New ontology: algorithmic laws and the passage of time

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Abstract

The concept of the algorithm, known from computability theory, should become the basis for an ontology of the Universe. This should lead to a change in the paradigm of natural science cognition. We argue that, with the exception of fundamental physical laws, all other laws are algorithmic. To illustrate this statement, the chess metaphor proposed by Richard Feynman is convenient, where the given rules of the game are the basic laws, and the laws of the deployment of compositions are the laws of the relationship between the basic elements in different situations. Since the game is algorithmic, it is possible to extend this property to the objective laws of the Universe. The main property of algorithmicity is the sequence of steps and information interaction. To express this, we introduce a new concept of time. The following definitions are given: 1) there is a set that we call "Time"; 2) this set consists of an infinite number of individual elements, which we call "Moments"; 3) all elements of a given set have a peculiarity: if one element is REAL, all other elements of the set are UNREAL; 4) we will call sets of this type – "AREAL SETS". It was found that the elementary areal relation is a logical law of contradiction: statements A and NOT-A together form an areal set of two elements. Formulating the law of contradiction, Aristotle and all the logicians after him constantly emphasized: there cannot be A and NOT-A in the same respect at the same TIME. We propose to rearrange the emphasis: in our formulation, AREALITY is a special logical relation that can simulate natural Time. The new model defines the time order in the form of definite characters' sequence. The proposed ontology is related to the definition and introduction of the digital physics paradigm.

Introduction

Theories of computability and theories of computational complexity are based on the concept of an algorithm. Features of the algorithm are discrete steps, sequential (and parallel) shift from the beginning to the end, memory operation, recording information, etc. In our opinion, the concept of an algorithm is also based on a special understanding of time. This particular understanding must be explicated and comprehended. This paper briefly presents the results of our research **[1]**, **[2]** concerning the results of the Integration project of the Siberian branch of the Russian Academy of Sciences "Computability and rationality: studies of the applicability of the Church-Turing thesis and the concept of effective computation to the problem of the ratio of deductive and empirical knowledge of cognitive and physical processes" **[3]**.

We base on one obvious fact: in modern nature study the geometrical interpretation of time prevails. In the twentieth century the philosophers of science, for example McTaggart (1908)

[4] and up to Julian Barbour (1999) **[5]**, the duration of the time referred to the sphere of subjectivity. Objectivity is a property of the sequence of events and corresponds to the order of points on a straight line. A similar understanding can be found in the common interpretation of space-time continuum of Minkowski where the temporal dimension has oneness. [1]

The reduction to the subjectivity is often associated with the name of the Christian theologian – St. Augustine. In his philosophical work "Confessions," he said that the notion of time is our memories of the Past , our contemplation of the Present, and our expectations for the future. There is no past, no future, and only in the soul of a human, are there forms of perception corresponding to them. **[6]** Nevertheless, it should be kept in mind, that according to this profound theologian, time is a creation of God, and therefore the characteristics of the flowing time are the objective properties of time as creation. Thus, St. Augustine is talking not about reducing time to the properties of the soul, but about structuring the temporal process as it is according to the mental properties.

In the same period of the early Christianity there was a specific Arian heresy, where God obeys the temporal order. "First, the Father, then the Son" – Arius says. It is interesting that, after a century, Isaac Newton adopted the philosophy of Arianism. This fact has been noted by various historians of science and we tend to believe that Arian approach is explicitly embodied in the classical idea of the absolute time. Even in a relativistic theory, the global time of the universe retains the absolute inclusiveness of all – all the instants are given on the time axis. The stream of time is in the eternity.

We have found out that in the modern science two concepts of time coexist – the geometric and the algebraic (the algorithmic). The first approach is well-recognized and is applied with skillfully, but the second has only now moved to the forefront, thanks to the development of computational tools. To illustrate our point of view, let us consider a story from the recent history of science.

