

**NATIONAL ACADEMY OF SCIENCES  
OF THE REPUBLIC OF ARMENIA**

**REPORT  
ON MAJOR RESEARCH OUTCOMES  
FOR 2023**



**Yerevan - 2024**

*The Report is prepared by the  
Scientific Organizational Department on the basis of materials submitted by the NAS RA  
Divisions of Sciences,  
Research Organizations and Sub-Divisions*

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## INTRODUCTION

On December 19-20, 2023, the 80th anniversary of the foundation of the National Academy of Sciences of the Republic of Armenia was celebrated. Over the past 80 years, the Academy has gone through a difficult but at the same time meaningful path, achieved high scientific results and worldwide recognition. The National Academy of Sciences is the highest scientific center of Armenia, the organizations of the Academy system conduct fundamental and applied research in all fields of science. The Academy has become a coordinating body for fundamental research and Armenian studies.

Throughout the year, events dedicated to the anniversary were held, in particular, conferences, scientific sessions, public lectures. Exhibitions of scientific achievements in various fields of science were organized. Prime Minister of the RA N.Pashinyan, President of the RA V.Khachatryan, members of the government, Deputies of the National Assembly, representatives of science, education and the private sector of the economy, accredited ambassadors of the RA, foreign delegations took part in the festive events. As part of the events, the ceremony of awarding the international scientific prize named after Victor Ambartsumyan for 2020 was held, and the anniversary scientific session of the Academy was organized.

In 2023, the Academy actively participated in the process of developing and presenting conceptual proposals on the “Academic City” megaprogram, on the consolidation of state universities and their merger with research organizations. The issue of cooperation with universities was discussed in all organizations of the Academy. Based on the proposals presented, a general conclusion was drawn up and submitted to the Ministry of Education, Science, Culture and Sports of the RA. The scientific community of the Academy, emphasizing the significance of science for the development and progress of Armenia, taking into account the necessity of preservation and further development of already established scientific traditions, emphasizing the key role and significance of the Academy in the scientific and scientific-educational system of the Republic, advocated the preservation of the current organizational-and-legal form of the Academy and diversity of forms of organization of scientific and scientific-technical activities in the Republic of Armenia.

In the reporting year, scientific organizations of the academic system continued fundamental and applied research, valuable scientific results were obtained, a number of applied programs were implemented. In particular, a cooperation agreement was signed between the research and production center “Armbiotechnology” and the Austrian company “GECCO INT”, within the framework of which it is planned to create the production of vegetable oils of cosmetic and food value, extracts and essential oils in the center. At the Byurakan Astrophysical Observatory named after V. Ambartsumyan, monitoring of near-Earth space continues in order to detect spacecraft debris and “lost” satellites. At the initiative and with the active participation of the Institute of Informatics and Automation, work on the creation of a national supercomputer center in Armenia is being completed, as a result of which a completely new computing ecosystem will be formed, which will be widely used in science, education, technologies, defense, healthcare, environmental protection and other areas.

In 2023, new initiatives were fully exploited. Professional problem councils organized professional discussions of problems existing in their areas, and provided expert advice and opinions to government bodies and departments. Twelve research projects were prepared on development of large-scale scientific and scientific-technological programs, which were

presented to concerned government bodies. The public investment program “Creation of a scientific and experimental center/cluster of preclinical and translational research” was presented to the Ministry of Economy.

The Academy Prize was established, and the first competition was announced. The prize will be awarded every two years in the fields of physical, mathematical and technical sciences; chemistry, life and Earth sciences; social and human sciences. In the first two areas, the prize will be awarded in two categories: in the field of fundamental research and applied developments.

Cooperation continued with international scientific structures, academies of sciences and scientific organizations of different countries. 606 employees of the Academy were sent on an official trip to foreign countries, 161 of them - to conduct joint work, 1026 foreign researchers visited Academy organizations, 301 of them participated in joint research. Over the past period, delegations of the Academy took part in many conferences, scientific and scientific-organizational events, in particular, in the anniversary event dedicated to the 300th anniversary of the foundation of the Russian Academy of Sciences, in the XI session of the Council for Cooperation in the Field of Basic Science of the CIS Countries, etc. The leadership of the Academy took part in the discussions of the prospects for cooperation with a number of universities and scientific organizations of Italy, France, the Russian Federation, with the Joint Institute for Nuclear Research (Dubna, Russian Federation) and other foreign scientific and educational organizations. Cooperation agreements were signed with the Academies of sciences of China, Moldova, Bulgaria and the Islamic Republic of Iran, and the Academy of Sciences and Arts of Montenegro.

In 2023, scientific organizations of the Academy, with state budget funding, carried out scientific and scientific-technical activities under 45 basic, 6 targeted program and 292 scientific grant programs. There was also some work carried out under 192 economic contractual and 77 international grant programs. 72 international and 86 republican conferences were organized and held. Based on the results obtained, the following were published: 171 monographs and collections (27 - abroad), 24 textbooks, 1528 articles in peer-reviewed journals (670 - abroad), 537 articles in collections of scientific conferences (236 - abroad), and 652 theses (285 - abroad). One doctoral and 43 candidate dissertations were defended.

*President of NAS RA, academician A.Saghyan*

## **DIVISION OF MATHEMATICAL AND TECHNICAL SCIENCES**

*Academician-Secretary – academician L.Aghalovyan*

*Scientific Secretary – L. Martirosyan*

The Division of Mathematical and Technical Sciences includes the Institutes of Mathematics, Mechanics, for Informatics and Automation Problems, as well as the Department of Hydromechanics and Vibrotechnics.

The Division includes 9 academicians, 7 corresponding members, 24 foreign members, 5 honorary doctors.

During the reporting year 1 general meeting of the Division was held.

At the annual general meeting held on April 20 the report of L.Aghalovyan "On the main scientific and scientific-and-organizational results of the Division for 2022" was discussed and approved. Scientific reports of NAS RA foreign member A.Sergeev, DSc(phys.-math.) V.Hakobyan (Institute of Mechanics), DSc(phys.-math.) R.Aramyan (Institute of Mathematics) and cand. (phys.-math.) S.Pogosyan (Institute for Informatics and Automation Problems) were presented at the meeting.

21 meetings of the Bureau were held. The following issues were discussed and approved: the working plan of the Division for 2023; the number of postgraduate vacancies and their distribution among the Institutes for 2023-2024 academic year; the results of admission to the postgraduate school, research advisers and scientific topics of the postgraduate students; applications for admission of postgraduate school for the 2024-2025 academic year; the decision project of the general meeting of the reporting year; applications for the programs of basic financing of scientific and scientific-technical activities as well as for scientific and scientific-and-technical state target program for 2023; applications of the Institutes of the Division on funding for the purchase of necessary equipment as well as applications for the scientific trips; programs of special importance presented by the Institutes; the draft of the new law of RA "On state awards and honorary titles", draft of decisions of the RA Government "On determining the size and procedure for providing monthly bonuses to scientific workers of budget financing of scientific and scientific-technical activities for an academic degree" and "On establishing the procedure for state financing of scientific and scientific-technical activities under target and grant programs"; the research carried out in the Institutes regarding robotic systems and unmanned aerial vehicles; events dedicated to the 80th anniversary of NAS RA; the work of cand.(phys.-math.) A.Vagharshakyan, submitted to the competition "The Best Scientific Work"; the main results of the activity of the scientific organizations of the Division, as well as other scientific-organizational issues.

