Mihailo Petrović ALAS

Life Work Times

Serbian Academy of Sciences and Arts

MIHAILO PETROVIĆ ALAS
150th birth anniversary

MIHAILO
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birth anniversary

SERBIAN ACADEMY OF SCIENCES AND ARTS

MIHAILO PETROVIĆ ALAS: LIFE, WORK, TIMES
ON THE OCCASION OF THE 150th ANNIVERSARY OF HIS BIRTH

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MIHAILO PETROVIĆ ALAS
LIFE, WORK, TIMES

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Exclusive editions, such as this monograph, call for the engagement, enthusiasm and cooperation of a number of individuals and institutions. We would like to use this opportunity and extend our gratitude to everyone who has taken part or in any way contributed to, or supported the creation and publication of this monograph.

First of all, we would like to express our gratitude to the authors of papers for their effort taken to provide expert and high level insights into some main points of Mihailo Petrović Alas' life and work, at the same time preserving an important aspect of being easy to read and appealing to a broader readership. In addition, we would like to thank to Ms. Snežana Krstić-Bukarica and Ms. Nevena Đurđević from SASA Publishing Section for performing a thorough proofread of the papers, thus making the writing even more articulate.

The monograph features a number of photographs and the copies of documents that have been obtained owing to the kindness of the SASA Archive, SASA Library, SASA Mathematical Institute, Archive of Serbia, Mr. Viktor Lazić from the "Adligat" Society, Mr. Jovan Hans Ivanović and his "Mihailo Petrović Alas" Foundation, "Mihailo Petrović Alas" Primary School, "Svetozar Marković" University Library, Belgrade City Museum, Zavod za udžbenike (Institute for Textbook Publishing) in Belgrade, Virtual Library of Faculty of Mathematics in Belgrade and Digital Legacy of Mihailo Petrović Alas.

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S. Pilipović, G. Milovanović, Ž. Mijajlović

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EDITOR'S FOREWORD

As soon as one first encounters the work of Mihailo Petrović, it becomes evident that he was a person that according to its numerous traits was a polymath. Above all, the academician Petrović was a gifted mathematician and a renowned professor at the University of Belgrade, but also a fisherman, writer, philosopher, musician, world traveler and a travel writer. He earned a degree in mathematics at the Belgrade Grand School and a licentiate degree in mathematics, physics and chemistry at the Sorbonne. At the age of 26, only a year after he had completed his studies, he defended his PhD degree in mathematics at the same university, as a student of the famous French mathematicians Henri Poincaré, Charles Hermite and Charles Émile Picard. In the same year (1894) he was elected to the position of professor at the Grand School to which he brought the spirit of the French mathematical school. It was at that point that his long and prolific journey through science began, whereas, owing to him, Belgrade achieved parity with other major European centers in mathematical sciences. He became an initiator and a leader of the Serbian mathematics and strongly contributed to the spirit of the modern European science in Serbia.

Petrović's expertize spanned several mathematical areas in which he achieved scientific results of world-class relevance: differential equations, numerical analysis, theory of functions of a complex variable and geometry of polynomials. He was also interested in natural sciences, chemistry, physics and biology, and he published scientific papers in these fields, too. In his scientific endeavor he managed to meet the most rigorous standards of the most developed European countries. In a brilliant rise, in a few years' time, up to the early 20th century, he wrote around thirty papers that he published in the leading European mathematical journals. It was due to this fact that he was elected a member of the Serbian Royal Academy as early as at the age of 30, and soon after he became a member of a number of foreign academies and prominent expert societies. He won the greatest respect of the global mathematical community: he was among few mathematicians (13) who delivered at least five plenary lectures or lectures as a visiting lecturer at the International Congress of Mathematicians (ICM). He delivered five such lectures (1908, 1912, 1924, 1928 and 1932). One such invitation has been considered by the mathematical community as an equivalent of an induction to a hall of fame. In addition, it has been considered that Petrović was a founder of new scientific disciplines, namely mathematical phenomenology and spectral theory. He invented several analogue computing machines, possessed technical patents and was the main cryptographer of the Serbian and Yugoslav Army.

