*Physics – Uspekhi* **59** (9) 931 – 933 (2016) 

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

# Mikhail Valentinovich Kovalchuk (on his 70th birthday)

DOI: 10.3367/UFNe.2016.08.037883

The 21st of September 2016 is marked as the 70th birthday of one of the leading Russian physicists, doctor of physico-mathematical sciences, Professor and Corresponding Member of Russian Academy of Sciences (RAS), Mikhail Valentinovich Kovalchuk. He is well known as an experimental scientist in the field of X-ray physics and crystallography. M V Kovalchuk initiated the use of X-ray and synchrotron radiations to investigate the structure of nanobiomaterials and nanosystems. He is one of the ideologists and organizers of the development of nanotechnologies in Russia.

In 1964, M V Kovalchuk entered the Faculty of Physics at Leningrad State University, where he specialized in the field of X-ray physics.

After he moved to Moscow in 1970, M V Kovalchuk continued developing this line of inquiry at A V Shubnikov Institute of Crystallography of the USSR Academy of Sciences. From the very beginning, his research was related to the development of X-ray diffraction methods for studying the structure of different materials.

In 1978, M V Kovalchuk defended his Candidate's degree thesis, "The method of the three-crystal X-ray spectrometer and the study of structural perfection of thin crystal layers." Further on, he became involved in working out the physical and methodical bases of an essentially new method of condensed media examination, namely, structure-sensitive spectroscopy with the use of standing X-ray waves. This method employed for the first time a combination of the unique capacities of X-ray spectroscopy and diffraction.

This research area received powerful backing for development, for which purpose a number of experimental laboratories were founded. One of them — the Laboratory of X-ray Optics and Synchrotron Radiation — was organized on the initiative of M V Kovalchuk, who headed it.

Owing to his energy and researcher talent, Mikhail Valentinovich made quick progress in X-ray physics, which was the area chosen by him. In 1988, he defended his Doctor's degree thesis, "The method of standing X-ray waves in the study of near-surface semiconductor layers", which made a decisive contribution to the development and practical implementation of the standing wave method. He carried out a series of pioneering studies on photoelectron yield under the conditions of two- and many-wave diffraction. This work developed a new area of investigations in the field associated with the construction of phase-sensitive X-ray methods, which are the basis of X-ray holographic research. The work on photoelectron yield demonstrated a unique structural sensitivity of the standing X-ray wave method and favored the advancement of X-ray methods as a tool for studying the structures of surface and thin crystal layers and two-dimensional systems.

Mikhail Valentinovich Kovalchuk

For already more than forty years, the scientific activity of M V Kovalchuk has been closely related to the A V Shubnikov Institute of Crystallography of RAS, where he has moved way from Researcher-in-Training to Director of the Institute.

During the years of M V Kovalchuk's directorship, the Institute of Crystallography has become one of the leading institutes of RAS. It was reoriented for the solution of essentially new scientific problems connected with the development of nanomaterials, nanodiagnostics, nanobiotechnology, and cosmic materials science. In 2016, three more institutions joined the Institute of Crystallography, scientifically guided by M V Kovalchuk, and the new structure took the name Federal Research Center of Crystallography and Photonics.

One of the most important stages of the scientific efforts of M V Kovalchuk is connected with synchrotron radiation. Since the early 1990s, alongside studies of semiconductor crystals and films and X-ray optics, M V Kovalchuk has paid considerable attention directly to synchrotron radiation. On the basis of a number of European sources of synchrotron radiation, he carried out a series of experiments highlighting

*Uspekhi Fizicheskikh Nauk* **186** (9) 1025 – 1026 (2016)
DOI: 10.3367/UFNr.2016.08.037883
Translated by M V Tsaplina

thin interferential effects in the region of anomalous dispersion. Using this experience, he began working out new experimental stations, first for the Zelenograd synchrotron and then for the Kurchatov Institute's one. The idea of designing a Russian source of synchrotron radiation was actively supported by Academician E P Velikhov, who, in 1999, appointed the Director of the Institute of Crystallography of RAS, M V Kovalchuk, to the post of Director-Organizer of the Kurchatov Center of Synchrotron Radiation. In this period, the foundation was laid of studies into high-resolution X-ray methods and coherent interaction between X-ray radiation and matter, and the base was established for the employment of synchrotron radiation in research work.

