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PERSONALIA

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In memory of Mikhail Izrailevich Rabinovich

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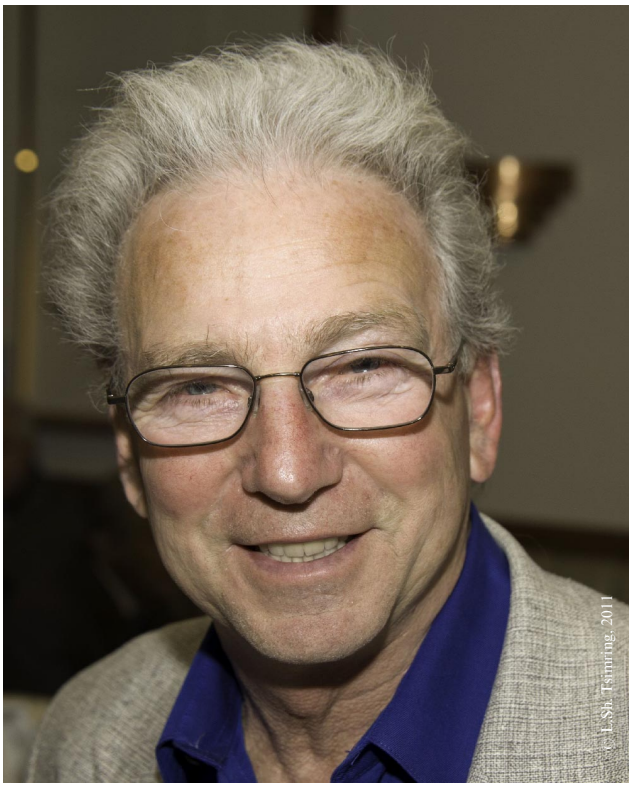
The outstanding physicist, corresponding member of the Russian Academy of Sciences (RAS), doctor of physical and mathematical sciences Mikhail Izrailevich Rabinovich passed away on March 31, 2025 at the age of 83. He was a member of the world-recognized scientific school on the theory of nonlinear oscillations founded in 1930–1950 by academician A.A. Andronov at N.I. Lobachevsky Gorky State University (GSU) and was one of its most prominent representatives.

M.I. Rabinovich (M.I.R.) was born on April 20, 1941 in the city of Gorky into the family of chemistry professor Izrail Veniaminovich Rabinovich. In 1962, immediately after graduation from the GSU Department of Radiophysics, M.I.R. began his scientific work and teaching at the Department of the Theory of Oscillations and Self-Regulation. In 1967, he defended his candidate thesis, "Self-oscillations of distributed systems." In a series of subsequent studies, which constituted the basis of his doctoral thesis, "Wave interaction in nonlinear dissipative and nonequilibrium media" (1974), M.I.R. laid the foundation of a new discipline — the physics of self-oscillating and autowave processes in distributed nonlinear nonequilibrium media. Many phenomena and effects theoretically predicted and studied by him, namely, stationary autowaves, explosive instability, mode competition, and localized autowave excitations, were later realized experimentally.

From the moment of organization in Gorky of the Institute of Applied Physics (IAP) of the USSR Academy of Sciences (1977), M.I.R. began working at the new institute, where he headed the sector of nonlinear dynamics, and where a group of gifted students and colleagues quickly formed around him. This period of M.I.R.'s scientific biography coincided with intensification of research around the world in the field of dynamic chaos, in which he is rightfully considered to be one of the pioneers. The "Rabinovich system" and the "Rabinovich–Fabrikant system," the results on chaotic solitons, the formation and dynamics of structures in nonequilibrium media, and the development of electronic generators of chaotic oscillations received wide recognition. He investigated multidimensional chaos in discrete systems — distributed chains of coupled oscillators. The methods of analysis developed here were then extended to the description of complex dynamics in continuous media. In particular, M.I.R. and his co-authors developed and experimentally investigated space-time chaos in a parametrically excitable capillary Faraday ripples and in shear flows. His review, "Stochastic self-oscillations and turbulence," published in the journal *Uspekhi Fizicheskikh Nauk* (*UFN*) in 1978 (English translation in *Sov. Phys. Usp.* **21** 443 (1978)), played an important role in the formation of the paradigm based on the interrelation of the complex behavior of systems with a large number of degrees of freedom (for example, hydrodynamic turbulence) and dynamic chaos. M.I.R. used this material when he prepared a new version of the chapter 'Turbulence' in the VIth volume (*Hydrodynamics*) of the Course of Theoretical Physics by L.D. Landau and E.M. Lifshitz (1986).



Mikhail Izrailevich Rabinovich
(20.04.1941 – 31.03.2025)

In the mid-1980s, M.I.R. considerably developed methods for describing the nonlinear dynamics of nonequilibrium dissipative media on the basis of the idea that they are determined by the interaction of localized nonlinear structures of different kinds (depending on the type of medium and its physical 'organization'), for instance, solitons, spiral waves, and topological defects. At the same time, M.I.R. got involved in the study of synchronization in coupled chaotic systems. His pioneering work in this field led to various applications, in particular, in the development of new approaches to encoding and protecting communication paths through synchronization of chaotic signals.

