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The end of space-time

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ABSTRACT

In bijective modelling, the physical reality is represented by the set X, the model of physical reality by the set Y. Every element in the set X has exactly one correspondent element in the set Y. Set X and set Y are related by the bijective function $f: X \rightarrow Y$. Bijective modelling is confirming that time is the duration of given system entropy increasing in time-invariant space.

Keywords: Space-time, Entropy, Time-invariant space, Bijective modelling.

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INTRODUCTION

In physics, time is deeply related to entropy. Bijective research methodology is based on set theory. Physical reality is set X, the model of physical reality is set Y. Every element in the set X has exactly one correspondent element in the set Y. Bijective modelling sees time as a duration of a given system entropy increase that happens in space. In the set X of the bijective model, we have time, space, and entropy which represents three physical reality elements: space S_X, time Δt_X, entropy increase ΔS_X as shown in formula below. The duration of entropy increase ΔS is the elapsed time Δt:

$$X: \{S_X, \Delta t_X, \Delta S_X\} \quad (1)$$

In the set Y we have the following correspondent elements:

$$Y: \{S_Y, \Delta t_Y, \Delta S_Y\} \quad (2)$$

Bijective modelling confirms that time is a duration of entropy increase of a given physical system happening in space. Here the crucial question "how the time, that is the duration of entropy increasing, could be the 4th dimension of space-time?" will be solved. The bijective analysis of Special Relativity formalism for 4th dimension in its original form shows that time t is not X_4:

$$X_4 = ict \quad (3)$$

Out of Eq. (3) it follows:

$$X_4 \neq t \quad (4)$$

The forth coordinate of Minkowski manifold can be called "temporal" only in the sense that time as duration is its element, but time itself is not the 4th dimension of space-time. X_4 is spatial in the same way as dimensions X_1, X_2, X_3 are(Fiscaletti & Sorli, 2015). Time, as a duration, is a physical property of every material change, i.e., motion happening in space, including the increase of entropy.

We have experimental data and theoretical models only related to the duration of material change, i.e., motion has some physical impact on space or is related to space in some other relation. The only real relation between space and time is that time is the duration of the change in space, which means that space is time-invariant. Increasing of entropy ΔS of a given physical process happens in time-invariant space, where time is the duration of the entropy increase.

The product of time t , as duration, with the light speed c gives the spatial distance $d = ct$. Einstein has added the imaginary number i to this spatial distance, so as a result we can write the 4th dimension as $X_4 = id$. This imaginary distance in the Minkowski model has no bijective correspondence with the physical world; the relation $f: id_X \rightarrow id_Y$ is not true and the imaginary distance id is not existing in the physical world. In Special Relativity, the space-time interval S has been defined as: $S^2 = c^2t^2 - (X^2 + Y^2 + Z^2)$.

With the introduction of natural units: $c = \hbar = 1$, the space-time interval becomes: $S^2 = t^2 - (X^2 + Y^2 + Z^2)$ and the fourth coordinate of Minkowski manifold was interpreted as time t; in its original form $X_4 = ict$ is turned into $X_4 = t$. With this incorrect interpretation time was fully merged with space; still today we think that time is the 4th dimension of space although we measure time as the duration of motion in space.

In the time-invariant space we do not have time-arrow. Time is not pointing anywhere, because it is the duration of material change running in the time-invariant space. Time-arrow, as the element of the model of the physical reality, has no correspondent model in physical reality. We have several models of time-arrows, but none has correspondent time-arrow in physical reality: thermodynamic time-arrow (t Hooft, 2018) does not exist in physical reality because entropy is increasing in time-invariant space. Also, cosmological time-arrow (Hawking, 1985) has no physical existence because universe is developing in time-invariant space. In this article we show that there is no flow of time in physical reality. Material changes, i.e. motion, run in time-invariant space and time is their duration.

Recent research is also suspicious about the flow of some hypothetical physical time: "Third, the statement that the flow of time causes entropy to increase and not the other way around is doubly misleading. Entropy, by itself, cannot be said to increase or decrease. The reason is that entropy is a state function, i.e., it is defined for a well-defined system at equilibrium. As such, it is not a function of time. The flow of time is not the cause of entropy increase! The "flow of time" (if it flows at all) has nothing to do with entropy increase!"(Ben-Naim, 2020).

