Alternative Transforms for Special Relativity

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Abstract

Alternative transforms of special relativity, which besides the two famous postulates of relativity also comply with the relativistic non localization and relate the unique times of two frames, are derived. The Current framework of relativity transforms a single instant of a frame to as many times in the other frame as there are points on the x coordinate, accepting it as an inherent law of nature, named relativity of simultaneity. The new formulation transforms the unique time of one frame to a single instant of the other, reproduces the so far proven results of relativity, embraces odd-order warping of space instead of time, predicts new relativistic phenomena, and is also experimentally distinguishable. The foundation of the new theory is laid down in the previous two papers in this series.

1. Introduction

In the current framework of special relativity, a single instant or time of a frame splits into as many instants or times in the other frame as there are points on the x-coordinate, due to the presence of synchronization term in Lorentz transform (LT) [1,2]. For example, the instant of formation of a particular pattern, a dash or a wave, in the rest frame by an infinite array of atoms spread along x while doing a zig zag in transverse dimensions, splits into infinite instants of the time in the moving frame (MF), one for each atom, which is accepted as a principle of nature - relativity of simultaneity (RoS). Is it possible to develop an alternative framework of relativity that maps a unique time of one frame to a unique time of the other? A big 'NO' for many of us because that will mean no synchronisation term and violation of the principle of RoS. Well if presence of a synchronisation term is all to RoS then this paper does derive a transforms free from synchronisation term, that too from the same two postulates from which LT are derived. But wait, does relating the unique instants of two frames really violate non-simultaneity? At the instant when these atoms formed the input pattern of simultaneous locations in the RF, they were also located somewhere in the MF at that instant forming some pattern of their simultaneous locations in the MF, and the new transforms (NT) map the input pattern from RF to that pattern of simultaneous events in the MF. Atoms by their very existence in the two frames are ever creating a series of independent events in the two frames, classified into two groups namely the 'events of RF' and the 'events of MF', which contain all the events of past, present and future of atoms. The new relativity (NR) treats these two groups of infinite sets of events independent of each other because the two observers observe them independently, having little in common except the number of the particles observed. Out of these infinite groups of events, the current framework mathematically maps a set of simultaneous events of one frame to a set of non-simultaneous events of the other based on the principle of RoS. The new framework however maps a set of simultaneous events in one frame to a set of simultaneous events in the other based on the principle of relativity of spatial concurrence (RSC). The claims of the two theories about the non-simultaneity and simultaneity of the mapped events do not contradict as they pertain to different sets of events in the MF. However they are not mere mathematical alternatives to each other as their physics of mapping an event from one to other frame differs drastically and emerges from their basic belief about the position of a particle like photon in the two frames: Current relativity (CR) assumes it exists at an overlapped position in different frames (OPDF) whereas the new relativity (NR) believes it exist at different position in different frames (DPDF) due to relativistic non localization (RNL) [3,4]. Moreover, despite the fact that both CR and NR can reproduce the so far proven results of relativity[4,5], the physics of the OPDF or RoS and the DPDF or RSC are experimentally distinguishable on the lines of newly suggested experiments [6-12].

2. More Motivation

The splitting of an instant of the RF into as many instants of the MF as there are points on the axial axis is not the only issue. This split time of the CR is shown to be self-contradictory in section 3 of [1], the solution being put as Kishori's second axiom (KSA) or the postulate of RNL:

To save the transformed time of LT from being self contradictory, the odd order terms in relative velocity v/c can not appear in the temporal transforms but in the spatial transforms. Also it *can not depend upon the location (x,y,z) besides the odd orders of v/c, where c is the lightspeed.*

CR violates KSA by choosing odd order warping (OOW) of time, causing the synchronisation term [1,2], while NR chooses the OOW of space over time, causing anisotropic spatial warping (ASW) in the cross frame [3]. CR, being unaware of ASW and relativistic non localization, assumes a particle exists at OPDF giving rise to RoS, while NR asserts relativistic non localization (RNL), DPDF or RSC [4]. LT maps the events of one frame to the other based on OPDF, deducing RoS, while the NT maps them based on DPDF and RSC, deducing no-RoS. Thus, there is no sign of OPDF and RoS in the NR, and no sign of DPDF and RSC in the CR, and this fact becomes the basis of experimental distinguishability between the two theories [7-12].

New transforms are also derived from the same two postulates of relativity that result in LT. However, the NR also complies with the axioms of Kishori, which are developed in our previous papers [3, 4], wherein a mathematical form of new transforms is also proposed in compliance with the new axioms. This mathematical form becomes our starting point in this paper for deriving the NT.

