Directional emissions from a moving light-source: Coincidence and simultaneity

Johan F Prins
CATHODIXX
8 Portland Place, Northcliff ext. 15, Johannesburg 2195, South Africa
johanprins@cathodixx.com

Keywords: Galilean-transformation, Lorentz-transformation, Minkowski's space-time, speed of light, simultaneity, time-dilation, length-contraction, light-clock, twin paradox, cosmic-ray muon.

Directional emissions of light-pulses from a moving point-source (which is stationary at the origin of a "moving" inertial reference-frame) towards co-moving detectors (which are all stationary at a constant radial-distance from the light source) are transformed into a "stationary" inertial reference-frame by means of both the Galilean-transformation and the Lorentz-transformation. Light-pulses along different directions are compared to the equivalent situation when a spherical-wave-front is emitted from the same source. The Galilean-transformation gives a transformed wave-front which is spherical within the "stationary" inertial reference-frame, where the centre of this sphere remains at the origin of the "moving" inertial reference-frame. The Lorentz-transformation gives a transformed wave-front which is not spherical within the "stationary" inertial reference-frame, and which is not instantaneously present within this "stationary" inertial reference-frame. This is compelling proof that the difference in position and time, for the same event within different inertial reference-frames, is caused by non-coincidence and non-simultaneity.

1. Background and introduction

1.1 Motion through space

In terms of Galilean terminology all bodies which are stationary relative to one another jointly define an inertial reference-frame (IRF), while all bodies moving with the same velocity **v** relative to these stationary bodies also define an inertial reference-frame (IRF) within which the latter bodies are stationary.

Motion of such bodies is mathematically modelled in terms of Cartesian coordinate-systems which are moving relative to one another through Euclidean space ("flat"-space). The coordinates (x,y,z) of a point within such a reference-frame must be mathematically linearly-independent: This demands that their quadratic sum $x^2+y^2+z^2$ can only be zero when x=y=z=0. If this is not the case, distances between separate coordinate-points have no physics-meaning. Obviously, x=y=z=0 are the coordinates of the origin of such a coordinate-system from which **all** distances to other coordinate-positions within this system are uniquely referenced for all time. Although the origin can be arbitrarily chosen, once it is chosen it is not possible to have another coordinate-point within an IRF that also has coordinates (0,0,0).

Origins can thus be arbitrarily chosen for the coordinates (x,y,z) of stationary points within a specific inertial reference-frame IRF=K, and for the coordinates $(x^/,y^/,z^/)$ of stationary points within another inertial reference frame IRF=$K^/$. Although, after having made these choices, the coordinates do not change within IRF=K and also not within IRF=$K^/$, the coincident points that they denote within IRF=K and IRF=$K^/$ move relative to one another when the reference-frames move relative to one another.

The relative motion of these points (with speed v) is usually chosen to be along the coinciding x direction. It is usually assumed that the time, as measured on clocks within both IRF=K and IRF=$K^/$, is set to zero when the respective origins 0 and $0^/$ of IRF=K and IRF=$K^/$ coincide: At that instant in time any point-position within IRF=K, which coincides with a point-position within IRF=$K^/$, has the **same** values for its coordinates within both IRF=K and IRF=$K^/$.

Since there are many bodies in space moving with many velocities relative to one another, a very large set of IRF's exists within our Universe. It is mathematically possible to have a coordinate-frame which does not have a body that is stationary within it: However, such an "empty" coordinate-system has, in essence, no physics-meaning, since there is no object within such a "reference-frame" which can "observe" what is happening "outside" of this "reference-frame". To know the latter, a person or object must be stationary within such a reference-frame. It is thus compelling to argue that an IRF is only physically relevant when there is at least one object that is stationary within it: An IRF must thus be the rest-frame or "primary coordinate-frame" for such an object, or more than one such an object.

The latter means that an object moving with a speed v relative to an IRF, is not a "primary" object within such an IRF: Its motion is the result of a coordinate transformation from its primary rest-frame into the latter IRF relative to which it is moving: In fact, such an object is moving **simultaneously** with **different** velocities within all the different IRF's which are not its rest-frame: It does not have a unique velocity in space! No wonder Zeno has claimed that the motion of a body is an illusion. As an aside it should be noted that momentum and kinetic-energy also do not have unique values. These parameters all change when transformed from one IRF into another, which is moving relative to the first: They are thus **not** invariant under a coordinate transformation from one IRF into another IRF.

1.2 Galilean relativity

In terms of Galileo's law of inertia and Newton's first law, the values of the coordinates for a point within an IRF (which is moving relative to another IRF) are at any time, other than at the time of synchronization (when the origins 0 and $0^/$ coincide), not the same within the two IRF's. Choosing IRF=$K^/$ as the "moving" IRF, which moves with a speed v along the x-axis of the "stationary" IRF=K, the point-coordinates (x,y,z) within IRF=K, which coincide with those of **any** point ($x^/,y^/,z^/$) within IRF=$K^/$ at a time $t^/$ (after synchronization) are given by the following equations of the Galilean-transformation:

$$x = x^/ + vt^/ \qquad (1a)$$

$$y = y^/ \qquad (1b)$$

$$z = z^/ \qquad (1c)$$

$$t = t^/ \qquad (1d)$$

The time on all clocks within both IRF=K and IRF=$K^/$ are instantaneous-simultaneous always exactly the same: The transformed coincident, position-coordinates within IRF=K, of a stationary point ($x^/,y^/z^/$) within IRF=$K^/$, change with time for different values of $t = t^/ \neq 0$ within IRF=K. Note that this is also the case when $t = t^/ < 0$: i.e. by assuming a future synchronization of the time. As far as these equations are concerned, all the clocks within our universe must be, have been and will always be keeping the same time; until the end of time.

The Galilean-transformation of a point ($x^/,y^/,z^/$) from a "moving" IRF=$K^/$ into a "stationary" IRF=K, is schematically illustrated in Fig. 1: After a time $t^/$=t>0 the origins 0 and $0^/$ are a vector-distance $\mathbf{u}^/$=$\mathbf{v}t^/$ apart, and the Gaussian-transformation can be written in terms of vector-notation as $\mathbf{r}$=$\mathbf{u}^/$+$\mathbf{r}^/$.

When a primary event (see the meaning of "primary event" below) occurs at a time $t^/$ within IRF=$K^/$ at a specific point ($x^/.y^/,z^/$) (which is stationary within IRF=$K^/$), this event is observed within IRF=K at the corresponding, coincident point (x.y.z) and instantaneous-simultaneous time t, given by the expressions in Eq. 1 of the Galilean-transformation.

Alternatively, one can choose IRF=K as the reference-frame that "moves" with a speed –v relative to IRF=$K^/$, where the latter IRF now serves as the "stationary" reference-frame. In this case the coordinate-transformation of a point (x,y,z) within IRF=K, from this "moving" IRF=K into the "stationary" IRF=$K^/$, is given by the expressions:

$$x^/ = x - vt \qquad (2a)$$

$$y' = y \qquad (2b)$$

$$z' = z \qquad (2c)$$

$$t' = t \qquad (2d)$$

The expressions in Eq. 2, are the reverse of the expressions in Eq. 1, in the sense that when a primary event (see meaning of "primary event" below) occurs at the position (x,y,z) within the IRF=K at time t, this event is observed within the IRF=K' at the corresponding, coincident point (x',y',z') and at the simultaneous instant in time t', as given by the expressions in Eq. 2 of the Galilean transformation.

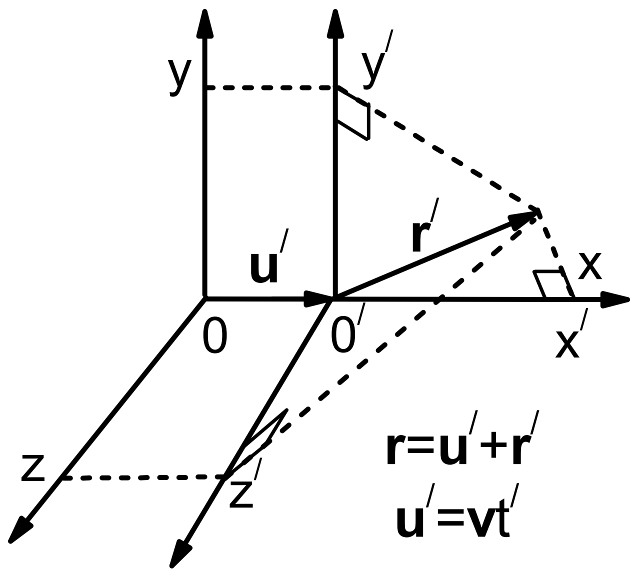

Figure 1: Galilean transformation of the coordinates (x',y',z') of a stationary point within a moving IRF=K' into the coincident coordinates (x,y,z) of the point within IRF=K, relative to which IRF=K' is moving with a speed v along the x-axis.

In addition, the expressions in Eq. 2 are also mathematically-inverse to the expressions in Eq. 1. When substituting for x' in Eq.1a from Eq. 2a, one obtains that x=x; and when substituting x from Eq. 1a into Eq. 2a, one obtains that x'=x'. This means that at any instant in time t=t' the space-coordinates (x,y,z) which coincide with the space-coordinates (x',y',z'), are simultaneously the coordinates of the **same** point in space; no matter which IRF is considered to be "moving" and which IRF is considered to be "stationary". We will term such coordinates "instantaneous-coincident" coordinates.

A distinction will be made between what is mathematically possible and what is physically posible: The mathematically-inverse relationship between the expressions in Eq. 1 and Eq. 2, does not define within which IRF a primary event occurs (see meaning of "primary event" in next pragraph). The latter fact has been missed in the mainstream literature: Mathematically-inverse has been assumed to be the same as physically-inverse.

Consider, for example, a small particle of TNT-dust that is stationary within IRF=K' at the position (x',y',z'), and which "explodes" at the time t': This explosion will be observed within IRF=K at the time t as determined by Eq. 1. But, it is not correct to argue that since this explosion also occurred **within** IRF=K it can therefore be transformed by Eq. 2 back into IRF=K': Mathematics allows this argument since the equations are inversely related, but it does not make physics-sense to do this. The "inverse" physics-situation would be when a small particle of TNT-dust, which is stationary within IRF=K at the position (x,y,z), explodes at the time $t=t'$: In this case the corresponding coordinates within IRF=K' are given by Eq. 2. Although mathematically-inverse, the Galilean transformation-equations are only physically-inverse when two identical events, which are primary events within IRF=K and IRF=K' respectively, are simultaneous-coincident when they occur.

We will postulate the following: A primary event within an IRF will occur at the same coordinates within this IRF if it were to occur at a later or earlier time. If it has to occur at different coordinates within an IRF for different times, it is not a primary event within this IRF. The emission of light from a stationary light-source within an IRF, is a primary event within that IRF: Similarly, the detection of light by a stationary detector within an IRF is also a primary event within that IRF. In contrast, the emission of light from a moving light-source is not a primary event within an inertial reference-frame relative to which the light source is moving. Similarly, the detection of light by a moving detector is not a primary event within the inertial reference-frame relative to which the detector is moving.

Instead of linear-motion relative to one another, the coordinate-axes (x,y,z) of the IRF=K and the coordinate-axes (x',y',z') of the IRF=K' can rotate relative to one another around a joint origin, $0=0'$; as shown in Fig. 2: The coordinate-axes (x',y',z') (dotted arrows in Fig. 2) and the coordinate-axes (x,y,z) (solid arrows within Fig. 2) start from coincidence of the coordinate-axes, when the magnitudes of the coordinates of each point in space are exactly the same within IRF=K and IRF=K', and then rotate relative to one another: The mathematical operator that effects the rotation of IRF=K' relative to IRF=K, is a 3x3 matrix. Depending on the rotation-axis, one has after the rotation that at least some of the coincident coordinates are, or even all of them could be different in magnitude in the sense that $x \neq x'$, $y \neq y'$ and $z \neq z'$.

