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SCIENTIFIC PAPERS OF MILUTIN MILANKOVIĆ IN HIS DIGITAL LEGACY

Abstract. In this paper we present scientific papers of Milutin Milanković, one of the greatest Serbian scientists, in his Digital Legacy. Papers are classified in accordance with the areas to which they belong.

1. Introduction

A group of participants of the Digitization project of the Faculty of Mathematics in Belgrade and the Mathematical Institute of the Serbian Academy of Sciences and Arts started in 2012 to build the *Digital Legacy*[1], an Internet site of the Faculty of Mathematics. The general idea of the Legacy was to present there biographies of the Serbian scientists from the past who worked in mathematical sciences: mathematics, mechanics and astronomy. Another goal was to have at a single place all their scientific and technical works and personal data such as photos, letters and other related documents in order to better understand their work and life. We also put there some writings of other people on these authors. This Internet site is designed having in mind the general audience, but the scientific community, too. At this moment, three scientists are presented there: Anton Bilimovič (1879–1970, mechanist, the founder of the leading Serbian mathematical journal *Publications de l'Institut Mathématique*, 1932), Bogdan Gavrilović (1864–1948, mathematician, one of the founders and rectors of the University of Belgrade) and the most cited Serbian scientist Milutin Milanković (1879–1958, geophysicist, astronomer, mechanist and civil engineer, best known for his theory of ice ages). We are planning to include there in the near future presentations of other prominent Serbian mathematicians: Mihalo Petrović Alas, Jovan Karamata and Đuro Kurepa.

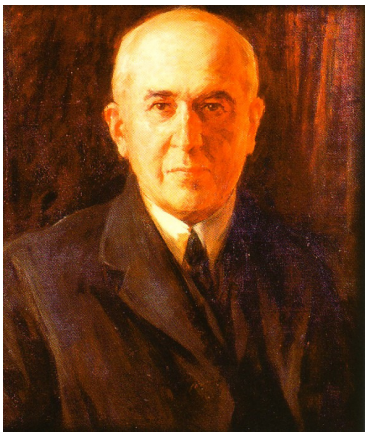
The current activities on the Legacy include the digitization and preparation of all scientific works of Milanković and this post is almost done. We recently finished digitization almost all of his scientific papers, books and lectures. His legacy includes a lot of additional materials: Milanković's photos and patents, but also books and papers of other authors on Milanković. This presentation is also the most complete in the Legacy. In this paper we present digitized scientific articles of Milutin Milanković posted in the Legacy.

2. Short biography of Milutin Milanković

Milutin Milanković (1879–1958) is one of the Serbian greatest and most cited scientists of all times. His theory of the Ice ages that accurately explains the change of climate

[1] http://legati.matf.bg.ac.rs

on a large time scale is accepted world-wide. In recognition of his scientific achievements, a crater on the Moon, another one on Mars and an asteroid were named after him. Besides his 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 tile 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 Alas, who both taught mathematics at the University. Milanković was at the Belgrade University till his retirement in 1955. He was 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.



