Experiment Proposed to Directly Test the Relativity of Simultaneity

Avibhajya Gajendra Singh Solanki
avi@muktmind.com, Mukt Mind Lab, WVC, UT USA

Abstract

The relativity of simultaneity and synchronization is considered as a fundamental underlying concept of the current framework of special relativity. However, it is deduced indirectly most often from the famous train embankment thought experiment where distant observers sitting at the midpoint of the two blasts take a decision about the simultaneity of the blasts in their respective frames depending upon if they receive the flashes simultaneously or not. Kishori's first axiom suggests that such an indirect method based on back estimating the time is prone to undesired cross-frame effects of finite signal speed. In this paper, experiments are proposed to directly detect the two blasts at their very locations to establish or refute the relativity of simultaneity.

1. Introduction

Current special relativity (CR) considers the relativity of simultaneity (RoS) as one of its fundamental aspects [1,2] while the new relativity (NR) deems it as an undesired effect (UE) of finite signal speed (FSS) [3-4] that has creeped into the framework of CR, and does not withstands the scrutiny of Kishori's first Axiom (KFA). Further in [3-6] an alternative framework of relativity is developed, which besides the two famous postulates of relativity complies with the third postulate of relativistic non-localization (RNL) by Kishori, reproduces the so far verified results of relativity without needing RoS, and also predicts some new phenomena. Temporal eq (2) of the new transforms (NT) is devoid of any synchronization term unlike (4) of the Lorentz transforms (LT).

NT: $$x' = em(x - vt)\ ,\ y' = em_{\perp}\, y\ ,\ z' = e\, m_{\perp} z \qquad (1)$$

$$t' = e\, t\ , \qquad (2)$$

LT: $$x' = g(x - vt)\ ,\ y' = y\ ,\ z' = z \qquad (3)$$

$$t' = g\,(t - vx/c^2)\ , \qquad (4)$$

where,

$$e = \sqrt{1 - v^2/c^2}\ ,\ m = \frac{1}{1 - (v/c^2)(x/t)}\ ,\ m_{\perp} = em\ ,$$

$$m' = \frac{1}{1 + (v/c^2)(x/t)}\ ,\ m'_{\perp} = em'\ ,\ g = 1/e\ , \qquad (5)$$

and c is the lightspeed.

However, RoS is often deduced indirectly using setups based on the famous train embankment thought experiment where distant observers, sitting at the midpoint of the locations of the two blasts, decide on the blasts' simultaneity for their respective frames depending upon if they receive the flashes from the blasts simultaneously or not. The event of the blast and the event of the receipt of flash by a distant observer are two different events, and the time of the former is back estimated from the time of the latter. This is the indirect testing method based on back estimation in contrast to the direct method of testing where detectors, put in the close proximity of the blasts, detect the events of the blasts directly. Because of a finite distance between the detector and the source of the blasts, the FSS plays a role in the former case, but not in the direct testing. The closer the detector is to the blast, the lesser is the play of the FSS. According to the KFA whose three tenets are stated below, the indirect method of testing is susceptible to UE of FSS that may distort the reality.

Three tenets of KFA [3]: 1. *To avoid any undesirable effects (UE) of finite signal speed (FSS) from creeping into the measured distances and times of one or more events, we must rely on a set of well synchronized clocks and detectors positioned infinitesimally closer to the event-locations. 2. Consider virtually every point of a frame fitted with* *synched detectors then the location of an event is the location of the detector in its immediate proximity and the time of its occurrence is the time recorded by that detector. 3. If any apparent effect disappears when examined under this axiom of infinitesimal proximity of the detectors to the respective events, then it is for sure a UE of FSS that need not be part of the framework of the relativistic physics.*

Therefore it is of paramount importance to design and develop experimental setups to directly test RoS by directly recording the time of blasts at their very sources using detectors set in the very proximity of the blasts.

2. Back estimation based indirect methods

Before we analyze the indirect testing of RoS of fig 1, let us take an everyday example of how signal speeds distort the temporal reality for a distant observer and how on a daily basis we smartly filter out these unwanted effects to enter into our description of reality. It also helps to understand that back estimation is successful for in-frame deatections and may fail for cross-frame ones.

