Review of: "Mathematics Is Physical"

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Potential competing interests: No potential competing interests to declare.

The Physicalization Of Mathematics And

The Mathematization Of Physics

In The Light Of Quasi-Physical

Integration And Differentiation Of Knowledge.

Article Review by Biao Wu «**Mathematics Is Physical**»

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1. Introduction to the review

The main topic of the article, presented in the title, can be formulated as the reintegration of knowledge divided as a result of the natural science revolution within the framework of the cognition model that dominates today and belongs to the post-paradigm phase of Thomas Kuhn's cyclic model. Although the author of the article does not talk about this, in fact, he concretizes this task as the integration of physics, mathematics and information technology, forming a conceptual apparatus for the development of quantum computers.

The author of the article did not accidentally put this aspect in the title. It really is of particular interest. With the advent of computers, the phenomenon of information has become a key object of cognition. However, in the picture of the world, which consists of nature and society, there is no place for information as a special entity. Therefore, instead of the dominant and not completely understandable model of cognition, a model is required that takes into account information phenomena in the picture of the cognizable world.

In this case, it does not matter how much the author managed to form the logical and conceptual apparatus necessary for this. Fundamental difficulties at such levels of abstraction are inevitable. And the author of the article does not avoid them. At the same time, he also solves an applied problem, trying to take into account horizontal (in terms of spheres of phenomena) and vertical (in terms of levels of abstraction) connections between scientific objects and subjects. Solving applied problems is a necessary condition for building a model of cognition. It is obvious that physics and mathematics are different levels of abstraction in the knowledge of physical phenomena. At the same time, in the information sciences, physics should play a role similar to the role of physics in biology, when several spheres of phenomena intersect.

This topic is considered from the perspective of a quasi - physical model of cognition and economic activity[2].

2. Comments on the article under discussion

2.1. “The world of mathematics is often considered abstract, with its symbols, concepts, and topics appearing unrelated to physical objects”(p.1).

Mathematics is a really deep level of abstraction, that is, simplification of things. But if it is not connected with real physical, biological, informational and other things and systems of things directly or indirectly, then it is a simulacrum, and in this case few people may be interested. For Newton and Leibniz, mathematics and physics were one. And only centuries after the division of knowledge, for which there were good reasons (first of all, the division of labor for the development and utilization of the results of the natural science revolution), it has to be proved.

2.2. ”However, it is important to recognize that the development of mathematics is fundamentally influenced by a basic fact: mathematicians and computers are physical objects subject to the laws of physic” (p.1).

A mathematician, of course, has physical and, moreover, biological properties, but his essence is that he is a reasonable person. It is subject not only to physical laws, but also to other laws, including those that have not yet been established. It is easy to forget about this and move from the mechanization of man to the humanization of machines.

2.3. ”Through an analysis of the Turing machine, it becomes evident that Turing and his contemporaries overlooked a physical possibility: information carriers can be quantum systems” (p.1).

A Turing machine is an abstraction of the physical level, which corresponds to a class (set) of physical devices capable of solving any computational problem represented by an algorithm. It is obvious that, for example, analog computing devices do not satisfy this requirement. Turing did not have to think about what element basis and how the algorithmic computing device would be implemented. Of course, the performance of a computing device depends on this, but the principle does not change from this, unless, of course, a quantum computer is an analog device.

2.4. ”As a result, computing models like the Turing machine can only process classical information, limiting their computing power” (p.1).

It would be necessary to explain what the author understands by the term "information", given that the definition of "classical" does not make it more understandable. Especially in the context of the theory of knowledge, it should not be used "by default". At a minimum, you need to have at least a hypothesis about their essential meaning. In the context of the topic of the cognition model covering information phenomena, this is fundamental. For the development of a quantum computer, this probably does not matter much, since there are physical signals inside the machine that are related to information, but are not.

2.5.”Gödel’s incompleteness theorem highlights the basic fact that mathematicians and computers are made up of finite numbers of atoms and molecules”(p.1).

In order to come to this conclusion, Gödel did not have to be a mathematician. First, a person is equated with a machine, then a computer is programmed that simulates the thinking of such a person. This is how the myth of artificial intelligence is supported. Natural intelligence is limited not only by the number of atoms and molecules, but also by a model of cognition, moreover, not fully realized. The intellect of mathematicians and physicists is even more limited by the choice of the cognizable sphere of phenomena and the level of abstraction. These are the proposed circumstances.

