ISSN 1063-7745, Crystallography Reports, 2018, Vol. 63, No. 2, pp. 155–157. © Pleiades Publishing, Inc., 2018.
Original Russian Text © M.V. Koval'chuk, 2018, published in Kristallografiya, 2018, Vol. 63, No. 2, pp. 173–175.

First Russian Crystallographic Congress: From Convergence of Sciences to Nature-Like Technologies

M. V. Koval'chuk

Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics," Russian Academy of Sciences, Moscow, 119333 Russia

National Research Centre "Kurchatov Institute," Moscow, 123182 Russia

e-mail: koval@rrcki.ru

Received November 9, 2017

For the last 100 years, crystallography has passed a complex and interesting way: from descriptive mineralogy; through chemistry, chemical analysis, and new crystal growth technologies; to physics (X-ray diffraction analysis, physical materials science) and then to biology and protein crystallography. Actually, the starting point in the development of modern crystallography is the discovery of X-ray diffraction. Specifically X rays revealed the complex, three-dimensional, and periodic structure of all materials surrounding us.

DOI: 10.1134/S1063774518020116

The first stage in the development of crystallography was related to copying natural structures and processes. This approach laid the foundation of the commercial technologies of artificial crystal growth. As early as in the first years of the existence of the Institute of Crystallography, the ideology of its scientific development was based on the growth–structure–properties triad and implied a deep mutual relationship between these concepts. The second stage was characterized by the development of methods for structural analysis, investigation of crystal structures by these methods, and transition to bioorganic crystals. The next (modern) stage is a radically new transition from:

(i) crystals to unstructured media and living systems;

(ii) macroobjects to micro- and nanoobjects;

(iii) three-dimensional to two- and one-dimensional structures;

(iv) diffraction to non-diffraction methods based on X-ray scattering, such as small-angle scattering, effects under total external reflection conditions, etc.

The methodology of crystallography has determined the way in which it evolved: from copying nature to design of artificial objects having no analogs in nature. It has developed from highly specialized mineralogy into a complex interdisciplinary science, whose essence is combination of the possibilities provided by geology, chemistry, physics, and (in the further stage) biology and the advances in these fields of science. This interdisciplinary approach has become a methodology of the 21st century science, when simultaneous summation of advances in many disciplines provides a breakthrough and a radically new result.

To date, we have reached a stage where the further development of science, education, and industry is possible only on the interdisciplinary basis, convergence, and interpenetration of sciences and technologies, because nature is convergent in its essence. This interdisciplinary symbiosis of nanotechnological approaches and achievements in molecular biology, bioengineering, genetic engineering, information technologies, and cognitive and socio-humanitarian sciences can be considered as a base for developing technologies of a new class: nano-, bio-, info-, cogno-, and socio- (NBICS) technologies. They will make it possible to elaborate anthropomorphic technical systems similar to living-nature designs. Hybrid nanobiosensor systems and biorobotechnical systems are to be developed based on the technologies of atomic–molecular design and self-organization.

An event important for the crystallography development occurred in Moscow in 2016 (November 21–26): the First Russian Crystallographic Congress was held. Russia scientists were united at the congress to develop modern crystallography as a methodology of 21st century interdisciplinary studies. The Congress was focused on the discussion of the role of the interdisciplinary crystallographic approach in the passage from convergence sciences to nature-like technologies. The Congress was organized by the National Committee of Russian Crystallographers; National Research Centre "Kurchatov Institute"; and Shubnikov Institute of Crystallography, Federal Scientific Research Centre "Crystallography and Photonics," Russian Academy of Sciences. The chairman of the congress was the President of the National Research Centre "Kurchatov Institute"; Corresponding Member of the Russian Academy of Sciences; leading scientist in the fields of crystallography, X-ray physics, and nanodiagnostics; professor Koval'chuk.

The congress became a uniting platform for experts working in most diverse fields of modern science: crystallography, physics, biology, chemistry, materials science, medicine, sociology, history, study of art, archaeology, nanotechnologies and information technologies, photonics, cognitive psychology, etc. The program of the congress included plenary reports, six thematic sections (Modern Crystallography, Methods and Technique of Structural Studies, Crystallography in Biology and Medicine, Crystallography and Cognitive Studies, Crystallographic Methods in Humanitarian Sciences, and Educational Aspects of Modern Crystallography), and eight microsymposia. Questions related to the technologies of fabricating materials for solar power engineering and micro- and nanoelectronics; superconducting materials; and construction, composition, chemically resistant, and radiation-proof materials were considered in them. The methods for studying the structure of new materials and the questions related to the development of modern instrumental base, necessary for solving crystallographic problems and carrying out investigations for the benefit of adjacent (including humanitarian) sciences, were discussed.

The Congress demonstrated a high activity of the Russian scientific community. The total number of Congress participants was about 2000; this is a very large value, exceeding the number of participants of the 24th Congress of the International Union of Crystallographers (held in August 2017). Representatives of more than 150 Russian scientific organizations from 27 regions and 60 towns of Russia took part in the First Crystallographic Congress.

Despite the fact that the primary purpose of the congress was to consolidate Russian crystallographers, about 20% of the reports declared in the congress program were presented in cooperation with foreign partners. This means that the scientific cooperation is not interrupted but continues in spite of the deterioration of the political relationship. Representatives of the International Union of Crystallographers and heads of leading European research centers were invited by the organizing committee and took part in the work of the congress in Moscow. Note that the role of Russia in the world (and especially European) science has greatly increased for the last 15 years. Russia is involved in all megaprojects implemented by the world scientific community in Europe: CERN, FAIR, ITER, XFEL, and ESRF. In other words, Russia is not only open to international cooperation but demonstrated a will to it by having entered the European megaprojects and supported them financially and, in many cases, intellectually and technologically.

