Relativistic Non Localization An Ignored Reality

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Abstract
Relativistic non-localization enables a moving particle such as a photon to exist at different positions in different frames at an instant and gives rise to an experimentally distinguished physics of relativity. A photon exists in a relativistic non-localized superstate until it is encountered by a detector which results in the collapse of the superstate so as to preserve the lightspeed across frames because the motion state of the detector affects the position of detection. But the current relativity inadvertently assumes the photons to be relativistically localized and invents the relativity of simultaneity. The relativistic non-localization, which is the nonlocality across frames, remained hidden so far under the mathematical elegance of Lorentz transform but is readily revealed by the real domain transform.

1. Introduction

The Current special relativity (CR) interprets Lorentz transform (LT) based on the localized existence of a moving particle or a photon across the frames and invents the relativity of simultaneity [1-5]. But, LT can also be interpreted based on relativistic non-localization (RNL) defined as the presence of a moving particle like a photon at different positions in different frames at a given instant, not at an overlapped position. Thus, RNL is the nonlocality across the frames, a bit different from the usual quantum nonlocality within a frame. Let's see how LT supports RNL.

$$X' = \gamma(x - vt)\ ,\ Y' = y\ ,\ Z' = z$$
$$T' = \gamma(\ t - vx/c^2) \qquad (1)$$

where v is the relative velocity between frames, c is the lightspeed, and $\gamma = 1/\sqrt{1 - v^2/c^2}$. We can also derive the relation between the clock-times t and t' of the two frames from (1) by putting $x=vt$ in a temporal transform there.

$$t' = t/\gamma \qquad (2)$$

Now, consider a photon emitted at the common origin at $t=t'=0$, found in the rest frame at x at time t. What is its location in the moving frame at that instant t? From (1), $X' = \gamma(x - vt)$ is its position in the moving frame at time $T' = \gamma(\ t - vx/c^2)$, not at the moving-frame clock-time t' that belongs to the instant t of the rest frame by (2). What is the position of the photon in the moving frame at the instant when it existed at x in the rest frame i.e at $t' = t/\gamma$, Surely, it exists at $x' = x/\gamma$, in the moving frame at t'. Next, in time t, the moving frame itself has moved a distance vt from the rest-frame origin, therefore this shift makes the positions of the photon in the two frames i.e. x and x' differ by at least vt in first-order. But, as we shall shortly see, the points x and X' overlap at time t, because of the moving frame's shift by vt. Thus, the photon exists at different positions in different frames (DPDF) at an instant, proving RNL using LT.

Above, we computed the position of one particle of one kind at one instant to prove RNL. To compute the position of any number of particles of any kind at any instant mapped with the clock-times of the two frames, the real domain transform (RDT) is derived in [6]. The forward version of RDT used for particles originating in the moving frames is produced here,

$$x' = em(x - vt)\ ,\ y' = em_\perp y\ ,\ z' = e\, m_\perp z$$
$$t' = e\, t\ , \qquad (3)$$

where,

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

Strikingly the synchronization term and relativity of simultaneity disappear in the real or clock domain without losing time-dilation. The physics of RDT is explored in [7]. LT and RDT are shown to be equivalent transforms [6,7] related by (4).

$$x'=e^2mX',\ \ t'=e^2mT' \qquad (4)$$

The difference between LT and RDT is that the LT maps the position of a moving particle from one frame to an overlapping position in the other frame and computes the time to occupy that position, leading to Minkowski or split domain, while RDT maps the clock time of one frame to the clock time of the other and computes the position of the particle at that time, operating in the real domain [6]. RDT being equivalent to LT reproduces the so far proven results of relativity [7]. LT hides DPDF under its mathematical elegance, but RDT readily reveals that a photon exists at DPDF not agreed with their mutual overlap. Another issue detailed in [8] is that the interval and phase invariance of LT is not compatible with its clock relationship of (2) but is readily resolved by RDT.

2. Equation of overlap of two frames

What do we mean by the overlapped positions of the two frames at a given instant? For a particle or probe that is at rest in the moving frame i.e. $x=vt$, both LT and RDT reduce to a common form,

$$X' = \gamma(x - vt)\,,\ Y' = y\,,\ Z' = z\,,\ t' = et \qquad (5)$$

This is the equation of overlap of the two frames where time t maps to $t'=et$ as in (2) and a point x in the rest frame overlaps with X' at that instant. Now consider a photon or a moving particle having non-zero velocity in either of the frames, LT maps its position x to the same X' given by (5), but it calculates a different time T', different from t', for the photon to occupy that overlapped position as mentioned in section 1. RDT on the other hand maps the clock times following (2), and calculates the position of the photon at that instant in the moving frame to be at $x'=ex$, different from the overlapped position of (5) or (1). Thus, from both LT and RDT, a moving particle is relativistically non localized and exists at DPDF, not agreeing with their mutual overlap given by (5).

