

Relativistic Physics of Real Domain Transforms of Special Relativity

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Abstract

In our previous paper the real domain transforms are derived and their equivalence with Lorentz transform is established. The latter operates in the Minkowski domain by mapping the positions and computing the times accordingly, thus taking advantage of four-vector-based covariant formulations by mixing spacetime, but the same makes it difficult to interpret. The former operates in the real domain that maps the times and computes positions, providing an alternative view to facilitate a correct interpretation of Lorentz transform. Besides exhibiting relativistic time-dilation, lightspeed preservation, length-contraction, velocity-addition, clock-compatible interval and phase relationship, and the Doppler principle, the new transforms also predict new phenomena like relativity of spatial concurrence and relativistic non-localization that remained hidden so far and challenge the interpretation of Lorentz transform based on the relativity of simultaneity.

1. Introduction

Lorentz transforms (LT), whose precursor-version was first used by Voigt [1], current version was proposed by Lorentz [2], then corrected and explored as a group by Poincare [3], re-derived again by Einstein as transforms of special relativity [4,5], embarked the four-vector-based covariant formulation in physics. The fact behind this success of LT is that they operate in the Minkowski or split domain [6] $(X'Y',Z',T')$ by mapping the position in one frame to an overlapped position in the other and computing the time in accordance with the second postulate, which results in mixing of spacetime, but the same makes them difficult to interpret. Equally valid approach that can facilitate the interpretation of LT is to map the times and compute the positions giving rise to real domain transforms (RDT) that operate in the real domain. RDT in eq (1-2) are derived in [7] and their equivalence with LT in eq (3-4) is also established.

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

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

$$X' = \gamma(x - vt), Y' = y, Z' = z \quad (3)$$

$$T' = \gamma(t - vx/c^2) \quad (4)$$

where,

$$e = \sqrt{1 - v^2/c^2}, m = \frac{1}{1 - (v/c^2)(x/t)}, m_{\perp} = em, \gamma = 1/e, \quad (5)$$

v is the relative velocity between two frames, and c the lightspeed. The real and split domain are related by the following scaling.

$$x' = e^2 m X', t' = e^2 m T', y' = e^2 m Y', z' = e^2 m Z' \quad (6)$$

The real domain, like Minkowski one, exhibits relativistic time dilation, lightspeed preservation, length contraction, velocity addition, clock-compatible interval and phase relationship and the Doppler principle. They however are free from synchronization term and bring to light many new phenomena that were so far hidden under the mathematical elegance of LT, such as particles presence at different position in different frames (DPDF) at an instant, relativity of spatial concurrence (RSC), and relativistic non localization (RNL), which can be shown to be implicitly present in LT also if current interpretation of LT is ignored. RDT advocates the re-interpretation of LT based on DPDF which is implicitly contained in them opposed to their currently imposed interpretation based on overlapped positions in different frames (OPDF). Thus, the current special relativity (CR)

alongwith its interpretation of LT and the neutral math of LT need to be differentiated because CR oblivious of DPDF interprets LT based on relativity of simultaneity (RoS). In this paper, the terms CR refers to the current interpretation of LT based on RoS and OPDF, while term LT refers to the LT's neutral math in the Minkowski or split-domain devoid of their interpretation by CR.