The inauguration of the European X-ray free-electron laser (XFEL) was held on September 1, 2017. The XFEL project, based on the developments of Russian scientists and the significant intellectual and financial contribution from Russia, is a unique complex for carrying out studies primarily in the field of nano- and biotechnologies. The use of extremely bright and ultrashort coherent X-ray pulses will make it possible to investigate the dynamic processes in the nanoworld, due to which the studies in the field of crystallography and its applications can be raised at a new level.

A separate microsymposium devoted to megascience, its state and prospects, and the role of Russia in the development of megascience in the world, was organized at the congress. The questions concerning the modern infrastructure of research reactors, accelerators, and synchrotron radiation sources in Russia and the research problems solved using these facilities were discussed within this microsymposium. Modern crystallography cannot be imagined without the use of synchrotron radiation. This radiation is a universal research tool, which helps researchers to see (at the level of atoms and molecules) and understand how various materials were formed in nature and how atoms and molecules interact with each other, study these processes, and apply them to design new materials and technologies. It was reported at this microsymposium about the research possibilities of the Kurchatov Synchrotron Radiation Source (KSRS-Kurchatov), which was open on October 1, 1999, and remains to be the only specialized synchrotron radiation source in the former Soviet Union space. The area of the experimental room of this synchrotron is almost 16 000 m^2. In total, there are more than 15 working experimental stations on the large Kurchatov accelerator. These stations serve as an instrumental base for studies in the field of nanodiagnostics, nanobiotechnologies, microelectronics, medicine, materials science, and archaeology. Currently, the existing stations are upgraded, and ten new experimental stations are being designed. A neutron research complex based on the IR-8 reactor is mounted on the same platform as the synchrotron; this configuration provides unique possibilities to solve successfully many problems in various fields of science, applying complementary techniques based on the use of neutrons and gamma radiation in a wide wavelength range.

With allowance for the accumulated experience and existence of promising problems, a concept of a radically new supermodern synchrotron radiation source of the fourth generation is being developed. The elaboration of such large scientific facilities for structural studies, including their filling with content and maintenance, is a very important and even strategic problems. These domestic megafacilities, possessing unique research possibilities, provide a high level of Russian science; its self-sufficiency; and, finally, technological independence of Russia.

Two subject areas that are new for the Russian crystallographic society were discussed at the congress: application of crystallographic methods for cognitive studies and in humanitarian sciences. The studies of cultural heritage sites by modern physical methods are being developed throughout the world both at art and historical museums, historical institutes, and natural science centers. The National Research Centre "Kurchatov Institute" has concentrated the most up-to-date equipment for elemental, phase, and X-ray fluorescence analysis; X-ray tomography and introscopy; gas chromatography and mass spectrometry; microanalysis and electron microscopy; genome analysis; magnetic resonance tomography and computer tomography; 3D scanning; etc. Obviously, this complex interdisciplinary approach provides most complete and reliable results.

Particular attention was paid at the Congress to the educational aspects in modern crystallography. As the participants of the Congress said, if crystallography is considered to be a methodology of new science, experts in this field of knowledge should be trained appropriately. Even now, it is necessary to pass gradually from highly specialized to interdisciplinary learning (by the example of crystallography and the institutions of higher educations the National Research Centre "Kurchatov Institute" closely interacts with).

Many talented, interested, and active youths took part in the congress. More than half of participants were young scientists, students, and even schoolchildren. A competition among young participants was performed within the poster session, at which about 400 reports were presented. A jury consisting of well-known scientists considered the presented reports and selected 15 best ones, whose authors were awarded with letters of commendation and prizes.

Crystallography, with its interdisciplinary essence, is expected to play a very important role in the development of convergent sciences and formation of nature-like technosphere. The congress became a large-scale scientific event and a platform for discussing urgent questions of interdisciplinary science. An important task is to develop communication both within the crystallographic community and between the scientific communities dealing with crystallography and using its tools.

According to the results of the congress, one can conclude that all the tasks put before it were performed completely, specifically:

(i) the congress gave a strong impetus to the development of communication within the Russian scientific community, which uses crystallographic tools to solve interdisciplinary problems;

(ii) the immense operation scope (in both geography and list of problems) of scientific sections at the congress made it possible to analyze in detail the achievements and new results obtained in different lines of research in crystallography and adjacent fields of science;

(iii) new fundamental and applied directions of crystallography development were determined;

(iv) talented youths were involved in the solution of urgent problems of crystallography.

The First Russian Crystallographic Congress has become an important stage in the elaboration of suggestions aimed at solving urgent problems of the priority lines of research in science and technology in the Russian Federation. In addition, the development of fundamental aspects and methodology, as well as the obtainment of new scientific solutions in crystallography, are necessary conditions for forming national policy in education. Thus, the congress contributed to the competitiveness, stable economical development, and national safety of Russia.

REFERENCES

1. M. V. Koval'chuk, Crystallogr. Rep. **56** (4), 539 (2011).
2. M. V. Koval'chuk, O. S. Naraikin, and E. B. Yatsishina, Vopr. Filosofii, No. 3, 3 (2013).

Translated by Yu. Sin'kov