2.1 Blasting balls and a distant observer

Consider some balls lying in the midst of the field blasting one by one due to heat, and an observer standing at a distance sees the visual act of blast happening before it is heard. The closer the observer moves to the blasting balls, the less is the time-gap he experiences between the visual act and the sound of the blast. This gap disappears when the observer places his visual and sound detectors in the infinitesimal proximity to the blasting ball. Observer has two options to conclude: He discards the time-gaps observed at a distance as an unwanted effect of finite and different signal speeds of light and sound, and concludes on their simultaneity at the ball as is evident from his last observation when he placed his detectors in infinitesimal proximity of the ball. Or he proposes a theory that the nature of these blasts is such that the time-gap between the act and the blast-sound is a function of the radial distance of the observer from the site of the blast. But, one can easily see the fallacy of the latter proposition because in this case for every single distant observation, the first proposition can be proved using the back estimation. Had the speed of both the signals been infinite, there would have not arisen any need of back estimation, but unfortunately no signal with infinite speed exists. Besides, the method of back estimation has also got its limitations. It works well in this case of in-frame measurements, where the blasting ball and the observer are in the same frame enjoying unwarped euclidean space between them. But the back estimation is prone to fail in the case of cross-frame observation i.e. when the observer and the balls are placed in different frames. If the observer is both, away from the ball and also moving w.r.t the ball, then back estimation is susceptible to undesirable effects creeping into the framework of our description of the relativity. However, KFA's scheme of 'detection in close proximity' always works, because it eliminates or minimizes the role of signal speed for both the in-frame and the cross frame detections.

2.2 The train embankment setup for RoS

Two simultaneous blasts flashed in the rest frame of embankment at point A and B such that $AB=x$ and $OA=OB=x/2$ at a time when points A', B' and O' of the train coincided with A, B and O respectively, where $A'B'=x'$, and $O'A'=O'B'=x'/2$. See fig 1. Observers are at O and O' in the two frames. This thought experiment has been analyzed in detail [5], here we reproduce the main claims of the two theories. CR claims [2]: Rest frame observer at O receives the flashes simultaneously from the two blasts to confirm simultaneity in her frame. Meanwhile the moving frame observer O' has moved to the right towards B and thus he will receive the flash from B first and A later to claim non-simultaneity of the blasts in his frame. The NR claims: CR being unaware of newly discovered

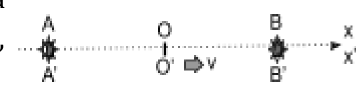

Fig 1. Famous setup for RoS. Points A and B in the rest frame are flashed when points A', B' of the moving train overlap with them. Observers O and O' in the two frames are also aligned at the time of flashing.

phenomena like ASW assumes the flashes exist at an overlapped position in different frames (OPDF) to arrive at an erroneous conclusion, whereas a photon exists at different positions in different frames (DPDF). Due to DPDF as flashes meet at *O* in the rest frame, they meet at *O'* in the moving frame, making the two blasts simultaneous in the moving frame too. As experiments have already been proposed to test the claims of the two theories [7], we move on to focus on the KFA based direct detection method to directly test RoS by employing multiple synchronised detectors to directly record the time of both the origin of the flashes at their very sources.

3. The Proposition of direct detection

Consider each of the two frames, fitted with a dense matrix of identical, intrinsic synchronized clocks and detectors at virtually every point. *The clocks are synchronized with the clocks of their own frame totally independent and oblivious of the other frame.* These synchronised clocks define the 'unique time of their frame', which can be read by an observer from the clock at her location.

Relying on the synched clocks of her frame, the Rest frame observer (RFO) produces two simultaneous blasts at points *A* and *B* in her frame, which also happen to coincide with points *A'* and *B'* at the time of blasts. Moving frame observer (MFO) using his own set of synchronised clocks and detectors at *A'* and *B'* detects the flashes at the very location of the two blasts to test if the blasts are simultaneous in the moving frame or not. Only assumption made here in this proposition is that the clocks within a frame can be synchronised to give a unique time for their frame, which is quite fair under the constantancy of signal speed. Mark it again that the observer synchronises the clocks of his frame with any reasonable method justified for his frame, without bothering how it appears from the other frame or whether the observer of the other frame is convinced with it. Even if the observer of the other frame interferes to tell you that your method does not convince him, ask him that he should apply his convincing arguments to synchronise his clocks of his frame. Same is true for the other frame so that both frames endup synchronising their clocks independently.

