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Time-arrow and the clarification of the "*peculiar consequence*" noted by Einstein

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Abstract

In a previous publication [5] it was shown the need and usefulness of the independent scalar variable τ, as an absolute time though keeping the coordinate x_4=ict, where t is the relative time, in order to handle accelerated movement in Mankowski space M4. Here I show how to formalize the concept of time-arrow using the independent scalar τ and thus prove that Einstein's *peculiar consequence* of relativity due to time dilation[2] in end effect implies no contradiction, in this manner the so called *symmetrical twin's paradox*[3] definitively vanishes.

Resumen

En una publicación anterior[5], se demostró la necesidad y utilidad de la variable escalar independiente τ, como tiempo absoluto, aunque manteniendo la coordinada x_4 = ict, donde t es el tiempo relativo, logrando así manejar el movimiento acelerado en el espacio de Mankowski M4. Aquí muestro cómo formalizar el concepto de *tiempo-saeta* usando el escalar independiente τ y así probar que la *consecuencia peculiar* de la Relatividad notada por Einstein, debido a la *dilatación del tiempo*[2] en efecto final no implica contradicción, de esta manera, la llamada *paradoja simétrica de los gemelos*[3] se desvanece definitivamente.

Newtonian Time

The dual meaning for the word "time" is clearly expressed by Newton in his book *Philosophiæ Naturalis Principia Mathematica* first published in 1687:

> Tempus absolutum, verum, & mathematicum, in se & natura sua sine relatione ad externum quodvis, aequabiliter fluit, alioque nomine dicitur duratio: Relativum, apparens, & vulgare est sensibilis & externa quzevis durationis per motum mensura (seu accurata seu incequabilis) qua vulgus vice veri temporis utitur; ut hora, dies, mensis, annus. [1]

One meaning he gives is of *absolute time*, true, and mathematical, of itself, and from its own nature, flows equably without relation to anything external.

The other meaning is of *duration*: *relative*, *apparent*, and common time, is some sensible and external measure of duration by the means of motion, which is commonly used instead of true time.

Instead of negating absolute time in Relativity Theory, the proposal in my publication *Trajectories in space-time M4: Reinstating the Newtonian time*[1], is to assign an independent scalar variable τ to absolute time and to express the relative time as the coordinate x_4=ict in Mankowski space M4. The combined use of both variables was applied to calculate the cosmic cloud G2 relativistic trajectory with quite accurate results.

Einstein's peculiar consequence of time dilation

In his 1905 relativity paper Einstein, in § 4 on the physical meaning of the formulas for moving clocks, he wrote the following intriguing paragraph:

> From this it results following peculiar consequence: if at the points A and B of K there are clocks at rest which, considered from the system at rest, are running synchronously, and if the clock at A is moved with the velocity v along the line connecting B, then upon arrival of this clock at B the two clocks no longer synchronize, but the clock that moved from A to B lags behind the other which has remained at B by $\frac{1}{2}tv^2/c^2$ sec. (up to quantities of the fourth and higher order), where t is the time required by the clock to travel from A to B. [2]

Remark: K refers to *ruhende Koordinatensystem* (coordinates system at rest)

This surprising result motivated some physicists like Langevin, Laue and Dingle to consider the so called *Twins or Clocks Paradox* as an argument to question Relativity Theory. Specially Herbert Dingle used it as an objection to the logical consistency of the theory with the following argument (also known as *the symmetrical clocks paradox*):

> According to the theory, if you have two exactly similar clocks, A and B, and one is moving with respect to the other, they must work at different rates,i.e. one works more slowly than the other. But the theory also requires that you cannot distinguish which clock is the 'moving' one; it is equally true to say that A rests while B moves and that B rests while A

moves. The question therefore arises: how does one determine, consistently with the theory, which clock works the more slowly? Unless the question is answerable, the theory unavoidably requires that A works more slowly than B and B more slowly than A - which it requires no super- intelligence to see is impossible. Now, clearly, a theory that requires an impossibility cannot be true, and scientific integrity requires, therefore, either that the question just posed shall be answered, or else that the theory shall be acknowledged to be false. [3]

Pair of time-arrows x and $\underline{x}$

Let us consider a formalization of the *time-arrow* concept using the independent scalar variable τ, which is not to be confused with the *Eigenzeit* defined as a length of arc in M4 expressed in time units, therefore it is not an independent scalar variable.

