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The Idea of Mathematicity of the Universe as a *Locus Theologicus*: Michael Heller and Representatives of "The Kraków School of Philosophy in Science"

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Abstract: In this paper, I focus on the analysis of the concept of the mathematicity of the Universe developed by Heller and his colleagues from the Kraków School of Philosophy in Science [KSPS]. For the representatives of this School, the mathematicity of nature was one of the most frequently discussed issues. Based on these philosophical discussions, several proposals were formulated with clear theological references, and these also constitute an area for a broader discussion at the interface between science and religion. From a philosophical point of view, the question of the mathematicity of nature remains an open metaphysical problem. The image of the world formulated on the basis of this idea can be an inspiration for theologians seeking common ground with the sciences. An example of this are the views of Heller himself and some representatives of the KSPS, which are analyzed in this paper, taking into account critical positions and indicating possible research perspectives.

Keywords: mathematicity of the universe; mathematical universe; Michael Heller; Kraków School of Philosophy in Science; science–religion

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1. Introduction

"The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve". These words were used by Eugene Wigner—a famous 20th-century physicist, one of the co-founders of quantum mechanics and a Nobel Prize winner—in his paper with the meaningful title "The Unreasonable Effectiveness of Mathematics in the Natural Sciences" (Wigner 1960, p. 14). Wigner and many like-minded scientists expressed their amazement at the fact that scientists are increasingly better able to explore and understand reality through the use of mathematics[1].

The possibility of investigating and understanding nature through mathematics raises some philosophical questions about the relationship between mathematics and reality itself (i.e., physical objects and physical states). This problem was one of the key issues addressed by Michael Heller and his colleagues from the Kraków School of Philosophy in Science [KSPS][2]. In this paper, I will reconstruct and analyze their views and show how the idea of the mathematicity of the Universe led them from epistemology (the world is able to be known thanks to mathematics) to a certain ontological concept (the idea of the mathematical character of the Universe[3]). This ontological conviction provides an area for certain theological considerations, including for Heller and his colleagues. If mathematics reveals the rational nature of the Universe, can the mathematicity of the world be considered a sign left by a rational Creator? (Sections 3 and 4).

I will also show in this paper how an image of the world formulated on the basis of the idea of the mathematicity of the Universe could inspire theologians looking to find common ground with the sciences, and it could even be considered a kind of *locus theologicus* (Sections 5 and 6). The views of Heller himself and some representatives of the KSPS are analyzed in this paper, taking into account critical positions and indicating possible research perspectives. I will precede the main portion of the considerations with a few historical remarks, showing the origins of the idea of the mathematicity of the world in the views of philosophers of earlier eras (Section 2).

2. Historical Roots of the Idea of the Mathematicity of the World (A Very Brief Outline)

The idea of the mathematicity of nature in its primary form already existed in the philosophy of the ancient Greeks. According to many philosophers of that period, the world shows signs of order and harmony. This is reflected in the term "*cosmos*", which can be translated as meaning "order" or "harmony". Some, such as the Pythagoreans and Plato (and his successors in the Platonic Academy), believed that the path to understanding the nature of the cosmos went through mathematics[4]. Mathematics was believed to be the key to understanding reality, including its ultimate causes. According to them, the world was organized according to "number and measure" by a divine being. The connections between mathematics and physics therefore have their extension in theological matters (Dembiński 2015, 2017).

The emphasis on order and harmony prevailing in the world featured very commonly in ancient Greek philosophy[5]. The Ionian thinkers of the 7th and 6th centuries BC were the first to ask questions about the elementary principle of the world (*arché*), and the idea that nature is rational was widespread. In the Middle Ages, an important issue for philosophers was the intelligibility of nature (*intelligibilitas entis*), which was in fact a question about the fundamental intelligibility of being. In the modern era, following the successes of Newtonian physics, there were attempts to answer the question about the effectiveness of mathematics for investigating the world (see Heller 2011). The method of modern physics became a combination of the theoretical element (i.e., mathematics) and the empirical element[6]. The phenomenon of the rationality of nature was closely related to the question of the relationship between mathematics and the world.

Nowadays, many scientists (e.g., Schrödinger 1996; Wilson 1998) emphasize the significant importance of the first philosophers of nature in the development of science. This significance is supposed to consist, among other things, of the fact that the first Greek philosophers treated nature as something that could be understood using appropriate research methods. The supposed comprehensibility of nature combined with the idea of the elementary nature and unity of the world caused some (e.g., Alfred N. Whitehead, Werner Heisenberg, Roger Penrose) to start tackling metaphysical questions about the nature of reality. In this field, a question emerged from the noticeable connections between mathematics (as the language of science) and the world itself: Does the Universe have a mathematical nature?

