Physics – Uspekhi **58** (2) 202 – 204 (2014)

PERSONALIA

PACS number: **01.60.+q**

Valery Anatol'evich Rubakov (on his 60th birthday)

DOI: 10.3367/UFNe.0185.201502i.0221

16 February 2015 is the 60th birthday of Academician Valery Anatol'evich Rubakov — one of the most prominent Russian physicists, a great teacher, and a popularizer of science. Almost 40 of these 60 years (counting from his first paper in 1976) have been devoted to research work. Over the decades, Rubakov has been among the world's leading experts on quantum field theory, elementary particle physics, and cosmology.

Rubakov received an excellent education: he graduated from physical–mathematical School No. 57, and then from the Department of Physics, Lomonosov Moscow State University. By the time he defended his diploma thesis at the chair led by N N Bogoliubov, he had already had four published papers. His subsequent career is closely connected with the Academy of Sciences Institute for Nuclear Research (INR). There, he was a post-graduate student (1978–1981) and held research positions, from junior (starting in 1981) to principal (1994 to the present time), and served as Deputy Director for Research (1987–1994); it is at this institute that he did his most interesting work, realized his brilliant ideas, and created a scientific school.

Rubakov has authored more than 200 scientific works, many of which have made a fundamental contribution to elementary particle physics, nonperturbative quantum field theory, and the theory of the early Universe. Rubakov's remarkable scientific style characteristically combines a commitment to the understanding of physical phenomena with rigorous quantitative analysis, which requires a broad education, brilliant insights, and an enormous capacity for work. Presently, "Rubakov's school" is distinctly recognizable by the primacy of the physical problem over the investigation method, with the latter to be selected or specially worked out so as to guarantee the validity of the solution. Rubakov's favorite saying, "If everything is done correctly, the end result must also be correct," is the motto. It is hardly possible to cover the entire variety of Rubakov's scientific achievement, especially if we recall that he actively keeps publishing new material that is invariably in the focus of the scientific community.

We therefore mention several noteworthy results. Quite possibly, to young physicists across the world, Valery Rubakov is known first and foremost as the author of the "braneworld" idea. In 1983, V A Rubakov and M E Shaposhnikov proposed the concept of a world with extra spatial dimensions and with the observable particles localized near a 3-dimensional manifold (domain wall), presently called a brane. Legend has it that this scenario was conceived and shaped into a scientific paper overnight. The braneworld models turned out to be appealing from the phenomenological standpoint and were rapidly developed in the late 1990s–early 2000s. The localization of particles and interactions in these models make the extra dimensions practically invisible, although they can give rise to exotic physical processes. A series of present-day studies by Rubakov are devoted to developing this class of models, in particular, investigating possible modifications of gravity at long and short distances, the limits of validity of the mass and electric charge conservation laws in the $(3+1)$-dimensional world, and the cosmological effects associated with extra dimensions.

Valery Anatol'evich Rubakov

Two years later, in one of his best-known works, Rubakov, jointly with V A Kuzmin and M E Shaposhnikov, laid the foundations for the approach explaining the baryon asymmetry of the present-day Universe in the framework of electroweak interactions. Notably, the evident absence of antibaryons in our world has no simple explanation from the cosmological standpoint, because practically all processes in the microworld affect baryons and antibaryons in the same way. Kuzmin, Rubakov, and Shaposhnikov have shown that a necessary condition for the formation of a baryon asymmetry of the Universe (fast baryon number nonconservation in early cosmology) is realized in the Standard Model

Uspekhi Fizicheskikh Nauk **185** (2) 221 – 222 (2015)
DOI: 10.3367/UFNr.0185.201502i.0221
Translated by S Alekseev

of particle physics and does not require any new hypothetical interactions. Subsequent calculations have revealed that CP violation in interactions of the known elementary particles and deviations from thermodynamic equilibrium in the Standard Model (Sakharov's time arrow), which are also necessary for the occurrence of an asymmetric Universe, are not sufficient for explaining its observed magnitude. Therefore, baryon number generation to this day remains one of the main cosmological mysteries, solving which has direct bearing on understanding the physics beyond the Standard Model. Anomalous electroweak processes with baryon number nonconservation in the early Universe, discovered by Rubakov and collaborators, play a key role or are taken into account in virtually all baryon asymmetry generation mechanisms.

This subject was naturally extended into a large series of studies devoted to nonperturbative effects, for example, electroweak violation of the baryon number, in collisions of high-energy particles. Rubakov and his students worked out nontrivial semiclassical methods applicable whenever a model involves large parameters of an external nature: energies or masses of colliding particles, temperatures or densities of the medium, the number of particles in the final state, and so on. A comprehensive nonperturbative analysis of such situations turned out to be a complicated task, and much time has been spent developing suitable semiclassical methods. The application of these methods, in particular, has allowed verifying the exponential suppression of the multiparticle production cross section in high-energy collisions.

