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OBITUARY: GENNADY ALEKSEEVICH LEONOV (1947-2018)

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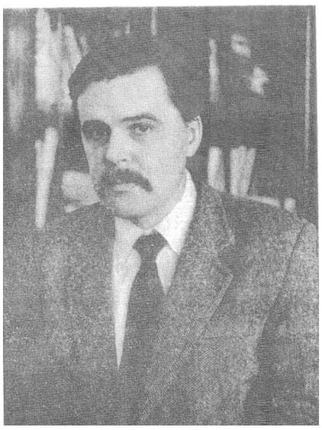
Abstract

The paper is written in memoriam of G. A. Leonov – the founding member of the *Open Mathematical Education Notes* Editorial Advisory Board, Dean (1988-2018) of the Faculty of Mathematics and Mechanics of St. Petersburg State University, the author/co-author of 20 books and more than 500 articles. The most important events of his life are considered through the lenses of mathematics education.

Key words: differential equations, control theory, mathematics education.

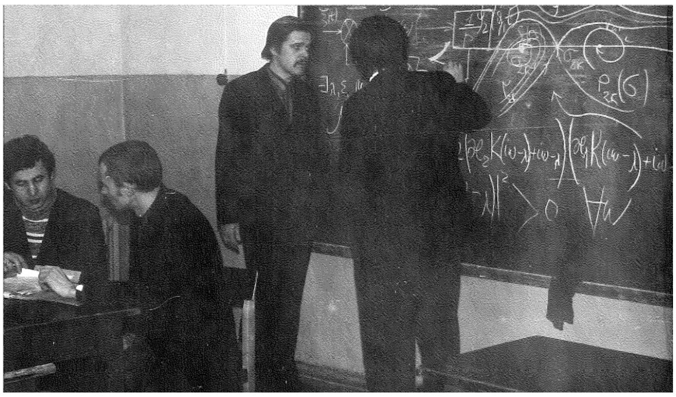
ZDM Subject Classification: **A30, A40, U90**



Gennady Alekseevich Leonov, a founding member of the *Open Mathematical Education Notes* Editorial Advisory Board, passed away on April 23, 2018 after a short battle with a grievous illness. His prolific life of Scholar and Teacher, which tragically ended at the zenith of his indisputable scientific creativity and unparalleled academic leadership, bestowed upon us the remarkable legacy of more 500 publications, 20 monographs, 10 patents along with the record of diligent supervision of five Doctors of Science (a habilitation degree), 16 Doctors of Philosophy

(PhD), and 37 Candidates of Science. Corresponding member of Russian Academy of Sciences, a bearer of many notable awards and well-deserved recognitions, a Council Member of International Federation of Automatic Control (2011-2017), a Foreign Member of the Finnish Academy of Science and Letters, the Highly Cited Mathematician of Russian Federation – the list of Professor Leonov's honors and decorations is too long to be fully presented in this brief obituary.

Gennady Leonov was born in St. Petersburg (then Leningrad) on February 2, 1947 in the family of Antonina Andreevna Leonova, an accountant, and Aleksey Michailovich Leonov, a blue-collar worker. Just as many ambitious youths of his generation, Gennady combined factory work during the day with studies in the evening to allow for a fast track (two vs. three years) graduation from high school followed by highly competitive enrollment (1964) into the cohort of mathematics students at the Mathematics and Mechanics Faculty of Leningrad State University, the very place he would later be Dean for 30 years (1988-2018). In 1969, Gennady began his post-graduate studies (aspirantura in Russian) within the scientific group of V. A. Yakubovich [1] at the V. I. Smirnov Research Institute of Mathematics and Mechanics of Leningrad State University. In 1971 he defended, ahead-of-schedule, his Candidate of Science dissertation in which a negative answer to a famous in control theory conjecture by Aizerman [3] was given in the most general case. Gennady then joined a newly developed Department of Theoretical Cybernetics (chaired by V. A. Yakubovich) as assistant professor in 1971 and was soon promoted to associate professor. Already by the early 1980s, under the direction of Professor Leonov, ten Candidate of Science dissertations have been defended in which important problems of differential equations and control theory were investigated. In 1983, Gennady Leonov defended the second (Doctor of Science) dissertation titled "Stability in the Whole", something that enabled his appointment as full professor.



Leningrad, 1976. After a seminar, working on a joint paper [2].
Near the board: G. Leonov (left) and Yu. Koryakin. At the desk: S. Abramovich (left) and V. Reitmann.

