SUMMING UP THE YEAR

In 2018, the National Academy of Sciences (NAS) of Ukraine duly fulfilled its key tasks, and its scientists obtained a number of significant results in a broad range of basic and applied research.

Mathematicians, for example, proposed effective methods to analyze resonance phenomena in mathematical models of physical and biological processes. Experts in informatics developed a novel information technology for protecting delegated remote computations from unsanctioned interventions. Academy's specialists in mechanics produced scientific methodology for analyzing the longitudinal stability of the new 'Tsiklon-4M' two-stage space vehicle now developed at the State Enterprise 'M.K. Yangel "Pivdenne" Design Office'. Physicists, in collaboration with their German and Israeli colleagues, experimentally discovered electromagnetic radiation generated by vortices moved by magnetic field. Geographers developed the concept of the atlas-based geo-information model of the current state of our country's cultural heritage.

For several years, scientists of the NAS of Ukraine have been involved in the research at the Large Hadron Collider (LHC), and last year they contributed to the discovery of a new doubly charmed particle. Its intriguing characteristic is the unusually long lifetime by the standards of attometer space of quarks and gluons. Precision measurements of solar neutrino fluxes generated by the proton-proton cycle were performed at the Borexino detector, and an evidence of the high metallicity of the Sun's interior was found. By the way, this result was published in the most famous and prestigious *Nature* journal. Under the EUROfusion program, which Ukraine joined as an associate member in 2017, the feasibility of controlled thermonuclear fusion was studied.

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Last year, NAS chemists were the first to obtain quantum dots of inorganic perovskites in the zeolite matrix with a high (up to 80%) photoluminescence quantum yield. Collaborative research of physicists, chemists and biologists showed that mechanochemically produced graphene-like tungsten disulfide is able to hinder the formation of amyloid-type structures, which can cause various human pathologies, in the lysozyme — the enzyme that ruins bacterial envelopes. Microbiologists successfully worked on the development of modern veterinary vaccines that would contain nanoparticles of silver and copper. Plant breeders continued to create new winter wheat varieties demonstrating high drought tolerance in severe climates and producing grain yields of 80-100 centners per hectare. Scientists in zoology, botany and mycology described over 100 new taxa (species and genera of living and fossil organisms) from nearly all parts of the world.

Scholars in socio-humanities studied the issues of society consolidation and migration and, relying on the results of that research, presented two national reports. In 2018, the work on multi-volume projects was going on (such as the 30-volume "Encyclopedia of Modern Ukraine", whose electronic counterpart takes the second place after *Wikipedia* among the most popular encyclopedic reference sources in Ukraine). A number of fundamental works were

also published, among them being "Ukrainian Folkloristic Encyclopedia", "Ecclesiastical Art in Ukraine", "Ukrainian Vocabulary of the Late 18th — Early 21st Centuries", "Encyclopedia of International Law", "Academy Sociology in Ukraine (1918-2018)".

The results of applied research conducted by Academy institutions are also worth of notice. For example, scientists in mathematics and mechanics developed a multi-purpose method of planning and stabilizing the motion of dynamic systems under limited control resources. Experts in cybernetics created CKIT4.5AI supercomputer for solving the problems of machine learning, which was already employed by the users of the Ukrainian National Grid. Metal physicists synthesized superlight aluminum–manganese alloys whose mechanical properties combine stable deformation plasticity with double strength. A radically new method of mine waters desalination by means of self-contained facility independent of power supply and having the capacity of 15 million cubic meters per year was developed. Materials scientists studied the feasibility of the simultaneous explosion welding of three-layered composite armor material; they also developed a technique to determine welding and heat treatment regimes, as well as estimated the shielding strength of multi-layered armor. During fundamental research at CERN, our scientists advanced the idea of metal foil detectors, which later formed the basis for developing a unique plasma chemical technology of producing super thin micro-strip metal sensors.

Chemists developed methods of synthesizing calixarenes that contain paracetamol in the macrocycle structure and are much superior in terms of their anti-edema and anesthetic action than both the initial paracetamol and sodium diclofenac. In collaboration with medical scientists, a thermoelectric device for measuring the heat flow from the eye surface was developed; it is intended for the diagnostics and monitoring of ophthalmological diseases. 'Helicotester' medical sensor device used for non-invasive express diagnostics of stomach helicobacteriosis was upgraded. A foaming agent for firefighting that uses fresh water was developed on the base of surfactants and eco-friendly additives.

Scientists in economics elaborated a system of indices for monitoring the achievement of Sustainable Development Aims at the regional level and conducted monitoring of Ukraine's regions advancement in 2011-2016. Detailed studies of the dramatic socio-political processes taking place in our country are going on. Legal scholars of the Academy produced recommendations concerning the feasibility and traits of peacemaking operation in Donbas. Historians analyzed the international experience of using sanction instruments in the context of its application for terminating the Russian military aggression against Ukraine. Experts in library science examined the peculiarities of negative information impacts during hybrid war and the problems of their neutralization.

Numerous Academy research outcomes are already used in practice or are being prepared for use in the immediate future. For example, in April 2018 consular offices of the Ministry of Foreign Affairs of Ukraine started to employ the E-Visa system developed by our informatics experts and intended for submitting visa applications on-line to obtain electronic visas. The work towards extending the operation life of the power units of Ukrainian NPPs was continued: last year NAS nuclear physicists involved in those activities examined witness specimens and conducted monitoring of the radiation load of the reactor vessel in power unit #2 at the Pivdenno-Ukrainska NPP. Relying on the research results obtained, they showed that the safe operation of that reactor vessel is possible until at least 2039; they also determined the irradiation of the supporting elements of reactor vessel in power unit #1 at the Khmelnytska NPP. Academy scientists adapted and deployed the RODOS-Ukraine information system of the online real-time decision support for emergency management in nuclear accidents for the conditions of the Chornobyl Exclusion Zone, including the forecasts of fire impacts. M.M. Gryshko National Botanical Garden of the NAS of Ukraine started to implement a major investment and social project that envisages the arrangement of a tactile (sensory) garden for visitors with disabilities, primarily, those with vision impairment.

Applied developments of the Academy deserve special notice. Since 2015 that work has been carried out under the targeted S&T program of the NAS of Ukraine 'R&D for enhancing the defense potential and security of the state'. To protect personnel and military equipment, promising armored structures were developed for extra protection of light-armored vehicles and aircraft cabins, as well as camouflage coatings for minimizing the military equipment noticeability in the super high-frequency, high-frequency and IR ranges. In the field of restoration and renovation of military and specialized equipment, Academy scientists developed novel technologies for the treatment of rifle bores to improve their

durability; up-to-date technologies to extend the operation life of aircraft and armored vehicles; technologies for laser and arc welding of thin-walled elements of missile rudders and nozzles, as well as technologies for underwater welding of battleship hulls during emergencies. In the field of military medicine, researchers proposed new biological materials for bone tissue regeneration, innovative wound dressing materials and combined means for stopping major bleedings, a technology for low-temperature storage of donor blood cells. Besides, radio physicists of the NAS of Ukraine developed an X-range radar station for the detection and classification of moving objects. Astronomers created an automated digital optical reconnaissance system intended for the exact determination of the coordinates of moving and stationary objects and transmitting the relevant information to the processing center. Materials scientists carried out an industrial check of the technology for producing all-cast, fragmented and armored cases and other elements for M60, M82, M120 mortar mines made of special and high-strength cast iron, and manufactured a pilot batch of those products for field tests. Under the assignment of the State Enterprise 'M.K. Yangel "Pivdenne" Design Office', researchers of the Academy developed an effective method of high-precision visual navigation for high-speed aircraft and a set of programs for the navigation of modern tactical missiles and unmanned aircraft. In general, the research aimed at the development of new science-intensive products of defense and dual purpose is one of the top-priority tasks of the NAS of Ukraine.

Alongside the basic and applied research in the priority science areas, scientists of the Academy continued to perform other socially important functions, in particular the expert and educational ones.

Regrettably, despite the immense contribution of science to the progress of Ukrainian society and the strengthening of Ukrainian statehood, funding of the Academy is still insufficient, meeting only about 70% of its needs. Last year, we lacked nearly ₴ 311 million for paying salaries in the regime of full working week. In 2019, the expected deficit of the salary fund will amount to approximately ₴ 330 million. Yet, there were some positive changes, the main of which was the launch, through the initiative of the Finance Ministry of Ukraine and the Academy, of the new public research program 'Support to the advancement of priority areas of scientific research' with the funding of ₴ 500 million. Its special feature is targeted and addressed nature. The funding under this program was provided to NAS research institutions for performing priority scientific research and R&D activities. The funding was channeled to those research units of Academy institutions that, according to the results of expert evaluation, produced significant scientific and practical results, won the highest national and international appreciation. Finance was also allocated for competitive scientific research projects and S&T developments that are of the utmost importance for the nation, including those with a high degree of readiness; for setting up youth laboratories and teams of young scientists; for conducting collaborative international scientific research; for procurement and upgrading of research equipment etc. This public research program is a kind of testing of the new model of finding the research activities of the NAS of Ukraine. Of great importance is the fact that an integral part, or even the foundation of this model, is the objective assessment of the efficiency of each institution's activities, both at large and of each of its scientific units, without any exceptions.

Due to the state support, numerous large-scale events were organized by the Academy to honor its great — 100th — jubilee, which was marked both across Ukraine and abroad, since it was entered in the UNESCO Calendar of Anniversaries. In general, the jubilee 2018 year was eventful and intense for the Academy, yet an interesting and important one. I hope its positive reverberations will stay in the society for long.

President of the National Academy
of Sciences of Ukraine
Academician  B.E. Paton

CELEBRATION OF ACADEMY'S JUBILEE

In November 2018, it was 100 years since the establishment of the National Academy of Sciences of Ukraine. Academy's jubilee became an outstanding event not only for its scientists but also for broad circles of Ukrainian and international public. By the decision of the 39th Session of the General Conference of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the centenary of the National Academy of Sciences of Ukraine was entered in the Calendar of Jubilees to be marked by UNESCO in 2018.

The official celebration of the 100th anniversary of the National Academy of Sciences of Ukraine — the jubilee session of the NAS General Meeting and a festive concert — took place on 7 December 2018 in Taras Shevchenko National Opera and Ballet Theatre of Ukraine. The event was attended by P.O. Poroshenko, President of Ukraine; V.B. Groysman, Prime Minister of Ukraine; G.G. Zubko, Vice Prime Minister of Ukraine — Minister of Regional Development, Building and Communal Services of Ukraine; L.M. Hrynevych, Minister of Education and Science of Ukraine; Ye.M. Nyshchuk, Minister of Culture of Ukraine; O.V. Spivakovskyi, First Vice-Chairman of the Verkhovna Rada Committee for Science and Education, People's Deputy of Ukraine, other Ukrainian high authorities, as well as representatives of Ukrainian and foreign scientific circles, Ukrainian mass media, and creative intellectuals.

Ukrainian President Petro Poroshenko in his greeting speech pointed out that in the years of its existence the Academy turned into one of the most powerful European scientific centers, the results of its scientific activities made Ukraine famous in the whole world. He stressed that Ukrainian science is at the forefront in electric welding, space-rocket industry, cybernetics, energy engineering, materials science and emphasized an important role of the NAS of Ukraine in enhancing the defense potential of the state. According to the President, the Academy has always been national — in the highest sense of this word, and that is crucial. After the speech, the President of Ukraine presented state awards to twelve of the Academy scientists whom he honored in his ordinance issued on the occasion of its centenary.

Separately, President Petro Poroshenko congratulated Boris Paton, President of the National Academy of Sciences of Ukraine, on his 100th anniversary. He marked that simultaneously with the Academy an eminent scientist and the undeniable leader of Ukrainian science was born and was to head the NAS of Ukraine for the greater part of its history. The President of Ukraine expressed his deep respect for Boris Paton, wished him strong health and joy with his work and with the people who are around him, and handed him the Order of Prince Yaroslav the Wise II Class.

Premier Volodymyr Groysman also addressed the audience with greetings. He stressed that Ukraine, as a large European state, is to remain a leader in science and technologies, be economically strong, and that cannot be achieved without the proper support to science and the development of technologies.

Academician Boris Paton, President of the NAS of Ukraine, thanked President Petro Poroshenko for the high praise to the work of Academy's scientists and for his speech that was full of understanding of the current state of science, scientific and technical progress, the true concern for their fate. He also expressed his gratitude to Volodymyr Groysman — a co-chairman of the Organizing Committee for preparing and marking the 100th anniversary of the National Academy of Sciences of Ukraine, Prime Minister of Ukraine — for his warm words addressing Academy's scientists and hard work on the preparation of festive celebrations.

The manifestation of the genuine interest to the jubilee of the National Academy of Sciences on the part of international scientific community was the participation in the jubilee session of the delegations of UNESCO, the Association of the European Academies of Sciences (ALLEA), the International Association of the Academies of Sciences (IAAS), the International Institute of Applied Systems Analysis (IIASA), the German Research Foundation (DFG), and the academies of sciences of Austria, Azerbaijan, Belarus, Bulgaria, Vietnam, Armenia, Georgia, Estonia, Kazakhstan, China, Lithuania, Moldova, Germany, Poland, Slovakia, the USA, the Czech Republic, Sweden, as well as representatives of foreign embassies to Ukraine.

The jubilee session was preceded by the exhibition of scientific and S&T achievements held in the 'Science' pavilion of the NAS of Ukraine on 6-7 December 2018. Scientists affiliated with 70 Academy institutions presented over 600 their research results in a broad range of fields — from information technologies to new plant varieties, as well as a number of academic publications. Concurrently, in the framework of this event a specialized presentation exposition of NAS R&D results and technologies 'Science — to the State Defense and Security', visited by O.V. Turchynov, Secretary of the National Security and Defense Council of Ukraine, and a round table talk 'Defense research of the NAS of Ukraine and the deployment of results. Prospects' were held. The latter was attended by the representatives of the Ministry of Defense of Ukraine, the General Staff of the Armed Forces of Ukraine, the State Space Agency of Ukraine, the 'Ukroboronprom' State Concern, Civil Union 'League of Defense Enterprises of Ukraine' and NAS experts. It discussed important issues of involving the national scientific potential in enhancing the defense capability of the state.

Grand meetings of scientific communities were held in major science centers of Ukraine — Dnipro, Lviv, Kharkiv, Odesa. They were attended by active members (academicians) and corresponding members of the NAS of Ukraine, the national sectoral academies of sciences, heads of Academy institutions, institutions of higher education, research scientists and academics, representatives of local authorities, trade unions etc.

Over the year, more than 400 jubilee scientific forums were held to mark NAS centenary: conferences, symposia, congresses, round table discussions etc. They included IX International Congress of Ucrainica Scholars (25-27 June, Kyiv), Gamow Astronomy Conference-School 'Astronomy and beyond: Astrophysics, Cosmology and Gravitation, Cosmomicrophysics, Radio Astronomy and Astrobiology' (12-18 August, Odesa), VI International Scientific and Practical Conference 'Nanotechnologies and Nanomaterials' (NANO — 2018, 27-30 August, Kyiv), the First Ukrainian Space Forum organized by the NAS of Ukraine, Space Research Institute NAS-SSAU and the SE '"Pivdenne" Design Office' (17-20 September, Kyiv), International Conference 'Welding and Related Technologies — Today and Future' (6-7 December, Kyiv), International Congress 'Scientific Potential of the Western Region of Ukraine in the Context of International Collaboration: Current Status and Development Prospects' (19-20 November, Lviv), International Scientific and Practical Conference 'Centenary of the NAS of Ukraine: Contribution to Studies of Migration Processes at the Turn of Millennium (27 November, Kyiv), the Forum of Ukrainian Research Diaspora 'Advancing Science through International Cooperation' (20-22 October, Kyiv) etc.

On 7 December 2018, the official celebrations of the 100th anniversary of the National Academy of Sciences of Ukraine – the jubilee session of NAS General Meeting and a festive concert – were held at Taras Shevchenko National Opera and Ballet Theatre of Ukraine

The editorial preparation and issuing of numerous jubilee editions was of considerable importance for popularizing scientific achievements of the Academy, informing broad public circles on its history and current work.

Among them was the deep generalizing study "The National Academy of Sciences of Ukraine. 1918-2018: the 100th Anniversary of its Foundation", "The National Academy of Sciences of Ukraine. Outstanding Achievements. 1918-2018". "The National Academy of Sciences of Ukraine. Chronology", "Membership of the NAS of Ukraine. 1918-2018", "Legal Status of the National Academy of Sciences: History and Present Day", "The Patons. Family Chronicles", "Helmsman of Ukrainian Science. Life and Achievements of B.E. Paton".

Fundamental achievements of the NAS of Ukraine, its history, scientific schools were also comprehensively covered by means of modern Internet technologies. The first version of electronic NAS museum was produced. A database of virtual tours presenting the research heritage of NAS institutions was compiled. The time-line of the historical view at

NAS activities, biographies of the founding scholars of the Academy, an interactive map of its institutions and memorial places were created.

To honor the Academy, its historical past and the memory of its eminent scholars, commemorative plaques were installed at the sites associated with the history of the NAS of Ukraine and the names of its renowned scientists. Toponymical objects in some communities were named and re-named after them. In particular, plaques commemorating well-known Ukrainian historians — Prof. I.O. Gurzhiy, Corr. Memb. of the URSR Academy of Sciences, and Prof. F.P. Shevchenko, Corr. Memb. of the URSR Academy of Sciences — were unveiled on the building of the NAS Institute of the History of Ukraine. The memorial plaque to NAS Acad. P.T. Tronko, Hero of Ukraine, was set on the facade of the central building of V.N. Karazin National University of Kharkiv. A decision was made to place a new commemorative plaque honoring Acad. V.I. Vernadsky in Kyiv, in 36 Yaroslaviv Val Str., where the first General Meeting of the Ukrainian Academy of Sciences was held. A portrait gallery of Academy Presidents was created and demonstrated in the building of NAS Presidium.

To honor NAS. Acad. P.T. Tronko, Hero of Ukraine, the streets in Kyiv and Kharkiv were named after him. Through the initiative of V.M. Koretsky Institute of State and Law of the NAS of Ukraine, one of the streets in Hlukhiv (Chernihiv Oblast) was named after Mykola Vasylenko. The issue of re-naming Kyiv streets in honor of NAS academicians P.H. Kostyuk and V.P. Kukhar is now under consideration.

In October 2018, the National Bank of Ukraine put into circulation ₴5 and ₴10 memorial coins '100 Years of the National Academy of Sciences of Ukraine'. An artistic postage stamped envelope devoted to NAS centenary and a postal stamp honoring B. Paton's 100th anniversary were issued.

Celebration events of the NAS of Ukraine were broadly covered by mass media, drawing attention of the society to science and prospects of its further advancement. Side by side with professional journalists, Academy's scientists joined the process: they made an active contribution to covering the activities of NAS institutions in the central and local newspapers, on the radio and TV, in social networks on the Internet. In the framework of the 'Morning with Inter' program, the *Inter* TV channel demonstrated video stories about the NAS of Ukraine. A number of TV programs, radio and TV interviews given by Academy's scientists on the research achievements and history of the NAS of Ukraine were issued. Large review articles were published in the *Den* and *Dzerkalo Tyzhnia* newspapers etc. A journalistic documentary dedicated to NAS centenary was produced and demonstrated during the celebrations of the Academy jubilee.

On the occasion of the 100th jubilee of the NAS of Ukraine, by the ordinance of the President of Ukraine of 07.12.18 #414, 31 scientists of the Academy received state awards, 58 scientists — awards of the Verkhovna Rada of Ukraine, 30 — awards of the Cabinet of Ministers of Ukraine. Academy employees were also awarded with NAS distinctions — memorial distinctions honoring the 100th NAS anniversary, with jubilee honorary diplomas, honorary diplomas of NAS Presidium and the Central Committee of NAS Trade Union, commendations, NAS distinctions 'For Research Achievements', 'For Training Young Scientists', 'For Achievements in Profession', 'For Contribution to Science Advancement', 'Talent, Inspiration, Work'.

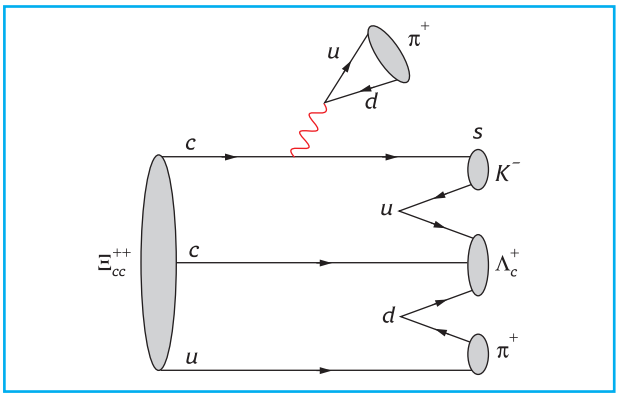
Undoubtedly, the celebration of Academy's centenary assured the society of the prospects of Ukrainian science and the ability of the National Academy of Sciences of Ukraine, with its rich traditions and powerful potential, to meet modern challenges. At the same time, marking of the NAS jubilee at the national level became, according to scientists, not only the recognition of its achievements, but it also induced a profound discussion of the role and place of science in modern society, promoted close communications of science with the authorities and society.

