THE NOTION OF SPACE IN SOME MODERN PHYSICS THEORIES[1]

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The article analyzes a number of modern physics approaches in different aspects, which are directly or indirectly affected by the problem of space. The variations of cosmologies based on the theory of relativity, quantum mechanics, the theory of inflation, the holographic universe model, the model of the virtual universe, etc. and their scientifically validated combinations are examined for specifics of category of space interpretation in each case. In reliance to the historical and philosophical analysis the connection between the traditional interpretations of the concept of space in philosophy and the modern ones in physics is established. The context of some modern physical theories is concluded to bring new dimensions to the understanding of space (while retaining certain classical concepts).

***Key words*:** concept of space, cosmology, philosophy of physics, history of science.

Introduction

This study is focused on the analysis of several hypotheses of the multiverse in modern physics in order to consider the interpretation of the concept of space in their contexts. The historical and philosophical scientific development of the problem is also taken into account within the interpretation.

Space is one of the fundamental concepts of physics. Modern theoretical physics affects this category in such a way that it becomes more and more difficult to formalize it in definitions and unambiguous representations. The theories of the multiverses became the one of the examples of same space appears differently. This article focuses on the category of space (and related concepts), which originates from the philosophical interpretation of several multiverse theories.

Short overview of the space problem

In relation to the concept of space, the following characteristics (also related to each other) are conventionally distinguished: finiteness or infinitude; presence of voids and matter or absence of such division; possibility of movement, continuity and discontinuity; existence of space, solidity. The history of the finiteness or infinitude issue of space has been discussed in detail in the work of Alexandre Koyré [Koyré, 1957] and some of the ideas on this subject are also expressed in the article

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of I.A. Karpenko [Karpenko, 2014: 105–118]. Koyré mentions an interesting detail: the concept of "cosmic space" in antiquity and in the Middle Ages is not the same as the "universe" of Modern Ages and is certainly a different thing with the global space in modern physics. The cosmic space of Aristotle, Hipparchus, and Ptolemy is a closed finite world, which has nothing beyond itself[2]. Nicholas of Cusa and Giordano Bruno have already researched the infinite universe; the worlds of René Descartes, Gottfried Leibniz and Isaac Newton (and probably the world of Galileo, too) are also infinite contrary to the ideas of Nicolaus Copernicus and Johannes Kepler (in fact, thanks largely to them). Moreover, space is not necessarily infinite in models that allow infinity – for example, Descartes' space as a matter dimension is finite but only God is infinite. Henry Moore's space is infinite as the "sensitivity of God (*sensorium Dei*)" and multiplicity of worlds does not follow infinity[3].

Today, the question of finiteness or infinitude of space remains open (perhaps, in some way because of the absence of space nature clarity). Theoretically, if the postulate of symmetry is granted and the general theory of relativity becomes the base, the options of the flat finite (but without boundaries), the spherical and the saddle shape spaces are possible (which follows from the work of Friedman[4], 1924). In other words, space can be zero, positive or negative cambered. The area of observed space is so small when comparing the dimensions of an expanding universe that it is difficult to deduce the configuration of space on available area. If the method of induction is to be trusted, the flat infinite space becomes the most probable because of the equality of "there" and "here".

Another problem concerns place and matter. Should the material object, its location and boundary place be distinguished? In such a case (in accordance with Democritus, epicureans and atomist followers), space is a "place" and matter differs from space. Then the question of essence of "place" arises – is it the empty space, is it nothing[5]? Even Eleatics have been aware of this problem – they have no voids and therefore a lot is impossible, including movement. Consequently, the Eleatics' world is joint, indivisible, motionless space[6]. In fact, the difference between space and matter disappears in this situation. Aristotle admitted the existence of "place" but not void, which led to inexpungible collisions.

One of the most important differences in the views on matter essence of ancient philosophers and scientists of the Modern Ages is that the first ones consi-

[2] Cosmic space of Aristotle is finite because "nothing infinite can have being" [Aristotle, 1998: 47], which follows from the analysis of Plato's arguments about the All and other.

[3] Descartes has not strongly allowed a plurality of worlds; see [Descartes, 1982, § 22].

[4] See the English version of article [Friedmann, 1999: 2001–2008].

[5] It is possible to distinguish the void from nothing by endowing the first with length.

