Baština Akademije nauka i umjetnosti Bosne i Hercegovine

Proceedings of the Conference on March 14 - International Day of Mathematics

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2024-12-26

Academy of Sciences and Arts of Bosnia and Herzegovina

https://bastina.anubih.ba/handle/123456789/798

Preuzeto s Baštine Akademije nauka i umjetnosti Bosne i Hercegovine

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PROCEEDINGS OF THE CONFERENCE ON MARCH 14 – INTERNATIONAL DAY OF MATHEMATICS
Special Editions ANUBiH, Book CCXVI, OPMN Book 30
Sarajevo 2024, **p. 5–14** DOI: 10.5644/PI2024.216.02

HAPPY YUBILEE PROFESSOR MIRJANA!

MEHMED NURKANOVIĆ

ABSTRACT. This special edition of ANUBiH, the Collection of papers presented at the Conference on the occasion of World Mathematics Day, ANUBiH, Sarajevo, March 14, 2024, and the Conference itself, is dedicated to our dear Academician Prof. Dr. Mirjana Vuković in honor of her significant jubilee. Here, we will give a brief overview of her life and work.

1. EDUCATION AND ACADEMIC CAREER OF PROFESSOR MIRJANA VUKOVIĆ

As a student and long-time associate of the Editorial team of the Sarajevo Journal of Mathematics, I am familiar with many details about the life of Professor and Academician Mirjana Vuković, a person I hold dear. However, considering her exceptionally rich academic career, intertwined with teaching activities at the universities where she worked, her extensive and successful scientific and research contributions, and her significant social engagements, it is impossible to include all the details of her life in a short essay. Therefore, I have provided a brief overview of her life and work.

2010 *Mathematics Subject Classification.* 01A70, 01A65.

Key words and phrases. Graded and paragraded structures: groups, rings, modules, radicals of paragraded rings, Krull's theorem, Wedderburn-Artin theorem, ADS-theorem for paragraded rings.

Mirjana Vuković was born in 1948 in Fojnica and from the maternity hospital arrived in Sarajevo. Due to the nature of her father's career as a partisan and high-ranking officer, her family frequently moved. Thus, she attended the first six grades of elementary school in Varaždin and Maribor and completed her primary education in Sarajevo upon the family's return. She then attended the Braća Ribar High School (now Third Gymnasium), graduating as one of the school's top students. She went on to study mathematics at the Department of Mathematics of the Faculty of Natural Sciences and Mathematics in Sarajevo despite having the qualifications to pursue any field of study, including the arts. She completed her studies in record time, graduating as the top student in her class. Her exceptional academic achievements earned her numerous accolades: all silver medals (for individual academic years), a gold medal (for overall academic excellence), and scholarships from the Hasan Brkić University Fund, the first of which was awarded upon the recommendation of her professors, Academician Mahmut Bajraktarević and Professor Šefkija Raljević who was the Dean at the time.

Immediately after graduating, she began her academic career at the same Department, first as an Assistant (1972), then as an Assistant Professor (1979), an Associate Professor (1984), and finally as a Full Professor (1989). It is worth noting that Professor M. Vuković also pursued her education at some of the world's most prestigious universities, including the Moscow State University Lomonosov (1975/76 academic year) and the Pierre and Marie Curie University in Paris in December 1976, when her collaboration with the renowned French mathematician Marc Krasner began. Thus, referring to her educational journey, she often says, "my three universities," meaning the University of Sarajevo, Moscow State University Lomonosov, and Paris's Pierre and Marie Curie University.

At the Faculty of Natural Sciences and Mathematics in Sarajevo, she completed a two-year postgraduate program, thus earning a Master of Mathematical Sciences degree (1975) with a thesis entitled "Hensel fields and Henselisations" (written in Serbo-Croatian). She then earned her Ph.D. in Mathematical Sciences (1979) by defending her dissertation "Some Problems on Summability and Their Applications to Generalised Fourier Series" (in Serbo-Croatian), under the mentorship of Academician Manojlo Maravić.

During her illustrious academic career, Professor Mirjana held several significant positions at the Faculty of Natural Sciences and Mathematics and the University of Sarajevo. She served as Vice-Dean for Science and Teaching (1982–1984) and was elected, in two consecutive terms, as the youngest Vice-Rector of the University of Sarajevo for Science, Teaching and Scientific Research (1988–1993). A crowning achievement of her scientific research contributions and her impact on the development of mathematics in Bosnia and Herzegovina was her election as a corresponding member of the Academy of Sciences and Arts of Bosnia and Herzegovina in 2012 and a full member in 2018. With this election, she became the first female mathematician and the first woman elected to the Department of Natural and Mathematical Sciences of the Academy.