One may ask about the method adopted to synchronize the two clocks of a frame. Under the constancy of the lightspeed, both CR and NR agree that the clocks of a frame can be synchronised for their frame, and thus any reasonable method can be employed to synchronize the clocks of the frame including the two way synchronisation suggested by Einstein [1]. For the NR, in principle, any signal with precisely known speed can be used to synchronize the two clocks stationary w.r.to each other, but velocity of light being the highest, constant, isotropic and universally known ensures more precision and less ambiguity as a signal. Let the stationary clocks be at *A* and *B*, where $AB=x$. Set the one at *A* to read zero and the other at B to read time x/c before starting them. Arrange them such that when clock *A* is started it emits a lightray that travels to clock *B* and starts it, synchronizing them in their frame. Optionally another ray from clock *B* to *A* can be used to confirm the synchronisation.

Would the two simultaneous blasts in the rest frame be detected as simultaneous by the synched detectors of the moving frame placed in infinitesimal proximity to the blasts?

CR's analysis:

Consider the very synchronisation process used to achieve the simultaneous blasts in the rest frame. Clock *B* is kept x/c time ahead of clock A, but for MFO, the light has to traverse vx/c distance short of x for the moving frame as clock *B* moves to the left, reaching vx/c^2 time earlier at clock B. Thus for MFO, the blast at *B* will happen vx/c^2 time before the blast at *A*, which exactly is the synchronization term in (4) of LT. Thus direct detection of the blast in the moving frame will not be simultaneous.

NR's analysis:

CR, being unaware of the phenomena like ASW and

RSC which are the outcomes of the NR, follows OPDF to map the lightray's position of his frame to the rest frame and arrives at an erroneous conclusion, as it fails to filter out the UE of FSS in its cross-frame analysis. Cross-frame detections involve the anisotropic spatial warping that the signal encounters in the other frame, and so the ray concurs with different locations in the two frames, and hence due to DPDF, its position in one frame cannot be directly mapped to the other frame. Therefore MFO predicted positions of the ray are true for his frame but not for the rest frame at all. This DPDF can also be verified from eq (1) and (2) of the NT. Another way to understand this is that in NR, the result of detection is affected by the motion-state of the detector. Had the MFO put a detector in its own frame coincident with clock *B*, it would have detected the ray there at that time when MFO claims the synchronizing ray to be at *B*. However, the clock B is stationed in the rest frame and is in a very different state of motion, and it detects the ray exactly at *x/c* and not earlier. If the two observers realize that a photon is relativistically non-localized, and exists at DPDF, then the disagreement on simultaneity disappears. Thus, NR predicts simultaneity in the moving frame as well.

It is obvious that NR and CR do not agree on the outcome of this experiment. Only way ahead is to actually perform the experiment based on direct detection of the blasts at their very location.

4. Experimental setups to directly test RoS

Here, a practical setup to test RoS directly on the lines of KFA is developed.

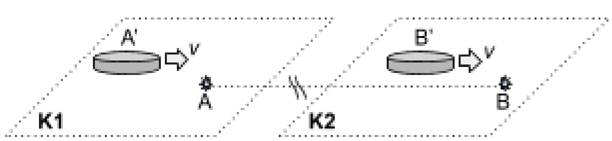

Fig 2. Setup A to test RoS under KFA. Moving frame's synchronized detectors at A' and B' pass over the vertical flash sources, A and B to record the time of the flashes in the moving frame.

Let K1 and K2 be two stations having no relative motion between them, forming the rest frame (RF), as shown in fig 2. At *A* and *B* are kept two flashing sources controlled by well synchronized identical clocks or triggers in the RF, programmed to flash the sources simultaneously. Simultaneity of the triggers is to be achieved for the rest frame without bothering how they appear for the moving frame (MF). MF is formed by two oval identical moving detectors (MD) *A'* and *B'* which cross over the flashing points at the time of the flash and whose detection area is ovally elongated. This way instead of harnessing all of the moving frame with a dense matrix of detectors in accordance with KFA, we have smartly enabled the oval area around *A'* and *B'* with a detection capability, avoiding any misalignment of MDs with the source-points *A* and *B* beneath., due to second or higher order warping. However, this oval broadening of MD must not affect their quick response, which has to be uniform across the area irrespective of where it is hit by the flash from beneath. Flashing sources are guided to flash vertically up minimizing lateral spread of light, and MD are tuned to receive this light hitting transversely from beneath. Detectors are equipped with identical well synchronized clocks to record the time of detection in the moving frame and are subjected to identical moving conditions to ensure they remain synchronized throughout their journey. Again the MD are synchronized for the MF without bothering how they appear from RF. There will be practical sources of errors to disturb the otherwise expected simultaneity of the events in this KFA based experimental setup. Suppose the time of detection for *A'* and *B'* are *ta'* and *tb'* respectively. Good news is that RoS demands a constant offset-interval, *c(ta'-tb') = vx/c*, for a given *x* and *v*, where *x* is the distance AB and *v* is the velocity of MD w.r.t the RF. So either by improving the experimental precision or by increasing *x*, one just needs to bring down the cumulative effect of all the errors well within a fraction of this constant *vx/c*. Repeated and reproducible measurements satisfying the path difference,

