# Relativity of Spatial Concurrence Analyzed and Put to Test

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***Abstract***

***Real domain formulation of special relativity explicitly exhibits relativity of spatial concurrence, relativistic non-localization, and anisotropic spatial warping in contrast to the relativity of simultaneity and synchronization of the current framework. The new formulation contradicts the current interpretation of Lorentz transforms based on the relativity of simultaneity and the assumption that the photon exists at an overlapped position in different frames. The existence of photons at different positions in different frames opens the doors to new exciting relativistic phenomena not explored so far. This paper, the sixth in the series of rudiments of relativity revisited, the previous one, and the next propose an array of experiments to distinguish between the two relativistic physics. Relativity of spatial concurrence and of simultaneity are mutually exclusive, the presence of one discards the other and vice versa.***

## 1. Introduction

Current special relativity (CR) [1-5] deduces relativity of simultaneity (RoS) while the new relativity (NR) deduces the relativity of spatial concurrence (RSC) as RoS is deemed as an undesired effect and a source of illusory time that can not be associated with any real clock until tenets of NR like RSC are accepted [6,7]. If the CR's interpretation of Lorentz transform (LT) based on RoS is discarded then the neutral math of LT does not contradict with the newly predicted phenomena like relativity of spatial concurrence (RSC), relativistic non-localization (RNL), and anisotropic spatial warping (ASW) and others. The new transforms (NT) derived in [6] are produced here along with LT.

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

$$t' = e\, t\ , \tag{2}$$

LT: $$X' = (x - vt)\ ,\ Y' = y\ ,\ Z' = z \tag{3}$$

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

where,

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

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

$v$ is the relative velocity between frames and $c$ is the lightspeed. The NT and LT are shown equivalent, but they operate in real and Minkowski domains respectively [6,8] as LT chooses odd-order warping (OOW) of time while NT chooses OOW of space. The Minkowski domain gives an advantage in terms of four-vector-based covariant formulation while the real domain facilitates plausible interpretation and visualization of relativistic phenomena. The term CR is used here for the current interpretation of LT based on RoS and LT for its neutral math devoid of CR's interpretation. Both NR and CR decipher and agree on a number of phenomena like relativistic time dilation, length-contraction, velocity addition, preservation of lightspeed, aberration angle doppler principle, etc, however, NR also predicts new phenomena like RSC, RNL, and ASW which are not contradicted by LT but by CR.

CR assumes a photon to be relativistically localized at an overlapped position in different frames (OPDF), while NR asserts the moving particles are relativistically non-localized, existing at different positions in different frames (DPDF). CR based on the OPDF maps a set of simultaneous events to a set of non-simultaneous events in the Minkowski domain giving rise to RoS, while NR based on the DPDF maps the same input set to a set of simultaneous events of the other frame in the real domain, giving rise to RSC. RoS and RSC are mutually exclusive like OPDF and DPDF. Which one does then follows true relativistic physics? This can neither be decided through arguments nor through the so far proven results of relativity. New tests in the wake of new development are needed. Therefore, an array of new experiments have been proposed in this series of rudiments of relativity revisited including this one [9-14].

**2. RSC or DPDF versus RoS or OPDF**

Consider a particle moving on a very long ruled scale as shown in fig 1. To read its position at any time we look for its spatial concurrence with the ruling marks on the scale at that particular time. That this spatial concurrence is relative is the revolutionary claim made by NR, termed as RSC.