As I write this text, I recall my time as a student at the Department of Mathematics of the Faculty of Natural Sciences and Mathematics in Sarajevo. Professor Mirjana Vuković, then a young and much-loved professor, taught Analysis 3 to third-year students in the teaching course and Complex Analysis to fourth-year students in the general mathematics course. Taking over the challenging legacy of her professor and distinguished lecturer, Academician M. Bajraktarević, Professor Mirjana successfully maintained the high quality of lectures in Complex Analysis, becoming thus a worthy successor to Academician Bajraktarević. I can confidently say that Analysis 1, taught by Academician Bajraktarević, and Complex Analysis were my favorite subjects during my studies. Later, Professor Mirjana also taught in other various fields of mathematics, such as algebra. It is particularly noteworthy to mention the wartime period when, despite extremely difficult circumstances and even being injured, she, along with a few other professors, made significant efforts to keep the Department of Mathematics at the Faculty of Natural Sciences and Mathematics functioning. She also taught mathematics at technical faculties within the University of Sarajevo during that challenging time.

2. SCIENTIFIC RESEARCH WORK OF PROFESSOR MIRJANA VUKOVIĆ

2.1. **About Her Scientific Contributions**

Professor Mirjana Vuković's scientific interest is related to several important and contemporary areas of mathematical analysis and modern algebra. Her scientific papers are predominantly of a foundational theoretical nature.

Her work in mathematical analysis primarily focuses on summability theory and Fourier analysis. While preparing her doctoral dissertation under the mentorship of Academician Manojlo Maravić, she explored issues related to the summability of multiple Fourier series and the summability of expansions in terms of the eigenfunctions of the Laplace operator. Initially, she investigated some properties of the class G_h^κ – summability methods and problems of the inversion for this class of methods, proving, in doing so, several Tauberian-type theorems [1] and a Convexity Theorem for the G_h^κ – summability method [2]. At that time, only two convexity theorems for summability methods were known. The first such theorem was established by the famous Hungarian mathematician M. Riesz, whose summability method was named after him i. e. Riesz summability method. Academician M. Maravić proved the convexity theorem for the G_θ^κ – method, while M. Vuković proved the third theorem for the G_h^κ – summability method [2]. The results that M. Vuković obtained in this research formed a significant part of her doctoral dissertation. However, later, in a paper [28], M. Vuković with her students E. Ilić-Georgijević and O. Stevanović applying Parseval's formula proved a G_h^κ – summability analogue of Avadhani's theorem for the Riesz–summability of the eigenfunction expansion. A crucial step in the proof of this theorem was to find a function $g(x)$ that would lead them to the kernel of the G_h^κ – summability, which is more complex than the kernel of the Riesz summability.

Let us also point out that Prof. Mirjana participated in research in the fields of *Functional Analysis* and *Theory of Distributions*. In a joint paper, M. Vuković with academicians S. Pilipović and F. Vajzović in [25] studied various classes of distribution of

semigroups on the spaces of functions $\mathcal{F}_r$, $r \in \mathbb{R}$ distinguished by their behavior at the origin. In the paper [26], M. Vuković with S. Pilipović and A. Bučkovska proved an approximation result for the bilinear Hilbert transform and used it for the inversion of the bilinear Hilbert transform. Also, they analyzed p-Lebesgue points ($p \geq 1$).

A little later, in [27], M. Vuković, as a good expert in Fourier analysis, together with I. Zubac analyzes quasiasymptotic boundedness of distributions and their wavelet transforms in general, as well as for a class of exponentially bounded distributions and their wavelet transforms in particular. The main idea of this paper is to use, instead of the quasiasymptotic behaviour, the notion of quasiasymptotic boundedness. In this way, they obtain new Abelian type theorems for the wavelet transform of distributions with different growth.

