Relativistic Physics of Real Domain Transform for Special Relativity

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

Abstract

In our previous paper, the real domain transform is derived and its 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 transform (LT), whose precursor-version was first used by Voigt [1], the 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. An equally valid approach that can facilitate the interpretation of LT is to map the times and compute the positions giving rise to real domain transform (RDT) that operates in the real domain. RDT of eq (1-2) is derived in [7] where its equivalence with LT of eq (3-4) is also established.

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

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

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

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

where,

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

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

$$x' = e^2 mX',\; t' = e^2 mT',\; y' = e^2 mY',\; z' = e^2 mZ' \qquad (6)$$

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 particle's presence at different positions in different frames (DPDF) at any instant, the relativity of spatial concurrence (RSC), and relativistic non-localization (RNL), which can be shown to be implicitly present in LT also if the current interpretation of LT is ignored. RDT advocates the re-interpretation of LT based on DPDF which is implicitly contained in them as opposed to their currently imposed interpretation based on overlapped positions in different frames (OPDF). Thus, the current special relativity (CR) along with its interpretation of LT and the neutral math of LT needs to be differentiated because CR oblivious of DPDF interprets LT based on the relativity of simultaneity (RoS). In this paper, the term CR refers to the current interpretation of LT based on RoS and OPDF, while the 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 transforms

Consider a light source stationed at the origin of the moving frame, which flashed at $t=t'=0$ when the origins of both the frames coincided. Two axially traveling 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 $\gamma\sim1$. Also 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 the 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, the 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 light source is located in the rest frame instead of the 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 [7].

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 the 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. The third category is the notions of CR, like RoS and OPDF, popularized as the basis of the 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 [9-14].

2. Established relativistic phenomena

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

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

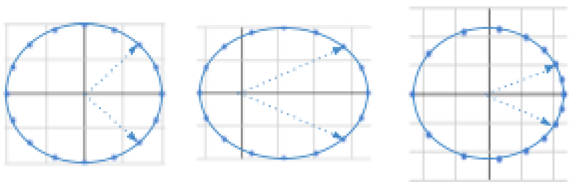
2.2 Constancy of the lightspeed: LT and NT both preserve the constancy of lightspeed and the principle of relativity. However, the NT besides preserving the lightspeed also accepts RNL. A growing light-sphere in the moving frame,

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

readily transforms to

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

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



(a) *(b)* *(c)*

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,

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

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,

$$v' = (u\text{-}v)/(1\text{-}uv/c^2) \qquad (9)$$

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:

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

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:

$$\cos\Theta' = (\cos\Theta - v/c) \;/\; (1 - v\cos\Theta/c) \qquad (11)$$
$$\varphi' = e^2 m\varphi \qquad (12)$$
$$\nu' = \nu(c - v\cos\Theta)/ec \qquad (13)$$
$$x'^2 + y'^2 + z'^2 - c^2t'^2 = e^2(x^2 + y^2 + z^2 - c^2t^2) \qquad (14)$$

3. New phenomena predicted by RDT

These new phenomena, not explored so far, are brought to light by RDT but are not contradicted by the neutral math of LT. CR may discard them due to its belief in OPDF and RoS, but as shown in the 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 the change in position of a body with time. But the process of measuring position involves recognizing 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* [7].

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 the x-$axis$ in time t. Based on the presence of the photon at P in the rest frame CR assumes the

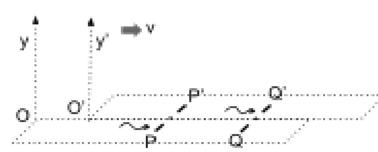


Fig 2. When photon is detected at P in the rest frame, it is not detected at an aligned point P' in the moving frame but at Q' that aligns with Q.

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 the 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' = ex,* thus RSC shift is

$$P'Q' = evx/c \tag{15}$$

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,

$$t' = et,\ x' = ex \tag{16}$$

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

$$t' = et,\ x' = -ex \tag{18}$$

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

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, the 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. Thus the MF position of photon maps to,

$$OQ = x + vx/c\,. \tag{20}$$

3.3 Relativistic non localization

How can the photon exist at two different locations once? That brings us to the principle of RNL, which is the nonlocality across the frames, a bit different from usual quantum nonlocality within a frame. Consider RSC again from the perspective of the rest frame observer (RFO), who detects the only emitted photon at *P* of rest-frame at a instant *t* after its

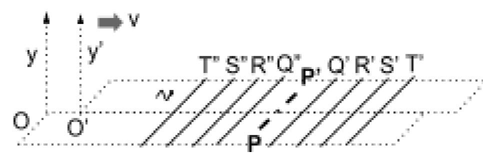


Fig 3. The positions of detection vary from T' to T" about P with various positive and negative v of the detector.

