MYKOLA MYKOLAIOVYCH BOGOLYUBOV
(to the centenary of his birthday)

This issue of the Ukrainian Journal of Physics is devoted to the centenary of the birthday of Academician Mykola Mykolaiovych Bogolyubov (21.08.1909–13.02.1992), one of the most outstanding physicists-theorists and mathematicians of the XX-th century, the founder of the Institute for Theoretical Physics of the NAS of Ukraine and a number of world-wide known scientific schools.

M.M. Bogolyubov obtained outstanding results in such branches of mathematics and theoretical physics as variational calculus, functional analysis, theory of differential equations, theory of probability, theory of almost periodic functions, nonlinear mechanics, high-energy physics, quantum field theory, theory of nuclei, and solid state physics. He developed the microscopic theory of superfluidity and superconductivity and novel methods of statistical mechanics.

In 1932–1937, M.M. Bogolyubov together with his teacher M.M. Krylov constructed the asymptotic theory of nonlinear oscillations – a new trend in the general theory of nonlinear oscillations, proposed methods of asymptotic integration of nonlinear equations describing various oscillatory processes, and gave their mathematical substantiation. The results of their studies in the field they named nonlinear mechanics were presented in a series of books, in particular: "On Some Formal Expansions in Nonlinear Mechanics" (1934), "New Methods of Nonlinear Mechanics" (1934), and "Introduction to Nonlinear Mechanics" (1937). Classical became the methods of averaging and integral manifolds developed by them in nonlinear mechanics. In the subsequent years, M.M. Bogolyubov developed the asymptotic theory of nonlinear oscillations jointly with his disciple, Academician Yu.O. Mytropol's'kyi, and his scientific school.

The asymptotic methods of nonlinear mechanics were applied by M.M. Bogolyubov to statistical physics. In his book "Problems of Dynamical Theory in Statistical Physics" (1946), the scientist presented a quite full form of perturbation theory for the solution of various problems of statistical mechanics, constructed a powerful method of derivation of kinetic equations on the basis of the mechanics of a system of particles. In particular, the idea of a hierarchy of relaxation times in a many-particle system he advanced and substantiated (1945) plays a significant role in the statistical description of nonequilibrium processes running in gases, fluids, and crystals. He proposed an efficient method based on chains of equations for the distribution functions of complexes of particles (the Bogolyubov–Born–Green–Kirkwood–Yvon or BBGKY method). This method, being extended on nonequilibrium processes, allowed M.M. Bogolyubov to propose a universal method of construction of kinetic equations for many-particle systems and to lay foundations of the modern theory of kinetic phenomena. In particular, he formulated the conditions for applicability of the Boltzmann kinetic equation, solved the problem of irreversibility of this equation in time, and obtained a kinetic equation for a system of particles with the Coulomb interaction (the Bogolyubov–Balescu–Lenard kinetic equation).

In 1947, M.M. Bogolyubov jointly with K.P. Gurov derived a quantum kinetic equation in the third order of perturbation theory by the interaction potential of atoms. In this case, it was shown that, due to this interaction, the atoms become quasiparticles, and their energy is transformed into a functional of the distribution function.

M.M. Bogolyubov also got important results in quantum statistics. In 1946, he developed the method of approximate secondary quantization and used it for the determination of the energy spectrum of weakly excited states of quantum systems which can be modeled by a weakly nonideal Bose-gas. In 1947–1948, he calculated the spectrum of elementary excitations of such systems and proved that they can be in a condensed state which corresponds to the appearance of superfluidity. In other words, their collective spectrum has the same properties as the spectrum of HeII. Then M.M. Bogolyubov created a microscopic theory of the superfluidity of Bose-systems which was presented in the article "On the theory of superfluidity" (1947). There, the canonical tranformations known now as the "Bogolyubov tranformations" were given.

The further development of the ideas and methods of the theory of nonideal Bose-gas allowed M.M. Bogolyubov to generalize it for Fermi systems and (in fact, simultaneously with the American theorists J. Bardeen, L. Cooper, and R. Schrieffer) to develop a successive microscopic theory of superconductivity and to describe the

phase transition from the normal state of a conductor to the superconducting one. He also paid attentionto that superconductivity can be considered as the superfluidity of an electron gas (1957).

The idea of superconductivity as the superfluidity of Fermi-systems led the scientist to the discovery of the phenomenon of superfluidity in the nuclear matter (1958). In 1968, M.M. Bogolyubov proposed a new variational method to study the superconducting and superfluid systems which considers the existence of correlated pairs of particles and generalizes the method of Hartree–Fock (the Hartree–Fock–Bogolyubov method).

In the field of quantum field theory, Mykola Mykolaiovych proposed a powerful method of elimination of ultraviolet divergences – a mathematically correct version of the theory of renormalizations which uses the apparatus of distributions and is named the "R-operation of Bogolyubov–Parasiuk" (1955). As a result, the mathematical sense of renormalizations was clarified.