Fundamental laws and algorithmic laws

In the lecture series "The Character of Physical Laws" the famous American physicist Richard Feynman described the chess model of physical reality. **[7]** If we accept a checkered board as the image of the physical space with a set of chess figures associated with elementary particles or objects, and the rules of reordering chess figures, then we will understand how the fundamental laws of motion revive the similarity of the universe and the chess games. In the real world, based on the fundamental physical laws, microparticles are combined into stable structures of different levels of complexity. Similarly, in various situations on the chessboard, the pieces are forming a variety of compositions. Feynman even makes a conclusion about a

[1] We think that there is some particularity in the position of the "deniers of time". Yes, of course, the ***iCt*** axis in the 4-dimensional pseudo-Euclidean space-time continuum can be interpreted as something given in the eternity, but, nevertheless, the appearance of events on this axis referee to the gradual formation process. It can, at it's best, be considered as predetermined events left in the past. (At the same time, the status of the past for the microworld, where quantum uncertainty is dominant remains controversial: for example, what did the microparticle possess at a certain moment of the past — the coordinate or the impulse?) Suppose that moments in the future are predetermined, but no events at these moments have yet occurred. There is no future in this respect from the point.

supposed possibility of a physical science to come to an end, once all the "rules of the game" have become known to scientists. Then the process of cognition will turn into modeling and constructing possible combinations of these elements according to given laws. All the elements of the world are constantly subordinated the same stable fundamental laws. Feynman explains: if a whitebishop moves only along white diagonals, then at any time of the game we will find it on a white square (unless, of course, it has not yet been removed from the board).

In addition to Richard Feynman, the chess metaphor was also used by the English physicist Arthur Eddington and many others. In fact, the analogy is fairly obvious. But today we want to draw attention to the fact that the game is an algorithmized construction of objects and moves, and it would be interesting to comprehend the comparison noted by the physicists from this point of view.

We immediately notice that in physics there is a double classification of the laws of nature. Firstly, these are the basic laws, and, secondly, particular laws governing the existence of various material systems. In reality, these are atoms and molecules, systems and bodies of various sizes, living organisms and technical devices. In a chess game, this role is played by compositions that are formed during the movement of pawns, knights, queens etc. We can only point out the algorithmic nature of the game and reverse the chess metaphor backwards in time. Then two subsets in the community of physical laws will look different. In one of them there will be the fundamental laws of physics. In the other there will be the second group of the natural laws connected with the existence and functioning of natural systems – microcosm, chemistry, biology, planets, stars, galaxies. All these patterns are described mathematically by models, and in the case of the digital's models it has a clear algorithmic nature of this kind of laws. It is usually assumed that algorithmization is just a human trick in the course of the learning process. We offer to change emphasis here. Yes, the numerical modeling in knowledge is implemented by using a special device – a computer, but the fact is that in the nature of the simulated patterns are of exactly the same algorithmic nature inside and it is based on a computational process.

However, this understanding was implicit in the cognitive process. It is enough to say that classical physics often used a similar metaphor that identified the Universe with a clockwork mechanism, but it is obvious that the functionality of a mechanical clock is one of the simplest algorithmically arranged processes. An important indicator of the algorithmic nature of physical regularities is the principle of the least action, when variations of the functional act as elementary steps of an algorithmically constructed process. It is no accident that this approach led to an elementary quantum of action – Planck's constant. We think that the algorithmic paradigm will allow us to understand the meaning of the transition from classical to quantum mechanics.)

So, we affirm that: with the exception of fundamental laws, in all other natural laws there are essentially algorithmic nature and patterns that are associated with computational operations of different levels of complexity. It must be considered and studied concerning this point. In this respect, the basic laws in their mathematical expression appear as a kind of timeless formulae

in themselves. In contrast, algorithmic laws can change depending on the initial conditions being under study and external parameters. They are filled in the time stream, and therefore they can be expressed by differential equations and digital computer models. In our opinion, in order to adequately express this fundamental fact, it is necessary to introduce a new understanding of time into science).

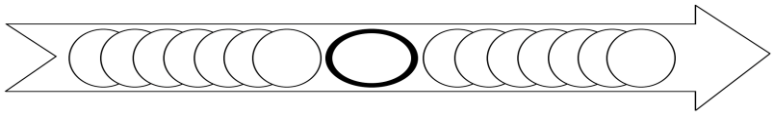
A new understanding of time

In our opinion, the algorithmic laws have a special concept of time that differs from the traditional one. The order of the moments is not initially specified in it, but it is formed in the course of the execution of the algorithm. Let's describe this new understanding of time.[2]

We offer a concept that takes the specific qualities of time into account, and it is expressed in the concepts of "Past", "Present," and "Future". We will take into account the properties and characteristic precisely for a target interval of time, and not for the frozen spatial extension as understanding of the time axis. We will take into account the new concept concerning the analysis of the structure of the natural time - "***areal sets***".