2. Minkowski and real domain transform

Consider a lightsource stationed at the origin of the moving frame, which flashed at $t=t'=0$ when origins of both the frames coincided. Two axially travelling photons are found at x and $-x$ in the rest frame at clock time t . Now there are two valid ways to transform these events to the moving frame, one of the LT and the other of the RDT: LT maps the positions x and $-x$ to overlapping positions $\gamma(x-vt)$ and $-\gamma(x+vt)$ in the moving frame and computes the times $\gamma(t-vx/c^2)$ and $\gamma(t+vx/c^2)$ to occupy these positions by the photons in accordance with the second postulate. These mapped positions are actually overlapped positions with x and $-x$ at clock-time t , which becomes obvious by assuming v to be low enough so that $\gamma \sim 1$, see section 2.5 below. Also, the position overlapping with x was occupied by the photon in the past, and the other one overlapping with $-x$ will be occupied by the other photon in future of the instant given by clock-time $t'=et=t/\gamma$ in the moving frame. Thus, LT is explicitly mum on the current positions of the photons at clock time t' , but from its computed split-times it is implied that the photons are not at overlapped positions mapped by LT because it itself assigns times of their occupation T' different from clock-time t' . Thus, DPDF is implicitly contained in LT. Next, take the equally valid RDT approach: RDT maps the clock-time t of the rest frame to clock-time $t'=et$ in the moving frame and the current positions x' of the two photons are computed in accordance with the second postulate to be at ex and $-ex$ respectively. Thus, real domain explicitly contains DPDF. Once DPDF is accepted, RoS of the kind defined and illustrated in [4,5] also disappears [9,10]. Thus one of the impacts of RDT

is the appeal to reconsider the current RoS based interpretation of LT. Next, if the lightsource is located in the rest frame instead of moving frame then a different relationship of clock times applies because then it is the moving frame that sees the rest frame, therefore a different set of RDT applies analogous to backward LT listed in [6].

Exploration of RDT below is grouped into three categories. First is the category of relativistic phenomena that are obvious from the Minkowski domain and are quite established in special relativity. In the second category are those relativistic phenomena that have not been explored so far, but are pronounced in real domain or are brought to light by RDT. They are not contradicted by LT, but are implicit or hidden there under its mathematical elegance, but the CR guided by its notions like RoS discards them. Third category are the notions of CR, like RoS and OPDF, popularized as the basis of current interpretation of LT. RDT by confronting them does generate an appeal to reconsider these notions of CR and its interpretation of LT based on them, at least the readiness to test them is expected [9-11].

2. Established relativistic phenomena

Relativistic phenomena that are obvious from both Minkowski and real domain and are quite established in current special relativity, are derived here using RDT.

2.1 Time Dilation: A moving clock slows down can be deduced from LT by putting $x=vt$ in (4), and is also explicitly evident eq (2) of the RDT.

2.2 Constancy of the lightspeed: LT and NT both preserve the constancy of lightspeed and the principle of relativity. However, the NT besides preserving the lightspeed also accepts RNL. A growing lightsphere in the moving frame,

$$x'^2 + y'^2 + z'^2 = c^2 t'^2 \quad (6)$$

readily transforms to

$$x^2 + y^2 + z^2 = c^2 t^2, \quad (7)$$

LT can also yield (7) from (6). However, the RDT preserves both the spatial and spacetime sphericity of the lightsphere, while LT renders a sphere not space but in spacetime. Thus, the Minkowski or split domain spatial shape of the lightsphere is not preserved.

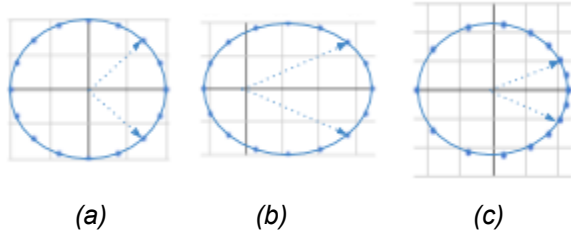


Fig. 1. (a) A lightsphere in the moving frame (b) The same transformed to the rest frame using LT (c) Using RDT.