TIME-INVARIANT SPACE IS CONFIRMING TIME TRANSLATION SYMMETRY (TTS) AND DENYING THE EXISTENCE OF TIME-REVERSIBILITY

The model of time-invariant space is confirming the validity of time translation symmetry (TTS) (Lehto, Nielsen, & Ninomiya, 1989), which is a rigorous way to formulate the idea that the laws of physics are the same throughout history. The history is running in the time-invariant space where the laws of physics are invariant on time and time is merely the duration of material changes.

In the time-invariant space there is no past and no future. Material changes are irreversible and do not run in some physical time. That's why the time-symmetry model, where the physical laws are symmetric in time, has no bijective correspondence in the physical world. No physical process can be reversed in some physical time, because time is just duration of the given physical process. In bijective modelling the duration is a discrete quantity. Every elapsed time is the sum of Planck times (Fiscaletti & Sorli, 2017):

$$t = t_{P1} + t_{P2} + \cdots + t_{Pn} = \sum_{i=1}^{n} t_{Pi} \quad (5)$$

Additionally, other research confirms that time may be seen as concrete quantity: "Time may be considered as a discrete quantity" (Lucia, Grisolia, & Kuzemsky, 2020). Planck time t_P has physical existence but is not a part of space, it is a part of duration. In this virtue, Planck time is the fundamental unit for measuring the duration of the increasing of entropy that runs in a time-invariant space. The model of time reversal symmetry (T-symmetry) has no bijective correspondence in the physical world. The equation below has no physical meaning:

$$T: t \rightarrow -t \quad (6)$$

Experimental research is confirming that time reversal symmetry is a model that has no bijective correspondence with the physical world (Müller, Guan, Vogt, Cole, & Stace, 2018). The idea of Stueckelberg and Dirac that particles could move back in time becoming antiparticles was never experimentally proved:"This configuration can be understood as *pair annihilation*; it was already known at that time that a particle running backwards in time can be understood, and observed, as an antiparticle going forward in time. This phenomenon occurs in the solutions of the Dirac equation, where the wave function of a particle going backward in time, under charge conjugation, describes an antiparticle moving forward in time. Dirac, in this way, discovered the positron, the antiparticle of the electron. Stueckelberg therefore called this configuration *pair annihilation in classical mechanics*" (L. Horwitz, 2020). The positron discovery does not prove that it is the electron moving backward in time. Experimental data prove that they are both discovered and they both move and exist in the same universal space. If positron would really exist in some negative time also the measurement system that detects positron should be there in a negative time which is not the case. This negative time is represented in the Minkowski manifold by the past light cone (Figure 1):

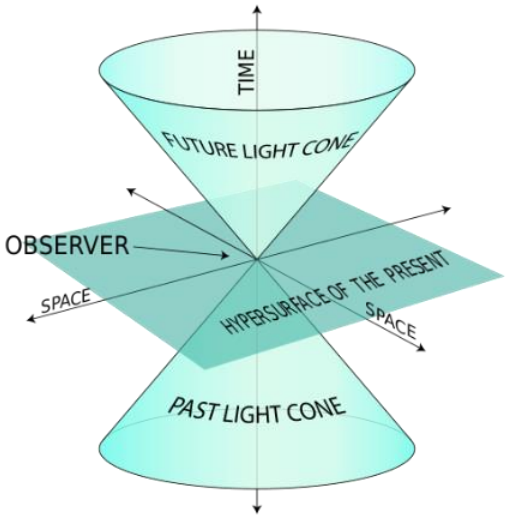

Figure 1: Minkowski manifold with positive and negative time

The universal space, in which electron and positron are discovered, is time-invariant in the sense that time is not the 4th dimension of space-time and that this 4th dimension has neither positive nor negative sign. The picture of Minkowski manifold has no bijective correspondence with the physical world.

Recent research suggests that two different types of time are existing in the universe: "We are now in a position to discuss the properties of entropy flow associated with the relativistic Boltzmann Equation.

This result, that there are intrinsically two types of time, the *observable* time *t* associated with the Maxwell equations and Einstein's formulation of special relativity (appearing in the Lorentz transformation), and the underlying universal parameter τ of dynamical evolution, as originally conceived by Newton, is a consequence of the Stueckelberg-Horwitz-Piron formulation of relativistic mechanics"(L. Horwitz, 2020).

The so called "invariant universal world time" τ (L. P. Horwitz, 2019) has been never observed and measured, and has no bijective correspondence in the physical reality. We suggest that the only existing time is the *observable* time *t*, which is the duration of material change, i.e. motion in the time-invariant universal space.