First, we will introduce the division of a single time stream into the Past, Present, and Future. Secondly, we represent the absolute time as an infinite number of individual moments.[3] A definite paradox is immediately revealed, because there is really no Future (it has not yet been reached), and we are talking about the existence of moments of the past in a certain specific sense since they are already gone. There is only a moment of the Present in fact. Moreover, if the moment is attributed to nonexistent, it could nevertheless be real sometime earlier, or it will become existent sometime later – the Time Flows. This is stated in the concept of the ***areal set***: an element of the areal set is real if and only if all other elements of the set are unreal. And for Time, this is obvious: the instant moment of the Present is real if and only if all the other moments are brought into unreality – in the Past or in the Future.

All instances of Time form an Areal Set.



PAST - unreal **PRESENT - real** *FUTURE - unreal*

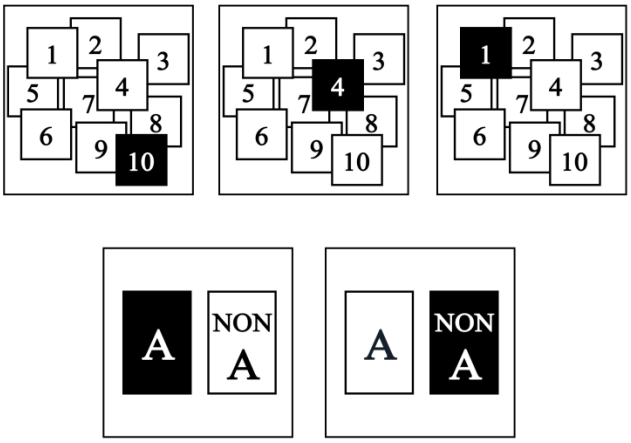
The formulation of the general concept implies that not only moments of time can be represented as an ***areal set***, but also some other sets of elements. Where are they? Yes, the

[2] Earlier in English, this concept was summarized in the abstracts of Poluyan P. A new model of time. Areal multitudes // Section 58: Philosophy of nature. XXIII World Congress of Philosophy. Philosophy as Inquiry and Way of Life. Abstracts. – Athens 04-10 August 2013, Greek Philosophy Society & FISP. University of Athens, School of Philosophy. P. 572-573.

[3] In his work "Five Contributions to Natural Philosophy" (2004), the American physicist Walter Knoll gives the same explanation: "The set of all instants is what one might call" absolute time". (Noll W. Five Contributions to Natural Philosophy (2004), pages 10. URL: http://www.math.cmu.edu/~wn0g/FC.pdf). Professor Francis William Lawvere paid our attention on this coherence in a private letter: "It seems that you might be interested in the interpretation of Neoclassical space-time suggested some years ago by my friend Walter Noll. The basic idea is a map projecting space-time onto time; partial sections of this map can then represent trajectories of individual particles. (The map need not be a product-projection, so that the fibers of the map represent the spaces at each individual 'now'.) There is then the question of what further structure to attribute to these objects and maps. There are various notions of fibration in both differential geometry and category theory. Somehow one must achieve at least a non-trivial sense to Hegel's 'Wesen is gewesen'."

relation of ***areality*** in mathematics and logic is found. For example, in geometry, when a Cartesian coordinate system for three-dimensional space is specified, it isusually noted that, depending on the order of the naming of the axes, two options are possible – the "left" coordinate system and the "right" one. If we choose "right" – "left" is excluded (and vice versa). We find another example of the areal relationship in the definition of the continuity of the one-dimensional continuum through the Dedekind section. The number producing the latter must be assigned either to the left side of the numerical axis (as the largest in this "lower" class) or to the right side (as the smallest in this "upper" class). Both variants are the same Dedekind section and are in the ***areal*** relation (when one is accepted, the other is excluded).