We consider M4 as a four-dimensional complex vector space. Let $\mathbf{x}$ and $\underline{\mathbf{x}}$ be two vectors in the luminic subspace $M4^-$ linked by a common pivot point, so that there is an angle $i\chi$ between both vectors which have a module (length from pivot to arrow point) given by:

$$(1) \quad |x| = |\underline{x}| = ic\tau$$

Remark: although both vectors have the same value module they have different directions defined by χ which is also a scalar variable that may be a function $\chi = \chi(\tau)$ otherwise a constant χ_0. In this sense we can consider $\mathbf{x}$ and $\underline{\mathbf{x}}$ as functions of τ.

Further we define the projection Pr of $\underline{\mathbf{x}}$ onto $\mathbf{x}$ and vice versa:

$$(2a) \quad Pr(\underline{\mathbf{x}} \rightarrow \mathbf{x}) \equiv |\underline{\mathbf{x}}| \cos i\chi = |\underline{\mathbf{x}}| \cosh \chi$$

$$(2b) \quad Pr(\mathbf{x} \rightarrow \underline{\mathbf{x}}) \equiv |\mathbf{x}| \cos i\chi = |\mathbf{x}| \cosh \chi$$

and also we define the projection Prn of $\underline{\mathbf{x}}$ onto the normal vector of $\mathbf{x}$ and vice versa:

$$(3a) \quad Prn(\underline{\mathbf{x}} \rightarrow \mathbf{x}) \equiv |\underline{\mathbf{x}}| \sin i\chi = |\underline{\mathbf{x}}| \text{ I } \sinh \chi$$

$$(3b) \quad Prn(\mathbf{x} \rightarrow \underline{\mathbf{x}}) \equiv |\mathbf{x}| \sin i\chi = |\mathbf{x}| \text{ I } \sinh \chi$$

Remark: The normal vector that is in the plane of $\mathbf{x}$ and $\underline{\mathbf{x}}$.

Applying this projections we define following relative t-variables:

$$(4a) \quad ict \equiv Pr(\underline{\mathbf{x}} \rightarrow \mathbf{x}) \qquad (4b) \quad ic\underline{t} \equiv Pr(\mathbf{x} \rightarrow \underline{\mathbf{x}})$$

Therefore we have:

$$(5a) \quad t = \tau \cosh \chi \qquad (5b) \quad \underline{t} = \tau \cosh \chi$$

Physical interpretation of the time-arrow vectors

Let us imagine two identical clocks C and $\underline{C}$ which are located at the head point of each time-arrow $\mathbf{x}$ and $\underline{\mathbf{x}}$, so that they follow trajectories in M4 according to the variation of τ and of the function $\chi(\tau)$. We assign the scalar variable τ to the instants marked by both clocks since there is no physical cause that could induce different rhythms just because they are moving relative to each other. Both clocks are capable to send electro-magnetic signals at equal intervals $\Delta\tau$.

Near to each clock C and $\underline{C}$ are installed a signal-receiver R and $\underline{R}$ specially designed to detect the signals sent by the other clock at each instant τ. We assign the variables t and $\underline{t}$

to the relative times of signal arrival from the moving clocks C and C to the also moving signal-receivers R and R corresponding to the send instant τ. This variables register the *time dilation* caused by the factor cosh $\chi(\tau)$ given in (5a) and (5b).

Remark: Here we understand by "moving clocks" moving the one relative to the other, we don't consider a preferred reference system. The same applies to the signal-receivers.

The *peculiar consequence* becomes clarified if we distinguish the absolute time τ used at clock synchronization (instants) from the relative apparent time used at the measurements of arriving signals (durations). It is interesting that in its conclusions of [4] Rodrigo de Abreu and Vasco Guerra express this idea from a different perspective but pointing to the same origin of conflicting misunderstanding: *Despite raising hot debates, the apparent conflicts are clearly solved by making the distinction between clock rhythms and clock time readings and by accepting there are quantities we may be unable to know*.

