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Considerations on the existence of a fifth dimension in universe

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Abstract. This paper proposes an analysis of the need to introduce a 5th dimension in the real physical world. Although it is difficult to imagine such an additional dimension orthogonal to the other 4 dimensions (the fourth being *time*), several observations lead to the idea that the introduction of a 5th dimension would answer some questions. We will show that, as the volume of a body is described by 3 dimensions, the life of that body involves the fourth dimension (duration, respectively the body's evolution process), the 5th dimension will represent the multitude of possibilities for the body's evolution at any instant. We will call the new dimension the "*axis of configurations*" whose orthogonality with respect to the other known axes is for now conjectured. The consequences of accepting the 5th dimension are multiple, ranging from *Quantum Physics* and the unification of all forces to the evolution of the Universe.

Keywords: dimension, world line, space-time curvature, axis of configurations.

1. Introduction

The problem of the need to introduce a 5th dimension dates back to approx. 100 years, more precisely after Einstein's publication of the *General Theory of Relativity*. Since then and until now, several theories have been developed, but a conclusion generally accepted by the scientific world has not yet been reached.

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One of the first theories that was developed independently by the German mathematician Theodor Kaluza [1] and the Swedish physicist Oskar Klein [2], proposed the introduction of a 5^{th} dimension in which electromagnetism and gravity can be unified. Klein suggested that the 5^{th} dimension cannot be perceived by the human eye, being extremely tiny (compared to the Planck length, i.e. 10^{-35} m) and wrapped in itself. In the end, the Kaluza-Klein theory was not successful and was later abandoned. However, it remains interesting in that it proves that the 5^{th} dimension would solve the problem of the "great unification".

Some more recent ideas were addressed by the famous physicist Stephen Hawking in his last book, namely the theory of "strings" (which predicts 10 dimensions) and that of the "multiverse" (parallel universes). The paper [3] was published in October 2018, just a few months after the author's death. Of those theories, he said that "*We are not a single universe, but our findings imply a significant reduction of the multiverse to a much smaller range of possible universes*."

Physicist Gerard't Hooft presented in 1993 the holographic principle (later developed by Leonard Susskind [4]) which explains that an extra dimension can be perceived as a curvature in a space with one less dimension. Holograms are exemplified here, which are 3D images printed on a 2D surface and which make the image appear curved as the observer moves. By analogy, the 4th dimension manifests itself in observable 3D space through the curvature of the trajectory of a moving test particle. From here, G. Hooft deduced that the 5th dimension would be space-time itself.

Another researcher, Paul S. Wesson, suggested [5] that a fifth dimension might be associated with rest mass via $x^4 = Gm/c^2$ where G = gravitational coefficient of attraction, m = rest mass, c = speed of light in a vacuum.

An idea close to the one proposed by the authors of this paper belongs to the Argentinian researcher Mariana Vernieri who claims in her papers [6] that although reality seems to be one and only one, it is possible that it is actually just one variant among other possible ones. We only see this because it is the result of our observation (similar to the quantum theory of wavefunction collapse). Further on, however, M. Vernieri develops the subject through connections with the psychological field.

2. Arguments in favor of the 5^{th} dimension

1) The phrase "*the trajectory of a particle in the space-time continuum*" is often used. Any trajectory involves the variation of a parameter. For example, in 3D, a particle describes a trajectory in time, so the parameter of the described curve is *time*, respectively a parameter from another dimension. In the case of 4D, we can ask what is the parameter that connects the 4D states to each other defining a trajectory? Proper time, as presented in the *Theory of Special Relativity*, cannot be considered an independent parameter, because it is related to the universal time. In the *Theory of Relativity*, the "trajectory" of an event in 4D space defines the "world line", but without specifying which parameter generates the respective "curve".

