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## IN WHAT SENSE CAN WE SAY THAT MOVEMENT PRECEDES SPACE AND TIME?

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### ABSTRACT

*The question of time is still not satisfactorily addressed in the various fields of thought. Without claiming to solve all the difficulties associated with it, we propose to insist on the link between time and space, as the theory of relativity invites us to do; but going further into the idea of a conceptual unity (relativity still keeps two distinct concepts, two types of instruments, rulers and clocks, and always considers in advance two sets of variables). A reflection of this kind cannot avoid a discussion on how our rationality works in building our knowledge. In composition with the more usual substantial rationality, it is appropriate to speak of a relational rationality: inside the world, we can only make comparisons / oppositions (time is not space, space is not time) without being able to assign to one or the other a list of characters of its own. In this context, we are led to give to movement a primary character (beginning with showing it, before defining it with words). Space and time are derived from it: space is associated with relatively slower movements than those on which we define time. This opens numerous consequences in physics and in humanities and social sciences.*

Keywords: space, time, movement, relation-based thinking, substance-based thinking, relativity theory, physics, humanities and social sciences, fiction, images

### 1. INTRODUCTION

Here, I will try to make you understand how I am dealing with the trilogy of concepts: time, space and movement. The topic is very general, and it might be of interest to different scientific disciplines. If I want to summarize the heart of my point, I would say that movement precedes both space and time that are derived from it. To make you grasp this idea, we could spend much time discussing epistemological and philosophical issues, or studying the working of clocks in relativity theory. I prefer to propose here a kind of thought experiment by use of some images.

Much could be said about some issues in epistemology and philosophy of knowledge at stake in my point: when one is dealing with time and space, the matter is not merely to build better clocks, better rulers; the matter is to discuss: what are we doing when we use such and such words in correspondence

with reality? The reader will refer to some papers on the subject e.g. [1], [2].

I will not discuss in details the consequences of my point of view in physics in the large, I will just list them. However, I will give some words about my proposition of a modified gamma factor for the Lorentz transformation: I presented it at the last general biennial conference of the French physical society, one year ago [3].

I would like to insist on the fact that, in order to make progress in physics today, it is imperative to make a detour through epistemological and philosophical reflection. This is a rather long and difficult work and we need to devote some time on it. But it is essential first to try to understand the point of view that I propose, at least as a game, even if one does not agree. Then everything can go faster. The applications are numerous and I will say a word about it, unfortunately not enough, because I do like equations!

### 2. TIME, SPACE, MOVEMENT

So let me present my vision of time. In my understanding, time does not exist. It does not exist alone, as an independent substance of the world. It is abstracted from the world, from which it cannot, ultimately, be separated. Specifically for me, time is abstracted from the movements in space of the material entities in the large. However, when we abstract time, we construct an object which has pragmatic effects that can be studied and discussed.

The understanding of time is the understanding of the abstraction of time. Let me make use of what French philosopher Bergson called the philosophical intuition [4], I call it the comprehensive, or relation-based thinking, often made of images, that comes in composition, not in opposition, with the discursive, disjunctive, substance-based thinking, mostly made of words. For issues that concern us, we especially need both. Let us then have, as Bergson also commented in this context, an artistic approach, trying to grasp at once, as a whole, the objects of thought.

How to speak of space and time? Let us start by noting that neither space nor time exist by themselves, but they are based on the phenomena of the world. Let us imagine a landscape in the mountains showing a great geological fold. Let us look at it, as other people have done before us. *Space*: some benchmarks borne by the peaks, as geographical markers that

are planted there, as a set of points connected by the GPS network. *Time* as the sun going across the sky, or as the clouds, or as a cart: their movement allows us to classify, to sequence the events: when the cart was here, I did this, when it was there, I did that. Or, another landscape: a volcano by the sea, another vision of time and space: a mountain allows to build space; ocean waves allow to build time: their progress serves me as a clock.

In what we have done, we feel that *we can look at space with no need to look at time*. But this is not the case, and this is the heart of my discourse: time and space are not only related to the world, but also relative to, or in relationship with each other. For a proof, a change of scale is necessary. Let us think through tens, hundreds of millions of years. The stone wave of the first landscape is then strictly identical to the ocean wave that we imagined a short time ago: it moves like it and can serve us to measure time. Which served us to define space now serves us to define time.