Rubakov's name is borne by a beautiful and experimentally verifiable nonperturbative effect — monopole catalysis of proton decay. Remarkably, the effect was predicted in one of Rubakov's earliest works, which, considering its complicated history, was a "baptism by fire" to the 26-year-old theoretical physicist and made him known worldwide. The effect he discovered is important and goes beyond the imagination. It is important for experimental verification of Grand Unification theories, which typically predict the existence of magnetic monopoles. Because a proton decays upon collision with a monopole, a bound can be set on the number of monopoles in the modern Universe by observations of protons (which are stable according to the present-day experimental data). The effect surpasses bounds of imagination, because the proton size is about 15 orders of magnitude greater than the size of the monopole and, hence, by this incompatibility of scales, the probability of their interaction should apparently be small. But this is not so: calculations show that in the magnetic field of a monopole, the quarks constituting the proton experience a "fall on the center," which means that the proton is "sucked inside" the monopole, where the decay then takes place. The mutual influence of different scales in the theory was later called ultraviolet–infrared mixing.

Rubakov has made a significant contribution to developing the theory of the very early Universe, the "pre-Big-Bang" cosmology. Widely known is his work on inflation theory, in particular, on the generation of gravitational waves in an exponentially expanding Universe (jointly with M V Sazhin and A V Veryaskin, 1982). His recent keen interest is in alternative models to inflation, where the spectrum of primordial cosmological perturbations is generated by other mechanisms. This leads to new spectacular cosmological predictions, whose experimental verification is currently at full tilt.

Other well-known studies by Rubakov are related to quantum gravity, supersymmetry, and a number of other exciting areas. Comprehensive knowledge in various fields and deep physical intuition allow him to be competent in practically all areas of modern particle physics and cosmology, in which quality he is constantly in demand by dozens of his colleagues and students, who turn to him for advice regarding their work.

The scientific accomplishments of Valery Rubakov have won awards: a Gold Medal and Prize for Young scientists from the Russian Academy of Sciences (1985) and then the Friedman Prize (Presidium of the Russian Academy of Sciences, 1999), Pomeranchuk Prize (ITEP, 2003), Markov Prize (INR, Russian Academy of Sciences, 2005), Pontecorvo Prize (JINR, 2009), Julius Wess Prize (Karlsruhe Institute of Technology, 2010), Lomonosov Prize (Moscow State University, 2012), and Bogoliubov Prize (JINR, 2014).

Rubakov is known not only for his scientific accomplishments but also for having created a unique scientific school. An attentive and demanding tutor, he has brought up numerous students, thereby continuing the best traditions of the scientific schools of N N Bogoliubov, A N Tavkhelidze, and V A Matveev. Rubakov's former students have taken key positions in leading scientific centers worldwide, but a truly unique property of his scientific school is that many return to their "birthplace" institute and, as a result, INR currently employs Rubakov's students of different ages: those in their twenties, thirties, and forties. The influx of young researchers is the result of tremendous personal effort by Rubakov, who for decades has been designing and working out unique lecture courses, delivered weekly, and sharing long hours of his time with undergraduate and post-graduate students. He is a distinguished professor at Moscow State University (1999) and since 2010 has chaired the Particle Physics and Cosmology Department of the Physics Faculty. The brilliant textbooks *Classical gauge fields* and *Introduction to the theory of the early Universe* (coauthored by D S Gorbunov) are being printed and reprinted in Russia and abroad; they can be found in libraries and on desktops of researchers in world's leading science centers.

Rubakov's contribution to popularizing science and disseminating knowledge among great masses of Russians must also be mentioned. This includes not only his work on the Russian Academy of Sciences Committee for Countering Pseudo-Science, but also his popular science lectures and interviews, whose filmed copies are massively shared on social networks. Rubakov is a member of editorial boards of Russian and international journals, such as *Theoretical and Mathematical Physics* and *International Journal of Modern Physics*, and manages a large amount of indispensable work as a first deputy editor-in-chief of *Uspekhi Fizicheskikh Nauk* [*Physics–Uspekhi*] journal.

Rubakov is capable of finding the required resources to take part in administrative and social work in times of need. In the early 1990s, he was the INR Deputy Director, and it is much due to his effort that the turn of the century saw the INR as a thriving science center of a global scale and that the Baksan Neutrino Observatory, which is a part of the institute, preserved its unique equipment and continues to be one of the world's leading players in particle astrophysics. In particular, the construction of a Gallium–Germanium neutrino telescope has been brought to completion, which yielded invaluable data on the solar neutrino flux. In 2013, being an acknowledged authority in this country and abroad, Ruba-

kov was among the first to lead the protest movement of scientists against the senseless reorganization of the Russian Academy of Sciences which was detrimental to science. Quite remarkably, these activities of his run parallel to his research work, by no means superseding it: students and colleagues keep coming to knock on the door of Rubakov's office, where thriving scientific discussions extend till late at night, piles of paper are covered with formulas, and ideas are born and shaped into papers and books.

Valery Rubakov is an exceptional personality. It is sometimes hard to believe that a single human being can combine such a variety of outstanding qualities both personally and professionally: a kind and caring attitude towards people, uncompromising integrity and fairness, a capacity for hard work and inspiration, and the talent to pose the problem and the ability to take its solution to the end. We wish Valery Rubakov new scientific insights, talented students, good health, and enough strength for the hard but rewarding and fascinating work covering the full diversity of his interests.

D S Gorbunov, L V Keldysh, L V Kravchuk,
D G Levkov, M V Libanov, V A Matveev,
O V Rudenko, M V Sazhin, S V Troitsky,
V E Fortov, M E Shaposhnikov, I A Shcherbakov