If we want to analyze the life-times of decaying particles at different velocities (μ-meson showers) we have to consider a time-arrow for each particle and one for the observatory clock which does not need to be considered "at rest". The measured life-times are given by the projections of the respective time-arrows of each particle onto the observatory clock time-arrow, thus the relative t-variables correspond to the measured life-times at different velocities, showing time dilation, but the "clocks" (the decaying particles them selves) decay with the same life-time given by the scalar τ as an intrinsic physical property of the kind of decaying particle which we are unable to measure directly, independent of its velocity. Time dilation is an apparent relativistic effect in this case, dependent on velocity of the decaying particle relative to the observatory signal (emited particle)-receiver.

Proper Cartesian Coordinates System

To each time-arrow **x** we build its Proper Cartesian Coordinate System X = {x1, x2, x3, x4} where $x_4 \equiv ict$. We trace the x_4 coordinate axis along the tetra-vector **x**. Thus the C clock is spacially at rest with coordinates {0,0,0, ict}, so that $t = \tau$. We can set the pivot point as {0,0,0,0} to the point in M4 where the clock C was at the initial time $\tau = 0$.

In X, the coordinates of the tip of **x** (clock C) are in the plane x-$\underline{x}$, so they are:

$x_1 = -\,|\,x\,|\sin(i\chi) = c\tau\sinh(\chi)$ $\quad x_2, x_3 = 0$ $\quad x_4 = |\,x\,|\cos(i\chi) = \iota\chi\tau\cosh(\chi)$

Since $|\,\underline{x}\,| = ic\tau = ic\underline{t}$ in $\underline{X}$ where clock $\underline{C}$ is spatially at rest, we have $t = \underline{t}\cosh(\chi)$.

As it was treated in detail in [5], from the above formulas we derive:

$$[5\text{-}5b] \qquad \beta(\tau) = \{\tanh(\chi(\tau)) + \alpha\tau\} / \{1 + \alpha\tau \tanh(\chi(\tau))\}$$

$$\text{where:} \quad \beta(\tau) \equiv v/c \quad v \equiv dx_1/dt \ \text{ and } \ \chi(\tau) = \chi_0 + \alpha\tau$$

Here $\beta(\tau)$ is the velocity (in c units) of clock $\underline{C}$ in accelerated movement relative to clock C which is spatially at rest in X. This function reaches a maximum $\beta(1.4) = 1.02048$ as discussed in [5].

The projection factors $\cosh(\chi)$ and $\sinh(\chi)$ in formulas (2), in the language of coordinates can be translated as the coefficients of the rotation matrix $\Lambda(\chi)$ that relates system $\underline{X}$ which is rotating relative to X as it was treated in [5]. When $\chi(\tau) = \text{constant}$, $\cosh(\chi)$ becomes the Lorentz coefficient $[1-\beta^2]^{-1/2}$.

Conclusions

Provided we introduce absolute time τ in the theory of space-time, the remark made by Einstein about a *peculiar consequence* of relativity can be clarified if we treat clocks at the same rhythm, because of equality (1), even if they move relative to each other, as common sense tells us, without detriment of relativistic time dilation valid for the relative, therefore apparent t-variables. Thus all related paradoxes vanish.

The Newtonian concept of absolute time that *flows equably* can also be understood with the help of the scalar variable τ, since so we can interpret the rate of flow as $dt/d\tau$ which can be set equal to one when the clock is spatially at rest in a system X.

The rotation matrix $\Lambda(\chi)$, where $\chi = \chi(\tau)$, represents a generalization of the Lorentz transformation for rotating coordinates systems (not only for fixed rotated systems).

In [5] it is shown how the independent scalar variable τ taken as the absolute time enables us to handle acceleration in space-time M4. A practical example of the G2 trajectory calculation was given. It was also suggested a posible explanation of a “black hole” due to time dilation which prevents signals from ever arriving to the observatory causing the apparent effect of “black hole” around a huge mass capable to accelerate a body to near c speed.

Acknowledgments

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References

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[4] 2013, Rodrigo de Abreu and Vasco Guerra , *Speakable and unspeakable in special relativity. I. Synchronization and clock rhythms.*

[5] 2013, Iván Guzmán de Rojas, *Trajectories in space-time M4: Reinstating the Newtonian Time* (http://vixra.org/abs/1311.0111)