[6] The origins of scientific worldview in antiquity and the Modern Ages have been detailed investigated in the works of P.P. Gaydenko [Gaydenko, 2011; 2012].

dered matter a shadow, a reflection of real world of ideas (as for Plato) or the "possibility", something that does not exist without shape (as for Aristotle). But, for example, Descartes' has supposed it to be a substance, actuality, the true reality. R. Descartes rejected the idea of void space and declared all to have material length: "The reason for this is that the very names of "place" and "space" do not mean anything really different from the so-called "taking place" object; these are just the denotations of its scale, shape and position among other objects" [Descartes, 1982: § 13] and therefore, material length forms space.

During the reconceiving of the Parmenides sayings, Leibniz asks why there is somewhat instead of nothing [Leibniz, 2006: 31–38] and brings the problem to a new level of complexity. The very question so far admits the possibility of "not-being", "nothing". Leibniz solves this problem by involving the religious aspect and the law of sufficient reason. However, his issue leads to another important question: is it supposedly possible that somewhat does not exist? Therefore, the assumption arises that everything has to be because there is no reasonable basis for the absence of anything. A detailed analysis of this problem through a historical and philosophical perspective can be found in an article by A.S. Karpenko [Karpenko, 2014: 51–74].

Contrary to Descartes, Isaac Newton definitively separates space and matter. He has clearly declared that "Place is a part of space which a body takes up, and is according to the space, either absolute or relative..." [Newton, Cajori, Motte, 1974: 6–7]. Matter for Leibniz is the relevant phenomenon, but space is an ideal abstraction, without length! So the space has no dimension. Descartes and Leibniz completely denied atoms (the latter has them as monads – particles of matter which have purposely no length) and determined the qualities of matter to be the result of immaterial substance. But Newton was the atomist (but in a different way than, for example, Christiaan Huygens and other atomists of 17th century – Newton's atoms have active forces and different shapes).

If there are no atoms and voids, continuous ether should exist for movement to be possibility (Aristotle introduced whirling motion, Descartes also used "whirls" for the explanation of movement in ether), which is basically space. The ether concept was further developed in the form of the "luminiferous ether", where the electromagnetic waves are guided. Also it has been applied to James Maxwell's discovery of electromagnetism – his calculations showed the speed of light, which is close to that established by experiments, but the question remained: 300 000 km/s used towards what? The answer is to ether. However, Einstein's special theory of relativity has shown that Maxwell's equations do not really need any ether and the light moves with (always the same) speed towards anything. Thus, the status of space has become unclear again – it is empty. Then the reference system has become necessary for movement possibility in empty space. Therefore, Newtonian "absolute" space appears (while the space of Descartes and Leibniz is relative). This has yet become other than "nothing", but it is although not quite clear that exactly. It is notable that in a strict sense the Einstein movement is according to Einstein himself) – space-time (the Minkowski space) may be interpreted as a reference system in the theory of relativity.

Consequently, the problem of movement is closely related to continuity and discontinuity. Zeno's famous paradoxes are still relevant proving that movement and multiplicity do not exist, that thus, mines the foundations of early Pythagorean mathematics with its objects forming discrete monads[7]. Started by Leucippus-Democritus (who tried to avoid these paradoxes), the atomism program, Pythagorean ideas, developed by Plato (his discretes are point, line, plane) and Eudoxus, Aristotle's physics and Euclidean geometry have resulted in interesting theories today[8]. In the 20th century, atomism has been established. On the one hand it states the atoms' substance (quarks, electrons, photons, particles that transmit interactions, etc. are more relevant here), but on the other hand, it considers atoms as points without physical dimensions in mathematical body. If particles are physically discrete, but mathematically continuous (without minimum size) units in the standard model of particle physics, then the string theory and loop quantum gravity theory state their both scopes to have finite size. However, this shows the discrete nature of "located" in space matter, but not the discrete nature of space itself. The attempts to assign space as discrete are equal to stating space as not fundamental but "consisting" of something. The question remains open nowadays[9].

The special mention should be made of space in Plato's system, where space is not a place for objects and is not sensually perceived or completely perfect [Plato, 2000: 52 a-b]. It acts as a mediator between ideas and the world of senses. The accurate perception of it is impossible: it is as if "seen in the dream", but still needed for geometry practice. Accordingly, movement in it is impossible, too. The movement in the world of geometry, according to Proclus [Proclus, 1992], is a convenient fantasy resulting from the characteristics of our perception of the world. Kant's conception of space is close to its Platonic interpretation as *a priori* form of sensibility, which is itself impossible to be felt and thought, but remains the condition of perception.