But, conversely, if we live at the scale of nanoseconds, the sand in the hourglass does not move for the duration of our entire life; the ratio of the nanosecond to the second is the same as that of the second to the century. The grains of sand may serve us as a distance gauge. What was used to set time is now used to set space. Over short time scales, the relief of the river water and its swirls is similar to the landscape we contemplated a while ago, we can pinpoint its irregularities to locate us.

You will say it is a beautiful allegory, but at some point we will be able to stop and say: here is space, here is time. Well, no, in this infinite transhumance that in a way transforms time into space and space into time, we cannot stop; we are inside the world and we cannot bring rulers and clocks from outside the world to measure it. We can only compare the phenomena to the other phenomena and, from this comparison, build space and time.

So if we stop, it is not that we would have found a pure time, a pure space, with words defined in advance, as waiting to be used; but this is because we are tired. We stop at a scale relevant to the phenomena that we want, or that we can, study, and make a provisional sharing, between what does not move too much, we build space on it, and what is defined by comparison, and that moves more, and we call it time; but we are not sure of the ultimate meaning of the very words we use to talk about them.

Of course, all this would need longer developments. Here are some first general consequences. Time and space are of the same nature; they are separated thanks to the multiplicity of relationships and the sharing of them in two classes defined in opposition to each other.

We use a relation-based thinking that needs to be stabilized by a decision left to the free will: that of a judgment by which we choose, within the same thought, a declared constant immobility (the spatial frame) in composition with a declared, also constant, mobility (the standard movement to define time, whether human or offered by the physical world, on which our knowledge builds and loops: the postulates of relativity theory are there). There are hidden conceptual loops

in this process (in a way we need movement to define movement).

A speed is defined by comparing two movements, one of which is selected as a standard. *There are no longer rulers nor clocks but only a standard movement*. So we do not talk about the speed of light because light defines both the standards of space and time; or we can say that this speed is unity, or merely say that light is the standard of movement. Initially, times are plural, as are spaces, supported by the multiplicity of local movements. All is not solved, the mystery of time is shifted, but we have new keys to reread many issues, from humanities and social sciences to physics.

### 3. MOVEMENT PRECEDES TIME AND SPACE

We may make a short stop to summarize in another way how we can consider that movement precedes both space and time. The movement expresses the first relationships to the world of the knowing subject. These first relationships are shown, before the words. The words later accompany the supposed qualities attributed to the objects. But there are hypotheses hidden.

Let us explain this again. We start by showing a movement. For instance, the movement of a man in Paris; or the movement of my hand in front of you. If we want to describe this movement by words, we are tempted to say: the position of this man in space is variable with time. Or the position of my hand with respect to the space of this room is variable with time.

But we are wrong, it is too early. Because, we use the words space and time too quickly. Actually, we do not know what space means: with the poets we could instance say that the Eiffel tower moves, this room may inflate during my talk. The only thing we know of is the comparison of two movements. We may then say: let us decide that the Eiffel tower does not move, we build space from this decision. By comparison the movement of the man may be taken as a standard for time. But we ultimately do not know...

It is only after we have decided these conventions and in a way defined the words space and time that we can go back on our steps and give a name on what we had only shown: the movement is the variation of spatial position with time... But, we must stress that, behind this phrasing, a fundamental undertermination is hidden and a fragility is there. But this convention is useful and strong by what it allows: a large social communication and the (provisional) building of our knowledge.

### 4. NEW REFLEXES

Let us go back to natural sciences. In this section I am giving you my own feeling, I call it my reflexes, about the statements I read in current research in physics. Of course, this is open for discussion.

■ **Emergence of time, as separated from space?** *No, time and space are the same construction/abstraction.*

■ **Quantization of a physical theory as a special task?** *No, quantization is a manifestation of the « non-linear »*

comparison of several phenomena, within a probabilistic approach.