2) The notion of "evolution in space-time" (quite often invoked in various papers) is ambiguous in the 4D Universe, because evolution takes place only in time. The very notion of "evolution" implies the passage of time. If we were to place ourselves in a higher dimension, then we could fully see a process unfolding in space-time. A 3D movie recorded on any 2D medium can be seen in its entirety at once, but from a higher dimension with respect to the recording medium.
3) The observable Universe is like a 4D photograph that we see because of the finite speed of light. Depending on the distance at which we make the observations, we actually see the image from the time the light was emitted, which reaches the observer after a time proportional to that distance. Given the cosmological principle, the 4D Universe must be spherical, with the virtual center in another dimension. According to the authors, the 4D Universe is actually a 3D spherical surface centered on the Big Flash (in the "time" dimension). However, a 4D photograph could be seen only from a 5th dimension!
4) It is known that light propagates due to space-time oscillations, which are actually disturbances manifested by small periodic deformations of space-time. So are the gravitational waves. Although one talks about the "intrinsic curvature" of space-time which does not require an additional dimension to be detected, yet the center of curvature in a certain direction cannot be located in the 4 dimensions where we lie.
5) The wave-particle dualism implies the presence of the 5th dimension: the associated wave represents oscillations in the 5^{th} dimension. The fact that a particle is described by a wave function shows that the particle can be found simultaneously in an infinity of states, respectively on the axis of the 5^{th} dimension. The "quantum tunneling" phenomenon can be explained in this way by the passage of the particle through the 5^{th} dimension and the subsequent return to the 4 dimensions that we perceive.
6) Einstein's equations from the General Theory of Relativity mention the curvature of space-time, but nowhere do they mention a possible torsion of it. In 3D geometry, curves and surfaces exhibit both curvature and torsion. Again an additional dimension is needed to introduce such geometrical properties for spacetime, so far not analyzed.
7) In a 4D space, the notion of "rest" makes no sense, because any object, even if it does not change its position, moves in time at the speed of light (along with the expanding frontier of Universe). Only at the event horizon of a black hole does time (theoretically) stop, but a body cannot stand still in the event horizon, so we cannot say that it is "at rest". On the contrary, he travels at the speed of light. From here it follows (by inference) the existence of an additional dimension that allows the definition of “rest” in 4D.
8) Let’s suppose there are only three dimensions: x, y, and z. We can ask ourselves the question: Can two different things occupy the same space at the same time? Answer: No, unless we introduce the fourth dimension: time. Two objects, located in the same place (x, y, z), can exist at different times. Now, moving on,

can two different objects occupy the same location (x,y,z) at the same time? No, unless we introduce the 5th dimension. The reasoning can continue.

9) Will we ever be able to communicate with or photograph the past or the future? The future cannot be known as the past cannot be changed. We cannot communicate or photograph even "now", because when, for example, someone photographs something at a distance L at the instant to, the image will show that "something" at the instant t = to - L/c, where c = speed of light in a vacuum. However, we could see a full process from the 5th dimension, but only up to the present.

10) The principle of minimum action implies the knowledge of all possible evolutions from a given state A to a state B (also given). In Classical Mechanics, however, state B follows from the initial conditions (state A) and the laws of motion which, together, define a trajectory in space and time, i.e. a process, with the highest probability in connection to the experimental observations on the basis of which the laws of motion were developed. We postulate that one can assign to this trajectory a unique coordinate compared to other possible trajectories, coming from the 5^{th} dimension. A natural question would arise: what would be the meaning of the other possible trajectories, which would be inconsistent with Newton's laws? Would universes governed by other laws be possible? Several theories regarding parallel universes governed by laws of *Physics* different from those we know already exist.

11) According to Einstein's theory, the speed of light is the maximum speed of energy propagation, therefore also the maximum speed of communication between two locations in 3D space. This would lead to the idea that it is impossible to achieve coherent communication at distances of light years, which means a dramatic physical limitation, at least at the level of current knowledge. However, if we accept the idea of a 5th dimension, this will theoretically remove that limitation. Moreover, it could pave the way for interstellar and intergalactic travel, currently only possible in science-fiction literature (which does not touch on the issue of spacecraft communication with monitoring centers on Earth!).

12) It is known that no material body (with non-zero rest mass) can reach the speed of light, regardless of the reference system against which the movement of the body is considered. However, in a 4D Universe, any body at rest moves through time at the speed of light, along with the expansion of the Universe. Consequently, additional clarifications are needed regarding the speed of material bodies in relation to the speed of light in vacuum (see the definition of vacuum in [7]).

13) The center of a black hole is postulated to be a singularity, which "swallows" any mass passing the event horizon. Where does that mass go? The problem exhibits some resemblance to a negative fluid source, which absorbs fluid without specifying where the absorbed fluid goes; it is known from practice that it (in the case of 2D) goes on a "pipe" from another dimension. A 3D fluid source cannot be designed without an additional dimension where the fluid comes from (or goes to).

14) The theory of wormholes (Einstein-Rosen bridges) says that the *General Theory of Relativity* admits the existence of tunnels in space-time through which one can pass from a certain place and at a certain moment of time to another 4D "location" at unimaginable distances in space and time. Under certain conditions, space-time can be curved to such an extent that two "points" can be connected, but the teleportation "tunnel" requires an additional dimension.