The following scientific journals are published on the Division specialities: "Proceedings of NAS RA. Mathematics" (6 issues), "Proceedings of NAS RA. Mechanics" (4 issues), "Proceedings of NAS RA and NPUA (series of technical sciences)" (4 issues), "Mathematical Problems of Computer Science" (2 issues), as well as the electronic "Armenian mathematical journal".

1 monograph (abroad), 2 tutorials (1 abroad), 191 scientific articles: 120 in the peer-reviewed journals (85 abroad) and 71 in the conference proceedings (18 abroad), 22 theses (13 abroad) were published in 2023 by the researchers of the Institutes of the Division.

The Institutes of the Division have organized 4 international scientific conferences, 6 projects on international grants have been implemented in the Institute for Informatics and Automation Problems.

1 Candidate's dissertation was defended at the Scientific Council of the Institute of Mechanics.

In December of the reporting year annual report meetings of the Institutes were held, the reports of the Institutes for 2023 were discussed and approved.

### **Institute of Mathematics**

#### *Major Achievements*

Based on the methods developed in previous works, complete characterizations for convergence and divergence have been given for series defined on metric spaces with measure (Sup.: DSc(phys.-math.) G.Karagulyan).

A condition that allows to find an unknown function using radon spheric transformations with the help of detectors located on a minor arc has been obtained (Sup.: DSc(phys.-math.) R.Aramyan).

A semi-supervised learning based on graphs using the theory of segregation of competitive systems has been considered. Methods of gradient projection and regularization have been proposed to reach some solutions. A model based on the spatial segregation of reaction-diffusion systems has also been considered, and on its basis, a new classification algorithm has been proposed. The results of numerical experiments have been presented to study the effectiveness and for comparison with other semi-supervised learning algorithms (Sup.: cand.(phys.-math.) A.Arakelyan).

A two-dimensional convex source of gravity has been restored by means of the values of its potential function on a union of halfplanes (Sup.: cand.(phys.-math.) A.Vagharshakyan).

#### ***Outcomes of applied developments***

Several problems for cloud infrastructures and applications have been considered. They are related to monitoring of such systems, prediction of malfunctioning or root cause analysis of the latest for accelerated remediation until the problems affect end users. The application of machine learning methods allows to handle large volumes of monitoring datasets and automate the process of investigations (Sup.: cand.(phys.-math.) A.Pogosyan).

Techniques have been described for generating HLSD for a textual format source code, which, when rendered, causes a display of visual content. The rendering of the source code generates a tree hierarchy of visual source elements, which logically is possible to map to any graph tree (Sup.: cand.(phys.-math.) A.Arakelyan).

A two-dimensional convex source of gravity has been restored by means of the values of its potential function on a union of halfplanes (Sup.: cand.(phys.-math.) A.Vagharshakyan).

### **Institute of Mechanics**

#### ***Major Achievements***

The monograph by NAS RA corr. member A.Avetisyan – “Electroacoustic Waves in Piezoelectric Layered Composites”, published in Springer Cham, briefly and coherently examines various issues related to electroacoustic waves in layered piezoelectric composites (Sup.: corr. memb. A.Avetisyan).

#### ***Outcomes of applied developments***

Through theoretical calculations, as well as direct experiments, it has been confirmed that the slip resistance indicators of clayey soils in states of both fluid-plastic and solid consistency when determined by the standard torsion method are lower than when determined by the test method, method using kinematic mode (Sup.: DSc(geol.) S.Hairoyan).

### **Institute for Informatics and Automation Problems**

#### ***Major Achievements***

Target class classification is a dynamic function, as a result of which, through successive classifications, an object is assigned to a certain, so-called target or normal class. The problem can be considered as an approach to the treatment phase management system. A combinatorial model of the problem is constructed in the form of a directed graph, where individual classification functions correspond to traversals through one directed edge of the graph. Transition policies aim to ensure the final assignment of subjects to the target class. The compliance issue with the specified policy has been resolved. It requires certain conditions of the transitive digraph in the form of vertices' degree and strongly connected component structure. The analysis of the problem has been given in terms of logic-combinatorial algorithms of recognition, as a result of which it is solved as an inverse recognition problem. An approach to improve the implementation of individual classifications in the form of a dynamic emission model has also been given (Sup.: corr.memb. L.Aslanyan).

The work is devoted to the development of new methods for constructing complete caps in the affine  $AG(n, 3)$  geometry over the Galois field  $F_3 = \{0, 1, 2\}$ . A cap in affine  $AG(n, q)$  or projective

$PG(n, q)$  geometry is a set of points, no three of which are collinear. It should be noted that there is more known about caps in projective geometry  $PG(n, q)$  than about caps in  $AG(n, q)$ . A description of a class of  $P_n$  sets, so-called  $b$ -saturated complete  $P_n$  sets, has been obtained. Using such odd (the number of 0-coordinates of each point is odd) complete and  $b$ -saturated  $P_n$  sets, new methods have been developed for constructing large complete caps in affine geometry  $AG(n, 3)$  for any integer  $n$ . The obtained results generalize some of well known results (Calderbank A., Fishburn P., Maximal three-independent subsets of  $\{0, 1, 2\}^n$ , “Designs, Codes and Cryptography”, 1994). In particular, the following lower bounds for the largest cap sizes are derived from the obtained results.  $c_{6,3} \geq 112$ .  $c_{7,3} \geq 236$ ,  $c_{10,3} \geq 2240$ ,  $c_{11,3} \geq 5504$ , where  $c_{n,3}$  denotes the size of the largest cap in  $AG(n, 3)$ . The latest lower bound currently is the best and cannot be obtained by the known methods (Sup.: cand.(phys.-math.) I.Karapetyan).

A software system has been developed for simulating swarms of self-organizing UAVs endowed with collective artificial intelligence, aimed at area surveillance and targeted tasks' performance. The methods and algorithms for constructing optimal and fault-tolerant schemes which implement information full exchange (Gossip/broadcast models) have been adapted and served as the basis for developing self-organizing decentralized swarms of logically linked UAVs. Generalized theorem for multi-particle walk for the Rotor-router model has been proved, based on which new algorithms have been developed for joint generation of the Eulerian cycle. During the quasi-random walk (rotor-router model), the UAVs perform dynamic shooting of the surveilled area, image encryption, full and reliable exchange of captured images and transfer of the results to the data processing centre. The dynamic image of the observed area has been constructed based on the integration of the collected data. Joint investigation of the results has been performed on a multi-user software platform, and, as a result, targeted tasks have been formulated, particularly, to direct a new swarm to newly calculated coordinates. Throughout the whole process of shooting and task execution the swarm does not use any means of external control. An experimental hardware/software system of a swarm over 4 unified and low-cost UAVs has been developed and implemented (Sup.: cand.(phys.-math.) V.Poghosyan).