emission by a distant stationary source that keeps on emitting a single photon periodically. Using progressively incremented values of the velocity of the detector, RFO detects the photon at the same instant *t* after emission of the photon 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 behavior 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 or 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 been averse to quantum physics 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 equation (15),

$$\Delta x_{rel} = \Delta v x / c \qquad (21)$$

where $\pm \Delta v/2$ is the spread in the 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. The importance of this formulation can be from the fact that emission and detection of microscopic particles involve microscopic phenomena 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 recognized as anisotropic temporal warping by CR in the name of synchronization term, which in case of photon demands odd order warping of time, despite the fact that all experiments so far confirm second or even-order time-dilation of a moving clock in *v/c*, not linear [15,16]. To understand this, 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 arguing that the well synched-clocks of the rest frame are not seen synchronized in the moving frame such that the ray going in *+x* direction gains the time and the other one loses it. But the observers in their respective frames observe independently, requiring no reference to other frame clocks, and thus the only way for the clocks to differ in linear-order is to run at rates depending on linear order in *v/c*. Thus, RDT neither blames non-synchronization nor anisotropic temporal warping for it, but it is the anisotropic spatial warping (ASW) of a moving interval that brings reconciliation here. Next, consider a unit-length of space traversed by a ray both to and fro. Equal times are assigned for each one-way-trip under the stipulation of homogeneous, isotropic euclidean space in the frame of that unit-length interval [5]. But for the cross frame observer moving w.r.t the unit-length, these two times are unequal. How then can the two frames reconcile? CR uses the argument that the clocks at two ends of the unit-length though synced in one frame are not synced for the other frame. However, RDT explains it as ASW i.e. a moving space-interval is anisotropically warped.

Further, the CR's argument of non-synced clocks fails in the case of Sagnac effect because here the clocks of source and detector merge into one which can not be non-synced with itself. Both the rays in Sagnac effect leave and meet at the same clock, so no scope for the time differing on the basis of non-synched clocks unless the rotating loop is anisotropically warped. Thus, ASW, RSC or RNL of RDT 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 the discovery of DPDF supported by both the 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 eq (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 eq (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 eq (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, the experimental refutation of RoS or OPDF will affect the status of spacetime mixing as well.

A word of caution is also needed about the interval and phase invariance [8]. Invariance does not mean the preservation of their values across the frames, but the invariance of their form. 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 very different criteria for mapping and operate in different domains. Phenomena like DPDF, RSC, RNL, and ASW, unexplored so far, are brought to light by the new transform. RoS, which is shown to disappear under relativistic non localization, is shown as a consequence of CR's assumption of localized photons. However, the relativistic physics of OPDF or RoS is experimentally distinguishable from that of DPDF or RSC [9-12]. RNL superstate can be the mechanism of preservation of lightspeed thereby opening avenues to manipulate the same [13,14]. Thus, new relativity and transforms are worth exploring further [17].

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

References

1. "On the Principle of Doppler" by Voigt Woldemar 1987. Original: "Ueber das Doppler'sche Princip Nachr.", Ges. Wiss. G¨ottingen 841–51. English translation.
2. "Electromagnetic phenomena in a system moving with any velocity smaller than that of light", Lorentz Hendrik, Proceedings of the Royal Netherlands Academy of Arts and Sciences, 1904, 6: 809–831.
3. "On the dynamics of the electron", Poincaré Henri, (1905), Original: "Sur la dynamique de l'électron", Poincaré Henri, Rendiconti del Circolo matematico di Palermo 21 129–176.
4. The English translation by Meghnad Shah of original paper by Einstein, Albert (1905), "Zur Elektrodynamik bewegter Körper", Annalen der Physik 322 (10): 891–921.
5. "Relativity, the special and general theory; the popular exposition" by Albert Einstein authorized translation by Robert W Lawson.
6. "Space and time", Minkowski Hermann, Lecture 1908 original: Raum und Zeit, Jahresberichte der Deutschen Mathematiker-Vereinigung, 1-14, B.G. Teubner, a lecture delivered before the Naturforscher Versammlung 1908.
7. "Real domain transforms for special relativity", Solanki G.S., communicated.
8. "On the physics of interval and phase invariance of Lorentz Transform", Solanki G.S., communicated.
9. "Relativity of simultaneity analyzed and put to direct testing", Solanki G.S., communicated.
10. "Relativity of spatial concurrence analyzed and put to test ", Solanki G.S., communicated.
11. "Einstein's famous thought experiment for simultaneity put to test", Solanki G.S. communicated.
12. "Experiment based on the spatial shape of a transformed light-sphere", Solanki G.S., communicated.
13. "Exploring ultra lightspeed communication using relativistic non-localization", Solanki G.S., to be communicated.
14. "Relativistic non-localization based interferometer and lightspeedometer", Solanki G.S., to be communicated.
15. "Around-the-world atomic clocks: Predicted relativistic time gains", J. C. Hafele and Richard E. Keating (Jul. 14, 1972), Science, New Series, Vol. 177, No. 4044, 166-168.
16. "Test of Time Dilation Using Stored Li+ Ions as Clocks at Relativistic Speed", Benjamin Botermann et al, Phys. Rev. Lett. 113, 12040 (2014).
17. "Relativistic non-localization: an ignored reality", Solanki G.S., communicated.