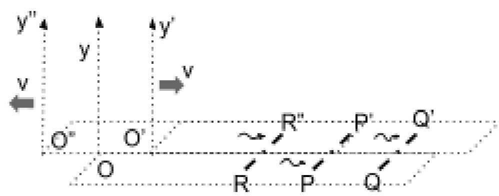


*Fig 1. If a photon is detected at P in the rest frame, it is detected at Q' in O' frame and at R" in the O" frame.*

Let the origins of three frames, *O, O'* and *O"* coincide at the time of emission of a sharp burst of photons at *t=t'=t"*=0, fig 1. While the photon is detected at *P* in the rest frame (RF), it is detected at *Q*' (not *P'*) in the moving frame (MF) *O'* at that instant owing to RSC. To a first-order approximation from (1) and (2)

$$PQ = vx/c \qquad (7)$$

where *v* is the relative velocity of the MF w.r.t the RF [4]. This linear order effect of (7) is quite measurable and testable. To further widen this gap or shift of detection, consider another MF *O"* having the same relative speed *v* but in the opposite direction and a detector installed in this frame would detect the photon at *R"*, a point concurring with *R* in the RF, giving a shift in positions of detection as

$$RQ = 2vx/c \qquad (8)$$

The direct fall-out of RSC is that at a given instant, a moving particle exists at DPDF, different locations are not mutually agreeable on the basis of the overlaps of the frames at that instant. When a photon is at *P* in the rest frame, at that instant the same photon is at *Q'* in the *O'* MF, and at *R"* in the *O"* MF. This DPDF goes against the very premises of the CR called RoS, which assumes the localized existence of the photon at an OPDF, because two simultaneous blasts in the rest frame can occur at different times only when the moving frame observer (MFO) forces the position of the photon in his frame at an overlapping point in the rest frame, and vice versa. This is also called overlapped positions syndrome (OPS) of CR. Thus, DPDF is related to RSC as inherently as OPDF is to RoS. From this point of view, the concepts of RoS and RSC are mutually exclusive, i.e. the acceptance of one rejects of the other, and vice versa, as shown below.

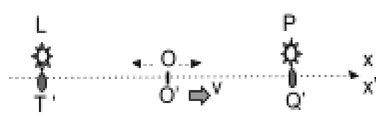


*Fig 2a. Two photons start off from O to the points P and L of the rest frame.*

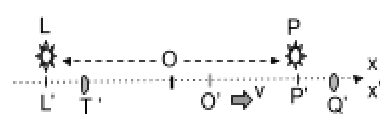


*Fig 2b. Photons reach at P and L at t, and trigger blasts in the rest frame.*

Two photons originate at the common origin at *t=t'=0* (fig 2a) and reach the points P and L at time *t* to trigger in the RF two simultaneous blasts as shown in fig 2b. By then the MF shifts to the right to align its new points *L'* and *P'* with the blast-sites of the RF. For MFO, the photon to be at *P* has to be at *P'* as well, and at *P'* it reaches earlier there for MFO by an amount $\sim vt/c$ than what RFO claims. Similarly, for MFO the other photon can not be at *L* to trigger the blast without being at *L'* of its frame and hence the blast at *L* is delayed for the MFO. So to claim non-simultaneity in the MF of the two simultaneous blasts of the RF or vice versa, one requires the positions of the photons in both the frames to overlap with each other. Thus, RoS is not possible without OPDF. Now consider another moving frame *O"*, moving to left with *v*. At the time of blasts, its point *P"* concurs with *P* of the RF, so photon has to be at point *P"* as well to trigger the blast at *P* and for the MFO of *O"*, it will take longer to be at *P"* than what the RFO claims, making for him the blast at *L* to go before the blast at *P*.

Thus, treating the particles localized to be at OPDF leads to RoS of CR. For CR in all three frames, the photon exists at overlapping points *P*, *P'* and *P"* of the three frames when it blasts at *P*. The photon can not approach *P* in the RF without approaching *P'* in the MF, and it can not be at *P* of the RF without being at *P'* for the *O'* frame. So, for *O'* frame, the time of the photon to reach *P'* becomes the time of the blast at *P*. Similarly for frame *O"*, the time of the photon to reach *P"* becomes the time of the blast at *P* in the RF. That's how they end up not agreeing with each other's claims about the timing and order of the two blasts due to OPS of CR.