The crowning achievement of Professor Mirjana Vuković's scientific work lies in her papers in the field of abstract algebra, to which she dedicated most of her time and where she achieved exceptional results. Her initial findings in this area emerged through collaboration with the renowned French mathematician Marc Krasner. In those papers a new abstract theory was established – *the theory of paragraded structures*, which are increasingly and rightfully referred to as the *Krasner-Vuković paragraded structures (groups, rings, modules)*. These represent fundamental theoretical results in algebra, which M. Vuković and M. Krasner obtained by addressing the long-standing question: *under what conditions are graded structures (groups, rings, modules) closed with respect to the direct sum and the direct product*? In this way, their solution led to structures more general than the Bourbaki-Krasner graded structures. These appeared for the first time in their joint papers, Paragraded Structures (in French) Parts I, II, and III [3–5], published in the prestigious *Proceedings of the Japan Academy, Japan Academy of Sciences*, based on reviews by one of the most prominent and influential Japanese mathematicians of the time, Academician Shokichi Iyanaga. Subsequently, their monograph Paragraded Structures (Groups, Rings, Modules) (in French) was published as part of the esteemed *Queen's Papers in Pure and Applied Mathematics* series at *Queen's University, Kingston*, Canada [6]. This paper gained significant attention, even during its announcement in the book *Il mondo Krasneriano* [7] by the renowned Canadian mathematician *Paolo Ribenboim*.

The significance of this monographic work is reflected in the fact that it, along with other papers by M. Vuković in this field, can be found in five world languages across 154 libraries worldwide, including: Université "Pierre et Marie Curie", "Sorbonne Universitée" (Paris); "Lomonosov – Moscow State University – MGU, Moscow"; "Universitée Joseph Fourier", Grenoble; "Karlshruer Institut für Technologie – KIT" (Karlsruhe); Mannheim Universität, and others. These works are also listed in libraries such as "Open Library" and "WorldCat." Additionally, they have been available for purchase online through the "Queen's University Bookstore" and "Amazon.com"...

Let us now elaborate further on the results of her subsequent research in the field of algebra. In [8], after proving the existence and uniqueness of the primary decomposition of moduloids, Prof. Mirjana Vuković and E. Ilić Georgievć briefly turned our attention to Krull's theorem and the existence of the primary decomposition of Krasner-Vuković

paragraded rings. In several articles, she then studied the primary and Jacobson radicals [9, 11, 14], as well as the general theory of radicals [10].

In a joint paper with her student E. Ilić Georgijević [11], they discuss the primary decomposition in the case of general graded modules – moduloids, a generalization of already done work for general graded rings-anneids. These structures, introduced by Marc Krasner are more general than the graded structures of Bourbaki since they do not require associativity, nor commutativity, nor unitarity in the set of grades. After proving the existence and uniqueness of the primary decomposition of moduloids, they briefly turn their attention to Krull's Theorem and the existence of the primary decomposition of Krasner-Vuković paragraded rings.

In paper [12], Prof. M. Vuković and E. Ilić Georgijević prove the paragraded version of the *Wedderburn-Artin Theorem*. Following the methods known from the abstract case, they first prove the Density Theorem and observe the matrix rings whose entries are from a paragraded ring. However, in order to arrive to the desired structure theorem, they introduce the notion of a Jacobson radical of a paragraded ring and prove some properties that are analogs of the abstract case. In the process, they study the faithful and irreducible paragraded modules over noncommutative paragraded rings and prove the paragraded version of the well-known Schur's Lemma.

In paper [13], Prof. Mirjana started with a short historical development of graduation which begins with Krasner's famous notion of a corpoid, introduced in the 1940s and general graded groups in Krasner's sense, which are more general than Bourbaki's. Also, she presented some results from the theory of Krasner-Vuković's para- and extra-graded groups including examples of paragraduations which are and which are not graduations, and some proofs of statements that were not given earlier, and finally provided the missing step in the proof of the result.

In paper [14], Prof. Vuković studied paragraded modules over noncommutative paragraded rings and, as a main result, proved the paragraded version of Schur's Lemma.

Her paper [15] is concerned with the theory of paragraded rings, which begins with a series of Krasner and Vuković's notes in Proceedings of the Japan Academy, which first appeared in the late 1980s. Prof. Vuković presented prime and Jacobson radicals, discussed the general Kurosh-Amitsur theory of radicals of paragraded rings, established that the theorem of Anderson, Divinsky, and Sulinski holds for paragraded rings, and characterized paragraded normal radicals. She also proved that all special paragraded radicals of paragraded rings can be described by appropriate classes of their graded modules.

Paper [16] by Prof. Vuković begins with a note about Aleksander V. Mikhalev and a short introduction to some historical facts about graded structures that are old and new by M. Krasner. Later, she gave a panoramic view of more general Krasner's graded groups, introduced Krasner-Vuković's paragraded groups, and concluded with some results in the theory of paragraded groups.