As a result of Albert Einstein's formulation of the special theory of relativity, modern cosmology prefers operating not with space, but with space-time as a single structure (as has been shown by Jules Henri Poincaré [Poincaré, 1906: 129–176] and Hermann Minkowski [Minkowski, 1909: 75–88]). In particular, this implicates the connection between movement in space and over time movement. In fact, the geometrization of the time concept[10] happened in the 20th century.

[7] The analysis of almost all possible solutions of paradoxes with specifying of these decisions inconsistency has been carried out by A. Koyre in the special work [Koyré, 1961]

[8] The influence of geometry and mathematics of the Middle Ages and the Modern Ages to modern science is certainly great, but the science starting points are only indicated here.

[9] The details about the history of atomism see, for example, in [Zubov, 1965].

[10] Einstein believed that it is typical for the human mind [Einstein, 1954: 141].

Types of multiverse

As pointed out by Nelson Goodman, "If there is but one world, it embraces a multiplicity of contrasting aspects; if there are many worlds, the collection of them all is one universe" [Goodman, 1978: 2]. In other words, a lot of worlds can be considered as one, the multiverse, but one world can be viewed as many, too. Indeed, such a problem exists and it has a long history (e.g. Plato's relation of the all and the many[11]), and therefore a special criterion of the multiverse is required. In this paper the term multiverse (and its synonym meta-universe) is used to imply a variety of worlds where some of them are identical to ours[12] (or almost identical). Identity is an essential aspect – if ignored, any other star system or galaxy in the observable universe may become the research object. The assumptions of other similar to our one star systems` inhabitation (or objects of the solar system) have been repeatedly expressed in the history of science, and in the Modern Age acquired a strong share in scientific literature and fiction. Giordano Bruno [Bruno, 1584], Cyrano de Bergerac [Bergerac, 1657], Bernard Fontenelle [Fontenelle, 1686], Gottfried Alfred Burger, Rudolf Erich Raspe and many others have turned to the subject of habitable space in their works.

The assumption of habitable universe is quite acceptable, but it is not related to the multiverse theories. The idea of multiple worlds in modern physics presupposes that the other worlds exist beyond the observable universe (perhaps "parallel" to it). The first key point of the multiverse concept is that it is extremely difficult and virtually impossible to observe those worlds due to certain restrictions imposed by the laws of nature. The second key point, as has been mentioned, is the assumption that there are identical (or nearly identical) worlds to the one in focus.

The simplest type of multiverse arises from a single assumption: space is infinite. Curiously, the ideas of Nicholas of Cusa and Giordano Bruno are most fitting for the concept of such a multiverse. However, Nicholas of Cusa believed that all worlds have to be unique [Nicholas of Cusa, 2001: 94] and this, as will be shown, is an unreasonable condition. Bruno also raised an important point, that "act and potency are the same thing" [Bruno, 2004: 66], thus postulating that everything imaginable exists. However, in the case of physically possible universes, the laws of physics restrict "everything imaginable"[13].

Let us assume that conditions (laws of nature) beyond the observable universe are the same as in the one observed. If so, there is a finite number

[11] See the Plato`s "Parmenides", which has the extensive review on this issue [Plato, 1998].

[12] "Our world" is used as the observable universe within its cosmic horizon.

[13] An important question arises here: is it possible to think of something contrary to physics if the thinking itself is the subject to the laws of physics?

of possible variations of the particles and their combinations[14]. The number of combinations is enormous, but there likely will be repetitions in an infinite universe (an infinite number of times). Consequently, there is an infinite number of worlds that are repeated endlessly. Repeatability turns out to be an important condition for the understanding of the multiverse. Otherwise, we return to the traditional variations of an infinite universe, typical for Modern Age beliefs. This model describes a single infinite space. It is classical in the sense that in terms of physics it is treated as discrete and means a place for all possible configurations of matter. Nevertheless, it cannot be called empty, as it is "permeated" by various fields, which within the quantum field theory can be identified with particles. Each particle has a field (as it is impossible to precisely localize a particle in a finite space, a fluctuating particle can be considered the field quantum). However, a field is not space; the fields are sort of "situated" in the space determining the properties of matter, interactions of which are active in the space.