Up to the Second World War he was the mentor of all doctoral thesis in mathematics defended at the University of Belgrade. Aforementioned is related to one of professor Petrović's greatest and most important achievements – he was a founder of the Serbian mathematical school that has produced a great number of renowned and successful mathematicians not only in Serbia but also around the world.

In 2018, the Serbian Academy of Sciences and Arts and mathematicians in Serbia celebrate the 150th anniversary of the birth of Mihailo Petrović Alas. Throughout this year, the Academy has organized a large exhibition dedicated to Petrović, alongside a solemn gathering and a conference. This monograph commemorates this important jubilee of the Serbian mathematics. Given the fact that a lot of articles on Petrović have already been written, and that his collected works were published at the end of the last century, the editors and authors of the papers in this monograph were faced with a daunting task of finding some new details from professor Petrović's life and career. Even more so given that his body of work is immense, spanning different scientific areas and encompassing topics that at first glance one finds difficult to combine. As Dragan Trifunović, Petrović's biographer and a man who most thoroughly studied his life and work, noted on one occasion that almost an institute was necessary that would encompass professor's entire body of work. Therefore, we set a relatively modest goal to ourselves to shed light upon some main points of Petrović's life and work, times and circumstances he lived in, as well as to elaborate on the present developments in relation to the Serbian mathematical school, through a selection of papers. The authors of the papers steered clear of technical details and excessive use of mathematical language. Hence, the monograph is intended for a broader readership, in particular to those readers who are interested in the history of Serbian science and its evolvement at the turn of the 20th century, but also to those who want to gain a deeper insight into the life of a brilliant mathematician and a polymath, and, we can quite freely say, an unusual personality.

Ž. Mijajlović, S. Pilipović, G. Milovanović

MIHAILO PETROVIĆ ALAS:
LIFE AND WORK

MATHEMATICAL PHENOMENOLOGY AND THE PHILOSOPHY OF MATHEMATICS*

Slobodan VUJOŠEVIĆ
Mathematical Institute of SASA

Twenty[89] papers discussing the representation of natural and social phenomena by mathematical means hold a noteworthy place in the corpus of work of Mihailo Petrović, founder of the mathematical school in Serbia. He published these papers throughout his career as professor, preparing the majority of them in both Serbian and French languages, since he, as a rule, wished to make them accessible to as wide an audience as possible. In them, Petrović laid the foundations of a general mathematical phenomenology, reminiscent of a philosophy of nature. The key philosophical assumption of this science is that each phenomenon can be mathematically represented, i.e. that it has its mathematics which can be determined. Its key goal was therefore to make a typology of analogous phenomena as a basis for a method for faithful representation of each individual phenomenon. And though Petrović was inspired by natural phenomena, what he had in mind was a very general science that would encompass all phenomena, natural and social, real and imaginary, including phenomena in literature and art. He believed such science was capable of becoming a "guiding principle in individual sciences,"[90] as well as shedding light on the "great problem of natural philosophy, the solution of which is the ideal asymptotic goal of all sciences, which consists of reducing to the least possible measure all that has to be assumed in order

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* A revised and supplemented version of the paper initially published in the catalogue *Mihailo Petrović Alas: The Founding Father of the Serbian School of Mathematics* (SASA, 2018).

to understand natural phenomena as well as the number of propositions that encompass everything that occurs in nature"[91].