The moment these observers give up OPDF and allow different positions of the photon in different frames, their disagreement on timing and order of the blasts melts away. Because then RFO may reply to the MFO of *O'*: yes photon did reach at point *P'* in the *O'* frame at an earlier time but it doesn't mean it was then also available at the overlapped position *P* in the RF to trigger the blast. MFO's estimation of the timings, order, or non-simultaneity of the blasts would have applied, had it set the triggers or blasts at its points *P'* and *L'* of its own frame. But this time, they are set at *P* and *L* in the RF and so the simultaneity prevails. Because, when the photon was at *P* in the RF it was at *Q'* in the MF, and similarly when the photon was at *L* in the RF it was at *T'* in the MF, accounting for the same time lapses for the two blasts in both frames since photons leave origin. One may ask what difference it makes if the detectors and blasts are at *P* of the RF or at *P'* of the MF, because at the time of the blast, the two points overlap. NR replies that despite being at the same location, it is the state of motion of the two detectors which is different, and that affects the position of detection of the photon in the two frames. When the photon is at *P'*, it is not there at *P* and vice versa. This explains how the RSC of NR deems the RoS unessential and how the RoS of CR deems the RSC unessential.

We derived eq (7), which is the statement of RSC, from the NT by interpreting its temporal transform as invalidity of RoS which is fair as they do not contain any synchronization term. Similarly, by interpreting the temporal transform (4) of LT, as the validity of RoS due to the explicit presence of synchronization term, which is interpreted as such by the CR, LT deduces the shift in the positions of the existence of the photon in the different frames to be, *PQ*=*PR*=0, which is a statement of OPDF or OPS of CR. However, if we do not interpret (4) of LT as a statement of RoS and do not interpret the synchronization term literally as CR does, i.e. if LT is interpreted in the light of new phenomena of NR, then eq (7) can be deduced from LT as well, and vice versa. Thus neutral math of LT devoid of CR's assumption does not contradict DPDF or RSC, but the CR does contradict new predictions as it assumes the moving particles like photons to be relativistically localized. Thus the main difference in the physics of NR and CR is whether the photon is treated relativistically non-localized as done by NR or localized as done by CR.

## 2. The proposition

It is proven beyond doubt that for CR to derive RoS, a photon must exist at overlapping positions *P'* and *P"* in the moving frames when it exists at *P* in the rest frame. But for NR, when the photon is detected at *P* in the rest frame, it is not available at *P'* or *P"* for detection in the respective frames, but at *Q'* and *R"* as shown in fig 1, and this DPDF leads to the RSC or vice versa. Secondly, for RNL, the motion-state of the detector affects the detected position of the photon and by setting different detectors in different states of motion, we can test what prevails, DPDF or OPDF? In the next section, two experimental setups are devised, one to test the OPDF, and the other one to test the DPDF or RSC.

As a precaution, it is recommended to maintain vacuum throughout the path of the photons from its emission to detection because it is not known how air as a medium affects the RNL-superstate of the photons. If RNL-state collapses before detection then RSC will disappear.

**3 Experiments to test RSC**

Two stations K1 and K2, separated apart and having no relative motion with each other, together form our rest frame as shown in fig 3. K1 has an extremely sharp pulsed laser at *O* to emit a pulse to be detected later at a time *t*, precisely at *P* on station K2. *OP=x=ct*. The plane of emission of the pulse is the yz plane through *O* and the plane of detection is a plane parallel to the *yz* plane passing through *P*, call it the plane of stationary detection (PSD). The detectors with an ultra-fast electronic shutter can operate for a very short duration to sense the presence of the pulse at a given position.

