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PERSONALIA

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In memory of Iosif Bentsionovich Khriplovich

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On September 26, 2024, at the age of 87, Iosif Bentsionovich Khriplovich, a world-famous theoretical physicist, doctor of physical and mathematical sciences, professor in the Department of Quantum Mechanics at St. Petersburg State University (SPbSU), and corresponding member of the Russian Academy of Sciences (RAS), passed away.

Iosif Bentsionovich Khriplovich was born on January 23, 1937 in Kiev. In 1954, he entered the Physical Department of Kiev State University (KSU). After graduating from KSU in 1959, I.B. Khriplovich entered the graduate school of the Institute of Nuclear Physics (INP) of the Siberian Branch (SB) of the Academy of Sciences, where, having progressed from graduate student (under the supervision of V.N. Baier) to chief researcher of the Theoretical Department, he worked until 2014. While working at the INP, I.B. Khriplovich concurrently taught at Novosibirsk State University (NSU), where from 1998 to 2009 he headed the Department of Theoretical Physics of the Physical Faculty. From 2014, Iosif Bentsionovich was a professor at the Department of Quantum Mechanics at St. Petersburg State University.

The range of I.B. Khriplovich's scientific interests extended from nuclear physics to the general theory of relativity. The results he obtained in quantum field theory, the theory of gravitation, cosmology, and other areas have long become classics about which new generations of physicists are taught.

His first scientific work, performed in 1960 and devoted to neutral currents in weak interactions, determined one of the main fields of his scientific interests: high energy and elementary particle physics. Further, he obtained important results in the theory of weak and electromagnetic interactions, gauge theories, and gravitation theory. This work brought I.B. Khriplovich worldwide recognition.

In 1969, he calculated one-loop charge renormalization, i.e., the first coefficient o the beta function, thus demonstrating, much ahead of his time, charge antiscreening in a non-Abelian Yang–Mills gauge theory. Deep inelastic scattering was not directly within the range of his interests, but no one else in the world scientific community, including his immediate circle, thought of his result as related to scaling in deep inelastic scattering, the understanding of which was then in an embryonic state. A full understanding of the meaning of the sign of this coefficient and the introduction of the concept of asymptotic freedom only became possible in 1973 owing to quantum chromodynamics, which appeared a year before, due to three Nobel prize winners, who calculated this coefficient without knowing about I.B. Khriplovich's work. Today, asymptotic freedom underlies our understanding of the nature of strong interactions.

In 1971, I.B. Khriplovich (together with A.I. Vainshtein) demonstrated non-renormalizability of the massive Yang–

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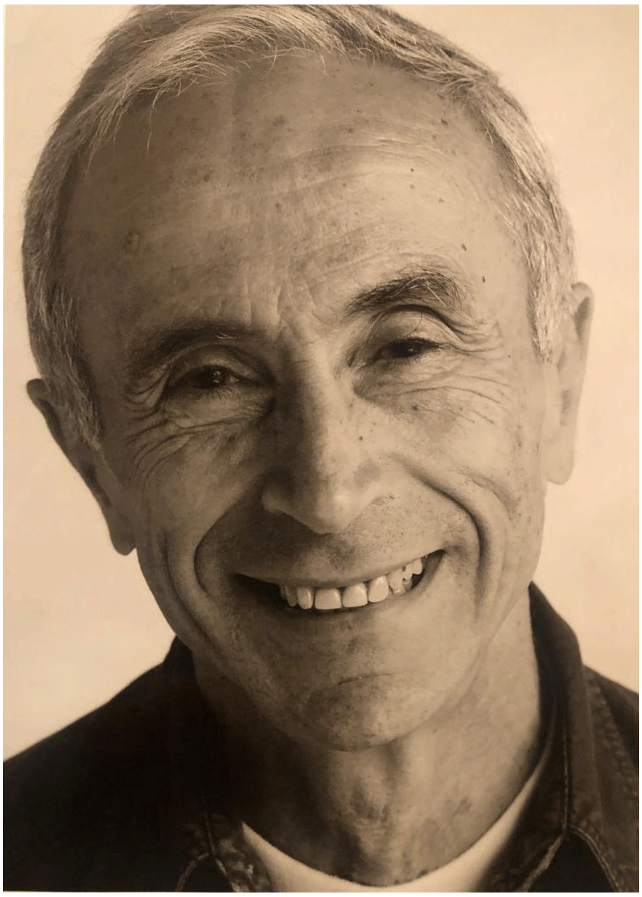
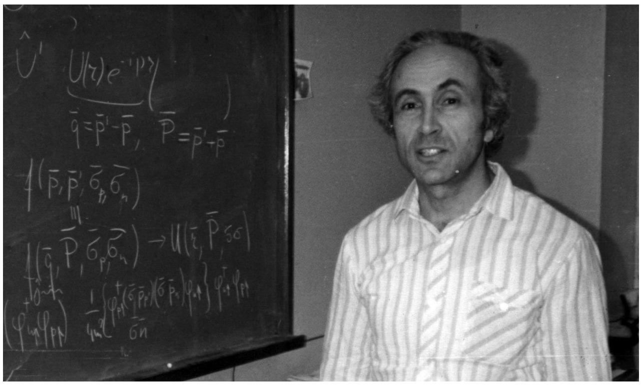


