

PERSONALIA

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In memory of Valery Anatol'evich Rubakov

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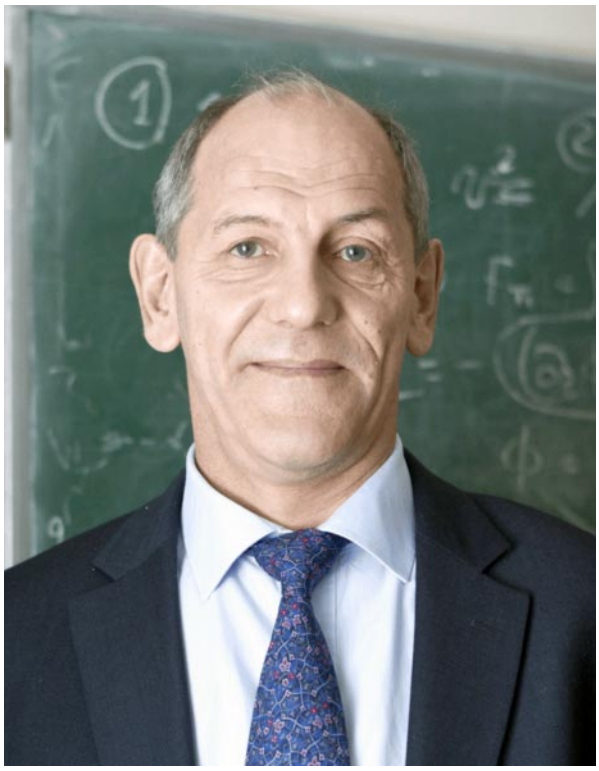
One of the most famous contemporary Russian scientists, academician of the Russian Academy of Sciences Valery Anatol'evich Rubakov, died suddenly on October 19, 2022. He was 67 years old.

V A Rubakov was a world-famous theoretical physicist, a chief researcher in the Department of Theoretical Physics of the Institute for Nuclear Research of the Russian Academy of Scientists (INR RAS), head of the Department of Particle Physics and Cosmology of the Physics Faculty of M V Lomonosov Moscow State University (MSU), head of the Nuclear Physics Section of the Physical Science Division (PSD) RAS. His studies concerned quantum field theory, elementary particle physics, and cosmology and received numerous Russian and foreign prizes, including a Gold Medal with the Prize for Young Scientists of the USSR Academy of Sciences, the A A Friedman, M A Markov, I Ya Pomeranchuk, H D Jensen, J Wess, N N Bogoliubov Prizes, the 1st degree M V Lomonosov and Solvay International Chairs in Physics Prize, the Demidov Prize, and the Hamburg Prize for contributions to the development of theoretical physics.

V A Rubakov's entire creative path after graduation from the Physical Department of MSU in 1978 was related to the Institute for Nuclear Research RAS. INR RAS is known all over the world as the institute where Rubakov works. His scientific school was born and matured there, and his most famous scientific results were obtained there. They relate to the development and application of nonperturbative methods of quantum field theory; the theory of the early Universe, including before the Big Bang; the search for an explanation of matter-antimatter symmetry breaking in the Universe; the origin of highest-energy cosmic particles; and the possible existence of additional spatial dimensions. The ideas suggested by Valery Anatol'evich were developed in thousands of papers by theoreticians and experimentalists throughout the whole world.

In the early 1980s, V A Rubakov and M E Shaposhnikov proposed the concept which later became known as the 'brane world.' Such an approach suggests the existence of infinite additional spatial dimensions only observable at high energies. At low energies, observed particles are localized on a three-dimensional submanifold called a brane, which is our observable world. The brane world conception gained exceptional popularity much later, at the turn of the millennia, when the prospects appeared of solving a number of the problems of the Standard Model of elementary particles in theories with large or infinite extra dimensions. The phenomenological and astrophysical consequences of this conception have been analyzed in thousands of papers, including those by Rubakov and his colleagues.

From the very beginning of his scientific research, V A Rubakov was engaged in the search for and study of physical phenomena in field theory that cannot be examined by traditional methods of perturbation theory and become apparent only in a nonperturbative regime. The probabilities of such processes calculated in perturbation theory are equal to zero, whereas in the complete theory the process is not forbidden. Valery Anatol'evich revealed and investigated many such striking and unexpected events, but he predicted the most well known of them at the age of 26 in one of his first scientific papers, whose path to publication was long and thorny. We are talking about the monopole catalysis of proton decay, a beautiful and experimentally verifiable effect of baryon number nonconservation in the presence of topological solitons, non-Abelian magnetic monopoles, predicted in unification theories. The search for monopoles using this process, although not yet successful, is still included in the scientific programs of the largest neutrino telescopes.



Valery Anatol'evich Rubakov
(16.02.1955–19.10.2022)

One of the most famous of V A Rubakov's works is devoted to the electroweak nonconservation of fermion numbers (1985, jointly with V A Kuzmin and M E Shaposhnikov). It showed that anomalous processes with a variation in baryon and lepton numbers in the early Universe may be very fast. This means that one of the necessary conditions of baryon asymmetry generation is satisfied in the Standard Model without introducing additional particles or interactions. Although further studies have shown that other conditions still require extension of the theory (the presence of baryon asymmetry is today one of the main arguments in favor of the incompleteness of the Standard

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Model), the anomalous processes studied in the above-mentioned classical work underlie or are an integral part of several approaches to the fundamental problem of the matter-antimatter asymmetry in the Universe.