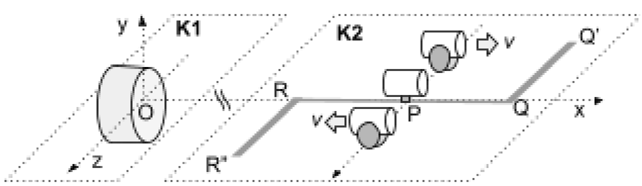


*Fig 3. Basic setup to test relativity of spatial concurrence.*

In addition to the fixed detector, let us have a set of two moving detectors (MD) on K2, which are otherwise identical to their stationary counterparts except being on wheels or levitated to move. The two MDs form the two MFs, moving in the opposite direction with speed *v* w.r.t the RF. Finally to achieve a spatially localized detection we rely on spatially limited electric paths shown as gray strips *QQ'* and *RR"* that momentarily turn on the MD's ultrafast shutter on their arrival on the strip so that to sense the presence of pulse at the position of the gray strip. Additionally, detectors are capable of recording the time of detection of the pulse, however spatially limited detection frees us of some stringent requirements to compare time.

**3.1 Experiment A:** Initially mount the MDs along with PSD in K2, moving away from PSD on either side, and the gray strips are moved about *vx/c* distance apart from PSD on either side as shown in the setup of fig 3. In the stationary frame, when the pulse reaches PSD at time *t* to be detected by a stationary detector (SD) at *P*, MDs moving at a velocity *v* will be at gray strips, laid at *vx/c* distance apart from PSD on either side, and will get triggered. All three detectors though apart from each other must detect the pulse at their respective locations to prove RSC, confirming the presence of pulse at DPDF, not concurrent with each other. The positive outcome of this experiment validates the RSC and DPDF of the NR and refutes the OPDF and RoS of the CR.

Alternatively, instead of using a detection-window using strips, we can measure the position of detection of the pulse by the two moving detectors in the opposite direction and compare the gap with *2vx/c*, ignoring second and higher-order effects. A non-zero gap between the positions of detection by the two oppositely moving detectors with velocity *v*, which compares with *2vx/c* will confirm the RSC and DPDF. Needless to say that we need a pulse-width << *2vx/c* and detection speed of detectors faster or at least comparable with the pulse-width for these experiments to rule out OOW of time and confirm OOW of space.

**3.2 Experiment B:** This time mount the moving detectors to be *vt* distance apart from PSD on either side, approaching PSD with a speed *v*. The gray strips in this setup are laid along with PSD so that when MDs arrive at PSD their sensing window is triggered on, as shown in fig 4.

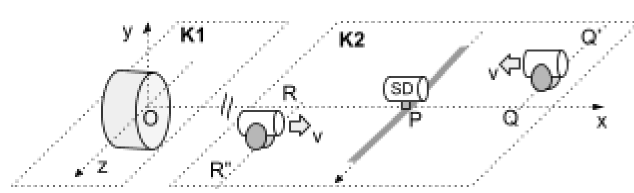


*Fig 4. Setup to test overlapped position syndrome.*

At the time $t$ when pulse will be at $P$ in the RF, the moving detectors will cross the gray strip laid along with the PSD, thereby triggering them to sense the pulse precisely at PSD. Effectively, all three detectors, one stationary and two moving are aligned along with PSD at time $t$ when the pulse reaches PSD in the stationary frame and the gray strip along PSD ensures that moving detectors are also triggered to sense the pulse there. Owing to RSC, while the photon is very much present in the RF at PSD to be detected, it must not be at PSD for the MDs. If MDs fail to detect any pulse at PSD while the stationary detector detects the pulse there unfailingly, then it invalidates OPDF and RoS. Positive detection at the PDS by all three detectors invalidates the RSC and DPDF, and validates the OPDF.

## 6. Conclusion

RSC or DPDF and RoS or OPDF are mutually exclusive concepts and it is shown they can be experimentally distinguished. DPDF is a neutral outcome of NR and also of LT, however OPDF and RoS are assumptions of CR taking the mathematical spacetime in the Minkowski domain literally. Validation of RSC and refutation of RoS opens the door to phenomena like RNL that is the nonlocaity across frames a bit different from usual quantum nonlocality within a frame not only brings relativity and qunatum closer but also provides the probability of superluminal communication. Various experiments including this one are proposed to validate the new phenomena [9-14] in this series of rudiments of relativity revisited.

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

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