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FIRST SERBIAN WORKS ON THEORY OF RELATIVITY

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Abstract. Even if A. Michelson, H. Lorentz, H. Poincaré and others performed experiments and wrote papers to the subject known later as the special theory of relativity more than two decades before Albert Einstein published his paper on this topic in 1905, it is usually considered that special theory of relativity originated in this year. This theory was soon accepted and many authors wrote papers on this matter. It is not so well known that several Serbian mathematicians and astronomers also wrote papers on special theory of relativity already in the twenties of XX century. Some of the papers were popular explanation of basics of this theory and they were intended to the general public, but there were also papers with original contributions. All papers were written in Serbian and certainly this is the main reason that these results were neglected. We shall present works in this field of a great Serbian astronomer and climatologist Milutin Milanković (1879-1958), a great Serbian mathematician and the founder of the Serbian mathematical school Mihailo Petrović Alas (1868-1943) and Sima Marković (1888-1939), mathematician, philosopher and politician, also known as one of the founder of the Communist Party of Yugoslavia.

1. INTRODUCTION

Albert Michelson, Hendrik Lorentz, Henri Poincaré and others performed experiments and wrote papers on the subject known later as the special theory of relativity in the interval ranging more than two decades before Albert Einstein published his first paper on this topic in 1905. However, it is usually considered that special theory of relativity originated in this year. A decade later the general theory of relativity was founded in the works of David Hilbert and Albert Einstein. These theories were soon accepted and many authors wrote papers on this matter. It is not so well known that several Serbian mathematicians and astronomers also wrote papers on the theory of relativity already in the

twenties of XX century. Some of the papers were popular explanation of basics of these theories and they were intended to the general public, but there were also papers with original contributions. All papers were written in Serbian and certainly this is the main reason that results offered there were neglected. We shall present works in this field of a great Serbian mathematician and the founder of the Serbian mathematical school Mihailo Petrović Alas (1868-1943), the great Serbian astronomer and climatologist Milutin Milanković (1879-1958), and Sima Marković (1888-1939), the mathematician, philosopher and politician (Figure 1).

There are some common details in personalities and writings of all three authors. Their first characteristic is the universality. In terms of scientific work, all three belong to a specific time. Due to the accumulated scope of scientific and mathematical knowledge, it was difficult, if not impossible, for an individual to know the whole body of natural sciences and mathematics. The time of universal mathematicians and scientists was slowly passing by. By understanding and the wideness of scientific work in mathematics, mechanics and philosophy, Henri Poincaré, French mechanist and mathematician, was certainly one of the last homo universal of sciences. And it was Poincaré who was one of the professors of Mihailo Petrović. After a later work in science, we can conclude that the spirit of universalism of his professor passed on to Petrović. Sima Marković was a Petrović's student and this universal determination and the wide scientific curiosity certainly was transferred from Professor to his student. A similar characteristic feature was presented in the work of Milutin Milanković. Hence all of them were not working only in their basic fields, but in many other areas as well, including theory of relativity. Their second characteristic is associated to the relationship of mathematics and physics. All three had a point of view that both disciplines are highly interconnected. Petrović even invented the whole new philosophical system, mathematical phenomenology, in which the main point in science should have establishing analogies, including physically disparate phenomena, by reducing to the same abstract essence. Of course, mathematics must have the main role in this reduction, in Petrović's case that were differential equations. The greatest scientific achievement of Milutin Milanković was insolation theory which characterizes the climates of all the planets of the Solar system and explanation of Earth's long-term climate changes caused by changes in position of the Earth in comparison to the Sun. The main tool in the development of his theories had advanced mathematical method and equations of celestial mechanics, the subject which was considered then as applied mathematics. It took several decades to find empirical evidences which led to recognition and the final acceptance of his theory. As we shall see, Marković had a similar, or even stronger attitude to the ties of physics and mathematics. All of them were very good popularizers of science and that was their third characteristic. They wrote many articles and books which appreciate science, ranging from history and philosophy of science to ichthyology and travelogues. They were very good writers and some of their books are still very popular and a part of obligatory school reading. Just to mention Milanković's Trough distant worlds and times (Kroz vasionu i vekove),

which consists of 37 letters on science addressed to an unnamed yang lady and the Petrović's books In the pirate's country (U zemlji gusara) and Eel's story (Roman jegulje).