A position in space, given by the position-vector **r** in Fig. 2, retains the same coordinates within the non-rotating reference-frame. One can write in terms of the unit vectors $\mathbf{e}_1,\mathbf{e}_2,\mathbf{e}_3$ along the axes x,y,z; and the unit vectors $\mathbf{e}_1',\mathbf{e}_2',\mathbf{e}_3'$ along x',y',z', that:

$$\mathbf{r}=x\,\mathbf{e}_1+y\,\mathbf{e}_2+z\,\mathbf{e}_3=x'\,\mathbf{e}_1'+y'\,\mathbf{e}_2'+z'\,\mathbf{e}_3' \qquad (3)$$

These coordinates are still linearly-independent within each reference-frame: This means that when **r**=0, one **must** have that each coordinate must be individually zero within each reference frame: i.e. x=y=z=0 and that $x'=y'=z'=0$. The magnitude r of the position-vector **r** of the same point in space has a quadratic-relationship in terms of its linearly-independent coordinates which can be written in terms of both (x,y,z) and $(x',y'z')$, as:

$$r^2 = x^2 + y^2 + z^2 = x'^2 + y'^2 + z'^2 \qquad (4a)$$

It has already been pointed out above that when the coordinates are linearly-independent, two different points in space cannot have the same coordinates within the same Cartesian-system: When $r^2=0$, one **must** have that $x^2=y^2=z^2=0$ and also in the rotating system that $x'^2=y'^2=z'^2=0$: i.e. $r^2=0$ is only valid at the origins of the coordinate-axes.

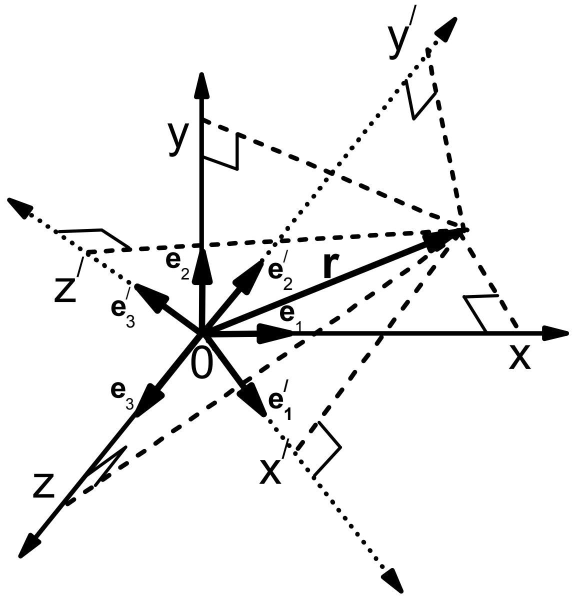

*Figure 2: The coordinates of a position within three-dimensional space within two Cartesian coordinate systems (x,y,z) and (x',y',z') which have been rotated relative to one another. Both sets of coordinates give the same position vector **r**.*

If one rotates the coordinate-axes (x',y',z') around an axis through an angle, and then rotate them back again through the same angle, the coordinates will again have the same coincident magnitudes at all points in space; so that $x=x'$, $y=y'$, and $z=z'$. Thus, just like the Galilean-transformation, these two actions are mathematically-inverse to one another. But again they are not physically-inverse for a primary event that occurs within only one of the two reference-frames.

From calculus it follows that at any point in space one can write for an adjacent infinitesimally-close point in differential format (for either x,y,z or x',y',z') that:

$$dr^2 = dx^2 + dy^2 + dz^2 \qquad (4b)$$

This means that the origin of these Cartesian coordinate-axes can be chosen at any point in space: Although this will change the magnitudes of the coordinates (x,y,z) of the same point, it does not change the physics in any way.

1.3 Motion "through" the ether

After Maxwell formulated his electromagnetic field-equations [1], which modeled the propagation of light through free-space in terms of harmonic electromagnetic-waves, it was accepted that these waves must, like all other waves known at that time, propagate within a medium which itself is stationary in space: And since light is propagating through all regions of space, this medium, which was termed the ether, must fill all space in our Universe. If such a stationary ether does exist, it must be a "body" which defines a uniquely-stationary IRF.

Michelson and Morley [2] attempted to measure the speed of the earth relative to the ether, but consistently obtained a null-result. The expected result (which was **not** found) had been derived in terms of the Galilean-transformation, according to which the speed of light must be different when measured relative to different bodies which are moving relative to one another. Attempts were made to modify the latter equations to obtain an alternative coordinate-transformation which will give a null result [3-9]. These attempts culminated in the formulation of a set of equations which was termed by Poincaré [9] as the Lorentz-transformation. These equations, from a "moving" IRF=$K^{/}$ into a "stationary" IRF=K, are given by:

$$x = \frac{x^{/} + vt^{/}}{\sqrt{1-\frac{v^2}{c^2}}} = \gamma(x^{/} + vt^{/}) \tag{5a}$$

$$y = y^{/} \tag{5b}$$

$$z = z^{/} \tag{5c}$$

$$t = \frac{t^{/} + \frac{v}{c^2}x^{/}}{\sqrt{1-\frac{v^2}{c^2}}} = \gamma\left(t^{/} + \frac{vx^{/}}{c^2}\right) \tag{5d}$$

Note that these equations require a transformation of time.

Lorentz considered the transformed-time as an "auxiliary variable": A kind of crutch. The consensus at that time was that these equations are valid since the null result of the Michelson-Morley experiment can be explained by a length-contraction of one of the two perpendicular arms of the spectrometer when this arm is oriented along the direction of motion relative to the ether: The so-called Lorentz-Fitzgerald contraction [10,11]. This means that the equations of the Lorentz-transformation can be obtained by using the Galilean-transformation in combination with the Lorentz-Fitzgerald contraction (see section 3.4 below). Einstein, however, postulated a better reason than the Lorentz-Fitzgerald contraction why the

the equations of the Lorentz transformation are valid when doing the Michelson-Morley experiment.

1.4 Einstein's relativity

In 1905 Einstein came to the astonishing-outrageous, but (at present accepted as) correct-insight that the real reason why the Lorentz-transformation is valid, **must** be that light **must** always be propagating through space with the same definite speed so that it has a constant magnitude which is approximately $c \cong 3x10^8$ m/s **relative** to **any and all** bodies, independent of the motion of these bodies relative to one another, and no matter with what velocities these bodies are moving relative to one another [12]. The last sentence is not quite how Einstein stated the constancy of the speed of light, but, as will be seen below, it is probably a better way to state it. What it means is that, in contrast to the speed of a material body, light speed has a unique magnitude in space and therefore does not have, or need a unique, primary, inertial reference-frame or moving body relative to which it can have another value than c.. All possible inertial reference-frames attached to any material body are primary reference-frames for the speed of light through space: i.e. the speed of light is invariant under a Lorentz coordinate-transformation.

According to the latter insight the time for a primary event within an inertial reference-frame, which is moving with a speed v relative to another inertial reference-frame, is actually different within any concomitant "stationary" inertial reference-frame: It is at present accepted that when a primary event occurs at a position $(x^/,y^/,z^/)$ and a time $t^/$ within a "moving" IRF-$K^/$ the same event occurs at a position (x,y,z) and a different time t within the "stationary" IRF=K. To repeat: In contrast to the Galilean-transformation, the time for a primary event occurring within a "moving" IRF=$K^/$, is not the same within the "stationary" inertial reference-frame IRF=K, relative to which IRF-$K^/$ is moving with a speed v.

Just as in the case of the Galilean-transformation, one can also assume that IRF=K is the "moving" IRF which moves with a speed –v along the $x^/$-axis of IRF=$K^/$: Lorentz-equations are then required to transform a primary event, which occurs at a stationary position within the "moving" IRF=K at a position (x,y,z) and a time t, into the "stationary" IRF=$K^/$, relative to which IRF=K is moving. The equations of this reverse Lorentz-transformation are:

$$x^/ = \frac{x - vt^/}{\sqrt{1-\frac{v^2}{c^2}}} = \gamma(x - vt) \qquad (6a)$$

$$y = y^/ \qquad (6b)$$

$$z = z^/ \qquad (6c)$$

$$t = \frac{t^/ - \frac{v}{c^2}x^/}{\sqrt{1-\frac{v^2}{c^2}}} = \gamma\left(t^/ - \frac{vx^/}{c^2}\right) \qquad (6d)$$

Note again, that, also in this case, the expressions within Eq. 5 and Eq. 6, are not, on their own, physically-inverse to one another. The expressions within Eq. 5 are only valid when a primary event occurs within IRF=$K^{/}$; and the expressions within Eq. 6 are only valid when a primary event occurs within IRF=K.

1.5 Space-time

In modern text books, the Lorentz-equations are justified by considering a spherical-wave-front being emitted from a point-source at the position in space where the origins 0 and $0^{/}$ of IRF=K and IRF=$K^{/}$ coincide at time t=$t^{/}$=0. Owing to the constant speed of light within both IRF's, this spherical wave-front must spread out with the same speed c around the origin 0 within IRF=K, as well as around the origin $0^{/}$ within IRF=$K^{/}$. This must be so even when the primary event of emitting a single wave-front occurs within either IRF=$K^{/}$ or IRF=K: The spherical, single wave-fronts within IRF=K and IRF=$K^{/}$ are thus, in such a case, "twin-images" of the same, primary, single wave-front from a source which is stationary at either the origin $0^{/}$ or at the origin 0 within IRF=$K^{/}$ or IRF=K.

Since, according to the Lorentz-equations (Eq. 5 and Eq. 6), the time for a primary event within either IRF=K or IRF=$K^{/}$, is different within the non-primary IRF, it has been assumed that the equations for the "twin" initial spherical wave-fronts within IRF=K and IRF=$K^{/}$, require different time-parameters t and $t^{/}$ ($t \neq t^{/}$) so that these twin wave-fronts must be written, respectively, as:

$$x^2 + y^2 + z^2 = c^2t^2 \qquad \text{within IRF=K} \qquad (7a)$$

And:

$$x^{/2} + y^{/2} + z^{/2} = c^2t^{/2} \qquad \text{within IRF=}K^{/} \qquad (7b)$$

It is a simple exercise to prove that if one replaces x, y, z, and t in Eq. 7a, with the Lorentz-transformed expressions from Eq. 5, one obtains Eq. 7b: And similarly, by replacing $x^{/}$, $y^{/}$, $z^{/}$, and $t^{/}$ in Eq. 7b, with the Lorentz-transformed expressions from Eq. 6, one obtains Eq. 7a. Equations 7a and 7b are thus mathematically inversely-related through the Lorentz-transformation.

In modern text books it is argued that since these equations are mathematically inverse when applying the Lorentz-transformation, these two equations are the generators of the Lorentz-transformation [13]. The Lorentz transformation is thus "derived" by claiming a linear relationship between these equations so that one can write that:

$$x^2 + y^2 + z^2 - c^2t^2 = x^{/2} + y^{/2} + z^{/2} - c^2t^{/2} \qquad (7c)$$

The equality in Eq. 7c is assumed to be given by a 4x4 matrix where this matrix defines the Lorentz transformation as a rotation within a four-dimensional space. It should be noted that what is done here is to equate two expressions which are both zero. It is known that to equate zero to zero in mathematics usually leads to nonsensical results, since one is in essence dividing zero by zero. One should thus be suspicious of this approach when "deriving" the Lorentz-equations in this manner. The logic invoked could be and is most probably wrong (see below). But how did this "derivation" come about?