Remark: In *Analytical Mechanics* there is the notion of "phase portrait", which describes all possible evolutions of a given mechanical system. In this portrait, we practically have the picture of a complete set of possible processes. However, in this case, the set of processes is defined by the possible initial states; the 5th dimension comes into discussion only when we refer to one of the processes in the phase space, which take place according to certain laws, derived from some fundamental principles (such as the principle of minimum action), in relation to other processes that might have place according to other laws.

3. Statements of new postulates

1) In 4D geometry (i.e. space-time), the basic notion is that of "event" (or more correctly "state"). Any event is defined by a specific location (3 coordinates) and a specific moment in time. Going further, a transformation (process) consists of a continuous sequence of events (states) through which the 4 space-time coordinates are modified.

In 5D the basic element will be the "process", which includes all the 4D states that define a certain transformation (for example, the life of a human or a star). A process can only be viewed in its entirety if the observer lies in a higher dimension.

2) At any moment, a process can evolve in an infinite number of ways, the trajectory it follows depending on a parameter that determines the process itself. At this time, a question arises: what is that parameter that differentiates one trajectory from another and what type of principle acts for the development of the process: deterministic or probabilistic?

3) We postulate that the 5th dimension represents the axis of all possibilities for the evolution of a process at a given moment. This axis will be "orthogonal" to the other 4 axes of the classical physical space. We will call it the "***axis of configurations***". The "length" element attached to this axis remains to be determined (Fig.1).

Remark: The meaning of the 5th dimension is also suggested by the *Theory of Probabilities* which operates with the notion of "sample spaces". Thus, any event (state) defined in the 4D Universe is part of a multitude of possible events that may be considered as belonging to the 5th dimension.

The equation of a curve in 3D space (the trajectory of a particle body) has the form:

$$x = x(t),\ y = y(t),\ z = z(t) \quad \Leftrightarrow \quad F(x,y,z) = 0 \quad \Leftrightarrow \quad z = f(x,y). \qquad (1)$$

By analogy, the equation of a curve in 4D space will be:

$$x = x(\varepsilon),\ y = y(\varepsilon),\ z = z(\varepsilon),\ t = t(\varepsilon) \quad \Leftrightarrow \quad F(x,y,z,t) = 0 \quad \Leftrightarrow \quad t = f(x,y,z) \qquad (2)$$

It thus appears that the parameter ε belongs to another dimension, postulated to be the configuration axis.

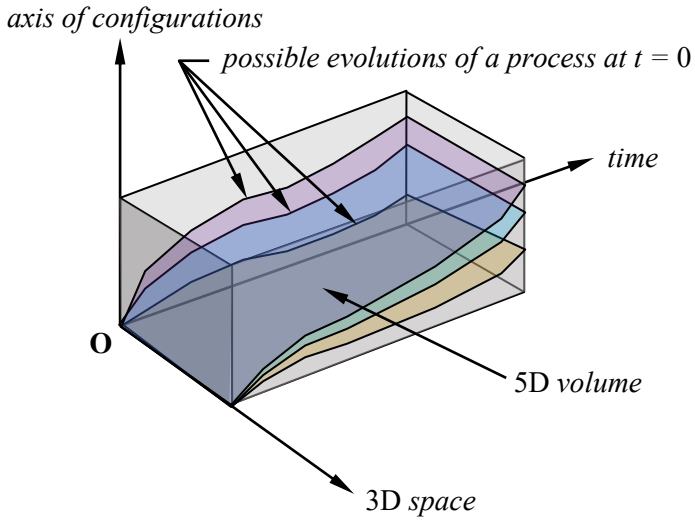

Fig. 1. Representation of a 5D volume

4. 4D and 5D universe

The Universe can be perceived in two ways:

- The ***luminous*** Universe, which is a four-dimensional sphere with the center at the moment of the Big Flash and with the radius $R_U = ct_U$ expanding at the speed of light (t_U is the age of Universe);
- The ***observable*** Universe, which is a three-dimensional sphere (the well-known "heavenly vault") with the center at the place of observation and with a radius denoted R_{obs}, different from the radius of the luminous Universe R_U, but proportional to it. It can be proved [8] that $R_{obs} \cong \pi R_U$.

By accepting the idea of a finite Universe, the notion of space-time size makes sense. The radial size of the Universe can be defined in relation to its age, considering that it has a spherical shape in a 4D space. However, the geometric size of the Universe represents a more complex characteristic.