Another popular type of the multiverse is related to the previous one and turns out to be its extended version. It originates from the principle of plenitude (a term introduced by Arthur Lovejoy), which comes from the Plato's theory of forms. The essence of this theory is best described as "anything is possible". Perhaps, the first to explicitly develop the ideas of Plato was Giordano Bruno. This theory is not a physical one in the scientific sense, since obviously absurd scenarios would take place in such a multiverse (this makes up the fundamental difference from the previous type). Everything conceived has to exist, including nothing and any kinds of worlds that are physically and logically impossible. Here, however, one nuance appears: the identifying of language (thinking) with the world can lead to a conclusion that anything conceivable is logically possible (this trend, by the way, appears in Plato's works). This was stated by Ludwig Wittgenstein in Logical-Philosophical Treatise [Wittgenstein, 2007]. Thus, we can not conceive something that contradicts logic or describes a world fundamentally different from ours. However, Wittgenstein admits the "mystical", which is impossible, but does exist[15]. Fullness of objective reality requires the existence of everything, but in this context, laws and key concepts of physics lose all their meaning. The space can be anything you want, with some made-up characteristics, sometimes even mutually exclusive. This makes the principle of plenitude quite speculative. The principle of plenitude is covered in the works by Arthur Lovejoy [Lovejoy, 1936], Robert Nozick [Nozick, 1981], David Lewis [Lewis, 1986], V.P. Vizgin [Визгин, 2007] and A.S. Karpenko [Karpenko, 2013].

[14] It is possible to object the finite number of possible configurations, because the particles can be anywhere, and the number of options is infinite. But there are fundamental limits on the measurement accuracy (the ability to localize the particles is limited by the uncertainty principle), so that the space still appears discrete.

[15] Do these thoughts of Wittgenstein once again refer to the Plato's reflections on the all and the other?

In inflationary cosmology space acquires specific properties. Inflationary expansion is a leftover of the Big Bang theory, which helps to explain similar temperatures of the relict radiation within the limits of the observable universe. We are interested in a particular scenario of eternal inflation (inflationary cosmology model). The original scenario of eternal inflation was proposed by Alan Guth [Guth, 1997], Andrei Linde [Linde, 1990] and Paul Steinhardt [Bardeen, Steinhardt, Turner, 1983: 679]. Alexander Vilenkin apparently became the first to realize and explain in lay terms that inflationary expansion can be eternal (this idea has been further developed by physicists mentioned above). For such an assumption infinite space should be assumed as filled with hypothetical inflaton[16] field, high energy of the latter is causing the ultra-fast expansion. When the field energy rolls down to low values, new worlds start forming (the energy of the inflaton field is converted into particles, which later constitute new galaxies). Inflaton field fall could be explained through the quantum field theory, which predicts that quantum fluctuations (inevitable random distortion of the field at the micro level) can "reset" the inflaton field from the high point, leading to the formation of universes. Thus, there is endless space (the inflaton field) which permanently creates new universes. It is worth mentioning that although from the point of view of a hypothetical external observer, which possibly stays within the inflaton, these universes are finite, from the perspective of an internal observer they are infinite (this happens due to the difference in the time flow inside and outside each universe). This means that each of these universes can be considered as a multiverse, which leads to the original concept of the multiverse within the multiverse. But there is a peculiarity: the calculations show that universes within the inflaton must have negative curvature. While the most widespread opinion is that our universe is flat (has zero curvature), it can also be negative (or positive). Within large space, as already mentioned, curvature can remain unnoticed. But if observations show that our universe has no negative curvature, the inflationary multiverse scenario will be disproved [Freivogel, Kleban, Rodrgiuez Martinez, Susskind, 2006: 39].

It is not clear, whether the terms "inflaton field" and "space" can be used as synonyms. It is incorrect in the conventional understanding of space. An inflaton field is not some place for an object's location. On the other hand, it is as if covering the universes. Another problem is the dimension. But if by inflaton we understand space, then there is a problem with the interpretation of the environment that is contained in the universes "inside" the inflaton: it would seem absolutely different.

Another unusual viewpoint on the nature of space is contained in the quantum multiverse theory. In quantum physics, multiverse concept derives from the problem of quantum measurements. The history of this problem and some modern ways of solving it has been analyzed, for example, in my

[16] The Higgs boson can probably be the quantum of this field.

works [Karpenko, 2014 a: 110–126; Karpenko, 2014 b: 16–28], as well as in some other distinguished papers[17]. In this case, we shall only provide a brief statement: the problem of quantum measurement is that the linear Schrodinger equation, which describes the microcosm (the time evolution of the wave function), does not seem to work in the conditions of the macrocosm.