The aim of paper [17] was to introduce two versions of paragraded Brown-McCoy radicals, the Brown-McCoy radical and the large Brown-McCoy radical of paragraded rings, and then, using inspiration from Halberstadt's results on Jacobson radicals of graded rings, to prove that the large Brown-McCoy radical of paragraded rings coincides

with the largest homogeneous ideal contained in the classical Brown-McCoy radical ring.

Although her scientific work is primarily focused on fundamental and theoretical research in the aforementioned fields of analysis and algebra, it is also important to highlight her contribution to the field of applied mathematics. Together with R. C. Hrosik, M. Tuba, and M. Pikula, she published three papers in 2014 on facial recognition using neural networks.

2.2. **Other publications**

Prof. Mirjana is the author of more than 10 books and university textbooks. However, among them, the following stand out specifically —chronologically: *Differential Equations* 1 [23] and *Differential Equations* 2 [24], *Group Theory and Representations with Applications in Physics* [18], *Algebra I – Group Theory* (An Overview of the Theory and Problems) [19] (co-authored with Acad. V. Perić), and her most recent work, *Mathematicians – Academicians* [21].

The books (textbooks) Differential Equations 1 & 2 – Theory and Problems cover a wide range of carefully selected problems with detailed solutions in ordinary differential equations, systems of differential equations, partial differential equations, and equations of mathematical physics.

These books are based on many years of Prof. Mirjana's experience in teaching the courses Differential Equations and Analysis 3 to Mathematics students at the Department of Mathematics, University of Sarajevo. Most of the problems included in these books she set in written examinations in the courses Differential Equations and Analysis 3, during 1972-79 when she was an assistant to Academician Fikret Vajzović. Apart from these, she has included a certain number of challenging problems earlier set by her professors and academicians: Mahmut Bajraktarević in examinations in the course Differential Equations for undergraduate students of mathematics, and Manojlo Maravić in the course Equation of Mathematical Physics for postgraduates students of different technical faculties.

As a result of Prof. Mirjana's extensive experience in teaching the course Introduction to Mathematics at the Department of Physics, where group theory and the theory of representations of finite groups were taught, the book (textbook) Group Theory and Representations with Applications in Physics [18] was created. This book is also directly related to her long-standing scientific work in the field of abstract algebra. It provides an excellent presentation of group theory and its applications, especially in physics. *"It should certainly be emphasized that, in the presentation and selection of material, the author's solid mathematical background was usefully complemented by her remarkable education in the field of physics,"* and that *"this textbook will happily fill a gap in the textbook literature in South Slavic languages, particularly in the area related to the theory of group representations and the theory of continuous groups."* (From the review by Academician Veselin Perić).

Also, as a culmination of the long-standing teaching experience of Academician Mirjana Vuković and Academician Veselin Perić in various algebra courses, at both under-

graduate and postgraduate levels, at the Department of Mathematics of the Faculty of Natural Sciences and Mathematics of the University of Sarajevo, and the Department of Mathematics and Computer Science of the Faculty of Philosophy of the University of East Sarajevo, a very high-quality book was created: *Algebra I – Group Theory (Overview of Theory and Problems)* [19]. As indicated by the title, the book is divided into two parts: a theoretical part and a part with problems, each consisting of five chapters. M. Džamonja, as a reviewer, wrote the following about this book: *"The theoretical part of the book reminds me of the legendary book Algebra 1 by Prof. Perić, which served as the main textbook for generations of mathematicians at the Faculty of Natural Sciences and Mathematics in Sarajevo and beyond."* By the way, the theory was written by M. Vuković.

Thus, this manuscript represents an ideal combination of an excellently executed theoretical section and an incredibly abundant and interesting selection of solved problems, making it a complete, useful, and engaging book that can be used both as a textbook and as a valuable addition to any bibliography.

One special book, of a slightly different nature than the previous ones, is Mathematicians – Academicians [21], in which Prof. Mirjana subtly writes about the academicians - her professors: Mahmut Bajraktarević, Manojlo Maravić, Branislav Martić, Veselin Perić, and Fikret Vajzović, but also about professors Vera Šnajder and Šefkija Raljević, who all made significant contributions to the development of mathematics in Bosnia and Herzegovina. In the introduction to the book, the author, Prof. Mirjana, wrote: "The goal of this book was not only to better familiarize the public with and rescue from oblivion the Bosnian-Herzegovinian mathematicians who became the first members of the Academy of Sciences and Arts of Bosnia and Herzegovina, but also, at the same time, to present in a certain manner the history of Bosnian-Herzegovinian mathematics through their stories." The reviewer of the book, Academician Dejan Milošević, emphasized the following: *"The main, third chapter, forms the backbone of the book. By skillfully combining biographical data, personal memories, and a knowledgeable description of academicians' scientific contribution, the author, academician Mirjana Vuković, has created a work of special significance, one which will be read with pleasure even by those for whom mathematics is not the main preoccupation in life. And it was precisely the extremely broad knowledge of mathematics, which the author of this book chose as her life path, that enabled academician Mirjana Vuković to write expertly about the various areas of mathematics that these academicians dealt with."*

