal bursts for different observers in the rest frame is a direct result of constancy of the signal speed s, which in turn is not possible without linear order (of the order v/s) relativity of either space or time or both. Had none of space or time been linearly warped, signal speed would have changed [2]. Further, allowing any linear or odd order relativity in the definition of time of the moving frame, even in part, gives rise to an illusory time or clock going both fast and slow w.r.t identical stationary clocks. Thus, Kishori takes up a revolutionary leap and declares Kishori's second axiom (KSA) on odd order relativity:

To save a moving frame's time from being illusory, abstract or contradictory, the linear or odd order terms in the relative velocity between two frames cannot appear in the equation of relativity of time (temporal transforms) but in the equations of relativity of space (spatial transforms). Further, a moving clock's *time can not depend upon the location of the observer or clock in the other frame, thus ruling out any dependence of moving frame time on x,y,z coordinates in addition to the odd orders of v*. Moreover, experimentally verifying her axiom Kishori finds no linear order disagreement between their rest frame clocks and Krishna's clock after the latter is subjected to a uniform motion in a line for a considerable span of length. This confirms to her that spatially rarefied and densified signal bursts in her frame for Lali and Lata were due to linear or odd order warping of space and not of time.

Lali argues: well, the moving clock can not run at different paces simultaneously for different observers in the rest frame. But how come such contradictions will not arise when linear velocity terms or coordinates affect the spatial lengths, rendering them as illusory or abstract? Kishori replies: because for different observers in the rest frame the signal from Krishna's clock traverses different segments of space and each spatial-segment can be differently warped depending on the combination of v and s for that location. Mathematically, time coordinate being one dimensional lacks sufficient degree of freedom to cater uniquely for each observer but length 'l' being a vector in three dimensions has sufficient degrees of freedom to cater to various vector-combination of s and v for differently located observers in the rest frame such that the corresponding 'effective length' for one such observer need not contradict the experience of the other, as both enjoy a different length vector joining them to the source of the event. So unlike an illusory or contradictory or abstract or unrealistic time, the question of an illusory contradicting space does not arise due to spatial linear dependencies on v/s or x.

KSA can also be stated in the following words: *If experimentally one can verify that nature follows the temporal transforms of the kind (1) or (2) wherein odd order terms in v/s or x,y,z appear then it tantamounts to nature following the relativity of illusory or abstract time*. So the claim of KSA is not to restrict the path of nature but to come up with understanding and experimentally verifiable predictions and leave it to the experiments to see which path nature actually goes with.

4. Anisotropic spatial warping

To shed some light on the nature of KSA predicted odd-order spatial warping, look at fig 1 from Krishna's frame, the frame in which the source of event is at rest, wherein the sonic bursts travelling are uniformly spaced irrespective of their direction of propagation to left or right. Thus sonic signal, emanated from its clock going to right or left, sees a uniform normal euclidean un-warped space on either side in the rest frame of the event (RFE). Unwarped space seen by signal in the RFE provides the scope for the distances traversed by the signal on either side to be unambiguously known, thereby possibility to avoid in-frame FSS discrepancies. But for Kishori's frame, the signal sees differently warped space on either side depending on its direction. The signal reaching Lali is squeezed but one reaching Lata is rarefied because Kishori's space is anisotropically warped. This anisotropic warping of Kishori's space for the signal depending on its direction, also known as anisotropic spatial warping (ASW), is the exact fall out of KSA, saving the isotropicity and constancy of the signal speed. As a consequence of KSA, the effective spatial lengths traversed by the signal in Kishori's frame might be very different from what appears to Krishna and vice-versa.

Furthering the consequences of KSA, due to ASW the concurrence of pulse in one frame at an instant can not be directly mapped to estimate its concurrence in the other frame leading to new interesting phenomena like relativity spatial concurrence (RSC) and relativistic non localization (RNL), which were unknown to and unexplored in CR, thereby making it succumb to cross-frame FSS discrepancies creeping into its framework. RSC and RNL have been pursued in our second paper [3] wherein we have also developed a mathematical framework for new transforms of special relativity (NTSR). In [4,5] NTSR are finally derived and explored.

5. Relativity of simultaneity scrutinized under the first axiom of Kishori

Applying the fourth tenet of KFA developed in section 2, if relativity of simultaneity (RoS) disappears under KFA then for sure its inclusion in the very definition of physical time and basing the framework of relativistic physics on it will be self defeating. First, Lali explains to Kishori one of the versions of the famous train (primed moving frame) and embankment (unprimed rest frame) thought experiment often used for deducing RoS [6] indirectly, as shown in Fig 2. At time t=0 of the rest frame, when observer O and O' coincide, flash-blasts happen simultaneously at point A and B in the rest frame such that $OA=OB=AB/2=x/2$. Further, at the time of lightning, the points coincident with A and B are points A' and B' of the moving frame respectively. At time $t=x/2c$, the rest frame observer O sees rays from both A and B, confirming to him the simultaneity of the event. Meanwhile as O' has moved away from A towards B therefore it is deduced that it will see the ray from B earlier to the ray from A, hence establishing RoS indirectly. This setup to deduce RoS indirectly, obviously does not conform to KFA as both frames are employing a single detector in their respective frames to record the two distant events. Kishori bewares that such a setup for cross-frame measurement is the perfect recipe to allow the UE of FSS to creep in the relativistic framework of time and space. Therefore, for a while, let us abandon the use of a distantly placed single observer to observe multiple events and instead use the direct detection method of KFA to test RoS by employing multiple synchronised detectors of the kind described in section 2 to directly measure the time of every event at its very source in the moving frame.