3. Derivation of the new transforms

Consider a primed frame moving at a velocity v w.r.t the unprimed frame in +x, with their origins coinciding at $t=t'=0$. Let us first define momentum potential as v *or* v/c and motion energy potential as v^2 *or* v^2/c^2 , where c is the velocity of light. The observer in one inertial frame sees every point of the other at a relative, non zero (1) momentum potential, and (2) motion energy potential. Thus, the relativity of motion between two frames has two aspects: relativity of momentum potential and relativity of energy potential. Both of these aspects contribute to the relativity of spacetime. Further, let the influence of relativity of momentum be represented by a factor '*m*' and that of relativity of energy by a factor '*e*' in the coordinate transforms. Factor *e* can be the function of even-order terms in *v/c* alone, to avoid any directionality or anisotropy in the relativity of energy while *m* factors may contain linear or odd order dependence in *v* or axial coordinate in addition to others. Further, one observer sees the other's frame at exactly the same energy potential at what the other-one sees his own but mutual momentum potential is differentiated at least by direction. With this background, let us begin with the mathematical form of NT proposed in [3], which comply with the axioms of Kishori,

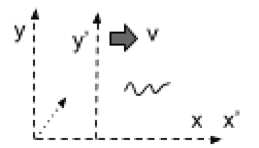


Fig 1. The primed frame moving with velocity v w.r.t. unprimed frame in +x.

$$x' = e\,m(x - vt)\,,\; y' = e\,m_\perp\, y\,,\; z' = e\,m_\perp z \qquad (1)$$

$$t' = e_t(v^2/c^2)\; t \qquad (4)$$

where (x',y',z',t') are the primed frame coordinates of a particle which originated at the moving frame's origin at $t'=t=0$ and (x,y,z,t) are the same for the rest frame observer. Arguments of e_t are just to show that e_t is a function of v^2/c^2 , Likewise e is also a function of v^2/c^2 and so e can also be written as $e(v^2/c^2)$ but arguments in (1) are omitted for brevity. Some salient features of NT are as follows. (a) Mathematical separability of warping factors e and m due to even and odd order terms respectively, (b) Absence of any m-type factor in temporal transform saves a moving clock or time from being illusory or self contradictory, (c) A different m factor for transverse coordinates from that of axial one due to expected directional dependence or anisotropy of m type warping (d) Symmetry of spatial transforms in e, because no directionality or spatial anisotropy is expected due to even order factor e. We have taken a different e in temporal transform from that of spatial ones to start with.

3.1 Longitudinal scaling factor *m*

Consider a rod of length L when stationary, which is set in the moving frame along x' with its one end lying at O' and the other at A'. Moving frame observer sends a light signal from O' to A' at $t=t'=0$, and confirms its length to be $x'=L=ct'=e_t(ct)$, claiming that the light hit the other end A' at t'. However, for the stationary observer, light moves with c-v velocity w.r.t the moving frame and thus his estimate for the length of moving rod, $(c-v)t'$, falls short by a value $vt' = e_t(vx/c)$ from actual length of the rod. To recover the proper length of the rod, $L=ct'$ for the moving frame observer, the rest frame observer has to magnify his own estimates by a factor $L/(L-e_t vx/c)$ This gives him the required m factor, as

$$m = \frac{1}{1-(v/c^2)(x/t)}$$

Thus, x coordinate transform becomes,

$$x' = e.\frac{1}{1-(v/c^2)(x/t)}(x-vt) \tag{5}$$

3.2 The temporal scaling factor e_t

For a photon, put $x/t=c$ or $x=ct$ in the RHS of (5) and divide it by (4) to yield $x'/t' = (e/e_t)c$. To conserve the speed of light in the two frames, both even order scaling factors have to be equal, $e_t(v^2/c^2) = e(v^2/c^2)$, and hence the temporal transform becomes

$$t' = e\,t \tag{6}$$

where arguments of e are omitted for brevity.

3.3 Transverse dimension scaling factor

Consider an oblique ray of light in the $x'y'$ plane originating at the origin of the moving frame at $t=t'=0$, and reaching to point (x', y') at t'. For such a ray,

$$x'^2 + y'^2 = c^2t'^2 \tag{7}$$

Putting x', y' and t' from eq (2), (5) and (6) in eq (7) and after following elementary algebra, we have

$$x^2 + m_\perp{}^2\,\frac{[1-(v/c^2)(x/t)]^2}{(1-v^2/c^2)}\,y^2 = c^2t^2 ,$$

where coefficient of y^2 has to be 1 to preserve lightspeed and hence,

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

Thus, transformations for the transverse coordinates are:

$$y' = e\,\frac{\sqrt{1-v^2/c^2}}{1-(v/c^2)(x/t)}\,y\,,\quad z' = e\,\frac{\sqrt{1-v^2/c^2}}{1-(v/c^2)(x/t)}\,z \tag{8}$$