So, finally, it is especially significant that we find the areal attitude in the very foundation of classical logic – in the law of contradiction. "It is impossible that the same thing at the same time should not belong to the same thing in the same respect" – Aristotle defined in his Metaphysics. **[8]** Here, the ***areal set*** is the set of two statements, consisting of statement **A** and its negation of **non-A**. If **A** is true (real), its denial of the **non-A** which is not true (that is, unreal), if true is **non-A**, then the opposite statement A is untrue (unreal). Here ***areality*** is obvious and not accidental, because the logical law the contradiction states that they cannot be true **A** and **non-A** at the same time. Thus, we see that the relation of ***areality*** is implicitly embedded in the basic law of logic – in the law prohibiting contradictions. But when we discover it explicitly, we must now generalize it – the ***areal set*** of two statements **A** and **non-A** is only the simplest case.



***AREAL SET*:**
The reality of one element of the set makes all other elements of the set unreal.

In all of the above examples, finite sets consisting of two mutually exclusive variants are ***areal***, and for modeling time, it would be more important for us to find an ***areal*** infinite set. It means, we have found the examples of the sets.

To operate with numbers, people use the so-called scale number systems. The decimal system is used in typical cases, binary ones work in computer science, but it is obvious that any natural number that is greater than one can become the basis of a positional system. Number systems are the essence of construction, invented as a simplified notation of numbers, algorithms for giving the formation of unique names. You select a certain basic number, which is taken as a

unit of the first category, and then the counting process goes so that the new units are recalculated a given number of times. All number systems rely on the scale setting property belonging to the numerical line, and the set of scale settings of the numerical axis is the set of variants of the unit-based measures. So, if one scale setting is selected (is made real), all other scale settings are unreal.

The scale setting of the numerical axis is not defined as a specific object for the study of mathematical science, since it is regarded as the simplest and trivial. All possible scale settings of the numerical axis will form a certain infinite set, but on this set, there is always a certain initial unit – a scale setting taken in a real way, and the rest of the scales setting is transferred to ***areality*** mode.

So, multiple scales' settings represent ***areal sets***. However, we started by defining time as an ***areal set*** as well. We offer to identify the ***areal set*** of the marking points of the axis of real numbers with the chronometry of the natural time. The time now finds its own theoretical representation, in this model, it obtains some mathematical structure, and most importantly – we can see here how the relationship of ***areality*** represents a gradual development process. We hope that this approach will be useful for logicians and mathematicians.

The ***areal set*** is only the primary mathematical structure for constructing a more adequate time model. This adequacy is obvious, for example, when comparing the ***areal set*** with traditional mathematical structures, which are defined as a whole, similar to the space that is defined as a given set of the tree coordinate lines points. The mathematical universe is traditionally a Platonic world of eternal ideas that have frozen like perfect sculptures. In the case of ***areality*** all is different: we have to comprehend the unity and the integrity of a structure whose elements cannot be valid at the same time.

Let's think about it: for an ***areal set***, each of its elements is real, in case that all the others are unreal. In the traditional approach, there is some element **A**, the condition for the existence of which is the unreality (absence) of certain elements. In addition, it would not seem to be unusual if we assume the existence of some other mathematical objects of this type. The innovation is that we define such elements as a real set. The traditional approach, as it is, implies that the set is actually a set within the existence of all its elements. Our unconventional approach implies that the ***areal set*** is defined as some existing object mostly because its elements are connected by an ***areal*** relationship: each of them is real if and only if the others are unreal. Nevertheless, both the set itself and all the elements of such a set have an existence, but the existence of one element is incompatible with the existence of others – and this is what unites them into a single set, into an ***areal set***! In other words, in the world of eternal ideas, an analogue of time is revealed when ideas come into existence in order, although they form a single world in their being. For the case of time they share the same existence in a sequence.

The new model has another specific feature. The Real Time defines a sequence of moments, structured according to the principle of "earlier-to-later". For naming, there is a structuring on the principle of "more-to-less" according to the value of the numbers taken as the scale setting.

