Dedication to the Memory of Prof. Nikolai Voitovich

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To work with your soul

Prof. Nikolai Voitovich (1940-2020)

Some independent of him reasons pushed him to leave the IRE and return back to Lviv, where Mykola Mykolyayovych (shortly M. M. - it is how he was addressed in Ukraine, or Nik Nik as his teacher Prof. Katsenelenbaum lovingly called him) was employed by the Physico-Mechanical Institute (PMI) as a senior scientist. Several years later, he received the position of the Head of Programming Department at the Computing Centre at the newly reorganized institute, now titled the Institute for Applied Problems of Mechanics and Mathematics (IAPMM). During all these years, his scientific and friendly contacts with Prof. Katsenelenbaum were continued.

M. M. has received his Doctor of Science Degree in radiophysics from the Kharkiv State University, in 1982. His D.Sc. contribution “Investigation of high-quality resonators and dielectric waveguides by means of generalized eigenvalue problems” was considerable complement to the well-known
generalized method of eigenoscillations (GMEO), which is successfully applied to solving the series of internal and external problems of electrodynamics. In 1991, M. M. has received the Professor academic title from the IAPMM.

II. PROF. VOITOVICH – CO-ORGANIZER OF THE DIPED SEMINAR/WORKSHOP AND THE FIRST IEEE CHAPTER IN UKRAINE

Prof. Voitovich paid considerable attention to organization of international scientific cooperation. Starting at 1982, the well-known scientific forum in the field of high frequency electrodynamics with participants from Georgia, Poland, Russia, and Ukraine, was established. This event was started as a form of scientific cooperation between the Institute of Radioengineering and Electronics, Academy of Sciences of USSR (Moscow), Tbilisi State University, Tbilisi, Georgia, and IAPMM, Lviv, Ukraine. The initiator and permanent leader of this meeting was his teacher Prof. B. Z. Katsenelenbaum. He was the head of this forum whereas Prof. Voitovich can be considered as its heart. Thanks to his enthusiasms, the forum got the title “Direct and Inverse Problems of Electromagnetic and Acoustic Wave Theory (DIPED)” and transformed into the annual International Seminar/Workshop.

Until 1990, DIPED was held annually in Lviv and Tbilisi in a turn and it brought together the scientists and engineers from various cities of FSU (Moscow, Tbilisi, Lviv, Kharkiv, Chelyabinsk, Novosibirsk, Saint Petersburg, etc.), as well as from the neighboring countries. The atmosphere of these meetings was characterized by the scientific adherence to principle and uncompromisingness; the novel ideas were discussed and checked by the joint cooperation; the young scientists freely contacted with their more experienced older colleagues and felt themselves comfortable in their company; the humor and goodwill prevailed in relations. At the beginning of 90s the work of the DIPED was temporary interrupted from the non-scientific reasons.

In 1995, owing to the IEEE initiative for involving the scientists of the Eastern Europe and the former SU countries in the worldwide scientific community, and thanks to efforts of Prof. J. Modelski (Warsaw University of Technology, Poland) prominent IEEE volunteer and officer during many years, and to efforts of Prof. Voitovich, the IEEE West Ukraine Joint Chapter was established. It was the first IEEE Chapter in Ukraine and one of the first in the FSU countries; initially, the Chapter joined IEEE Electron Devices and Microwave Theory & Techniques Societies and one year later the IEEE Antennas & Propagation Society. The next development of Chapter was joining the IEEE CPMT (now Electronic Packaging) and SSC Societies in 1997 and 1999, respectively. The first years of being the West Ukraine Chapter was a great and impressive work with Prof. Voitovich serving as the Chapter Chairman. The IEEE Membership was increased to 55 IEEE members; the student group consisting of 25 IEEE student members was supported using the Chapter budget and the IEEE MFSP for low income countries. In 2000, Chapter won the IEEE CPMT 1999 Chapter of the Year Award being the first among the IEEE Chapters from the Eastern Europe and FSU countries earning such recognition. During these years, an effective basis was laid for the development of the Chapter's activity. The Chapter improved its activity in the scientific and technical areas related to the supporting IEEE Societies. The next awards were not long in coming. In 2001, the Chapter was recognized by the 2001 IEEE Region 8 Chapter of the Year; in the second decade of 2000s, the Chapter won the IEEE Antennas and Propagation Society 2017 Outstanding Chapter Award, IEEE Electron Devices 2017 Region 8 Chapter of the Year Award, and IEEE Microwave Theory and Techniques Society 2017 MTT-S Outstanding Chapter Award. The other people served the Chapter as Chapter Chairs, but the role, efforts, and enthusiasms of Prof. Voitovich, permanent honorary Chapter Chairman, were decisive to obtain the above awards.