Poincaré [14] probably started it all by pointing out that these equations resemble expressions within a four-dimensional space with coordinates (x,y,z,w) if one chooses an imaginary space coordinate w=ict where $i=\sqrt{-1}$. Minkowski [15] took this approach further by showing that one can rewrite Maxwell's wave-equations in terms of such coordinates; so that these equations remain invariant under a Lorentz coordinate-transformation. He then went even further and proposed a reformulation of Einstein's Special Theory of Relativity by postulating that time and space should **always** be treated as equal coordinates within our universe, even when the physics does not directly involve Maxwell's electromagnetic waves [16]. According to this approach, the Lorentz-transformation is a four-dimensional transformation from a space-time position, with space-time coordinates ($x^/,y^/,z^/,t^/$), into **coincident** space-time coordinates (x,y,z,t): Just as in the three-dimensional case when Galilean space-coordinates are being rotated.

Using the imaginary representation of the time-coordinate, a space-time distance **s** is thus obtained, by analogy with Eq. 3, from the origin of the space-time coordinates for a space-time point (x,y,z,t), so that:

$$\mathbf{s}=x\,\mathbf{e}_1+y\,\mathbf{e}_2+z\,\mathbf{e}_3+(ict)\,\mathbf{e}_4 \qquad (8)$$

The magnitude s of **s**, can thus be calculated and is found to be:

$$s^2=x^2+y^2+z^2-c^2t^2 \qquad (9a)$$

It has been reasoned that, owing to Eq. 9a, one can, by analogy with Eq. 4b, at each space-time point write in differential format that:

$$ds^2=dx^2+dy^2+dz^2-d(ct)^2 \qquad (9b)$$

As already pointed out above, if the latter can be done one should be able to choose the origin of Minkowski's four-dimensional space-time at any space-time position without altering the physics involved.

It is, however, compelling that, also in the four-dimensional case (in fact in all dimensions, no matter how many there are), the coordinates (x,y,z,w=ict) of each (in this case) space-time point, must be linearly-independent in order to obtain space-time distances which are unique for each space-time point. This, in turn, demands that when **s**=0 (and thus s=0) the coordinates must always be such that x=y=z=ict=0. If this must be so in Minkowski's space-time, and it is unlikely that it can be otherwise since this will mean that the distances between space-time points are not uniquely defined, Eq. 7a (and thus also Eq. 7b) cannot be valid when Minkowski's space-time fabric is valid: In Eq. 7a, the four coordinates are not linearly-independent, since one has in this case that s^2 must be zero without requiring that each term x^2,y^2,z^2 and $-c^2t^2$ must be simultaneously exactly zero.

Simply stated, it implies that **if** Minkowski's space-time models physics-reality, a spherical wave-front cannot form and expand into three-dimensional space. It is, however, experimentally well-established that the latter does happen. Furthermore, as pointed out above, it is argued in text books that the expressions in Eq. 7, act as the generators of the Lorentz-transformation [13]; even though the mathematics involved in such a derivation is suspect (see above). Nonetheless, one expects that the expressions in Eq. 7a and Eq. 7b, must somehow be integral elements of Minkowski's space-time manifold if this space-time actually models real physics. But, if the space-time coordinates **must** be linearly-independent (as one expects that they must be for such a manifold), these expressions cannot be integral elements of Minkowski's space-time. There is thus an apparent paradox which requires further investigation.

1.6 The approach

In this manuscript a light-pulse is considered which is emitted from a moving point-source (at the origin $0^/$ of IRF=$K^/$) along a particular direction, defined by spherical angles $\theta^/$ and $\varphi^/$, towards a detector situated at a constant distance $R_D^/$ from the origin $0^/$. For different directions, the concomitant detectors, moving with the source, are thus situated at the same radial distance $R_D^/$ from the source, so that every light-pulse reaches its own detector after the same time $t_D^/ = R_D^/ / c$ has elapsed within IRF=$K^/$.

If the source emits a spherical wave-front at time $t^/$=0, this wave-front will also reach the same detectors simultaneously within IRF=$K^/$ after the same time-interval $t_D^/$ has elapsed. By transforming simultaneous, separate events (when light pulses within IRF=$K^/$ reach their respective detectors) into IRF=K, one obtains Lorentz-transformed (LT) positions and times within IRF=K, which, if a spherical wave-front had instead been emitted, must all be simultaneously situated on a LT wave-front within IRF=$K^/$: In terms of Eq. 7a and Eq. 7b, one expects that these LT coordinates must be situated on the twin wave-front within IRF=K. If not, it will be further proof that the assumption on which Eq. 7c is based, must be wrong.

In this study, the position of one of the detectors within IRF=$K^/$, when its single light-pulse from the origin $0^/$ reaches it, is transformed into the "stationary" IRF=K by using both the Galilean- and Lorentz-transformations; and the results are compared. It is found that the LT coordinates on a primary spherical wave-front around the origin $0^/$ within IRF=$K^/$ do not lie on a sphere around 0 within IRF=K. Thus the LT wavefront is not the twin wave-front which must be present within IRF=K. This result is found to demand a re-interpretation of Einstein's Special Theory of Relativity which is not commensurate with time-dilation and with length-contraction.

2. Emitting a light-pulse at synchronization

2.1 Schematics

The motion of a light-source (which is stationary at the origin $0^{/}$ within IRF=$K^{/}$) relative to the origin 0 within the IRF=K, is schematically shown in Fig. 3 at the time $t_D^{/}$ when an emitted light-pulse reaches its detector at the radial position $R_D^{/}$.

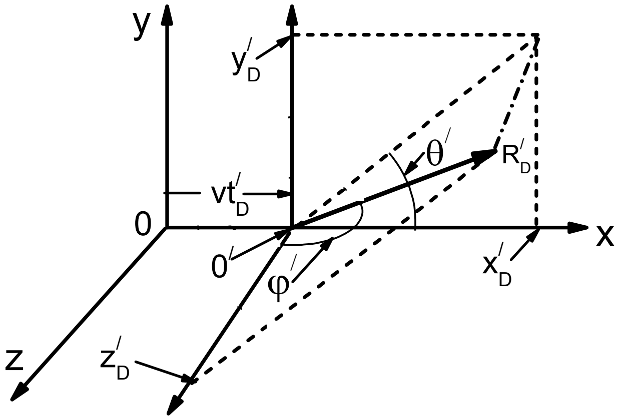

Figure 3: The relative positions of the stationary inertial reference-frame (IRF=K) with origin 0 and the moving inertial reference-frame (IRF=$K^{/}$) with origin $0^{/}$, when an emitted light pulse from $0^{/}$ reaches the detector within IRF=$K^{/}$ which is situated at a radial-distance $R_D^{/}$, as determined by the angles $\theta^{/}$ and $\varphi^{/}$, from the origin $0^{/}$.

The distance that the origin $0^{/}$ has moved from the origin 0 is given by $D_D^{/} = vt_D^{/}$. This is the same distance $u^{/}$ shown by the vector $\mathbf{u}^{/}$ in Fig. 1: The Cartesian position-coordinates of such a detector within IRF=$K^{/}$ are given by:

$$x_D^{/} = R_D^{/} \sin\varphi^{/} \cos\theta^{/} \tag{10a}$$

$$y_D^{/} = R_D^{/} \sin\varphi^{/} \sin\theta^{/} \tag{10b}$$

$$z_D^{/} = R_D^{/} \cos\varphi^{/} \tag{10c}$$

When a light-pulse is emitted towards such a detector at time $t^{/} = 0$, the time $t_D^{/}$, at which it reaches the detector, is given by:

$$t_D^{/} = \frac{R_D^{/}}{c} \tag{11}$$

2.2 Galilean-transformation

Using the expressions in Eq. 1, the corresponding Galilean-transformed (GT) coordinates of the primary event within IRF=K$^{/}$ (when the light pulse reaches the stationary detector) are given within the IRF=K by:

$$x_{GD} = x_D^{/} + vt_D^{/} = x_D^{/} + \frac{v}{c}R_D^{/} \qquad (12a)$$

$$y_{GD} = y_D^{/} \qquad (12b)$$

$$z_{GD} = z_D^{/} \qquad (12c)$$

$$t_{GD} = t_D^{/} \qquad (12d)$$

The concomitant radius of a GT spherical wave-front from IRF=K$^{/}$ into IRF=K at the time $t_{GD} = t_D^{/}$, can thus be calculated as:

$$R_{GD}^2 = x_{GD}^2 + y_{GD}^2 + z_{GD}^2 = (x_D^{/} + \frac{v}{c}R_D^{/})^2 + y_D^{/2} + z^{/2} \qquad (13)$$

R_{GD} is not spherical around the origin 0 of IRF=K: It, however, remains spherical around the origin 0$^{/}$ of IRF=K$^{/}$.

In Fig. 4 the wave-fronts when v/c is equal to zero (no motion), 0.5 and 0.9 are compared in terms of normalized coordinates, so that in each case $R_D^{/} = 1$:

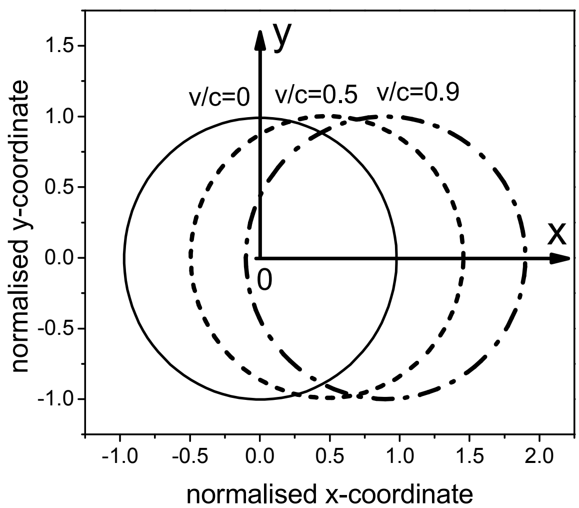

Figure 4: The Galilean-transformed wave-front in normalized coordinates within the x-y-plane around a light-source moving with speed v relative to the origin 0 of a stationary inertial reference-frame. The wave-fronts are shown when the speeds v are v/c=0, v/c=0.5 and v/c=0.9. In each case the wave-front stays spherical around the position of the moving light source.

The position-coordinates within IRF=K and IRF=$K^{/}$ of the primary event within IRF=$K^{/}$, when the light-pulse reaches its detector, are thus simultaneous-coincident; as expected that they must be when the Galilean transformation applies.

Since the light pulse is emitted when the origin $0^{/}$ of IRF=$K^{/}$ (at which the source is situated) coincides with the origin 0 of the stationary IRF=K, the light pulse must be seen within IRF=K to have moved from 0, to the position of the detector R_{GD} within a time-interval $t_D = t_D^{/}$ with a speed c_G given by:

$$c_G = \frac{R_{GD}}{t_D^{/}} = c\frac{R_{GD}}{R_D^{/}} \qquad (14)$$

Within IRF=K, different positions on the wave-front move with velocities which have different magnitudes. At any point on the wave-front the velocity of light is given by the vector $\mathbf{c_G}$ which can be written as:

$$\mathbf{c_G} = \mathbf{e}_r c + \mathbf{e}_x v = c\,(\mathbf{e}_r + \frac{v}{c}\mathbf{e}_x) \qquad (15)$$

Where $\mathbf{e}_r$ is the unit vector along the radial direction, as measured from the origin $0^{/}$, and $\mathbf{e}_x$ is the unit vector along the x-direction. This is illustrated in Fig. 5 within the (x-y)-plane.

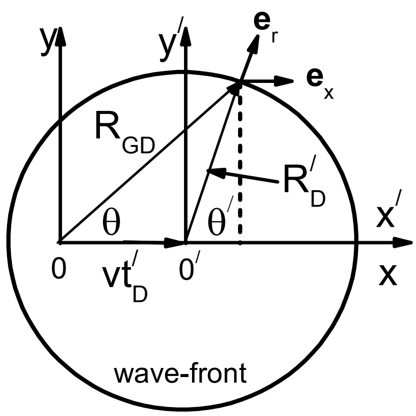

Figure 5: The Galilean-transformed spherical wave-front of a light-pulse, which has been emitted at time $t^{/}$=0 when the origins 0 and $0^{/}$ coincided, after a time $t_D^{/}$ has elapsed. At each point on the wave-front there are two unit-vectors $\mathbf{e}_r$ and $\mathbf{e}_x$ showing the direction of the velocity components of magnitude c and v respectively. Since the direction of the component with magnitude c is different at different positions on the wave-front, the velocity of light has different directions and magnitudes at different positions on the wave-front when observed within the "stationary" reference-frame.