RESEARCH ACHIEVEMENTS. NATURAL AND ENGINEERING SCIENCES

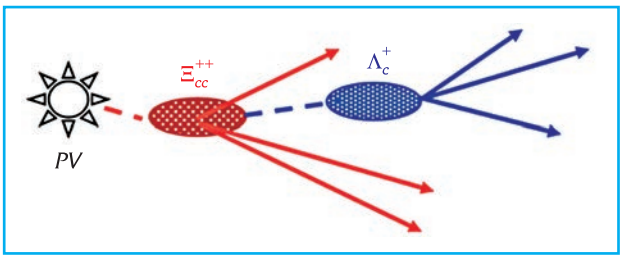
Discovery of New Doubly Charmed Particle at the Large Hadron Collider

A new doubly charmed particle was discovered at the Large Hadron Collider (CERN, Geneva) in the LHCb Collaboration, involving scientists of NAS Institute for Nuclear Research. The intriguing property of the new baryon with two charm quarks Ξ_{cc}^{++} is its unusually long life ($2{,}5 \cdot 10^{-13}$ sec.), which is 10 billion times longer than the time of its formation (10^{-23} sec.) in proton-proton collisions with the energy 13 TeV.

The theoretical interpretation of the phenomenon of Ξ_{cc}^{++} long life is only possible at the junction of the Standard Model and the New Physics. The new particle, which is the product of the strong interaction of two high-energy protons, having been born at the primary vertex, proceeds through intermediate processes to the field of weak interactions, ending its long life (by the standards of the quark-gluon world) with the decay into lighter baryons.



Feynman diagram of the doubly charmed baryon Ξ_{cc}^{++} decay



Scheme of baryon Ξ_{cc}^{++} formation and decay

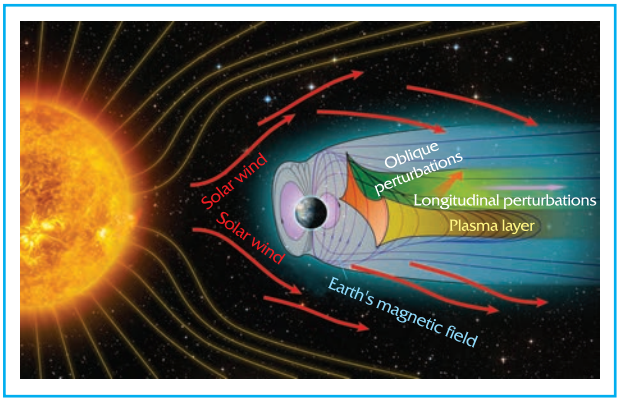
Further research is to clarify the role of the phenomena of New Physics, beyond the Standard Model, in these processes. These studies are scheduled to be reproduced at a greatly improved level after 2021, when the upgrading of the Large Hadron Collider and its experimental facilities is to be completed, including an important element of the LHCb detector — the radiation monitoring system. It was developed and in the last 10 years operated with the contribution of INR of the NAS of Ukraine.The investigations of the INR of the NAS of Ukraine were carried out with the grant support of the NAS targeted program 'Basic research in high-energy and nuclear physics (international cooperation, 2018-2020)' and in the framework of the activities of the International Associate Laboratory LIA IDEATE.

This scientific achievement became possible due to the associate membership of Ukraine in CERN, which opened up the opportunity for Ukrainian scientists to investigate fundamental properties of matter and interaction in the new energy range of up to 10^{13} eV, whose scale exceeds the energy of the traditional processes of nuclear fusion and fission by several billion times. Such high energy is sufficient for investigating the structure of matter in the new spatial region with the characteristic attometer sizes of objects (quarks, gluons) (10^{-18} m) and lifetime span of 10^{-26} sec.

V. Pugatch, O. Fedorovich, A. Kovalchuk

Wave and Turbulence Processes in Magnetotail of the Earth

A characteristic feature of today's space exploration is reliance on theoretical approaches and mathematical models that enable researchers to plan expensive experiments and verify their results with maximum efficiency. In particular, after processing the results of the measurements conducted under the CLUSTER international multi-satellite space project, it was established that plasma flows coming from the Sun (solar wind) generate wave and turbulence processes when they interact with the night side of the Earth's magnetic field. It was found that these processes, which play a significant role in



Interaction of solar wind with the magnetotail of the Earth

forming the space weather, are localized at the boundary of moving and stationary plasmas, i.e. are under conditions when the development of the Kelvin—Helmholtz instability becomes possible. This classical instability appearss as the growing oscillations of the interface between two mediums when there is a velocity jump. Such conditions are present in solar wind, comet tails and solar plasma structures.

Further analysis of the wave processes detected by satellites shows that the dominating role in their development is played by oblique perturbations that propagate at an angle with respect to the velocity vector. Although in the past, L.D. Landau and S.I. Syrovatsky had made a major contribution to investigating the Kelvin—Helmholtz instability, the stability and generation of oblique perturbations on the boundary of compressible plasma mediums in the presence of magnetic field and velocity jump remained unstudied.

Scientists of the Space Research Institute of the NAS of Ukraine and the State Space Agency, in collaboration with researchers of Max Planck Institute for Solar System Research (Germany), investigated this problem analytically and numerically, were able to find a rather simple mathematical model for its analysis and propose a new method of determining the form of oscillations. They derived an equation that relates the temporal and spatial scales of longitudinal and oblique wave modes localized at the velocity discontinuity. It takes into account the presence of magnetic field and the compressibility of the medium. The numerical analysis of the equation showed that for a single specified velocity of moving plasma eight different wave modes could be generated. Since in nature the velocity of plasma flows is always changing, the generation of a large number of wave modes is to be expected, which results in turbulence phenomena at the medium boundary. This conclusion coincides with the results of measurements made by spacecraft. It was established that of the eight possible modes only one can be unstable at the velocity jump. Analytical expressions for the criteria and characteristic time of instability development were obtained for this mode.

Hence, this new mathematical model extends and supplements earlier fundamental research of the Kelvin–Helmholtz instability in plasma mediums. It is this newly discovered unstable branch of oscillations that can be the source of the geomagnetic pulses registered on the night side of the Earth. This provides new opportunities for forecasting magnetic storms, their development and effect on technological and biological systems on the Earth.

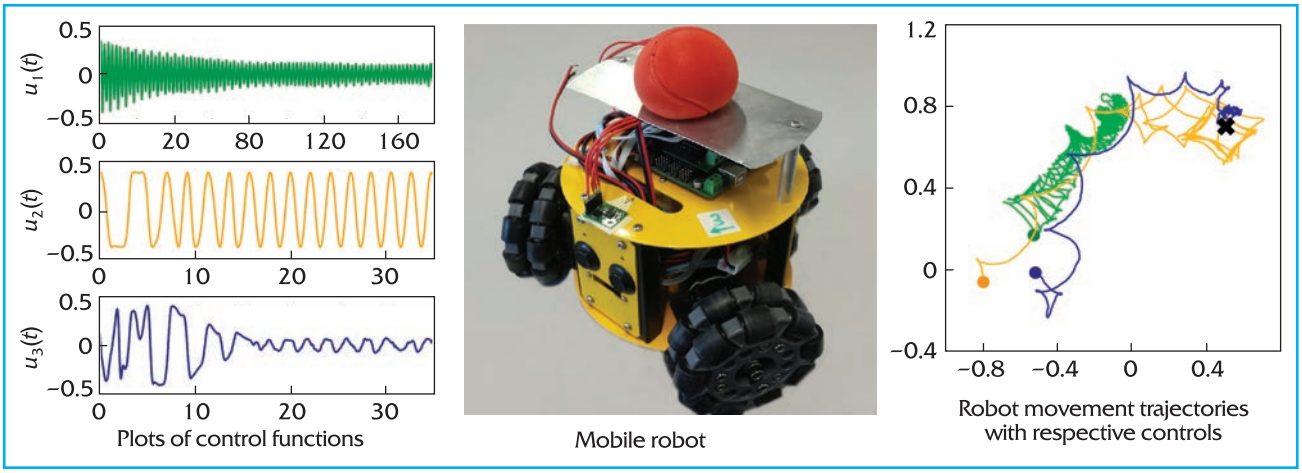
Magnetohydrodynamic waves and the Kelvin-Helmholtz instability at the boundary of plasma mediums. *Physics of Plasmas*, **25**, 102119 (2018).

O. Cheremnykh, S. Cheremnykh, L. Kozak, and E. Kronberg

Adaptive Control Algorithms for Dynamic Optimization Problems

In the framework of collaboration between the NAS Institute of Applied Mathematics and Mechanics and the Institute for Systems Theory and Automatic Control of the University of Stuttgart (Stuttgart, FRG), the problems of synthesizing control algorithms that optimize the motion of a dynamic system in terms of minimizing a certain value function were studied. The specific feature of the problem investigated is the limited nature of the information available, in particular, the optimum configuration of the system and the analytical expression of the value function are considered unknown *a priori*. Such a formulation of the problem is determined by the requirements of an important class of engineering tasks that appear in various fields of today's industry, such as maximizing the energy efficiency of solar batteries or wind turbines, optimizing the non-isothermal reactions, tracing the target of an unknown trajectory, coordination of multi-agent systems with limited information exchange etc.

The classical methods of control theory cannot be directly used to solve the formulated problem of dynamic optimization due to the lack of information concerning the analytical expression of the value function.



The results of the experiment on robot's search for the target with unknown coordinates. Three types of control were used: those proposed in the works by H.-B. Dürr et al. (u_1 (t), green), A. Scheinker et al. (u_2(t), yellow), V. Grushkovskaya et al. (u_3(t), blue). When the latter type of control was used, the highest precision and fluctuation extinction were observed

As a result of the investigation conducted, a new class of control functions was found for the problems of dynamic optimization; it is of both theoretical and practical importance. In terms of theory, this class generalizes a number of available algorithms of the search for extremum and provides new ways of control. From the practical point of view, the result obtained permits the synthesis of control algorithms with the necessary characteristics that meet various practical demands. Such properties include the increased algorithm precision and decreased amplitude variation; the ease of application; the reduced time of achieving the goal set; limited resource consumption (including computational facilities in computer operations) etc.

It is also important to note that in the majority of cases of using the available algorithms of the search for extremum the necessary system closeness to the optimum state is provided by choosing the sufficiently high frequency of control, while the system itself has sustained fluctuations. As opposed to such approaches, the description of a subclass of high-precision controls that lead the system arbitrarily close to the optimum state was obtained by using the signals of limited frequency. This provided a significant improvement in the methods of extremum-search theory and an increase in the efficiency of respective controls.

The research outcomes were tested at the Institute for Systems Theory and Automated Control of Stuttgart University by using them in a system for computer control of mobile robot movement trajectories. The experiments conducted allowed a direct demonstration of the advantages of this new algorithm, which provides a much higher precision and leads to the extinction of fluctuations. The results obtained open up new prospects in the theory of the optimization of complex dynamic and multi-agent systems, and have a broad potential for further development and practical implementation.

V. Grushkovskaya

Discovery of Electromagnetic Radiation Generated by Vortices Moved by Magnetic Field

Physicists of B. Verkin Institute for Low Temperature Physics and Engineering of the NAS of Ukraine (Kharkiv), in collaboration with academics of V.N. Karazin National University of Kharkiv and universities of Germany and Israel, experimentally found electromagnetic radiation generated by vortices moved by magnetic field. These vortices are known to exist in the so-called Shubnikov phase of semiconductors, which had been discovered in Ukraine in the past.

To observe this effect experimentally, the spatial modulation of semiconductor properties in nanoscales was carried out, and to intensify it, radiation coherence conditions were provided. That could be implemented due to the creation of a multi-layered structure in which superconducting molybdenum layers 2.2 nm thick were alternated with dielectric silicon layers 2.8 nm thick. Under the action of

current and magnetic field, such a superstructure emits an electromagnetic field: the system of superconducting vortices, moving as a whole, crosses dielectric layers, which intensifies the radiation generated by each vortex. It is of utmost importance that the frequencies of this radiation correspond to the radio frequency band, and by changing the current continuously, it can be blocked completely.

The discovery made can form the basis for developing super miniature broadband generators of microwave radiation that would cover the wave range from radio to sub-terahertz frequencies. Nano-emitters that contain nano-superlattices controlled by electric current and applied magnetic field can have numerous applications required by both civilian and defense industry sectors.

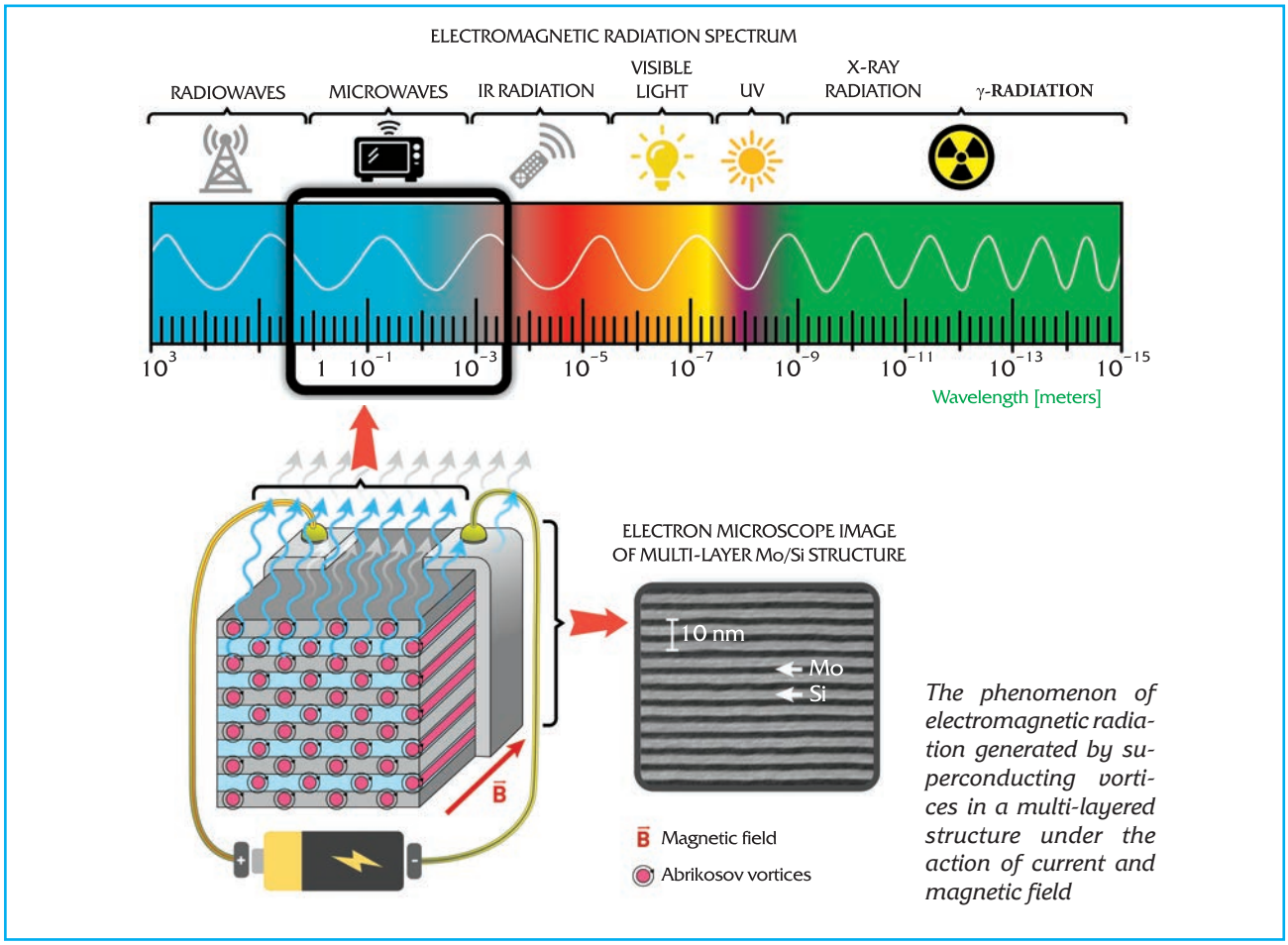
These research results were published in the high-rating scientific journal *Nature Communications* (vol. **9**, article number: 4927 (2018), https://doi.org/10.1038/s41467-018-07256-0).

M. Mikhailov, O. Yuzephovich

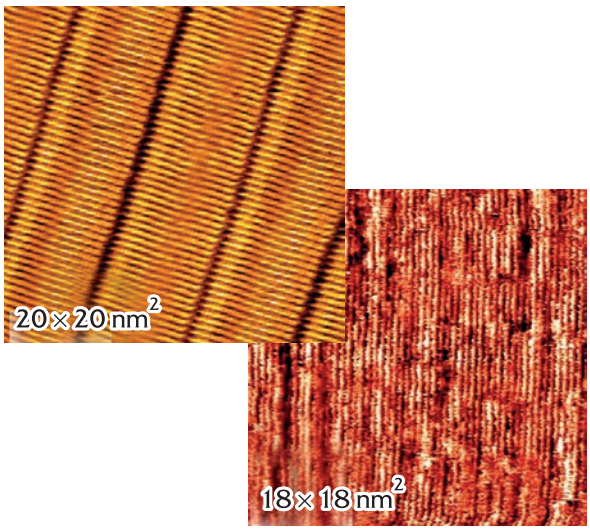
Anomalous Reduction of Friction in Monolayer Films of *n*-Alkane Binary Mixtures

Friction is one of the oldest physical problems with huge practical importance. In economically developed countries, the costs of overcoming friction amount to approximately 6% of GDP, so the reduction of friction by at least 1% can provide a considerable economic effect. Yet, despite many-year efforts, scientists were not able to achieve the full understanding of friction process.

It is common knowledge that friction between the surfaces in contact is caused by three main factors: the roughness of the surfaces in contact, the fluidity of the lubricating substance (its viscosity) and the interaction of lubricant molecules with the surface (the interface interaction). While the effect of the first two factors can be estimated in macroscopic experiments, the effect of interface interaction requires further detailed studies relying on non-destructive nanometer-scale measurements of friction coefficient, the preparation and stabilization of atomi-



The phenomenon of electromagnetic radiation generated by superconducting vortices in a multi-layered structure under the action of current and magnetic field



STM image of the monolayer: n-$C_{48}H_{98}$ (Left) and the binary mixture $C_{24}H_{50}$ + $C_{48}H_{98}$ (Right) on an atomically smooth graphite surface

cally smooth surfaces under non-vacuum conditions, as well as the studies of lubricating materials with precisely determined composition. These very problems were studied in depth at the physical electronics department of the NAS Institute of Physics, which proposed and implemented an innovative experimental method for measuring friction coefficient based on the pendulum levitating in magnetic field (*Tribology Letters*, 2018, 66-74). That made possible the first non-destructive studies of the tribological properties of monolayer molecular films.

The experiments were carried out on atomically smooth surfaces of graphite single crystals. One- and two-component monolayer films of normal alkanes $C_{24}H_{50}$ and $C_{24}H_{50}$ + $C_{48}H_{98}$ mixture (in equal concentrations) as lubricating films were studied for the first time ever. The film structures before and after measurements were determined with a scanning tunneling microscope (STM). It was established that all single-component monolayers have lamellar molecular packaging, in which each molecule is locked in its adsorption site (Left). In contrast to this, the STM image of the monolayer of $C_{24}H_{50}$ + $C_{48}H_{98}$ binary mixture (Right) proves that the long-range order in the mutual arrangement of molecules is absent due to their increased mobility along surface grooves (a 2d nematic phase is formed). By means of magnetic levitation tribometer, it was also found that this increased molecular mobility leads to an almost two-fold reduction of friction coefficient in mixed nematic monolayers as compared to the single-component ones. This effect was accounted for by the one-dimensional model proposed by O. Marchenko; it took into account at the atomic level the disproportionality in the periods of alkyl chain and graphite substrate. The result obtained can serve as the basis for the development of systems with reduced friction and test objects for nanotribology.

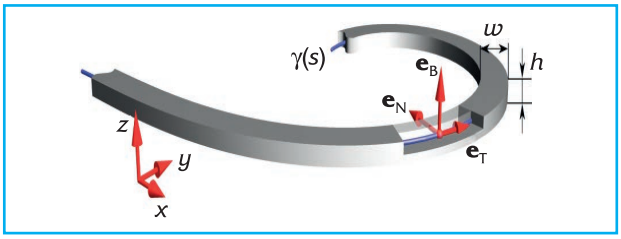
A. Naumovets, O. Marchenko, O. Braun, V. Kutsenko, A. Vasko, Ya. Lopatina, V. Cherepanov, A. Senenko

Domain Wall Drift in Ferromagnetic Nanowires under the Action of Curvature Gradient

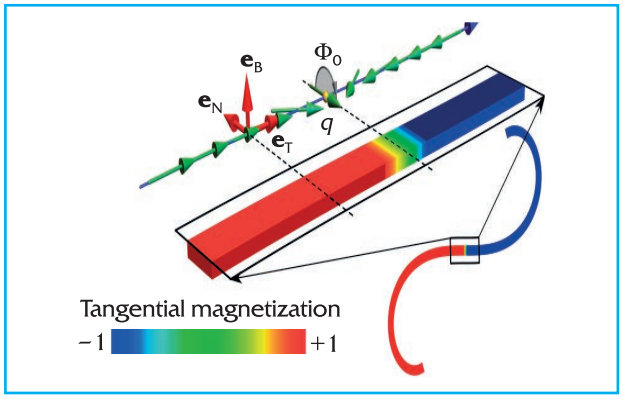
Computer manipulation of topological solitons in ferromagnetic structures is a promising spintronics area. The simplest soliton of this kind in ferromagnetics is a domain wall, or a boundary between two domains with different (usually opposite) orientations of magnetization.

Due to the topological preservation of their structure, domain walls, like other topological solitons, are stable with respect to local deformations of the magnetic structure, which are caused by temperature fluctuations or the effect of external fields. Yet, the motion of a domain wall can be effectively controlled by spin-polarized current, i.e. the current whose all carriers have the same spin direction. That opens up broad prospects for using domain walls in spintronic devices, i.e. as information bits in energy-independent track memory, where one bit of information is encoded by one domain.

