Mihailo Petrović ALAS

Life Work Times

Serbian Academy of Sciences and Arts

MIHAILO PETROVIĆ 150th ALAS birth anniversary


MIHAILO
PETROVIĆ
150th ALAS
birth anniversary

SERBIAN ACADEMY OF SCIENCES AND ARTS

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

Publisher
Serbian Academy of Sciences and Arts
Knez Mihailova 35, Belgrade

Acting publisher
Academician Vladimir S. Kostić

Editor-in-chief
Academician Marko Anđelković

Editors of publication
Academician Stevan Pilipović
Academician Gradimir V. Milovanović
Professor Dr Žarko Mijajlović

Cover design
Dragana Lacmanović-Lekić

Prepress
Dosije Studio, Belgrade

Selection of artworks
Maja Novaković

English translation
Tatjana Ćosović, Natalija Stepanović
Tanja Ružin Ivanović, Žarko Radovanov, Dora Seleši

Proofreading and editing
Jelena Mitrić

Printing
Planeta print, Belgrade

Print run: 500 copies

ISBN 978-86-7025-818-1

The publication was financially supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia and Telekom Srbija.

MIHAILO PETROVIĆ ALAS
LIFE, WORK, TIMES

ON THE OCCASION OF THE 150th ANNIVERSARY OF HIS BIRTH

SERBIAN ACADEMY OF SCIENCES AND ARTS

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.

The publication of the monograph was financially supported by JP Srbijagas, the Ministry of Education, Science and Technological Development, primarily through scientific projects in which the majority of the authors of the papers takes part, and Telekom Srbija. We would like to express our deep gratitude for their support.

Finally, we would like to express our gratitude to Mr. Mirko Milićević from the publishing house "Dosije Studio" for excellent prepress preparation of the monograph.

S. Pilipović, G. Milovanović, Ž. Mijajlović

CONTENTS

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

GROUP FOR NUMERICAL MATHEMATICS IN NOVI SAD

Tradition of applied mathematics started by Mihailo Petrović Alas

Nataša KREJIĆ
Department of Mathematics and Informatics,
Faculty of Sciences, Novi Sad

The founding father of mathematics in Serbia, Mihailo Petrović Alas, devoted a significant portion of his career to applied mathematics. Mathematical modelling requires a broad spectrum of mathematical knowledge alongside a broad education, which academician Petrović had, and the focus of his work in the applied (or, to put it better, motivated) mathematical research was on phenomenology, i.e. defining the certain systems of equations that describe phenomena, regardless of objects or phenomena that are being modelled. Today, mathematical modelling is a well-developed and very important branch of mathematics, so this allows the conclusion that it also belongs to pioneering contributions by Mihailo Petrović Alas.

The Group for Numerical Mathematics at the Department of Mathematics and Informatics of the Faculty of Sciences in Novi Sad gathers mathematicians who deal with numerical mathematics, mathematical modelling and simulation at the University of Novi Sad. Almost all researches are the direct mathematical descendants of Mihailo Petrović Alas. The Group grew into an independent research group out of the Group for Mathematical Analysis during the 1980s, headed by professor Dragoslav Herceg. Professor Herceg earned his PhD on numerical

Faculty of Sciences, University of Novi Sad

solving of singularly perturbed differential equations, under the supervision of academician Bogoljub Stanković, in cooperation with professor Erich Bohl from the University of Konstanz in 1980. A few years later, Prof. Herceg founded the Group for Numerical Mathematics with numerous students, among whom is the author of this paper.