In 1955, M.M. Bogolyubov together with his disciple D.V. Shirkov developed the theory of scattering matrix which (we cite the authors) "is constructed, by starting from the Heisenberg's positions which were, however, restricted to a significant degree by the admission of the expansion in the coupling constant. We accept the concept of adiabaticity and, what is the main point, the requirement of causality formulated in the form of a strict condition of microscopic causality or localization". The following analysis of the procedure of renormalization performed by M.M. Bogolyubov and D.V. Shirkov led them (1955) to the renormalization group and, following M. Gell-Mann and F. Low (1954), to the construction of its successive mathematical theory.

M.M. Bogolyubov was one of the founders of the trend which then was called axiomatic field theory. The advantages of the approach were demonstrated by M.M. Bogolyubov in the cycle of his works on the method of dispersion relations for the scattering amplitudes describing various processes of scattering and creation of elementary particles. The proof of the dispersion relations for the scattering of pions on nucleons (1956) favored the development of a new mathematical apparatus of the analytic continuation of distributions of many variables.

In 1961, M.M. Bogolyubov introduced the fundamental notion of quasiaverages which underlie, in essence, a new theory of phase transitions. The extension of these ideas onto elementary particle physics was named "spontaneous symmetry breaking".

In 1964–1966, the scientist wrote works on the theory of symmetry and quark models of elementary particles. Of important value for their subsequent development was a new quantum number of quarks known now as "color" which was proposed in 1965 by M.M. Bogolyubov and his disciples B.V. Struminsky and A.N. Tavkhelidze (independently of Y. Nambu and M.-Y. Han). It allowed one to solve the problem concerning the statistics of quarks and is used in the construction of the theory of strong interactions.

A lot of forces and energy were given by Mykola Mykolaiovych to the pedagogical and scientific-organizational work. He worked as Professor and then Head of a chair of the Kyiv University in 1936-1949 and Dean of the Mechanical-Mathematical Faculty in 1946-1949. In 1946-1949, M.M. Bogolyubov headed a department of the Institute of Mathematics of the Academy of Sciences of Ukraine; from 1947, he was Head of a department of theoretical physics of V.A. Steklov Mathematical Institute of the AS of USSR in Moscow; from 1953, he was Head of a chair of theoretical physics of the Moscow State University. In 1956-1965, M.M. Bogolyubov was Director of the Laboratory of Theoretical Physics of the Joint Institute of Nuclear Research (JINR) in Dubna (Moscow region), and, in 1965-1989, he was Director of this Institute. From 1966, M.M. Bogolyubov headed a new Institute for Theoretical Physics of the AS of Ukraine till 1973. This Institute now bears his name. For many years, M.M. Bogolyubov headed also V.A. Steklov Mathematical Institute of the AS of USSR and was the Academician-Secretary of the Division of Mathematics of the AS of USSR

During his life, M.M. Bogolyubov was generally recognized in the native land and abroad. He was twice the Hero of Socialist Labor (1969, 1979), a laureate of the Lenin Prize (1958) and three USSR State Prizes (1947, 1953, 1984), was decorated with M.V. Lomonosov Gold Medal (1985) and a number of state's orders and medals. He was Honored Science Worker of UkrSSR (1970), a foreign member of many foreign academies and scientific institutions and communities, Honored Doctor of a number of Universities, a laureate of international prizes, in particular, Heineman Prize, Max Planck Medal, B. Franklin Medal, Helmholtz Medal, and Dirac Medal (posthumously). The Presidium of the NAS of Ukraine founded M.M. Bogolyubov Prize. Despite the worldwide recognition, Mykola Mykolaiovych Bogolyubov was a person simple in communication and a sincere man entrained by science. He will remain forever in the memory of his grateful disciples and colleagues as the brilliant example of scientific and labor feats.

The Ukrainian scientific community and the National Academy of Sciences of Ukraine solemnly celebrate the

centenary of the birthday of the great scientist. The International Conference "Statistical Physics 2009" (L'viv, 23–25 June, 2009), Ukrainian Mathematical Congress (Kyiv, 27–29 August, 2009), International Bogolyubov Kyiv Conference "Modern problems of theoretical and mathematical physics", and General meeting of the NAS of Ukraine devoted to this outstanding date were held, a series of materials about M.M. Bogolyubov has been published, and the mobile photoexhibition "Bogolyubov and Ukraine" is in operation.

The main part of works included in this issue were written by the materials of plenary reports presented at the International Bogolyubov Kyiv Conference "Modern problems of theoretical and mathematical physics" (Kyiv, September 15–18, 2009). The conference gathered about 200 participants from Ukraine, Russia, Austria, Germany, Moldova, Israel. The topics of the conference were concentrated on problems of theoretical and mathematical physics, mainly on those, whose development was significantly influenced by M.M. Bogolyubov. Those are mathematical methods of theoretical physics, quantum field theory, statistical physics and kinetics, nuclear physics, and solid-state theory.

The Proceedings of the Conference will be published also in the additional special issue of the Ukrainian Journal of Physics.

On behalf of the Editorial Board and the Organizing Committee of the International Bogolyubov Kyiv Conference

V.G. Bar'yakhtar, A.G. Zagorodny, V.M. Loktev, S.V. Peletminsky, I.R. Yukhnovs'kyi