When realizing such memory elements, it is necessary, first of all, to take into account the presence of the limiting value of the driving force (current or external magnetic field) and the so-called Walker boundary, which determines the velocity of domain wall motion. The Walker boundary separates the translational and precessional wall motion regimes. The latter is a parasitic one, since it is characterized with a small average velocity and does not permit



Geometry of the w-wide and h-thick curved wire is determined by the central line γ(s), in this case this is an Euler spiral. Vectors $\mathbf{e}_T$, $\mathbf{e}_N$, $\mathbf{e}_B$ *are Frenet basis*



Scheme of the transverse domain wall in the curved wire. In Frenet basis, the wall is described by two collective coordinates – position q and phase Φ (which determines the orientation of the magnetization of the domain wall itself). Green arrows and colored scale illustrate magnetization distribution in the wire

the wall position to be controlled. Second, the track memory geometry envisages the availability of bent elements, which can change the wall motion in the ferromagnetic significantly. In particular, the wall can stop on the bending of the magnetic wire.

Scientists of Bogolyubov Institute for Theoretical Physics of the NAS of Ukraine, jointly with their colleagues from Taras Shevchenko National University of Kyiv, Helmholtz Zentrum Dresden-Rossendorf and Leibniz Institute for Solid State and Materials Research (Dresden, Germany), showed that in the wire with monotonously increasing curvature the curvature gradient is the driving force for the domain magnetic wall. It is important that walls in such systems move in the absence of any external impacts with a rather high velocity (~100-200 m/s) in the direction of curvature increase. It was shown that the domain wall motion induced by the curvature is characterized with the absence of Walker boundary, which exists in the motion caused by the external field or current. Researchers also found the asymptotic motion velocity, which is only determined by material parameters and ferromagnetic wire geometry. The results obtained open up new opportunities for designing fast-operating elements of computer memory.

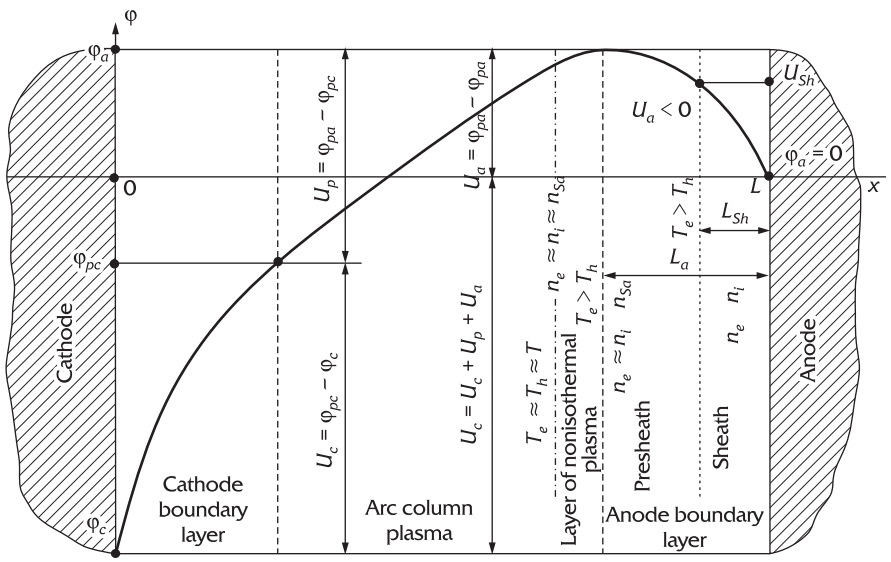
These results were published in one of the leading scientific journals *Physical Review B, Rapid Communications* (https://doi.org/10.1103/PhysRevB.98.060409)

K. Yershov, V. Kravchuk, D. Sheka, O. Pylypovskyi, D. Makarov, Yu. Gaididei

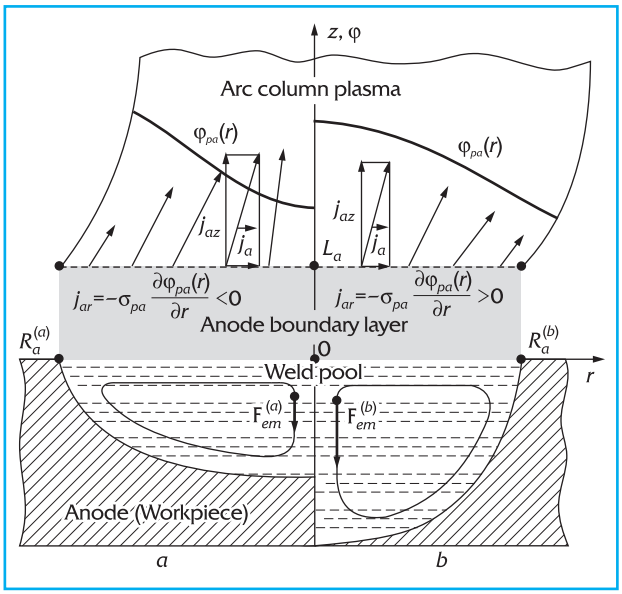
Model of Anode Processes in Welding Arcs

Today, one of the main technologies of obtaining permanent joints of metal materials is fusion welding. In today's industrial production, such welding methods as metal in inert gas, metal in active gas welding (MIG/MAG) and tungsten in inert gas welding (TIG) are the most widely used technologies of arc welding. The efficiency and quality of these welding methods are determined to a great extent by anodic processes in welding arcs, namely, the processes of thermal and electromagnetic interaction of arc plasma with the anode material (a drop of electrode metal in the case of MIG/MAG welding and weld pool in the case of TIG welding). In the former case these processes determine the melting of the electrode wire, formation and transfer of drops, and in the latter – the penetration of the welded metal and the formatting of the weld seam. Since the experimental determination of such technologically important welding arc characteristics as heat flow and electric current density on the surface of the drop or weld pool are difficult, the analysis of these processes by the methods of mathematical modeling is important.

For that purpose, scientists of E.O. Paton Electric Welding Institute of the NAS of Ukraine developed a self-consistent mathematical model of the physical processes in the arc column and anode area of high-current (~10^2 A) welding arcs that burn in an inert gas under the atmospheric pressure. It took into account the multi-component nature of the arc plasma, which is due to the evaporation of anode material. In the mathematical description of the physical processes occurring in the near-anode plasma of such arcs, it can be divided into two regions: the anode layer of ionizationally and thermally unbalanced plasma that includes presheath and sheath, as well as the arc column, where plasma is in the state of local thermodynamic equilibrium (LTE).The presheath plasma is described by a system of multiliquid hydrodynamics equations presented in the diffusion approximation and taking into consideration the thermally and ionizationally unbalanced state of the plasma. It is assumed that the evaporation of the anode metal happens in the diffusion regime. The processes of energy, mass and electron transfer in isothermal ionizationally equilibrium plasma of the arc column (LTE model) are described by a system of magneto-gas-dynamic equations, which are supplemented by the equation for convective diffusion of the metal vapor.



Characteristic distribution of electric potential and the structure of near-anode plasma of welding arcs: φ_c is cathode surface potential; φ_{pc}, φ_{pa} – potentials of arc column plasma on the electrodes boundary layers; $\varphi_a = 0$ – potential of anode surface; U – full arc voltage; U_c, U_a – cathode and anode potential drops; Up – potential drop on the arc column; L – arc length; L_a – anode layer thickness



Schematic presentation of the electrical characteristics of the near-anode plasma of the welding arc and the process of melting of the metal welded in TIG process: a – discharge distributed over anode surface; b – arc contraction on the anode

Relying on the proposed model, numerical investigations of the anode processes in electric arcs with non-consumable (water-cooled) electrodes and in welding arcs (arcs with consumable electrodes) were carried out. It was shown that the drop of the anode potential in the arcs that are under consideration is negative and has an essentially inhomogeneous distribution in the area of anode arc connection. Since the potential of the anode metal is practically constant, that leads to the appearance of the components of electrical potential gradient and, respectively, of current density vector along the anode layer boundary with the arc column. This determines the processes of electric current passage between the anode and the arc plasma (arc contraction on the anode or the discharge distributed over the anode surface).

In turn, the distribution of electric current density in the area of anode connection of the welding arc (drops of anode metal or weld pool) is the main factor determining the arc force effect on the molten metal and, eventually, on the drop transport regime in MIG/MAG welding (large-, small-drop or stream-like), as well as the depth and shape of metal penetration in TIG welding.

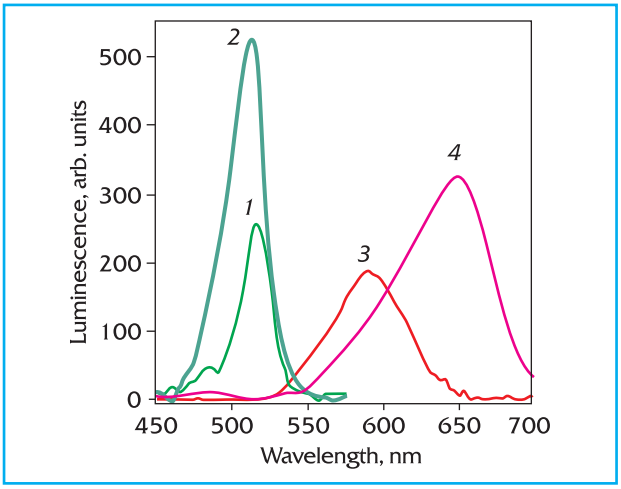
The results obtained concerning the patterns of anode processes in welding arcs are important for developing new and upgrading the available techniques of arc welding.

I. Krivtsun

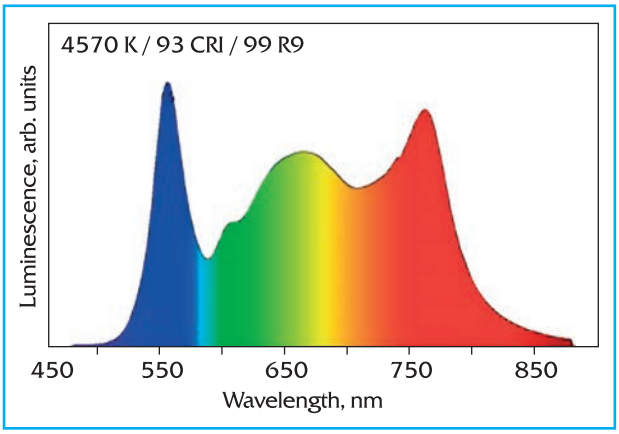
New Luminophores Based on Inorganic Perovskites for LED Illuminator Devices

L.V. Pisarzhevsky Institute of Physical Chemistry of the NAS of Ukraine was the first to obtain quantum dots of inorganic perovskites $CsPbBr_{3-y}I_y$, incorporated in the pores of X and Y types $(Cs(X)PbBr_{3-y}I_y$ and $Cs(Y)PbBr_{3-y}I_y)$, whose quantum yield of photoluminescence (PL) is as high as 80%.

In the process of obtaining these materials, the idea of creating new nanostructured haloid perov-



Photoluminescence spectra of the powders of inorganic haloid perovskites in zeolite matrices: $Cs(X)PbBr_3$ (1), $Cs(Y)PbBr_3$ (2), $Cs(Y)PbBr_{1.2}I_{1.8}$ (3), $Cs(X)PbBr_{1.2}I_{1.8}$ (4)



Spectra of the prototype of white LED based on $Cs(X)PbBr_{1.2}I_{1.8}$, $CH_3NH_3PbBr_3$ and GAG:G for excitation λ_{ex} = 458 nm

skites was implemented. Those would increase the emission intensity of the available white LEDs in the 480-510 nm range and improve the quality of color reproduction.

The relation between photoluminescence characteristics of the materials produced (position of the maximum, bandwidth, color, quantum yield) and the type of zeolite matrix was studied. It was found that the zeolite properties (SiO_2/Al_2O_3 ratio, the number of Bronsted acid sites) can influence the concentration of cesium ions that replace sodium ions (the first stage of materials production) and PbX_2 chemisorption, as well as perovskite formation (the second stage), determining the content of $CsPbBr_{3-y}I_y$ nanoparticles incorporated in matrix pores.

Prototypes of white LEDs based on the abovementioned perovskite luminophores were produced. It was shown that the use of red luminophore $Cs(X)PbBr_{1.2}I_{1.8}$ in combination with green $CH_3NH_3PbBr_3$ and yellow GAG:Ce permits obtaining of high-quality white light with the color reproduction index (CRI) 93-95 and partial R9 color rendering index (saturated red color) as high as 99, while the LEDs based on the rare-earth luminophore (GAG:Ce) are only able to emit light with CRI at the level of 80.

V. Pokhodenko, V. Koshechko, O. Posudievsky, N. Konoshchuk

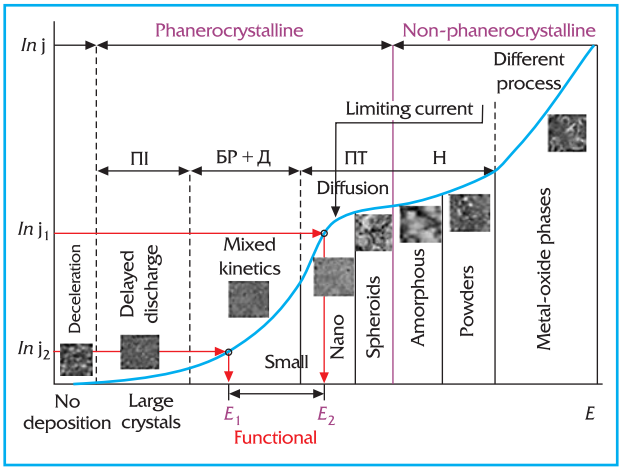
Electrosedimentation and Electrocatalysis Involving Coordination Compounds of Metals

V.I. Vernadsky Institute of General and Inorganic Chemistry of the NAS of Ukraine, relying on the proposed theory of discharge-ionization of electrochemically active complexes, developed a methodology for the electro-chemical synthesis of functional coatings and electrocatalysts that do not contain noble metals.

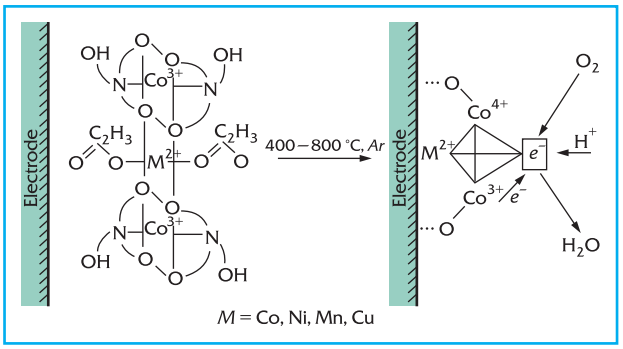
The conditions of the steady operation of the process of metals electrosedimentation were grounded theoretically and proved experimentally. It was shown that the steady oscillations of the derivative dE/dj (the electrochemical resistance of the system) are minimal when the polarization current is in the range of a half of the limiting current and they do not depend on the nature of complex ion. It was established that in this very regime of dynamic stability the most favorable energy for crystal growth was observed and the coatings with a stable set of the necessary functional characteristics were formed.

The conditions of high-rate electrochemical synthesis of multifunctional (magnetic, corrosion-resistant and electrocatalytic) dense films of nano-structured binary alloys M_1M_2 (where M_1 are metals of the iron subgroup (Ni, Co, Fe) and M_2 are Mo, W, Re) from different types of complex water electrolytes with controlled compositions and reproducible structures were found.

The interrelations between nitrogen and oxygen atoms that contain coordination centers of complexes with electrocatalytic characteristics were investigated. Due to the results obtained, researchers discovered the rules of selecting precursors based on coordination compounds of transition metals for syn-



Interrelation of electrochemical kinetics and functional electrodeposition



Formation of electroactive centers of oxygen reduction catalysts

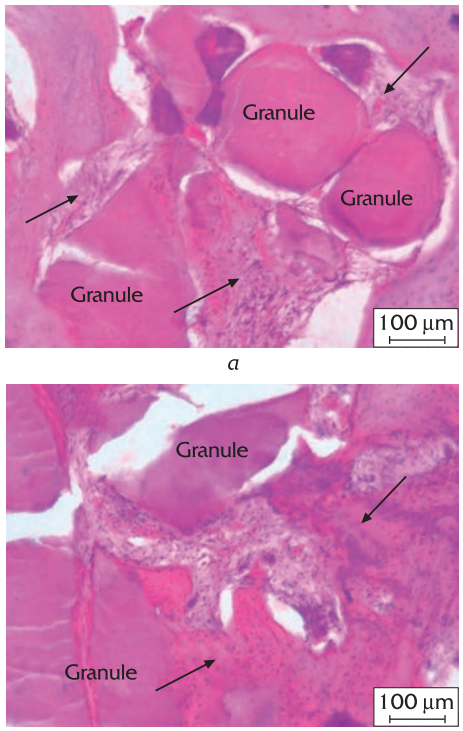
thesizing electrocatalysts of oxygen reduction, oxidation of hydrogen and ethanol in metal-air chemical current sources and air-hydrogen fuel cells.

The approach proposed and the data obtained allow high-efficiency electrocatalysts to be developed, and galvanic coatings of metals, alloys oxides and composites to be deposited.

V. Kublanovsky, O. Bersirova, Yu. Pirskyy

Novel Modified Bioactive Ceramics with Osteoinductive Properties

Today the most biocompatible synthetic material used for osteoplastics is bioactive ceramics based on calcium phosphates, which is a synthetic analog of the mineral component of bone tissue. The significant advantage over all other implant materials is its high biocompatibility, gradual dissolution and replacement with bone tissue. At the same time, it is believed that synthetic materials cannot have osteoinductive properties (stimulation of bone formation)



Histological structure of bone regenerate when silicon-doped bioactive ceramics was used for bone plastics. Arrows show the newly formed bone tissue around granules (particles of bioactive ceramics): a) without adding the autologous plasma (coloring is less intense and the regenerate does not fill the entire volume but vigorous activity of bone cells is observed); b) in the composite with platelet-rich autologous plasma (intense coloring of fully functioning newly formed bone tissue, the formation of a large number of bone cells (dark dots) is observed)

as opposed to autoplastic or alloplastic bone grafts. To solve this problem, repeated attempts were made to provide bioactive ceramics with osteoinductive properties by producing composites with various biopolymers (collagen, chitosan). Yet, foreign proteins deteriorated the biocompatibility of bioactive ceramics, caused its uncontrolled resorption and degradation of the regenerate bone.

Scientists of I.M. Frantsevich Institute for Problems of Materials Science and Bila Tserkva Agrarian University proposed and implemented the idea of the synergistic effect of calcium, silicon and phosphate on the process of bone formation. In particular, they developed and examined a silicon-doped bioactive ceramic composite with platelet-rich autologous plasma, and performed grafting of bone defects in rabbits with the composite produced.

The examinations of the histological structure of rabbit bone tissue from the defect zone on the 60th day after graft implantation showed that silicon-doped bioactive ceramics has osteoinductive properties, which is manifested in a considerable increase in the number of bone cells around ceramic granules. The newly formed bone tissue in the defect is superior, in terms of maturity, to the bone tissue from bioceramics without added silicon.

The employment of silicon-doped bioactive ceramics jointly with platelet-rich autologous plasma significantly improves the reparative properties of bioceramics and considerably accelerates the regeneration of fully functioning mature bone tissue. Specifically, a newly formed bone tissue at the final stage of regeneration was observed at the implantation site.

Besides, when the abovementioned composite was used, there were signs of cartilaginous tissue regeneration around the defect, which proves the possibility of developing implant materials for restoring not only bone but cartilaginous tissues as well. In view of the low regeneration ability of cartilages, this effect is of high relevance and requires further research.

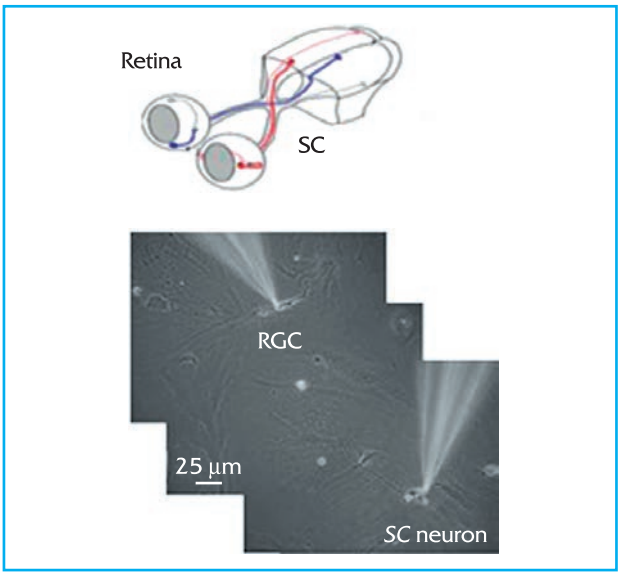
The results obtained show the feasibility of the complete substitution of autoplastic and alloplastic grafts, as their disadvantages are the need for additional surgery, restriction in their numbers, the limited mechanical properties of auto transplants, transmission of infection from the donor, the difficulty of conservation and safekeeping of cadaver bones, the suppression of tissue incompatibility, legal and moral permissions for bone withdrawal from donor in the case of allotransplants. In addition, a significant acceleration of forming the fully functioning bone tissue will reduce complications after fractures, and provide fast consolidation of bone fragments and restoration of bone tissue in major defects.