3.4 Even order scaling factor *e*

Consider a light ray going on y'-axis in the moving frame from O' to hit a mirror M'. For both mirror and ray, $x/t=v$. In the rest frame, ray-path OM' is oblique, whose projection on y is OM such that $y=OM=O'M'=y'$. Substituting this along with $x/t=v$ in the first equation of (8), we get,

$$e = \sqrt{(1-v^2/c^2)} \tag{9}$$

4. New transforms summarised

Equation (5) through (9) summarize the primed frame transform (PFT) NR reproduced here.

$$x' = em(x-vt)\ ,\ y' = em_\perp y\,,\ z' = e\,m_\perp z\,, \tag{10}$$

$$t' = e\,t\ , \tag{11}$$

where,

$$e = \sqrt{1 - v^2/c^2}\,,\ m = \frac{1}{1-(v/c^2)(x/t)}\,,\ m_\perp = \frac{\sqrt{1-v^2/c^2}}{1-(v/c^2)(x/t)} \quad (12)$$

PFT apply for the events of the moving frame observed from either of the frames, to get the view in one frame from the data of the view collected in the other frame. We can derive, in a similar fashion, a separate set of unprimed frame's transforms (UFT) for the events of the rest frame viewed from either frame to predict their respective coordinates in the rest frame or vice-versa:

$$x = em'\,(x' + vt')\ ,\ y = em'_\perp y'\,,\ z = e\,m_\perp z' \quad (13)$$

$$t = e\,t'\ , \quad (14)$$

where,

$$e = \sqrt{1 - v^2/c^2}\,, m' = \frac{1}{1+(v/c^2)(x'/t)}\,, m'_\perp = \frac{\sqrt{1-v^2/c^2}}{1+(v/c^2)(x'/t)} \quad (15)$$

Eqns (13-15) summarize unprimed frame's backward transforms (UFBT). For primed frame's backward transform (PFBT), invert PFFT:

$$x = gm'(x' + vt')\,,\ y = gm'_\perp y'\,,\ z = gm'_\perp z' \quad (16)$$

$$t = g\,t'\ , \quad (17)$$

where $g=1/e$. PFFT are used to transform the rest frame's view of an event in the moving frame to the moving frame's view while PFBT transforms the moving frame's view of the moving frame's event to the rest frame's view. Similarly, invert UFBT to get unprimed frame's forward transform (UFFT)

$$x' = gm(x - vt)\,,\ y' = gm_\perp y\,,\ z' = gm_\perp z \quad (18)$$

$$t' = g\,t\ , \quad (19)$$

UFBT are used to transform a primed frame's view of an event in the unprimed frame to the unprimed frame's view while UFFT transforms the unprimed frame's view of the same to the primed frame's view.

In the NR, spatial warping of a span of space is revealed to a particle that traverses that span. In other words spatial coordinate transforms are sensitive to the speed and direction of the particle that explores them. Therefore, for the *NT* unlike *LT*, x and x' in general are interpreted as effective lengths traversed by a particle of non zero speed. If the velocity of the particle is v_p for time t, then eqn (10-12) become,

$$x' = em(v_p t - vt)\ ,\ y' = em_\perp y\,,\ z' = em_\perp z \quad (20)$$

$$t' = e\,t\ , \quad (21)$$

$$e = \sqrt{1 - v^2/c^2}\,,\ m = \frac{1}{1-(vv_p/c^2)}\,,\ m_\perp = \frac{\sqrt{1-v^2/c^2}}{1-(vv_p/c^2)} \quad (22)$$

As such only in limited cases, when the particle starts its journey from the common origin of the two frames at time $t=t'=0$, only then (x,t) or (x',t') become the final coordinates of the particle in the two frames. Suppose instead of origin, if particle starts its journey from x-coordinate X in the rest frame at time $t=0$, then its final positions in the rest frame is $x_f = X+x$ and in the moving frame both X and x have to be separately transformed first using (10) and then added to give:

$$x_f' = e\{X + m(x - vt)\} \quad (23)$$

A stationary point in the moving frame i.e. x/t = v in (10-11) translates as,

$$x' = (x - vt)/e\,,\ y' = y\,,\ z' = z\,,\ t' = et \quad (24)$$

4. Salient Features

1. As evident from eq (11) or (14), temporal transform of the NT does not contain any x dependent synchronization term and are also devoid of odd order terms in v/c, complying Kishori's axioms. Thus, the NT are free from relativity of simultaneity or synchronisation.
2. Unlike LT, the temporal transform of NT relates the unique times of the two frames, t and t' ,from their respective clocks stationed in their own frames , which were reset to $t=t'=0$ when origins of the two frames coincided [3].
4. Second order factors like e affect all coordinate transforms symmetrically and are responsible for time dilation and spatial contraction of the clocks and objects in the other frame. Had there been no

m factors, a three dimensional sphere would have symmetrically contracted retaining its spatial shape.