Prof. Voitovich played a defining role for establishment of the IEEE MTT/ED/AP Georgian Chapter. In those times, Georgia did not have its own IEEE Section, so it took a lot of effort to join the Chapter to the IEEE Ukrainian Section. The first Chapter Chairman of the new established Chapter was Prof. Zaridze, one of the coauthors of this paper. He is very grateful to Prof. Voitovich for the possibility for Georgian scientists-radiophysicists to join the world's leading scientific and technical organization, which is IEEE.

The cooperation with the IEEE helped to renew the DIPED and reconstruct it in the annual joint Seminar/Workshop of both the MTT/ED/AP/EP/SSC West Ukraine and MTT/ED/AP/EMC Georgian Chapters. The DIPED obtained such status in 1995. Since 1997, the DIPED received charter of the IEEE AP, ED, and MTT Societies Technically Co-sponsored event that enables to include the DIPED Proceedings into IEEE Xplore Digital Library. The successful holding all DIPEDs in many aspects indebts to Prof. Voitovich, his enthusiasms, organization efforts, and permanent care.
The scientific results of Prof. Voitovich are very impressive. He is the author of nine monographs, more than 190 papers in the international scientific journals and conference proceedings. His scientific results are well-known in the world scientific community. In 1989, Prof. Voitovich together with his teacher, Prof. Katsenelenbaum and other authors of the GEMEO were recognized by the Ukrainian State Award in the Area of Science and Technique for the series of scientific papers “The Theory of Resonant Scattering and its Application in Radiophysics”. The scientific results obtained in the process of developing the GEMEO were summarized in the monograph [1] and in the improved and translated to English monograph [2] several years later.

Among the methods of solving generalized eigenvalue problems that arise in GEMEO, the most promising are the variational methods based on the functionals, which are stationary on the eigenfunctions of these problems. The boundary conditions that contain a spectral parameter must be natural for these functionals. A technique has been developed that allows to modify the functional in such a way that an arbitrarily chosen linear boundary condition (or several of them or even all at once) is natural for it [3], [4]. The contribution of Prof. Voitovich to this area of GEMEO is decisive.

At the same time, the foundations of a new scientific direction in the synthesis theory of radiating systems were laid and it turned out that the GEMEO is especially effective for the investigation of resonator systems, in which the characteristic of radiated field is weakly dependent on excitation. In particular, using GEMEO a method of constructive synthesis of resonator radiating systems was created, which allows to solve directly the inverse problems related to the reconstruction of the body shape, its transparency, and the parameters of internal inclusion according to a given scattering pattern, without solving the direct problems [5] – [9].

One of the computational problems, which are directly related to GEMEO, is solving the spectral problems, the eigenvalues of which are closely grouped modulo near the first (largest) of them. For this purpose, a special modified iterative method of finding eigenvalues (eigenvalues and eigenfunctions) of homogeneous problems with a completely continuous operator was developed, focused mainly on problems of this type. The method consists in sequential iteration by the operator of some initial function and simultaneous processing at each step the results of all previous iterations [10].

The second direction of Prof. Voitovich's activity, initiated in his joint works with Prof. Katsenelenbaum, is also gaining intensive development in Lviv. These are the so-called optimization problems with a free phase. This direction covers variational problems of the approximation type, in which the complex function to be approximated is given only by its modulus (amplitude), and its argument (phase) remains arbitrary [11] – [13]. In many applications, where such problems arise, the use of the freedom of choice of the phase of approximated function allows to approach its amplitude much better. Mathematically, these problems are close to the so-called phase problem, in which the modulus of the Fourier transform image is given on the entire real axis, it is necessary to reproduce its prototype [14]. Given this proximity, the corresponding optimization problems are called the modified phase problem (MPP).