Petrović began forming his viewpoint on the role of mathematics in the phenomena of nature and the world during a period of a sudden blossoming of natural sciences and, at the same time, of an increasing presence of mathematics in them. Similarly to many philosophers and scientists of the time, he believed in the unlimited power of natural sciences, and thus of mathematics, as mathematics played such an important role in their success. In terms of his education, Petrović was not only a mathematician, but he also graduated in physics at Sorbonne in 1893 and engaged in the study of chemistry and other sciences as well; therefore, he had an opportunity to see directly that mathematics permeated and connected science and contributed to its unity. He perceived that one and the same analytical apparatus appeared in completely disparate areas of science, that "disparate phenomena" could be "analogous," that is, represented by the same mathematics. "One of the most important such analogies [...] exists among the phenomena of electric current, heat transfer and the flow of fluids. It is so complete that these three kinds of phenomena, with their multiple and diverse variations, represent from an analytical point of view one and the same problem, the solution of which only needs to be interpreted in three different ways." He believed that this connection was not random and tried to explain its regularities. Independently and without relying on any predecessors, he very patiently gathered an immense body of material and established a branch of science which he termed *mathematical phenomenology*.[92] He defined its conceptual apparatus, similar to that of mathematics,[93] in which it was possible to determine groups of analogous phenomena "from which the mechanism of this or that phenomenon could be extrapolated directly as the concepts which figure in them are assigned this or that concrete meaning. A set of such analogies, once there is a sufficient number of them, will make up a separate branch of natural philosophy, a kind of a general mechanics of causes which will, just like other mathematical disciplines and notwithstanding its vast general application, operate with a small number of general basic concepts". Hence the key problem of phenomenology is the "mathematical explication of particularities of disparate phenomena of all kinds and all concrete natures as necessary consequences of the similarities of (their) mechanisms."


СРПСКА КРАЉЕВСКА АКАДЕМИЈА

ЕЛЕМЕНТИ

МАТЕМАТИЧКЕ ФЕНОМЕНОЛОГИЈЕ

МИХАИЛА ПЕТРОВИЋА

У БЕОГРАДУ

1911.

Cover page of the book *Elements of Mathematical Phenomenology*, published in 1911 (Digital legacy of Mihailo Petrović)

Petrović elaborated his science in a voluminous work of around eight hundred pages entitled *Elements of Mathematical Phenomenology*, published in 1911. He believed it could prove really fruitful in other disciplines as well, by helping them reconstruct valid mathematical models for natural and social phenomena. In order to transcribe a phenomenon into a mathematical form, he elaborated a method of phenomenological mapping: once its “mechanism” is determined, the phenomenon is represented as a “figurative point” in space and its mechanism is then mathematically described in the way mechanisms of phenomena are described in classical mechanics. He expounded this method in his monograph *Phenomenological Mapping* published in 1933. However, Petrović did not stop at phenomena in nature and some phenomena in society, but invested a great deal of effort to confirm the universality of his method in literature as well. The material he gathered for the accomplishment of this goal was published in 1967 in his book *Metaphors and Allegories.*

Phenomenon is undoubtedly the fundamental concept of mathematical phenomenology. And just as in mathematics, where its basic concept, the set, is not defined, in establishing his science Petrović did not define its key concept, the phenomenon, either. But whereas in mathematics the set has its clearly defined main interpretation, in a cumulative hierarchy, defined by a general inductive procedure, in mathematical phenomenology there is no detailed explanation of what is assumed under its fundamental concept. Phenomena are classified by analogy, but nothing is said of analogy as a relation between phenomena and its possible mathematical properties. The key properties of a set are its *extensionality* and *regularity,* i.e. sets are equal if they have the same elements and the relation *to be an element* has no cycles. By contrast to the set, the phenomenon is in all likelihood an *intensional* concept that is at the same time *irregular,* i.e. it allows for cycles, as there is no reason not to consider the manifestation of all phenomena a phenomenon. This actually means that there are phenomena in our world that cannot be fully represented mathematically, hence considerations of a quite generally understood concept of phenomenon are much closer to philosophy than to mathematics and positive science, to which Petrović generally had an affinity. During his schooling, the entire French educational system was based on a strictly rationalistic and entirely positivist spirit, to which each form of metaphysics was alien,