In today's standard quantum mechanics (SQM), we are still having the wrong imagination that quantum objects exist in some physical time: "It is a fundamental question in standard quantum mechanics (SQM) of what type of restrictions the Schrödinger evolutionism poses on the behaviour in time of basic objects.

In particular, it is of interest to ask if SQM allows for self-adjoint operators having the so-called Lyapunov property, that is, monotonicity of the expectation value irrespective of the initial state of the system. Clearly, such an operator would indicate the direction of time" (Strauss, Silman, Machnes, & Horwitz, 2011). Experimental physics is confirming that basic objects are existing only in space, and time is the duration of their motion. We suggest that the duration cannot have a direction, and the existence of the arrow of time as direction of time would be then excluded.

BIJECTIVE MODELLING OF RELATION BETWEEN EPR-TYPE ENTANGLEMENT AND ENTROPY

In the bijective model, the increase of entropy ΔS requires the duration Δt:

$$\Delta S \rightarrow \Delta t \tag{7}$$

EPR-type entanglement is immediate, it is carried by the time-invariant space having its physical origin in the superfluid quantum vacuum (Šorli, 2019). The elapsed time of EPR-type entanglement is zero, which means that EPR-type entanglement has no entropy:

$$\Delta t = 0 \rightarrow \Delta S = 0 \tag{8}$$

Several researches suggest that entanglement and entropy are related: "The entanglement can be quantified by an entropy. One can define it as the measure of the information about quantum states which is lost when these states cannot be observed. In many-body systems, which are the subject of the present work, "observable" and "unobservable" states can be located in different regions" (Fursaev, 2006).

We suggest that by EPR-type entanglement there is no loss of information, which can only take place when information transfer has duration; no duration means no information loss. Entanglement and entropy are not related. In this view also Misra, Prigogine and Courbage's no-go theorem that excludes possibility of immediate information transfer (Strauss et al., 2011) seems questionable, because the time-invariant space can be seen as the immediate medium of entanglement (Fiscaletti & Sorli, 2017; Šorli, 2019).

TIME AS THE RESULT OF THE OBSERVER'S MEASUREMENT

Recent research suggests that flow of time, which runs in the universe independently is an illusionary invention of classical physicists and perhaps an illusion created by our brain: "We notice that for Einstein, the sense of "flow of time" is subjective and perhaps it is an illusion generated by our brain. Also, it is known that Einstein was profoundly influenced by Ernst Mach who believed that the "Newtonian time" was a "pointless metaphysical entity", because it cannot be "measured" independently from the phenomena.

Ludwig Wittgenstein too, probably convinced by the idea of Mach, writes in his Tractatus that: "We cannot compare a process with 'the passage of time'-there is no such thing-but only with another process (such as the working of a chronometer" (Wittgenstein & dos Santos, 1994). This conception of time, which is based on the act of measurement and very operational, led to the idea according to which time is an illusionary invention of classical physicists (Ebadi, 2019).

Our research confirms that in the universe there is no flow of physical time in which material changes would occur. Material changes run in time-invariant space and have no duration on their own. The duration of a given material change is the result of the observer's measurement (Fiscaletti & Sorli, 2015). In this sense, the idea of classical physics that time runs in the universe seems not right.

In physics, we experience the flow of changes running in time-invariant space in the frame of linear psychological time "past-present-future" which has its physical origin in the neuronal

activity of the brain. That's why we experience that linear time is running in the universe, although linear time runs only in our brain. Several pieces of research confirm that animal and human experience of linear time has the origin in neuronal activity of the brain (Buhusi & Meck, 2005; Ivry & Spencer, 2004; Mauk & Buonomano, 2004).

We are projecting our psychological linear time "past-present-future" into the physical world. We think that any change requires the existence of time, that change run in time. The truth is that the measurement of change with clocks creates time as the duration. In this sense is right to say that time is an illusion created by our brain. Understanding that material changes run in time-invariant space and that duration is the result of the observer's measurement is an important element of physics and cosmology progress.

CONCLUSIONS

The progress of physics is in building the most accurate models of the physical world. A bijective research methodology is a useful tool in this task; it confirms that entropy increases in a time-invariant space and that time is the duration of entropy increase. The Space-time model where time is supposed to be the 4th dimension of space has no bijective correspondence with the physical world. It is replaced with the time-invariant space where time is the duration of a given material change.

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