It is a simple exercise to calculate the magnitude c_G of the wave-front within IRF=K by calculating the square root of the dot-product of Eq. 15: It is found to be:

$$c_G = c\sqrt{1+\frac{v^2}{c^2}+2\frac{v}{c}\cos\theta'} \quad (16)$$

This result is not possible when the Lorentz-transformation applies, since, in the latter case, the magnitude of the velocity of light must have everywhere the same value c and nothing else but c within IRF=K.

2.3 The Lorentz transformation

Using the expressions in Eq. 5, the corresponding Lorentz-transformed (LT) coordinates (x_{LD},y_{LD}, z_{LD},t_{LD}) within IRF=K, when a light-pulse reaches its detector, can be derived: After a bit of algebra it is found that the radial distance R_{LD} from the origin 0 of IRF=K is given by:

$$R_{LD} = \sqrt{x_{LD}^2 + y_{LD}^2 + z_{LD}^2} = \gamma R_D'\left((1+\left(\frac{v}{c}\sin\varphi'\cos\theta'\right)\right) \quad (17)$$

And the time to reach this radial-position from 0 is given by:

$$t_{LD} = \gamma t_D'\left(1+\left(\frac{v}{c}\sin\varphi'\cos\theta'\right)\right) = \gamma\frac{R_D'}{c}\left(1+\left(\frac{v}{c}\sin\varphi'\cos\theta'\right)\right) \quad (18)$$

The speed with which the light moves from the origin 0 of IRF=K to the LT-position of the detector at R_{LD}, as referenced within IRF=K, is thus given by R_{LD}/t_{LD}: Using Eq. 17 and Eq. 18, the speed is found to be c_L=c at every point on the LT wave-front within IRF=K: Just as Einstein concluded that it must be for the Lorentz-transformation to be valid.

It is important to note that, within IRF=K, the speed of light **must be** the same constant value c relative to the stationary origin 0, **as well as** relative to the LT position-coordinates of the detector. The light moving from the origin to the LT-coordinates of the detector is thus not “chasing” the detector within IRF=K with a relative speed other than the speed of light c. The detector has a stationary LT-position within IRF=K in order to ensure that the speed of light relative to this stationary position is the same constant value for the speed of light, c, as it is relative to the origin 0.

As already pointed out above, a spherical wave-front within IRF=K$'$ must reach **all** the radial positions R_D' at the **exact same** time t_D', so that one can write for this wave-front at time $t' = t_D'$ within IRF=K$'$ that:

$$R_D'^2 = x_D'^2 + y_D'^2 + z_D'^2 = c^2 t_D'^2 \quad (19)$$

From Eq. 17 and Eq. 18 one obtains within IRF=K that:

$$R_{LD}^2 = x_{LD}^2 + y_{LD}^2 + z_{LD}^2 = c^2 t_{LD}^2 \quad (20)$$

This again confirms that the expressions in Eq. 7a and Eq. 7b are mathematically inverse under a Lorentz-transformation.

But, they are not the coordinates for two coincident wave-fronts within space-time: The expression in Eq. 7a, (supposedly corresponding to Eq. 20) has been interpreted, over the past 100 years, as also being the physically-inverse of Eq. 7b, so that it models the corresponding “twin” spherical wave-front within IRF=K: This requires that at any instant in time t (including $t=t_{LD}$) within IRF=K, Eq. 20, should be the equation for a spherical wave-front around the origin 0 of IRF=K.

Although Eq. 20 is the Lorentz-transformation into IRF=K of an instantaneous radial position on a primary, spherical wave-front around the origin $0^{/}$ within IRF=$K^{/}$ (at the time $t^{/} = t^{/}_{D}$), the LT-radii of this wave-front within IRF=K, are different along different directions around 0: They **do not** define an instantaneous spherical wave-front around the origin 0 of IRF=K at a single instant in time t_{LD}; as it should have been the case if Eq. 7c were to be valid. To emphasize this, these parameters will be written as $R_{LD}(\theta^{/},\varphi^{/})$ and $t_{LD}(\theta^{/},\varphi^{/})$.

This fact is illustrated in Fig. 6 where the LT wave-fronts for v/c=0, 0.5 and 0.9 are compared in normalized format (using $R^{/}_{D} = 0$). The LT wave-front for v/c=0 is spherical around the origin 0, as it must be since the origins 0 and $0^{/}$ are not moving away from one another: This is the same result as for the Galilean-transformation when v/c=0 (see Fig. 4).

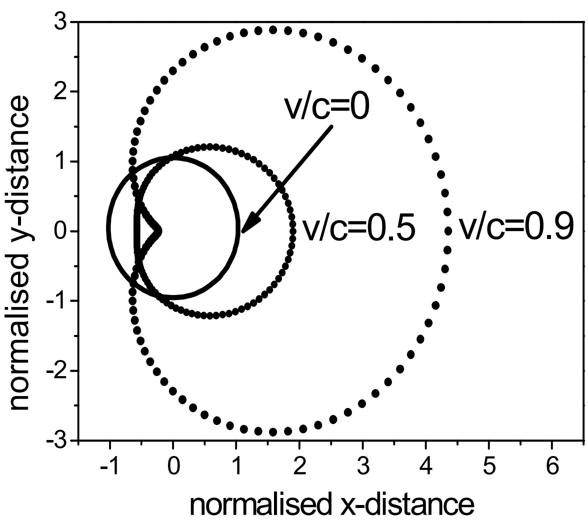

Figure 6: The Lorentz-transformed wave-front in normalized coordinates within the x-y-plane around a light-source moving with speed v relative to the origin of a stationary inertial reference-frame. The wave-fronts are shown when the speed v has the values so that v/c=0, v/c=0.5 and v/c=0.9. In contrast to the Galilean transformation, the wave-front does not stay spherical around the position of the moving light source for non-zero values of v/c, but distorts in both space and time: Nor is it spherical around the stationary origin 0. Each position on the wave front can only be reached at a different time on a clock within the stationary inertial reference-frame.

For v/c>1, the LT “wave-fronts” (as given by the LT positions of the detectors), although surrounding the origin 0 within IRF=K, are not centered on this origin and also not centered on $0^{/}$ as in the case of the Galilean transformation. The LT space-time coordinates within IRF=K are thus not simultaneous-coincident with the space-time coordinates in IRF=$K^{/}$: The LT positions of the detectors are distorted in space **and** time since their radial distances are different from the origin 0: And each radial distance $R_{LD}(\theta^{/},\varphi^{/})$ from 0 is only reached by the emitted relativistic-“twin” wave-front when the time $t_{LD}(\theta^{/},\varphi^{/})$ on a clock within IRF=K, corresponds to the time it takes for light to cover this radial distance from the origin 0 with the speed of light c relative to 0 **and** relative to the LT position of the concomitant detector within IRF=K.

The fact is that the actual “twin” wave-fronts within IRF=K and IRF=$K^{/}$ spread out from their respective origins 0 and $0^{/}$ with the same speed c; as if in both cases these origins are stationary. There is thus no physics-reason whatsoever why the length-units and time-units, experienced by each wave-front, should be different within their respective inertial reference-frames; whether it be IRF=K or IRF=$K^{/}$. As far as each wave-front is concerned, it is moving within Galilean space with the speed c relative to its stationary origin.

It has already been pointed out in Fig. 3 that the distance between the origins at the time $t_D^{/}$ within IRF=$K^{/}$ is given by $D_D^{/} = vt_D^{/}$. Similarly one must have that at a time t_D (not necessarily t_{LD}) within IRF=K, the distance between the origins 0 and $0^{/}$ must be $D_D = vt_D$. Unless the instantaneous distance between the origins 0 and $0^{/}$, measured by a clock within IRF=K, differs from the same distance measured by a clock within IRF=$K^{/}$, which is unlikely to be the case since such a situation would be absurd, one must have for any instantaneous distance between 0 and $0^{/}$, that this distance, derived by using a clock within IRF=K as well as a clock within IRF=$K^{/}$, **must** be the same: One must have simultaneously that $vt_D^{/} = vt_D$: And thus that:

$$t_D = t_D^{/} \qquad (21)$$

Thus, when the spherical wave-front within IRF=$K^{/}$ reaches the detectors at the exact-same radial positions $R_D^{/}$ at time $t_D^{/}$, its relativistic-“twin” wave-front within IRF=K must be at a the exact-same radial-distance $R_D = R_D^{/}$ from 0 at the same instant in time $t_D = t_D^{/}$ within IRF=K. As already pointed out above, these wave-fronts are **not** simultaneous-coincident, as they would have been if the Galilean-transformation applied. The relativistic-“twin” wave-front within IRF=K must, at the instantaneous, synchronous instant in time $t_D = t_D^{/}$, be the same as the wave-front shown within Fig. 5 when v/c=0. One has for the two wave-fronts at any instant in time that there are points for which $x=x^{/}$, $y=y^{/}$, and $z=z^{/}$ even though these points do not coincide.

The positions of the LT-detectors for v/c=0.5 and v/c=0.9 within IRF=K, which find themselves at the instant in time $t_D = t'_D$ situated within the spherical volume of the relativistic-"twin" spherical wave-front around 0, have already been reached by this wave-front at times before the time within IRF=K became $t_D = t'_D$. The latter conclusion seems to fly in the face of causality: How can it be "known" within IRF=K that an event is going to occur within IRF=K$^{/}$ before it actually occurs within IRF=K$^{/}$? On the other hand, if there is not a primary event within IRF=K$^{/}$ at t'_D there will also not be a LT-event within IRF=K. Thus, although a LT-event can occur within IRF=K before the primary event occurs within IRF=K$^{/}$, it will not occur unless the primary event does not actually occur within IRF=K$^{/}$: It is thus still caused by the primary event within IRF=K$^{/}$ (see also section 3.1 below).

When the time now increases further, this relativistic-"twin" wave-front within IRF=K expands further away from its origin 0 to reach the LT stationary position-coordinates of the other detectors, situated at larger, transformed distances $R_D = R_{LD}(\theta', \varphi') > R'_D$ within IRF=K; so that these positions are reached at different times $t_D = t_{LD}(\theta', \varphi')$, which are larger than t'_D. Thus, when the Lorentz-transformation applies, some detectors are reached within IRF=K, **before** they are all simultaneously reached within IRF=K$^{/}$ at the time $t'_D = t_D$, and the rest are reached **after** the synchronous time t=t$^{/}$ within IRF=K **and** IRF=K$^{/}$ has increased to become larger than $t'_D = t_D$.

It is thus abundantly clear that the LT detector-coordinates within IRF=K are not simultaneously reached by the relativistic-"twin" spherical wave-front within IRF=K: The different times to reach the detectors are thus not related to two clocks keeping different time-rates within the two IRF's, but to the fact that the distances that light must travel with the constant speed c within IRF=K, to reach the stationary LT-positions of the detectors, are not the same as referenced relative to 0$^{/}$ within IRF=K$^{/}$.