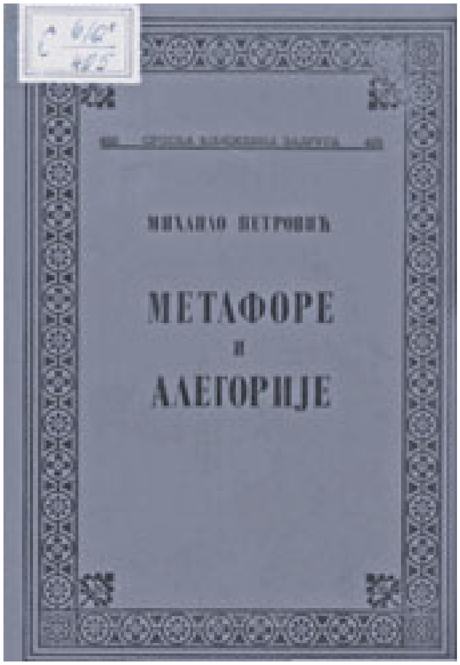

СРПСКА КРАЉЕВСКА АКАДЕМИЈА

ФЕНОМЕНОЛОШКО ПРЕСЛИКАВАЊЕ

од

МИХ. ПЕТРОВИЋА

Cover page of the book
Phenomenological Mapping,
published in 1933
(Digital legacy of Mihailo Petrović)



The front cover page of the book *Metaphores and Allegories*, published in 1967 (Library of SASA, C 6/12;405)

Front cover page of the book *Mecanismes communs aux phenomenes disparates*, published in 1921 (Library of SASA, 687/12)

in science just as in philosophy. Aware that the key problem of his science, *the role of mathematics in our understanding of the phenomena of the world,* greatly surpasses the bounds of mathematics, Petrović who, in the spirit of his epoch, believed in the omnipotence of science, tried to shed light on this problem within the framework of a "general mechanics of causes which will, just like other mathematical disciplines and notwithstanding its vast general application, operate with a small number of general basic concepts." For some reason, he did not wish to see this as a purely philosophical problem, though that is what it essentially is.

Namely, already in German classical philosophy of the first half of the 19th century, in the period from Kant to Hegel, there were very detailed discussions about the phenomenon and its essence, and the circumstances in which we acquire knowledge of it, while in 20th-century philosophy this issue practically took centre stage in phenomenology as the prevailing philosophical orientation.[94] Thus, Kant made a distinction between noumenon and phenomenon. Noumenon is the essence of the phenomenon or the thing-in-itself, while phenomenon is that part of the noumenon that is accessible to consciousness. Science only deals with phenomena, i.e. with what is cognizable by the senses and fitted in apriori forms of consciousness, or more freely said, in mathematical and logical forms. Hence phenomenon is the collection of inteligible thruts about the noumenon, while the noumenon is unknowable and each rational attempt to determine its entity and the truth about it leads to a contradiction; science should, therefore, leave noumena to religious experience and theology. It is quite possible that Petrović's view of the phenomenon had some common points with Kant's understanding that our knowledge of phenomena is based on sensory data fitted into apriori mathematical and logical forms. Still, judging by the significance he attached to mathematics when studying phenomena, it is more likely that he perceived mathematics as an element of the very essence of the phenomenon, which, according to Kant, is not accessible to the rational consciousness.