Iosif Bentsionovich Khriplovich
(23.01.1937 – 26.09.2024)

Mills theory with a rigid introduction of mass, and, in 1973, they derived a strong limitation on the mass of the charmed quark, which was unexpectedly discovered already the following year, in 1974.

In 1974, I.B. Khriplovich theoretically proposed and calculated an optical experiment to detect parity nonconservation in atoms due to a direct weak interaction between electrons and nucleons. Such an experiment, in which the light polarization plane rotation was measured during the passage of atomic bismuth vapor, was successfully carried out by L.M. Barkov and M.S. Zolotorev at the INP SB RAS in 1978. This meant proof of the universality of weak interactions in nature — universality similar to that of gravity and other fundamental interactions. The need for precision calculations of *P*-odd effects led to the development by I.B. Khriplovich and his disciples of new methods in the theory of multi-electron atoms. The work on parity nonconservation in atomic phenomena became the subject of the popular (over 700 citations) monograph by Iosif Bentsionovich (see [1]).

A large series of I.B. Khriplovich's fundamental studies was devoted to the search for physical manifestations of



Iosif Bentsionovich Khriplovich in his study at INP (mid-1980s; the photo by M.P. Ryutova).

violations of fundamental symmetries in processes with elementary particles and atomic nuclei.

Together with his disciples O. Sushkov and V. Flambaum, I.B. Khriplovich made a decisive contribution to the theory of nuclear electromagnetic moments that violate fundamental symmetries. In this work, they formulated a theory of the nuclear anapole moment and demonstrated that the magnetic interaction of atomic electrons with the nuclear anapole makes the dominant contribution to nuclear-spin-dependent atomic effects of parity nonconservation. The anapole moment leads to a difference in parity nonconservation effects in atomic transitions among different hyperfine components, which allows examination of parity violating nuclear forces in atomic experiments. The discovery of the nuclear moment, violating fundamental symmetries, is also interesting. Following the idea and calculations of Khriplovich and his co-authors, the nuclear anapole moment was revealed in an experiment performed by the group of the Nobel Prize laureate K. Weinman.

Together with his disciples, I.B. Khriplovich performed the first calculation within the Standard Model of nuclear forces violating invariance under time (T) and space (P) reflections. He also calculated the nuclear magnetic quadrupole moment and the Schiff moment violating T and P. Iosif Bentsionovich named the Schiff moment after the Schiff theorem on the screening of the electric dipole moment (EDM) of a nucleus by atomic electrons. His work also demonstrated that magnetic interaction of atomic or molecular electrons with a nuclear quadrupole magnetic moment leads to the occurrence of the EDM violating T and P invariance. The Schiff moment creates the EDM due to electrostatic interaction with electrons.