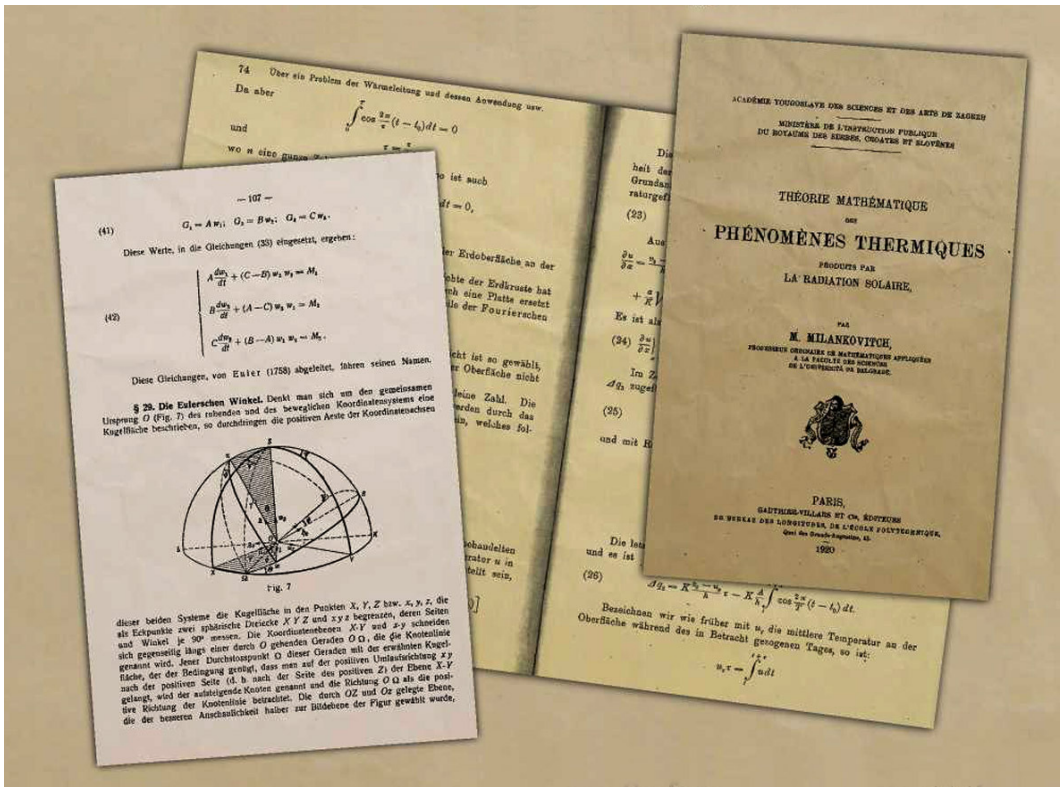
Portrait of Milutin Milanković (by Paja Jovanović)

3. Scientific papers of Milutin Milanković

Milanković was a universal scientist with wide interest in many areas of natural sciences. Besides that, he was a very educated mathematician. His understanding and ability to use mathematics in advanced areas of sciences, particularly in theoretical mechanics, exceeded in great extent an average knowledge of a civil engineer where his basic education laid. All these aspects of his scientific abilities are reflected in his scientific opus very well, not only in scientific papers but in his books and monographs as well.

We should mention a few other general characteristics of his scientific work. There is a number of recognized scientists and engineers who originated from Serbia. But their main work was done abroad, out of Serbia. Milanković was born in Dalj, then a village in Austro-Hungarian Empire (now in Croatia). His complete education was in Austro-Hungary, first in a secondary school in nearby Osijek then in Vienna where he moved to study civil engineering. He got his PhD there and started to work as civil engineer. However, his main scientific work and achievements were completely accomplished in Belgrade. Secondly, most of his scientific treatises were written in Germany, many of them in Serbian and just a few in French. A possible explanation why so many papers Milanković wrote in Serbian could be that he published them in the publications of the Serbian Academy of Sciences. Then the Academy had the rule that papers published there should be in Serbian. However, papers written in Serbian and even in French were almost always accompanied with long abstracts in German. Sometimes the abstracts were longer than the original papers! Finally, we should mention that

he was very talented as a writer. His writing gift particularly can be seen in his popular books on science. Here we present in short his scientific work and papers grouped into suitable subjects.



Samples of digitized publications

Astronomy. Milanković was not the first Serbian astronomer. However he was certainly the most recognized and most important Serbian astronomer. His work is enormous and so important that it is not possible in a short article as this one to present even in a part all his scientific achievements. His astronomical works were mostly concerned with perturbation of planet orbits, planets rotations and planets climates. His main stand point of view was that the planets climates are strongly influenced by these astronomical phenomena. So Milanković's papers in astronomy are closely related to his work in geosciences and climatology.