Valery Anatol'evich did many interesting things in the theory of the very early Universe before the Big Bang. In 1982, together with M V Sazhin and A V Veryaskin, he investigated the effect of gravitational waves born in the exponentially expanding Universe on the relic radiation anisotropy. This effect opened up the possibility of observing the development of the Universe at the earliest inflationary stage. Returning to this topic in the last decade, Rubakov became interested in models alternative to inflation and proposed several other mechanisms to explain the observed data concerning the period before the Big Bang with the potential for observational verification. After the discovery of the accelerated expansion of the contemporary Universe, so-called dark energy, V A Rubakov devoted many studies to constructing models with modified gravity, including the formulation of a consistent theory with massive gravitons, which turned out to be a much more difficult task than previously imagined.

A theoretical physicist who sometimes dealt with very abstract topics, V A Rubakov always emphasized the importance of linking the theory to the description of the real world, be it a distant prospect of applying developed methods to a particular difficult problem or the of direct verification or falsification a constructed model through experiments or observations in the foreseeable future. As a consequence, he was well aware of what was going on in modern experimental particle physics and observational astronomy, so that theoreticians went to him and not to experimentalists to discuss the possibility of testing their ideas. The broadest outlook and amazing physical and mathematical intuition allowed him to quickly get involved in the problem, even if he had heard about it for the first time in his life, and suggest an unexpected or beautiful solution, or even find an error in the constructions of his colleagues.

All his life, Valery Anatol'evich made great efforts to raise the next generations of scientists. He created and delivered several advanced author's courses at the Physical Faculty of MSU, first at the Department of Quantum Statistics and Field Theory, and then at the Department of Particle Physics and Cosmology founded with his direct participation. Death awaited him on a trip to Sarov, where he went to give lectures to students. His public lectures on various issues of modern physics were attended and watched in records on the Internet by tens of thousands of those interested in science.

V A Rubakov's books, significantly expanding the material of his lectures, have gone through many editions in different languages around the world. Among them is the textbook on his first author's course, *Classical Gauge Fields*, which opens up the opportunity for third-year students to learn a number of modern sections of field theory before mastering quantum mechanics; the two-volume book *Introduction to the theory of the early Universe*, written together with D S Gorbunov, which not only became the main textbook on cosmology but also contains painstakingly selected applications that can be recommended for studying quite different areas of particle physics; and the recently published two-volume textbook *Theory of groups and symmetries*, written together with A P Isaev.

Rubakov's scientific school includes not only tens of disciples, doctors, and candidates of sciences — his scientific 'children' — but also 'grandchildren' and even 'great grandchildren.' A special approach to the statement of and solution to scientific problems, typical of Rubakov's school, allows solving interesting and complicated problems in different areas of modern science in different countries in the world.

Only a person of enormous stature and tirelessness, such as Valery Anatol'evich, is able to combine the highest-level work and the activity of an outstanding organizer of science. In the difficult years (1981–1994), he was deputy director for research at INR RAS, and it was his efforts that ensured retention of the institute as a world scientific center, the development of the Baikal and Baksan neutrino observatories, laying the foundation for their current success. Until the last days of his life, he remained an informal leader and tireless adviser in many areas of the institute's life. It would not be an exaggeration to say that in many other scientific organizations in the country the current situation would be quite different without his constant efforts. He participated in the work of expert commissions of public and private foundations that support fundamental science and young scientists involved in it; he conducted active educational work and withstood serious battles in the RAS Commission to combat pseudoscience. Until the outbreak of the coronavirus pandemic, every two years he led the organization of the international scientific seminar Quarks, which gained worldwide fame owing to his and his colleagues' efforts. As a member of the RAS Presidium and head of the Section of Nuclear Physics of PSD RAS, he devoted much time and mental strength to this work. The life of the Russian Academy of Sciences will be different without V A Rubakov.

In the last quarter of a century, the contents of the journal *Uspekhi Fizicheskikh Nauk* (*UFN*) have been formed under the significant influence of V A Rubakov, a member of the *UFN* editorial board beginning in 1999, deputy editor-in-chief from 2004, and editor-in-chief from 2016. It is largely thanks to him that the journal exists in its current form, being published in the Russian and English languages, and starting in 1982 he authored brilliant, multifarious, and heavily requested (judging by citations) reviews in *UFN*. He was also a member of the editorial boards of the journals *Teoreticheskaya i matematicheskaya fizika* (*Theoretical and mathematical physics*) and the *International Journal of Modern Physics A*.

Valery Anatol'evich was an outstanding personality. Becoming tough and implacable in the face of lies, acquisitiveness, or incompetence, he was at the same time exceptionally kind and sympathetic and always and in everything helped both near and far. He always fought for the future of science and even in the hardest times sought to design and develop unique scientific installations, which today bring worldwide fame to Russian science. He also defended the rights and the honest name of scientists as one of the founders of the July 1 Club, which defended the Russian Academy of Sciences in 2013.

It is difficult to comprehend the unexpected loss of such a great person. The memory of the prominent scientist and remarkable personality, Valery Anatol'evich Rubakov, will remain with us forever.

V N Gavrin, D S Gorbunov, G V Domogatsky,
L V Kravchuk, M V Libanov, V A Matveev,
O V Rudenko, A M Sergeev, A A Starobinskii,
I I Tkachev, S V Troitsky, I A Shcherbakov