2.3 Lorentz Fitzgerald length contraction: Under RDT, a rigid sphere of radius R in the moving frame, $x'^2 + y'^2 + z'^2 = R^2$, transforms in the rest frame to,

$e^2(x - vt)^2/m^2R^2 + e^2y^2/m_{\perp}^2R^2 + e^2z^2/m_{\perp}^2R^2 = 1$. Both e and m scale the moving rigid sphere, but e affects it isotropically and m anisotropically. Using $x/t=v$ in the expressions of m ,

$$(x-vt)^2 / R^2(1-v^2/c^2) + y^2 / R^2 + z^2 / R^2 = 1, \quad (8)$$

2.4 Relativistic velocity addition: Consider a particle going with a velocity $x/t=u$ in the rest frame, The rest frame observer wishes to calculate its velocity w.r.to the moving frame. Put it in the first eq. of (9) and divide the same by (10) to get,

$$v' = (u-v)/(1-uv/c^2) \quad (9)$$

2.5 Equation of agreed overlap: For cases when $x/t=v$ i.e. when the moving physical entity under observation is moving with the moving frame (at rest in the moving frame) or vice versa, then both the RDT and LT reduce to the same common form:

$$X' = (x - vt)/e, y' = y, z' = z, t' = et \quad (10)$$

2.6 Interval, phase and Doppler principle: As shown in [8] the interval invariance of LT

contradicts its own clock time, however the interval relationship in real domain agrees with clock time. Same is true for phase φ relationships in the real domain. Aberration angle θ and doppler frequency ν are also reproduced, as shown below:

$$\cos\theta' = (\cos\theta - v/c) / (1 - v\cos\theta/c) \quad (11)$$

$$\varphi' = e^2 m \varphi \quad (12)$$

$$\nu' = \nu(c - v\cos\theta)/ec \quad (13)$$

$$x'^2 + y'^2 + z'^2 - c^2t'^2 = e^2(x^2 + y^2 + z^2 - c^2t^2) \quad (14)$$

3. Phenomena pronounced by RDT

These new phenomena, not explored so far, are brought to light by RDT, but are not contradicted by neutral math of LT. CR may discard them due to its belief in DPDF and RoS, but as shown in fourth axiom, these tenets of new relativity save the LT's transformed time from being illusory.

3.1 Relativity of spatial concurrence

We define motion as change in position of a body with time. But the process of measuring position involves recognising spatial concurrence. Consider a particle, say photon, moving on a very long ruled scale. To read its position at any time we look for its 'spatial concurrence' or its overlap or alignment with the ruling marks on the scale at that particular time. *Now, this spatial concurrence is relative is the revolutionary statement being made over here [6].*

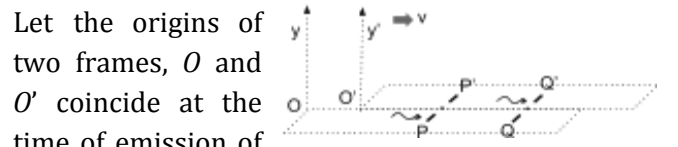


Fig 2. Relativity of spatial concurrence: When photon is detected at P in the rest frame, it is not detected at an aligned point P' in the moving frame but at Q' that aligns with Q.

Let the origins of two frames, O and O' coincide at the time of emission of a sharp burst of photons at $t=t'=0$, fig 2. Consider one of many simultaneously emitted photons, traveling a length x in the rest frame from origin O to a point say P on x axis in time t . Based on the presence of the photon at P in the rest frame CR assumes the presence of the photon in the moving frame at a point P' that overlaps with the point P in accordance with (10), also called OPDF. But, for a true believer in relativity of space, there is no

reason to assume so. If the photon is at P in the rest frame at any instant, it does not mean it is also available at the coincident point P' for detection in the moving frame at that instant. A detector in the moving frame is in relative motion with the detector of the rest frame and hence finds or meets the same photon at a different position Q' , a point in alignment with point Q of the rest frame owing to RSC. From (1) $O'Q' = x' = vx/c$, thus RSC shift is

$$P'Q' = vx/c \quad (15)$$

3.2 Different positions in different frames

The availability of the photon (or any particle) for detection at different positions in different frames (DPDF), incompatible with the frame's mutually agreed overlap at that instant, is a strange aspect of relativity revealed by RDT. Consider (10), the eq of agreed overlap of two frames, to understand overlapped or different positions. At an instant t , the point x of the rest frame is seen overlapped to $(x-vt)/e$ or vice versa. Now consider the two photons, introduced in section 2 above, which originated in the MF at $t=t'=0$ and found at x and $-x$ in the rest frame. Using RDT and LT to transform this scenario of rest frame at time t to the moving frame,