Figure 1: From left to right: Mihailo Petrović, Sima Marković and Milutin Milanković.

Their writings on relativity appeared in the early stage of development of this theory. When their books appeared, there were discoveries that were still waiting to emerge. For example, Petrović's writing was printed in 1921, while Friedmann equations appeared in 1922. Marković's book was published in 1924, several years before Georges Lemaître and Edwin Hubble discovered the Universe expansion and the property of the universe what is now known as the Hubble law. They had a positive attitude to the theory of relativity and were very curious about it. But this not was the case in general. There were many opponents in science and even more in broad parts of general community, sometimes very hostile. To illustrate these circumstances, we mention the following extreme opinion of Justin Popović (1894-1979), Eastern Orthodox theologian, archimandrite and professor of Belgrade University (at the Faculty of Theology): "No doubt, relativism is also the logic, and the nature and soul of humanism. Einstein's theory of relativity is the final, aggregate resultant of humanism and all its philosophical, scientific technical and political branches. But not only this, nevertheless in the last line to its own, humanism is nothing else but - nihilism... Humanism inevitably evolves into atheism, passes through anarchism and ends with nihilism. If anyone today is an atheist, know, if he is consistent, tomorrow he will be an anarchist, and the day after tomorrow, a nihilist. And who is a nihilist, know, that it has come to him from humanism through atheism... Humanism is in fact the basic evil, the original evil of man." Justin Popović was proclaimed a saint in 2010.

2. MIHAILO PETROVIĆ ALAS

Mihailo Petrović was an outstanding mathematician and a colorful character of the public life of Belgrade in the first half of the twentieth century. He studied mathematics in Belgrade and Paris at Sorbonne (École normale supérieure) where he got diplomas in mathematics and physics. In the year 1894 he defended his doctoral dissertation on differential equations under supervision of the prominent mathematicians Charles Hermite and Charles Émile Picard. In the same year he returned to Belgrade and was elected for the professor of mathematics at the Grand School, the later University of Belgrade. He was scientifically very productive and soon became the leading Serbian mathematician. When he was only 32, he was elected as the full member of the Serbian Academy of Sciences. As the representative of French mathematical school, he brought in Belgrade the spirit of the contemporary mathematics, particularly in analysis and ordinary differential equations. He has the great merit for the development of mathematics in Serbia and by the general opinion, he is considered as the founder of Serbian mathematical school. For example he was the supervisor for all doctoral dissertations in Serbia until the Second World War and the founder of the first international Serbian mathematical journal.

Mihailo Petrović had a rich, interesting and an unconventional life. It is even difficult to list in one place everything that Petrović was dealing with, let alone to describe it. In addition to the interest in various branches in mathematics, we meet him in many other, often unexpected places. He was a writer of laws and proposals of interstate agreements, but also an inventor and owner of successful and realized patents. Petrović is the creator of an original theory in natural philosophy, mathematical phenomenology and by many he is included in the group of Serbian most important philosophers. He wrote several nice and interesting novels and some of them are a favorite part of Serbian youth literature. He wrote scientific papers and was interested in other natural sciences, e.g. in ichthyology, astronomy, theory of relativity, and chemistry. He was the creator of the coding system and the main cryptographer of the Serbian and later of Yugoslav army. He played violin and led the music band "Suz", which had one of the main places in the bohemian life of Belgrade. Finally, he was a big and passionate fisherman and a great world traveler and sailor in the north and south seas.