The latter conclusion mandates that the concept of "time-dilation" on a moving clock must be wrong physics. In fact, just as in the case of the Galilean-transformation, the instantaneous times on all perfect clocks within all inertial reference-frames must have been, still is, and must be exactly the same; ad infinitum (see again Eq. 21): And just as in the case of the Galilean-transformation the space-coordinates of two moving IRF's must be simultaneous-coincident at the same instant in time: The only difference is that, in the case of the Lorentz-transformation, a primary event which occurs within the moving IRF (IRF=K$^{/}$) at a position which **must** at that instant in time be simultaneous-coincident with a position within the "stationary" IRF (IRF=K), is not "observed", or referenced, at that instant in time and at this coincident position within IRF=K; unless this event occurs at the origins 0 and 0$^{/}$ when they coincide at the time t=t$^{/}$=0: An observer must be at the simultaneous-coincident position of the event in order to experience the event at the same time on the clocks (which keep synchronous time) within the two IRF's (see section 3.1 below).

3. Consequences

3.1 Three collinear, simultaneous events

Consider three equally-spaced, identical, primary events occurring simultaneously along the $x^{/}$-axis of IRF=$K^{/}$ at distances X apart (see Fig. 7).

In Fig. 7a, the origins of IRF=K and IRF=$K^{/}$ are chosen to coincide with the center-event when all three the events occur simultaneously. The events thus occur at the coordinate-positions $x_0^{/} = 0$, $x_+^{/} = X$ and $x_-^{/} = -X$ along the $x^{/}$-axis within the "moving" IRF=$K^{/}$; at the instant in time $t=t^{/}=0$. Using the expressions in Eq. 5, the corresponding LT position-coordinates x_{L0}, x_{L+}, x_{L-}, and LT time-coordinates t_{L0}, t_{L+}, t_{L-}, can be derived:

(i) The event at $x_0^{/} = 0$ gives that:

$$x_{L0}=0 \text{ and } t_{L0}=0 \qquad (22)$$

This LT-event is coincident and occurs simultaneous-instantaneously at the same time and position within both IRF=$K^{/}$ and IRF=K.

(ii) The event at $x_+^{/} = X$ gives that:

$$x_{L+} = \gamma X \text{ and } t_{L+} = \gamma\left(\frac{v}{c^2}\right)X \qquad (23)$$

This LT-event occurs within IRF=K further away from the origin 0 than it occurs from the origin $0^{/}$ within IRF=$K^{/}$, and it occurs at a later time than t=0. When it occurs within IRF=K, the origins 0 and $0^{/}$ of IRF=K and IRF=$K^{/}$ do not coincide anymore but are a distance vt_{L+} apart.

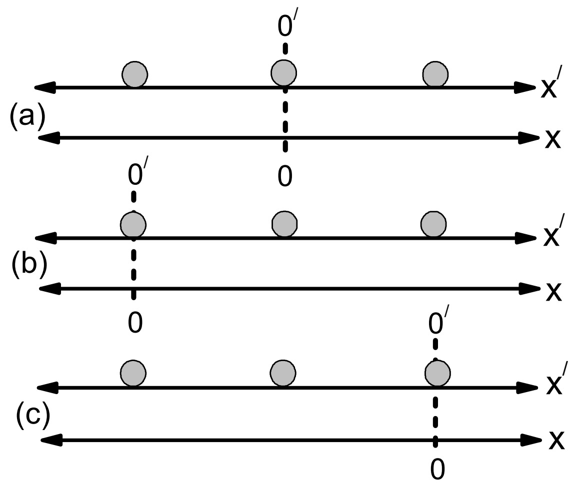

Figure 7: Three identical collinear events (circles), spaced a distance X apart, occurring along the $x^{/}$-axis of a moving IRF=$K^{/}$: (a) Choosing the origins 0 and $0^{/}$ to coincide at the centre-event; (b) Choosing the origins 0 and $0^{/}$ to coincide at the trailing-event; (c) Choosing the origins 0 and $0^{/}$ to coincide at the leading event.

(iii) The event at $x'_- = -X$ gives that:

$$x_{L-} == -\gamma X \text{ and } t_{L-} = -\gamma\left(\frac{v}{c^2}\right)X \qquad (24)$$

This LT event also occurs within IRF=K further away (along the negative x-direction) from the origin 0 than it occurs from the origin $0'$ within IRF=K$'$. In addition the time at which it occurs, t_{L-}, is now negative, so that the transformed event occurs within IRF=K before it occurs within IRF=K$'$. The latter "anticipation" of the event within IRF=K, is (also here) the result of the non-simultaneity within IRF=K, of separated, simultaneous events within IRF=K$'$: It is, however, still causal since the LT event will not materialise unless there is a primary event within IRF=K$'$. The origins 0 and $0'$ are thus a distance $-v|t_{L-}|$ apart when the LT event occurs within IRF=K: i.e. the LT event happens before synchronization: This demands that the clocks within IRF=K and IRF=K$'$ must have always kept the exact same time.

The rule is as follows: When a primary-event event occurs at an actual distance X from the origin $0'$ within IRF=K$'$, while this primary-event is moving away from the origin 0 within IRF=K, the non-simultaneous Lorentz time-difference between the clocks, when the LT-event occurs within IRF=K, is positive: The LT-event is in the "Lorentz-future" since it occurs **later** within IRF=K than the primary-event occurs within IRF=K$'$; which means that the origins 0 and $0'$ have moved further apart when the LT-event occurs within IRF=K. When the primary-event occurs at an actual distance X from the origin $0'$ within IRF=K$'$, while this primary-event is moving towards the origin 0 within IRF=K, the non-simultaneous Lorentz time-difference between the clocks, as judged from 0, is negative: The LT-event is in the "Lorentz-past" since it occurs **earlier** within IRF=K than the primary-event within IRF=K$'$; and at a distance between the origins when the origins are still moving towards one another.

To summarize: Only when a primary-event within IRF=K$'$ occurs at the position of the coinciding origins, is the transformed-event simultaneous-coincident within IRF=K. When not, the transformed-event occurs at a further-distance from the origin 0 (within IRF=K) than the primary-event occurs from the origin $0'$ (within IRF=K$'$) and at a different, non-simultaneous time on a clock within IRF=K, than the primary-event occurs according to a synchronous clock within IRF=K$'$. This is further proof that the time differences for events within two passing IRF's have nothing to do with a clock within IRF=K$'$ keeping time at a different rate than a clock within IRF=K. The clocks keep the exact same time: An LT-event, which does not occur at the coincident origins, occurs relative to the origin 0 within IRF=K at a non-simultaneous time and a noncoincident position than the simultaneous time and the coincident position at which it actually occurs within the two IRF's.

One could just as well have chosen the coinciding origins 0 and $0'$ at the trailing event (see Fig. 7b). In this case the transformation of the trailing event will be observed to be simultaneous and coincident with the primary event: The LT center-event is obseved to occur at a non-coincident position which is further away, and at a later non-simultaneous time than the actual time at which the primary-event occurs. The LT leading-event is observed to occur at non-coincident position which is even further away and at an even later non-simultaneous time than the primary-event. When choosing the origins to coincide at the leading event, the Lorentz-transformation of this event will be simultaneous and coincident with the primary event, while the LT trailing event will occur at a non-simultaneous time before the primary-event and at a non-coincident distance which is further away than 2X from the origin 0 within IRF=K. The LT center-event will also occur at a non-simultaneous time before the primary event occurs, and also at a non-coincident distance which is further away than X from the origin 0 within IRF=K. Thus, whether a transformed event within IRF=$K^{/}$ is simultaneous-coincident within IRF=K, is determined by the choice of the origins within IRF=K and IRF=$K^{/}$.

If there are more than one observer at different positions within IRF=K, each observer will experience events within IRF=$K^{/}$ as if he/she is at the origin of IRF=K. Each one will thus experience the events differently. This means that the physics does change when different space-time origins are chosen: And this, in turn, serves as further evidence that Minkowski's space-time cannot model the actual physics of the Special Theory of Relativity.

3.2 The light clock

A well-known thought-experiment, which can be found in most text books on modern physics, is based on a fictitious light-clock: The clock is imagined to consist of a pulse of light that is cyclically, vertically reflected between two mirrors spaced a height-distance L_M apart (see Fig. 8a). Two identical clocks at the respective origins 0 and $0^{/}$ within IRF=K and IRF=$K^{/}$, are synchronized when these origins 0 and $0^{/}$ coincide, so that the light pulse starts off from the bottom-mirror, to the top-mirror, where it is reflected back to the bottom-mirror to be again reflected; and so forth. For an observer travelling with the clock in IRF=$K^{/}$, the time $\Delta\tau_S^{/}=2\Delta\tau^{/}$, required to complete a single up-and-down cycle, is given by:

$$\Delta\tau_S^{/}=2\Delta\tau^{/}=\frac{2L_M}{c} \qquad (25)$$

If one could view the clock at $0^{/}$ (within IRF=$K^{/}$), from IRF=K, the situation is as shown in Fig, 8b: The pulse of light moves at an angle from the vertical towards the top-mirror where it is reflected to move at an angle from the vertical to the bottom-mirror.

If the Galilean-transformation could have applied, the observer within IRF=K, would have seen the light-pulse following the dashed path in Fig. 8b (at an angle to the vertical) from the bottom-mirror to the top-mirror, while the clock at $0^{/}$ moves a distance $v\Delta\tau^{/}$ from the origin 0. The speed c_M with which the light-pulse would have been observed within IRF=K can be obtained by using the theorem of Pythagoras; and is found to be.

$$c_M = c\sqrt{1+\frac{v^2}{c^2}} \qquad (26)$$

But the observer in IRF=K cannot see this light-speed since within his/her inertial reference-frame IRF=K, light **can only** move with the invariant speed c. This means that the light-pulse cannot reach the top-mirror during the time interval $\Delta\tau^{/}$ but requires a time-interval $\Delta\tau>\Delta\tau^{/}$, so that the inclined path-length within IRF=K, must be given by $c\Delta\tau$. This, in turn, means that within IRF=K, the light-pulse reaches the top-mirror when the distance between the origins 0 and $0^{/}$ has become $v\Delta\tau$. The vertical distance is still $L_M=c\Delta\tau^{/}$, but the horizontal distance is now $v\Delta\tau$, and the distance that the light has travelled is $c\Delta\tau$. By again applying the theorem of Pythagoras and taking cognizance of the symmetry of the up and down motions, one now obtains that:

$$\Delta\tau_S = 2\Delta\tau = \frac{2L_M}{c\sqrt{1-\frac{v^2}{c^2}}} = \gamma\frac{2L_M}{c} = \gamma 2\Delta\tau^{/} = \gamma\,\Delta\tau_S^{/} \qquad (27)$$

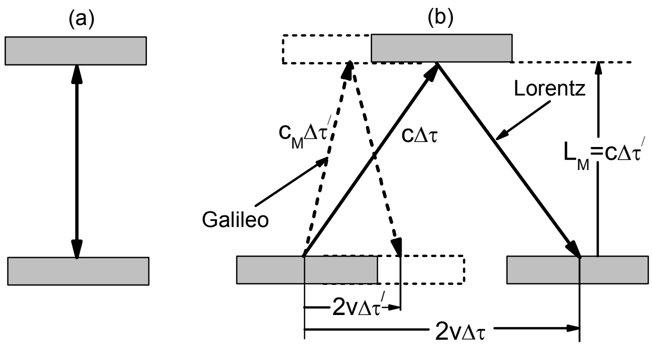

Figure 8: A light clock consisting of a pulse of light which moves to and fro between two mirrors: (a) The clock is stationary. (b) The clock is moving past at a speed v: When the light-pulse reaches the top-mirror, the clock has moved through a horizontal distance $v\Delta\tau^{/}$: If the Galilean transformation were valid the inclined path followed by the light-pulse would be the dashed path which requires the light-pulse to travel at a higher speed than the speed of light c: The Lorentz-transformation demands that the speed of light must remain c: Thus, the light-pulse will be observed to follow a longer inclined path (the solid path). While following this longer path, which requires a time interval $\Delta\tau>\Delta\tau^{/}$, the clock itself moves further to cover a longer horizontal distance $v\Delta\tau$. According to a stationary observer the light-pulse reaches the top-mirror at a later, non-simultaneous time than the actual time $\Delta\tau^{/}$ which is observed when moving with the clock.