Over the past century, several approaches to tackling the question of the mathematicity of nature have been proposed. Here are some of them (see Życiński 1987, p. 173):

1. The neo-positivist tradition omitted considerations of the mathematicity of nature, treating the possibility of investigating nature using mathematics as a natural fact that did not require further philosophical interpretations.
2. The Kantian approach explains the effectiveness of mathematics by referring to the mental activity of the subject who attributes mathematicity to the world. In other

words, we can cognize the world not as it really is (*noumenon*) but as it presents itself to our minds (*phenomenon*).

3. The Platonizing approach assumes the real existence of a mathematical reality as objects or structures prior to human beings. Mathematics is effective for investigating the world because the world is mathematical in nature (in the metaphysical sense).

Heller's views on the mathematicity of nature are situated within the Platonic interpretation.

3. Michael Heller's Views: From Physics and Cosmology to Theology

Heller's views on the mathematicity of the Universe have developed over many years. They took on a more mature form in the 1980s and 1990s and inspired many other scientists, especially physicists, and philosophers who collaborated with Heller in the Kraków milieu. The problem of the mathematicity of nature could be considered one of the key issues that Heller and the KSPS took up (Trombik 2021, p. 225). This is reflected in the number of publications on this topic and the many discussions held in the KSPS milieu, as well as local scientific events (e.g., conferences, seminars) devoted to the idea of a mathematical Universe, that have been organized since the 1980s. Initially, philosophers of science (e.g., Heller's long-time collaborator, Józef Życiński) and physicists from the Jagiellonian University in Kraków (e.g., Andrzej Fuliński, Leszek M. Sokołowski) took part in discussions about this issue (see, e.g., Trombik 2023). Over time, this idea spread even more, and the idea of the mathematicity of nature was also taken up by a new generation of KSPS representatives with an interest in the philosophy of mathematics (e.g., Janusz Mączka, Jerzy Dadaczyński), the history and philosophy of science (e.g., Jacek Rodzeń), science–religion relationships (e.g., Wojciech Grygiel), or the philosophy of computer science (e.g., Paweł Polak, Roman Krzanowski).

3.1. Basics of the Concept of the Mathematicity of the Universe

In his programmatic paper titled "How is philosophy in science possible?" Heller writes about several philosophical assumptions of empirical sciences: (a) the assumption of the mathematicity of nature, (b) the assumption of the idealizability of nature, (c) the assumptions of an elementary character, and (d) the unity of nature. According to Heller, these assumptions are accepted by contemporary science and can be especially noticed in methodologically advanced sciences like physics. From the point of view of my considerations here, point (a) is particularly important, although it is worth adding that the mathematicity of the Universe is also closely related to the other assumptions mentioned by Heller (see Heller 2019, pp. 243, 245).

What does Heller mean by the mathematicity of nature? He writes as follows: "From the most general point of view, the mathematicity of nature boils down to the fact that nature can be described mathematically. It may be considered a fact since it is 'empirically' confirmed by the development of the sciences from the times of Galileo and Newton. Moreover, this development is extremely efficient, documented with a sequence of successes, both theoretical and pertaining to the 'technical' conquest of nature" (Heller 2019, p. 241).

Heller treats the concept of the mathematicity of nature as a modern equivalent of the idea of *intelligibilitas entis*, which already has some ontological references. The assumption of the mathematicity of nature, as indicated by Heller, can be primarily considered an epistemological assumption. The world is knowable through the use of mathematics, as a result of which we obtain a mathematical description of natural phenomena. Empirical research provides knowledge about physical phenomena, while mathematics provides rigorous methods for formally describing phenomena using appropriate symbols and formulas and allows for the formulation of new empirical predictions and research hypotheses.

Mathematics is a language used to formulate scientific theories, and it also indicates what follows from these theories. Regardless of how one understands "objective reality" ontologically, mathematical formulas correspond to the structures of natural phenomena; there is a certain correspondence between mathematical creations and the scientific models in physics. From a philosophical point of view, it is worth reflecting on the question of why this agreement occurs at all.

3.2. Ontological Reference Points

The mathematization of nature generates many questions, including one about the property of the world in an ontological sense. The idea of the mathematicity of nature is therefore founded on epistemology, but the consequences flowing from this idea may also include ontology. In the context of this issue, Heller formulated the hypothesis that the world has a specific property that allows it to be effectively investigated. The starting point of Heller's ontological considerations is the following problematic question: Why is mathematics so effective at describing nature?