$$t' = et, x' = ex \quad (16)$$

$$T' = (c-v)t/ec, X' = (x-vt)/e \quad (17)$$

$$t' = et, x' = -ex \quad (18)$$

$$T' = (c+v)t/ec, X' = -(x+vt)/e \quad (19)$$

Positions x and $-x$ have been exactly mapped by the LT in (17) and (19) to the agreed overlap of (10), while RDT, in (16) and (18) that map the clock times, calculates the positions different from the agreed overlap. For the photon moving to the right RSC shift of (15) is reproduced below in (20) by finding the difference between RDT and LT positions of this photon in (16) and (17). This explains the terms overlapped and different positions. At an instant the photon exists at DPDF.

$$x' - X' = vx/c \quad (20)$$

3.3 Relativistic non localization

How can the photon exist at two different locations once? That brings us to the principle of RNL. Consider RSC again from the perspective of the rest frame observer (RFO), who detects the only emitted photon at P of rest frame at an instant t after its emission by a distant stationary source that keeps on emitting a single photon periodically.

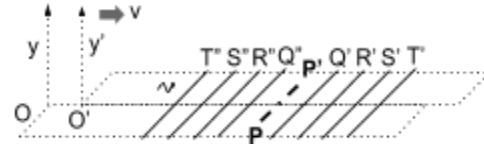


Fig 3. The positions of detection vary from T' to T'' about P with various positive and negative v of the detector.

Using progressively incremented values of velocity of the detector, RFO detects the photon at the same instant 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 particle at Q'', R'', S'', T'' and so on, all progressively shifted to the left of P . The points from T'' to Q' denote the DPDFs of the particle at a given instant as shown in fig 3. From the particle's perspective, all these DPDF namely $Q', Q'', R', R'', S', S'', T', T''$ relativistically concur owing to OSW and the particle has no difficulty to occupy each at an instant or to instantly communicate across them. But for RFO 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 behaviour of a localized particle in many ways: First, the outcome that is the particle's position at the instant of detection is influenced 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. It implies the particle is capable of communicating instantly across all the possible cross frame detection positions. Unable to

escape relativistic non localization, RFO is ready to lay down the various tenets of the in-frame and cross-frame detection process of the particle.

1. The moving particle before being detected exists in some strange non-localized non-classical super state encompassing all possible cross frame detection-locations, superposing all possible detection-states in all possible frames.
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 and makes itself available as a whole at the detected location.
3. The outcome i.e. position of detection for a given time of detection, for a given position of the detector, is influenced by the state of motion of the observer. For a stationary detector, the position of detection is P , but for moving detectors the positions of detection shift in accordance with their velocity. *Thus, the state of motion of the observer 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 RSC not been ignored or hidden under the mathematical elegance or symmetry of LT, the genius of Einstein would have not missed the quantum physical attributes of relativity and would have not averse to quantum mechanics in its very infancy. From the discussion of previous section we can write an expression in first order for 'relativistic spread' in detected position of a photon using equation (15) ,

$$\Delta x_{rel} = \Delta vx / c \quad (21)$$

where, $\pm \Delta v/2$ is the spread in relative velocity of the detector at a distance x from the source of the photon. It is assumed here that inherent quantum mechanical uncertainty or spread of the particle is negligible in comparison to one due to RNL.

Importance of this formulation can be from the fact that emission and detection of microscopic particles involves microscopic phenomenon and it's not always possible to control the relative motions involved while detecting them.