In mathematical sense, such problems are reduced to nonlinear integral equations of the Hammerstein type, in which the modulus and the argument of unknown function appear separately. A method for investigation of the branching solutions of these problems has been developed, numerical methods for their solution have been elaborated, and new physical effects in specific applications have been identified [15] – [18]. The results of theoretical research in this direction are partially summarized in monographs [19], [20].

A variational-iterative method of the generalized separation of variables was proposed and developed, designed for approximate solution of n-dimensional linear and nonlinear equations (primarily integral or matrix). It consists of representing the desired function in the form of a finite-dimensional sum of terms with separated variables [21]. The terms in sum are determined sequentially, provided that the corresponding functional is minimized. To determine the next term in sum we obtain at each step a system of $n$ one-dimensional nonlinear equations (integral or algebraic) with respect to $n$ unknown functions of one variable (or $n$ vectors). Numerical experiments have shown a rapid convergence of the method: as a rule, sufficient accuracy for practice can be obtained in 4-5 steps [22] – [24].

The variational approach applied successfully to solving the synthesis problem was extended also on the modeling the multi-element quasioptical systems. Such systems can be used for two goals: either as an antenna in the antenna-rectenna transmission line or as linear antenna array creating the field
with the radiation pattern of desired structure. The results related to this area were published in [25] – [27].

A class of Hammerstein-type equations is identified, which covers specific cases of MPP’s equations related to integral Fourier transforms (integral and discrete) and Hankel, the solutions of which are expressed through polynomials of finite powers with complex roots [28]. This allowed to develop a method of analytical and numerical investigation of the set of solutions of these equations and to describe its structure, including all possible types of branching of these solutions. The results of many years of this research were presented in papers [29] – [33] and summarized in the monograph [20].

In recent years, Prof. Voitovich and his colleagues developed a new scientific direction related to the creating the methods for solving non-classical inverse scattering problems, which concern to reconstruction of the bodies’ shape. The beginnings of this approach were laid back in the works published in the early 90s of the last century [34] – [36].

At the beginning of the 2000s, this approach was supplemented by the use of a non-orthogonal set of Herglotz functions and modified for the case of solving the problems of forming anti-radar coatings [37] – [39].

This method uses the approximating Herglotz functions for reconstruction of the body shape at the eigenfrequencies of its inner domain, and it is based on the properties of the set of scattering characteristics (diagrams) at the eigenfrequencies of the body inner domain. If the field of eigenscillation of this domain is analytically extended into the outer domain by a function without singularities, which diminishes at infinity, then the specified set is incomplete. The orthogonal complement function to this set, which exists in this case, is the kernel of Herglotz function, for which the surface of the body is one of its zero surfaces. Otherwise, the field of eigenscillation within the region can be approximated by the sequence of Herglotz functions in the metric of the corresponding Sobolev space. The recent results related to this topic were published in [40] – [44].

Prof. Voitovich extensively focused his attention on scientific growth of young scientists. Having been employed at the IAPMM in the position of the head of the Department of Numerical Methods in Mathematical Physics, he organized the scientific school in the field of the antenna synthesis theory, nonlinear integral equations, and non-classical inverse problems of electrodynamics.

Nine Ph.D. and two Doctors of Science are among his progeny. In the recent time, the novel research directions in the field of the optimization problems with free phase have been intensively developed under the leadership of Prof. Voitovich. These directions unify the variational problems of approximation type. The novel scientific results in this area were published in the monograph [20]. As Prof. Katsenelenbaum, his teacher, said: “Nik Nik has many followers”, and this fact is not only due to his scientific potential, but also his humanity, that denotes his high intelligence.

IV. INSTEAD OF CONCLUSION

Such was M. M. in his scientific achievements and positions. One wants to say a few words about his human qualities. M. M.’s favorite saying, which he frequently told to his colleagues and which first of all describes his own style of work, was: “To work with your soul”. This phrase is the epigraph to this article, because it most fully characterizes the spiritual essence of M. M. He not only worked with his soul. He lived, always listening to his conscience and the impulse of his soul.

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