Kant represented a kind of a turning point in the history of philosophy. After him, philosophy for a great part made a turn towards science, i.e. towards a positivist understanding of the world, by trying to describe and anticipate phenomena in the most accurate and comprehensive way possible, without asking questions about their sense. There was also a different point of view which disputed the view on the unknowability of the essence of phenomena in the world and continued to look for it through metaphysical means. The key representatives of this other orientation were Hegel and the phenomenological school of philosophy. In his *Phenomenology of Spirit,* Hegel developed a philosophical method to enable the knowing of the absolute metaphysical entity of the phenomenon, while the school of phenomenology, based on the works of Edmund Husserl, appeared as a form of resistance to the increasingly prevailing influence of a positivist position in science and philosophy. Interestingly, Husserl was an affirmed mathematician, inspired by similar ideas as Petrović, but when he embarked upon phenomenology or the "seeing of the essences", he distanced himself radically from positivism. He believed that the very essence of the phenomenon could be seen through the interaction of the consciousness and the phenomenon. In seeing the essence, it is important to liberate oneself from everything that is irrelevant for a given phenomenon, but also from everything that is irrelevant for seeing the phenomenon in the consciousness itself, i.e. from predispositions and apriori assumptions about the phenomenon. In a sense, Petrović's conceptual apparatus was designed so as to enable a sort of a "phenomenological reduction", but with the goal to mathematically represent a given phenomenon. However, Petrović's teaching undoubtedly had no common points with this school of phenomenology. He could have had some knowledge of it because he was friends with philosophers, primarily Brana Petronijević, at a time when this school was very current. In order to distance himself from philosophical teachings that were not close to him, it is possible that over time he began to use other names for his science, such as general mechanics of causes and similar.

If by education Petrović was connected with the positivist school in philosophy and science, the key problem of mathematical phenomenology, because of the mathematics present within it, turned him somewhat unexpectedly back to metaphysics. Namely, in the foundations of mathematics in the 20th century, it was necessary to raise questions about the philosophical status of mathematics and its abstract ideas; hence, a new branch of philosophy emerged – the *philosophy of mathematics.* It was dominated, though not exclusively, by an entirely metaphysical view of the nature of mathematical objects, mathematical *platonism*, and the philosophical assumptions that Petrović explicitly highlighted reveal that his teaching was close to this view.

Portrait of Mihailo Petrović Alas (work of Uroš Predić, oil on canvas, Belgrade, 1943 – Library of SASA, photographer Vladimir Popović)

The two assumptions that can certainly be viewed as fundamental to his mathematical phenomenology are:

1. *Each phenomenon in nature can be mathematically represented.*
2. *There is a minimal set of assumptions from which is possible to derive all laws of nature.*

The first assumption posits that each phenomenon in nature has its mathematics, i.e. that it determines a set of mathematical statements that are true for the given phenomenon. It should not be understood as a position that each science of a phenomenon can be reduced to mathematics, but that in the science of that phenomenon there is invariably a purely mathematical part comprising mathematical truths and a part comprising truths of the science itself about that phenomenon. Mathematical truths are universal and indispensable, they apply in this, but also in all past and future worlds. This cannot be said for truths of individual sciences regarding natural phenomena, as they are contingent, they hold true in this, but not necessarily in any other world, they are not eternal and cannot be derived from purely mathematical assumptions. In all likelihood, Petrović's first assumption was originally his and had not been taken over from another author. The second assumption is purely logical,[95] and had been taken over from Mill as a "problem of natural philosophy, the solution of which is the ideal asymptotic goal of all sciences." Petrović claimed that "there are general statements, the least numerous ones, from which it is possible to derive all regularities existing in nature" and he believed that this "asymptotic goal of all sciences" was achievable in mathematical phenomenology.

We will demonstrate that, taken together, both of Petrović's assumptions in the philosophy of mathematics belong to mathematical platonism. Metaphysics and platonism are not customary in the philosophy of nature, and they are completely alien to the mechanicism that all Petrović's commenters find in Petrović's work. Possibly because when Petrović mathematically represents a phenomenon, he relies on classical mechanics, but he uses mechanics as a form of a language for mathematical representation of phenomena in nature, because he does not view mathematics itself and its language as the universal language of science.

To a different degree, natural sciences aspire to base and present their research in the framework of a mathematical model. The more elaborate and perfected it is, the more complete, reliable and ultimately closer to reality do we consider its results to be. This also holds true for a substantial number of social sciences, the contemporary development of which greatly relies on the presence of mathematics in their research. Mathematics is omnipresent in science and the greater its presence, the more perfect a branch of science is considered to be. Science believes that each phenomenon, everything that changes in the world, can be clad in an appropriate mathematical form. The usefulness of this can sometimes be nil, or it may even generate a completely distorted image about a phenomenon, but in the main, and in the case of natural phenomena in particular, the advantages brought by mathematics are immeasurable.