Gennady Leonov authored/co-authored many books on differential equations and control theory. The first major book *Stability of Stationary Sets in Control Systems with Discontinuous Nonlinearities* (English edition in 2004 by World Scientific [19]), was written jointly with A. Kh. Gelig and V. A. Yakubovich. Leonov's chapter in this book was devoted to the development of mathematical theory of phase-locked loop systems for which only non-rigorous engineering methods of investigation existed. His insightful awareness of mathematical methods as tools of investigation of pivotal real-life problems resulted in the major scientific achievement: as stated in the award citation, for "the development of the theory of phase synchronization in radio engineering and communication" a team of researchers, Gennady Leonov included, was awarded a 1986 State Prize of USSR, the second by the societal prestige and the academic standing award that existed in the Soviet Union.

The significance of Leonov's contribution to such highly recognized research work was indubitably corroborated during the last decade of the 20th century when the systems of phase synchronization suddenly gained the status of tools of vital importance due to their ubiquitous integration into new information systems. In particular, frequency synthesis devices present in every modern computer are based on such systems of phase synchronization. Phase-locked loops have also been used in the Global Navigation Satellite System (GLONASS) and the Global Positioning System (GPS). The effectiveness and error-free functioning of such systems would not be possible without designers' utilization of rigorous mathematical methods developed by Gennady Leonov.

On the merits of his outstanding research, Professor Leonov had secured a rightful place in the St. Petersburg school of control theory, the eminent leaders of which have been Corresponding Members of Russian Academy of Sciences A. I. Lur'e (1901-1980), V. A. Yakubovich (1926-2012), and V. I. Zubov (1930-2000). He was a member of St. Petersburg regional group of the Russian National Committee of Automatic Control chaired by Academician V. G. Peshehonov. In 2011, upon the recommendation of Academician A. B. Kurzhanski, Chairman of Russian National Committee of Automatic Control, he was elected to the Council of International Federation of Automatic Control and served full two-term limits (2011-2017) there.

Leningrad, 1996. At Yakubovich's residence.
From left to right: G. Leonov, V. Yakubovich, A. Pervozvansky, and A. Fradkov.

Japan, 2012. IFAC Council meeting.
G. Leonov (left), A. Kurzhanski (center), and N. Kuznetsov.

By carrying on and expanding work by V. A. Yakubovich and V. A. Pliss, his major academic forefathers, and, at the same time, drawing on the ideas rooted in the school of A. A. Andronov [4], Professor Leonov was able to establish his own scientific school of control theory, qualitative theory of dynamical systems and their applications in science and engineering. He was instrumental in bringing to fruition his insightful proposal of splitting the study of the problems of cybernetics in two parallel tracks – theoretical cybernetics, dealing mostly with the synthesis and adaptation of new systems, and applied cybernetics, concerned with the rigorous study of the existing systems. As a result, in 2007, in close collaboration with N. V. Kuznetsov, he established a new Department of Applied Cybernetics of which the former became the first academic appointee.

The importance of the applied cybernetics track can be illustrated through the paper by Leonov and Kuznetsov [13] (memorable in a sense that it was submitted for publication two hours before the sudden death of the first author) on the study of flutter suppression in the design of aircraft. The genesis of research on the gravity of the avoidance of flutter – an oscillation often destructive for an aircraft, when the latter absorbs energy from the airstream – can be found in a classic research by Mstislav Keldysh (1911-1978), President of the Soviet Union Academy of Sciences during 1961-1975, who, while being successful in the design of aircraft free from flutter, nonetheless admitted that his applied mathematics research work does not offer a rigorous mathematical proof but, rather, it provides aircraft designers with a number of conclusions based on intuitive considerations. Just as in the case of the systems of phase synchronization, it is by using research tools developed within the Department of Applied Cybernetics chaired by Professor Leonov that a combination of rigorous analytical and reliable numerical methods allowed for a mathematically thorough confirmation of Keldysh's intuitive considerations enabling the avoidance of flutter in aeronautics.

The above-mentioned case of rigorous flutter research (made possible due to the modern methods of investigation, unfortunately not available in Keldysh's era) is just one of many instances demonstrating that Professor Leonov possessed an acute sense of the importance of historical roots in the contemporary study of applied control systems. In his books [5-8, 10, 12, 15-17, 19], he built the state-of-the-art discussion of the behavior of trajectories of dynamical systems on the classic studies of the theory of differential equations by Aleksandr Lyapunov (1857-1918, Russia), James Maxwell (1831-1879, Scotland), Oskar Perron (1880-1975, Germany), Henri Poincare (1854-1912, France), Francesco Tricomi (1897-1978, Italy), Balthasar van der Pol (1889-1959, Holland), Vito Volterra (1860-1940, Italy), Ivan Vyshnegradsky (1832-1895, Russia), Nikolay Zukovsky (1847-1921, Russia) and other scholars. From an educational point of view, such thoughtful attention to historical perspectives in the development of new ideas is extremely important for it demonstrates to students that the modern-day scientific advances would not be possible without taking into consideration the past experience as the psychological foundation of productive thinking.