According to Heller, it is doubtful that this effectiveness of mathematics can be explained solely by subjective factors, i.e., through the role of the active rational human subject constituting knowledge through the functioning of the mind (in light of this view, mathematics could be considered an invention of the human mind)[7]. The relationship between mathematics and cognition is an inverse one; mathematical models describing reality are closely related to reality itself, and they fit so well because reality itself is mathematical (in the ontological sense). This concept is closely related to a moderate version of mathematical Platonism, which assumes the existence of mathematical objects or structures, independent of the mind.

In the context of this view, mathematics constitutes reality (as a network of structures) prior to the human being and its cognitive possibilities. Heller's views are basically closest to Platonism in its structuralist version[8]. The world can be understood as a mathematical structure, the nature of which is approximated by the mathematical structures used in science. Heller poses a strong ontological hypothesis: the Universe has a mathematical nature. This Mathematics (written with a capital letter) serves as a fundamental ontology and is essentially broader than the mathematics (written in the lowercase) used by humans. The language of mathematics used by scientists is an approximation of certain fragments of objectively existing Mathematics. Mathematics—as the ontology of the world—is primary in relation to the human mind. The human mind does not "create" mathematics (and in any case the creative aspect is not fundamental here), which it then projects onto the world, but the world has a mathematical nature, and the mathematics we use is only a reflection of Mathematics as such.

The ontic property of the world is described by Heller through the concept of the mathematical character of the Universe (in this case, Heller sometimes talks about the "Structure of the World", see e.g., Heller 2006). This ontological, speculative statement begs many questions and opens a series of discussions that often go beyond the framework of ontology. For Heller and some representatives of the KSPS, the idea of a mathematical character of the Universe is interesting and inspiring from a theological point of view. If we accept, following Heller, that Mathematics reveals the rational nature of the universe, then can we say that this is a sign of the creation of reality by a rational Creator?

3.3. Theological Aspects of the Mathematicity of the World

Epistemological and ontological considerations on the mathematicity of nature constitute a foundation for theological reflection. Heller connected the mathematical property of the world with the broader idea of rationality: The mathematical world is a realization of the rationality of a mathematical type. Therefore, we can use the phrases "Mathematical character of the Universe" or "rational world" interchangeably (in this case, we can speak of the ontological rationality of the world hypothesis; see Heller 1997; Coyne and Heller 2008).

Ontic rationality manifested in the stability of physical structures is, according to Heller, a manifestation of God's immanence in the world. The mathematicity of the world can be considered in two ways: (1) as a sign left by a rational Creator (through the act of creation that has been accomplished) and (2) the manifestation of God's continuous presence in the world, which is knowable thanks to mathematics. Heller considers this double creative action in the context of the traditional theological ideas of *creatio ex nihilo* (point 1) and *creatio continua* (point 2).

According to Heller, God uses mathematics to create the world. He creates and sustains the existence of the Mathematical Universe. The tool for understanding the "book of nature" (i.e., the Universe) is the language of mathematics. Divine rationality is known (at least to some extent) by man who investigates reality through mathematics. In Heller's view, practicing natural sciences is a way of studying God's plan for the world, and this way is no less valid than traditional theological models for describing God's action that use the much less precise language of philosophy, such as Aristotelian (Thomism) or Platonic (e.g., the main trends in Patristic Theology). Heller stated that "science is but a collective effort of the Human Mind to read the Mind of God from the question marks out of which we and the world around us seem to be made" (Heller 2008, p. 17; see also Heller 1994b).

These theological interpretations of the mathematicity of nature led Heller to the view that physicists are in fact engaged in discovering the effects of God's creation in their research. However, Heller's conception of the Universe does not match with the popular idea of "Intelligent Design". He also does not exploit the gaps in our knowledge of the world to propose the God hypothesis there. Indeed, Heller is very critical of the idea of "God of the gaps" and "physicotheologies" projects. He fully accepts the scientific image of the evolution of the Universe that has emerged from contemporary sciences, both cosmology and modern synthesis in evolutionary biology (see, e.g., Heller 2010). He also notes that the theistic vision of the world is often argued against on the basis of the idea of chance, which is supposed to undermine the concept of a rational (implicitly created by God) world. According to Heller, however, the idea of chance does not rule out the theological perspective. It is worth discussing this thread briefly, because his approach is relatively original and goes beyond the common views in this area, formulated on the basis of the science–religion relationship.