Calendars. Milanković's main contribution in this field was his proposal and an improvement of the Gregorian time reckoning. It was accepted by the Orthodox Christian Community during a Congress of Orthodox Churches in Constantinople in 1923. Milanković's calendar-reform was accepted by the Orthodox Christian Community, but not by all Churches, including the Serbian one.

Mechanics. Milanović's papers in mechanics are mainly in the area of dynamics and he was particularly interested in *n*-body problem. Milanković wrote these papers in his early period of scientific work.

Geosciences - Climatology. Milutin Milanković is best known for his theory of glacial ages. The theory takes into account the complex secular computation of perturbations in planet motions and it were published in *Théorie mathématique des phénomènes thermiques*

produits par la radiation solaire in 1922. Due to these results that were also published in scientific papers, he became well known in the world scientific community, so that great German climatologist W. Köppen invited him to cooperate in building a great work *Handbuch der Klimatologie*. For this purpose a part, which was published in 1930, entitled *Mathematische Klimalehre und Astronomische Theorie der Klimaschwankungen* was written by Milanković. Here his theory of planet heating based on insolation was extended with a special reference to the Earth. By applying this theory to the run of glacial ages it was shown that Milanković had created a good and mathematically exact theory of terrestrial climate. Milanković also created a theory of motion of terrestrial poles and succession of glacial ages. Results published in the scientific papers and mentioned works are sithetized into his main work *Kanon der Erdbestrahlung und seine Anwendung auf das Eiszeitenproblem* printed shortly before the beginning of the Second World War. Due to this, the scientific world community learnt about Milanković's theory with some delay. As a consequence the world recognition arrived with postponement. This work appears as a synthesis of his earlier works which concern his research activity within boundary fields between many natural sciences and mathematics.

Theory of relativity and cosmology. Milanković did two short excursions to these areas. In fact these papers 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. T. Anđelić and A. Stojković wrote an extensive paper on Milanković's views expressed in theses papers.

History of Science. Milanković wrote several books on history and popularization of science and autobiography books, for example *Through Space and Centuries*, *Through the Realm of Science* and *Recollection, Experiences and Vision*. But he also wrote several papers on topics ranging from biographical to the discussion of some ancient problems related to geometry and mechanics. These papers often touched philosophical themes but also history of mechanics and astronomy.

Building and construction (civil engineering). Milanković wrote these papers in the beginning of his scientific work, in the first decade of XX century. Most of these papers were concerned with the theory and calculation of statics of girders and membranes used in construction. Mathematical apparatus used in some of these papers was rather advanced.

4. Conclusion

Milutin Milanković published about fifty scientific papers, most of them related to astronomy, geosciences and theoretical mechanics. All these papers are digitized and they are now a part of his digital legacy. We believe that the material presented in the legacy will serve to better understand Milanković's life and scientific work.

5. Acknowledgment

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Supplement: Scientific papers of Milutin Milanković in Virtual Library and his Digital Legacy - thematic division (with active links in electronic version of this paper)
Papers denoted by * can be found in Digital Legacy, http://legati.matf.bg.ac.rs/milankovic.
Papers denoted by † are published in *Publications Mathémat. Univers. de Belgrade* and can be found in the repository of this journal at the address http://elib.mi.sanu.ac.rs.

A. Astronomy

A.1. Calendars

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A.2 Celestial mechanics

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2. *Нумеричко израчунавање секуларне путање Земљиних полова ротације**, 3-38, 1933. Глас СКА. Extended abstract*: Numerische Ausrechnung der säkularen Bahnkurve der Rotaionspole der Erde* (7 p.), 1933, *Bulletin* Académie Sciences Mathémat. et naturalles de Belgrade.
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5. *Ein neues Kapitel der exakten Wissenschaften und dessen Anwendung in den beschreibenden Naturwissenschaften*†, Tom VI-VII, 13 - 31, 1938, *Publications* Mathémat. Univers. de Belgrade.

A.3 Planetary climatology

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