3. Different positions in different frames

In fig 1, a photon that was emitted in the moving frame at the common origin at $t=t'=0$ is shown to be detected at P at time t that overlaps with point P' of the moving frame at that time,

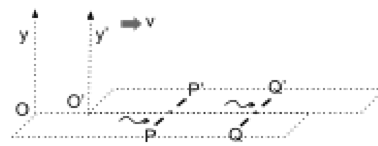

Fig 1. When a photon is detected at P in the rest frame, it is not detected at an aligned point P' in the moving frame but at Q' that aligns with Q.

$$OP = x = ct,\ O'P' = X' = \gamma(x - vt) \qquad (6)$$

At that instant, the photon, by substituting $x=ct$ in (3) of RDT, exists in the moving frame at point Q' that overlaps with point Q of the rest frame, $O'Q'=x'=ct'$ and $OQ'=x'+vt'$. Thus, the gap in two positions of the photon in the two frames at that instant,

$$P'Q' = evx/c\,. \qquad (7)$$

This DPDF also referred to as relativity of spatial concurrence is the proof of the non-localized nature of a moving particle termed as RNL.

3.1 Motion-state of detector affects the position

What makes the photon to be detected at P in the rest frame but at a different point Q' in the moving frame that aligns with Q and not P of the rest frame, even when identical detectors are used in the two frames? If one detector finds the photon at P why does not the detector of the moving frame find it there too? From the point of view of any of the rest or moving frame observers, there is only one difference that exists in the process of detection i.e.

the motion-state of the two detectors are different w.r.t the source of the photon. Thus, the state of motion of the detector affects the position of the photon's detection so as to preserve the lightspeed. Consider one more frame moving in *-x* with *v*. Then it would have shifted the position of detection to the left following (7), making RNL a potential mechanism behind the constancy of lightspeed.

Let us take another example. At *t=t'=0,* a pair of photons are emitted at the common origin traveling axially opposite to each other. Fig 2 shows the two frames at a later time *t* when MF has moved by a distance *vt* to right and one the photon is detected at point *P* and other at *R* in the rest frame simultaneously at *t* as *OP*=*-OR*=*x*. In the moving frame, however, at that instant they are not found at *P'* and *R'*, the points concurring with *P* and *R*, but at *Q'* and *S'* respectively as shown in fig 2, which align with the points *Q* and *S* of the rest frame following (7). From both RDT and LT, it can be shown, *t=x/c*, *O'S'=-O'Q'=x'=ex*, and the time when two photons reach *S'* and *Q'* in the moving frame is *t'=et*. Finally, the time for photons to be at *P'* and *R'* in the moving frame are $\gamma(1-v/c)\,t$ and $\gamma(1+v/c)\,t$ respectively. Thus at the instant given by clock-time *t* in the rest frame and clock-time *t'* in the moving frame photons exist at different places in the two frames. We shall also use this example in section 5 to prove how RNL replaces relativity of simultaneity and synchronization with the relativity of spatial concurrence.

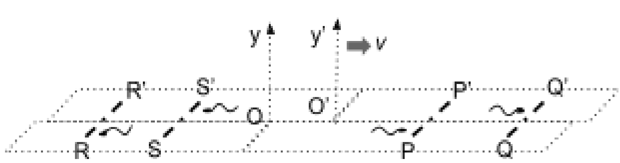

Fig 2. Photon to the right is at P and to the left at R in the rest frame, but in the moving frame, they are at Q' and S' respectively then.

4. Relativistic non-localization

How can the photon exist at two different locations once? That brings us to the principle of the RNL superstate which can be the mechanism behind the constancy of the lightspeed across frames. Consider DPDF again from the perspective of the rest frame observer who detects the only emitted photon at *P* of the rest-frame detected at a time-lapse *t* after its emission by a distant stationary source that keeps on emitting a single

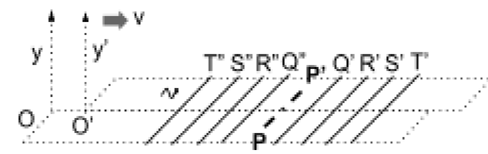

Fig 3. The positions of detection vary from T' to T" about P with various positive and negative v of the detector.