### *Outcomes of applied developments*

The following technologies have been developed and implemented to prevent cyber attacks: NEMO - designed to detect and prevent DDOS attacks, and MISP - designed to detect, process and propagate cyber vulnerabilities (Sup.: cand.(phys.-math.) S.Abrahamyan).

Battlefield RGT Solvers have been developed and extended over previous versions: based on the constructed model, aerial images have been processed to detect 8 military unit classes; groups of military units have been developed with military experts. With the acquisition of expert knowledge, the used classifiers have been expanded to include nuclear, basic classifiers, operations, objectives, plans, the description of battlefield situations has been expanded in ways available in RGT Solvers, based on the necessary nuclear classifiers. The planning and decision-making algorithms available in RGT Solvers have been analyzed to propose actions for the given situations, which effectively enhances the solutions by available knowledge-based TZT and PPIT algorithms (Sup.: DSc(phys.-math.) E.Pogossian, cand.(tech.) S.Grigoryan).

Existing standard animation libraries (Adobe Mixamo, Blender) have been studied for the possibility of application in automatic animation of 3D models. Some simple animations have also been created for the same research purposes. As a result, the Adobe Mixamo library has been chosen, based on which a software system has been created that allows to apply any animation from the specified library in real time on a rigged 3D model. Software prototypes have been improved, allowing the addition of a skeletal system to the model of a person standing in a special pose (A-Pose). An application programming interface (API) has been created for controlling, managing PI3D-8 and PI3D-12 typed 3D-scanners, processing data obtained from them, and as a result — calculating 3D meshes and textures. As a result of the application of the above approaches, a software package has been created that provides the entire chain of “scanning a real person - obtaining a three-

dimensional model - calculating the bone system - applying animation” (Sup.: cand.(tech.) S.Abrahamyan, cand.(tech.) S.Balyan).

In order to expand the capabilities of the eduroam service operating on the ASNET-AM network, new possibilities for freeradius settings have been investigated. Different freeradius server performance settings of the eduroam service have been tested. Work has continued on the development of the MEET.ASNET.AM videoconference service operating on the ASNET-AM network, new features of the system have been developed and added. Options for expanding the capabilities of the automated system for centralized distribution of SSL certificates operating in the ASNET-AM network using the ACME2 protocol have been investigated. The possibility of developing a DNS system operating in the ASNET-AM network has been investigated. Experimental versions of the distributed system update of interconnected DNS master, slave and resolver servers have been developed. All results have been implemented in the ASNET-AM network (Sup.: cand.(tech.) A.Petrosyan).

To ensure the stability and speed of the ASNET-AM network, reconfiguration work with all routers has been done. Changes have been made to the internal structure, routing criteria, dynamic OSPF protocol settings. In order to improve the network monitoring system, the Zabbix system has been tested. As a new type of notification system the Telegram bot function has been tested. All results have been implemented in the ASNET-AM network and research work is ongoing (Sup.: cand.(tech.) R.Tadevosyan).

## **Department of Hydromechanics and Vibrotechnics**

### ***Major achievements***

The multi-mode, efficiently functioning stabilizer of wave and oscillatory processes has been developed, which reduces pulsations of pressure and fluid flow in pipelines (Sup.: cand. (tech.) G.Avetisyan).

### ***Outcomes of applied developments***

The accuracy of the “velocity-surface” method for measuring water consumption in canals has been increased, which gives a significant economic and environmental effect, in particular regarding the amount of water discharged from Lake Sevan (Sup.: A.Simonyan).

**DIVISION OF PHYSICS AND ASTROPHYSICS**  
*Academician-Secretary – academician R.Kostanyan*  
*Scientific Secretary – N.Davidyan*

The Division includes the Byurakan Astrophysical Observatory after V.Ambartsumian, the Institute for Physical Research, the Institute of Radiophysics and Electronics, the Institute of Applied Problems of Physics and the International Center for Relativistic Astrophysics Network – Armenia.

The Division includes 5 academicians, 10 corresponding members and 24 foreign members.

During the reporting year 2 general meetings and 15 Bureau sessions were held. Constant communication was established with the Division organizations to discuss and solve numerous current issues.

At the annual general meeting held on April 20, the report “On the main results of scientific and organizational activities of the Division for 2022” by the Academician-Secretary of the Division, academician R.Kostanyan was presented and approved. The issues of the implementation of the projected programs in science and education in the RA, non-disruption of the progress of work carried out in scientific organizations, the need to revise the approved topics of scientific organizations that are not provided with sufficient personnel and need modernization, were discussed. The prospects for the realization of innovative activities, based on the outcomes of the fundamental research, especially in the fields of Security and Healthcare, were considered. Reports were delivered by the corresponding member A.Hakumyan (IRPhE), DSc(phys.-math.) N.Sahakyan (ICRANET-Armenia Network), cand.(phys.-math.) V.Kocharyan (IAPP), cand.(phys.-math.) E.Nikoghosyan (BA) and cand.(phys.-math.) A.Manukyan (IPhR).

At the meetings of the Bureau the applications for basic financing of scientific and technical activities on “Preservation and development of infrastructures” for 2023, admission to postgraduate studies, business trips (9 applications) were discussed and approved. An expert assessment to the letters from governmental authorities and appropriate answers were provided to the applicants. The program “Re-equipment of the organizations of the NAS RA system” was discussed and approved, within which the applications for the purchase of equipment for IPhR, IAPP and IRPhE were funded.

In the scope of the “Best Scientific Work” contest, the Committee chaired by R.Kostanyan determined the list of the winning candidates.

At the general meeting of the Division, the candidacy of V.Kocharyan for the position of the director of the IAPP was discussed, approved and presented to the NAS Presidium for discussion. The new Scientific Council of the Institute was approved.

The issues of increasing the efficiency of scientific works, expansion of applied research, assessment of the activity of the scientific organizations were continually discussed.

Local seminars and international conferences were organized, new agreements were signed, collaboration with other branches in science and education was in progress. Basic applications for 2023, 2023-2028 programs, developmental strategy of the Institutes for the upcoming years were discussed and approved.

In December, annual general meetings were held in the scientific organizations of the Division, where the reports on scientific and organizational activities for 2023 were discussed and approved.

One Candidate’s dissertation was defended.

The Institutes of the Division received 2 author licenses. 7 monographs (3 abroad), 200 articles: 177 in pre-reviewed journals (104 abroad) and 23 in conference proceedings (all abroad), 151 theses (56 abroad) were published.