In 1988, in the spirit of perestroika, Professor Leonov was elected through an open search process to become Dean of Mathematics and Mechanics Faculty, a position he held continuously till the very last day of his life. In the 1990s, during difficult years for Russian science, Professor Leonov was instrumental in preserving rich traditions of scientific achievements of mathematicians, mechanical engineers, and astronomers of the Faculty. At the same time, Professor Leonov was successful being not only the major custodian of celebrated traditions of the St Petersburg University mathematics, but also persevering his own research advancement. As Dean, he paid great attention to the issues of mathematics education at all levels. At the tertiary level, the main pedagogical goal of the formation of the Department of Applied Cybernetics was to connect fundamental mathematics education at the Faculty of Mathematics and Mechanics with the demands of international companies of information technologies (IT) that graduates of the Faculty working in that area have to satisfy. During the era of educational innovations, the preparation of qualified computer programmers is impossible without offering field experience in software engineering. Furthermore, students of mathematics with apprenticeship-like experience working for an IT company have come to possess a high-level appreciation of theoretical courses that deal with the issues of governance of IT projects and the quality of the development of programming products [11].

Such revision of the traditional preparation of mathematicians that connects theory and practice can be described in terms of the modern-day signature pedagogy construct – the "types of teaching that organize the fundamental ways in which future practitioners are educated for their professions" [18, p. 52]. To this end, Professor Leonov drew on the experience of Professor Neittaanmäki of the University of Jyväskylä (Finland) Faculty of Information Technology.

Productive collaboration between St. Petersburg State University and University of Jyväskylä towards the joint preparation of highly qualified workforce for the frontiers of information technology research has been in place for the last ten years and resulted in more than ten successful PhD defenses. As a result, in 2017, the Finnish Academy of Science and Letters elected Professor Leonov as its foreign member, one of only six representatives from the Russian Federation.

Jyväskylä, Finland, 2011. After a PhD defense.
From left to right: N. Kuznetsov, G. Leonov, S. Abramovich, O. Kuznetsova, P. Neittaanmäki.

Jyväskylä, Finland, 2016. A multinational collaboration.
G. Leonov with P. Neittaanmäki (left) and S. Abramovich.

Helsinki, 2017. Professor Leonov, Member of Finnish Academy of Science and Letters.

Professor Leonov had strong belief that advances in the development of mathematical sciences are the result of studying concrete problems. In [6], he advised the learners of control theory that it is the study of concrete control systems that motivated the development of mathematical machinery needed for solving such problems. At the same time, the power of tools developed for solving concrete problems at the level of rigor enabled far-reaching generalizations of those tools to make them applicable to solving a multitude of problems both within and outside mathematics. In [7], he argued that a student is interested in studies and appreciates learning as an intellectual endeavor if he or she is confident in the usefulness of material to be studied. The usefulness implies applicability. That is, Leonov's pedagogical motto was the importance of concrete problems as pedagogical tools in the teaching of mathematics. Furthermore, he demonstrated [7] that experience in the study of concrete systems makes it possible to carry out qualitative analysis of many complex systems without presentation of their formal mathematical models. For example, a dynamical system in which its every subsystem develops with a positive derivative, the effect of instability is subdued. That is, a continuous growth within a system implies stability of the system's functioning. This principle can inform the policy of management – try not demote employees but only promote them. That is, any element of a system that moves only forward is a guarantee of the system's desirable stable behavior. Such a qualitative understanding of the stability of functioning of a dynamical system has important implication for the success of the enterprise of mathematics education: never blame a student for an erroneous answer but instead, turn an incorrect answer into a thinking device keeping in mind that one of the main responsibilities of a mathematics teacher at any educational level is to encourage rather than to suppress a mathematical discourse.

In order for such a discourse to flourish at the pre-college level, Professor Leonov always strived to provide conditions for continuous uplifting of mathematically talented high schoolers, both from urban and rural areas of Russian Federation [9]. Those conditions included the availability of summer camps and, most importantly, a reliable cohort of sponsors financially supporting diverse students' participation in programs offered by the camps. Also, he paid special attention to the work of boarding schools and other already established centers of preparation of youths with interest in STEM disciplines [14].

To conclude, it is with great respect, immense admiration, and profound grief that we celebrate the prolific life of our never-to-be-forgotten Friend, Teacher, and Colleague by acknowledging his intellect, talents, kindness, wisdom and acumen, while expressing confidence that his qualities will serve as a guiding star for anyone with true aspirations to become a productive member of the modern society.

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