I.B. Khriplovich successfully calculated the electric dipole moments of elementary particles caused by interactions noninvariant under time inversion. He calculated the dipole moments of quarks in the Standard Model and, jointly with his disciple M. Pospelov, proved a theorem, according to which the EDM of an electron cannot appear when, contrary to what was believed earlier, three quark loops are taken into account, but requires allowance for higher orders. The modern approaches to searching for EDMs of atoms and molecules were anticipated in the brilliant monograph by I.B. Khriplovich and S.K. Lamoreaux [2], which was cited over 750 times and played a great role in the development of this area of physics. Today, physics searches beyond the Standard Model are focused precisely on measurement of the EDM of particles, nuclei, atoms, and molecules as a key to CP nonconservation beyond the Standard Model, without which the experimentally observed asymmetry between matter and antimatter in the Universe cannot be explained.

Iosif Bentsionovich carried out some important studies on the dynamics of spin particles in a gravitational field and also on the physics of black holes. His work on black hole physics was notably ahead of its time. He was the first to consider the interaction of small black holes with Earth as they fly through our planet. In the last two to three years, this has been actively discussed in connection with the possibility of the existence of primary black holes with a gravitational radius equal to the Bohr radius and a mass of nearly 10^{20} grams. I.B. Khriplovich showed that the passage of microscopic black holes leads to potentially observable effects and can, in principle, be recorded. This is one of the methods of current observations of black holes and the assessment of their contribution to the density of cosmological dark matter. In light of this, I.B. Khriplovich's work of 2006 on determining the upper limit on dark matter density in the Solar system is worth noting.

In the series of studies from 2004 to 2006 on quantized black holes, the efficiency and the energy spectrum of their emission were calculated, opening a new window for their observation. In a series of joint studies with A.D. Dolgov, A.I. Vainshtein, and V.I. Zakharov, I.B. Khriplovich discovered a new type of quantum anomaly in a gravitational field, a so-called boson chiral anomaly, and discussed its observational consequences and, in particular, the possibility of the manifestation of the boson anomaly in macroscopic effects.

I.B. Khriplovich successfully combined scientific work with teaching. For many years, he was one of the most popular lecturers at NSU. As a professor in the Department of Theoretical Physics at NGU, I.B. Khriplovich worked out and delivered original courses on quantum mechanics, the theory of weak interactions, and the general theory of relativity, as well as his author's special courses. On the basis of these courses, remarkable textbooks on quantum mechanics (jointly with V G. Serbo), the general theory of relativity, and selected problems in theoretical physics were written and published. From 2014, when already a professor in the Department of Quantum Mechanics at St. Petersburg State University, he gave lectures on additional chapters of theoretical physics. I.B. Khriplovich was a regular contributor to *Uspekhi Fizicheskikh Nauk* (*UFN*) [3 – 11].

I.B. Khriplovich's creative energy, profound knowledge and pedagogical talent allowed him to found a scientific school that trained a whole group of candidates and doctors of sciences, many of whom occupy leading positions in major scientific centers. He used any opportunity to promote and support his students in both large and small matters — from nominations for prestigious awards and promotions to assistance in housing.

Iosif Bentsionovich regularly gave invited talks at the most prestigious international conferences. His deep understanding of physics and broad outlook made him an indispensable expert in discussing various scientific problems. And given his goodwill and wit, discussions with him not only enriched the interlocutor with new scientific knowledge and ideas, but also gave great pleasure.

I.B. Khriplovich's achievements were recognized by the Dirac Medal awarded jointly by the Australian Institute of Physics and the University of New South Wales, and the Pomeranchuk Prize awarded for work in theoretical physics.

Iosif Bentsionovich Khriplovich's work will be forever included in the golden annals of physics. The bright image of this outstanding scientist and remarkable person will forever remain in the hearts of his friends, colleagues, and disciples.

A.E. Bondar', A.I. Vainshtein, M.I. Vysotsky,
A.D. Dolgov, L.N. Labzovskii, P.V. Logachev,
N.N. Nikolaev, M.E. Pospelov, A.N. Skrinskii,
O.P. Sushkov, V.V. Flambaum, V.M. Shabaev

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