The following scientific journals are published on the Division specialities: “Proceedings of NAS RA. Physics” (imp.f. 0,486, 4 issues), “Astrophysics” (imp.f. 0.673, 4 issues) and the electronic “Armenian Journal of Physics” (4 issues).

**Byurakan Astrophysical Observatory after V. Ambartsumyan**  
*Major achievements*

RNO 54 has been examined by means of the Russian 6m telescope and it has been established that the star in it is a very old Fuor the age of which flares up more than 1000 years. This finding has

gained swift confirmation from US astronomers. It is the oldest Fuor known to this day (Sup.: DSc(phys.-math.) T.Magakian).

Extragalactic radio sources of diverse FR (Fanaroff-Riley) classes have been studied for the connection of their characteristics to the surrounding environment. It has been found that the triple approach of the galaxies could be the reason for the renewed radioactivity of the FRI class 3C31 radio galaxy. This is substantiated by the fact that the galaxies NGC380 and NGC386 were close to the central member of the galaxy cluster NGC383 about 100 million years ago, and began to move away from it in opposite directions. Those directions coincide with the directions of the radio jets of 3C31. Around the same time, 100 million years ago, the eruption of radio jets began (Sup.: cand.(phys.-math.) R.Andreasyan).

K.Gigoyan has explored the physical characteristics of 236 M dwarfs, discovering that many of them exhibit flaring. Two exoplanets, approximately 1.1 solar masses each, have been found orbiting the star FBS 0250+167. Among these M dwarfs, 25 form double systems, and triple systems have also been identified. A large number of new C-CH, C-N, carbon stars have been detected in the galactic halo at altitudes of 7 kps and above from the DFBS survey. Spectral classes have been confirmed using the Gaia DR3 database. Some CH stars exhibit radial velocities exceeding 450 km/s and display signs of binarity. During the examination of TESS variability curves, a large number of new ecliptic variables have been discovered in SDSS and FBS M dwarfs (Sup.: cand.(phys.-math.) A.Mickaelian).

The calculation and definition of the “relative velocity” of a test particle in arbitrary pseudo-Riemannian space concerning an observer have been established and have posed a significant unsolved challenge in “General Relativity” since 1915. This velocity is computed in various crucial physical scenarios, including the Robertson-Walker metric. Notably, in the latter case, it is demonstrated that the “kinetic” speed of departure for an astronomical body, regardless of redshift, remains below the speed of light propagation in a vacuum (Sup.: DSc(phys.-math.) G.Ter-Kazarian).

The electrical conductivity of neutron star shells has been determined under the influence of strong magnetic fields in the liquid phase of the material. The equations of the first and second order relativistic hydrodynamics with the presence of dissipation in the material have been obtained. Additionally, the second viscosity of moderately hot and dense, neutrino-transparent neutron-proton-electron-muon matter resulting from direct Urca processes in weak interaction has been studied (Sup.: DSc(phys.-math.) A.Sedrakian).

### ***Outcomes of applied developments***

At the joint Armenian-Russian station 537000 measurements have been performed altogether and 570 orbits of artificial satellites have been restored during 240 observational nights (Sup.: cand.(phys.-math.) H.Harutyunian).

Work has been continued on the creation of a new software package and new methods of processing observational material. The automatic processing package (pipe line) is also being improved, which enables to process the scientific images received throughout the night, using many additional images (bias, flat-field, dark etc.) (Sup.: DSc(phys.-math.) T.Magakian).

## **Institute for Physical Research**

### ***Major achievements***

Using high-temperature nanocells, it has been shown that in addition to van der Waals (VDW) atom-surface interactions, the “red” shift of atomic resonance frequencies also causes dipole-dipole (DD) atom-atom interactions. Neglect of the latter leads to inaccuracy in determining the value of the C3 coefficient of VDW. For the first time, based on experimental measurements of the “red” shift, a decrease in the value of the C3 coefficient has been shown as the nanocell thickness decreases from 130 nm to 30-50 nm, thereby confirming the theoretically predicted effect of “weakening” of the VDW (Sup.: DSc(phys.-math.) D.Sarkisyan).

A new mechanism for implementing Hong-Ou-Mandel (HOM) interference for two independent photons at different wavelengths, based on parametric interaction, has been developed. The mechanism makes it possible to transmit encoded quantum information in a controlled manner

over hybrid networks, such as the quantum Internet, where different material nodes operate at different resonant frequencies, providing protection from decoherence. The HOM effect is independent of photon polarization, which gives the proposed model flexibility for use in hybrid quantum networks (Sup.: DSc(phys.-math.) Yu.Malakyanyan).

Based on the approaches of optical holography and non-diffracting Bessel beams, a new method for creating tweezers for capturing microparticles has been developed, allowing controlled movement and fixation (localization) of micro- and nanoparticles through photovoltaic fields induced by a laser beam on the surface of a photorefractive crystal and maintained for months. Using the developed method, micro-movement and capture of biological objects - DNA molecules – have been carried out. The formation of clusters of DNA molecules with a size of 4  $\mu\text{m}$  in a NaCl solution has been discovered. The small dimensions of the crystal (10x10x2 mm) make it possible to create an autonomously operating “lab-on-a-chip” system for moving and capturing micro- and nanoparticles (Sup.: DSc(phys.-math.) R.Drampyan).

### ***Outcomes of applied developments***

A system has been developed for detecting objects that are somewhat warmer than the surrounding background, at a distance of up to 30 m, which consists of a conical concentrator horn (lens alternative), a thermal infrared sensor and an Arduino module. The computer program provides signal registration in millisecond time mode. It has been shown that the sensitivity of the system with a conical horn is significantly higher than that of traditional PIR sensors (Sup.: corr. member A.Papoyan).

A method for producing an optically transparent field-effect transistor (FET) has been developed. By means of diffuse deposition of acceptor (ZnO:Li) and donor (ZnO:Ga) layers on a sapphire substrate, the source and drain of the FET are formed. The FET gate insulator is created by a dielectric layer of MgF<sub>2</sub>, on which a layer of ZnO:Ga with high conductivity is deposited. The resulting transparent FET has high output power, high current gain, high efficiency and small size. Based on the method an RA patent has been obtained (Sup.: cand.(phys.-math.) R.Hovsepyan).

To register Raman scattering and luminescence emissions with the DFS24 spectrophotometer and the DAQ device National Instruments USB6002, a necessary software algorithm has been developed. Based on test measurements, the program has been refined. The system makes it possible to digitally record light induced by an exciting laser at a wavelength of 473 nm with sufficient accuracy (Sup.: acad. R.Kostanyan).