Max Born was the first to realize the stochastic nature of the wave function [Born, 1926: 863–867] and introduced the term "probability wave"[18] describing the behavior of particles that create an interference pattern. In other words, the particle can be regarded as a wave (demonstrated by Louis de Broglie [Broglie, 1965]), which means that there is a certain probability to find a particle in a particular location[19]. In those spots where the value of the wave is high (the amplitude is large) finding the particle is most likely.

The essence of the problem is: a probability wave shows (or rather, it is shown by the Schrodinger equation) that a particle can equally be found in several spots. However, when a measurement is being conducted (an interaction of the microcosm with the macroscopic measuring tool), the wave collapses, and only one spot for the particle is selected. This leads to a regular question: why the particle "has chosen" this spot rather than another – the wave function evolution shows us that the particle could be discovered elsewhere with the same probability. Of course, one can answer that such a choice has happened for no reason; it has been just an absolutely undetermined accident of nature. Such an answer is unacceptable for two reasons: obviously, science cannot rely on such grounds. Secondly, in this case it is necessary to state that the Schrodinger equation ceases to work after the transition from micro to macro level (when interacted with large measuring tools[20]), just as the Copenhagen interpretation claims.

For us, an important interpretation is the one proposed by Hugh Everett[21]. He suggested the so-called "many-worlds interpretation", the essence of which is that all possible outcomes take place. This means that any potential spot of the particle, described by a probability wave, is taken but in a separate, parallel universe. The huge advantage of this approach is that the Schrodinger equation never stops working. The obvious drawback lies in the extreme difficulty of proving this theory. David Deutsch asserts that the experiment with two (or more) holes definitively proves the existence

[17] See, for example [Bell, 1987; Wheeler, Zurek 1983].

[18] Waves of probability are related with wave functions, but they do not congruent with them. In fact, the possibility can not hold negative values, but the value of the wave function can. If it has been limited to probability waves, the interference pattern would not occur.

[19] Later Richard Feynman has shown that quantum field theory does not need the concepts of "particle" and "wave" for the valuable work; instead of that the composition of state vectors (summation over trajectories) is effected [Feynman, Hibbs, 2005].

[20] Of course, this can be explained by decoherence, but in this case it has no effect on essence of the many-worlds interpretation.

[21] The original version of the Everett`s thesis can be found in the book [DeWitt, Graham, 1973].

of parallel worlds [Deutsch, 1997: 32–55], since interference is the result of a photons (or electrons) collision from our world with photons (or electrons) from a parallel world, the history of which is still very close to ours. But since this is a "parallel reality", we are not able to see it. His theory becomes untenable if the elementary particles are considered as the waves. However, based on such phenomena as the photoelectric effect, he does not accept the principle of wave-particle duality. It is worth pointing out that despite the very considerable credibility of Deutsch in the world of physics, these arguments have not found substantive support in the scientific community.

If the many-worlds interpretation is accepted, the relevant question appears: where do these universes arise from and exist at every moment and in such large numbers? In a certain space? If so, they cease to be parallel, because there is a common space for them, which allows the possibility of their intersection. If not, and a new space appears every time, it appears nowhere. We have to assume the transformation of something into nothing, but such assumptions are obviously dead ends[22], which brings us back to how the problem was formulated in the times of Antiquity.

Another problem is that the quantum field theory works not in an ordinary three-dimensional space, but in Hilbert space (a variant of configuration for quantum theory), which can have any number of dimensions. Quantum-mechanical description deals with the usual space only if there is a single isolated particle wave function. But to describe each new particle, the three new spatial dimension axis are set up, so the number of dimensions would be three times bigger than the number of particles. It is clear that with macroscopic objects, such as measuring tools or people, the calculations become even more complex. But we are interested in another question: is the Hilbert space real and in what sense? It is considered to be a mathematical fiction, but the usage of the term "mathematical fiction" does not anyhow prove that the designated phenomenon is unreal.