Taking up the issue of the structure of the Universe, Heller points out the elements of necessity (i.e., laws of nature) and the elements of chance. He indicates that chance does not breach the rationality of nature but is an integral part of it, with it being the effect of various laws of nature. Chance does not violate the structure of the Universe but is its integral component. It has a mathematical character and is an aspect of the mathematicity of nature. According to Heller, chance does not oppose God's plan but is a part of it (see Heller 2013). At this point, it is worth giving a voice to Heller himself, who expressed the theological message on the relationship between chance and necessity in the evolution of the Universe as follows: "Is chance a rival force of God's creative Mind, a sort of manicheistic principle fighting against goals of creation? But what is chance? It is an event of low probability which happens in spite of the fact that it is of low probability. If one wants to determine whether an event is of low or high probability, one must use the calculus of probability, and the calculus of probability is a mathematical theory as good as any other mathematical theory. Chance and random processes are elements of the mathematical blueprint of the universe in the same way as other aspects of the world architecture. Mathematical structures that are parts of the composition determining the functioning of the universe are called laws of physics. It is a very subtle composition indeed. Like in any masterly symphony, elements of chance and necessity are interwoven with each other and together span the structure of the whole. Elements of necessity determine the pattern of possibilities and dynamical paths of becoming, but they leave enough room for chancy events to make this becoming rich and individual" (Heller 2008, p. 16).

According to Heller, chance is an essential element of the structure of nature. It is necessary for harmonizing this structure, and it also enables development within it, constituting the basis of processes that lead to increased complexity. Heller does not oppose chance and necessity but believes that they complement each other.

4. The Idea of the Mathematicity of Nature in the Kraków School of Philosophy in Science

Heller was one of the main supporters of the idea of the mathematicity of nature in the Polish philosophical milieu. His views had a local influence, especially in the Kraków circle. Hence, the hypothesis of the mathematicity of the world was one of the key issues undertaken at the KSPS. Simultaneously with Heller, this idea was at the center of Joseph Życiński's philosophical interests. Życiński's views were close to Heller's position. Życiński identifies the mathematicity of the Universe with the rationality of being (rationality in the ontological sense). In the context of the problem of the mathematical character of the Universe, he develops the hypothesis of the "field of rationality". This philosophical proposition explains the mathematicity of nature by assuming that formal structures are ontologically prior to physical phenomena. Życiński claims that a field of structures is the basis of the rational structure of the world. He called this field the "field of rationality" or, interchangeably, the "field of potentiality", but he also refers to other names, such as formal field, nomic structure, or even Logos and "the Mind of God". According to Życiński, the field of rationality is necessary to explain the mathematicity of the Universe (see Życiński 1987, 2006; Grygiel 2022).

Życiński's concept is a development of Plato's philosophy of ideas, and it is also close to the supporters of Platonism in the contemporary philosophy of mathematics (one of the main inspirations for Życiński's philosophy were Whitehead's views). Życiński's views are close to Platonism in structuralism form (which can be considered a kind of Platonism); mathematical objects constitute a network of structures that is prior to the entity investigated in science. Like Heller, Życiński interprets the phenomenon of the mathematicity of nature ontologically, and on the basis of ontology he formulates propositions of a theological nature.

The basis of the rationality of the Universe is a rational God who makes himself present in the world, mainly through the laws of nature. Życiński's theology, which is based on the idea of the mathematicity of nature, is extensive and touches upon, among other things, the issue of God's action in the world. Życiński propagates the panentheistic model of God's presence in nature. God ontologically transcends the world, but the Creator also acts through natural processes and reveals his presence in the rational structure of nature. God acts in the world, constituting the rational basis of nature from which new qualities emerge over the course of evolution (*creatio continua*). According to Życiński, panentheism is the most mature form of the doctrine combining theses on God's immanence and transcendence (Życiński 1988, p. 150) and at the same time allowing for the interpretation of Christian theism as being consistent with the theory of evolution.

The philosophical and theological ideas of Heller and Życiński found fertile ground in the KSPS. The philosophical aspects of the issue of mathematicity were taken up by collaborators, such as Janusz Mączka, Jerzy Dadaczyński, Jacek Rodzeń Jacek Dębiec, Bartosz Brożek, Mateusz Hohol, and others (e.g., Rodzeń 2005, 2011; Brożek and Hohol

2014). In turn, the theological significance of the concept of the mathematicity of nature was noticed by, among others, Tadeusz Pabjan, Wojciech Grygiel, and Paweł Polak. Polak reinterpreted Heller's idea by referring to the contemporary philosophy of computer science and the concept of pancomputationalism (e.g., Polak 2017). Pancomputationalism views nature as the product of computational processes (or, directly, nature as a computational process). A stronger version of this concept treats the Universe as an equivalent of a computer program[9]—a program that could be programmed by God the Mathematician (or the Programmer). Although these ideas are inspired by the development of the philosophy of new technologies, they have historical roots, e.g., in the views of the Pythagoreans or the philosophy of Leibniz. According to Leibniz, the best of all possible worlds is organized in accordance with the principles of mathematics, which he expressed in the famous sentence "*cum Deus calculat et cogitationem exercet, fit mundus*". God thinks mathematically (calculates), as a result of which a mathematical world emerges. The mathematicity of the Universe is considered a manifestation of God's mathematical thought.