Thus, although the time-interval $\Delta\tau_S$ is longer than $\Delta\tau_S^{/}$, this increase in time is required by the fact that, within IRF=K, the light pulse reaches the top mirror at a **later** time than it reaches the top mirror within $IRF=K^{/}$.

It has been erroneously accepted for more than 100 years that the light-pulse reaches the top-mirror simultaneously within IRF=K and $IRF=K^{/}$, and therefore the time-rate of the moving clock must be slower. This has led to paradoxes, which became accepted as correct physics. A paradox in physics is usually an indication that, at worse, the theory is wrong; or, at best, that the model, or interpretation, developed in terms of the theory is wrong! In the present case the physics only becomes non-paradoxical when it is accepted that the Lorentz-transformation is the "terminator" of events which would have been simultaneous if the Galilean-transformation could have applied: Just as Einstein also correctly concluded in 1905.

The light clock has also been used to "derive" "length-contraction". A typical example is found in the physics lectures of Prof. Michael Fowler of the University of Virginia [17]. The scenario is as follows: "*Imagine Jack standing on the ground with his light clock next to a straight railroad line, while Jill and her clock are on a large flatbed railroad wagon which is moving down the track at a constant speed v……*

Consider now the following puzzle: suppose Jill's clock is equipped with a device that stamps a notch on the track once a second. How far apart are the notches? From Jill's point of view, this is pretty easy to answer. She sees the track passing under the wagon at v meters per second, so the notches will of course be v meters apart. But Jack sees things differently. He sees Jill's clock to be running slow, so he will see the notches to be stamped on the track at intervals of $1/\sqrt{1-v^2/c^2}$ *seconds (so for a relativistic train going at v = 0.8c, the notches are stamped at intervals of 5/3 = 1.67 seconds). Since Jack agrees with Jill that the relative speed of the wagon and the track is v, he will assert the notches are not v meters apart, but* $v/\sqrt{1-v^2/c^2}$ *meters apart, a greater distance. Who is right? It turns out that Jack is right, because the notches are in his frame of reference, so he can wander over to them with a tape measure or whatever, and check the distance. This implies that as a result of her motion, Jill observes the notches to be closer together by a factor* $\sqrt{1-v^2/c^2}$ *than they would be at rest. This is called the Fitzgerald contraction, and applies not just to the notches, but also to the track and to Jack—everything looks somewhat squashed in the direction of motion!"*

We all agree that the railroad track is stationary within Jack's reference-frame, so that, even though Jill stamps coincident notches on the railroad track, the positions of the notches from Jack's perspective, who is situated at the origin of his reference-frame, is determined by the Lorentz-transformation, according to which an event, of stamping a notch at a position which does not coincide with the position of Jack, is not observed by Jack to be simultaneous-coincident with Jill's action within her IRF. It is purely for the latter reason why Jack observes the notches to appear consecutively at distances which are $v/\sqrt{1-v^2/c^2}$ apart.

This does not require that Jill's clock must be running slower. Neither does it mean that any distance within Jack's IRF will become contracted when viewed from Jill's IRF: As already argued in section 1 above, the Lorentz-transformation is only valid for a primary event from a "moving" IRF into a "stationary" IRF relative to which the "moving" IRF is moving: Jack's observation of the transformed position coordinates of the primary-events (Jill stamping notches within IRF=$K^{/}$) is not a primary event within Jack's IRF=K which can, therefore, be transformed back into Jill's IRF=$K^{/}$. Einstein made the same mistake when he "derived" a contraction in length of a moving rod [18].

To deduce that a length within Jack's IRF will appear contracted within Jill's IRF, one must use the reverse Lorentz-transformation for primary events within Jack's IRF=K into Jill's IRF=$K^{/}$. This requires that Jack must be moving with a speed –v along a railroad track which is now stationary within Jill's inertial reference frame IRF=$K^{/}$. If Jack now stamps a mark every second on the railroad track, which he is sure must be v meters apart and will be v meters apart if the Galilean-transformation applied, Jill will see the notches appearing within her IRF=$K^{/}$ at distances $v/\sqrt{1-v^2/c^2}$ apart. Thus, she will also see an **increase** in these distances! Even if Jack decides to stamp the notches at times $1/\sqrt{1-v^2/c^2}$ apart, Jill will then see the notches appearing even further apart at distances $v/\left(1-v^2/c^2\right)$. There is thus no length-contraction within Jill's IRF, of a length in Jack's reference-frame; or a length-contraction within Jack's IRF, of a length within Jill's reference frame.

But is the argument correct that Jack will, after Jill's passage, actually measure the longer distances "*because the notches are in his frame of reference, so he can wander over to them with a tape measure or whatever, and check the distance*"? Assume that there are telephone poles along the track and Jack stands at one of them. When Jill passes by, their clocks are coincident, and the notch appears at their coincident positions. This also means that Jill will, from her perspective, stamp a notch onto the railroad track at the position of every pole along the railroad track. Jack can now take up a position at any one of the poles and he will observe that when Jill passes by, so that their origins coincide, a notch is left on the track exactly at the position of the pole at which he is standing (see also section 3.1 above).

Alternatively, one can have an army of Jacks, each manning a pole, and each one will see a notch appearing exactly at the position of the pole at which he is standing when he coincides with Jill: However, each Jack will conclude that the other Jacks must be lying, since from his position, he did not see the notches appearing precisely at the positions of the other poles. Nonetheless, the Jacks can check the positions of the notches after Jill has passed by "*because the notches are in **their joint** frame of reference, so **they can all** wander over to the poles with a tape measure or whatever, and check the distance*" between the notches.

Will they really find the notches further apart? It seems highly unlikely. It seems less absurd to conclude that they will measure all the distances to be equal to v: Each one of the events must thus have actually occurred simultaneous-coincidently within Jack's and Jill's inertial reference-frames; just as would be the case when the Galilean-transformation applies. The longer lengths at the other poles are only observed by each one of the Jacks since each one of them remains stationary at the position of a single pole. Each one of them forms an origin within IRF=K when the event occurs at his position. But after Jill has stopped, they can all wander along the railroad track and measure the notches to be distances v apart: Thus it turns out that Jill is right!

3.3 Einstein's time-dilation

Einstein "deduced" time-dilation by using the Lorentz-equation for time transformation. If the time-unit on the moving clock is $\Delta\tau_s^/$ within IRF=K$^/$ (which can be taken as one second, as Einstein did), he argued that after synchronization, and the elapse of one unit in time $\Delta\tau_s^/$ on the moving clock within IRF=K$^/$, the Lorentz-transformed time-lapse within IRF=K must be given by Eq. 5d as:

$$\Delta\tau_{Ls} = \frac{\Delta\tau_s^/}{\sqrt{1-\frac{v^2}{c^2}}} = \gamma\Delta\tau_s^/ \qquad (28)$$

He then interpreted this result as follows [19]: "*As judged from K* (IRF=K in the present discussion)*, the clock is moving with the velocity* v*; as judged from the reference-body* (IRF=K in the present discussion)*, the time which elapses between two strokes of the clock* (within IRF=K$^/$) *is not one second* (the time-interval $\Delta\tau_s^/$ in the present discussion) *but* $\gamma\Delta\tau_s^/$ *seconds: i.e. a somewhat larger time. As a consequence of its motion the clock goes more slowly than when at rest.*

To reach the conclusion that the moving clock keeps time at a slower rate, Einstein inherently accepted that the LT time $\Delta\tau_{Ls}$ is **simultaneously** the time on the clock within IRF=K when the time on the clock within IRF=K$^/$ is $\Delta\tau_s^/$. But Eq. 28 (obtained by using Eq. 5d) is only one-half of the Lorentz-transformation: Eq. 5a **must** also be used, and according to this equation, a transformed distance D_{Ls} is obtained (for the position of the origin $0^/$ within IRF=K$^/$) from the origin 0 within IRF=K which is given by:

$$D_{Ls} = \gamma(v\Delta\tau_s^/) = \gamma D_s^/ \qquad (29)$$

Where $D_s^/ = v\Delta\tau_s^/$ is the distance between 0 and $0^/$ at the instant in time $\Delta\tau_s^/$. Thus, according to Eq. 29, the distance between 0 and $0^/$ at the time $\Delta\tau_{Ls}$ must be D_{Ls}, which is not the same as $D_s^/$.

The clock at the origin $0^/$ of IRF-K$^/$, which is, at the time-interval $\Delta\tau_s^/$, a distance $D_s^/$ from the origin 0 of IRF=K, is observed from the latter origin to be a distance $D_{Ls} > D_s^/$ from 0 when the clock at the origin 0 records the LT time-interval of $\Delta\tau_{Ls}$: The time $\Delta\tau_{Ls}$ on the clock within IRF=K, is thus not instantaneous-simultaneous with the time $\Delta\tau_s^/$ on the clock within IRF=K. In fact, when the clock within IRF=K records the time $\Delta\tau_{Ls}$, the clock within IRF=K$^/$ must instantaneous-simultaneously also record the same time $\Delta\tau_{Ls}$. Similarly, when the time on the clock in IRF=K$^{/}$ is $\Delta\tau_s^{/}$, the clock within IRF=K must instantaneous-simultaneously record the same time $\Delta\tau_s^{/}$.

Eq. 28 and Eq. 29 demand that the transformed time-interval $\Delta\tau_{Ls}$ is **only** recorded by the clock within IRF=K after the two clocks have moved further apart to be at a larger distance D_{Ls} from one another than the distance $D_s^{/}$ at which they were apart when the time on the moving clock was $\Delta\tau_s^{/}$. This is confirmed by the fact that $D_{Ls} / \Delta\tau_{Ls} = v$; which is the relative speed with which the two clocks are moving apart.

This (again) compellingly demands that the two clocks must keep time at exactly the same rate: The "time-dilation", given by Eq. 28 can thus (again) **not** be caused by the "moving" clock keeping time at a **slower** rate than the "stationary" clock. It only means **that the time at which a <u>primary event</u> occurs at the position of a "moving" clock**, cannot be instantaneous-simultaneously recorded as an event, by a non-coincident "stationary" clock when the Lorentz-transformation applies; even though the times on both clocks are instantaneous-simultaneously **always** exactly the same and even though the event is actually **simultaneous-coincident** within both IRF's.

3.4 Einstein's train

Einstein proposed the following thought experiment to illustrate non-simultaneity when the Lorentz-transformation applies [19]: He considered a train passing through a station when two lightning bolts strike the embankment instantaneous-simultaneously at a position A near the tail of the train, and a position B near the nose of the train; a lateral distance 2D apart. When the lightning bolts strike, there is an observer M on the platform standing precisely midway between the lightning bolts at points A and B; as well as an observer M$^{/}$ on the train, so that the latter observer is also, at that moment, instantaneously midway between A and B. They also synchronize their clocks at that instant in time, so that the observer M$^{/}$ is situated at the origin 0$^{/}$ on the train and the observer M is situated at the origin 0 on the platform. A top-down view, when the lightning bolts strike, is schematically given in Fig. 9.

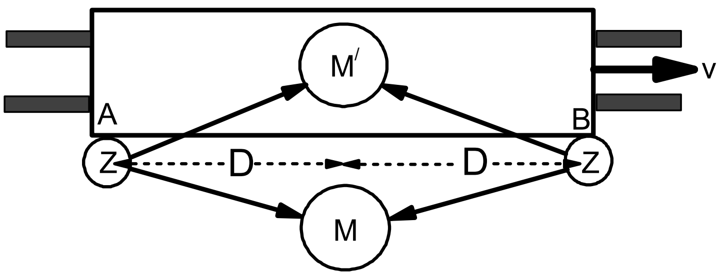

Figure 9: A schematic top-down view of a railway-coach passing through a station with speed v when two lightning bolts strike the embankment simultaneously at positions A and B apart: An observer M on the platform is midway between the lightning-bolts and an observer M$^{/}$ on the train is also, at that instant in time, midway between the lightning bolts.

