Robert Adol'Fovich Minlos (28 February 1931–9 January 2018)

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On 9 January 2018, the eminent mathematician Professor Robert Adol'fovich Minlos passed away. A renowned researcher and outstanding teacher, he was a expert in the area of functional analysis, probability theory, and contemporary mathematical physics.

Minlos was born on 28 February 1931 into a family of humanists. His father, Adol'f Davidovich Miller, was a professor at the Institute of Oriental Studies, and his mother, Nora Romanovna (Robertovna) Minlos, was a historian–ethnographer. Her brother, Bruno Robertovich Minlos, Candidate of Historical Sciences, was a specialist in the history of Spain. This is perhaps why Robert Adol'fovich loved poetry, wrote verses himself, was an avid theater-goer from his school years, and was seriously occupied with painting after the age of 40.

Nothing foreshadowed a mathematical future, but when he was 15, young Robert accidentally saw a poster about the Moscow Mathematical Olympiad for schoolchildren. Participating in it, he received the Second Prize and, inspired, began to attend the school club led by E. B. Dynkin. Already having entered the

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School of Mechanics and Mathematics of Moscow State University in 1949, he continued to participate in Dynkin's seminar, which together with A. S. Kronrod, had a great influence on Minlos as an undergraduate.

He prepared his first scientific paper (course work) in 1950 while participating in the Moscow State University seminar on the theory of functions of a real variable under the leadership of Kronrod. But the real scientific interests of the young mathematics student began to form after he became acquainted with I. M. Gelfand. Their joint publication "Solution of the equations of quantum fields" (*Doklady Akad. Nauk SSSR*, n.s., **97**, 209–212, 1954) became Minlos's diploma thesis. It was devoted to the functional integral, which has a direct relation to quantum physics. As Minlos himself admitted: "My further life in mathematics was predetermined by this work because I was subsequently mainly occupied with mathematical physics. There were, nevertheless, more works on random processes, on measure theory, and on functional analysis."

One such paper, "Extension of a generalized random process to a completely additive measure" (*Doklady Akad. Nauk SSSR*, **119**, 439–442, 1958) brought Minlos worldwide fame. It became the basis of his candidate's dissertation "Generalized random processes and their extension to a measure," which was published in *Trudy MMO*, **8**, 497–518, 1959. This result, important for the theory of random processes and functional analysis, is now known as the Minlos theorem on the extension of cylindrical measures to Radon measures on the continuous dual of a nuclear space.

Minlos's contact with mathematical physics at that time was expressed in writing (jointly with Gelfand and Z. Ya. Shapiro) the monograph *Representations of the Rotation and Lorentz Groups and Their Applications* (Pergamon, London, 1964, translation of the 1958 Russian edition). It was published in 1958, when the need for physicists to understand representation theory was motivated by the discovery of symmetries of elementary particles and also their spin and relativism.

From 1956 to 1992, Minlos worked in the Department of the Theory of Functions and Functional Analysis in the School of Mechanics and Mathematics of Moscow State University. In that period, there was a need to organize a joint seminar with F. A. Berezin, primarily to discuss the mathematical problems of quantum mechanics and field theory.

But the real surge in activity in the School of Mechanics and Mathematics at Moscow State University in the field of mathematical physics was connected with the organization by Minlos and R. L. Dobrushin of a seminar on statistical physics in 1962. It soon became widely known in the Soviet Union and abroad as the Dobrushin–Malyshev–Minlos–Sinai seminar. The topic of the quantum aspects of statistical mechanics at the seminar was primarily associated with Minlos. The seminar lasted until 1994 and had a huge impact on all modern mathematical physics.

The early 1960s were extremely fruitful for Minlos. In the first place, this concerns new results obtained jointly with L. D. Faddeev in the quantum mechanics of three particles (1961). There followed further work devoted to studying the thermodynamic limit in classical statistical physics (1967). Minlos obtained the first rigorous mathematical definition of the limit Gibbs distribution for an infinite system of interacting classical particles and also analyzed the properties of this distribution (*Funct. Anal. Appl.*, **1**, 140–150 and 206–217, 1967). This result anticipated the appearance of the concept of the Gibbs state in the sense of Dobrushin–Lanford–Ruelle (1968).

The discovery (together with Sinai) of the phenomenon of phase separation in lattice systems at low temperatures (*Math. USSR-Sb.*, **2**, 335–395, 1967; *Trudy MMO*, **17**, 213–242, 1967 and **19**, 113–178, 1968) was a fundamental result in the mathematical theory of phase transitions. This result was the basis of Minlos's doctoral dissertation, which he defended in 1968.

Another joint work with Sinai (*Theor. Math. Phys.*, **2**, 167–176, 1970) laid the foundation for a new approach to the study of the spectral properties of many-particle systems. In combination with cluster expansions, this approach has made significant progress in describing the properties of these systems, including the spectrum of elementary particles of quantum fields and the mathematical description of the

quasiparticle picture in statistical physics. The results of a large series of collaborative works in this direction by Minlos, Malyshev, and their students were summarized in two monographs, *Gibbs Random Fields*: *Cluster Expansions* (Springer, 1991, translation of the 1985 Russian edition) and *Linear Infinite-Particle Operators* (Amer. Math. Soc., 1995, translation of the 1994 Russian edition).

A peculiarity of the Dobrushin–Malyshev–Minlos–Sinai seminar was not only its duration (amazing foreign guests) and the assertive directness in communicating with the lecturer but also the opportunity to "get" an interesting problem to be solved. In essence, the seminar worked as a "machine" generating questions and possible ways to convert them into answers. Minlos was always one of the sources of interesting questions and problems. For example, projects thus originated related to the quantum three-particle problem, cluster expansions, Gibbs semigroups, and many others.

Minlos was a wonderful teacher, a patient and wise mentor. Directness, accessibility, and enthusiasm attracted numerous students and followers to him. In this regard, the range of problems connected with the theory of operators and quantum physics should be especially noted. This theme began in the joint work with Gelfand and was since then traditionally in the focus of Minlos's attention until recently (see "A system of three quantum particles with point-like interactions," *Russian Math. Surveys*, **69**, 539–564, 2014). Some of the results were published in the journal *Theoretical and Mathematical Physics*.

Minlos was notable for his figurative Russian language and good wit, often with subtle mathematical humor. Once in a conversation with Dobrushin at one of the Vilnius Conferences on Probability Theory, he doubted that "the life of a Soviet man is *complete* with respect to the *norm* of the anti-alcohol campaign," which was on-going at that time in the country. Since then, this allusion to the completeness of life and the normed spaces has entered the folklore of the mathematical community.

Always surrounded by relatives and intimates, and also by his loving students, colleagues, and friends, Robert Adol'fovich Minlos lived a complete life. And in each of those who knew him, he left a bright drop of memory of himself.

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