The process of heating an aqueous solution of ferromagnetic nanoparticles Fe-Fe<sub>3</sub>C and Fe-Fe<sub>3</sub>O<sub>4</sub> of the “core-shell” structure, synthesized by solid-phase pyrolysis of iron phthalocyanine (FePc, Pc=C<sub>32</sub>N<sub>8</sub>H<sub>16</sub>) and ferrocene (FeC<sub>10</sub>H<sub>10</sub>), in an alternating magnetic field with a frequency of 350 kHz and amplitude of 200 Oe has been studied. The possibility of using these nanomaterials for magnetic hyperthermia has been demonstrated (Sup.: cand.(phys.-math.) A.Manukyan).

## **Institute of Applied problems of Physics**

### ***Major achievements***

The angular distribution of coherent radiation from a bunch of electrons with an energy of 3.7 MeV moving along the axis of a hollow cylindrical waveguide made of fused quartz in the frequency range 10-100 GHz has been experimentally studied. It has been shown that with the help of cylindrical waveguides of certain sizes in accelerators it is possible to generate powerful radiation in the GHz-THz frequency range (Sup.: cand.(phys.-math.) V.Kocharyan).

It has been shown that with a certain choice of the parameters of the problem, a chain of relativistic electrons rotating around a dielectric ball can generate powerful, quasi-coherent, “resonant” radiation (Sup.: DSc(phys.-math.) L.Grigoryan).

As a result of X-ray diffraction studies of  $\alpha$ -LiIO<sub>3</sub> single crystals grown with an admixture of valine, it has been established that a new, hitherto unknown substance Li<sub>2</sub>3IO<sub>3</sub>H<sub>3</sub>O has been obtained (Sup.: cand.(phys.-math.) A.Atanesyan).

### ***Outcomes of applied developments***

A new software package for X-ray microtomography has been developed and created, which makes it possible to separate areas of different densities and simultaneously view various slices and arbitrary sections to visualize the internal structure of three-dimensional images of samples (Sup.: cand. (phys.-math.) V.Kocharyan).

Together with the employees of the NAS RA Institute of Geophysics and Engineering Seismology, research has been conducted with the aim of creating a new class of seismoacoustic wave conversion and registration system (Sup.: corr. member A.Mkrtchyan).

A new method of crystal growth has been developed and appropriate crystallizers have been prepared, in which large-sized single crystals of promising optical quality have been grown for application. The developed new technology has been patented (Sup.: cand.(phys.-math.) R.Sukiasyan).

In the BaO(SrO,CaO)-TiO<sub>2</sub>-B<sub>2</sub>O<sub>3</sub> system, glasses have been obtained by ultrafast cooling in order to obtain new ferroelectric materials after the crystallization of these glasses. As a result, a new ferroelectric compound with the formula Sr<sub>3</sub>Ti<sub>3</sub>B<sub>2</sub>O<sub>12</sub> has been obtained (Sup.: cand.(phys.-math.) A.Aramyan).

To correct data from infrasound wave recorders, acoustic wave sources with adjustable output power up to 120 dB have been developed and created for frequency ranges up to 20 Hz, up to 100 Hz and up to 1 kHz (Sup.: A.Arakelyan).

Transmitters and receivers with a 300 angular aperture have been created to transmit the output signals of infrasonic wave recorders-transducers developed and created at the Institute (Sup.: V.Badoyan).

A new class acoustic system with adjustable output power has been created for the formation and dispersion of water formations in the atmosphere (Sup.: K.Egiazaryan).

To conduct research in the field of medical physics, a laser system with a power of 50 W with a wavelength of 532 nm and 1064 nm has been developed (Sup.: cand.(phys.-math.) V.Nalbandanyan).

## **Institute of Radiophysics and Electronics**

### ***Major achievements***

A method for microwave heating of an aqueous mixture with a complex dielectric permittivity has been proposed based on interaction with the electrical component of the electromagnetic field using resonators with a loop gap. To solve the problem of limiting the gap size, a loop resonator with a coplanar capacitance and an extended region of a strong and localized electric field has been proposed. The proposed structure is effective for generating an aerosol from a mixture (Sup.: corr. member A.Hakhoumian).

The mobile setup for RCS measurement of radar targets has been developed. Various measurements for different bodies, including balls and corner reflector vs motion velocity and direction have been carried out (Sup.: cand.(phys.-math.) T.Zakaryan).

A device prototype CO<sub>2</sub> of gas optical sensor has been created on the p-InSb-n-CdTe heterojunction photo-detector, which is highly selective against the CO<sub>2</sub> molecules and has very high gas sensitivity (Sup.: corr. member S.Petrosyan, L.Matevosyan).

The analytical model of a nanowire bio-sensor has been developed on the basis of junctionless nanowire field effect transistor model. The developed analytical model has been validated with numerical simulations and high accuracy has been observed. The model allows to predict the sensor sensitivity dependence on system parameters (Sup.: cand.(phys.-math.) A.Yesayan).

### ***Outcomes of applied developments***

A device prototype CO<sub>2</sub> of gas optical sensor has been created on the p-InSb-n-CdTe heterojunction photo-detector, which is highly selective against the CO<sub>2</sub> molecules and has very high gas sensitivity (Sup.: corr. member S.Petrosyan, L.Matevosyan)

The mobile setup for RCS measurement of radar targets has been developed. Various measurements for different bodies, including balls and corner reflector vs motion velocity and direction have been carried out (Sup.: cand.(phys.-math.) T.Zakaryan).

Various stable current circuits have been investigated for physiotherapy devices. It has been found that for high currents the transformer solution has some disadvantages. An electrical circuit has been developed with a current mirror using high-power transistors (Sup.: cand.(phys.-math.) N.Yezakyan).

Aqueous solutions containing different noble metal nanoparticles (NPs) have been examined using a thermoelastic sensor operating in the microwave frequency range (8-12 GHz). The near-field interaction between the radiated microwaves and the aqueous solution with Ag, Pt, Au which were prepared through a laser ablation process, have exhibited sensitivity to both the NPs concentration and their structural characteristics at the resonant frequency. The measured minimum detectable concentration has been found to be between 0.01 and 0.05 (mcg/ml). The exceptional sensitivity of the measurement system can be attributed not only to variations in the concentration and electromagnetic properties of the solution, but also to additional structural changes in water clusters resulting from the NPs suspensions. Furthermore, the results reveal a linear relationship between the averaged signal intensity, which correlates with NPs concentrations, and the size of the metal NPs (Sup.: cand.(phys.-math.) R.Khachatryan).

The method of recovery of special electrical nodes and then the measurement of their specifications has been developed for the recovery of antenna system of C-300 air defense system. The system of mechanical sine vibrations up to 600Hz has been developed for testing purposes. The electrical source and amplifier are based on novel frequency converter. The method of indirect measurement of acceleration has been developed, and mechanical frequency response of the system has been investigated (Sup.: N.Poghosyan).

Low noise amplifiers for Ku, X, C and S bands have been developed and their prototypes have been prepared for many civil applications such as agriculture, environment and special purposes as well. The magnetic sensor with two ferro-probes has been proposed (Sup.: K.Dadalyan).