Einstein argued that since M on the platform is not moving relative to the positions where the lightning bolts struck, he/she remains midway between A and B; so that "*the flashes of lightning A and B would reach him simultaneously; i.e. they would meet just where he is situated*". In the case of $M^{/}$ on the train, Einstein reasoned: "*Now in reality (considered with reference to the railway embankment) he is hastening towards the beam of light coming from B whilst he is riding on ahead of the beam of light coming from A. Hence the observer will see the beam of light emitted from B earlier than he will see that emitted from A. Observers who take the railway train as their reference body must therefore come to the conclusion that the lightning flash B took place earlier than the lightning flash A. We thus arrive at the important result: Events which are simultaneous with reference to the embankment are not simultaneous with respect to the train, and vice versa.*

Inherent in Einstein's argument is the following: According to the observer M on the platform the light-pulse emitted from position B must be approaching the observer $M^{/}$ on the train with a speed that is higher than the speed of light (i.e. with a speed c+v) while the light-pulse emitted from position A must be approaching this observer $M^{/}$ with a speed that is lower than the speed of light (i.e. with a speed c-v): Thus, the fact that the observer $M^{/}$ on the train sees the light-pulse from B, before seeing the light-pulse from A, has, according to Einstein's argument, nothing to do with the constant speed of light relative to a moving body (in this case $M^{/}$). The speed of light can only be different from c relative to $M^{/}$ when the Galilean-transformation applies! In fact, Einstein's argument in this thought-experiment violates his own postulate that the speed of light must have the same value c relative to both M and $M^{/}$.

So why does $M^{/}$ see the light from B before he sees the light from A? According to $M^{/}$ the platform is moving past him with a speed –v: Owing to the constant speed of light relative to him, the distances D must become $D^{/}$; which are both longer than D (see previous section 3.1), and since the event at B is "moving" towards him, the lightning flash at B must **actually** occur at a non-simultaneous, earlier time on the clock on the train before it occurs on the synchronous clock on the platform. The event at A moves away from $M^{/}$ and must thus actually occur on the clock on the train at a non-simultaneous, later time than it occurs on the synchronous clock on the platform.

An alternative take on Einstein's train can be found in Fowler's lecture notes [16]: In this case the synchronization of two clocks, which are spaced apart, is discussed. The two clocks with photocells are placed at the back and the front of a railway coach with a light at the center of the coach between them. It is common cause that when the light-bulb flashes, then, within the train, the light will approach the two clocks with the same speed c and they should thus commence keeping time at the same instant in time: The situation as seen from the embankment is illustrated in Fig. 10. Since the light is stationary on the train, the light reaching the detectors which are also stationary on the train are both primary events.

Quoting again from Fowler [17]: "*Let's look carefully at the clock-synchronizing operation as seen from the ground. In fact, an observer on the ground would say the clocks* *are **not** synchronized by this operation! The basic reason is that he would see the flash of light from the middle of the train travelling at **c relative to the ground** in each direction, but he would also observe the back of the train coming at v to meet the flash, whereas the front is moving at v away from the bulb, so the light flash must go further to catch up."*

The latter is clearly the same argument that Einstein has used, and just as in that case this argument is only valid if the Galilean-transformation could have manifested. It has nothing to do with the Lorentz-transformation! In order to "erase" this Galilean-aspect of his argument, Fowler argues that: "*In fact, it is not difficult to figure out how much later the flash reaches the front of the train compared with the back of the train, as viewed from the ground. First recall that as viewed from the ground the train has length* $L\sqrt{1-v^2/c^2}$ *"*

Letting t_B be the time it takes the flash to reach the back of the train, it is clear from the figure that

$$vt_B + ct_B = \frac{L}{2}\sqrt{1-\frac{v^2}{c^2}}$$

from which t_B is given by

$$t_B = \frac{1}{c+v}\frac{L}{2}\sqrt{1-\frac{v^2}{c^2}}$$

In a similar way, the time for the flash of light to reach the front of the train is (as measured by a ground observer)

$$t_F = \frac{1}{c-v}\frac{L}{2}\sqrt{1-\frac{v^2}{c^2}}$$

End of quote!

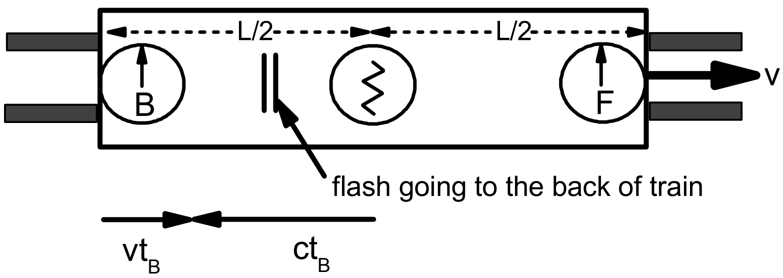

Figure 10: Quoting from [17]: "The train is moving to the right: the central bulb emits a flash of light. Seen from the ground, the part of the flash moving towards the rear travels at c, the rear travels at v to meet it."

Let us now do this derivation to ensure that light moves with the same speed c relative to all moving objects, and thus also those that approach or move away from the emitted light. In other words the observer on the platform must see the emitted light approaching the back of the train with the speed c, and not with the speed (c+v); and also the front of the train with the same speed c, and not with the speed (c-v).

The times to reach the back and the front of the train have already been correctly derived in section 2, and are given for the back of the train when setting $R_D^{/} = L/2$, $\varphi^{/} = \pi/2$, and $\theta = -\pi$, in Eq. 18, to obtain t_B as:

$$t_B = \gamma\frac{L}{2c}\left(1-\frac{v}{c}\right) = \frac{1}{c+v}\frac{L}{2}\sqrt{1-\frac{v^2}{c^2}} \qquad (30)$$

When now setting $\theta = \pi$, one obtains t_F:

$$t_F = \gamma\frac{L}{2c}\left(1+\frac{v}{c}\right) = \frac{1}{c-v}\frac{L}{2}\sqrt{1-\frac{v^2}{c^2}} \qquad (31)$$

The mahematical formulas are the same as in reference [17] (see above): But the physics is not!

As discussed in section 2 the distances at which the light-pulses reach the back and front of the train, as observed from the platform, are given by Eq. 17, according to which these distances are $L_B/2=ct_B$ and $L_F/2=ct_F$. Thus, the light pulses move with exactly the same speed c relative to the back and the front of the train, also when viewed from the platform. But (as viewed from the platform) the light pulse reaches the back of the train before the light-pulse within the train actually reaches the back (when viewed within the train), and (as viewed from the platform) the light pulse reaches the front of the train, after the light-pulse within the train reaches the front of the train (when viewed within the train).

The clocks on the train do not keep a slower time rate than a clock on the platform. No matter when and how they are synchronized, all the clocks on the train and all the clocks on the platform keep the same simultaneous-instantaneous, synchronous time. The only difference is that the times for the events on the train, are observed from the platform to be non-coincident and non-simultaneous to the primary events that occur on the train.

But does this mean that the two clocks are synchronised with reference to the train but not with reference to the platform? Not at all! Although it is observed from the platform that the light pulses reach the clocks at different positions and time, the event of a light pulse reaching a detector is actually simultaneous-coincident with reference to both the train and platform. Thus the clocks will be synchronised even though from the platform it seems that they cannot be synchronized in this way. What is seen from the platform are not the primary events, which determine that the clocks must be synchronized, but a relativistic “distortion” of these events.

Consider the following thought experiment. When the train passes, there are a row of closely-spaced clocks on the platform which keeps synchronous time. Each clock on the train has a mechanism that switches off the clock on the platform that coincides with this clock on the train when the light pulse reaches the clock on the train. After the train has passed, an observer on the platform will swear that the two light pulses did not reach the two clocks on the train simultaneously. But he/she can afterwards wander and look at the row of clocks on the platform. He/she will find that the two clocks that were stopped by the clocks on then train, read the exact same time, and are spaced at exactly the same distance apart as the two clocks on the train.

But why does Fowler's derivation [17] give the same formulas as those in Eq. 30 and Eq. 31? These equations have been derived by Fowler in the same manner that Lorentz would have derived them before Einstein realized that the Lorentz-transformation is not caused by a Lorentz-Fitzgerald contraction, but by the fact that the speed of light must be the exact same value relative to any object, no matter how such an object is moving. Although the Lorentz-Fitzgerald contraction gives the same results, Einstein's postulation of his Special Theory of Relativity, immediately made the Lorentz-Fitzgerald contraction redundant: It should never again have been invoked: Also not by Fowler. There is no length-contraction, since the arm of a Michelson-Morley interferometer does not need to contract to explain the famous null result: It is fully explained by Einstein's postulate that the speed of light relative to all bodies must be c and nothing else but c.

4. Discussion

The deductions above are compellingly not consistent with "length-contraction", nor with "time-dilation" and also not with Minkowski's space-time being physics-realities. The time-difference observed for the same event within a "moving" and a "stationary" inertial reference-frame is caused by non-simultaneity of the same event within the two IRF's, as recorded by clocks which keep the exact same synchronous time within all IRF's. Time is thus not a fourth coordinate which is instantaneously different at different separate positions within free-space. It is, in fact, a global parameter which is instantaneously the same at all positions in space, independent of the velocity of a clock at that point.

In the latter respect, Newtonian space-time and Einsteinian space-time do not differ at all. If it were possible to instantaneously stop time everywhere and to teleport an observer from one position in space to another, the observer will find that all perfect clocks, if they have been synchronized at any time, are showing the exact same time, and that all events, occurring at that instant in time, are coincident within all the IRF's.

What is really happening is that the position-coordinates for an event occurring within IRF=$K^{/}$ at a time $t^{/}$, are Lorentz-transformed to be at a non-coinciding position within IRF=K, and to occur at a non-simultaneous time within IRF=K: This happens to ensure that the relative speed of light relative to all objects, moving with any speed relative to one another, remains constant and equal to c; no matter within which inertial reference-frame the motion of light relative to any object is referenced. In other words, if a person on a motorcycle passes by, and switches on the headlight, **both** the cyclist AND a stationary observer along the road will see that the light is moving relative to the motorcycle with exactly the same speed c.

The latter conclusion differs from a thought-experiment discussed by Michio Kaku, in his book "Einstein's Cosmos" [20]. He assumes that a stationary observer witnesses a traffic officer who chases a speeding motorist, and then considers the situation when replacing the speeding motorist with a light beam. Kaku then writes that "*the observer concludes that the officer is speeding just behind the light beam, travelling almost as fast as light. We are confident that the officer knows he is travelling neck and neck with the light beam. But later, when we interview him, we hear a strange tale. He claims that instead of riding alongside the light beam, as we just witnessed, it sped away from him, leaving him in the dust. He says that no matter how much he gunned his engines, the light beam sped away at precisely the same velocity*".

According to the derivations above, the stationary observer will not be at odds with the traffic officer, since he/she will also observe that the light-beam speeds away from the officer at precisely the same velocity of magnitude equal to c; even though light-speed relative to the stationary observer is also the same speed c. It is difficult to imagine such a situation, but this is what the Lorentz-transformation demands that the situation must be. The problem has been that, even after Einstein's genius in 1905, all physicists (including Einstein) remained trapped within the paradigm of the Galilean-transformation: It can only be as Kaku describes if the stationary observer could add the velocities of the officer and the light-beam he is chasing according to the rules of Galilean-relativity. This is not possible when the speed of light must be the same relative to all objects, no matter with what speed they are moving.