The mathematical representation of a phenomenon usually emerges quite independently of mathematics, in concrete individual endeavours by scientists to explain that phenomenon. With time, this representation is adjusted for results in mathematics: the already existing results and theories are used, or mathematics is given an impetus to arrive at new results on its own and develop new theories. Such relationship between mathematics and other sciences has existed since antiquity and is really quite natural. To understand this relationship, one should first answer a purely philosophical question:

Does each phenomenon conceal immanent mathematics in itself?

If the answer is yes, then it is a scientist's job to discover and determine the unique inner mathematics of the phenomenon he is studying. Also, in this way, mathematics is given the key place in science – it is the foundation and the binding tissue of all sciences and ensures their unity.

If the answer is no, the mathematics in which a given phenomenon is represented is created by the very science of it, relying on its degree of development. This does not at all mean that each phenomenon has its own unique mathematics, as there can be more of them or none at all. They are more or less useful tools for studying phenomena in nature and the world at large, and it is up to a specific science which of the tools it will use, including the possibility not to use mathematics at all in studying some phenomena. It is left to the intuition of the researcher whether to choose mathematics or not, and this choice can be motivated not only by scientific but also by very specific cultural, ideological or utilitarian reasons. In this case, mathematics does not have a special place among sciences, and is only significant to the extent to which it actually contributes to them.

Petrović's mathematical phenomenology is based on an affirmative answer to the above question, i.e. the position that each phenomenon can be mathematically represented. This certainly refers to phenomena in nature. Even more than that, Petrović believed that there are always the tools to enable this representation. He constructed these tools and considered them completely universal, applicable to all phenomena in nature. Petrović, therefore, assumed that each natural phenomenon has its mathematics, i.e. that each such phenomenon has a corresponding set of mathematical truths about it, which can at all times be determined. Although he himself did not argue in favour of the uniqueness of this set, it actually follows from his assumptions. Namely, if there were two such sets that contradict each other and are at the same time true for a given phenomenon, the science of nature would be contradictory. Hence, each phenomenon has its unique mathematics. If this holds true for individual phenomena in nature, as there is a "minimal set of statements from which it is possible to derive all regularities in nature," than the same thing holds true for nature taken as a whole, i.e. the entire world is built upon unique mathematics. This is an entirely metaphysical view and it is very close to Plato's. In the *Timaeus,* his Demiurge uses mathematical laws to assemble the world from Plato's bodies. In the beginning was mathematics, interwoven into the physical world which is entirely subject to its abstract and ideal laws; mathematics is its metaphysics.

It is possible that Petrović did not wish to go that far, but this is where his assumptions lead. On the other hand, as we have already mentioned, starting from the time of Descartes and under the impact of his rationalism supported by an overall development of natural sciences which brought fundamental change to the life of man, metaphysics and all forms of platonism were systematically removed from philosophy. Today, only their traces can be found in philosophy and they are not welcome at all, while in sciences they are deemed entirely unthinkable. Still, Petrović's leaning towards Platonism has its justification in a part of the philosophy of mathematics.

Namely, when the question about the presence and uniqueness of mathematics in natural phenomena is limited to phenomena in mathematics only, i.e. to purely abstract mathematical objects and statements, it then gets the following form:

Does mathematics express the actual relations of actually existing objects?