Another effect of quantum mechanics (derived from the well-known experiment of Einstein-Podolsky-Rosen) is the nonlocality of space, which later became an important element of the de Broglie-Bohm theory [Bohm, 1983: 369], indirectly confirmed in the works of John Bell [Bell, 1964: 195–200] and Alain Aspect [Aspect, Grangier, Roger, 1982: 91–94]. Conventional ideas on the structure of space are based on the fact that space is local, meaning that a certain distance should be passed for some impact transfer, the speed of which is limited by the speed of light. However, nonlocality violates this principle: the so-called entangled photons instantly correlate, transferring the impact on one of them from one to another. This process obviously exceeds the speed of light (in fact, the speed has generally nothing to do with it). It definitely contradicts the special relativity theo-

[22] The problem arises precisely because of the emergence of new worlds, otherwise the "where"-question becomes redundant.

ry, which sets this upper limit of the speed[23]. While the elimination of this inconsistence is a purely mathematical problem, the philosophical foundations of physics can vary greatly depending on whether the space is local or not. If such confusion is interpreted as an effect of nonlocality, so the very concept of distance would change: it would lose its objective meaning and turn into an illusion of perception. And, apparently, the correlation remains no matter how far apart the particles are (last year Nicholas Gisin and his colleagues measured a distance of 25 kilometers [Bussiéres, Clausen, Tiranov, Korzh, Verma, Sae Woo Nam, Marsili, Ferrier, Goldner, Herrmann, Silberhorn, Sohler, Afzelius, Gisin, 2014: 775–778]). In such an instance, what makes "there" and "here" distinct for us if such a distinction does not really exist and space is nonlocal? Why does the human experience vary from the scientific data and a man has to pass nonexistent distances to get from one point to another? Does it all supposedly happen due to the same difference between the microcosm and macrocosm in the Copenhagen interpretation and space is nonlocal only at the micro level? Such a hypothesis requires a great deal of explanations.

Gisin's experiments have shown that quantum teleportation is possible, which actually means the instantaneous dislocation of an object from one spot in space to another (thus far it concerns elementary particles). This may mean that despite nonlocality, the concept of "place in space" remains: the essence of teleportation is that an identical double of an object appears in a different place, while the original object stays in the same place. The connections between objects in space might be named nonlocal, while space, as considered by the classical physics (by Newton, Einstein, and others), is local and provides "spots" to locate objects.

It is worth mentioning that the many-worlds interpretation, apart from being hard to prove, comes across another serious difficulty. The very concept of probability loses its sense within such an interpretation. If all possible outcomes are real, why do any of the outcomes become more or less probable? Being statistical by its nature, quantum calculations show that during a repeated experiment, a particle would most likely appear in a certain place, however, the probability of some outcomes may be higher than others. So the particle will not necessarily appear in the most probable place, but it will get there more often. Nevertheless, with the mandatory execution of all outcomes the meaning of such probability – the foundation of quantum mechanics – vanishes.

Another unconventional vision of space occurs in the concept of a virtual multiverse. This concept allows the existence of virtual worlds, which are the specific representations of imaginary things by sentient beings. Let's refer to computer simulations for simplicity of research, though, more broadly speaking, any result of consciousness activity can be named by vir-

[23] The limit is imposed on movement in space, but space may expand faster.

tual reality: scientific theories, visual arts, literary works, dreams and more widely, thought at all.

Since the growth of technological capacities and, therefore, processing power of computers, the reasonable assumption has been formulated according to the future creation of computers, which will precisely simulate the environment. Long before the introduction of computers, Alan Turing showed [Turing, 1937: 544–546] that it is basically possible to create a universal computing machine which carries out all possible calculations, except noncomputable statements[24]. To prove the existence of noncomputable environments Turing has used a modification of the diagonal method of Georg Cantor. Considering this, According to Turing's result (and also a similar independent result of Alonzo Church [Church, 1936: 345–363] and Kurt Gödel's [Gödel, 1931: 173–198] incompleteness theorem) with a computer world's simulation it is reasonable to discuss only the computable procedures. There are an infinite number of noncomputable objects (worlds), but discussing them is useless – we cannot think of them (if we consider the brain as an analogue of a classical computer) and the computer cannot simulate them[25]. Is it possible to imagine such an uncomputable world? Deutsch believes that it is possible – this is the world that constantly and completely changes its shape (but there is no way to find yourself there). These worlds are physically impossible, but logically possible.

Thus, if there is sufficient processing power (and other parts resulting from the complexity theory – but some calculations will take too much time), the creation of an accurate, interactive, changeable computer model of reality is possible. Furthermore, there is no need to model something that cannot be observed directly (this would require incredible additional calculations) – for example, the universe beyond the cosmic horizon, the interior of stars, distant planets, etc., and a microcosm of elementary particles –these are being simulated during the observation. If our existence within a simulated universe is assumed, that explains the problem of quantum measurements: some configuration is calculated only at the moment when the measurement begins. It should be recognized in such cases that the problem of measurement is a program failure, and thus it notifies us of our simulated state of being.