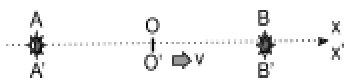

Fig 2. Famous setup for RoS. Points A and B in the rest frame are flashed when points A', B' of the moving train overlap with them. Observers O and O' in the two frames are also aligned at the time of lightning.

We need two identical clocked detectors for the rest frame and two for the moving frame. If the location of the event are not known prior then consider the two frames fitted with a dense matrix of identical detectors at virtually every point. The clocks of all the detectors within a frame are synchronized with each other for their own frame and we need not bother about how they appear to the observer of the other frame. The rest frame's synchronized detectors at A and B would confirm the simultaneity of the two flashes, in accordance with the similar method developed in Section 2, by recording the time of both flashes, say at time t in the rest frame. Now, consider the moving frame O' where the points A' and B' correspond to the points of blasts A and B respectively such that A' coincides with A and B' coincides with B at the time of blast. Synchronized detectors of the moving frame at A' and B' also being infinitesimally closer to the source of the event at the time of flash, fig 2, will also detect the flash as immediately as detected by the detectors of the rest frame at A and B, because under KFA-scheme the signal has to traverse almost zero distance from source to detectors in both the frames thus ruling out any undesirable play of FSS in the definition of time and space in any frame. Though moving frame's synchronized detectors may show a time t' different from RF time t (due to second or higher even order relativity) but this time is the same for both the moving detectors at A', B' synchronised in the moving frame. Thus, the observer in moving frame based on his own synchronised detectors at the event-points A' and B' will deduce the simultaneity of the flashes in his frame in the same way as observer in the rest frame deduces the same based on his own set of synchronised detectors at A and B. So, RoS disappears when examined under KFA, proving it to be an undesirable side effect of FSS that creeped into the framework of conventional relativity. This again enunciates the importance of KFA which directly measures the time of an event at its very source in all the frames ruling out any role of delays due to signal traversal! In [7,8] we present a practical experimental setup to test RoS directly.

6. Lorentz Transforms viewed under Kishori's axioms

Lali writes down the Lorentz transforms (LT) to check herself if CR really violates KSA.

$$x' = g(v^2/c^2)\,(x - vt)\,,\ \ y' = y\,,\ \ z' = z \tag{3}$$

$$t' = g(v^2/c^2)\,(t - vx/c^2) \tag{4}$$

where $g(v^2/c^2)$ is the gamma factor that encapsulates the even order dependence in *v/c*, where *c*, the speed of light, plays the same role as *s* in Kishori's love-world. The first thing she notes is the appearance of terms like *vx* in the temporal transform of (4), defying KSA. Further, Lali notes had the threesome experiment of fig 1, been performed with light-bursts as signal, then equation (4) would degenerate exactly into two equations, one for the bursts approaching Lata (*x= -ct)* and other approaching Lali (*x=ct)* respectively.

$$t'_{lata} = g\,\frac{(c+v)}{c}\,.\,t \tag{5}$$

$$t'_{lali} = g\,\frac{(c-v)}{c}\,.\,t \tag{6}$$

If we ignore all second and higher order dependence effectively yielding $g\sim1$, the above equations are replicas of (1) and (2). The moment (4) of LT is identified as a temporal transform between the times of the two frames, a single rate of Krishna's clock t degenerates to two in Kishori's frame, one for Lali and the other for Lata. Further, these bifurcated time rates can neither be associated to Krishna's real clock as it can not run both slow and fast for Lata and Lali nor to the real clocks of Lali and Lata as both stationed in the same frame are running with the same rate. Lali at this stage craves for the RoS, but to no avail for her anymore as RoS has already been deemed as UE of FSS in section 5.

7. Conclusion

This paper develops Kishori's axioms for avoiding undesirable effects of FSS, and suggests odd order warping of space instead of time for saving moving frame time from being illusory. It lays the foundation of an alternative experimentally distinguishable formulation of relativity free of RoS, which complies with Kishori's axioms besides the two postulates of relativity, reproduces so far proven results of relativity, and predicts some new experimentally verifiable phenomena [3-5]. Schemes are developed to directly and indirectly test RoS, RSC, ASW, and RNL [7-13]. The work of subsequent papers [3-5, 7-16] in this series is based on the foundation of this paper.

Acknowledgement: I am thankful to Mukt Mind Lab for always standing with me during this extensive research.

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