It is worth noting that although the issue of the mathematicity of nature was widely discussed in the KSPS milieu, not all the members of this School fully accepted Heller's ontological and theological views. Some, such as physicists Andrzej Fuliński and Lech Sokołowski, pointed out difficulties with this concept, especially its Platonic version. In the context "of the question of whether a scientific theory discovers objectively existing laws or just constructs a description of the world, Fuliński answered that the problem was apparent and that the two claims should not be considered to be contradictory. A scientific theory can be a reflection of reality as well as its reconstruction, structuring, and even a kind of 'creation'" (Trombik 2023, p. 247). Sokołowski also showed some caution in formulating an unequivocal position on the issue of the mathematicity of nature. Although he believed that the hypothesis of the mathematical nature of the world was worthy of serious consideration, he also followed Einstein in believing that in the ontological sense the nature of the Universe is more complex than the possible philosophical positions adopted in the dispute (Sokołowski 2015, p. 67). In this regard, Sokołowski expresses doubts about modern Platonism, e.g., in the Penrose style (Sokołowski 2011, p. 218). Nevertheless, it is worth noting that Sokołowski was willing to accept the milder ontic position that nature is rational. However, this view is not equivalent to the stronger position that the Universe is mathematical in terms given to this view by the supporters of radical Platonism (see Sokołowski 2001, p. 215).

Representatives of the KSPS also addressed the issue of "the surplus of mathematics". They point out that a specific property of mathematics is noticeable in the fact that its formulas, derived independently of any physical interpretation, correspond to the structures of phenomena in nature (see, e.g., Życiński 1992). The boundaries between so-called pure mathematics, developed independently of research on nature, and applied mathematics are often blurred. The blurring of these boundaries occurs especially when the sciences assimilate the results of mathematics. However, it has been historically confirmed that mathematics develops faster than the process of assimilation of its results in natural sciences. There are many examples of this. Probability theory developed much earlier before it was used in quantum mechanics, and non-Euclidean geometries found application in Einstein's physics after several decades.

Because so-called pure mathematics develops faster than sciences such as physics, and the process of accumulating mathematical knowledge is more dynamic than the process of its "absorption" into empirical sciences, some are inclined to recognize a specific "surplus of mathematics" in relation to physics, and consequently perhaps in relation to nature itself (Sokołowski 1992). From the point of view of ontological considerations, this is of significant importance. As Sokołowski writes: "The entire world is a realization of one specific mathematical structure, some fragments of which we already know, and others await to discovery. Mathematics contains and allows for the existence of many different structures, which, at least conceptually, could be assigned to various worlds [. . .] Mathematics has many more possibilities than can be realized in a world that, although astonishing in its diversity of phenomena, has a uniform character. Mathematics is enormously surplus in relation to nature" (Sokołowski 1992, p. 69). "The surplus of mathematics" is undoubtedly one of the interesting problematic issues emerging in the context of the mathematicity of nature.

It should be added that some doubts about the views of Heller and Życiński were also expressed by other members of the School, such as Łukasz Lamża (Lamża 2019). According to Lamża, Heller and other supporters of his concept made a mistake by ontologically interpreting a certain phenomenon of an epistemological nature. The fact that one can investigate the world using mathematical equations and models does not mean that the objects occurring in the world have a mathematical structure. In the context of the question about the mathematicity of nature, Lamża suggests agnosticism: "The only honest answer to the question of what the world is like is the good old Buddhist answer: silence. In other words, no matter what feature I 'really' attribute to the world, I will be wrong. This is the Śūnyatā doctrine, a specific version of which we also studied in Europe when wondering what God 'really' is like" (Lamża 2019). This criticism of the ontological interpretation of mathematics also negates its theological significance.

The nature of all these doubts, and especially the scope and specificity of the discussions held within the School on the mathematicity of nature, testify to the importance of this issue among the Kraków milieu[10]. Discussions about the mathematicity of nature have been occurring within the KSPS for several decades. Indeed, this part of the paper discusses just certain selected aspects of these discussions, leaving the more detailed issues to be examined and discussed in a more extensive work.

5. Selected Areas of Influence for the Concept of the Mathematicity of Nature

The views of Heller and his colleagues show how reflection on the effectiveness of mathematics in science can lead from epistemology through ontology to theological considerations. The philosophical idea of the mathematicity of the Universe can serve as a bridge for discussions on many questions, e.g., on the existence and nature of God, God's action in the world, and even certain issues in the area of the "Science and Religion" debate. These remarks require more detailed commentary.