S. Firstov, N. Ulianchich, V. Kolomiiets', M. Rublenko, V. Andriets

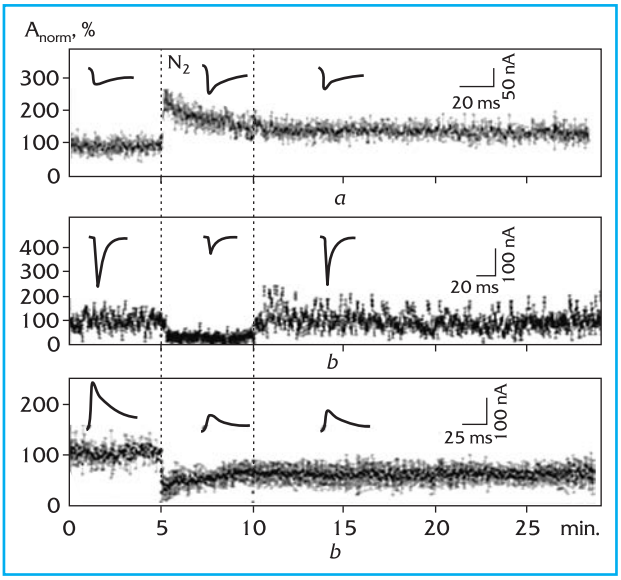
Study of Pathological Mechanisms of Hypoxia-Induced Optic Nerve Lesion

Hypoxia is one of the causes of optic nerve degeneration that leads to gradual and often irreversible vision impairment. Hence, the study of the pathological mechanisms of the action of the optic nerve hypoxia lesion is important for medical approaches to correcting the hypoxia-mediated vision disorders.

Scientists of Bogomoletz Institute of Physiology of the NAS of Ukraine were the first to investigate hypoxia-induced pathological states of visual information transfer by the innovative optic nerve model *in vitro* — the co-culture of retina cells and *Superior colliculus* neurons. They also registered the effects of hypoxia lesion at the level of the individual pairs of retina ganglion cells — *Superior colliculus* neuron. It was found that short-term (up to 5 min.) hypoxia



Microphotograph of synaptically connected co-cultivated pair of retina ganglion cell (RGC) and Superior colliculus (SC) neuron



Hypoxia-induced pathological bidirectional plasticity of the excitatory and inhibitory neurotransmission between RGC and SC neurons

leads to protracted pathological bidirectional plasticity of excitatory and inhibitory neurotransmission. Pre- and post-synaptic mechanisms of this plasticity were evaluated. It was discovered that hypoxia produced a predominantly presynaptic effect on the excitatory neuro transmission and both the pre- and post-synaptic effect on the inhibitory neurotransmission between retina ganglion cells and *Superior colliculus* neurons.

Thus, the hypoxia-induced bidirectional protracted synaptic plasticity of optic transmission was shown for the first time, and main target cells were identified in the search for pharmacological and therapeutic approaches to the correction of vision disorders caused by hypoxia-induced optic nerve lesion.

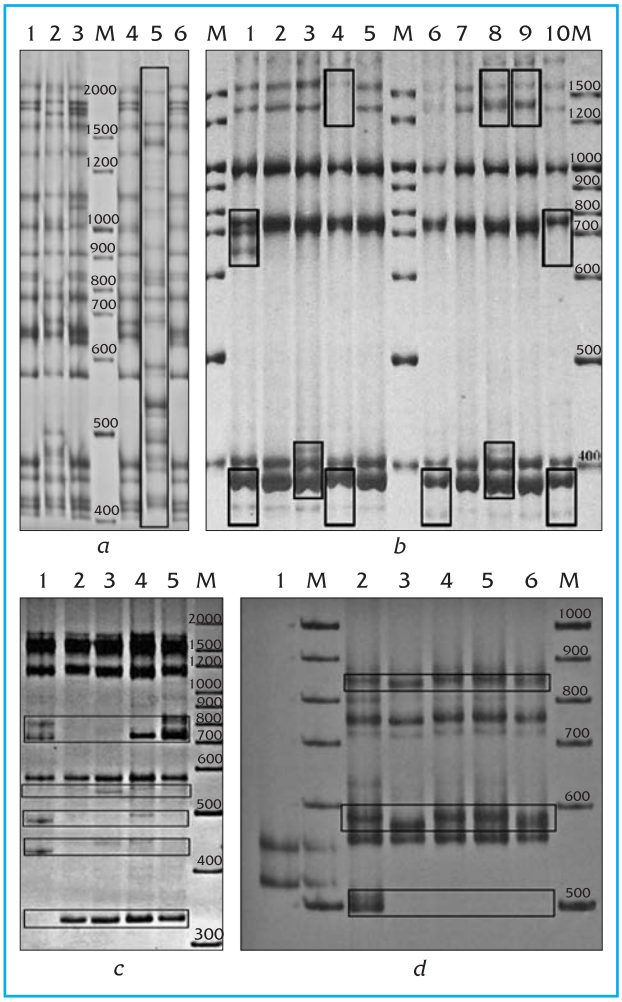
G. Dumanska, N. Veselovsky

New Approaches to Plant Genotyping

Molecular genetic markers are effectively used for solving numerous problems of modern genetics, genomics and in molecular plant breeding. A new approach in this area, which is gaining ever-increasing practical application, is the evaluation of intron length polymorphism (ILP). The versatility, reproducibility and information content of ILP markers allows the DNA profiling and genotyping of plants to be carried out. One of reliable ILP marker systems is the evaluation of tubulin-based polymorphism (β-TBP) — the protein that is the key element of eukaryotic cell tubules and provides the division of cells, their shape preservation and intracellular transport.

Genetics scientists of the NAS Institute of Food Biotechnology and Genomics investigated the feasibility of using DNA markers based on the evaluation of TBP for molecular genetic analysis of plants. As a result, it was established that TBP could be used for genotyping of not only higher plants (see Figure) but lower plants as well.

Since in the organism the gene sequences of α-, β-, and γ-tubulins are highly conservative, the introns of these genes can be good targets for developing TBP-based marker systems. Relying on the analysis of exon-intron structure of α-tubulin genes, multi-purpose DNA markers were developed for evaluating the first TBP of plant α-tubulin. Their use for the analysis of model plants and various flax, rice, potato and tomato genotypes allowed scientists to detect the formation of characteristic DNA



Electro foregrama with amplicons containing introns: a – β-tubulin genes in various flax species; b – β-tubulin in various barley varieties; c – γ-tubulin in various rice varieties; d – γ-tubulin in arabidopsis (1) and various flax varieties (2-6); M – molecular mass marker (100 base pairs). Rectangles show the zones of polymorphism

profiles in various plant species and genotypes, which permits their effective differentiation.

A new marker system of evaluating the TBP of γ-tubulin was proposed. It is based on examining the TBP of the I-st and II-nd introns. The ease and versatility of using the proposed marker system in the molecular genetic analysis of various plant species was demonstrated.

It was established that the methods based on evaluating TBP of various tubulins enable fast and reliable differentiation of plant species and genotypes, so they can be considered as a promising and effective instrument of molecular genetic analysis.

Ya. Pirko, A. Rabokon, A. Postovoitova, Ya. Blume

Designing New Strains of Yeast Capable of Glycerin Superproduction

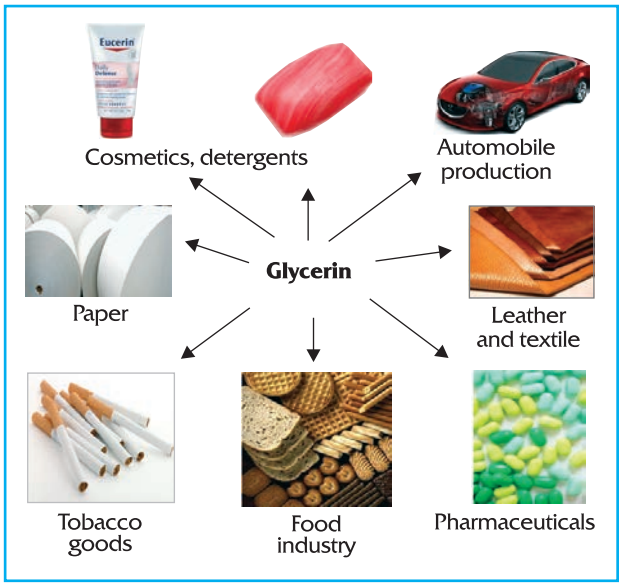
Glycerin (1,2,3-propanetriol) is widely used in cosmetic, automobile, food, tobacco, pharmaceutical, pulp and paper, leather, textile and other industries, which necessitates the search for novel methods of its production.

Beside two traditional methods of glycerin production (by chemical synthesis from petrochemical raw materials and as a byproduct of soap and biodiesel production), in recent years, scientists have considered the feasibility of using microorganisms for obtaining glycerin from inexpensive renewable raw materials. The latter method is the most environmentally acceptable one and provides glycerin of high purity.

Scientists of the NAS Institute of Cell Biology chose facultative anaerobe yeast *Saccharomyces cerevisiae* as glycerin producer, which is able to grow without oxygen. To improve glycerin production, a number of modifications were introduced in the genome of this yeast — those for limiting the expression of *TPI*1gene and for enhancing the expression of *GPD*1-*GPP*2*fus*, *FPS*1*m*, *ILV*2 genes.

It was shown that the limitation of the expression of TPI1 gene or enhancing the expression of *GPD*1-*GPP*2*fus* gene results in the increased glycerin production. The integration of several modifications provides a cumulative effect.

The integration of the described modifications in the genome of the recombinant *Saccharomyces cerevisiae* strain provided a significant rise in glycerin production as compared to the wild-type strain under microanaerobe and anaerobe conditions (by 9.3 and 4.7 times, respectively).



Spheres of using glycerin

In general, the recombinant *Saccharomyces cerevisiae* strains obtained can be used for glycerin production in anaerobe conditions or serve as a platform for introducing further genetic modifications to improve the strain viability and raise the efficiency of glycerin production.

A. Sibirny, M. Semkiv, K. Dmytruk

RESEARCH ACHIEVEMENTS. SOCIAL SCIENCES AND HUMANITIES

The Section of Socio-Humanities of the NAS of Ukraine obtained a number of important results in studying highly relevant issues of the socio-economic and cultural development of Ukraine.

The tradition of preparing the national reports by the Section, which addressed the issues of utmost importance for the state and the society, was continued. In 2018 that work resulted in two national reports: **"Ukraine: the Road to Society Consolidation" and "Ukrainian Society: Migration Dimension"**. They were presented at and approved by the meetings of NAS Presidium on 18 April and 19 December, respectively.

The first report was prepared on the base of I.F. Kuras Institute of Political and Ethnic Studies of the NAS of Ukraine by a team of Section's experts led by NAS Acad. S.I. Pyrozhkov. It stresses that the history of independent Ukraine's development shows that our country still has not been able to overcome crisis phenomena in the economic and socio-political development of the state, to move into the trajectory of the up-to-date sustainable civilizational development. To a great extent, that is due to the fact that as yet the Ukrainian society has not united into a coherent political nation. Ukraine, which is today one of the local territories of the global hybrid war, as never before needs society consolidation. The Ukrainian society should be ready to provide a joint response to the global challenges and threats. The insufficient consolidation of our society can be seen in the preservation of the historically established and new lines of confrontation and in the mutual distrust between the citizens and the authorities, the hired labor and the capital, between different social strata. The key question for the Ukrainian society is how to achieve the domination of consolidation over confrontation.

Relying on modern theoretical concepts and the analysis of political practices, the report provides an integral analysis of the problem issues of the Ukrainian society consolidation in the situation of internal socio-economic crisis and external challenges and threats. It assesses the level of nation's integrity, reveals the causes and factors of confrontation phenomena in social relations, and grounds the model of the national unity and the strategy to achieve it.

The pivotal concept of this joint work of NAS scholars is the idea that the successful movement towards nation's unity is only possible through the orientation towards a dialogue. That gives rise to the atmosphere of trust, which turns into consensus and partnership that envisage the resolving of contradictions on the platform of shared values and essential social unity.

The structure of the society consolidation model includes those elements that reflect the common values and interests of country's citizens to the fullest degree. This is, first and foremost, the socio-economic sphere, where consolidation develops on the basis of striving for a better quality of the material life. A no less important role in model's functioning is to be played by the resolution of social contradictions through partnership in addressing them, as well as by reliance on shared ideas about country's geopolitical future. The nation should be united by a common socio-political system based on democracy in all its manifestations.

The strategy for achieving society consolidation should be the focusing on those decisions and actions which could ensure the adoption of the common system of values, social and legal justice, access of citizens to social administration, enhancement of political culture, development of high-technology, socially and environmentally oriented economy. The implementation of the society consolidation strategy requires coordinated activities of state power bodies, NGOs, scientific and educational spheres.

The other report, prepared on the base of M. Ptoukha Institute for Demography and Social Studies by the research team headed by Ella M. Libanova, notes that migration is the key manifestation of globalization and is an objective process. It is quite possible that migration scale will increase continuously, in particular, due to the assumption that active and mobile groups of population will several times in their lifetimes change the places of residence, including the country or continent. That will be encouraged by the fourth industrial revolution and digitalization of the economy linked to it, the development of transnational corporations, the de-

ployment of a large part of production facilities in the countries (regions) other than the registration address of their head offices, simplification (cancelling) of border crossing procedures, in conjunction with demographic processes proper — dramatic ageing of the population and labor force in economically developed countries.

The main element of migrations in today's world is resettlement due to economic factors, primarily, temporary moves for earning higher wages. In such migrations, the decisive role is played by the ratios of life quality in the countries (regions) of origin and the countries (regions) of destination.

The key idea of the National Report "Ukrainian Society: Migration Dimension" is that migration is not a challenge but the reality which is to be taken into account and augmented. As of today, the principal task of Ukraine's migration policy is to ensure the full use of the positive potential of migration with concurrent minimization of is negative consequences.

The report also discloses problems in labor, education, internal and forced migration etc. An important element of the report is the coverage of immigration problem — the issue that induced significant transformations in the societies of EU countries and very soon will become critical for the Ukrainian society and state.

The report grounded the areas of the migration policy of our state, which should be aimed at reducing the population outflow, facilitating the return of migrants, first of all, labor emigrants who consider living abroad as a temporary situation, and stimulating workforce immigration needed by the economy, integrating migrants in the interests of the communities they established in. In the sphere of internal migration, the most pressing issues are providing the assistance, accommodation, employment, access to medical care, education, social service for internally displaced persons.

Scholars of the NAS Institute of the History of Ukraine, in the framework of fundamental academic publishing project "Encyclopedia of the History of Ukraine", published the **first book of the topic volume "Ukraine – Ukrainians"**(the head of the editorial board is V.A. Smolii, NAS Acad.; deputy heads — H.V. Boriak, NAS Corr. Memb.; S.V. Kulchytsky, Sci. Dr. (Hist.)).

The topic volume "Ukraine – Ukrainians" is the generalizing, synthetic summary of the 10-volume project "Encyclopedia of the History of Ukraine". It provides readers with the integral image of Ukraine in its basic categories — state, territory, people — from the viewpoint of their formation and development from the earliest times to the present. Due to the exceptional nature of this volume, it is designated not by the order number of its publication but with the key entries that determine its idea and contents. At the same time, they present the entire range of articles that were once selected from the corpus of entries starting with the Ukrainian letter "Y" of the tenth volume of the encyclopedia – the entries Ukraine..., Ukrainian... It is symbolic that the last entry of the volume is "Ukrainians".

The volume consists of two books that present a series of some kind of encyclopedic narratives. The first book includes generalizing essays on the state system of the country; its geography and resources; the history of its territory formation and boundaries, administrative-territorial system; the number, composition and migration of the population that lived on its lands since the earliest times (anthropological and demographic parameters in retrospect). They are also concerned with their traditional material and spiritual culture (economic practices, trades and homecrafts; transport; diet and foodstuffs; dwellings; clothes; folk knowledge; mythology; calendar and life-cycle rituals; verbal and musical folklore, as well as visual folklore, i.e. decorative applied arts; choreography etc.).

An integral part of the abovementioned ethnological section is a number of essays dealing with

the ethnic history, material and spiritual culture of the main ethnic communities that live in Ukraine — Byelorussians, Bulgarians, Armenians, Gagauzians, Greeks, Jews, Karaites, Crimean Tatars, Krymchaks, Moldovans, Germans, Poles, the Romani, Russians, Romanians, Slovaks, Hungarians, and Czechs (presented according to the Ukrainian alphabet).

The work on the second book is underway. It will contain a special article about the history of Ukraine, concluding the narrative section, as well as the dictionary part of the edition — those are nearly 400 entries of the classical encyclopedic format, which in different contexts supplement, deepen and accentuate the encyclopedic narratives of the first section. In the Ukrainian encyclopedic tradition, such a structure of content presentation was implemented in the "Encyclopedia of Ukrainian Studies", which, in particular, was divided into the "General Part" in three volumes (1949-1952) and the "Dictionary Part" in ten volumes (1955-1989).

Scholars of the Ethnology Institute of the NAS of Ukraine published **"Ukrainian Folkloristic Encyclopedia"** (the head of the project, scholarly editor, and compiler was V.V. Sokil, Sci. Dr. (Philol.); NAS Acad. S.P. Pavliuk was in charge of publishing).

This collaborative work is the first edition in Ukrainian ethnology studies that represents outstanding achievements over two hundred years of its development, since the early 19th century to the beginning of the 21st century. The book contains articles about folklorists, beginning from M. Tsertelev to our contemporaries, presents oral literature genres, studies in folklore theory and poetics, and shows the system of folklore characters. The edition covers the phenomena from the territory of both today's Ukraine and all its ethnic lands.

The articles about Ukrainian and foreign collectors of and scholars in folklore provide the detailed analysis of their folkloristic work, some articles focus on scholarly institutions whose activities are associated with folkloristics. A number of articles are devoted to kobza and lyra players, whose art is the unique phenomenon of Ukrainian culture.

The book presents the major folklore collections that are the treasury of Ukrainian oral poetic heritage – certain folklore collections (personal, thematic and containing mixed genres), whole corpora or major series ("Oral Folk Art" etc.).

This work analyzes the genre system of Ukrainian folklore. Genre-addressing articles are differentiated according to their relations to rituals and ceremonies (ceremonial and non-ceremonial lyrics), characteristic features of presenting the material (songs, narratives, recitations), the medium where different varieties of the works of art emerge (carols, spring ritual songs, émigrée songs), age-specific features (child folklore) etc. It also presents folklore prose (fairy tales, legends, history tales and stories). Of considerable importance are essays in the theory and poetics of Ukrainian folklore.

The Encyclopedia examines mythological, Bible-hero, fairy-tale, epic, historical characters created by folk tradition. Their specific, typical and canonical features are analyzed in detail.

All articles of this edition contain abstracts and are well-balanced, objective, generalizing and at the same time they are concrete, rich in bibliography, as they are accompanied by the lists of major references with comprehensive bibliographic data.

The rich contents of the Encyclopedia demonstrate the national characteristics of Ukrainian folklore, they provide convincing evidence of the multidimensional and unique nature of this edition, its great importance for the development of Ukrainian culture and socio-humanities.

Providing Longitudinal Stability of 'Tsiklon-4M' Space Rocket

R&D experts of the Institute of Technical Mechanics of the National Academy of Sciences and the State Space Agency of Ukraine proposed and implemented a novel approach, based on methods of mathematical modeling, to eliminating the low-frequency oscillations of the body of liquid-propellant rocket along its longitudinal axis, which emerge on the active flight-path segment. These oscillations can reach dangerous values, which renders impossible the normal operation of rockets, disrupt the functioning of their control system equipment and lead to emergencies.

Despite the available experience of dealing with the problem of providing the longitudinal stability of liquid-propelled rockets, this remains relevant and is one of the most important problems of rocket engineering, as it requires an individual solution for each rocket model that is designed or upgraded. Besides, the fact of stability (or stability loss) of a liquid-propelled rocket on the active flight-path segment cannot be determined experimentally during ground testing, it can only be discovered during flight tests, which requires significant material and financial costs.

To analyze the longitudinal stability of the new "Tsiklon-4M" two-stage space rocket, which is under construction at the SE "Pivdenne" Design Office', a mathematical model of the closed dynamic system "sustainer rocket engine – rocket body" was developed. It describes the interaction of elastic longitudinal oscillations of the rochet body with low-frequency processes in the propulsion system of the first stage. Relying on this model, the theoretical prediction of the longitudinal stability of "Tsiklon-4M" was made by using Nyquist criterion. According to its results, the rocket can lose its longitudinal stability on the active segment of the flight path when the sustainer engine of the first stage is operating.

To prevent this problem, it was proposed to install longitudinal oscillation dampers into the oxidant feeder mains of the sustainer engine system in the rocket's first stage (at the input of each of its four engines). That would enable the experts to change dynamic characteristics of the oxidant feeder mains and eliminate the resonance interaction of the propulsion system and rocket body. In this case, there is no need to install longitudinal oscillation dampers in propellant feeder lines.

"Tsiklon-4M" two-staged space rocket

Computations showed that the installation of the abovementioned dampers with bellows-valve division of the mediums provides the longitudinal stability of "Tsiklon-4M" space rocket with sufficient margins during its entire flight, given the nominal values and different combinations of the limiting values of pressure and temperatures at the engine inputs.

O. Pylypenko, O. Nikolayev, S. Dolhopolov

Carbon-Carbon Composite Material for Nozzle Insert of Athodyd Jet Engine

Experts of the National Science Center "Kharkov Institute of Physics and Technology", relying on the analysis of their earlier data on the stability of carbon-carbon composite materials (CCCM) in gas flows and factors affecting material stability, selected promising structures of CCCM reinforcement to be used in jet engines and produced test samples of the materials.