Within several years, M V Kovalchuk and his colleagues carried out a scaled scientific project on the elaboration of, design of, and putting into operation a package of unique scientific research equipment, namely, experimental stations using the beams of the first Russian specialized source of synchrotron radiation intended for collective use of the scientific community.

The realization of the synchrotron project is a serious contribution on the part of M V Kovalchuk to the development of experimental and technological potentials of Russia for implementing research in fundamental sciences, materials science, nano- and biotechnologies, and molecular biology and medicine, and also to the development of diagnostic methods with atomic resolution.

For the ten years since the launching day, in spite of extremely difficult times for all of Russian science, the Kurchatov Institute's synchrotron (the only research mega-installation designed within recent decades in the Russian Federation) has turned into a serious scientific complex where scientists, engineers, and specialists of various specialties and branches of science work jointly.

In 2005, M V Kovalchuk was appointed Director of the Russian Research Centre 'Kurchatov Institute'.

The whole research logic of M V Kovalchuk has led him to the investigation of systems with a progressively small number of atoms, to the determination of the position of separate atoms and molecules, and to comprehension of the necessity to develop technologies of atomic–molecular construction and establishment of adequate methods of diagnostics. Relying on the long-standing experience of interdisciplinary studies, M V Kovalchuk realized the role of nanotechnologies not only as an essentially new technology, but also as a new technological culture — a material basis for moving to the next stage of technological development.

The interdisciplinary studies initiated by M V Kovalchuk at the Institute of Crystallography and continued at the Kurchatov Institute got a boost after 2006 when Mikhail Valentinovich started developing an essentially new scientific discipline — the convergence of nano-bio-info-cognitive and socio-humanitarian (NBICS) sciences and technologies. He worked out the strategy of the advancement of this breakthrough in Russia and founded the Kurchatov NBICS Center, which has no parallel in the world. The technological basis of convergence of modern technologies with 'constructions' of an animate nature was laid at this center under his scientific guidance.

In recent years, M V Kovalchuk's scientific interests have been pointed towards the development of a fundamentally new scientific and technological field, namely, nature-like technologies that do not blemish the environment but are in harmony with it and allow restoration of the balance between the biosphere and technosphere violated by humans.

M V Kovalchuk was the first to put forward the conception of the formation of a nature-like technosphere as a logical stage in the evolution of human civilization and to formulate the ideology and the basic principles of using the convergence of nano-, bio-, informational, cognitive, and socio-humanitarian (NBICS) sciences and technologies as a tool to create a nature-like technosphere.

An innovative educational system in the field of convergent sciences and technologies was formed under the guidance and with direct participation of M V Kovalchuk with the purpose of forming a personnel base for interdisciplinary studies and work. As far back as 2005, the Chair of Nanosystem Physics was founded on his initiative at Lomonosov Moscow State University, and the Faculty of Nano-, Bio-, Informational, and Cognitive Technologies (the first in the world) was organized and headed by him in 2009 at MPTI. In 2011, M V Kovalchuk became the Dean of the Faculty of Physics at St. Petersburg University. Before that, he had founded at the same faculty the Chair of Nuclear-Physical Research Methods.

Working at different synchrotron centers around the world at the beginning of his scientific activity, Mikhail Valentinovich realized the importance and high research functionality of complex mega-installations. A qualitatively new stage of employing mega-installations began for M V Kovalchuk in the period of work at the Kurchatov Institute, which traditionally developed breakthrough scientific disciplines at large-scale facilities, such as accelerator complexes, thermonuclear facilities, and neutron and synchrotron sources.