The expansion of the Universe actually represents its evolution in the 4th dimension, namely the increase of the radius R_U with the speed of light. Along with the continuous "dilation" of the border, the 3D distances between the various points on it also increase (fig. 2). The presented geometric model confirms that the departure speed of the bodies on the outer 3D surface is proportional to the spatial distance between them (the spectral red shift observed in very distant cosmic objects). In other words, the 4D Universe model is consistent with Hubble's law. According to the model of 4D Universe, an observer on Earth sees a landscape bordered by a "horizon" (spherical this time) located at a distance defined as the

radius of the observable Universe. Just as the saylor in the middle of the ocean does not perceive the curvature of the earth, neither does the astronomer "see" the curvature of the Universe (but both can determine the respective curvatures by indirect means). On the other hand, while the saylor's horizon is circular, the astronomer's is spherical.

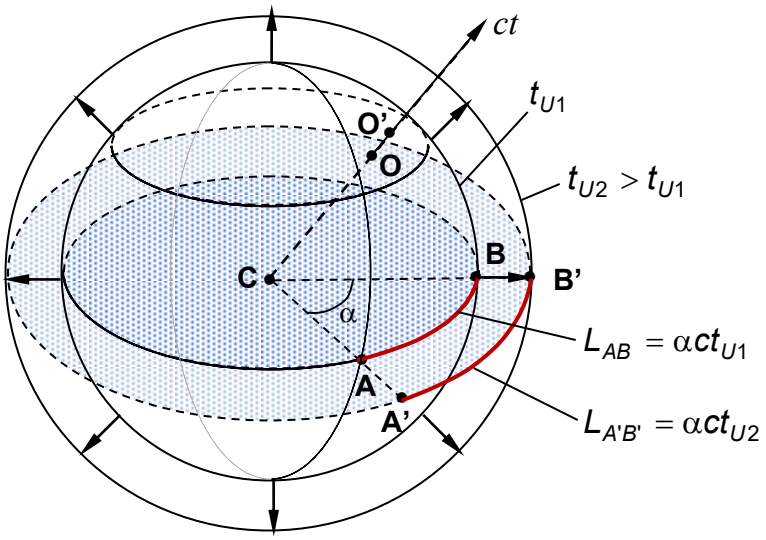

Fig. 2. Diagramatic representation of 4D Universe
(t_U = age of Universe, C = center of Universe = Big Flash instant)

As the Universe is isotropic (according to the cosmological principle), it follows that from any other point of observation, the perceived global image of the Universe is similar, i.e. the observer is in the "center" of the celestial vault. Consequently, the notion of "center of the Universe" as an absolute spatial reference has no meaning, the apparent center of the Universe can be considered anywhere. The expansion of the Universe takes place in all directions, a specific "point" in space from which it started cannot be determined. The only reference that can be established is the temporal one, namely the Big Flash, which can be considered the absolute center of the 4D Universe.

Since the expansion of Universe takes place at a constant rate (according to the authors [8]), the 4D Universe is considered "flat" in time and curved only as space. Spatial curvature determines gravitational effects on a cosmic scale. A completely "flat" Universe would be devoid of gravity. The center of the spatial curvature is the very center of the 4D Universe and is identified with the Big Flash instant.

By considering the multitude of possibilities of evolution of Universe at every instant, this can be understood only by introducing the 5th dimension as the authors postulated.

5. Possible consequences of the introduction of the new dimension

(1) The unification of all the forces of nature.
(2) The possibility of traveling in space and time over long distances.
(3) Real-time communication over astronomical distances.
(4) Teleportation.
(5) The possibility of explaining the nature of dark matter.
(6) The possibility of human colonization of other habitable planets, located at astronomical distances from our solar system, currently impossible to figure out.
(7) The explanation of some phenomena that, at present, fall into the category of the "paranormal".

6. Conclusions

In this paper, several arguments for introducing a 5^{th} dimension are analized. Although many scientists tried to find a meaning for a 5^{th} dimension, we have proposed an original meaning which seems to be consistent with actual physical laws. We have called the 5^{th} dimension "axis of configurations" which is postulated to be orthogonal on the other axes of space-time continuum.
However, this research needs to be continued since, for example, the unit of length on this axis is to be determined, as well as the metrics in 5D space.
Regarding the consequences of introducing the 5^{th} dimension, if only one of the consequences listed above will be accomplished, a great step forward for the scientific world will be done!

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