2.6. “Just as Landauer claimed that information is physical, mathematics is also physical, limited or empowered by the physical entities that carries it out or embodies it”(p.1).

The analogy in this case is incorrect. Information is phenomena whose essence (ontology) has not been definitively established. The assumption that "information is physical" may mean that it is involved in the same entity as physical bodies. Of course, it, like, for example, biological organisms, has physical properties, but it is not reduced to them, but is characterized by its own, only inherent, essence. This assumption aims at the formation of a fundamental, that is, ontological, science of signs. The existing semiotics is not suitable for this role. When forming a relevant model of cognition, it is necessary to proceed from the need for a different science of signs.

On the other hand, mathematics is a scientific subject that does not have its own special sphere of phenomena. In this sense, it can be not only physical, but also biological, sign or universal. The latter determines the possibility of its isolation from the integral knowledge as an independent subject. Mathematics approaches the corresponding bodies and organisms with abstractions deeper than the level of fundamental sciences, ensuring their greater ordering and simplification.

2.7. ”Mathematics originated as a practical tool, but it rapidly transcended its practical origins and ventured into the realm of abstract concepts like pure numbers, perfect circles, and lines without width – objects that do not exist in the physical world»” (p.2).

If such objects did not exist, then the connection between physics and mathematics would continue to remain a mystery. According to the quasi-physical approach to cognition, more or less abstract and concrete knowledge are signs. Signs have a signifier and a signified, which must be in accordance. The signified is a set of effects of phenomena, some properties of which are more, and others are less significant. In any case, it is impossible to know all the properties of cognizable things. In this sense, any not only multiple, but also singular, that is, a concrete thing is an abstraction. This feature of cognition in philosophy is formulated as follows: "the name of a thing is the thing itself, but the thing is not its name."

2.8. “Notwithstanding the exertions of mathematicians such as Hilbert, Whitehead, and Russell to establish pure mathematics through axiomatization, Gödel’s incompleteness theorem proved in 1931 declared such endeavors futile [1, 2]” (p2.).

From the standpoint of the theory of knowledge, this statement is of fundamental importance, but its context is insufficient. It recognizes the limitations of human capabilities, but does not say anything about what else, besides the purity of mathematics, the real ideal can be, whether mathematics can at least approach it, and how it should happen. A purely mathematical solution to the problem is proposed, including the hypothesis of the finiteness of mathematicians and computers. There are no questions about the genesis of knowledge, about the metamorphoses that occur with them, about the cyclicity, not the linearity of cognition. The author is looking for support in physics, and this is correct, since physics is not only abstractions, but also an experiment. Physics is closer to practice, but only in the context of holistic knowledge, including practice, the question arises where primary knowledge comes from and what it is. According to the quasi-physical approach, they are the material effects of conscious phenomena that manifest themselves in the processes of any, not only cognitive activity.

2.9. “In his 1991 article “Information Is Physical” [3], Landauer posed a fundamental question: “Computation is inevitably done with real physical degrees of freedom, obeying the laws of physics, and using parts available in our actual physical universe. How does that restrict the process?” Gödel’s incompleteness theorem furnishes an answer to Landauer’s query, demonstrating how the underlying physics constrains mathematics and computation”(p.3).

The interpretation of Gödel's theorem is based on a highly simplified (abstract) physical model of the subject (actor) of cognition, unable to change, when necessary, the model of cognition. Subjects (actors) are really limited in their capabilities. However, there are also objective quasi-physical factors affecting cognition. These are, for example, cycles and phases of cognition, the influx of primary knowledge at the end of each cycle, metamorphoses occurring with knowledge, etc. In fact, as set theory and Godel's theorem itself show, mathematicians are able to cope with infinities, but the problem of cognition, as the author of the article showed, is not only mathematical and physical, but also quasi-physical (sign) in nature.

2.10. “...new understanding, enabled by physics, can greatly expand the scope and power of mathematics. This illustrates the profound relationship between mathematics and the physical world, and suggests that progress in one field can remarkably benefit the other” (p.3).

This statement concerns not only physics, mathematics and the not mentioned science of information. It deserves to be elevated to the principle according to which the world and knowledge about it are, by their nature, one, and the separation of knowledge and work associated with it comes at a certain stage of maturity and is due not only to the limited capabilities of the subjects (actors) of knowledge, but also to the structural features of holistic knowledge.