5. Thus, m-factors attribute to asymmetry, spatial anisotropy and physical phenomena like ASW, RSC, DPDF and RNL.

6. NT or NR without a trace of RoS, do reproduce all the so far proven results of special relativity like length contraction, time dilation, velocity addition, provide an improved picture of a growing lightsphere and also predict some very new phenomenon like ASW, RSC and RNL [3-5], which have remained unexplored till date.

7. Though exploration of the physics of NT in contrast to LT and CR is deferred to [5], Here let us focus and derive on the impact of m factor present in spatial transform of NT, leading to DPDF. Suppose a photon emitted at $t=t'=0$ when origins of both the frames coincide, is detected at $OP=x$ in RF. This point coincides with P', $OP' = e(x-vt)$, while point of detection in MF is Q', $OQ'=x'=ex$ from (10), giving rise to a shift in detection points in two frames,

$$P'Q' = evx/c \,, \qquad (25)$$

which is a measure of RSC, equivalent to eq (9) of paper [4]. Based on the strict or soft interpretation of (24) the two versions of NR derived in [14].

8. The presence of x dependent m terms in transverse spatial coordinates must at least not surprise conventional relativists who advocate even the time of the other frame to be affected by the x. According to NR, not only the space and time of the other frame appear warped but even the transverse spatial coordinates appear tilted along the direction of motion and this is the real cause of the aberration angle, not the linear order warping of the moving frame's time.

5. Interpretation

Eq. (24) maps the space and time of the two frames with each other for both the CR and the NR. However, if a moving particle like a photon lies at P in the RF, CR as a believer in classical localization assumes it exists at an overlapping position P' mapped by (24) in the MF, but NR advocates relativistic non-localization, called RNL, to assert that a photon exists at DPDF, not mapped by (24).

Below are listed chronologically the events *(X, T)* pertaining to a set of five particles lying on x symmetrically about the origin, doing zig zag motion in y, as observed from both the frames independently. LT follows physics of OPDF resulting in RoS as it maps a horizontal set of simultaneous events to a diagonal set of events spread all over the time of the other frame, while NT follows DPDF and RSC as it maps them to a horizontal set of simultaneous events. See fig 2.

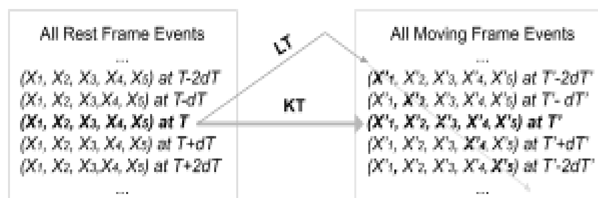
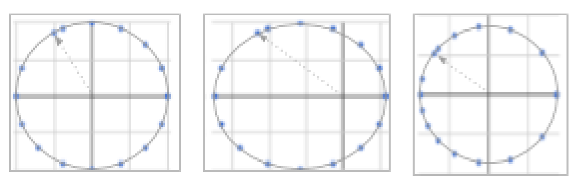


Fig 2. The bolded set of events in the RF is mapped to a horizontal set by NT, but to a diagonal set by LT in the MF.

Next, see how a growing lightsphere at time t of the RF that started off at the common origin of the two frames at $t=t'=0$, transforms to the MF under LT and NT to understand the role of OPDF and DPDF in mapping the events. See fig 3.



(a) (b) (c)

Fig. 3 Spatial of lightsphere (a) as detected in the RF, (b) LT-transformed in the MF (c) NT-transformed to the MF.

Spatial profiles of originally detected lightsphere in the RF of panel a in fig 3, and the NT-transformed one of panel c are both spherical about the origins of their respective frames. LT however generates a sphere in spacetime, but lacks spatial sphericity about the MF's origin as shown in panel b of fig 3.

This is because CR assumes OPDF i.e. overlapped positions of the photons in the two frames, so in both frames the photon's centre remains the origin of the RF, but MF's origin shifts to the right causing asymmetry in the MF. This created asymmetry in the MF is compensated by tweaking their times accordingly. Thus, CR generates an artificial non-simultaneity in the MF due to its overlapped position syndrome. However, NR believes that a photon exists at DPDF, and thus while the photons are centred about the origin of the RF in the RF, they are also centred about the origin of the MF in the MF. The mapping of the events based on DPDF or RSC shows no signs of RoS.

6. Conclusion

The alternative transforms of special relativity have been derived from scratch which not only comply with the two postulates of special relativity but also with the axioms of Kishori, or say the NT comply with the third postulate named RNL besides the original two. CR maps the events of one frame to another based on the OPDF and so encounters the RoS, NR however maps the events based on the DPDF or RSC devoid of the RoS, reproduces all the results of relativity proven so far [5], and is experimentally distinguishable [6-10]. The new phenomena like ASW, RSC, and RNL makes NR enriching, interesting and worth seeking [9-15].

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