The affirmative answer to this question determines the most acceptable philosophy in mathematics, *mathematical platonism.* Mathematicians who never asked themselves this question are platonists, hence a vast majority. But this can certainly not be said for philosophers of mathematics, who by nature of their work certainly asked themselves this question. They, with only very few exceptions, give a uniform negative answer to it. This answer, however, does not constitute a uniform view in the philosophy of mathematics that would contradict platonism. The denial of each form of actual existence of some (or even all) mathematical objects as a rule restricts mathematics and calls for a special interpretation of the meaning of its regularities. Depending on the extent of this denial and for some other reasons, a whole range of views emerged in the contemporary philosophy of mathematics, which is possibly infinite: constructivism, formalism, intuitionism, logicism, conventionalism, structuralism... With the exception of logicism, which is quite close to platonism, the denial of platonism is the common point of all these philosophies of mathematics, but what they also have in common is that they contradict one another and that each of them individually is incomplete. And whereas platonism is a completely natural and effective viewpoint, all of its disputations have had the character of academic objections that only rarely shed light on anything, most often bear no fruit, and are irrelevant for mathematics itself. Because they are reduced to a denial of platonism alone, they have made the philosophy of mathematics in which they prevail to a large extent useless for mathematics, much like Aristotelian logic interpreted in the scholastic tradition. The position on the uniqueness of mathematics in each individual phenomenon makes Petrović quite close to mathematical platonism. True, it does not follow necessarily from mathematical platonism, but it is quite in agreement with it and strongly supports it. Hence, the Platonism of Petrović's assumptions or their support to this position are not disputable at all when it comes to mathematics, though they may seem that way in the modern-day philosophy of nature to which all form of metaphysics is alien. Mathematical platonism was advocated by many mathematicians and philosophers from Petrović's time, including Cantor, creator of the contemporary set theory, Frege, who laid the foundations of the syntax of contemporary mathematical language, and finally Gödel, the greatest logician in history if judging by his works. He himself stated that platonism enabled him to understand the relationship of syntax and semantics on which he based his results.

Though they have a philosophical justification, Petrović's assumptions definitely call for additional explanations in the light of achievements of contemporary logic, i.e. in the light of Gödel's incompleteness theorems. The problem is that Gödel's theorems show that mathematics cannot be based on a simple non-contradictory set of assumptions. For Petrović's assumptions, this means that two questions need to be answered: *which part of mathematics is necessary to describe a given natural phenomenon, and which part is necessary to describe all phenomena in nature?* If that part of mathematics contains the summing and multiplication properties and is closed for mathematical induction, Gödel's theorems make this Petrović's thought impossible to be realised. By contrast, although contemporary science uses very complex mathematics, primarily the tools of mathematical analysis, i.e. the tools of second-order arithmetic, this still does not mean that they are necessary in the description of phenomena in nature. It is quite possible that this part of mathematics of natural phenomena is much less complex or even very simple. In physics, for instance, opinions are greatly mixed with regard to this question. If it is indeed possible to unify the general relativity theory and the quantum field theory, as postulated in the so-called *theory of everything,* we would obtain a complete description of all physical phenomena. Hence Petrović's other assumption, when reduced to physics, would get a significant justification, but would still not be confirmed. Stephen Hawking, one of its key proponents, believed that Gödel's theorems quite seriously put into question the theory of everything[96]. A similar view is held by Roger Penrose[97] because he believes that there are phenomena in nature that are not computable. On the other hand, a group of authors advocate a completely contrasting view, a variant of Church's thesis according to which all physical processes are computable. This position is justified by the fact that the speed of exchange of information in nature is limited by the speed of light. The theory of everything in which the tools of its mathematics would be limited only to the decidable fragment of arithmetic would entirely confirm Petrović's second assumption. In addition to the above, there is also a completely realistic possibility that there is a theory of everything, as a complete theory of the world of physics, while at the same time its mathematics is incomplete, i.e. the postulates that are not provable in this mathematics do not relate to purely physical regularities at all.

Petrović's aspirations to set the foundations of a science that could tailor an appropriate mathematical framework for each phenomenon, and his belief that the entire world is structured according to unique mathematical laws the assumptions of which can be determined, have not yet found their confirmation in science. Contemporary logic has undoubtedly proved that each language, even the universal language of mathematics, has a limited power of expression. To the extent that today's science relies on mathematics, where such limitations have been proved, it is natural to face the limited power of science as well. There is no justification for its omnipotence. One could rather say that this power is not even sufficient for a complete description of some more complex natural phenomena. This is possible in some ideal cases only, but by no means can a complete description of the entirety of nature be provided.