In the preliminary tests of the prototype material at the KC-2Г test bench of "Ivchenko-Progres" State Enterprise (Zaporizhia), the samples were treated with gas flow of 1500° and the weight loss of the samples during testing was determined. The best results were shown by CCCM with the reinforcing

Successful first ground firing tests of "Grom-2" propulsion system in Ukraine in 2018

structure produced by layer-wise spreading of carbon tissue. This material had the lowest burn-up (0.57-0.91%), which gives promise of using it in further research and testing.

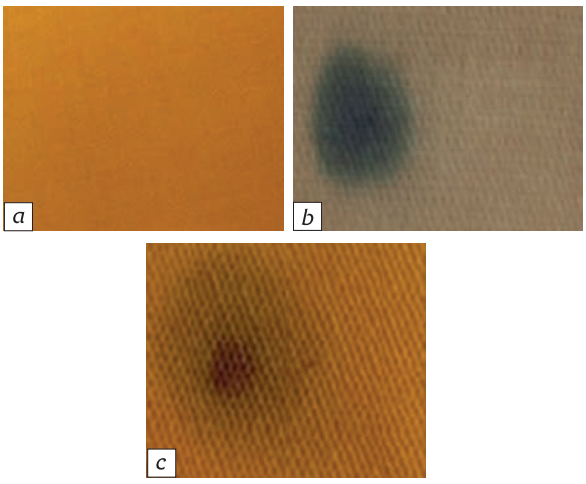
For that purpose, a test mock-up of the nozzle unit was produced from the selected CCCM and its firing tests at the temperature 1500° were carried out at "Ivchenko-Progres" State Enterprise, with kerosene used as fuel. The test results showed that this material had satisfactory resistance to burn-up (at the level of ~1%) during more than 400 seconds. The erosion wear of the material selected corresponded to earlier data, the stability of the material was sufficient to ensure workpiece operation for the abovementioned time. The material developed has low specific density (half of that of aluminum) and improved thermophysical properties.

On the basis of the results obtained, "Ivchenko-Progres" State enterprise made a decision to use this material for manufacturing the critical-section insert in athodyd jet engine, continuing the development of the nozzle unit of the engine and conducting further research.

I. Gurin, V. Kolosenko, V. Gujda

High-Sensitivity Chemical Detection Sensor of Ammonia Leaks

Monitoring of the leak tightness of heat pipes in heat-regulation systems and electrically heated ammonia-fueled engines of space vehicles is an important element of safe testing and successful operation of spacecraft. For this purpose, scientists of L.V. Pisarzhevsky Institute of Physical Chemistry of the NAS of Ukraine determined the optimum qualitative



Surface appearance of the chemical detection sensor of ammonia leaks: a – before interaction with ammonia; b – 5 minutes after the contact with a point source of ammonia leak of the order 10^{-6} m^3 Pa/sec; c – after 2-week storage of the material

and quantitative composition of a new detector sensor of ammonia leaks resulting from damage to such systems. They developed a technological process for producing this sensor and set up the production of its pilot batch at "Koloran" State Enterprise. It was successfully tested at the State Enterprise "M.K. Yangel "Pivdenne" Design Office".

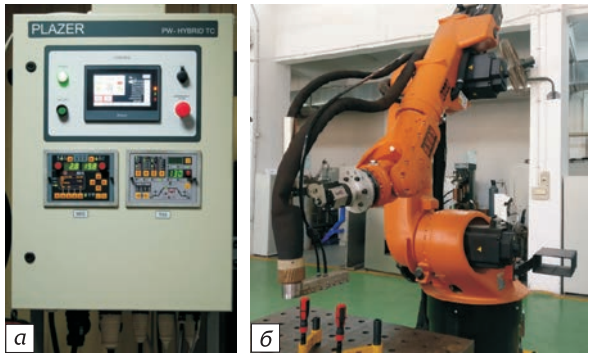
This chemical detection sensor consists of a specially prepared substrate coated with chemical reactant which, when in contact with ammonia point source, dramatically changes its color to dark blue and then to reddish violet, as can be seen in the pictures above.

The test results demonstrated the potential of using the new chemical detection sensor as a means of controlling the leakproofness of not only spacecraft but of other ammonia container systems and tanks as well.

P. Manoryk, O. Shulzhenko, V. Grebennikov

Innovative Equipment for Implementing Plasma-Based and Hybrid Plasma-Arc Welding Technologies

E.O. Paton Electric Welding Institute of the NAS of Ukraine developed intelligent equipment and set up its manufacturing for implementing new plasma-based technologies of high-quality high-speed welding. It includes hardware/software means for the



Intelligent control system of the complex for robotic plasma and hybrid plasma-arc welding (a) and a welding plasmatron in the hand of anthropomorphous welding robot (b)

optimum choice and precise adjustment of technological regimes, as well as an intelligent control system with its own software and the ability to be integrated with various types of manipulators and robots.

The equipment combines two main advanced technologies: plasma welding (including that based on asymmetric heteropolar current) and the hybrid process of plasma arc welding.

When welded joints are formed with such equipment, the speed of plasma welding of 2-mm thick Al-Mg-Mn alloys with asymmetric heteropolar current is 300 cm/min, while in the traditional process of arc TIG welding this figure is 30-40 cm/min. In addition, plasma-welded joints are characterized with a 40-60% smaller width and the volume of deposited metal, a more highly-dispersed structure, a 1.5-fold smaller size of the zone weakened by the heat-source impact, a 2.5-3-fold smaller heat input, an improved weld seam appearance, and with the absence of internal defects in the form of oxide inclusions.

When the hybrid plasma-arc welding technology based on this new equipment is employed, a combined (hybrid) concentrated heat source is formed, which involves the compact plasma arc and the consumable electrode arc. That ensures a deeper fusion of the base metal, with a lower rate of electrode wire feed. The implementation of this technology provides a 25-40% higher welding speed, at least a 50% reduction in the loss of electrode wire (which is necessary for the formation of the welded joint) and in the volume of the deposited metal, as well as a lower level of residual welding strains in welded products, as compared to the traditional processes of arc welding with consumable and non-consumable electrodes.

These new facilities are intended for the manufacturing of welded structures and critical parts from hardly weldable aluminum, titanium, nickel alloys, alloyed and high-strength steels with improved service characteristics, which are to be used in aerospace industry, automobile and railway transport, shipbuilding, energy engineering, oil and natural gas transportation. This equipment is deployed at '"PLASER" Research-and-Production Center' Ltd (Kyiv) for industrializing the technology of producing welded bimetallic pipes for oil and natural gas transportation and manufacturing welded structures for automobile and railway transport from high-strength aluminum alloys. The facilities were also successfully tested in the PRC in the development of industrial technologies for manufacturing stainless steel tanks in food and processing industry at KNC Petroleum Equipment Co. Ltd. (Zibo, Shandong Province), and for ship hull structures made from welded long-span Al-Mg alloy panels at the Guangzhou ship-building plant and at E.O. Paton Chinese-Ukrainian Institute of Welding (Guangdong Province).

V. Korzhyk

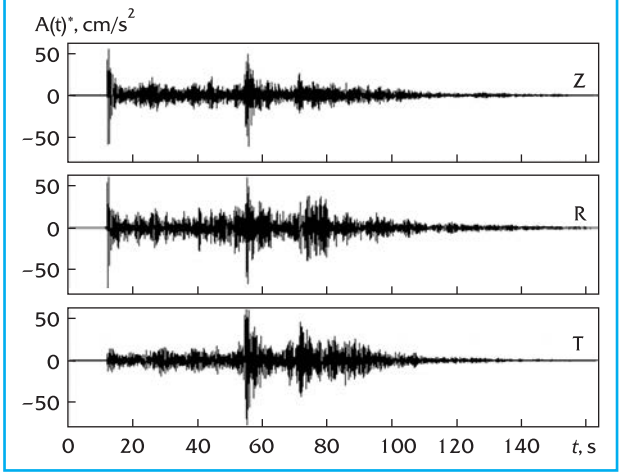
Procedure for Determining Seismic Hazards at Construction Sites, Intended for Earthquake-Resistant Design and Construction

Experts of S.I. Subotin Institute of Geophysics of the NAS of Ukraine developed a new innovative procedure for determining seismic hazard parameters that are necessary for the protection of houses and buildings against earthquakes in accordance with the state construction norms and the European construction standards.

The characteristic feature of the procedure developed is using Green's empirical integral functions to generate computational accelerograms that can be instrumental in allowing for the spectral characteristics of the radiation of seismic energy from earthquake foci, its propagation to construction sites, and taking into account non-linear effects of thick sedimentary layers in major seismic events.

This procedure enables scientists to specify the level of seismic hazard across the territory explored and identify in it the sites with soil conditions that strengthen or weaken seismic vibrations. Computa-

Identification of the seismically homogeneous areas at the site of Tashlyk hydro accumulation power plant



Example of a computational accelerogram for modeling a magnitude 6 earthquake at the geological site of Tashlyk hydro accumulation power plant

tional accelerograms and response spectra are generated for each site, taking into account nonlinear soil strain. Due to avoiding the effect of resonant and intensifying properties of the medium under the buildings designed, that permits designing and constructing earthquake-proof buildings and industrial structures to be erected without considerable extra expenses and provides a significantly better evaluation accuracy of the seismic hazard at the sites examined.

The procedure developed is widely used to determine seismic hazard parameters necessary for protecting buildings and structures against earthquakes in accordance with state construction norms B.1.1.2014 "Construction in seismic regions of Ukraine". In particular, seismological monitoring in the zone of Tashlyk HAPP influence was carried out for the SE '"Energoatom" NNEC'. Under the contract with 'BANKOMZVIAZOK' joint-stock company, the design documentation for a system of seismic monitoring in the region of Khmelnytska NPP location was coordinated. Besides, research to determine more accurately the seismicity of the construction site of a trade-and-service agrarian marketing complex with office facilities was carried out in Khmelnytskyi, and the seismicity of the site of the renovated sports facilities 'Stadium "CSC of the Armed Forces of Ukraine" was specified.

O. Kendzera, Yu. Semenova, S. Verbytskyi, O. Verbytska, Yu. Lisovyi, R. Spytsya

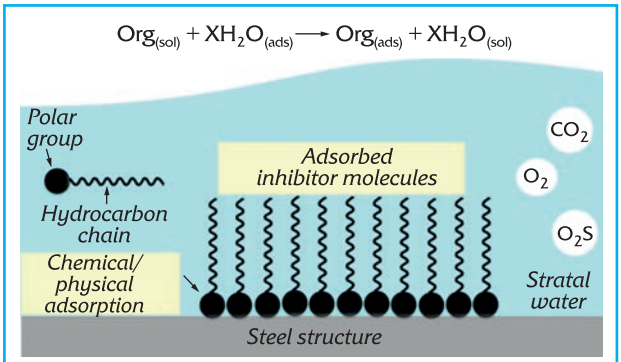
Novel Environmentally Safe Inhibitors Based on Biogenic Surfactants for Anti-Corrosion Protection of Oil-and-Gas Industrial Equipment

Organic inhibitors are widely used in various industries for protecting metal structures against corrosion. A large number of these substances are synthetic, environmentally hazardous, polluting the natural environment, while the environment-friendly surfactants produced by microbial synthesis from renewable plant raw materials can form the basis for developing novel inhibitors of metal corrosion.

Scientists of G.V. Karpenko Physico-Mechanical Institute of the NAS of Ukraine discovered that, as of today, such promising substances are bio-surfactants synthesized by bacteria of the *Rhodococcus erythropolis* genus, which contain disaccharide trehalose. Their surface-active properties are practically the same in a wide range of salt concentrations, which determines their potential anti-corrosive effect. An additional advantage of bio-surfactants is the feasibility of obtaining them from by-products of the production of vegetable oils, biodiesel etc.

Synthesized bio-surfactants reduce steel corrosion rate due to the adsorption of their molecules via acceptor–donor mechanism involving carbonyl and

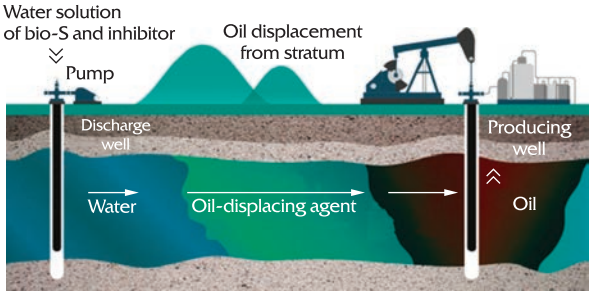
Synthesized trehalose lipid surfactants produced by microbial synthesis from plant raw materials (bio-surfactants)



Mechanism of metal anti-corrosive protection by biogenic corrosion inhibitor

hydroxyl groups and sedimentation of complex compounds with divalent iron cations in the anode regions of the metal. The hydrophobic part of molecules are turned towards the solution surface and form a repulsive barrier, reducing the metal corrosion rate. According to gravimetric test data, the maximum degree of carbon steel protection in the stratal water environment is observed at the critical micelle concentration of bio-surfactants in the corrosive solution of around 0.3 g/l and that amounts to 80–85%.

Another property of such bio-surfactants, beside a high degree of anti-corrosive protection and environmental safety, is their ability to enhance the inhibitory effect of well-known inorganic substances, phosphates in particular. The addition of a small amount of zinc phosphate to the corrosive medium inhibited by bio-surfactants raises the degree of steel protection to 93-96 % owing to synergism, i.e. such an inhibitory composition provides a higher degree of carbon steel protection than its components individually. This is due to the increase in the solubility of phosphates provided by waste products of *Rhodococcus erythropolis* bacteria.



Using the inhibitor in secondary oil recovery

The new environment-friendly inhibitor of carbon steel corrosion based on trehalose lipid bio-surfactants is promising for protecting the equipment of water circulation systems and can reduce the corrosive aggression of highly mineralized stratal water in low-yield oil wells.

V. Pokhmurskii, I. Zin, S. Korniy

New Medicine to Improve Functioning of Brain and Cardio-Vascular System

Scientists of Palladin Institute of Biochemistry of the NAS of Ukraine created an effective, affordable and safe '*Alphacognitin*' medicine that accelerates homocysteine metabolism and effectively reduces its level. Homocystein is a metabolite of methionine essential amino acid and, when in excess in the organism, due to its oxidation, it can form a large number of free radicals that damage endothelium cells and incite the development of atherosclerosis and thromboses. Besides, a high homocystein level is a risk factor of Alzheimer's disease and *Dementia senilis* development, it can cause cardio-vascular diseases, chronic cardiac insufficiency, cerebral stroke, migraine, hearing loss, vascular complications of diabetes mellitus etc.

'*Alphacognitin*' contains a complex of folic acid, vitamins B_{12}, B_6 and B_1 with choline in the optimum proportion, and due to this, it can also be used as an extra source of vitamins for normalizing the functional state of the cardio-vascular system and improvement of cognitive functions. Laboratory tests proved the positive effect of this medicine on the general state of the higher nervous activity.

Now, with the contribution of "Nutrimed" Ltd. (Kyiv), the technical specifications and manufacturing scheme of the '*Alphacognitin*' medicine production were developed, the pilot technology of pro-

A package of the 'Alphacognitin' dietary supplement

ducing the capsulated preparation was perfected, and the conclusion of the State Sanitary-and-Epidemiological Expertise of Ukraine was obtained.

It is expected that the introduction of this substance in medical practice will have a significant social and economic effect, as a considerable part of Ukrainian population have the abovementioned diseases.

S. Komisarenko, D. Kolybo, N. Lugovska, S. Romaniuk, T. Tykhonenko, A. Siromolot, K. Manoilov, M. Guzyk, O. Galkin, T. Kuchmerovska

Medical Preparation for Therapy and Prophylactics of Herpes Disease

Scientists of D.K. Zabolotny Institute of Microbiology and Virology of the NAS of Ukraine developed and successfully tested in pilot-production conditions a new technology for obtaining extracellular sialo-specific lectin from the strain of saprophytic bacteria *Bacillus subtilis* IMB B-7014. This lectin is the most active inhibitor of the adsorption and reproduction of 1- and 2-type herpes and is considered as the drug substance of a radically new highly effective preparation for the therapy and prevention of diseases caused by the viruses mentioned.

The advantages of using bacterial lectin as the basis of anti-herpes drug is its high specific activity, therapeutic efficacy, a wide spectrum of action, the absence of forming the virus resistance, as well as toxic, mutagenic and proliferative properties and complications of use.

The basis for developing the new technologies were the optimized processes of growing the producent without the use of chemical antifoaming agent, as well as lectin isolation by the ultrafiltration method.

The technologies developed for obtaining the lectin substance from the culture liquid were refined

The form of lectin substance

F-701 fermenter for obtaining the culture liquid of lectin producent in semi-industrial conditions

БИОР-0.1 fermenter for growing lectin producent inoculate

in industrial conditions at "ENZIM" State Enterprise (Ladyzhyn, Vinnytska Oblast) for further deployment.

V. Pidgorsky, O. Kisten, K. Getman, S. Skrotsky

Production and Transfer of Bacterial Fertilizers Based on New Strains of Fungicide-Resistant Nodular Bacteria

In the growing of soy, whose area under crop cultivation in Ukraine amounted to 1.7 million hectares in 2018, an important role is played by microbial preparations based on effective symbiotic nitrogen-fixing bacteria, which in symbiosis with plants fix atmospheric nitrogen and considerably increase crop capacity and land fertility. Besides, rhizobia (symbiotic nitrogen-fixing bacteria) that are components of such preparations are able to act as plant growth regulators and synthesize a wide range of biologically active substances — hormones, amino acids etc.

The Institute of Plant Physiology and Genetics of the NAS of Ukraine, through breeding, obtained strains of nodular bacteria (*Bradyrhizobium japonicum*) with high resistance to a number of modern fungicides used in the pre-sowing protection of soy plants. The production technology and application of the new "Rizostim-M" liquid and solid multifunctional bacterial preparations based on the strains created were improved. The preparation developed permits a concurrent seed treatment with plant protection agents, it ensures the formation of effective symbiotic soy systems and increased soybean grain productivity as compared to other preparations.

New "Rizostim-M" multifunctional bacterial preparations were successfully tested on the area over 3000 hectares in "Ukrsoya-21" and 'Podillia-Agrokhimservis' agricultural enterprises.

S. Kots, N. Vorobey, R. Kukol, P. Pukhtaievych

Next-generation composite "Rizostim" and "Rizostim-M" preparations based on fungicide-resistant strains of soy nodular bacteria, produced by the NAS Institute of Plant Physiology and Genetics

"Oberih" Innovative Preparation for Apple Storage

The implementation of innovative technologies and materials is one of the most necessary requirements for ensuring their competitiveness on both the domestic and international markets. That concerns not only industrial production but agrarian sector as well, as it is winning increasingly more attention. In particular, in recent years Ukraine has significantly increased the number of apple orchards, which, in turn, has necessitated the construction of new specialized apple storage facilities and the use of new methods of extending the shelf-life of apples.

The State Scientific Institution "Institute for Single Crystals" of the NAS of Ukraine, jointly with the Institute of Horticulture of the NAAS of Ukraine, under the assignment of a private investor, developed a new domestic preparation "Oberih^{PRO}" which significantly extends the shelf-life of apples stored in special facilities without the loss of their taste. The preparation is based on methylcyclopropene, for which the absence of toxic effects as well as damage for human health and the environment was proved. The action mechanism of the preparation relies on the inhibition of ethylene, therefore it is effective against apple dehydration, rot, mold and the majority of fruit diseases.

The main disadvantage of using methylcyclopropene is its instability in the air. However, scientists of the State Scientific Institution "Institute for Single Crystals" were able to synthesize a special nano-container that prevents the decomposition of this substance during transportation. That permits the efficient use of "Oberih^{PRO}" preparation for delaying the post-harvest ripening of fruit and vegetables and the development of storage diseases. A single 24-hour application of this substance is sufficient, and the apples can be consumed immediately after the exposure.

"Oberih^{PRO}" preparation was registered by the Ministry of Ecology and Natural Resources of Ukraine, received permission documents for use in agribusiness. It must be stored in undamaged packaging in the facilities specially equipped for storing pesticides, at temperatures in the range 0-25 °C, and relative air humidity should not exceed 85%. When working with the preparation, strict safety measures required by the State Sanitary Rules "Transportation, storage and use of pesticides in the national economy" SSR8.8.1.2.001-98 must be taken.

V. Chebanov

ON THE PATH OF REFORMS

Setting Up the National Research Foundation of Ukraine

The Cabinet of Ministers of Ukraine with its resolution of 4 June 2018 # 528 established the National Research Foundation as a nonprofit budget-funded organization and approved the statute of this Foundation. The activities of the Foundation will be guided directly by the Cabinet of Ministers, and its main objective is to provide grant support to basic and applied scientific research, as well as R&D (experimental) projects.

Besides, the Foundation will ensure, within its powers, in particular, the integration of the national research area to the world research area, build-up of research infrastructure in Ukraine and its integration into the international research infrastructure. It will also promote the S&T collaboration among research institutions, institutions of higher education and representatives of the real sector of economy and service industry, the international exchange of information and scientists.

Of great importance is the clause that the Foundation is the main administrator of the finance allocated from the state budget. The supervisory board functions (as well as those of identification committee) are imposed on the Scientific Committee of the National Council of Ukraine for Science and Technology Development, while the executive body of the Foundation is its academic board.

In late December of 2018, the Government approved the personal membership of the academic board of the National Research Foundation numbering 30, including 16 NAS scientists.

The top-priority task of the academic board in 2019 is to elect the Chairman of the National Research Foundation and to form its directorate, in particular, to hold the contest for the election of its Chief Executive Officer. After that, for the proper start of Foundation's activities (the finance for that amounting to ₴ 262.5 million are provided for by the State Budget of Ukraine), it is necessary for the academic board to specify contest rules as soon as possible, identify thematic areas and for the Foundation to carry out expert assessment and selection of projects.