$$c(t_a' - t_b') << vx/c \qquad (6)$$

unambiguously refutes the RoS once and forever and if the same is proven to be zero within the experimental errors validates the no-RoS of the NR.

To minimize the errors of synchronization between independently moving detectors, we can employ a spatially limited window of detection for both MD. The detection capability is enabled only when MDs cross over the gray metal or field strips running normal to AB, see fig 3.

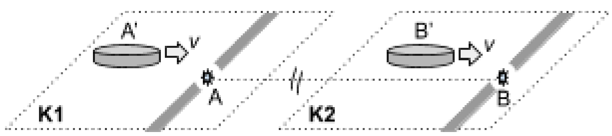

Fig 3. Setup 2 to test RoS under KFA. Moving detectors A' and B' are enabled by spatially limited gray metal strips engraved about A and B for a short duration.

If we also employ a pair of stationary detectors (SD) in the RF, positioned in the vicinity of the flash-sources such that they are also enabled to detect alongwith MD only when MD traverse over the strips, then a successful detection of the flash by the MD and SD both will ensure the simultaneity of the flashes in the two frames. In [7] a setup to test the meeting point of flashes in the moving frame from the simultaneous blasts is developed.

6. Conclusion

In addition to the two postulates of relativity, NR also complies with the Kishori's axioms, and successfully derives transforms that do not contain the synchronization term being free from the relativity of simultaneity. CR however is based on the RoS. Both of them present cogent arguments to defend their claims. In this paper the claims of both the theories are carefully analyzed, an experiment to directly test the relativity of simultaneity is proposed. Basic experimental setups are designed and devised under Kishori's first axiom. If RoS withstands this test of direct testing then the NT can be deemed as an alternative form of LT. However, if RoS is refuted in the direct testing then it opens the doors for other remarkable phenomena like RSC and RNL of NR, and also for supra or infra luminal light travel based on RNL. Including this one, at least our six papers [7-12] analyze and propose various experiments that can distinguish the two formulations. Paper [13] compares reinterprets LT in the light of NT, and [14] extends them for the static fields.

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

References

1. The English translation by Meghnad Shah of Original paper by Einstein, Albert (1905), "Zur Elektrodynamik bewegter Körper", Annalen der Physik 322 (10): 891–921.
2. "Relativity, the special and general theory; the popular exposition" by Albert Einstein authorised translation by Robert W Lawson.
3. "Rudiments of relativity revisited", Solanki G.S., communicated.
4. "Relativity of spatial concurrence and relativistic non localization", Solanki G.S., communicated.
5. "Alternative transforms for special relativity", Solanki G.S., communicated.
6. "Relativistic physics of new transforms of special relativity", Solanki G.S., communicated.
7. "Einstein's famous thought experiment for simultaneity put to test", Solanki G.S., communicated.
8. "Experiment proposed to test the relativity of spatial noncurrence", Solanki G.S., communicated.
9. "Experiment based on the spatial shape of a transformed growing lightsphere", Solanki G.S., communicated.
10. "Exploring ultra lightspeed communication using relativistic non localization", Solanki G.S., communicated.
11. "Relativistic non-localization based interferometer and lightspeedometer", Solanki G.S., to be communicated.
12. "Relativistic non localization: an ignored reality", Solanki G.S., communicated.
13. "Comparing Lorentz and the new transforms of special relativity", Solanki G.S., to be communicated.
14. "Energy potential transforms", Solanki G.S., to be communicated.