The next required step for virtual multiverse term recognition contains acceptance of facts that consciousness can be considered as a program, which provides processing procedures, and that the presence of a biological carrier is not a mandatory term for the existence of consciousness. In other words, consciousness can be simulated on an electronic medium in the form of program code (strong evidence suggests that the creation of artifi-

[24] This refers to the so-called "halting problem", which postulates that there is no general algorithm to solve all possible problems and, therefore, formulated by Gilbert problem of mathematics solvability has no solution.

[25] We can not exclude that quantum computers will show differently.

cial intelligence is nothing more than a matter of time[26]). From this assumption the very important conclusion arises: all reality, including consciousness, can be presented as a program code. Moreover, inhabitants of this will naturally assume their reality to be the true one (at least, up to a certain stage of their science development). It is not clear what should be considered the space of this reality: software or hardware (hard disk, CPU, memory, etc.). Furthermore, inhabitants of this simulation may sooner or later create a simulation within a simulation and inhabitants of the new simulation, too, and so on indefinitely. Any number of simulations within simulations is possible. Of course, here raises the question of the primary world, where the very first computer model of the world was created – the discovery of this reality will provide answers to the world structure, its real physical laws and the properties of space. In fact, the problem of search for the ultimate cause was set up. It is reminiscent of Thomas Aquinas's proof of the existence of God, where one of the points comes from the necessity for the ultimate cause of existence [Thomas Aquinas, 1948: 11–14].

However, his critics have questioned the fact that there must be some ultimate cause, the cause of all causes, which does not need a reason. There are no convincing (scientific) arguments that there necessarily has to be an ultimate cause (for example, some models of cyclic universes in the theory of eternal inflation do not have it). Thus, simulation within simulation can extend both infinitely into the future and into the past. But in this case, when simulations are the only affordable reality, is it possible to state that there is some genuine space outside simulations? So if there is no other reality than simulations, which are processing objects, this reality has a mathematical nature or rather equals mathematics. In this sense, the concept of physical space makes no sense at all. On the other hand, the problem of how these simulations work and where they are located still remains. Can they work without the original hardware or is the idea of the "hardware" just a projection, caused by the limitations of our perception? And so they still are mathematical objects, same as the observable world in Plato's theory – a shadow of the world of ideas.

Leibniz claimed that if there is the difficult, there must be the simple, inseparable (monads), which forms the basis. Kant's monads turn into things in themselves, incognoscible substances, which also form the basis and become the causes of phenomena[27]. But according to time infinity of simulations[28] the very substances, which formthe phenomena, may not be

[26] On the history and current problems of artifical intelligence see, for example [Hutter, 2005; Nilsson, 2010; Rajani, 2011: 173–176].

[27] "…we will begin here with the category of substance, and thus go backwards throw the series" [Kant, 1998: 413].

[28] "Time" concept is also not easy: considering it as infinite is possible only in case of external time existence in relation to all simulations, otherwise the internal time of each individual simulation exists and in this case simulations can not be sequentially arranged in time.

present. In such a world, the whole reality is mathematics (or it is itself this substance), and cognition of world is the study of mathematics itself. This accords with the Pythagorean concept "everything is number", which was clearly formulated by Philolaus and formed the program of development of mathematics as a key science, which was supported by Plato and his school (in the sense of the program of mathematics development), developed by Galileo and later involved the increasing number of supporters[29]. Roger Penrose is known for his extreme position on the question of the role of mathematics – he firmly believes that the only reality is a world of mathematical abstractions [Penrose, 2004: 12]. If we accept this version of the multiverse, it is necessary to recognize that the concept of space as physical reality represents fiction.

Conclusions

In discussed theories it could be frequently found that space appears as a certain scene of actions, where events of microcosm and macrocosm occur. However, its specific features are defined by an emphasis on certain basic theories, which form the concept of multiverse. For example, the space of the quantum multiverse is a fluctuating field (and there is no sense asking what is behind this field or where it is), which is associated with particles, the probable positions of which set up new universes. However, it seems to be possible to simplify the concept of quantum multiverse as follows. New worlds appear "nowhere". In quantum theory all possible worlds are already set up initially – but only potentially. The wave function of the system is a mixture of all possibilities of its implementation – it already describes quantum multiverse. Its unmeasured positions and particle momenta (thus, basically unknown) in particular constitute the true multiverse – this quantum uncertainty can be interpreted as "everything possible is possible". In this sense, the space of quantum field theory (directly unobservable at the micro level) is the repository of an infinite number of possibilities. This is not the actual, but the potential multiverse, which nevertheless exists.