The problem of the existence and nature of God, considered in a philosophical way (without any apologetic purposes), has been discussed in Western tradition since ancient Greece. The fact is that the value of the traditional arguments for the existence of God (i.e., ontological, cosmological, moral, and others) has long been rightly questioned. Natural theology has been in crisis since at least the Enlightenment, and it is now at an impasse due to the development of the sciences. Based on the results of science, philosophical positions are often formulated in contrast to Christian doctrine, which is expressed in theological (not always clear) conceptual forms. The argument for a theism based on the idea of the mathematical Universe is currently being discussed in the philosophical literature (e.g., Hołda 2014). It is treated as a variant of the epistemological argument because it makes investigating the world the starting point of reasoning. This argument is of course susceptible to criticism. The fact that scientists effectively investigate reality using mathematical methods does not in any way follow that the world can be attributed with the property of mathematicality, or even that it is a mathematical structure created by God.

On the other hand, for philosophers who do not exclude the theological perspective, the concept of God as the source of the mathematicity of nature can provide an interesting point of reference for reflection on God's action in the world. It is worth adding that the idea of the mathematicity of the world can encompass a wide range of views in this regard. The concept of Heller and other like-minded philosophers opens up various interpretative perspectives. Therefore, it can be stated that the traditional questions about the value of various models of God's relationship to the world (including deism, pantheism, and panentheism) have gained renewed importance.

The theological interpretation of the mathematicity of nature can take various forms. The idea of a mathematical character of the world does not determine the nature of the Absolute. Some who follow Leibniz or contemporary pancomputationalism may be inclined to claim that God thinks mathematically (the idea of God the Mathematician) or acts like a programmer (the idea of God the Programmer), and the world is the result of this mathematical thinking or programming. As Heller wrote: "In the work of creation, God's rational plan was realized (...) God's creative plan is mathematically precise, because God, in creating the world, thinks mathematically" (Heller 1994a, p. 256). Heller interpreted the theological remarks on creation in close connection with Christian beliefs[11]. However, it seems that this is not the only way of interpretation. The above statements can be interpreted in the context of both deism and pantheism or panentheism:

(a) The deistic position limits the role of the Absolute to creating (programming) the world. Thus, the world is permeated by divine, mathematical thought. However, this is where divine action in the world ends. God can be understood here as an impersonal being that does not enter into any additional interactions with nature and humanity.
(b) The pantheistic position, on the other hand, extends divinity to all of nature, identifying the rationality of God with the rationality of nature. In this approach, the boundaries between mathematics and Mathematics are blurred (for comparison, see Section 3.2).
(c) The panentheistic model of God's action in the world is based on the belief that God is the rational basis of reality. His immanence in the world consists of the fact that he constantly permeates reality through the process of its development (this view can be understood in the context of the idea of *creatio continua*), making himself present, for example, in the laws of nature, as the ontological condition of the cosmic order.

The position of panentheism, as understood in this way, is relatively close to the views of Heller and Życiński. I believe that from a theological point of view, one of the advantages of the idea of the mathematicity of nature is the potential to discuss different models of God's action in nature. This concept can also serve as a platform for discussion with more subtle ideas, not necessarily traditional ones. The phenomenon of the mathematical rationality of the world could be interpreted here even within the context of Einstein's idea of a "cosmic religion" (see, e.g., Einstein 1954). Einstein rejected the anthropomorphic representations of gods in monotheistic religions but shared the belief that the rational order of nature refers to something metaphysical that cannot be expressed by means of language (speaking in the language of "early Wittgenstein", it is what is "mystical") but whose nature can be explored through scientific research. In this context, the idea of the mathematicity of nature seems to be—at least to some extent—compatible with the idea of a "cosmic religion", which, although far from traditional theism and the concept of a personal God, is at the same time distant from extreme scientistic philosophies convincing that the world does not constitute any metaphysical mystery to man.

It is worth adding here that the idea of the mathematicity of nature may constitute, as a philosophical concept, an important *locus theologicus* for theologians, considering the issue of God's action in the world. This concept could open up new avenues for interpreting many theological ideas. The foundation for the concept of the mathematicity of nature is the scientific image of the world, interpreted philosophically in a way that allows for the formulation of more metaphysical theoretical constructs.

The historical perspective shows that, in past eras, theological trends (or even theological models) were formed on the basis of intellectual currents that prevailed in culture. The dependence of theological trends (the theological image of the world) on philosophy, and often science as well (i.e., on philosophical and scientific images of the world), has been historically confirmed. We could mention, for example, popular trends in patristic theology rooted in Neoplatonism, medieval scholastic theology based on Aristotelian philosophy, or contemporary process theology inspired by an evolving vision of the world built on the foundations of the modern sciences. Currently, the idea of the mathematicity of nature can fulfill a similar function as a source of inspiration for a new way of thinking in theology. This is a philosophical idea that has theological potential. This potential was noticed by both Heller and his colleagues in the KSPS (e.g., Polak 2017).