## **ICRANet Armenia**

### ***Major achievements***

A new method utilizing machine learning algorithms has been developed to classify gamma-ray emitting blazars. By training various algorithms such as Artificial Neural Networks, XGBoost, and LightGBM on the spectral and temporal properties of known blazar types, the resulting models can successfully classify blazar candidates of uncertain type. This advancement in classification offers improved perspectives for statistical population studies of blazars and aids in planning the monitoring of blazars (Sup.: DSc(phys.-math.) N.Sahakyan).

**DIVISION OF NATURAL SCIENCES**  
*Academician-Secretary – corresponding member R.Aroutiounian*  
*Scientific Secretary – cand.(biol.) S.Atshemyan*

The Division includes the Scientific and Production Centre (SPC) “Armbiotechnology”, the Scientific Centre of Zoology and Hydroecology, the Institute of Botany after A.Takhtajian, the Centre for Ecological-Noosphere Studies, the Institute of Biochemistry after H.Buniatyan, the Institute of Hydroponics after G.Davtyan, the Institute of Molecular Biology, the Institute of Physiology after L.Orbeli.

The Division includes 6 academicians, 8 corresponding members, 27 foreign members as well as 12 honorary doctors.

One general meeting, 17 Bureau meetings of the Division, 8 reporting meetings of the scientific Institutes were held during the reporting year.

At the annual meeting of the Division the main fundamental and applied results of the Institutes were discussed.

At the 17 meetings of Bureau the following issues were discussed and approved: working plan of the Division for 2023; the reports of the institutions of the Division on 2022 base funding, on the maintenance and development of the infrastructure, on the maintenance of the scientific objects of national importance and scientific and scientific-technical state projects of target programs; the applications for the positions of postgraduate studies and doctoral candidacy for 2023-2024; the applications of the Institutes for new appliances, applications on funding the scientific business trips.

As a result of discussions at the meetings of the tender commission of the NAS RA, the Institutes of the Division were provided with financing for purchase of necessary equipment.

Bureau has approved 15 funding applications for scientific business trips.

Within the framework of NAS RA 80th anniversary events one employee of the Division's organizations was awarded a State award - Medal of Gratitude, one employee was awarded a Commemorative medal of the Prime Minister of the RA, 2 employees were awarded Letters of Appreciation from the RA MESCS, 22 employees were awarded a Commemorative medal of NAS RA.

The Division was the co-organizer of the Functional Food Center's 31st International Conference “Functional Food and Bioactive Compounds” with participation of representatives of 26 countries.

44 local and international events were organized by the Institutes of the Division including seminars, conferences, scientific expeditions, a total of 1506 participants, 258 of which were from abroad.

273 articles – 232 in peer-reviewed journals (182 abroad) and 41 in conference proceedings (32 abroad), 93 theses (72 abroad), 17 monographs, 3 educational tutorials were published by the Institutes of the Division, 3 patents were obtained.

11 Candidates' dissertations were defended by the researchers of the Institutes at 5 specialized councils of the Division.

**Institute of Botany after A.Takhtajian**

***Major achievements***

Three new species for the Armenia flora: *Malva mauritiana*, *Alcea persarum*, *A. wilhelminae* have been discovered (Sup.: DSc (biol.) G.Oganezova).

Palynotaxonomical analysis of representatives of the family *Iridaceae* of the Armenian flora has served as the basis for compiling a key using pollen characteristics (Sup.: DSc(biol.) A.Hayrapetyan).

The Botanical Museum of the Institute has been established, where fossils and modern plants growing now and in past geological eras on the territory of the Republic of Armenia are presented. A new location of *Vaccinium myrtillus* L. has been discovered and studied in the mountain system in the Aparan-Hankavan direction. As a result of re-identification of herbariums, a new locality of *Vaccinium uliginosum* L. has been found in Lori region. A new habitat of the relict species *Dentaria*

*quinquefolia* Bieb. has been discovered in Syunik region, near Dzorastan village (Sup.: DSc(biol.) I.Gabrielyan).

The Seed Bank of Armenian Flora (SBAF) currently preserves about 2700 specimens, 1620 species of 120 families, 630 genera, 90 species of which are listed in the Red Book. The treatments and addition of taxonomic and nomenclature data to the international website CARYOPHYLLACEAE CHECKLIST have continued in frames of cooperation with the Berlin Botanical Garden, Germany (Sup.: cand.(biol.) A.Nersesyan).

The database on plant species introduced to Armenia published by the Global Reference Fund (GBIF) has been supplemented. About 700 alien species introduced into the botanical gardens and arboretums of the Republic and used in greening cities and towns are included. Field research data have been entered into the Transcaucasian Vegetation Database - a phytosociological database of the Southern Caucasus (Sup.: DSc(biol.) G.Fayvush).

The prospects of using native xerophilic ornamental plants for greening purposes in the arid regions of Armenia have been evaluated (Sup.: cand.(biol.) A.Ghukasyan).

## **Centre of Ecological-Noosphere Studies**

### ***Major achievements***

In the frames of interdisciplinary studies, for the first time an attempt has been made to assess and provide a scientifically sound rationale behind the effectiveness of a “green wall” aimed at reducing the risks associated with pollution. The research outcomes regarding street dust, backyard dust, and particulate matter (PM) deposited on the leaves of “a green wall”, created as a model object on the territory of one of the Yerevan preschool institutions, have been generalized. The microscopic examination of 1915 leaf PM has indicated that the size range of 76.6% is 2.5-10  $\mu\text{m}$  and 16.2% are smaller. Through collation between methods of machine learning and compositional data analysis it has been established that based on the detected contents of Si, Al, Fe, Mg, K, Cl and Ca the studied PM is grouped into 2 clusters: I-carbonates, II-alumocilicates and iron oxides/hydroxides. PM also contains Mo, Cu, Ba, Zn and Cr associated with metal melting, vehicular exhausts, tire fragments, and building paint. The contents of elements in street and backyard dust pose a health risk to kids. It has been verified that after using “green wall” Cu contents in backyard versus street dust decrease which is indicative of a certain positive impact and the effectiveness of the solution (Sup.: cand.(biol.) G.Tepanosyan, cand.(geogr.) Sh.Asmaryan, cand.(geogr.) L.Sahakyan).

### ***Outcomes of applied developments***

Through collation between food consumption data and data on the contents of chemical hazard the studies have continued to assess and characterize the exposure and risk. The studied samples of honey and some samples of pond-farmed fish collected across the RA contain residues of antimicrobial substances (nitrofurans metabolites), although the risk assessment results have indicated that their dietary exposure poses no health risk. Of 10 studies antibiotic drugs residues of tetracycline, sulfadiazine, benzylpenicillin, streptomycin and salinomycin have been detected in the honey of domestic production. Chronic risks caused by the effect of antibiotics on the population are in the allowable range, but their presence may hamper food exporting (Sup.: DSc(food) D.Pipoyan).