Although the logic above is impeccable, physics is judged by experimental results: There are claims in the literature of experimental proof that a "moving" clock does keep slower time than a "stationary" clock. The most quoted experiment, which can be found in elementary textbooks on modern physics, involves cosmic-ray muons which are formed above the earth. Within a laboratory on earth, these muons decay with a half-life of $\Delta\tau_{\mu} \cong 2.2$ μs, which is so short, that most muons should not reach the surface of the earth from the height at which they are detected to be created: It has been consistently found that more muons reach the surface of the earth than would be the case if their half-life stayed the same value while travelling towards earth from this height. It is thus argued that this proves that a **clock, moving with such a muon,** must keep time at a slower rate than a stationary clock on earth.

In fact, the muon itself acts as the clock which starts ticking at a time $t'=0$ within the IRF=K', within which the muon is stationary when it is created within its IRF=K', and as measured within IRF=K' at a distance H' above the surface of the earth. At that same instant in time one can choose the time on the clock on earth to be t=0. In other words the origin $0'$ of the IRF=K' within which the muon is created at the height H', coincides at this instant in time with the position of the clock on earth at the origin 0 of the IRF=K.

That the decay of the muon will slow down within its own IRF=$K^{/}$ is unlikely, since the muon is stationary within its own IRF which is approaching the earth at a speed v. Within this IRF its decay-time is a primary event and it cannot be longer than for a muon which is stationary within a laboratory on earth. In both cases the respective IRF's act as primary reference-frames for the muon: So that in both cases the same lifetime must prevail. Thus, for such a muon, moving with speed v to reach the earth, the height $H^{/}$ above the earth at which the muon itself experiences its birth within its primary IRF=$K^{/}$, must be such that the time it takes the muon to reach the earth has to be less than, or at most equal to its actual "stationary" lifetime: Assuming that its average "stationary" decay-time $\Delta\tau_{\mu}$ is its lifetime, a muon can thus, on average, only reach the earth when:

$$H^{/} \leq v\Delta\tau_{\mu} \tag{32}$$

But since IRF=$K^{/}$ moves with speed v towards the earth (which is the "stationary" IRF=K from which the muon is being observed) the birth of the muon at time t=0 occurs at a height $H_{L\mu}$, which is higher than $H^{/}$, and thus, as just derived above (see Eq. 23), must be given by:

$$H_{L\mu} = \gamma H^{/} \tag{33}$$

Furthermore, the muon is born at a time $t_{L\mu}$ on the clock on earth, before this clock reads t=0 (see Eq. 24): i.e.

$$t_{L\mu} = -\gamma\left(\frac{H^{/}v}{c^2}\right) \tag{34}$$

According to the clock on earth, the muon has already lived for a time interval $\left|t_{L\mu}\right|$ before it forms within the IRF=$K^{/}$. After a further increase in time $\Delta\tau_{\mu}$ the muon reaches the earth. The time-interval $\left|t_{L\mu}\right|$ must thus be added to the actual lifetime $\Delta\tau_{\mu}$ of the muon to get the "relativistic-lifetime" $\Delta\tau_{L\mu}$ of the muon relative to the clock on earth within the IRF=K. One thus obtains that:

$$\Delta\tau_{L\mu} = \Delta\tau_{\mu} + \gamma\left(\frac{vH^{/}}{c^2}\right) \tag{35}$$

The amazing aspect is that according to the measurement from earth, the muon actually forms at a higher distance $H_{L\mu}$ and not at the height $H^{/}$, as measured within IRF=$K^{/}$. Thus relative to earth this distance elongates and does not contract. The muon reaches the earth owing to the non-simultaneity of the creation of the muon within IRF=$K^{/}$ and IRF=K. It thus has a longer half-life relative to earth, even though a clock travelling with the muon keeps exactly the same synchronous time that the clock on earth is keeping.

Although this seems weird, this interpretation is physically more consistent than assuming that the muon decays at a slower rate while it is stationary within its own primary inertial reference-frame, than it would be decaying as a stationary muon within a laboratory on earth; which, in this case, also acts as the muon's primary inertial reference frame. A muon **must** decay at the same rate within **any** IRF within which it is stationary; since such an IRF is its primary rest-frame. If not, Einstein's first postulate on which he based his Special Theory of Relativity must be null and void.

The height $H^{/}$ measured within IRF=$K^{/}$ gives the condition, which must be fulfilled for a muon to just reach the earth, but it is not the relativistic-reality observed from earth. The Lorentz-transformed change in position-coordinates for the approaching muon is thus a **real** change relative to earth: Just as the parabolic-path followed by a bomb dropped from an airplane is real relative to earth but not relative to the airplane from which it has been dropped.

Analyses have been done on data which had been gathered by flying atomic clocks in opposite directions around the world [21,22], and then, after returning them back to earth, comparing these clocks with a clock which remained "stationary" on earth . Since gravity and the Sagnac-effect [23] had to be taken into account, these analyses are complicated. It is claimed by the experimenters that the results they obtained, after subtracting all other effects, can only be explained by accepting that a moving clock actually keeps time within its own IRF at a slower rate than the "stationary clock" which remained on earth.

Since the conclusion, reached above, is that clocks moving at constant speeds relative to one another must keep the same synchronous global time-rate, the "flying-clock" data raise questions. On the other hand, these studies have been done on clocks which were first accelerated within a gravity-field, then decelerated and brought back together. The existence of a global time-rate on clocks moving with constant speeds relative to one another within gravity-free space, does thus not necessarily contradict the time differences measured when clocks have been accelerated and decelerated and stopped and then compared.

Nonetheless, it places a serious question mark behind the analysis and interpretation of this data. A better understanding of what happens during acceleration and deceleration is required. For example, when doing flying-clock experiments one should keep the acceleration and deceleration times the same for different clocks, while using different coasting-times during which the clocks move with a constant relativistic speed relative to one another within a constant gravity-field.

The concept of time-dilation on a moving clock is regularly invoked to claim that a space traveler, being sent away from the earth, will enter the future. See for example references [24], [25], and [26]. The same concept has also been used in science-fiction movies like "Star Trek" and "Planet of the Apes". This concept is also at the origin of the so-called "twin-paradox" according to which a twin who returns to earth after a long journey through space will be younger than his sibling who stayed behind.

When, however, comparing twins moving away from, and returning to one another, by assuming that acceleration and gravity-effects can be ignored, one obtains the following from the Lorentz-transformation: Twin1 who is leaving earth will move “into the Lorentz-future” of twin2 who remains on earth since every instant in time on the traveler’s clock will only register at a later LT-time on earth: But as soon as twin1 starts his/her return-journey, he/she will approach twin2 “from the Lorentz-past” since every instant in time on the traveler’s clock will now register ahead of time on earth. The “future-time” on the outgoing leg of the journey, and the “past-time” on the return-leg of the journey cancel, so that the twins must be the same age when they meet up again. More simply stated: The clocks of the twins keep simultaneous-instantaneous, exactly the same synchronized time during the whole journey.

6. Conclusion

The relativistic position and time of a primary event within an inertial reference-frame, which is “moving” relative to another “stationary” inertial reference-frame, are not coincident and also not simultaneous within the two IRF’s unless the event is referenced within the stationary inertial reference-frame at the exact coincident position in space where it occurs. Therefore the difference in times for the same event between the “moving” and “stationary” inertial reference-frames, is not the result of time-dilation on a “moving” clock or a length-contraction of a “moving” body: All perfect clocks when synchronized keep the same time ad infinitum; and all distances are instantaneously exactly the same within all IRF’s.

The latter conclusions do not mean that curved space-time is not responsible for gravity, but it does imply that the concepts of “time-dilation” and “length-contraction” which were incorrectly derived from Einstein’s Special Theory of Relativity, cannot be used to argue (as Einstein had done [27]) that there must be curved space-time. Neither can Minkowski’s space time be used for this purpose.

The Special Theory of Relativity demands a constant speed of light measured relative to all material bodies, while Einstein’s model of gravity does not demand that this must be so: It has been experimentally verified that light is refracted by a gravity-field and must thus move slower within such a field. This effect has probably very little to do with the Special Theory of Relativity. The reason for the existence of gravity might have another explanation: It might possibly be an emergent aspect of the wave-nature of matter.

References:

[1] J. C. Maxwell, A Dynamical Theory of the Electromagnetic Field, Philosophical Transactions of the Royal Society of London **155**, (1865) 459–512.

[2] A. A. Michelson & E. W. Morley, On the Relative Motion of the Earth and the Luminiferous Ether, American Journal of Science **34** (1887) 333–345.

[3] W Voigt, On the Principle of Doppler, Nachrichten von der Königl. Gesellschaft der Wissenschaften und der Georg-Augusts-Universität zu Göttingen **2** (1887) 41–51.

[4] H. A. Lorentz, Attempt of a Theory of Electrical and Optical Phenomena in Moving Bodies, Leiden (1895).

[5] J. Larmor, On a Dynamical Theory of the Electric and Luminiferous Medium, Part 3, Relations with material media, Philosophical Transactions of the Royal society of London **190** (1897) 205–300.
[6] J. Larmor, (1900), Aether and Matter, Cambridge University Press (1900).
[7] H. A. Lorentz, Simplified Theory of Electrical and Optical Phenomena in Moving Systems, Proceedings of the Royal Netherlands Academy of Arts and Sciences **1** (1899) 427–442
[8] H. A. Lorentz, Electromagnetic phenomena in a system moving with any velocity smaller than that of light, Proceedings of the Royal Netherlands Academy of Arts and Science **6** (1904) 809–831
[9] H. Poincaré, The Principles of Mathematical Physics, Congress of arts and science, universal exposition, St. Louis, Boston and New York: Houghton, Mifflin and Company **1** (1904). 604–622.
[10] G. F. FitzGerald, The Ether and the Earth's Atmosphere, Science **13** (1899) 390.
[11] H. A. Lorentz, The Relative Motion of the Earth and the Aether, Zittingsverlag Akad. V. Wet **1** (1892) 74–79.
[12] A. Einstein, Zur Elektrodynamik bewegter Körper, Annalen der Physik **17** (1905) 891-921.
[13] H. Goldstein, Classical Mechanics, Addison-Wesley, Reading (1959) p. 187.
[14] H. Poincaré, Sur la dynamique de l'électron, Rendiconti del Circolo matematico di Palermo **21** (1905/6) 129–176.
[15] H. Minkowski, Die Grundgleichungen für die elektromagnetischen Vorgänge in bewegten Körpern, Nachrichten von der Gesellschaft der Wissenschaften zu Göttingen, Mathematisch-Physikalische Klasse: (1907/8) 53–111.
[16] H. Minkowski, Raum und Zeit, Physikalische Zeitschrift **10** (1908/9) 75-88.
[17] M. Fowler, Special Relativity: What time is it? http://galileo.phys.virginia.edu/classes/252/srelwhat.html (2012).
[18] J. F. Prins, The length of a laterally moving rod, Physics Essays, submitted (2013).
[19] A. Einstein, Relativity: Special and General Theory, Crown Publishers, New York (1952) p. 35-37.
[20] M. Kaku, Einstein's Cosmos, Phoenix, London (2005) p.35.
[21] J C Hafele & R J Keating, Around-the-World Atomic Clocks: Predicted Relativistic Time Gains, Science **177** (1972) 166-168.
[22] J C Hafele & R J Keating, Around-the-World Atomic Clocks: Observed Relativistic Time Gains, Science **177** (1972) 168-170.
[23] G Sagnac, The demonstration of the luminiferous aether by an interferometer in uniform rotation, Comptes Rendus **157** (1913) 708–710.
[24] S. Hawking, A Brief History of Time (Bantam Books, New York, 1996) p. 22.
[25] K. S. Thorne, Black Holes and Time Warps (Papermac, London, 1995) p. 37
[26] M. Rees, Just Six Numbers (Weidenfeld & Nicholson, London, 2000) p. 33.
[27] A. Einstein, Relativity: Special and General Theory, Crown Publishers, New York (1952) p. 79-82.