It is worth adding that the idea of the mathematicity of nature in its theological interpretation is a construct that may prove helpful for breaking down barriers in the science–religion relationship. Thinkers like Heller reject the view that there is a conflict between these two spheres (i.e., the "conflict model" in Ian Barbour's views), and they also critically evaluate the "independence model". They recognize that science and religion have certain important points of reference. At the same time, in their opinion, these references are not mutually contradictory but can be harmonized.

Heller and his colleagues proposed a theology that is open to the achievements of science and accepts its latest findings, and they also believe that scientific knowledge allows theological concepts to be enriched with new perspectives. The project of this "new theology" is, in the case of Heller and his colleagues, a departure from the Thomistic tradition. Heller's theology is developed on the basis of philosophy, which in turn is based on a scientific image of the world (see Heller 1996). This philosophy has a serious ontological commitment, especially in the conception of the mathematical character of the Universe. According to Heller, a theology built on the idea of the mathematicity of nature, where nature is understood as a manifestation of the divine *Logos*, coexists in harmony with scientific theories, e.g., with the theory of evolution. He also considers the conflict between science and religion to be an alleged one. This thread would undoubtedly require a more extensive commentary and examination of whether this is really the case; this problem is worth considering in a later publication.

6. Summary and Some Research Perspectives

The concept of the mathematicity of nature is a very debatable one. In the epistemological sense, it seems obvious, but its ontological interpretation poses many difficulties (some of which have even been pointed out by members of the KSPS)[12]. The interpretation of ontological propositions in the context of theology is even more debatable. In this paper, I tried to show that the image of the world formulated on the basis of this idea is interpreted theologically (Heller and his collaborators) and can also be an inspiration for other theologians seeking common ground with the sciences.

Therefore, the concept of the mathematicity of nature can even be considered a kind of *locus theologicus*, i.e., an idea that can provide a basis for a theological vision of the world, which, instead of traditional models of theological thinking (e.g., Aristotelianism), proposes a concept that is closer to contemporary discussions at the interface of science and philosophy. In this context, the views of Heller and his colleagues deserve attention as an example of a theologically and philosophically fertile concept, built on a scientific view of the world[13]. The ideas of Heller and the KSPS deserve further research because they represent an interesting example of the mutual influence of philosophy, as inspired by the achievements of modern science, and theology, which is open to new proposals for reinterpreting old convictions about God and his action in nature[14]. They also constitute an interesting discussion platform for thinkers who are critical of the idea of God rooted in Christianity. For example, God the Mathematician could be considered an impersonal being that permeates mathematical reality. Perhaps this is where the perspectives of theists and more unorthodox thinkers could come closer.

The above remarks lead us to the thought that the idea of the mathematicity of nature could in fact serve to rethink many fundamental issues that touch upon the borders between science, philosophy, and theology, including, for example, the problem of evil and suffering in relation to the idea of God the Mathematician (in a deistic interpretation or some version of the "cosmic religion", this issue does not have to be a riddle, because an impersonal Absolute does not have to establish any moral order, while it constitutes a serious challenge to traditional theism and panentheism). Although the concept of the mathematicity of nature seems to be a highly abstract idea, separated from the "existential problems of man", it could in fact creatively influence the understanding of existential issues, i.e., the understanding of man and his place in the world. Just like with Stoicism or Epicureanism, for example, considerations of the fate of man were undertaken in close connection with, or rather depending on, the vision of the world, so these days, the concept of the mathematicity of the Universe, understood both ontologically and theologically, constitute an interesting plane for a philosophical discussion about humanity. This issue has already been reported in some of Heller's works (see e.g., Heller 2010), but it has not yet been developed in more detail and comprehensively discussed by other thinkers.

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Notes

1 The success of modern sciences (starting with Newton's physics in the 17th century) began with the consistent use of mathematical methods to describe phenomena occurring in the world, both on a macro and micro scale. Quantitative physics proved more effective than qualitative physics. The mathematical language—in close connection with the empirical research method—proved to be much more effective at exploring nature than the previous attempts made by earlier generations of scholars who were accustomed to more speculative philosophies; the aim of them was to develop a holistic vision of the world based on theoretical foundations (as basic beliefs, see "foundationalism") and intended to constitute a reference system for all knowledge (see, e.g., the image of the world in the Aristotelian–Thomist tradition).