Described macrocosm theories are based on the general theory of relativity. The space of the general theory of relativity is inseparable from time. It is particularly obvious with the consequences of the theory of black holes. "Inside" the black hole, space and time are reversed, so movement in space becomes movement in time after the crossing of the (hypothetical) event horizon. In that case, is it possible to refer to space as a place (in other words, can time become place)? Another question arises: does a black hole itself holds a place in space? Apparently, the answer "yes" is impossible, because inside the black hole, the space-time structure changes so that the current mathe-

[29] See [Heisenberg, 1952; 1979].

matics does not answer (or rather gives meaningless answers – this is a common problem of singularities). In this regard, the idea of "place" could be abandoned and the Cartesian space could be revived by acceptance of new the interpretation of Einstein's results on curvature of space caused by massive objects: a massive object "drives out" its spanning field, thus producing its curvature. Such an interpretation returns us to denying void (as the idea of separation between space and matter) and, therefore, atomism concepts.

The research in the field of such general theory of relativity result as black holes or even their entropies, also supplemented by superstring theory, has led to the idea of the universe, based on the holographic principle. The first steps in this direction were made in the works of Karl Schwarzschild [Schwarzschild, 1916: 189–196], and afterwards developed by Jacob Bekenstein [Bekenstein, 1976: 2333–2346], Stephen Hawking [Hawking, 1974: 30–31], Leonard Susskind [Susskind, 1995: 6377–6399] and Gerard 't Hooft [Stephens, 't Hooft, Whiting, 1994: 621] (in the standard model of physics). Based on these studies, string theorists Edward Witten [Witten, 1998: 253–291] and Juan Maldacena [Horowitz, Maldacena, Strominger, 1996: 151–159] have shown that the observed three-dimensional universe may be regarded as a reflection (hologram) of physical events taking place on a distant two-dimensional plane, which in a certain sense is the true reality because it generates the three-dimensional reality of our existence. A mysterious boundary plane is not material in the regular sense: the so-called matter and space in this concept are the holograms, but "real" matter and space are somewhere else (if it is worth making such a distinction at all). This position is close to the correlation between Plato's ideas and their shadows – the sensual world – but it also maintains one significant difference. From Plato's point of view, it is pointless to perceive the world of the senses – it is a dead end track – so you should immediately contact an ideal world, containing prototypes. In the concept of Maldacena and Witten, the situation is different: there is a mathematical duality – the complicated properties of three-dimensional reality can be described and established by the language of two-dimensional plane and vice versa, which is in terms of Plato the way from the sensual, the observed, to the intelligible.

While conducting research on the possible characteristics of space, the following question should also be considered closer: what are the impossible characteristics? Regarding the question of the probable distribution of intelligent life in the multiverse due to the anthropic principle, Steven Weinberg [Weinberg, 1989: 1–23] drew the conclusion that the formation of galaxies (with the admitted mandatory condition of observers occurrence) is possible only for certain values of the cosmological constant[30]. Thus, theoretically the values of a constant can vary. This means that there is no sense in asking about the properties and structure of the universe, space and

[30] This refers to what is commonly denoted as gravitational repulsion or dark energy.

time – for what reason they are as they are and are not different. It makes no sense, because all possible configurations appear to be realized in the multiverse. In more detail, there are some fundamental values of our universe (other than the mentioned constant, for example, the electron mass), which are known from experience, but have not been calculated mathematically. Their mathematical calculation will give justification of their origin. Meanwhile mathematics offers a wide range of possible values. We know them from experience and insert them to equations (for example, quantum field theory operates this way). These result in the description of our world. But it is possible that these values are not generally able to be processed, which means that for the mathematics theory any value is allowed. This may mean that the multiverse is real – all the possibilities are being realized in it. But such a position may affect the nature and method of science. The logical, in terms of the traditional science question of the exact origins of space properties, loses sense because there is no need to explain anything in an infinite number of worlds with all implemented properties. The answer is: this is just one of all possible configurations. However, even considering this, the former questions of whether it is place or matter – it has the length or not, it is continuous or discontinuous, it is fundamental or not – still remain relevant and fit into the modern scientific paradigm.

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