Joint Session of Presidium of the NAS of Ukraine and Committee for Science and Education of the Verkhovna Rada of Ukraine

On 17 October 2018, a joint session of NAS Presidium and Verkhovna Rada Committee on Science and Education was held. It addressed the issue "The National Academy of Sciences of Ukraine: main principles of development and state support". This function became the first guest session of the Verkhovna Rada Committee on Science and Education of the eighth convocation. The meeting was co-chaired by Academician Boris Paton, President of the National Academy of Sciences of Ukraine, and Olexander Spivakovskyi, People's Deputy of Ukraine, First Vice-Chairman of the VR Committee on Science and Education.

The participants of the session heard and discussed the following presentations: "On the main principles of the development and state support of the National Academy of Sciences of Ukraine" (Academician Anton Naumovets, NAS First Vice-President, Head of the NAS Section of Physical, Engineering and Mathematical Sciences); "On the NAS involvement in elaborating the draft state strategy of the advancement of science, technologies and innovative activities, and the ensuing Academy's tasks" (Academician Anatolii Zagorodnyi, NAS Vice-President, Director of Bogolyubov Institute for Theoretical Physics of the NAS of Ukraine); "The history of the foundation and development of the NAS of Ukraine, its current status in the Ukrainian state"(People's Deputy Ivan Kyrylenko, Vice-Chairman of VR Committee on Science and Education, Head of the Subcommittee on Scientific and S&T Activities).

Academician Boris Paton, NAS President, and People's Deputy Olexander Spivakovskyi signed the Memorandum of Collaboration between the National Academy of Sciences of Ukraine and the Verkhovna Rada Committee on Science and Education.

The session approved the resolution that specified the main principles of NAS development, gave commissions to the Academy and the Committee to ensure their implementation, and recognized the advisability for the Committee to address the Cabinet

Joint Session of the Verkhovna Rada Committee on Science and Education and NAS Presidium

of Ministers of Ukraine as to the solution of the crucial problems of science sphere and taking measures towards the development of the NAS of Ukraine.

To implement the decisions of the Joint Session of VR Committee on Science and Education and NAS Presidium, as well as the relevant commission of the Prime Minister of Ukraine, NAS Presidium with its resolution of 19 December 2018 #338, nominated NAS executives responsible for the fulfillment of the tasks facing the Academy as a result of the abovementioned decision. It also assigned those responsible for ensuring the NAS participation in the discussions of enhancing the state support to Academy's activities by MES and other central bodies of executive power.

Large-Scale Evaluation of the Activities of Research Institutions

The large-scale evaluation of the activities of research institutions of the NAS of Ukraine in accordance with the procedure approved for permanent use in 2017 went on. Thorough analysis of the activities of 51 institutions, which assessed each of their structural divisions, was provided by expert commissions involving both NAS experts and those outside the Academy, as well as foreign experts in the ratio of 56:33:11 per cent, respectively. The evaluation results mainly showed high efficiency of their activities (category A was given to 43 research institutions and to 88% of the total number of research subunits). The procedures permitted the identification of the most promising research projects that needed additional support, including projects involving young scientists and those headed by them, and in certain cases that became the objective reason for the structural reorganization of some institutions.

The standing commission of the NAS of Ukraine, which involved representatives of relevant ministries, science-intensive enterprises, and foreign scientists, carried out the unbiased and objective analysis of the expert reports presented and approved the evaluation results. It is important that the results of the evaluations carried out in 2017-2018 became the basis of targeted and earmarked funding under the new public-research program of the Academy "Support to the top-priority trends of scientific research" scheduled for 2018-2019.

Start of a New Program of Public Research

In 2018, the NAS of Ukraine started a new public-research program "Support to the advancement of top-priority trends in scientific research". That became a kind of test of a new funding model. It consists in the broad use of the results of evaluating the research efficiency and competitive principles when determining priority studies that are important

for science and society, including joint international research efforts, focused support to the scientific teams that carry out internationally recognized research, including that conducted by young scientists, providing these research efforts with state-of-the-art equipment.

Under this program, five areas of spending budget money were specified. In the first area — "Support to scientific research projects and R&D (experimental) works that are of top priority for the state" — the financial support was given to research units that had won the highest category in the evaluation of the efficiency of NAS institutions, carried out in 2017-2018. 240 such units were included in the list of the executors of research projects funded under this budget-supported program, which is 15.5% of the total number of research units in all Academy institutions.

In the second area — "Competitive research and R&D (experimental) projects that are of the utmost importance for the state, including projects with a high degree of fulfillment" — the support went to research projects that are important for the national economy and for enhancing Ukraine's defense potential, as well as to certain targeted projects. Their choice was competitive, with wide involvement of external experts.

In the third area — "Scientific research and R&D (experimental) projects advanced by young scientists through setting up research laboratories (teams) of young researchers on the competitive basis" — a contest for NAS grants for research laboratories/teams of young scientists was declared and carried out last summer. According to its results, 10 laboratories and 20 teams of young scientists won the grants. In total, these laboratories and teams employ 126 researchers affiliated with 37 NAS institutions.

In the fourth area — "Competitive collaborative international scientific research" — financial support was provided to projects selected in accordance with the results of joint contests of the NAS of Ukraine and the Science and Technology Center in Ukraine (4 projects), the NAS of Belarus (10 projects), the National Center for Scientific Research of France (CNRS) (2 projects). The distinctive feature of these contests is that projects here undergo concurrent expert assessments by contest providers, and the winners are financed on the parity basis.

In the fifth area — "Procuring the state-of-the-art equipment and upgrading the available research facilities" — almost 50 research institutions of the NAS of Ukraine received earmarked funds for the maintenance and upgrading of 65 equipment units and the advancement of 4 computational clusters of the Ukrainian National Grid. It should be noted that this equipment is used both by researchers of Academy institutions and by university academics.

Due to the implementation of the new public-research program — "Support to the advancement of top-priority trends in scientific research" — in 2018 the grant (competitive) projects in the NAS of Ukraine consisted of more than 45% of the total number of research projects and received 21% of their total amount of funding.

Activities of NAS Working Group

To implement the decision of the General Meeting of the National Academy of Sciences of Ukraine, whose session was held on 26 April 2018, NAS Presidium set up a working group to prepare proposals for the draft state strategy of the development of science, technologies and innovations. The group is headed by Academician A.G. Zagorodnyi, NAS Vice-President, its members are leading NAS scientists and representatives of the national sectoral academies of sciences.

In April 2018, the Working Group discussed possible versions of the development model of science sphere in Ukraine, determined the main principles of the structure of the abovementioned state strategy and ensured that Working Group members proposed amendments to the structure and contents of this document.

The draft strategy of the development of science, technologies and innovations, which was prepared, taking into account the proposals of Working Group members, was discussed at the joint session of NAS Presidium and Verkhovna Rada Committee on Science and Education on 17 October 2018. The draft strategy elaborated with the account of critical remarks and proposals made at this joint session, after discussion and approval by the Working Group, will be considered by NAS Presidium and will be sent to the National Council of Ukraine for Science and Technology Development.

YOUNG SCIENTISTS

In 2018, the National Academy of Sciences launched a program of grant support to youth research laboratories/teams for conducting research in the top-priority trends of the advancement of science and technology.

It was decided that these grants are to be provided on the competitive principles for encouraging young researchers to active work at scientific institutions of the Academy, preventing the departure of young people abroad, and stimulating the return of young scientists working abroad to Ukraine, identifying promising prospective science managers, promoting the collaboration of young scientists with foreign partners.

It was also conditioned that the membership of young scientific team that aspire to win a grant cannot exceed five persons. The head of the project is to have significant research results confirmed by publications in leading international journals, long (at least 2-year) experience of internship in renowned research centers abroad or of the participation in international projects.

Under the call announced in July 2018 for winning grants, the NAS Commission on the work with young scientists received 75 applications, and in accordance with contest results, 10 laboratories and 20 teams of young scientists obtained the above-mentioned grants. Each laboratory was allocated ₴150 thousand, each group — ₴100 thousand, and in total, the funding was provided to 126 young scientists affiliated with 37 research institutions of the NAS of Ukraine. All in all, in 2018 the budget of youth laboratories/teams amounted to ₴ 3.5 million under the public-research program "Support to the advancement of top-priority research trends" with budget index 6541230.

Due to those grants, even in 2018, quite a few of new results were obtained.

E.g., members of the youth laboratory of the NAS Institute for Nuclear Research (*led by O. Polishchuk*) examined the radioactive contamination of low-activity scintillating $ZnWO_4$ crystals, which enabled them to implement low background experiments of searching for dark matter, whose nature is one of the key problems of modern fundamental physics.

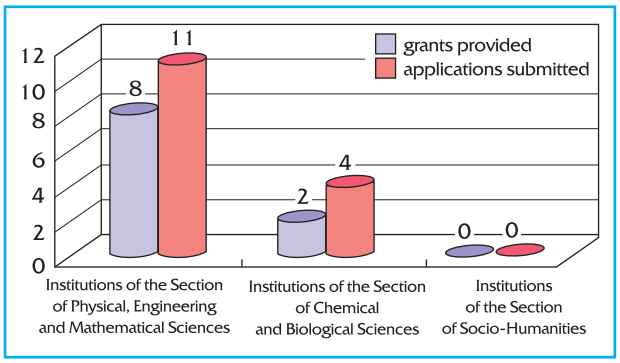
The youth team of the International Research and Training Center for Information Technologies and Systems, operating under the NAS of Ukraine and the MES of Ukraine, (*led by O. Kozhokhina*) took part in the elaboration of the basic platform for developing the system of autonomous navigation of unmanned aerial vehicles (UAV). These young scientists investigated the main available algorithms of UAV navigation, computer vision algorithms and possible versions of using and combining those, with a view to developing their own method and algorithm of autonomous navigation. This will facilitate the development of new high-precision systems of UAV navigation that will use relatively inexpensive hardware with minimal changes in UAV design and mass.

Young scientists of R.E. Kavetsky Institute of Experimental Pathology, Oncology and Radiobiology of the NAS of Ukraine (*team leader — I. Gordiienko*) searched for new approaches to regulating chronic lymphatic leukemia pathobiology. They discovered that the activation of CD150 and CD180 surface cellular receptors leads to lower levels of mPHK cytokines of interleukin 6 and interleukin 10 in malignantly transformed lymphocytes of chronic lymphatic leukemia patients.

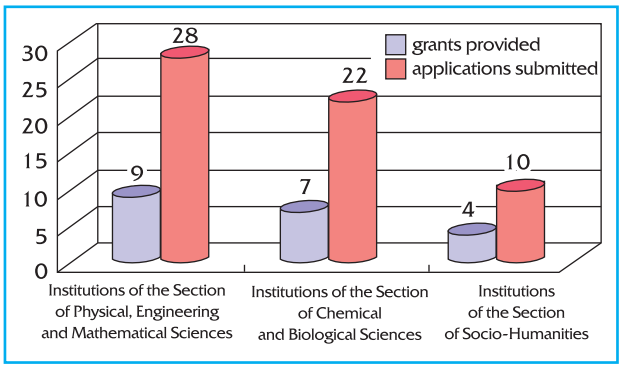
The youth laboratory of NAS Institute for Scintillation Materials (*headed by V. Kononets*) developed novel scintillation detectors for γ- and X-ray registration devices, which will permit the operation life of those devices to be extended and their maintenance costs to be reduced.

Young scientists of V.I. Vernadsky Institute of General and Inorganic Chemistry *(team leader — Yu. Shlapa*) synthesized ferromagnetic particles of manganite $(La,Sr)MnO_3$ with perovskite structure. Due to their ability to heat up effectively and controllably under the action of alternating magnetic field, they are important for the use in medicine, in particular, in the treatment of malignant tumors by magnetic hyperthermia method.

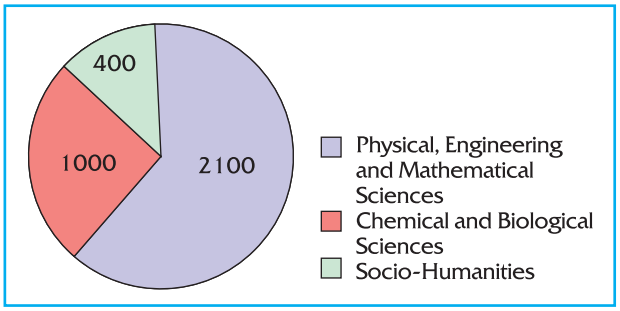
The youth laboratory of the NAS Institute of Environmental Geochemistry (*headed by V. Kovach*) carried out the analysis of the causes and effects of the emergencies of oil spills in aqueous environ-



Results of the contest for grants for setting up youth laboratories



Results of the contest for grants intended for youth research teams



Distribution of grant funding in 2018 (₴ thousand)

ments. They proposed a new technology of producing highly dispersed nano-sorbent and fast mobile equipment that implements it. The sorbent obtained will have several times higher sorption characteristics, and the equipment will be considerably better in terms of cost, productivity, mass and size than the available counterparts.

The youth laboratory of the Institute of Physics of the NAS of Ukraine (*headed by A. Senenko*) produced a stable water colloid based on multi-walled carbon nanotubes and studied graphene oxide films. The use of such structures with various layers of metals, semiconductors or insulators is a promising platform for constructing heterostructures with new electronic, optical or magnetic properties, elements of flexible electronics, as well as optoelectronic devices — photoreceivers, photoelectric and light emitter devices with unprecedented characteristics or unique functional properties.

Young scientists of the NAS Institute of Food Biotechnology and Genomics (*team leader is Yu. Krasylenko*) studied cell mechanisms of the interaction of parasitic plants (representatives of *Orobanche* and *Cuscuta* genera) and their host plants. The results obtained provide the basis for improving plant adaptability to the negative effects of biotic stress factors under productivity decrease, transfer of pathogenic viruses and cattle poisoning.

In collaboration with their colleagues from Graz Medical University (Austria), researchers of the youth laboratory of Palladin Institute of Biochemistry of the NAS of Ukraine (*laboratory head is L. Kasatkina*) developed a protocol of the quantitative analysis of protein expression (synthesis level) in neurons. The use of this protocol will allow the quantitative analysis of SNARE proteins, receptors and transporters of neuro mediators, adaptor proteins on experimental neuropathology models.

It should also be noted that owing to grants young scientists took part in international workshops "Dark Matter and Stars" (Lisbon, Portugal) and "Ways of Fast Response to Oil Products Spills in Seaports" (Rome, Italy); implemented internship programs at the National Institute of Chemistry (Ljubljana, Slovenia) and the Institute of Experimental Physics (Košice, Slovakia). The results of the studies conducted were published in 21 papers in Ukrainian and foreign professional journals. 17 more papers were submitted for publication, and a patent application was also submitted.

INTEGRATION INTO INTERNATIONAL RESEARCH AREA

Last year, the major steps towards integrating NAS institutions into the international (first and foremost, European) research area were the signing of new agreements with leading European partners, an increase in the number of bilateral and multilateral projects with organizations of EU countries, wide presentation of research results at numerous international events.

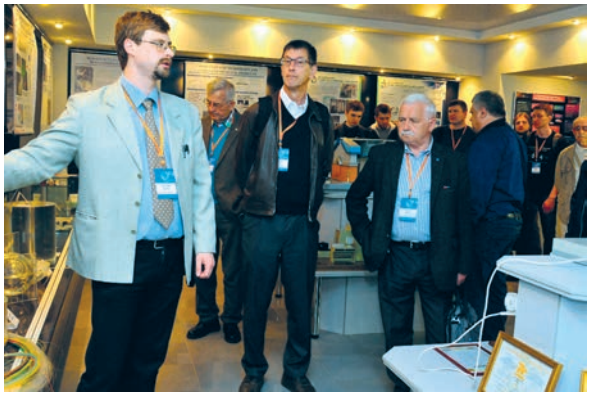
In particular, of significant importance was the signing of the Agreement on granting Ukraine the status of an associate member in the Federation of National e-Infrastructures and European Intergovernmental Research Organizations EGI Foundation. This status permits the Ukrainian grid community to take part in project calls concerning the development of the European Open Science Cloud (EOSC) and, in collaboration with EGI, to develop the national open science cloud in conformity with EU standards and as a part of EOSC.

In the framework of cooperation with the National Centre for Scientific Research of France (CNRS), the NAS of Ukraine signed an agreement on setting up the international associate laboratory "Nano-Porous Heat-Resistant Polymer Materials" — "POLY-NANOPOR", which involves researchers of the Institute of Macromolecular Chemistry, the Institute for Nuclear Research and the International Research Network "EUREA: European Network for Ultra-Relativistic Energies". Its executors on the part of the NAS of Ukraine are scientists of Bogolyubov Institute for Theoretical Physics.

Active involvement of Academy's scientists in "HORIZON 2020" EU Framework Program for Research and Innovation and its complementary "EURATOM" Program, numerous regional programs, in particular, "INTERREG", a number of projects for realizing the EU Strategy for the Danube Region was continued. Last year, the total number of projects under "HORIZON 2020" program implemented by NAS institutions rose to 35. An important event of the previous year was the meeting of the Board of Governors of the EC Joint Research Centre (JRC), which was attended by Academician A.G. Zagorodnyi, Vice-President of the NAS of Ukraine. In addition to discussing the status and prospects of the cooperation between the NAS of Ukraine and JRC, the meeting also considered the possibility of donating research equipment for Academy institutions.

The successful implementation of long-term NATO Program "Science for Peace and Security" was going on. Under it, Ukrainian experts carried out research, including applied one. It was concerned with the development of compact sensor systems for unmanned aerial vehicles, holographic and pulse radars of subsurface sounding for detecting mines and self-made explosive devices, a microwave imaging curtain, a system of noise radars for the hidden surveillance of sea and airspace borders, magnetic resonance and microwave recording of self-made explosives and banned materials etc. The jubilee session devoted to the 60th anniversary of this program (November 2018, Brussels, Belgium) highly appreciated the results produced by Ukrainian scientists. Prof. K.O. Lukin affiliated with O.Ya. Usikov Institute for Radio Physics and Electronics, who is the Ukrainian co-chair manager of the project "Compact sensor systems for unmanned aerial vehicles" was honored with the Special Award of the Alliance.

For the first time in Ukraine, NAS Institute for Scintillation Materials hosted the international conference "Status and Prospects of Ukraine—CERN Cooperation", which was attended by Ukrainian researchers and leading scientists of Belgium, Holland, Italy, Germany, France who represented ma-



Presentation of research results during the scientific conference "Status and Prospects of Ukraine-CERN Cooperation", Kharkiv, Ukraine

UNESCO Aristotle Gold Medal

Participants of the IX International Congress of Ucrainica Scholars, Kyiv, Ukraine

jor CERN collaborations. CERN representatives informed the participants of the event about the main objectives set for themselves by this organization's researchers and the feasibility of collaboration with Ukraine. Ukrainian scientists, on their part, shared their own experience of conducting experiments in high-energy physics, the results of implementing joint projects with CERN, new ideas concerning further research.

The continuation of the fruitful cooperation with UNESCO and active involvement of NAS researchers in this organization's scientific programs "The Man and the Biosphere" and "Information for Everybody", International hydrological program, the Intergovernmental Oceanographic Commission of UNESCO should be noted as well. The Academy initiated the discussion of Ukraine's proposal to the UN General Assembly to declare 2025 the international year of caves and karst by the National Commission for UNESCO.

A sign of UNESCO's high respect and appreciation was the awarding, in the framework of celebrating Academy's 100th anniversary, of Boris Paton, NAS President, with Aristotle Gold Medal for his invariable dedication to the values of this organization and promotion of peace and tolerance through science. On behalf of UNESCO Director General, Mrs. Peggy Oti-Boateng, Director of the Division of Science Policy and Capacity Building in the Natural Sciences of UNESCO Secretariat, who represented UNESCO at the celebration of Academy's centenary, handed that honorary award to Academician B.E. Paton.

The first ceremony of awarding women scientists with the Ukrainian Prize of L'ORÉAL-UNESCO "For Women in Science" within the program under the auspices of Ukraine's National Commission for UNESCO and with the support of the NAS of Ukraine and the NGO "Center for Development of Corporate Social Responsibility" was held. In the framework of this event, the jury of the contest considered 255 applications and elected three winners. Among them were two representatives of the National Academy of Sciences of Ukraine: Olena Vaneeva, Senior Research Associate of the Institute of Mathematics, PhD in mathematics and physics, and Natalia Shcherban, Senior Research Associate of L.V. Pisarzhevsky Institute of Physical Chemistry, PhD in chemistry.

On the occasion of the 25th anniversary of the International Association of the Academies of Sciences (IAAS), whose member Ukraine is, the National Academy of Sciences of Belarus hosted jubilee events, which were attended by a NAS delegation headed by Academician A.G. Naumovets. A jubilee session of the IAAS Council, a plenary session of the International Congress on Intelligent Economy, a number of international scientific-and-practical conferences were held. The IAAS Council approved the decision on establishing the IAAS Prize named after Academician B.E. Paton, who headed the Association for 23 years.

A significant event in the international collaboration of the Academy was the IX International Congress of Ucrainica Scholars, whose co-organizers were the NAS of Ukraine and the International Association of Ucrainica Scholars and which gained special relevance in the context of the Ordinance of President Petro Poroshenko on the Decade of the Ukrainian Language (signed on 31 May 2018). The

G. Zelenko (Right) at the 25th World Congress of the International Political Science Association, Brisbane, Australia

Congress became a resonant cultural and scholarly event attended by more than 500 national and foreign experts from Austria, Belarus, Bulgaria, Great Britain, Canada, Italy, Moldova, Germany, Poland, Russia, Serbia, Slovakia, the United States of America, Hungary, and other countries.