Petrović wrote the first paper on relativity under the title "Theory of relativity" already in 1921. The paper had 12 pages and was published in somewhat unusual journal regarding its content, Serbian literary messenger. But this is understandable if one knows that the paper was popular in nature and intended for the general audience. There were not formulas and most of the paper is devoted to special theory of relativity. The significant part of the paper is devoted to the genesis of this theory. Beside the explanation of the basics, he mentioned contributions of various people to this theory, e.g. Michelson - Morley experiment, then Lorentz - FitzGerald contraction, Poincare and Einstein final

foundation of the theory. At the end he mentioned some phenomena related to the general theory of relativity, Mercury orbit precession and the light bending in the gravitational field. In this contexts he mentioned two expeditions to Principe (the northern island of São Tomé and Príncipe) and Sorbel (Brazil) organized respectively by Eddington and Crommelin in 1919. These famous expeditions had the goal to test Einstein prediction, the stars rays bending during the Solar eclipse.

The second paper, "The physical constants in the relativity theory" was published in Глас of the Serbian academy of science in 1927. The paper had 16 pages and was dealing with the measurement of time. The basic idea of the paper is "tacit assumptions", as Petrović wrote, that the physical constant, such as coefficient of electrical conductivity, are invariant from transitions from one inertial coordinate system to the another one. Petrović recalls a device and an experiment produced in 1887 by Gabriel Lippmann which he made for time measuring. The whole idea was that a certain interval time Δt is proportional to the electrical resistance ρ of mercury and that Δt can be measured by Lippman's device. Petrović discussed there two possibilities. The first conclusion was that the measurement of ρ and ρ' in two relativistic systems S and S' would depend not only on the speed of S and S' but also on the orientation of apparatus and even their design. If the absoluteness of ρ is assumed, i.e. $\rho = \rho'$ then we would have $\Delta t = \Delta t'$ what, of course, contradicts the special theory of relativity. Petrović's conclusion was that according to the theory of relativity physical constants do not have always the same values, they depend on how they are measured and they may be accidental. He suggested how to overcome this antinomy by proposing general forms of transformation for values of physical constants in two relativistic system. Petrović most probably met Lippman and was introduced in his ideas during his studies in Sorbonne since Lippmann there was professor of mathematics (since 1883) and physics (since 1886). Finally, we should mention in the favor of Petrovi's paper that the transformation rules for physical values in two relativistic systems in general is still open. Probably the most known example of this type is the relativistic transformation of temperature. M. Planck proposed a transformation formula in 1908, but H. Ott corrected it in the quite opposite way in 1963 (see H. Ott: Zeits. Phys. (1963) 175, 70).

Petrović's third paper on relativity was Physical etalons for time measuring, see Etalons physiques de temps, Publ. de l'Observatorie astronomiquc de l'Université de Belgrade, 1933, t. 11, pp. 5-10. The paper was published in 1933 and in the greatest part it is a compilation of his previous paper on this matter.

3. SIMA MARKOVIĆ

Sima Marković was a talented mathematician, gifted philosopher and a tragic figure at the Yugoslavian political scene and of the communist movement. He finished studies in mathematics with honor in 1911 and immediately became an assistant of Professor Petrović at the mathematical department of the Belgrade University. He completed his doctoral dissertation on Riccati differential equation

in 1913, but the beginning of the First World War broke the academic activities in Serbia and his scientific work as well. After the war he started his political career, was a member of the parliament and in 1920 he was elected together with Filip Filipović, also a mathematician, for the first general secretary of Yugoslav communist party. In the same year the University nominated him for the assistant professor but due to his political activities, the Yugoslav king Alexandar did not want to sign the proclamation for this appointment. Soon he was expelled from the university and even more during twenties he was sent to prison several times where he spent altogether four years. In the thirties he moved to Moscow where he was the scientific associate at the Philosophical institute of the USSR Academy of Sciences, but had high positions in the communist establishment, too. He was also involved in the fractional fights in the party. Seemingly, he was on the wrong side as in 1939, April 19th, in Stalin's purges he was sentenced to death by shooting. He was executed in the same day. Ironically, he did not support offensive or violent methods in politics as he believed in means of parliamentary democracy, in the institutional and legal methods.