2 Michael Heller is one of the most famous contemporary Polish philosophers and theologians. His works in the field of the philosophy of science (especially the philosophy of physics) and the science–religion relationship are well known around the world. He was awarded the prestigious Templeton Prize in 2008 for his contribution to breaking down the barriers between science and religion. Heller's achievements include over a thousand works, some of which are available in English. It should be added that since the turn of the 1970s and 1980s, Heller organized an interdisciplinary milieu in Krakow and became the creator of the so-called Kraków School of Philosophy in Science. The School has been developing for several decades, engaging many Polish scholars in work at the interface of science, philosophy, and theology. For more on the history of this milieu, see (Brożek and Heller 2015; Trombik 2019; Polak and Rodzeń 2021; Polak and Trombik 2022).

3 In this article, I refer to the idea of the "mathematical character of the Universe" with synonymous phrases, such as the "mathematicity of nature", the "mathematicity of the world", and "the mathematicity of the Universe".

4 I assume—following Dembiński (e.g., Dembiński 2010, p. 46)—that the Pythagorean tradition had a significant contribution to the shaping of the philosophical profile of Platonism. The connections between Platonic philosophy and Pythagorean philosophy were very deep—to such an extent that it can even be understood as a continuity between Pythagoreanism and Platonism in relation to the issue of understanding mathematics and its connections with the world.

5 On the idea of order in ancient (and medieval) thought, see, e.g., (Heller 2007; Wildiers 1982). It is also worth comparing the philosophy of the ancient Greeks with other traditions of antiquity, represented, for example, by Indian thinkers (see, e.g., Hamilton 2001).

6 This issue deserves more extensive commentary. In this paper, I will only indicate that historical aspects of the development of the modern scientific method were undertaken by Heller (e.g., Heller 1992, p. 73), as well as by members of the KSPS (e.g., Życiński 2000) and scholars cooperating with the Kraków milieu, such as Olaf Pedersen (see, e.g., the metaphor of the "Book of Nature" in Pedersen 1997, p. 218).

7 In his works, Heller discusses views critical of the idea of the mathematicity of nature (see, e.g., Heller 1997).

8 It is worth pointing out here that for over 20 years there have been numerous discussions about the structural realism (see, e.g., Ladyman 1998, 2002; Krzanowski 2017).

9 The "Computing Universe" concept.

10 It is worth adding that in Kraków, in parallel with KSPS, a group of Józef Tischner's students and collaborators was developing and gaining importance. Tischner was the author of an original philosophy called the "philosophy of drama" (see, e.g., Tischner 2024). There were discussions between Heller (and his students) and Tischner's collaborators on their philosophical proposals. In recent years, some papers have been published that highlight certain connections between these two ways of practicing the philosophy (e.g., Sierotowicz 2018, 2023).

11 For example, one could mention the connection of the idea of ontic mathematicity of the world with the Christian concept of the *Logos*, which is identified by Heller as Christ; e.g., "Christ is the Logos implies that God's immanence in the world is its rationality" (Heller 2003, p. 57).

12 The context for many discussions in contemporary philosophy of mathematics is the traditional dispute between realism and antirealism. In recent decades, many concepts have emerged on the basis of earlier views shared by, for example, Gödel, Quine, or Putnam (see, e.g., the views of Penelope Maddy). It is worth mentioning here the development of several varieties of structuralism in the philosophy of mathematics, for example, in the views of Michael Resnik, Geoffrey Hellman, or Stewart Shapiro. A certain form of structuralism has also been adopted in recent years by James Franklin (see e.g., Franklin 2014). The views of these several thinkers show that structuralism can have different faces. It is important to note that some of them support Platonism, while others serve to criticize Platonism. I think that in later publications it would be worthwhile to compare the views of Heller and the representatives of the KSPS with the views of other representatives of structuralism, placing them in the context of broader discussions among representatives of different varieties of structuralism (e.g., by comparing the views of Heller and Franklin).

13 Some contemporary theologians, e.g., Peter Hünermann, explicitly include a contemporary image of the world, shaped on the basis of the sciences, among the "*modern loci alieni*" (Hünermann 2003).

14 It is worth emphasizing here that the research tradition developed in the KSPS milieu was present in the international area. Heller published many works in English, often in collaboration with esteemed scholars such as Derek Jeffrey Raine, Odon Godart, and George Coyne. Over the course of several decades, Heller collaborated with many research centers in Europe and the USA. He was, among others, a member of the Vatican Observatory and also headed the Georges Lemaître Chair at the Université catholique de Louvain. He regularly participated in interdisciplinary seminars organized in Castel Gandolfo during the pontificate of John Paul II. He also developed the "philosophy in science" project in the USA in collaboration with A. Pacholczyk from the Steward Observatory of the University of Arizona in Tucson and William R. Stoeger from the Vatican Observatory Research Group in Tucson. It should be added that many of Heller's students and collaborators have published numerous works that are recognizable in the international area among philosophers and scientists (see, e.g., Polak and Trombik 2022).

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