The jubilee 25th World Congress of the International Political Science Association (IPSA) was held in Brisbane, Australia. At this highest-scale gathering of political science experts, which was attended by over 2000 delegates of 50 countries, including Ukraine, Sci. Dr. (Politology) Galyna Zelenko, Head Research Associate of Kuras Institute of Political and Ethnic Studies became the official representative of Ukraine in IPSA Council.

Alexander Van der Bellen, Federal President of the Republic of Austria, during his 3-day official visit to Ukraine, visited Vasyl Stefanyk Lviv National Scientific Library of Ukraine. There he took part in the presentation of the publishing projects of the Austrian Cooperation Agency, which is a cultural partner

Alexander Van der Bellen, Federal President of the Republic of Austria, hands books that will be a part of Vasyl Stefanyk Lviv National Scientific Library collection

of the Library, examined the exhibition "Austrian books in historical collections of Vasyl Stefanyk Lviv National Library of Ukraine", and made a gift of the books that would be a part of Library's collection.

Jules Hoffmann, renowned immunologist and cytologist, 2011 Nobel Prize winner in physiology and medicine, visited the National Academy of Sciences of Ukraine. During the meeting, Academician Anton Naumovets, First Vice-President of the NAS of Ukraine, presented J.A. Hoffmann the diploma on conferring the title of Doctor Honoris Causa of the National Academy of Sciences of Ukraine on his foreign colleague — "for a significant contribution to the advancement of science, social progress, promoting peace, mutual understanding and cooperation among peoples". The program of Jules Hoffmann's visit included a public lecture "Inborn Immunity: from Insects to Mankind" for students and young scientists, and the complimentary address at the ceremonial opening of the third stage of the all-Ukraine contest of research papers of schoolchildren who are members of the Junior Academy of Sciences of Ukraine.

SCIENCE POPULARIZATION. PUBLIC RELATIONS

Popularization of science and research achievements of Ukrainian scientists within the country and outside it for enhancing the prestige of scientific profession in the society and formation of scientific outlook is among the main tasks of the NAS of Ukraine, according to its Statutes.

In 2018, Academy scientists continued their active work in this important area of their activities. They regularly informed the society about scientific achievements in Ukraine and across the world in thematic articles in printed and electronic media, as well as TV and radio programs, organizing numerous educative events intended for the broad circles of people interested. Researchers of NAS institutions are also the founders, permanent lectors and demonstrators of numerous large-scale national popular-science projects that have been functioning for several years running.

The central educational event of Academy's jubilee year was the XII All-Ukraine Science Festival, which was held on 16-18 May across our country. Traditionally, its ceremonial opening took place in E.O. Paton Electric Welding Institute. French Nobel Laureate Serge Haroche and Academician Vitalii Kalchenko, Director of the NAS Institute of Organic Chemistry, attended the festival and gave lectures there. In accordance with the schedule of the first day of the Festival, a presentation exposition of the scientific achievements of NAS institutions and a presentation of research projects and poster reports of members of the Junior Academy of Sciences of Ukraine and students of secondary education institutions were also opened in its main location.

Academy's scientists were actively involved in the events under the umbrella of two other leading Ukrainian popular-science initiatives — "Science Days" and "Scientific Picnics in Ukraine", which in the fall of 2018 marked their first — the five-year — jubilee. "Science Days" were held four times: twice — on 12-13 May and on 10-11 November 2018 — they received visitors at their regular traditional events, on 17 March — at "neural" "Science Days" at Bogomoletz Institute of Physiology in the framework of the global campaign "Brain Awareness Week" in Ukraine, and on 2 September — at the "ArtDay" annual festival in the Ukrainian capital. "Scientific Picnics in Ukraine" also organize their educative functions twice, but, as opposed to the chamber-scale "Science Days", they hold them out-of-doors, in city parks and squares. For example, "Medical Picnics" took place in Kyiv on 19 May, and on 22 September — "Scientific Picnics" proper. The All-Ukraine Science Festival, as well as spring "Science Days" and "Scientific Picnics" were timed to coincide with the professional holiday of Ukrainian scientists, which is celebrated on the third Saturday in May, while the autumn popular-science events, as a rule, were synchronized with the World Day of Science for Peace and Development.

On 12 May the Children's Scientific Festival "Science Holiday" was held by researchers of

Autumn "Science Days" at M.H. Kholodny Institute of Botany of the NAS of Ukraine

"Science Holiday" at G.V. Kurdyumov Institute for Metal Physics of the NAS of Ukraine

Scientists of M.M. Gryshko National Botanical Garden of the NAS of Ukraine with visitors of IV Educative Festival "Arsenal of Ideas"

Excursion to the dig in Metropolitan's Garden on the territory of the National Kyiv-Pechersk Historical and Cultural Reserve

G.V. Kurdyumov Institute for Metal Physics of the NAS of Ukraine and Kyiv Academic University of the NAS and MES of Ukraine. Young guests of the festival were invited to visit popular-science lectures, games, contests, demonstrations, a scientific show, as well as actual experiments, which they could join.

On 13 September, Kyiv streets saw another Ukrainian Dictionary Holiday — a public event intended to popularize Ukrainian books, first and foremost, dictionaries. The Ukrainian Lingua-Information Fund of the NAS of Ukraine and the National Center "Junior Academy of Scientists" were among its leaders.

On 26-30 September, the IV Educational Festival "Arsenal of Ideas" was conducted. Academy biologists took part in it, organizing the work of creative laboratories and holding a number of interesting masterclasses for children and adults.

On 29 May and 1 June, open days took place at the NAS Institute for Nuclear Research: during them Institute's researchers presented their achievements and nuclear physics facilities they make experiments on to all comers.

In 2018, the public lecture center in archeology "What Archeology Tells Us" continued its work. It functions under the umbrella of the Archeological Museum of the NAS Institute of Archeology. The attractive feature of this educative initiative is that each season starts and ends with excursions to archeological digs, historical sites, memorial places of culture and architecture.

Among the novelties of the previous year was the first PhysMathDay, which took place on 17 November at the NAS Institute of Mathematics. This scientific festivity is to popularize physics and mathematics among young people, schoolchildren, first of all. Guests of the event had an opportunity to join games and a mathematical quest, watch demonstrations in physics and listen to interesting lectures.

Visitors of the first PhysMathDay with lecturer Kateryna Terletska, Senior Research Associate of the Institute for Mathematical Machines and Systems Problems of the NAS of Ukraine, PhD (Phys. and Math.)

Astronomers also launched a new popular-science event: a Telescope Day was held at the Main Astronomical Observatory of the NAS of Ukraine on 22 September. On that day, Kyivans and guests of the city had an opportunity to see the telescopes of the Observatory with their own eyes and to listen to its scientists' accounts of how they work with telescopes, what objects they observe, and what discoveries were made in the years of MAO existence. Besides, for several years running, Ukrainian astro-

During spring "Astronomy Day" at the Main Astronomical Observatory of the NAS of Ukraine

March for Science in Kyiv

nomers, like their colleagues across the world, mark the spring and autumn Astronomy Days. Last year these days fell on 21 April and 13 October. Among the astronomical popular-science events is also Holosiiv Astronomical Autumn, when scientists of the Academy Observatory tell the visitors about their main research achievements, present new books and hold discussions.

An interesting happening intended for drawing the attention of society and authorities to the achievements and problems of Ukrainian science took place on 14 April: a procession of Ukrainian scholars, scientists of the NAS of Ukraine in particular, went along capital's streets in the framework of the worldwide initiative — the second March for Science.

Academy scientists also present their research outcomes at large-scale specialized exhibitions. On 5 June 2018, they took part in the presentation exhibition of the products of Kyiv's manufacturers "Made in Kyiv" organized by the Kyiv City State Administration, on 17-19 October — in the XI International Exhibition LABComplEX, on 23-26 October — in the "SECURITY" International Exhibition, on 21-23 November — in the International Forum "Innovation Market".

On 6-7 December 2018, two large-scale exhibitions devoted to the NAS 100th anniversary were held in "Science" Academy Expocenter: the presentation exhibition of scientific and R&D products of NAS institutions and a specialized presentation exhibition of NAS R&D products and technologies "Science — for Defense and Security of the State".

Last year, scientists of the NAS of Ukraine continued their close collaboration with Ukrainian media, in particular, with TV channels *UA: Pershyi, Rada, Priamyi, Inter, the 5th Channel*; radio stations "*UA: Ukrainian Radio*" (*the First Channel of the Ukrainian Radio*, "*Promin*", "*Kultura*"), *Hromadske Radio, Radio Svoboda, Radio NV*, "*Holos Stolytsi*" (in 2018, "Academiya Nauk" popular-science program was started on the radio waves of the latter). Also went on the collaboration with printed periodicals *Den, Dzerkalo Tyzhnia, Holos Ukrainy, Uriadovyi Kurier, Svit, Demokratychna Ukraina, Ukrainske Slovo, Ukrainskyi Tyzhden, Kraina, Siohodni, Fakty*, and with electronic resources *Ukrainska Pravda, Weekend in Kyiv, WoMo* etc.

On 7 December, the press conference "100 Years of the National Academy of Sciences of Ukraine" was held at "*Ukrinform*" Press Agency. It elucidated the history of the Academy foundation, the previous and the latest achievements of its scientists, as well as pressing problems of Ukrainian science sphere. To mark the NAS jubilee, short video cycles focused on major achievements of Academy scientists were demonstrated on two national TV channels — *UA:Kultura* and *Inter*, while *Rada* Parliamentary Channel presented the documentary "The National Academy of Sciences of Ukraine: 100 Years of Service to People and State". The interviews given by Academician Boris Paton, NAS President, who, like the Academy, turned 100 on 27 November 2018, were published by *Dzerkalo Tyzhnia, Ukrainske Slovo, Siohodni* and *Svit* newspapers. Another of his interviews appeared on the site of *Times Higher Education* British online edition.

BACKGROUND INFORMATION. STATISTICS

Structure of the NAS of Ukraine

The structure of the NAS of Ukraine includes 3 sections and 14 departments, which incorporate 154 research institutions and research-and-production organizations (R&D offices, pilot production facilities etc.). Functioning within some research institutions are science objects that have the status of National Asset (nuclear, physical and astronomical research facilities, testing equipment complexes, archive scientific collections and museum displays, plant genetic funds, collections of microorganism strains and plant lines, landmarks of history and culture etc.), as well as centers for shared use of scientific equipment.

Research organizations that have the National Institution status:

- V.I. Vernadsky National Library of Ukraine
- National Science Center "Kharkov Institute of Physics and Technology"
- "Olbia" National Historical and Archeological Reserve
- M.M. Gryshko National Botanical Garden
- "Sofiivka" National Dendrological Park
- National Museum of Natural History
- V. Stefanyk Lviv National Scientific Library
- National Center "Junior Academy of Sciences" of the MES of Ukraine and the NAS of Ukraine.

Functioning in the Academy are **five regional science centers** of dual subordination with the Ministry of Education and Science of Ukraine:

- Donetsk Science Center (Kramatorsk, Donetsk oblast)
- Western Science Center (Lviv)
- Southern Science Center (Odesa)
- North-East Science Center (Kharkiv)
- Prydniprovskyi Science Center (Dnipro),

as well as the Center for Evaluating Research Institutions and Scientific Support to Regional Development (Kyiv).

The statutory activities of Crimean Science Center and its funding from the NAS budget were suspended in 2014.

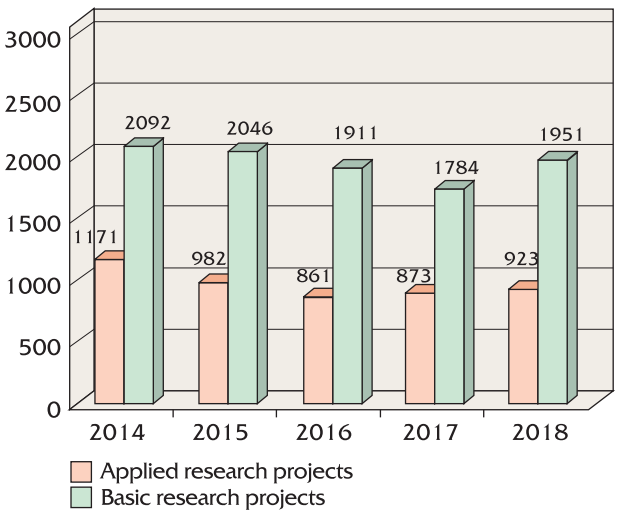
DISTRIBUTION ACROSS SECTIONS AND DEPARTMENTS

Department	The number of research institutions	The number of pilot production organizations	The number of objects that have the National Asset status	The number of centers for shared use of equipment
The Section of Physical, Engineering and Mathematical Sciences				
Dpt. of Mathematics	4	—	—	—
Dpt. of Information Science	7	—	—	—
Dpt. of Mechanics	6	3	3	6
Dpt. of Physics and Astronomy	16	3	9	16
Dpt. of Earth Sciences	14	1	—	5
Dpt. of Physical and Technological Problems of Materials Science	11	18	1	12
Dpt. of Physical and Technological Problems of Power Engineering	11	7	2	4
Dpt. of Nuclear Physics and Power Engineering	6	2	2	6
The Section of Chemical and Biological Sciences				
Dpt. of Chemistry	13	7	—	11
Dpt. of Biochemistry, Physiology and Molecular Biology	8	1	5	9
Dpt. of General Biology	22	1	19	12
The Section of Social Sciences and Humanities				
Dpt. of Economics	9	—	—	—
Dpt. of History, Philosophy and Law	17	3	5	—
Dpt. of Literature, Language and Art Studies	9	—	4	—

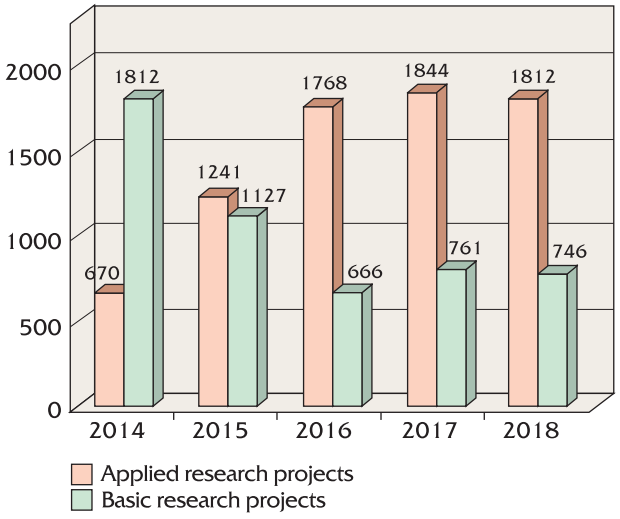
Regional structure of the NAS of Ukraine

Numerals in the diagram show the number of research institutions
** The status of NAS institutions located in the Crimea Autonomous Republic is defined by the Law of Ukraine "On guaranteeing the rights and freedoms of citizens and the legal regime of the temporarily occupied territory of Ukraine"*

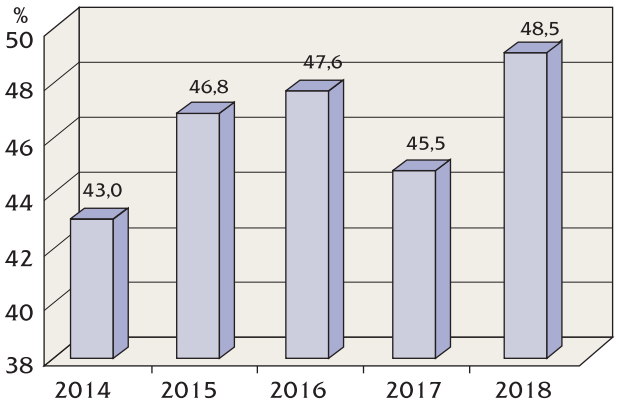
Conducting research



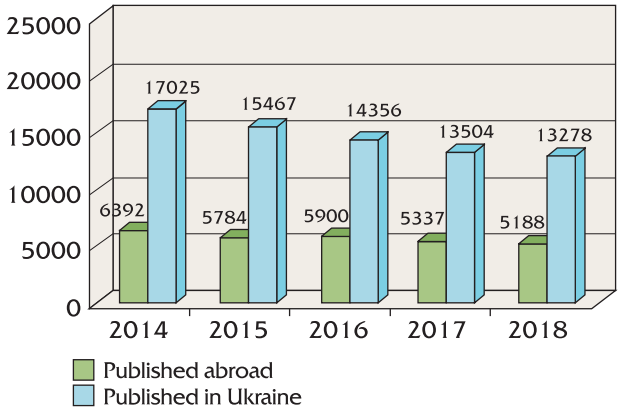
The number of research projects financed by the general fund of the state budget



The number of research projects financed by the special fund of the state budget



The proportion of targeted-program and competitive projects in the total number of projects



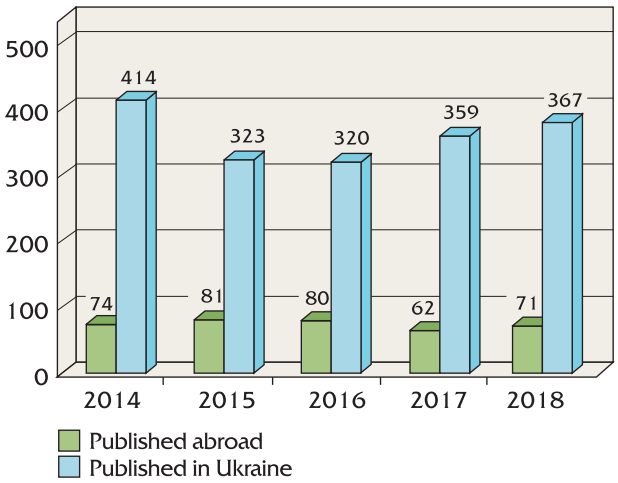
Papers of NAS scholars in periodicals

NAS targeted-program and competitive projects in 2018 involved research conducted under:

- 8 NAS targeted programs of basic research;
- 16 NAS targeted programs of applied research;
- 7 separate targeted projects;

and were based on the results of:

- joint contests with foreign and international organizations;
- a contest of S&T (innovation) projects;
- a contest of research projects in socio-humanities;
- a contest of research projects of young scientists carried out under NAS grants.



Academic monographs

Publishing

- **The total number of Academy journals:**

84 scientific journals,
1 popular-science journal — "Svitohliad",
and Ukrainian abstract journal "Dzherelo" in four thematic series

- **10 journals are published in English in Ukraine:**

1. Science and Innovation
2. Semiconductor Physics, Quantum Electronics & Optoelectronics
3. Journal of Mathematical Physics, Analysis, Geometry
4. The Paton Welding Journal
5. Journal of Thermoelectricity
6. Ukrainian Journal of Physics
7. Functional Materials
8. Biopolymers and Cell
9. Experimental oncology
10. Problems of Cryobiology and Cryomedicine

- **21 journals are published in English abroad:**

by Springer Publishers

1. Ukrainian Mathematical Journal
2. Cybernetics and Systems Analysis
3. International Applied Mechanics
4. Strength of Materials
5. Materials Science
6. Theoretical and Experimental Chemistry
7. Neurophysiology

by Pleiades Publishing, Inc.

