Physics – Uspekhi **49** (7) 773 – 774 (2006)

PERSONALIA PACS number: **01.60.+q**

Boris Lazarevich Ioffe (on his eightieth birthday)

DOI: 10.1070/PU2006v049n07ABEH006112

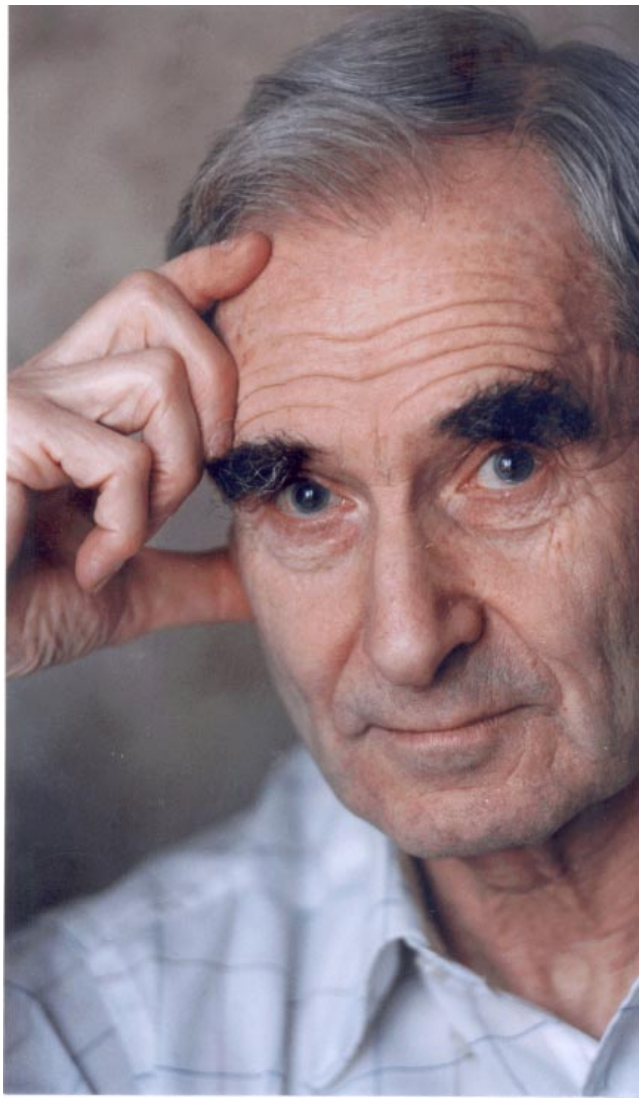
The outstanding theoretical physicist Boris Lazarevich Ioffe, Corresponding Member of the Russian Academy of Sciences (RAS), Professor, Head of Laboratory of Theoretical Physics of the Russian Federation State Scientific Center 'A I Alikhanov Institute for Theoretical and Experimental Physics', celebrated his 80th birthday on July 6, 2006.

Boris Lazarevich, known as BL to his close colleagues and students, graduated from the Physics Department of Moscow State University on December 31, 1949 and started working at the Laboratory of Theoretical Physics of the USSR Academy of Sciences Laboratory No. 3 on January 1, 1950. The title Laboratory No. 3 was later changed to the Teplotekhnicheskaya (Thermotechnical) Laboratory (TTL) and then to its current title 'The Institute for Theoretical and Experimental Physics' (ITEP). The director of Laboratory No. 3 at the time was A I Alikhanov, while the Laboratory of Theoretical Physics was headed by I Ya Pomeranchuk. In addition to the obligatory exams for university students, BL also passed L D Landau's nine exams covering the program developed specially to select young talented theoretical physicists (the so-called theorminimum) and was therefore added to the list of 'Landau's school'. BL himself considers Landau, Pomeranchuk, and Alikhanov his mentors.