The scientific program intended first of all to carry out interdisciplinary scientific research at these large research facilities was created on the initiative and with the direct participation of M V Kovalchuk in the NRC 'Kurchatov Institute'. Realization of this program made it possible to carry out research work at a qualitatively new level in many areas of modern science: from power engineering, convergent technologies, and elementary particle physics to high-tech medicine, biology, and information technologies.

To implement this program, a pilot project for the creation of the first national research center (NRC) was initiated according to an edict of the President, Russian Federation. By the decree of the RF Government of 31 December 2010, M V Kovalchuk became the first Director of NRC 'Kurchatov Institute' under the aegis of which a considerable part of the nuclear–physical and materials-science potential of the country is now united.

By the decree of the President, Russian Federation of 7 December 2015, M V Kovalchuk was appointed President of NRC 'Kurchatov Institute'.

Owing to M V Kovalchuk's intense activity, the position of Russia in such global international scientific projects as the Large Hadron Collider (LHC, CERN), the international thermonuclear experimental reactor (ITER), and the European accelerator center for research with heavy ions and antiprotons (FAIR) has strengthened substantially in recent years. M V Kovalchuk is an initiator and visionary of the participation of Russian Federation as one of the main partners in the project to create the European X-ray Free Electron Laser (XFEL) in Hamburg, Germany.

In recent decades, a whole number of important areas of applied research and design for the purpose of national

security have been renewed at the NRC 'Kurchatov Institute' on the initiative of M V Kovalchuk.

Along with hydrogen safety of nuclear power stations, the research work in the field of bulk combustion and explosion of fuel–air mixtures conducted under the scientific guidance of Mikhail Valentinovich suggested a new approach to the solution to problems of safety and stability of the fuel-energy complex.

The formulated conception for the forward development of nuclear medicine on the basis of nuclear–physical research centers has been supported by the authorities of the country and is being successfully realized today in the Moscow and St. Petersburg regions.

The organization at NRC 'Kurchatov Institute' of pilot-scale production of second-generation high-temperature superconductors opens up the prospect of designing new systems of electromotion, electric energy transport, and new electrotechnology.

Small nuclear power engineering facilities, together with systems of direct energy conversion, are now being worked out under the guidance of M V Kovalchuk in conjunction with SC Rosatom.

Another important trend is connected with solving the problem of the life-cycle closure at nuclear energy facilities. In 2015, the NRC 'Kurchatov Institute' designed and delivered to SC Rosatom a modern complex for submarine reactor-compartment storage and nuclear waste reprocessing (Saida-Guba).

Work based on the application of natural-science methods for studying cultural heritage objects has begun in recent years on the initiative of M V Kovalchuk at NRC 'Kurchatov Institute'. This is an important stage in the development of historical materials science.

Since 2001, M V Kovalchuk has been member of the Presidium of the Committee under the RF President on Science and Education, in which he was Academic Secretary from 2001 to 2012. He is Chairman of the National Committee of Russian Crystallographers, and since 2006 he has been editor-in-chief of the RAS journal *Kristallografiya*.

M V Kovalchuk greatly focuses on popularization of scientific knowledge. Since 2007, he has been the author of and conducted the popular scientific series 'Stories from the future' on TV. Over 200 programs have already been on discussing the most topical subjects and avenues of investigations in science and technology.

M V Kovalchuk is a laureate of Russian Government prizes in science, engineering and education; he was awarded the orders ''For merits for the Fatherland'' of IIId and IVth degree, and is laureate of the E S Fedorov Prize of the RAS Presidium.

Colleagues and friends of Mikhail Valentinovich Kovalchuk heartily extend their best wishes on his jubilee and wish him inexhaustible energy, creative inspiration, and new discoveries and achievements for the benefit of Russian science.

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