Marković's main interest in mathematics was teaching, education and methodic and he wrote several works on these topics. However, his main concern was the political philosophy and to some extent philosophy of science, particularly views based on physics. He wrote several books and booklets on the philosophy of science and related topics. For example, in the book The Principle of Causality and Modern Physics, Marković emphasizes the connection between physics and mathematics. He believed that the key feature of modern physics is its mathematics and that mathematics as all other sciences originates from the experience and from the needs of the everyday life. He also wrote in twenties a short book (80 pages) on the theory of relativity and a longer paper (31 pages) on the same topic published five years later. It interesting that he wrote the book during his stay in prison. The paper is more or less a compilation of the book, so we shall give some comments only on the book.

Sima Marković published his first work on relativity, the book Теорија релативитета, популарна-научна скица (Theory of relativity, a popular-scientific sketch) in Belgrade in 1924 (Figure 2). As the title says, the book is intended to the broad audience, particularly to those readers who are inclined to physics and science in general. It is interesting that the author in the foreword writes: "Even if Theory of relativity is physical by content, by form it still belongs to the most abstract parts of Theoretical mathematics". He glorifies mathematics often and compare it to the highest men's achievements. However, he did not use in the book a mathematical language, except few times some very simple formulas. He explains the main goal of the book as follows: "In this sketch, only the most important facts that characterize the theory of relativity are exposed to the goal to which it has to serve. This sketch represents, therefore, only the skeleton of Relativity Theory, which cannot be revived without mathematics. But, I hope, more careful readers can still get at least an approximate idea of what the Relativity Theory is.". The book consists of two parts:

- Part 1. Special theory of relativity, pages 6 - 45.
- Part 2. General theory of relativity, pages 46 -80.

The first part starts with presentation of views of classical mechanics, Galileo relativity principle and Newton's cosmology: absolute space and absolute time. We could say that Introduction does not differ much from those in modern books, even if the book was written almost a century ago. Rest of the Part 1 is devoted to the explanation of basics of special theory relativity. Relativity of length and time are explained and shown why in this theory is not possible to talk about simultaneous events. Lorentz coordinate transformations, which he called Lorentz formulas, and the contraction factor γ are explained. He presents how special theory of relativity succeeded in the explanation of some old problems in astronomy such as the stellar aberration is. He also explained four-vectors, namely events in the Minkowski space. He ends this part with the very modern view that the physical laws are nothing else but the invariants under coordinate transformation.

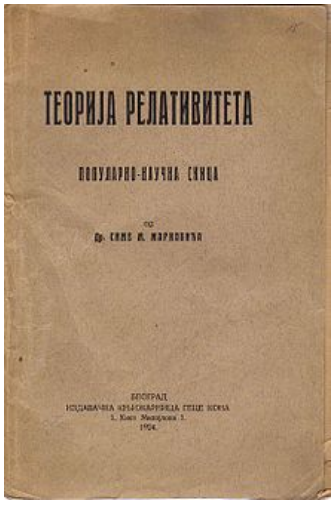

Figure 2: Cover page of the Theory of relativity, a popular-scientific sketch book by Sima Marković.