■ **There may be different physical laws (imposed) in different universes?** *No, the laws are not strictly imposed by reality. They need social conventions, and there is a theoretical pluralism (Poincaré).*

■ **General relativity is the theory of space and time?** *No, several space-times may be constructed by different classes of phenomena.*

■ **Time and space may be quantized alone?** *No, the quantization is always a way to compare two different space-times scales that are both present (one visible, the other hidden).*

■ **The velocity of light is constant in any reference frame?** *No, we choose the phenomenon of light propagation to build our time and space representations (frame/ clock).*

■ **The second law is a universal law of nature?** *No, its value is statistical. It may be violated.*

■ **The arrow of time is another wording of the second law?** *No, it cannot be separated from the spatial gradients or « space arrows ».*

■ **Proper time is read on clocks that are considered as punctual at the given location?** *No, a clock can never be considered as punctual; a clock is a point of view on a movement.*

■ **c, h, e... are universal constants?** *No, we decide them as constants, we need such decision; during history, the choice of what is « constant » has changed.*

■ **etc.**

Generally speaking the working of the equations in natural sciences must incorporate a number of points we have put forward. For instance, we cannot distinguish the pair  $(t, \mathbf{r}) = (\text{space}, \text{time})$  from the other pairs of physical fields such as  $(\mathbf{E}, \mathbf{B})$ , etc.; any one of them can be taken to define time and space ( $t$  is the three-dimensional position of the mobile that defines time). The discussion of the possible connection between general relativity and quantum mechanics may benefit from this statement. The very forms of the equations are the trace of the reasoning conducted and which involve movements in different ways.

All these statements may be considered as the foundation for new researches... I have started some researches by myself and this is a list of the different issues that can be discussed with the space time connection I have presented: -Composition of non collinear Lorentz transformations and Wigner - Thomas' rotation; - Understanding light « velocity »; - An interpretation of the twins paradox: the « Phileas Fogg » effect; - Functioning of the « zeroth degree » physical laws; - Epistemic undetermination relations; - Time's irreversibility; - Think the link between quantum mechanics and general relativity; (...), see [5], [6], [7], [8] among others.

Each of these items would need several hours to be presented with some details. There are very numerous practical consequences. And, as I pointed out, there are also many implications for the humanities and social sciences. They are

the subject of seminar papers, articles in journals, e.g. [9], [10], [11], and various collaborations.

## 5. THE GAMMA LORENTZ FACTOR

It is interesting to make a stop on one consequence. Just to show (the previous items could also show it) that my vision is not only 'philosophical' but it has technical consequences for the physical equations.

One of the consequences of the above discussion is that *a clock is a point of view on a movement* (there is no scalar time flowing everywhere) and the same assumption must be made about the constancy of the standard movement as seen from different points of view (i.e. in different reference frames). I have tried to articulate the understanding/building of time with the writing of the Lorentz' transformation in relativity theory.

Refer to Fig. 1. In the first figure a, the situation described by the classical relativistic approach is presented. Two reference frames R and R' of origins O and O' are moving to the relative speed  $v$  ( $OO' = vt$ ). Each of the two frames is equipped with a clock, H and H' (in French, clock is 'horloge' starting with a 'h'). We consider the displacement of a photon P and assume that its displacement speed is the same as viewed from R and as viewed from R' (this is the second relativity postulate). This photon can move in all directions: this possibility has been represented by the wave surface centred on O', i.e. a two-dimensional circle (on which two photons P have been transferred).

Let us ask again: what is a clock? In figure b, the clocks H and H' are opened and we discover that each uses the movement of a photon,  $P_H$  and  $P_{H'}$  (these are the standard atomic clocks of today). We now have three photons,  $P_H$ ,  $P_{H'}$  and P, counting the latter as an infinity in the different directions. So the question is: what kind of hypothesis should we make about the first external photon and the two photons inside the two clocks? Well, if we want our approach to be consistent, we must take the same hypothesis for the three photons.

In Fig. c, we unified the approach, being led to postulate the same behavior for the different photons that are now one at the conceptual level. In order to have clocks needed to "measure time" in both frames, one must particularize a photon that will serve for both time in R and R' (while "embodying" the second postulate of relativity):  $t$  is the position of the photon as seen in R and the same for  $t'$  in R'. The two clocks H and H' as defined in figure a are destroyed (or forgotten, they were fictions).