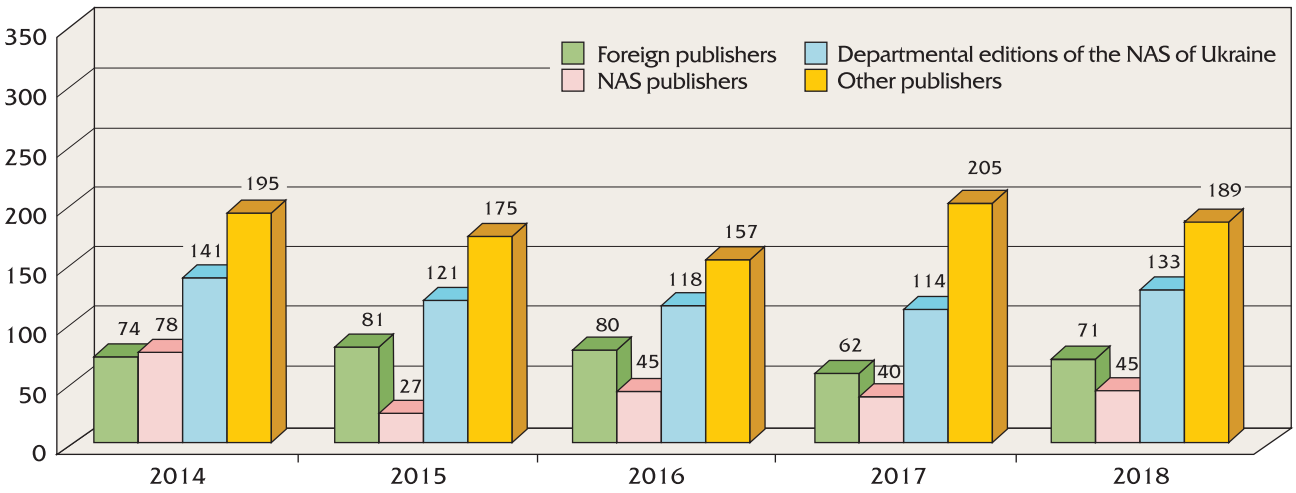
1. Kinematics and Physics of Celestial Bodies
2. Journal of Superhard Materials
3. Journal of Water Chemistry and Technology
4. Cytology and Genetics

by Begell House Inc. Publishers

1. Journal of Automation and Information Sciences
2. Radio Physics and Radio Astronomy
3. Telecommunication and Radio Engineering
4. Inernational Journal on Algae
5. Hydrobiological Journal
6. International Journal of Physiology and Pathophysiology

by other publishers

1. Low Temperature Physics — American Institute of Physics



Distribution of academic monographs across groups of publishers

2. Technical Diagnostics and Non-Destructive Testing — *Cambridge International Science Publishing*
3. Advances in Electrometallurgy — *Cambridge International Science Publishing*

Electronic editions in English produced abroad

1. Vestnik Zoologii — *De Gruyter*

Scientific expertise

In 2018, NAS specialists contributed to the preparation of:

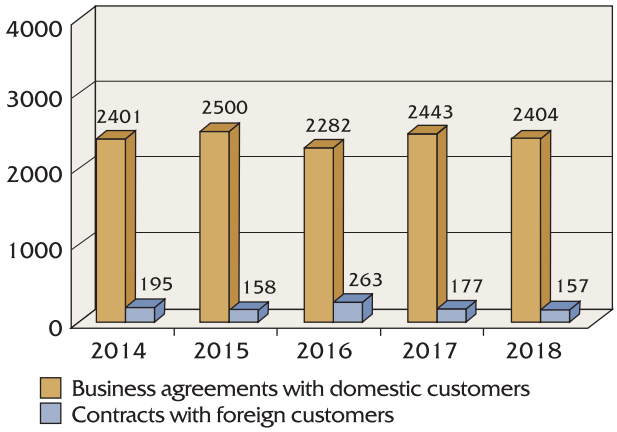
- Strategy of the development of the industrial complex of Ukraine till 2025
- State report on the implementation of governmental policy in counteracting human trafficking in 2017 — 1st half of 2018
- Annual Address of the President of Ukraine to the Verkhovna Rada of Ukraine "On the Domestic and International Situation of Ukraine in 2018"
- Comprehensive program of the development of rural territories in Donetsk oblast for 2018—2020
- National reports: "Ukraine: the Road to Society Consolidation", "Ukrainian Society: Migration Dimension"
- Concept of the state ethno-national policy of Ukraine

NAS scholars prepared expert conclusions, comments and proposals, in particular those to the draft laws:

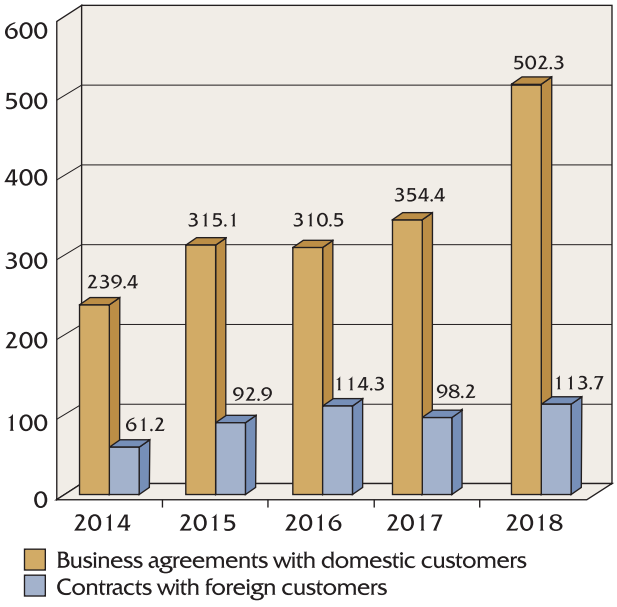
- On the national security of Ukraine
- On the principles of territorial administrative structure of Ukraine
- On the Strategy of Sustainable Development of Ukraine till 2030
- On the main principles of the state agrarian policy and the state policy of rural development
- On the national infrastructure of geospatial data
- On Ukraine's accession to Metre Convention
- On waste management
- On the state biosafety system in developing, testing, transporting and using genetically modified organisms
- On the simplified procedure of organization liquidation
- On the education for adults

Expert conclusions	2014	2015	2016	2017	2018
Expert conclusions concerning normative legal documents, information and analytical documents on various issues of socio-economic development, sent to state authorities	1500	2017	2160	2200	2320
Expert conclusions as to the advisability of conducting public basic research	492	1752	606	393	378

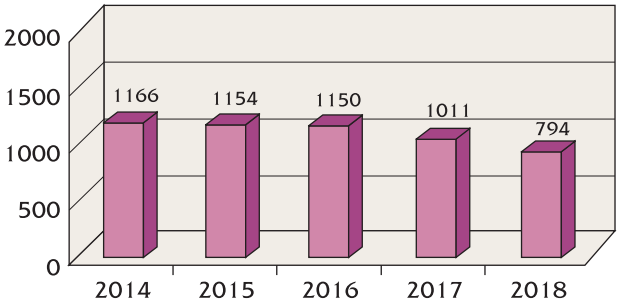
Innovation activities



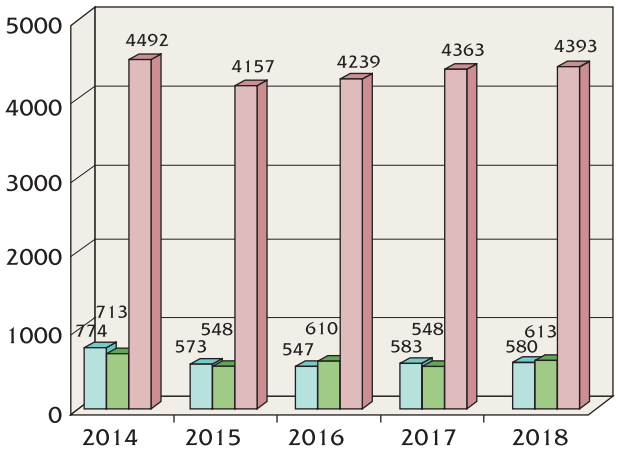
Implemented economic agreements and contracts, the total number



Revenues received by NAS institutions from implemented business agreements and contracts, ₴ million



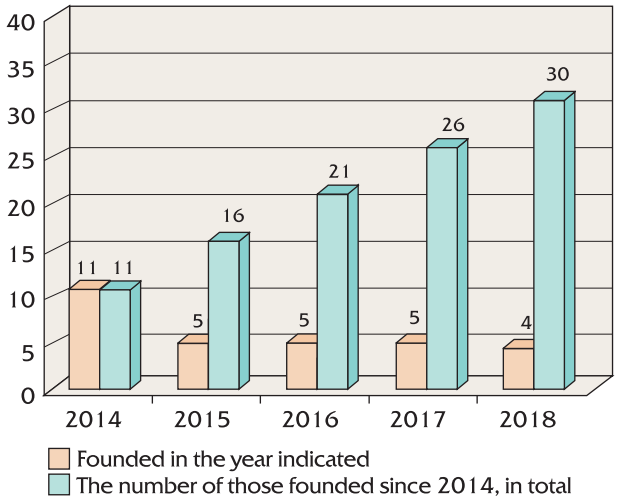
The number of implemented research findings



Protection and use of intellectual property rights

Collaboration with higher education institutions and organizations of the MES of Ukraine

Collaboration agreements concluded by research institutions and institutions of higher education	262
Research projects implemented collaboratively with academics	218
Published monographs co-authored with academics	104
Research scientists who worked in education:	1313
including:	
NAS active members	41
NAS corresponding members	82
Published textbooks and manuals for institutions of higher education	80
Scientists at the head of chairs in institutions of higher education	68
Students of higher education institutions who pursued/are pursuing Master's degree programs at joint research-and-training agencies hosted by scientific organizations:	
in academic year 2017/2018	460
in academic year 2018/2019	455
Students who wrote their graduate papers at research institutions	1078
Academics incorporated to specialized academic councils of research institutions	520
Scientists of research institutions incorporated to specialized academic councils of higher education institutions	580
Newly arrived graduate specialists who attended study groups of the Junior Academy of Sciences in their school days	16



Joint research-and-training organizations

Research scientists and lecturers of higher education institutions and MES organizations who upgraded their professional skills at research institutions	449
Theses of academics defended at specialized academic councils of scientific research institutions	185

International ties

The contractual framework for the international collaboration of the NAS of Ukraine (effective agreements, contracts, memorandums etc.) – a total of 136 documents.

In 2018, the Academy signed seven new collaboration agreements:

• Memorandum of mutual understanding and scientific collaboration between the National Academy of Sciences of Ukraine and the Kuwait Institute for Scientific Research

• Memorandum of mutual understanding between the National Academy of Sciences of Ukraine and the National University of Singapore

• Coordination Agreement between the Academy of Sciences of Shandong Province (PRC) and the National Academy of Sciences of Ukraine on the activities of joint scientific center

• Agreement on S&T cooperation between the National Academy of Sciences of Ukraine and the Academy of Sciences of Shanxi Province of the People's Republic of China

• Agreement on S&T cooperation between the National Academy of Sciences of Ukraine and the China Association for International Science and Technology Cooperation

• Agreement on Cooperation between the National Academy of Sciences of Ukraine and the National Institute for Astrophysics of Italy

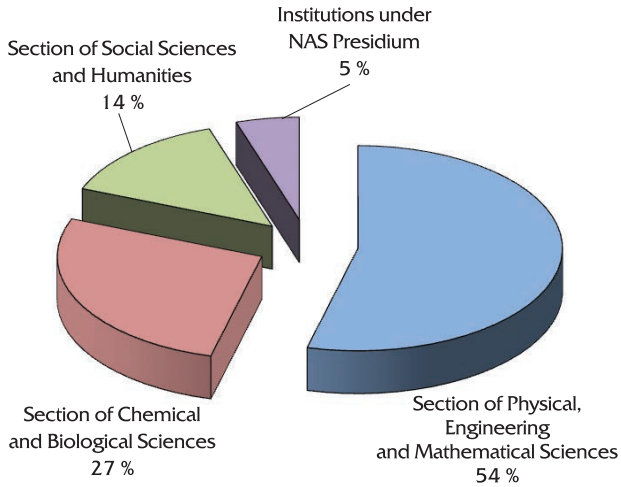
• Agreement on S&T Cooperation between the National Academy of Sciences of Ukraine and the University of Lisbon

Two cooperation agreements were renewed:

• Agreement on Scientific Cooperation between the National Academy of Sciences of Ukraine and Vietnam Academy of Science and Technology

• Agreement on Scientific and Technological Cooperation between the National Academy of Sciences of Ukraine and the Austrian Academy of Sciences

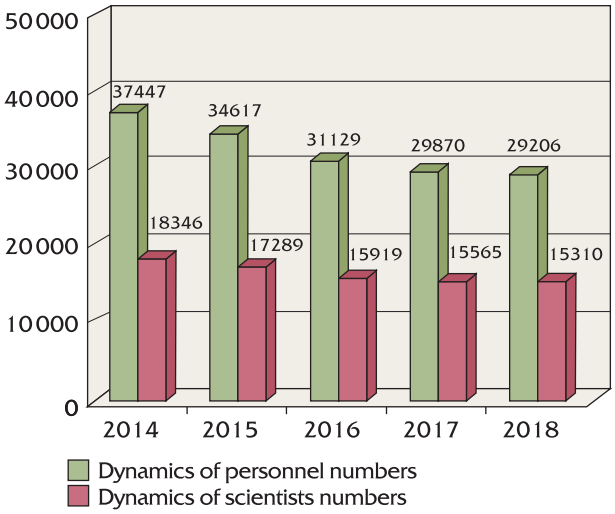
There are about 600 direct agreements and contracts, concluded by NAS institutions with foreign partners.



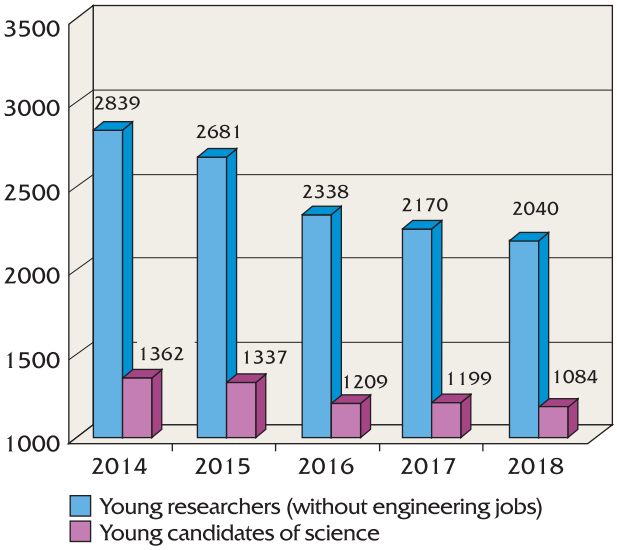
The distribution of direct agreements and contracts across institutions of NAS sections

Personnel data sheet (as of 1 January 2019)

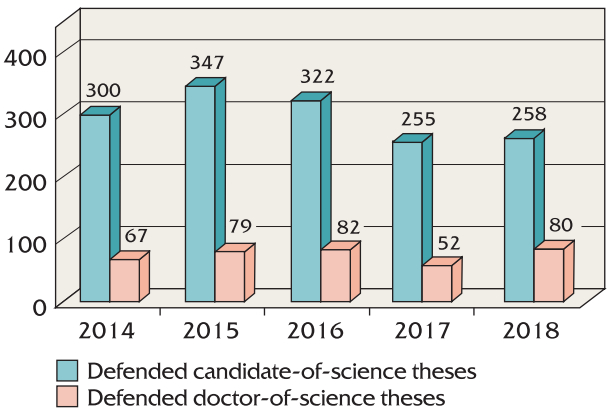
The total number of employees	29206
of them:	
in research institutions	27595
in research-and-production facilities	1295
in services organizations	316
The number of research scientists	15310
of them:	
doctors of sciences	2367
candidates of sciences (PhD)	6746
researchers without an advanced degree	6197
The number of young specialists recruited in 2018	398
The number of those who pursued post-graduate studies	1022
including full-time studies	773
Defended PhD theses	258
Doctoral fellowships	106
Defended doctor-of-science thesis	80



The number of employees

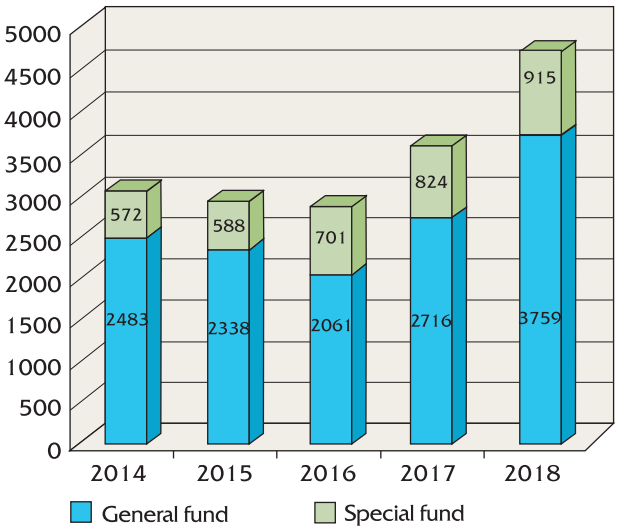


The number of young researchers

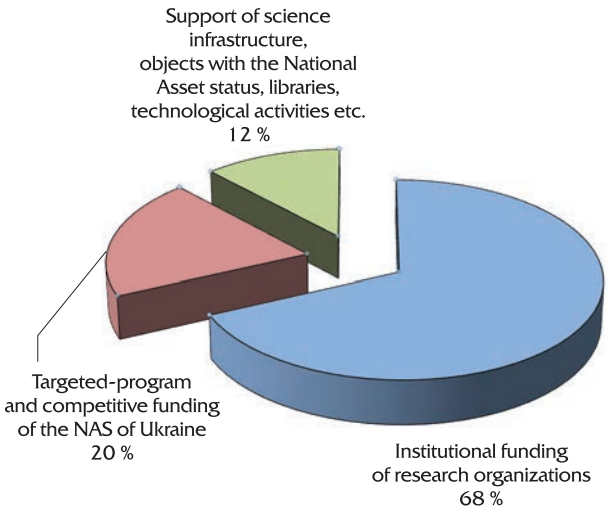


Dynamics of research scientists training

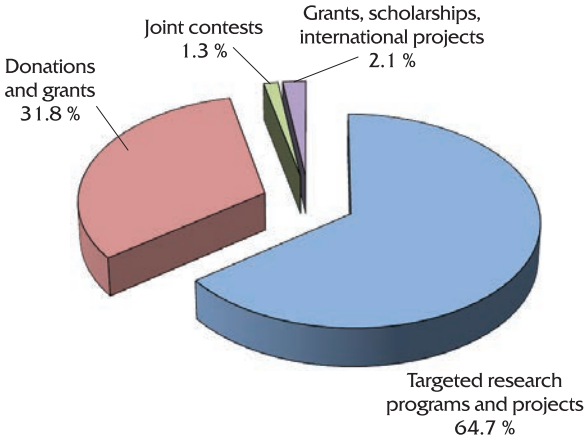
Financial provision



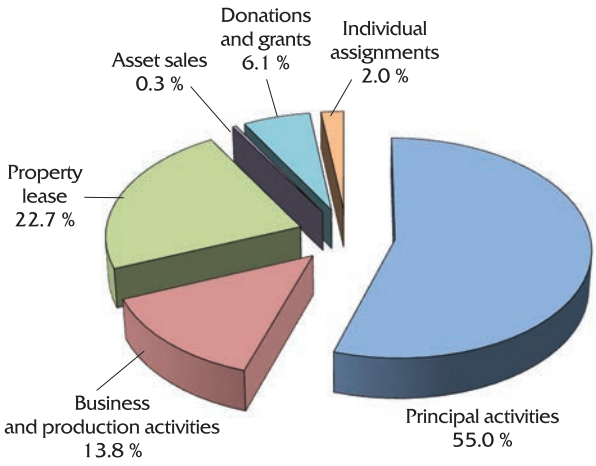
The total amount of NAS funding, ₴ million



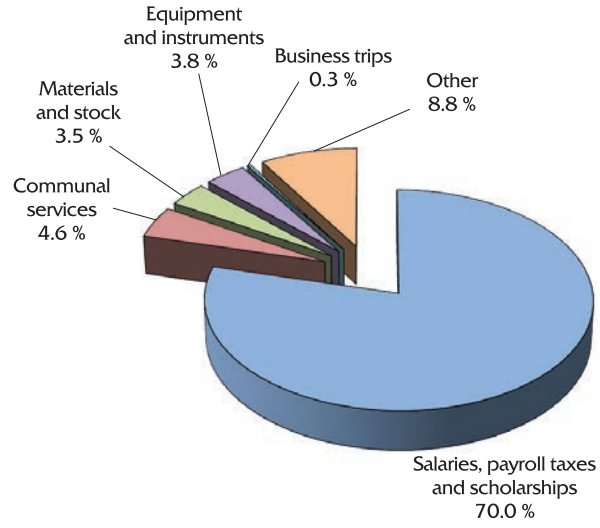
Distribution of the general fund finance



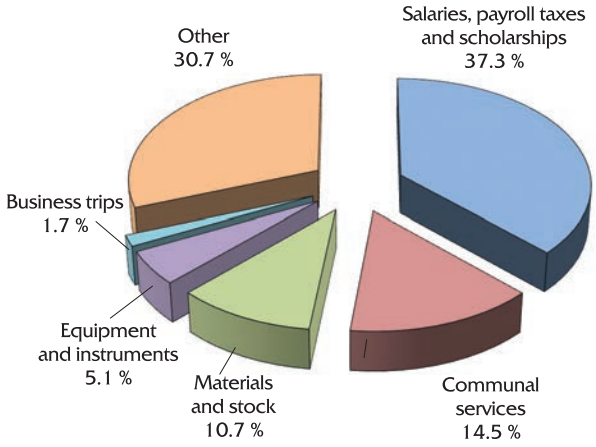
Targeted-program and competitive funding



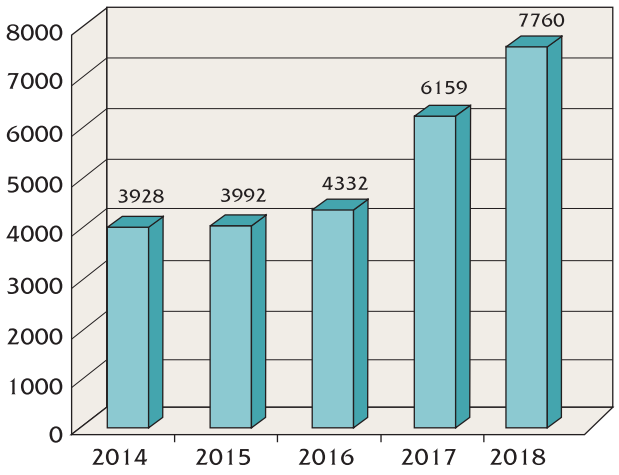
Structure of revenues to the special fund



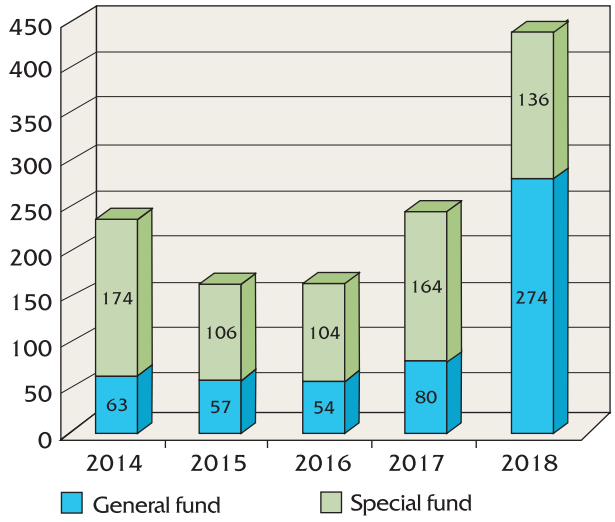
Structure of general fund expenses



Structure of special fund expenses



Average monthly salaries of employees, ₴



Expenses for procurement of equipment and materials, ₴ million

CONTENTS

Переклад англійською мовою
І.І. Рахманової

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