The second part starts with the discussion of the equivalence principle which deals with gravitational and inertial mass and the role of gravitation in General theory of relativity. There are presented virtually then all known facts from this theory. He mentioned main tests of General theory of relativity such as perihelion precession of Mercury's orbit and the bending of light rays in the gravitational fields. There is mentioned the Eddington's measure of star light bending during the Solar eclipse in 1919, just few years before the book appeared. He implicitly

speaks about Riemann space explaining that General theory of relativity assumes a non Euclidian geometry. Some elements of differential geometry are mentioned such as the geodesics and the parallel transport needed for covariant derivative. It must be said that Marković showed the great skill in presenting these highly mathematized content, but not using a single mathematical symbol. He also described a phenomena such as the gravitational time dilation. He discussed also relation between the general theory of relativity and cosmology. He explains that the universe occupies a closed but unbounded space. As an application of the theory he deduced a formula of the size of the universe which depends only on the density ρ of the matter in the universe.

There are no references in the book, but the author mentioned that his book is based on the works of Einstein, Lorentz, Minkowski, Weyl, Riemann, Pauli, Helmholtz and few other physicist. The book is written in a nice and vivid language, and even today it could be interesting to a general reader.

4. MILUTIN MILANKOVIĆ

Milutin Milanković and his work are well known to astronomers. So we will highlight here just few facts from his life and work. Milanković is one of the Serbian greatest and most cited scientists of all times. His theory on the ice ages that accurately explains the change of climate on a large time scale is accepted world-wide. In recognition of his scientific achievements, a crater on the Moon, another one on the Mars and a planetoid were named after him. Besides his the most famous work Kanon der Erdbestrahlung und seine Anwendung auf das Eiszeitenproblem (published in 1941) and many other scientific papers, he also wrote an excellent book on celestial mechanics and books that popularize science. He is also known as a good civil engineer. Milanković came to Belgrade from Vienna in 1909 to teach applied mathematics at the Faculty of Philosophy of Belgrade University. His coming was a merit of Bogdan Gavrilović and Mihailo Petrović, who both taught mathematics at the University. Milanković was at the Belgrade University till his retirement in 1955, lecturing there applied mathematics. It should be mentioned that theoretical physics, mechanics and astronomy were considered then as the areas of applied mathematics. Milanković also was the first professor who started lecturing celestial mechanics at the University of Belgrade.

Milanković did two short excursions to relativity. He wrote his first paper "O teoriji Michelsonova eksperimenta" (On the theory of Michelson's experiment), Rad JAZU, vol. 190 pp 65-70 already in 1912. He was doing research in this theory in the period 1912-1924. In fact his papers on this matter were on special relativity and both are on Michelson experiment (now known as Michelson-Morley experiment) which gave the strong evidence against ether theory. He discussed there, in the light of the Michelson experiment, the validity of the second postulate of Special theory of relativity, that the speed of light is the same

in all reference frames. Tatomir Anđelić and Andrija Stojković wrote an extensive paper on Milanković's views expressed in theses papers, so we shall not enter into discussion of his works on this matter. We should just mention that he was teaching special theory of relativity, most probably in arrangement with Mihailo Petrović, at the Belgrade university in the twenties of the last century.

5. OTHER SERBIAN SCIENTISTS

There were few other Serbian scientists who were engaged in scientific work or wrote about the theory of relativity. Probably Mileva Einstein - Marić (1875-1948), a mathematician and the first Einstein's spouse, is the most known as a possible contributor to the theory of relativity. There is a big debate if she really had any major contribution to the early Einstein work. We will not enter in this discussion, mainly because we do not know her signed scientific papers. Vladimir Varićak (1865-1942), the well-known mathematician of the Serbian origin, was a professor at the University of Zagreb. He wrote first of all, already in 1910, a paper on special theory of relativity. It interesting that he was a Milanković's high-school teacher. Few physicists and philosophers, Milivoje Dobrosavljević, Ognjen Prica and Dušan Nedeljković also discussed and wrote before the Second World War on the theory of relativity in various contexts. Nikola Tesla, the famous inventers, was strongly against this theory, while Mihailo Pupin, the other famous Serbian electrical engineer ant the professor at the Columbia University in New York, accepted it (Anđelić, Stojković, 1983).

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