So we can do some geometry as defined by comparisons of pieces of movements (see Fig. 1c). The two frames R and R' have a relative movement at speed  $v$ . We have only one clock photon P). The angle between  $v$  and the photon in R' is  $\delta$ . The velocity modules ratio is  $\beta$ . There is no substantial time nor space, waiting to be dilated or contracted; no influence of movement on the passage of time (which does not exist). We only see movements compared to each other. During the time (this is a piece of movement) that the frame R' moves from  $vt$ , the photon moves from  $ct$  in R and from  $ct'$  in R', with the same

c (second relativity postulate). By writing the relationships between sides and angles in the OO'P triangle, we obtain the following ratio  $\gamma = t/t'$ :

$$\gamma = \frac{\beta \cos \delta \pm \sqrt{1 - \beta^2 \sin^2 \delta}}{1 - \beta^2}$$

This proposal makes the relativistic approach consistent. The meaning of the relativity factor is extended, making it depend not only, as in the standard case, on the ratio  $\beta = v/c$  of the velocity modules (the relative movement of the reference frames and light), but also on the angle  $\delta$  between these two movements. The relationship proposed makes it possible to find in the same framework various transformations already known, including that of Lorentz (for  $\delta = \pi/2$ ). The +/- sign refers to choice for orientation of the axes and angles, see [3].

As I told, the general approach allows for new insights into a range of issues under discussion. Here, it suggests new experiments to study temporal distortions between reference frames in relative motion. We can now speak of the angle of time!

### 6. CONCLUSION

To conclude, I dare to tell you about a book (unfortunately written in French) that has just come out, in which I go back at length to the points I have made here [2]. I chose a literary genre, mixing dialogue and phantasmagoria, in the Imaginary Land (Neverland) of Captain Hook, the enemy of clocks. I examine a plurality of facets, in the different sciences (both human and social and so-called hard sciences) whose boundaries I revisit. I allow myself to dialogue with various scholars, without forgetting poets and artists, nor the inhabitants of the Neverland.

*"I'm not painting the being, I'm painting the passage."  
 "Consistency itself is nothing but a more languid move."  
 (Montaigne)  
 "All is time... Motionless time, I call it space.  
 All is space... Moving space, I call it time." (BG)*

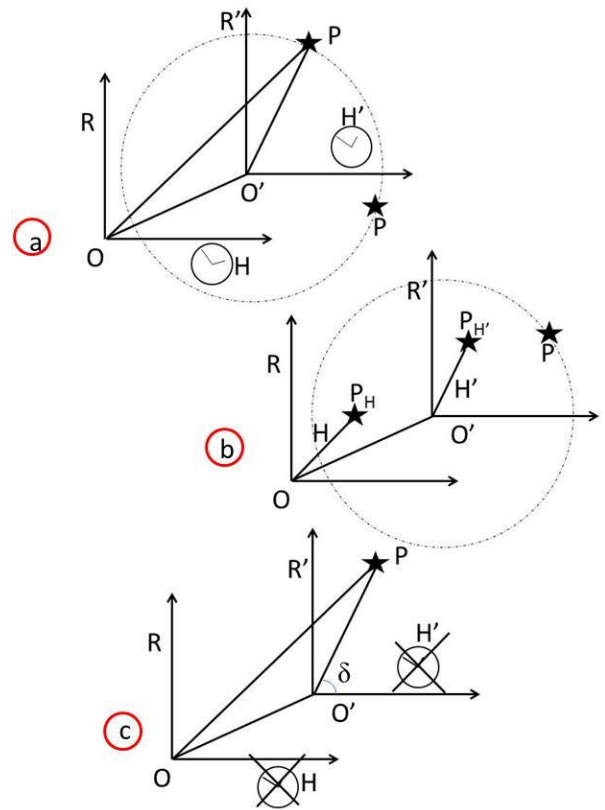
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**FIGURE 1: THE GAMMA FACTOR OF THE LORENTZ TRANSFORMATION**

Determination of the gamma factor of the Lorentz transformation as a function of the direction of the hidden movements in the clocks. Two frames R and R' moving at the relative speed v are envisaged, with two clocks (a); in (b) the clocks are open and show their photons; in (c) one photon remains in a unique space of movements; see text.