For the purpose of creating a RS system of ecological monitoring of landscapes works have been continued on creation of a multidimensional information system (a datacube) (<http://datacube.sci.am>) for satellite imagery compilation and processing in partnership with the NAS RA Institute for Informatics and Automation Problems and University of Geneva in Switzerland. The system’s dataset includes Landsat and Sentinel imagery and is upgraded periodically. An attempt has been made to introduce the Sentinel 5P satellite imagery visualization and processing service into the system (Sup.: cand.(geogr.) Sh.Asmaryan).

## Scientific Centre of Zoology and Hydroecology

### *Major achievements*

Based on the results of high-frequency continuous measurements of epilimnetic dissolved oxygen and meteorological parameters in Lake Sevan, the gross primary production of the lake phytoplankton and the possibilities of its consumption in the food chain, as well as the trend of its changes in the context of expected climate warming have been assessed (Sup.: cand.(biol.) G.Gevorgyan).

In 2023 one of the distinctive features of phytoplankton development in Lake Sevan was the absence of mass summer blooms of cyanobacteria, the predominance of green algae in different seasons of the year, range expansion and quantitative growth of *Euglenophyta* species, which are indicators of organic pollution. Unprecedented structural changes in the lake's ecosystem, the emergence of monodominants in a community and decreased role in some of the main groups (diatoms) in plankton can be regarded as manifestations of eutrophication (Sup.: cand.(biol.) L.Hambaryan).

Five species of beetles from Armenia and additional 14 species of beetles from other zoogeographic regions, all new to science, have been discovered in Armenia. Four invasive species of beetles and 1 invasive true bug species have been discovered (Sup.: cand.(biol.) M.Kalashyan).

One species of spider belonging to the family of *Eresidae* new to science has been discovered. 50 species of arachnids, 10 species of *Tardigrada* and 23 species of aphids new to the fauna of Armenia have been documented (Sup.: cand.(biol.) K.Dilbaryan).

In the mountain-steppe and forest areas of the Lori region, there has been a significant decline in the population of aquatic animals and loss of nesting grounds of Common Crane (*Grus grus*) and most members of wetland-dependent avifauna due to uncontrolled drainage of wetland habitats (Sup.: cand.(biol.) M.Ghasabyan).

New habitats of Darevsky's viper have been identified in the Ashotsk region of Shirak Marz in Armenia (Sup.: cand.(biol.) A.Aghasyan).

*Dicrocoelium* eggs have been found in rabbits for the first time in the Tashir region of Armenia (Sup.: cand.(biol.) M.Vardanyan).

*Bunodera luciopercae* species of trematode has been recorded in the River trout raised on fish farms (basins) of Armenia (Sup.: cand.(biol.) O.Shcherbakov).

As a result of *Toxoplasma gondii* genotyping carried out for the first time in Armenia, two genotypes with medium and low pathogenicity have been identified (Sup.: cand.(biol.) H.Gevorgyan).

### *Outcomes of applied developments*

Within the frames of agreement signed with the RA Ministry of Environment in 2023, the assessment studies of biological resources in Lake Sevan have continued. In 2023 the total fishery stock of whitefish in the lake was 513.11 tons, which is approximately 100 tons less than in 2022. The total allowable catch in the spring-summer period of 2024 was set at the level of 257 tons, which is about 50% of its commercial stock (Sup.: DSc(biol.) B.Gabrielyan).

Studies of crayfish have shown that their biomass in Lake Sevan has slightly increased compared to the previous year and equalled 95 tons. The share of infected individuals in the population has nearly remained unchanged - 6%. The illegal catch of crayfish in the lake continues to persist. To restore the productivity of crayfish it has been proposed to ban the crayfish harvest in the lake (Sup.: cand.(biol.) E.Ghukasyan).

A methodology has been developed to assess the potential of cultural ecosystem services of active recreational areas in catchments of small mountainous rivers (Sup.: cand.(biol.) V.Asatryan).

A collection of algae has been created (180 species from 27 genera), collected from coastal and deep water samples of Lake Sevan (Sup.: cand.(biol.) A.Mamyan).

Water samples collected from some rivers in the northern Armenia and recreational areas on the eastern shore of Lake Sevan contained protozoa that are harmful to human health. Based on the study results, water sample monitoring recommendations have been developed for stakeholders (Sup.: cand.(biol.) H.Gevorgyan).

The current state of the hunting species populations in Armenia has been assessed. An inventory list of game species, their population estimates, allowable hunting grounds and dates of

hunting seasons have been determined for 2023-2024 and submitted to the Ministry of Environment of the RA (Sup.: cand.(biol.) M.Ghasabyan).

### **Institute of Biochemistry after H.Buniatyan**

#### ***Major achievements***

The enzyme adenosine deaminase (ADA<sub>er</sub>) has been purified from human erythrocytes. ADA<sub>er</sub> and ADA<sub>bov</sub> from bovine lung have been citrullinated *in vitro* using peptidyl arginine deiminase (PAD2) and polyclonal antibodies to these preparations (IgG<sub>er</sub> and IgG<sub>bov</sub>) have been obtained. The interaction of IgG<sub>er</sub> and IgG<sub>bov</sub> antibodies with the *in vivo* citrullinated ADA<sub>SF</sub> from the synovial fluid of patients with rheumatoid arthritis has been observed. Studies of *in vitro* effects on the ADA and DPP4 activities of more than 100 compounds synthesized at Scientific Technological Center of Organic and Pharmaceutical Chemistry (STCOPC) have continued. Six compounds may serve as basis for development of anti-diabetic and anti-inflammatory medication (Sup.: cand.(biol.) A.Antonyan).

Studies on some parameters of plasma hemostasis on healthy animals to determine the functional activity of the amino acid mixture (AA mixture), consisting of  $\gamma$ -aminobutyric acid, glutamine,  $\beta$ -alanine and ethanolamine-O-sulfate, has revealed that in comparison to control animals, the total time of blood coagulation and recalcification is extended by up to 48%, prothrombin time slows down by 2–4 times. The AA mixture performs an indirect anticoagulant function and can serve as an alternative treatment for coagulation related diseases (Sup.: cand.(biol.) Z.Paronyan).

As a result of non-covalent binding of hyaluronic acid with various cationic porphyrins, porphyrin complexes with hyaluronic acid have been obtained and a method of purification from unbound compounds has been developed. The simplicity of obtaining complexes of hyaluronic acid with photosensitizers and their fairly strong interaction allows to assert that these complexes can be successfully used in targeted photodynamic therapy of tumors (Sup.: cand.(biol.) A.Gyulkhandanyan).

#### ***Outcomes of applied developments***

Lectin-based transport systems have been studied and developed for targeted drug delivery to cancer and bacterial cells. The system is composed of lectin purified from wheat and antibiotic loaded drug-delivering ferritin. This system is approximately 10 times more effective than the free antibiotic. AuSe, AgSe, ZnSe, CuSe and Se-chitosan nanoparticles, very promising both for tumor imaging and heir therapy, have been synthesized and their fluorescent properties have been studied (Sup.: cand.(biol.) V.Gasparyan).