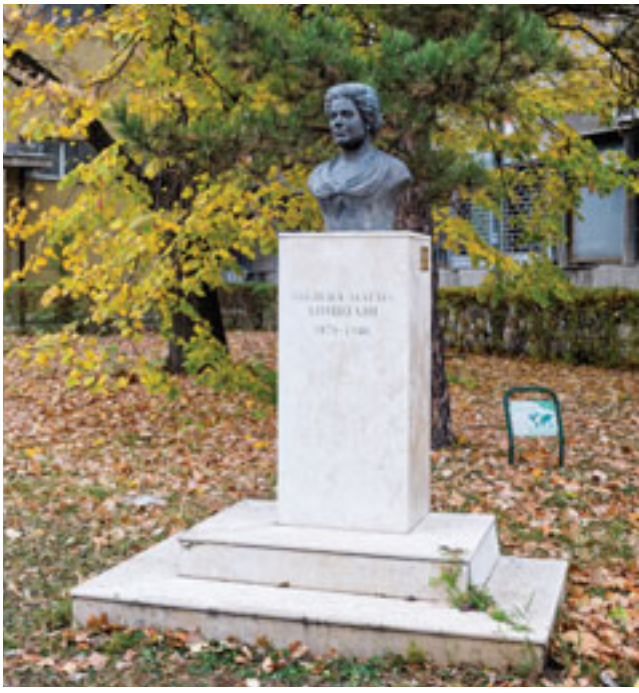
During the 1980s and 1990s, research was primarily focused on two topics – numerical solving of differential equations and numerical methods of linear algebra. In both areas, significant results were achieved and intensive cooperation was established with universities in Germany, Ireland and the USA. In the field of numerical solving of differential equations, research was dealing with singularly perturbed problems on non-equidistant discretization meshes which achieve parameter-uniform convergence, spline collocational methods and differential methods. Later on, the research was expanded to problems of partial differential equations with perturbations and finite element method. In the same period, the research focus in numerical linear algebra was on relaxation iterative methods for solving systems of linear equations. In this period a series of PRIM conferences on applied mathematics was organized (PRIM – Primenjena matematika (applied mathematics)).

At the beginning of this century, numerical optimization became an important part of research, in line with the trends in modern mathematics. Research is mainly focused on the problems of nonlinear optimization, with or without constraints, of continuous type and of large scale, with a strong emphasis on theoretical results on the convergence of iterative methods. The achieved results include a contribution to convergence theories of Quasi-Newton method, definition and the analysis of new Newton-type methods for solving nonlinear complementarity problems, as well as new methods for solving singular systems of nonlinear equations. Close cooperation was established with a research group headed by professor

Petrovaradin fortress in Novi Sad

Martinez from Campinas in Brazil and with many European research groups, which significantly expanded the spectrum of scientific topics.

At the same time, research in the field of numerical linear algebra, under the leadership of professor Ljiljana Cvetković, has been expanded to special classes of matrices (diagonally dominant matrices and their generalizations), which pave the way towards new results in various other areas of numerical linear algebra. Those were primarily results on eigenvalue localization by the Gershgorin-type theorems, which were achieved in cooperation with professor Richard Varga from Kent State University (Ohio), and which were later crowned by the construction of advanced algorithm for drawing a minimal Gershgorin matrix set. In the next few years, the cooperation was significantly expanded, resulting in joint papers published with colleagues from universities in Valencia and Saragosa (Spain), Poznan (Poland), Ioannina (Greece), Rostov (Russia), Beijing (China) and Kansas (USA). Besides results in localization of eigenvalues of matrix pencils, an efficient evaluation of norms of matrix inverses were achieved, which were later used for obtaining first results in the



Monument to Mileva Marić Einstein
(Author: Lazar Lazić, 2018)

Group photograph of mathematicians from Novi Sad from the 1970s. Second row, the tallest figure: Academician Mirko Stojaković (1915–1985), one of the leading mathematicians from Novi Sad at the time.

localizations of matrix pseudo-spectrum in various norms. As per numerical methods, the iterative methods for solving problems of linear complementarity stood out based on matrix decomposition, for which convergence areas were improved. In addition, new optimization algorithms for problem of distance to general instability for medium– and large-scale matrices were developed. Finally, the mentioned results in the field of numerical linear algebra were efficiently applied in the area of stability of dynamic systems, especially for optimization of operation of wireless sensor networks, for obtaining robust indicators of ecological stability of empirical food networks, overcoming the Schmidt paradox in climate modelling, as well as the analysis of the impact of nanotubes on intercellular communication. Research activities in the area of numerical methods of linear algebra on an international level resulted in the organization of the GAMM 2013 conference in Novi Sad, as well as in a series of the ALA conferences over the previous twenty years.