Today, physical data processing technologies, as a result of application to information practices, produce primary material knowledge (empirical knowledge base) about the infosphere, which require awareness and, in this regard, revision of the entire existing knowledge architecture. This, in particular, is the meaning of V.I. Vernadsky's foresight of the noosphere and C.S. Pierce's foresight of the sign character of the world, which together gives a new structure to the space of cognition.

The article under discussion shows that the revision of the dominant model of cognition is important not only for the systematization of the empirical base of the infosphere, but also for the intensification of the development of traditional natural sciences.

2.11. “Mathematics is intrinsically connected to physics in two fundamental ways. First, it is performed by physical entities such as human mathematicians or machines, both of which have finite resources. This was famously demonstrated by

Gödel's incompleteness theorem. Second, when mathematical symbols are embodied by physical systems, they can possess properties beyond the purely mathematical. The emergence of quantum information and computing furnishes a compelling example of this" (p.3).

The author touches upon a complex problem. Its solution requires a relevant logical and conceptual apparatus. It can develop approximately in this direction. There are phenomena whose essences are intertwined, but not reduced to each other. Today these are physical bodies, living organisms and presumably information (signs).

The source of primary knowledge is any activity. At the technological and applied level, there is an accumulation of experience in repeating and applying the successful effects of this activity in life. As a result, a fundamental theoretical science is formed, which is one of the levels of abstract (simplified) description of things related to the spheres of phenomena.

Mathematics can describe the same thing, but at a deeper level of abstraction. At the same time, its abstractions, such as probability theory, can also describe the biosphere, the sociosphere, etc. Thus, mathematics can be both a universal and specialized tool focused on the ontology of a certain sphere of phenomena.

The application of mathematical theory in the processes of computational practices, including computational algorithms implemented by man or machine, should be considered independently from its application to fundamental theories. This mathematics is related to the infosphere (user data structures and calculation formulas) and the physiosphere (machine data structures and calculation algorithms). Ordering the effects of phenomena by reducing them to a minimum number of invariant nuclei creates the conditions necessary for further practical development through unification, standardization, scaling of production, invention and rationalization.

2.12. "The above introduction illustrates that a Turing machine is an idealized mechanical device employed for computation. Although it was proposed during a time when quantum mechanics was well-established, Turing and is contemporaries did not conceive it as a computer related to classical physics" (p.5).

There is nothing unexpected in this. They did not perceive it because the computer belongs to the ontological class of electromechanical devices that process electrical signals. The main thing is that the computer reproduces algorithms performed by a person, regardless of what the calculations relate to, objects of classical or quantum physics.

This is important when calculations are carried out on analog devices. In these cases, in order to calculate a certain system, its abstract similarity (model) is built, which at the mathematical level functions the same as this system.

For the productivity of computing systems, the data structure is important, which, as the signifier part of the sign, depends on the structure of what is signified.

3. Conclusions

Scientific knowledge in the existing configuration really cannot solve a number of important practical problems. At the same time, within the framework of the existing model of cognition, it cannot change itself for this. Interdisciplinary research cannot be an instrument of change, since there is no real scientific discipline on information phenomena today, and it is impossible to form it within the framework of the inherited and at the same time not conscious model of cognition that dominates today.

The article matters. She says that it's time to collect the "scattered stones", that is, divided knowledge. Without this, it is impossible to systematize new and divided primary knowledge in order to go to a new division on this basis.

The author of the article touched upon an important, urgent and complex problem of changing the existing model of cognition by integrating knowledge. Physics (quantum mechanics) and mathematics (Gödel's theorem) act as the components of conceptual tools for its solution. At the same time, the technologies of computer transformation of physical signals, which may be associated with information, more precisely, sign practices, are also affected. In addition, he mentioned mathematicians who are actually forced to act within the framework of their discipline and the general unchanging model of cognition.

The main link in this set is not physics and mathematics, but the sphere of information phenomena, which requires knowledge by determining the ontology of information based on experience with programs and data. This task should be solved together with the formation of a relevant model of cognition.

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[2] Polyakov Maxim, Khanin Igor, Bormatenko Nikolai. Quasi-physical Model of Knowledge. In the search for a unified basis of integration of technology and society// https://www.thinkmind.org/index.php?view=article&articleid=iccgi_2020_1_30_10023