BL was not simply their pupil but also their nearest collaborator, and their collaboration was fruitful for both sides. Ioffe, A D Galanin and Pomeranchuk had to a great extent induced the famous paper by Landau, Abrikosov and Khalatnikov in which the three came to the conclusion of inconsistency of quantum electrodynamics at high energies — the so-called zero of charge. Galanin and BL discovered an error in the preliminary version of this paper — where asymptotic freedom resulted instead of the zero of charge. Later on, Landau put it this way: ''Galanin and Ioffe saved me from infamy''. BL wrote 15 papers jointly with Pomeranchuk. The starting point of the proof of Pomeranchuk's theorem was a paper by Ioffe. Pomeranchuk's last paper, completed two days before his death, was written together with V N Gribov and Ioffe. BL developed projects of atomic reactors suggested by Alikhanov, including the first atomic power station with a heavy water reactor, designed in the USSR.

In his more than 50-year career of active research, BL has made a large contribution to the progress of the theory of elementary particles, high-energy physics, the theory of nuclear reactors, and applied nuclear physics. We will cite here only most important results.

The paper written by him and L B Okun' and A P Rudik in 1956 established for the first time that P-parity violation must be accompanied by charge symmetry or time-reversal symmetry violation, and that experimental detection of P-odd pair correlations between particle spins and momenta should mean charge symmetry violation. This conclusion, so fundamental for the theory of elementary particles, was obtained before the discovery of parity violation and later stimulated Landau to formulate the hypothesis for the conservation of CP invariance and the two-component neutrino theory. This Ioffe – Okun' – Rudik result was assigned the discovery certificate and was quoted by T-D Lee and C N Yang in their Nobel lectures.



Boris Lazarevich Ioffe

In 1958, soon after M Gell-Mann and R Feynman advanced their hypothesis for the conserved vector current (CVC) in weak interactions, Ioffe and V G Vaks derived an important relation proving that in such a theory the structural component of the vector current in the amplitude of the pion's radiative decay $\pi \to e + \nu + \gamma$ is determined by the lifetime of the neutral π-meson. This is one of the few direct consequences of the CVC hypothesis, and it was experimentally confirmed in 1963 in a paper by P Depommier, J Heintze, C Rubbia, and V Soergel.

Uspekhi Fizicheskikh Nauk **176** (7) 799 – 800 (2006)
Translated by V I Kisin

In 1967, Ioffe and E P Shabalin showed that a theory of the weak interactions containing only ordinary and strange hadrons becomes invalid at energies on the order of several GeV. This result served as a starting point for the hypothesis, formulated later by S L Glashow, J Iliopoulos and L Maiani, for the existence of charmed particles and for the form of the weak interaction of hadrons (the GIM mechanism).

In 1969, BL established that the interaction in the process of deeply inelastic scattering of leptons by hadrons takes place in the spacetime region close to the light cone and is characterized by longitudinal ranges that grow linearly with energy. Times corresponding to such longitudinal distances are known in world literature as Ioffe times. These results were certified as a discovery. They lie at the foundation of the current description of deeply inelastic processes — the method of operator product expansion on the light cone — and are widely used in analyzing reactions of interaction between virtual photons and nucleons and nuclei.

In 1976, BL suggested an efficient method of searching for the Higgs boson in the electron – positron annihilation, when a Higgs boson is created jointly with the Z boson: $e^+e^- \to ZH$. The search for the H-boson at CERN was conducted using this very method.

Ioffe proved that the proton mass (as well as the mass of other baryons and nuclei) in the theory of the strong interaction (quantum chromodynamics) arises owing to the spontaneous violation of chiral symmetry in the QCD vacuum and is expressed in terms of the vacuum quark condensate. This clarified the nature of the mass of baryon matter. The relation he derived for the proton mass and quark condensate is known as the 'Ioffe formula', and the quark current describing the proton as the 'Ioffe current'. Hans Bethe highly valued these results. BL introduced into QCD the concept of magnetic susceptibility of the quark condensate and showed that this phenomenon determines the magnitude of the magnetic moments of baryons. He was able to calculate the magnetic moments of the proton, neutron, and hyperons, i.e., he solved the problem that Richard Feynman considered as the most important for proving that QCD is the true theory of the strong interaction.