An extensive series of M.I.R.'s studies on nonlinear dynamics in application to various physical systems and

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Mikhail Izrailevich Rabinovich (from left to right): giving a talk at conference devoted to his 70th birthday at the University of California, San Diego (2011); in his home office (2015); with a book of his poems at home (2015). Photos by L.Sh. Tsimring

phenomena became widely known in our country and abroad. In 1991, M.I.R. was elected a corresponding member of the RAS.

Working intensely in science, M.I.R. never cut his deep ties with his *alma mater*. For many students in the Radiophysical Department of GSU in the 1970–1980s, the course on the theory of oscillations and waves delivered by Professor M.I. Rabinovich remained in their memory as one of the most brilliant, that organized their 'coordinate system' of radiophysical education. These lectures made up the basis of the well-known textbook, *Introduction to the theory of oscillations and waves*, written by M.I.R. in co-authorship with his colleague and friend Professor D.I. Trubetskov from Saratov State University (the Russian edition appeared in 1984 and the English translation in 1989).

We must mention M.I.R.'s considerable contribution to the organization and success of Gorky schools on nonlinear waves. The first such school was held in 1972, and then they regularly took place every odd year until 1989. In those heady 'nonlinear' years, the language of nonlinear oscillatory wave processes extended to various fields of physics and related sciences very quickly, and therefore the idea of academician Gaponov-Grekhov concerning the organization of such schools turned out to be compelling, for they acquired an interdisciplinary character and widespread popularity. Suffice it to say that at these schools most prominent physicists and mathematicians of that time delivered lectures for young scientists and students. M.I.R. invariably remained the 'engine' of these schools and, together with Gaponov-Grekhov, was a scientific editor of the many volumes of collected papers based on those lectures and published by Nauka Publishers. The traditions of those Gorky Schools are kept to this day: since 2000, Schools on Nonlinear Waves have been regularly organized by the IAP RAS, the 21st School was successfully held in 2024. Over the years, the lecture program has become wider in terms of topics and geography of participants, and leading scientists continue to take part in its work.

At the turn of the 1980s–1990s, with the opening of the 'iron curtain,' M.I.R. quickly established contacts with many foreign colleagues. In the mid-1990s, he was invited to work at the Institute for Nonlinear Science at the University of California in San Diego, where he initiated work on the study of the dynamic properties of neuron systems. M.I.R. started a new significant stage in his scientific biography. In close collaboration with neurobiologists, M.I.R. began to study nonlinear phenomena in relatively small neuron ensembles, for instance, those responsible for generating biological rhythms. He made significant progress in understanding the role of fundamental nonlinear phenomena (dynamic chaos, structure formation, and synchronization) in the behavior of such systems.

Using numerous experimental data, including those obtained *in vitro* in specially synthesized neuron ensembles, models were constructed describing neuron activity patterns, and on their basis electronic devices were designed that reproduced this process. Gradually, M.I.R. moved on to describing the space-time dynamics of large neuron ensembles based on the concept he proposed, according to which the competitive dynamics of neuron networks follow the principle of 'winnerless competition,' i.e., a competition without a global winner. The mathematical representation of this concept is a stable heteroclinic channel in the phase space of the system connecting its numerous saddle equilibrium states. Developing a new apparatus, M.I.R. applied it to the description of cognitive activity of the human brain and formulated a nonlinear-dynamic model of interaction of cognitive and emotional functions in the course of generating new knowledge in the form of a multimodal competitive interaction of basic brain neuronets (cognitive modes) acting in parallel, but without global dominance of one of them.

M.I.R. presented the general framework of the 'mathematics of thinking' based on this approach in a 2021 *Usp. Fiz. Nauk* review (English translation *Phys. Usp.* **64** 801 (2021)). M.I.R.'s pioneering ideas in this field are being developed nowadays by his students and successors.

In the mid-1990s, hard times for Russian science and scientists, M.I.R. established a scientific foundation called International Center — Foundation for Promising Research in Nizhny Novgorod. The aim of the foundation was to support young scientists through their participation in implementation of projects with international collaboration. The key requirement for the projects selected through competitions was that they be carried out jointly with leading world specialists and directly in laboratories of Nizhny Novgorod institutes of the RAS. The center worked successfully up to the early 2000s with parity funding from the Open Society Institute, the Administration of Nizhny Novgorod

region, and the Ministry of Industry and Science. Its activity was a unique experience in supporting science in Russia in those years.

M.I.R. had a gift for foreseeing the future, which allowed him to quickly notice the emergence of new promising areas in the field of nonlinear sciences. M.I.R.'s passion for new problems invariably attracted many colleagues, both young and experienced, with whom he generously shared interesting unsolved problems and fresh ideas.

M.I.R.'s interests were never limited to science alone. He was an athlete, and, in his youth, participated in various interuniversity ski competitions. Later on, M.I.R. became seriously interested in poetry, and nine of his poetic collections were published. In his poetry, as in science, he had an original viewpoint and a desire to 'get to the very essence.'

With the passing of M.I. Rabinovich, Russian and world science has lost a brilliant physicist and a versatile, deeply optimistic, and always benevolent person. Friends and colleagues express their sincere condolences to the relatives of Mikhail Izrailevich. The blessed memory of him will always remain with us.

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