photon periodically. Using progressively incremented values of the velocity of the detector, the rest-frame observer detects the photons after the same equal time-lapse *t* after their emission at *Q'*, *R'*, *S'*, *T'* and so on, all progressively shifted to the right of *P* and by using incremented negative velocities of the detector, he detects the particles at *Q"*, *R"*, *S"*, *T"* and so on, all progressively shifted to the left of *P*. The points from *T"* to *T'* denote the DPDFs of the particle at a given instant as shown in fig 3. From the particle's perspective, all these different positions in different frames, namely *Q'*, *Q"*, *R'*, *R"*, *S'*, *S"*, *T'*, *T"* may relativistically concur owing to odd-order spatial warping of RDT, and the particle has no difficulty to occupy each and all at an instant. But for the rest-frame observer, these points are quite separate in space, and thus the particle's simultaneous availability for detection at them, just depending upon the velocity of the detector, seems to defy the classical behavior of a localized particle in many ways: First, the outcome of detection i.e. the particle's position at the instant of detection is affected by the state of motion of the detector. Second, the simultaneous presence at multiple widely separated positions in space defies the localized nature of the particle. Further, once the particle is detected at any of the above positions, its presence for other locations has to vanish immediately to avoid its multiple detections. Unable to escape the RNL, the rest frame observer lays down its various tenets of the in-frame and cross-frame detection process of the particle, preserving the constancy of lightspeed:

1. The moving particle before being detected exists in some strange relativistic non-localized super-state encompassing all possible cross-frame detection-locations, superposing all possible detections in all possible frames at any instant.
2. The very process of detection of the particle results in the collapse of that superstate. Particle instantly withdraws its possibility of detection from other possible locations.
3. The outcome i.e. position of detection for a given time of detection is influenced by the state of motion or the frame of the observer so as to obey the second postulate. As in fig 3, for a stationary detector, the position of detection is *P*, but for moving detectors the positions of detection shift according to their velocity. *Thus, the state of motion or the frame of the detector affects the outcome.*

So, a moving particle exists in an RNL superstate before it is detected and the process of detection collapses the superstate. For the first time to our knowledge, relativity and quantum physics are shown here connected so inherently to the extent of interdependence. Had the DPDF and RNL not been ignored or hidden under the mathematical elegance and symmetry of LT, the genius of Einstein would have not missed the quantum physical attributes of relativity and would have not been averse to quantum mechanics in its very infancy. From the discussion of the previous section, we can write an expression in first order for 'relativistic spread' in the detected positions of a photon using (8),

$$\Delta x_{rel} = \Delta v x / c \qquad (8)$$

5. Relativity of simultaneity versus of spatial concurrence

We shall use the scenario of fig 2 detailed in section 3.1 to show how treating the photon relativistically localized i.e. assuming its presence at an overlapped position in different frames (OPDF) leads to the relativity of simultaneity (RoS) and treating it relativistically non-localized i.e. allowing its presence at DPDF shuns RoS replacing it with the relativity of spatial concurrence (RSC). Mount two photon-triggered blasts on points *P* and *R* of the rest frame, which are triggered simultaneously by the two photons of fig 2 that originate at the common origin at $t=t'=0$ and reach the sites of blasts, *P* and *R*, at time $t=x/c$. Assuming the photons relativistically localized and the OPDF, the current relativist insists that to be at *P* and *R*, photons must also be at *P'* and *R'* in the moving frame, and thus the time of each blast in the moving frame is the time when photons reach *P'* and *R'*, and hence the two blasts are not simultaneous in the moving frame. However, the points *P* and *R* are in a very different state of motion from the moving-frame points *P'*, *R'*, and it is erroneous to assume the presence of photons at the latter when they hit the blasts mounted at the former owing to DPDF. So, when the photons concur with the blasts at *P* and *R*, they concur with the points *Q'* and *S'* in the moving frame owing to the different motion-states of the detectors. As the moving frame observer calculates the time for the photons to be at Q' and S' in its frame, it comes out to be simultaneous. Thus the simultaneity of the blasts is not contradicted in either frame. Had the blasts been mounted at *P'* and *R'* in the moving frame then blasts would have been non-simultaneous for both the frames. Thus new relativity based on RNL replaces the RoS with the RSC, and this difference is experimentally verifiable [9-12].