Mathematical phenomenology should be seen as a separate large-scale project in the total opus of Mihailo Petrović. Philosophers and scientists often work on several independent projects, spending some time on one, then moving on to another, while often some of the projects remain unfinished. In parallel with working on mathematics and philosophy, throughout his life Leibnitz worked on four such projects simultaneously: logic, ideal language, encyclopaedia of knowledge and a general scientific method.[98] They all remained unfinished and, logic excluded, the other three great projects by Leibniz strikingly overlap with and permeate Petrović's mathematical phenomenology. The ideal language is conceived as a universal symbolical language for science, mathematics and metaphysics, which would be "a basis of the calculation or the algebra of thinking," the encyclopaedia of knowledge was his systematic collection intended to enable the realization of the project of the ideal language, while within the project of the general scientific method, Leibnitz tried to formulate a procedure for an accelerated expansion of knowledge. Mathematical phenomenology fits quite well in the general scientific method project and it is possible that Petrović was inspired by the idea of accelerated expansion of science and knowledge of phenomena. Unlike Leibnitz, who found the cornerstone of his grand project of commonality of

Gottfried Wilhelm Leibnitz (1646–1716), German philosopher, painted by Christoph Bernard Francke, before 1729 (Herzog Anton Ulrich-Museum, Braunschweig) science in logic, but not necessarily in the logic of his time, Petrović sought the foundation stone of his science in classical mechanics. To him logic seemed empty, and the relationship between the cause and the effect too abstract, so he tried to formulate the concept of a cause in "concrete sciences" in which it "always appears inseparable from its substratum and its material nature." He gave his concept of cause "a natural-science-like form" implying that the cause is "every phenomenon which aspires to change some state of affairs or to introduce perturbation in some other phenomenon." At the time when he was laying his groundwork for mathematical phenomenology, contemporary logic was in its early days, hence logic was reduced to Aristotle's teachings about the four types of categorical statements. He had every reason to turn his back on such logic and base his mathematical phenomenology "closer to nature." He constructed a not entirely articulate conceptual apparatus with "active causes" and "necessary effects" on which he built a kind of a general mechanics of phenomena modelled on classical mechanics. Quite possibly, Leibnitz's and Petrović's attempts to reinstate unity to science and knowledge did not yield the expected results for the same reason, because of the Aristotelian logic. Petrović did not want to rely on that logic due to its perceived shallowness, but with this he also rejected contemporary logic which was developing powerfully in parallel with his phenomenology and which could have been useful to him. Leibnitz formulated the first contemporary logical systems and was the first to identify the significance of language for logic and science. Therefore it can be said that he tried to realize his project with some of the tools of contemporary logic, whose forefather he had been, but his hands were tied by the scholastic legacy in logic from which he could not free himself. Therefore in both Petrović's and Leibnitz's case, the problem was that, at the time when they were beginning their project of description of all phenomena, mathematics did not have its own language. In search of this language, Petrović relied on the language of classical mechanics, the expressive power of which lagged far behind the power of the contemporary language of mathematics. Leibnitz did try to establish such a language, but he had problems with its logical basis.

When Petrović began his project of mathematical phenomenology, the process of division of the existing branches of science, and the emergence of new disciplines, was in full swing. He held that for the benefit of science this process should not go too far, and believed that this fragmentation of science could be counteracted, and its former unity restored. In his view, mathematics was to play a key role in that and to become the main counterweight to the process of auto-fragmentation of science and knowledge in general. He was partially right in the sense that the language of mathematics and its syntax, created in the early 20th century in contemporary logic[99], became the theoretical basis for the development of the syntax of programming languages that enabled the realization of digital computers.[100] With them, mathematics entered the world of science in great style and perhaps created conditions for a renewal of its unity, to which Petrović had aspired.