Moreover, the question arises: should the "more-to-less" relationship on the set of scale setting units be identified with the "earlier-to-later" order, characteristic of the time orientation? Responding to the question, we find an interesting particularity: it is clear that aligning scale setting in a certain series according to the "more-to-less" principle is just one of the options for constructing a sequence of scale setting, and in the general case, an infinite number of such options can be proposed. In order to correspond a series of scale setting to be unambiguously compared with a series of instants, it is only necessary to repeat the scale setting while constructing of the series. The direction is determined by the order of scale setting in a sequence, but the concrete implementation of the queue of scale setting in this sequence can be optional. In other words, in real time, scale settings are arranged in a row in a random order in an infinite number of options – this is how a sort of symbolic sequences is realized (metaphorically like a genotype chain, but not from a finite set of symbols-elements, but from an infinite number of elements). The mathematical aspects of symbolic sequences are studied by bioinformatics; correspondingly, in our time model, an application area for such studies is opened. So, unexpectedly, we return to the algorithmic patterns discussed in the first part of the article.

As far as future investigation is concerned, we must say that different levels of matter organization correspond to the ideas of the algorithmic repetitions (algorithmic cycles), necessary preliminary state (algorithmic conditions), and order of stages (algorithmic sequence) that all refer to system programming. Besides, parallel processes handling, randomizing and disjunctive branches of algorithms, and other forms of algorithmic patterns and structures can be formed over the function trees over the values of the physical, chemical, biological, psychological, social, and management systems. The natural language texts can set a mind state that works like an algorithmic agent, so, textcode can program the behavior of a system – alive or not alive. That is how social algorithms work. The regulations can be made in a textcode descriptions manner that needs further investigations.

Of course, the proposed model leads to the formulation of new problems, the consideration of which will require a bigger review. **[9]**

Conclusion

The concept of an algorithmic understanding of physical laws and the new understanding of time under investigation are related to the field of heuristic constructions of digital physics. This trend refers to the names of scientists such as Konrad Zuse ("Calculating Space"), John Wheeler (John Archibald Wheeler "it from bit"), up to modern research by Seth Lloyd, Edward Fredkin, Max Tegmark, David Deutsch, Stephen Wolfram, and others. In Russia, this area is underdeveloped, to name a few independent researchers: A.A. Grishaev, A.V. Kaminsky. Institutionalized scientists refrain from making extreme judgments. This is understandable, because we are talking about creating a new ontology. **[10]**

We believe that for physics, the main result of research in the field of computer sciences and computability theories was precisely the application of the algorithmic approach to natural reality. However, how will this approach be combined with the paradigm – this question is

traditional for physics – the future will show. It is possible that the result will be an approval of a new ontology based on the recognition of the objectivity and fundamental nature of information connections and interactions, as well as a new algorithmic paradigm. We believe that the way to build new concepts of time and space associated with the introduction of discreteness is promising. It seems promising to formulate the so-called quaternionic time-space with a special constant expressing the limiting minimum of time for a complete revolution of the reference system around its axis. **[11]** But this is only a hypothesis. Although there is hope that it can be verified experimentally.

Another area where, in our opinion, experimental verification is possible is the experimental discovery of informational interactions in inanimate nature. So, for example, in Russia in the early twentieth century, some work was carried out to search for electromagnetic effects capable of catalyzing the chemical reactions of combustion and explosion. As you know, the interaction of electromagnetic waves with chemicals culminated in the discovery of Raman scattering. Research should be continued. At the end of 2019, the authors of the proposed article created a startup on the development of digital fundamental ontology, which can find application in economic processes.

In our essay, we insisted on the algorithmic nature of objective laws operating in the universe. But at the same time, we proclaimed a special status of the fundamental laws. This, of course, is an arbitrary assumption. For example, John Archibald Wheeler exclaimed: "Are the basic laws of physics really basic? Are they eternal? Or are there important conclusions about the laws of physics that can and should be drawn from the fact that the universe itself does not exist forever?" **[12]** Accordingly, we would like to finish your essay with an important statement. It is known that in the modern times the natural science view to the world triumphed over theology. The idea of the divine creation of the world led to insoluble questions. How did God create the world? What happened before the act of Creation? At the same time, it was described by classical physics that material Nature existed forever according to unchanging laws - this was clear and understandable enough. What could be the questions in this respect? But in the twentieth century, physics led to the idea of a kind of developing world, it was generally accepted that a harmonious system of physical laws arose in the course of a chaotic explosive process. All this raises questions of a metaphysical nature. And, in our opinion, further progress in physics requires the formation of a special non-classical ontology.

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