Thus, Prof. Mirjana, alongside providing biographical data, highlighted the scientific activities of each of the academicians she wrote about in this book, thereby contributing to the history of mathematics in this region [20], [21].

Additionally, Prof. Mirjana has participated as the principal researcher or project leader in around twenty scientific research projects, including four international ones: two in the Central European Research Support Scheme, and, during her time as a visiting professor in Grenoble and Maribor, co-leader of the French project "Paragraded Structures and their Applications to Non-archimedian Analysis" at the Joseph Fourier Institute in Grenoble (with Prof. A. Panchishkin) and the project "Connections be-

tween Krasner-Vuković paragraded structures (groups, rings, modules) and Lie superalgebras" in Maribor (with Prof. D. Pagon), which were funded by the Rhône Alpes TEMPRA-PECO region (2001), i.e. from the funds of the JoinEU-SEE - ERASMUS Mundus Project Partnership (2013). This latter project aimed to connect the results of two magnificent algebraic schools: the French school of algebra on one side and the Russian—Moscow school on the other.

Thanks to her new theory and interest in the unknown and still insufficiently researched paragraded structures, M. Vuković has been invited to numerous important conferences and symposia.

Thus, by invitation, she spent a month at the renowned *"Fields Institute"* (ICRA X, Toronto, 2002, Canada) and gave lectures at numerous other prestigious European universities, such as: *"Charles University"* (Prague, 1999), *"Joseph Fourier"* University (Grenoble, 2000 and 2001), *"Johannes Kepler"* University (Linz, 2001), and participated with a paper or poster at all post-war world congresses up to 2012. She also took part in the *"Third Croatian Congress of Mathematicians"* in Split (2004); the Mathematical Institute of the Serbian Academy of Sciences and Arts (*Mathematical Colloquium*, Belgrade, 2009); the *"International Algebra Conference dedicated to the 100th anniversary of the birth of the great mathematician A. G. Kurosh and the 250th anniversary of Moscow State University – Lomonosov,"* as well as at the conferences: *Международная конференция "Современные проблемы математики механики и их приложений"* (Moscow, 2009) and *Международный алгебраический симпозиум посвящен 80-летию Кафедры высшей алгебры Механико-математического факультета МГУ и 70-летию профессора А.В. Михалева* (Moscow, 2010), etc.

3. Awards and Recognitions

Prof. Vuković has received numerous awards and recognitions for her scientific and overall work. Some of these include: the highest Republic Award *"Veselin Masleša"* (1987) for scientific work in the field of mathematics; the *Memorial Plaque of the City of Sarajevo* on the occasion of the 40th anniversary of its liberation (1985); the *Order of Labor with a Silver Wreath* from the presidency of former Yugoslavia (1987); the *Charter on the occasion of the 50th anniversary of the founding of the University of Sarajevo* (1999), etc.

4. Happy Jubilee, Professor Mirjana!

Finally, it is important to highlight the human side of Prof. Mirjana. As her student and collaborator for the past ten years, I can say that Prof. Mirjana is a kind person, an outstanding intellectual, and especially a mathematician with all her being. She has dedicated her whole life to mathematics and often proudly emphasizes how much she loves it. In recent years, we have witnessed her enthusiasm as she strives, as the editor-in-chief of the scientific journal Sarajevo Journal of Mathematics, published by the Department of Natural Sciences and Mathematics of ANUBiH, not only to keep it alive but to elevate it to the highest possible level.

I must also point out that she is always ready to help others whenever she can. I still remember with gratitude how she helped me to obtain literature for an exam during my postgraduate studies, especially when it was very difficult to find appropriate literature at the time. But she also helped many other math students and was always willing to assist anyone in need. On behalf of generations of her students, on behalf of generations of mathematicians, dear Professor Mirjana, thank you so much.

And especially, I congratulate our dear Professor Mirjana on this jubilee, wishing her many more years of health, happiness, and success in all areas, particularly in mathematics.

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