6. The fourth axiom

Though the experiments detailed in [9-14] must have the final say in distinguishing the current relativity based on OPDF and RoS and the new relativity based on RNL, DPDF and RSC, here we extend a series of argument to land at the fourth axiom. Referring to fig 2 again, suppose following current relativity's OPDF the two photons exist at overlapping points *R'* and *P'* in the moving frame when they are at *P* and *R* in the rest frame, then how to justify their different times of travel to *P'* and *R*' from the origin, $\gamma(1-v/c)\,t$ and $\gamma(1+v/c)\,t$ differing linearly in *v/c*, different from the rest-frame time *t* to reach *P* and *R*? One way is to assume the time of emission of the photons are different in the two frames. Using LT, the left photon's travel time to *R'* is more than *t*, therefore it must have originated in the moving frame before it emitted in the rest frame. Similarly, the right side photon would have originated at a later time. But that would mean the two photons that originated at the same time, same place in the rest-frame, originated at different times in the other frame, contradicting the current relativity itself. If they originate at the same time at the origin of the moving-frame too, then it means when photons concurred with points *P* and *R* in the rest frame, they concurred with *Q'* and *S'* in the moving frame, proving DPDF and RSC. Next, the current relativist (CRist) may fantasize some illusory moving-frame time such that a photon's position do overlap in the two frames throughout their journey from the origin to its destination, but the moving-frame clocks somehow accumulate different times given for the two photons to be at *P'* and *R'*. But, this violates the clock-time relation (2) of LT itself, which says the time lapsed in the two frames after the instant when their origins coincided can only differ from each other in second or even-orders given by (2), whereas the time for the photon to be at OPDF requires a linear-order difference of clock-times, *(v/c)t*. Moreover, the moving frame clocks are not going to run at different rates for the two photons moving in the opposite directions as is evident from (2). Next, CRist may put the pretext of non-synchronization of the well-synchronized clocks of one frame to the observer in the other frame. But the truth is that each observer makes these observations independently dealing with the clocks of his frame alone, without requiring any reference to the clock of the other frame. Thus, for the clocks to differ in linear order, they have to run at a rate that differs in linear order. Besides, the moving frame clocks can not run at two different rates for photons moving in the opposite direction, but again that violates (2), which is not just a theoretical abstraction but an experimentally verified time-dilation of a moving clock depending on the second-order of *v/c* [15-16].

Finally, CRist, leaving aside the moving frame clocks, argues to consider the different linear-order times accumulated by the photons moving in opposite directions. However, as we derived (2) from LT for the clocks in moving frame, we can derive a similar equation for the clocks in the photon's frame by replacing *v=c* to find that in photon's frame time slows down eternally and also a clock moving with *c* is not going to display different rates just by reverting its direction. Thus, CRist exhausts all his arguments failing to associate the time transformed by LT to any real clock by assuming OPDF - the relativistc localized existence of the photon. This brings us to the fourth axiom of relativity that '*it is impossible to associate the transformed time of LT to any real physical clock without accepting the tenets of RNL-based new relativity such as DPDF or RSC*.' [7,9,10].

7. The Impact of RNL

As shown, RNL lays down relativistic physics that is experimentally distinguished from the currently accepted interpretation of LT and the special relativity based on DPDF and RoS. A few impacts of RNL on relativity are summarized below.

7.1 Relativity of simultaneity (RoS) is the result of CR's assumption of relativistically localized photons as briefed above and detailed in [9]. Therefore, in the light of DPDF of RNL, RoS-dependent interpretation of LT needs to be revisited, debated, and tested. The experiments to test RoS directly and indirectly based on a famous train embankment thought experiment used by Einstein have also been proposed in [9-12]. The two photons emitted at the origin in fig 2 hit points *P* and *R* of the rest frame to create simultaneous blasts. However, due to RNL, the two photons need not be at *P'* and *R'* in the moving frame when they hit the blasts in the rest frame as they exist at very different points *Q'* and *S'*, and the time *t'* for the two photons to be there is same, *t'=et,* in the moving frame as well, thus deducing simultaneity of the two blasts for the moving frame observer also.

7.2 New phenomena that have remained hidden under the mathematical elegance of LT such as RNL, DPDF, RSC, and anisotropic spatial warping (ASW) are explored.

7.3 Various experiments to test the new phenomena are proposed in [9-14].

7.4 If RNL-superstate is the mechanism behind the preservation of lightspeed as is hypothesized in section four then there is a scope to manipulate the collapse of the RNL-state so that to achieve slower or faster travel of light through the vacuum. Papers [13,14] in this series explore supra or infra lightspeed communication.

7.5 But as shown in [13], the qualified second postulate still holds that the light-speed is constant '*in the frame of detection'*.

7.6 RNL brings the two fields, relativity, and quantum, closer. However, the non-localization owing to the relative velocity of the detector w.r.t particle or the source of the particle is termed as RNL. This is different from non-localization due to the quantum physical spatial uncertainty of the particle.

8. Conclusion

The existence of a moving particle at different positions in different frames, which is revealed by RDT and is also not contradicted by LT, is the basis of relativistic non-localization. The current special relativity, however, assumes the photon to be relativistically localized existing at an overlapped position in different frames and interprets LT based on the relativity of simultaneity. Further, the new relativistic physics based on relativistic non-localization, which reproduces all the so far proven results of relativity [7], can be experimentally distinguished from the current relativity in terms of RoS and RSC [9-12].

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