In his analysis of the spin structure of the proton, BL found an elegant linkage between the Gerasimov – Drell – Hearn sum rule for creation of hadrons by polarized photons and the Bjorken and Ellis – Jaffe sum rules for spin-dependent structure functions of deeply inelastic scattering. He also developed a method of nonperturbative calculation of quark distributions in nucleons, meson, and photon. The calculated quark distributions agree with experimental data. It was thus shown that the QCD describes not only the evolution of parton distributions with the variation of momentum transfer, but also their absolute magnitudes. Interesting results were also obtained when studying the properties of hadrons in nuclear matter at finite temperature and density: mixing of vector and axial mesons was established at finite temperatures, and mass shift and meson broadening in nuclear matter were calculated. In recent years, he carried out systematic studies of QCD at low energies: a number of low-energy properties of hadrons, condensate magnitudes, and topological characteristics of a vacuum were determined. He also found the relation between the topological susceptibility of a vacuum in the QCD and the fraction of the spin carried away by quarks in the longitudinally (relative to momentum) polarized proton.

Ioffe contributed in important ways to the theory of nuclear reactors and to the solution of other problems in applied nuclear physics. He developed the theory of high burnup of fuel in nuclear reactors. Yu B Khariton recalled that this work was highly valued by I V Kurchatov; in our days it still forms the basis of calculations of the variation of reactivity and other physical characteristics of nuclear reactors at atomic power plants. BL headed the program of physical calculations and took part in launching an industrial-scale heavy-water reactor at the electric power station A-1 in Czechoslovakia in 1973 and also some research-oriented reactors in the USSR (ITEP), China, and Yugoslavia. In the 1970s, he came up with the initiative of building at ITEP a neutron generator — a subcritical nuclear reactor driven by an accelerator. This work continues to this day. In 2005 – 2006, BL proposed for atomic power stations a certain type of heavy-water gas-cooled reactor using the thorium – uranium cycle and satisfying the requirements of nonproliferation of nuclear weapons, with reactor safety ensured by the laws of physics.

BL made significant contributions to the hydrogen bomb effort in the USSR (1951 – 1953): he calculated the thermal conductivity of completely ionized gas with relativistic electrons. Together with Ya B Zel'dovich's group, Ioffe, A S Kronrod, and L V Kantorovich proved that the super-bomb project 'Truba' ('Pipe') was totally infeasible. By solving the relativistic kinetic equation describing the three-dimensional problem they calculated the energy transferred to photons in such a gas and established that with this energy loss taken into account, the energy balance in the system is negative. The project was closed. (Edward Teller and his group worked on a similar project — code-named 'Classical Super' — in the USA. They came to the same conclusion and that project was likewise terminated.) In connection with this work, BL studied the effect of polarization on the propagation of photons in totally ionized gas. The results of this study are used for analyzing a number of problems in astrophysics.

Ioffe is credited with two discoveries and is the author of 300-odd research papers, and wrote two monographs. In 1994, he was awarded The Alexander von Humboldt Prize (Germany). In the same year, he was elected as a 'Fellow' of the American Physical Society. He wrote two literary pieces — an essay "Top secret assignment" (*Novyi Mir*, Nos 5 – 6, 1999) and a book *Bez Retushi* (*No Retouching*) (Fazis Publ., 2004) — that are known not only to readers among physicists but earned positive reviews from literary critics. The essay brought Ioffe the '*Novyi Mir*' Prize on the occasion of the 75th anniversary of the journal.

BL spends his vacations mountaineering and trekking of higher-difficulty classes — more than forty in all. He has been hiking in almost every mountainous region of the former USSR, and after 1990, when the borders opened up, in the Himalayas (3 times), the Alps, the Appalachian mountains, the Yosemite Valley, and in New Zealand; he has traversed mountain passes and climbed peaks up to 6,000 m in altitude.

Our best wishes to Boris Lazarevich Ioffe on his birthday, and we wish him excellent health and a continuation of the next chapter of his wonderfully fruitful career in physics.

J D Bjorken, A Wagner, B V Geshkenbein,
V L Ginzburg, A V Gurevich, I M Dremin,
A B Kaidalov, L A Kondratyuk, L M Lederman,
L Maiani, V I Subbotin, B Yu Sharkov