Over the last ten or so years, a large number of activities of the Group have been focused on mathematical modelling and the development of applied mathematics, in line with contemporary European and global trends. The Department of Mathematics and Informatics joined ECMI – European Consortium for Mathematics in Industry in 2003 as an educational and scientific center. A master's program in applied mathematics has been established with the focus on mathematical modelling and education of young mathematicians who have additional knowledge in economy and technics, and who are capable of working in multidisciplinary teams and applying fundamental mathematical knowledge to real problems.

Group photo of mathematicians. First from the left: Academician Mirko Stojaković.
Second from the right: Academician Đuro Kurepa

Significant efforts were made to establish cooperation with non-academic institutions aiming at applying mathematical knowledge and methods to real problems. These efforts resulted in raising some new research topics, mainly concerning the application of numerical mathematics methods in economy, medicine, chemistry, biology, meteorology and technics. A series of results achieved in the field of numerical optimization is motivated by problems stemming from algorithmic trading, which is a dominant method for the execution of transactions on stock exchanges, which is, by its definition, based on a mathematical model and statistical characteristics of the market.

Contemporary trends in numerical optimization, as well as the importance of modelling and solving of real problems, stirred up interest in problems of stochastic optimization and in the mathematical simulations of real systems. Given the fact that in the real systems random parameters are often present, or values of parameters are known only with some degree of certainty, the minimization of stochastic functions is of great importance. Basic problem in solving problems of stochastic optimization is the efficiency of numerical methods, because good approximation of stochastic objective function requires working with very large samples, which is very challenging computing-wise, and often inapplicable. By using the apparatus of numerical optimization and stochastic analysis, a series of results with variable sample sizes is obtained, which greatly increased the efficiency of a method. At the same time, international cooperation has been broadened, and scientific cooperation with numerous ECMI research groups in this field has been established.

A lecture at the Department for Mathematics, University of Novi Sad

In the Big Data era in which we live today, machine learning and deep neural networks are very important topics. Both topics are fundamentally mathematical problems and very often a significant part of the method comes down to the problem of function minimization. With the explosion of data quantity, a need for distributed optimization appeared. Namely, the available data is often stored in different geographical locations and its centralization is not technically feasible, or the data quantity exceeds computer's capacity or data centralization is avoided due to data privacy challenges. Besides, concepts of federated and online learning involve partial data processing at the source, and partial cooperation within a group of agents in order to get the final result. Therefore the methods of distributed optimization are being developed, which implies that there is a network of computers that are mutually interconnected by architectures of various types, and each computer in the network has access to a specific set of data and its local objective function, whereas the objective is the minimization of aggregate objective function. A reformulation of the standard methods of continuous optimization in distributed environment is a non-trivial challenge; the lack of central node makes

A chess tournament at the Department of Mathematics, University of Novi Sad

classical methods inapplicable, the mutual communication of each node with all other nodes is impossible because it is either too expensive or is opposed to various privacy limitations, and communication within the network, when possible, is expensive, can be slow and interruption-prone. Therefore, the non-trivial redesigning of classical (efficient) methods of numerical optimization is necessary. Research in this field has been in the focus of the scientific efforts of the Group for Numerical Optimization over the last few years. Its current activities encompass several research projects in the field of Big data realized within the H2020 and IPA programs. Besides, a doctoral program focusing on the mathematical challenges in the field of Big data is formed, and it is being implemented in cooperation with universities in Milan, Lisbon and Eindhoven and seven European companies, within the Marie Sklodowska Curie H2020 program.

Researchers from the Group for Numerical Mathematics are active in the Center of Research Excellence for Mathematical Research of Non-linear Phenomena, headed by academician Stevan Pilipović and SKALA center headed by professor Ljiljana Cvetković.