3.4 Anisotropic spatial warping

Another way this DPDF or RSC can be seen is anisotropic warping of the cross frame space, which is recognised as anisotropic temporal warping (ATR) by CR. To understand ATR, consider the two photons of section 2 and 3.2, which traversed equal distance x on either side, but the moving frame observer assigned different times to their journey in the rest frame and vice versa in the name of well synched-clocks of the rest frame are not seen synchronized in the other frame. RDT also assigns different times for these journeys, but does not blame the non-synchronization for it. It is the anisotropic spatial warping (ASW) seen by the cross frame observer. Consider a unit-length of space traversed from one end to the other and back by light. Equal times are assigned for each one-way-trip under the stipulation of isotropicity of the euclidean space in that frame [5]. But for the cross frame observer moving w.r.t the unit-length, these two times can not be equal. How then can the two frames reconcile? CR uses the argument that the clocks at two ends of the unit-length though synched in one frame are not synched for the other. However RDT are free from sync-term and the cross frame observer explains it as ASW i.e. a moving space interval is anisotropically warped. Argument of non synched clocks of CR fails in the case of sagnac effect because here the clocks of source and detector merge into one which can not be in non-sync with itself, but ASW explains it well. This debate culminates into what we call the fourth axiom: *It is impossible to assign time T' of LT to any real physical clock without accepting the tenets of new relativity like ASW, RSC and RNL.*

4. Notions of CR that need reconsideration

LT operating in the Minkowski domain is interpreted by CR on the basis of RoS, which

however as shown is not possible without assuming OPDF to be true. In the wake of discovery of DPDF supported by both real and Minkowski domain, there is a need to reconsider such notions of CR and to put them to test.

4.1 OPDF and RoS

This issue has been taken in detail in [9-12] where the experiments to test OPDF, DPDF, RoS and RSC are also proposed. Consider the two photons of sections 2 and 3.2, and assume they trigger simultaneous blasts at x or $-x$ of the rest frame. Now if the moving frame assumes OPDF and insists that for the photons to be at x and $-x$, they have to be at overlapped positions in the moving frame given by eqs (17,19) and so they are non-simultaneous. However, the DPDF, established in section 3.2 along with RNL of section 3.3 that the state of motion of the detector (in this case the blasts) affects the position of the photons, removes this contradiction on simultaneity. When photons are at $-x$ and x in the rest frame they are at $x'=ex$ and $-ex$ in the moving frame given by eqs (16,18) which has been proven even by LT in section 2. Had the blasts been planted at x' and $-x'$ in the moving frame, the rest frame observer would have resolved in the same way. However, if the blasts are planted at positions given in eqs (17,19) only then they will be non-simultaneous for both the frames. Thus, if OPDF is discarded and the RNL is adopted then RoS also disappears.

4.2 Spacetime mixing and interval invariance

Next come to the effects that are exhibited by LT in the Minkowski domain and which might just be of mathematical nature, but CR interprets them physically and assumes them to hold universally true including in the real domain. For example, spacetime mixing of the Minkowski domain disappears in the real domain, but CR takes it as a universal principle. However, it is possible that this effect is just limited to the Minkowski domain to mathematically support the four vector based covariant formulation. Even RoS is projected by CR as a consequence of spacetime mixing, which

shows that the CR interprets this spacetime mixing also under its assumption of OPDF. Thus, experimental refutation of RoS or OPDF will affect the status spacetime mixing as well.

A word of caution is also needed about the interval and phase invariance [7,8]. Invariance does not mean the preservation of their values across the frames, but the invariance of their form [8]. Thus values of interval and phase are scaled by LT but the scaling factors of the Minkowski domain do not comply with the clock times. But, this issue is resolved in the real domain [8].

5. Conclusion

Both the RDT and LT reproduce the so far proven results of relativity. However, they follow a very different criteria of mapping and operate in different domains. Phenomena like DPDF, RSC, RNL and ASW, unexplored so far, are brought to light by RDT. RoS, which is shown to disappear under DPDF, is shown as a consequence of CR's assumption of OPDF. However, relativistic physics of OPDF or RoS is experimentally distinguishable from that of DPDF or RSC [9-14]. RNL throws light on the mechanism of preservation of lightspeed thereby opening avenues to manipulate the same [12-14]. Thus, NR and NT are worth exploring further.

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