Probiotics *Lactobacillus acidophilus* strains INMIA 9602, *L. rhamnosus* V 300, *L. casei* VKPM B-7657, grown in lactose and BRS Broth nutritional environment, have been studied and selected, the quantity of bacteria and their antimicrobial properties have been determined. The bacteriocins synthesized by these probiotics demonstrate high antimicrobial properties against *Staphylococcus aureus*, *E.coli* pathogenic bacteria and *Candida albicans* and can be recommended for treatment of diseases caused by the studied pathogens (Sup.: cand.(biol.) R.Madoyan).

### **Scientific and Production Centre “Armbiotechnology”**

#### ***Major achievements***

Methods for the synthesis of new non-protein amino acids with their subsequent introduction into the peptide chain have been developed. As a result, new potentially biologically and pharmacologically active peptides have been produced (Sup.: cand.(chem.) Z.Mardiyani).

By the methods of genetic engineering, a recombinant strain of *Bacillus subtilis* has been obtained that produces alfa-amylase (Sup.: cand.(biol.) A.Hambardzumyan).

By the method of chemical mutagenesis and selection, a number of promising mutant strains of *Phaffia rhodozyma* yeast have been obtained, which at the temperature of 25-28°C on optimized

nutrient media synthesize up to 3 g/l of the valuable carotenoid pigment – astaxanthin (Sup.: cand.(biol.) A.Hovsepyan).

A method for reliable processing of elemental analysis indices of N, C, H, S of chiral compounds has been developed, which promotes a significant increase in the service life of a quartz reactor (Sup.: cand.(chem.) A.Tsaturyan).

Mutants resistant to 5-fluorotryptophan (5-FT-r) have been obtained by the method of genetic selection, using chemical mutagenesis based on the *Brevibacterium flavum* 4 (m-FP-r) strain (Sup.: cand.(biol.) G.Avetisova).

A comparative description of the enzymatic activity, synthesis of arginine and exopolysaccharides by strains of lactic acid bacteria and enterococci, depending on the composition of the nutrient medium has been carried out (Sup.: cand.(biol.) F.Tkhruni).

It has been shown that the strains of *Pseudomonas aeruginosa* MDC5249 and *P. syringae* MDC8733 on the synthetic nutrient media retain proteolytic activity in relation to all substrates (casein, gelatin, fibrin) used (Sup.: cand.(biol.) N.Hovhannisyan).

A valid method for the spectrophotometric determination of “mertylene” in ripe blackberries, blueberries, black currants and their squeezes with a reliability of 95±2% has been developed (Sup.: DSc(chem.) S.Dadayan).

It has been shown that alcoholic extracts of some medicinal plants, depending on the concentration, can exert stimulating and inhibiting activity on lactic acid bacteria (LAB) (Sup.: cand.(biol.) L.Danielyan).

An effective consortium of nitrogen-fixing symbiotic bacteria and cyanobacteria has been created, which increases the growth characteristics of lentil and chickpea plants by 1.5 and 2.0 times, respectively (Sup.: cand.(vet.) V.Goginyan).

It has been established that pre-treatment of copper concentrate (Armanis) with biogenic Fe<sup>3+</sup>, obtained using the *Leptospirillum ferriphilum* CC bacterium immobilized on activated carbon makes it possible to extract almost twice as much copper upon its further leaching (Sup.: DSc(biol.) N.Vardanyan).

To form stable consortia of wine yeasts, 15 yeast cultures have been isolated from 11 samples of autochthonous Armenian grape varieties. Work has been carried out on the development of a new probiotic preparation. The most promising amino acid producing strain, *Brevibacterium flavum* MDC 5090 has been identified (Sup.: cand.(biol.) V.Bagiyanyan).

### **Outcomes of applied developments**

Within the framework of the Cooperation Agreement, the Company “GECCO INT.” LLC (Austria) has supplied and installed a production line for the production of natural vegetable and essential oils. Experimental production of over 20 types of preparations for cosmetic and food purposes has been launched (Sup.: cand.(chem.) A.Tsaturyan).

Export agreements have been concluded with the companies “Thomas GMHB sp.z.o.o.” (Poland) and “ZARETIS s.r.o.” (Czech) with distribution rights on the territories of these countries for biologically active food supplements “Narine” and “Narargin” (Sup.: cand.(vet.) V.Goginyan).

The production of the biologically active supplement “Narargin” based on the lactic acid bacteria *Lactobacillus acidophilus* MDC9602 and *L. rhamnosus* MDC9631 has continued (Sup.: cand.(biol.) F.Tkhruni).

Production of fermented milk products and the biologically active food supplement “Narine” in enteric capsules has been continued (Sup.: cand.(biol.) R.Hairapetyan).

Production of biological fertilizers “Ecobiofeed” and “Ecobiofeed+” for agriculture has been continued (Sup.: cand.(biol.) G.Avetisova).

Production of hydrogen peroxide, boric acid, magnesium sulfate, potassium permanganate, ammonium aqueous solution, castor oil, glycerin, 5% iodine solution has been continued (Sup.: cand.(chem.) G.Hovsepyan).

Production of natural vegetable oils of sea buckthorn, flax, milk thistle, almond, white and black sesame, apricot, peach, black cumin, pumpkin seeds and prune pits has been continued (Sup.: DSc(chem.) S.Dadayan).

## **Institute of Molecular Biology**

### ***Major achievements***

A high prevalence of carbapenem resistance has been revealed among the studied *K. pneumoniae* clinical isolates (15%). A genome-wide analysis has determined the affiliation of carbapenem-resistant *K. pneumoniae* strains to international high-risk clones of sequence types ST395 and ST15, which also possess the phenotype of extreme antibiotic resistance (XDR) (Sup.: cand(biol.) A.Sedrakyan).

Molecular identification and documentation of wild grape genotypes of four regions of Armenia have been carried out in cooperation with the Institute for Grape Breeding (Germany). The multi-crop passport descriptors characteristics of the genotyped samples will be uploaded to the Armenian Vitis Database (www.vitis.am) (Sup.: cand(biol.) K.Margaryan).

### ***Outcomes of applied developments***

An infectious vivarium conforming to international standards has been created in the Laboratory of Cell Biology and Virology of the Institute (Sup.: DSc(biol.) Z.Karalyan).

Models for predicting the carcinogenic activity of molecules have been created using modern machine learning algorithms (XGBoost, LLS, MBNN, GCN), on the basis of which a carcinogenic risk coefficient has been developed. The prognostic accuracy of the latter is higher compared to standard *in vitro* and *in vivo* models. Using the molecular transformer algorithm, a model has been created that is able to predict possible metabolites of biotransformation of chemical compounds in the human liver (Sup.: cand(biol.) N.Babayan).

Using the Denovo Sciences molecular design platform, new chemical compounds have been created that interact with the enzyme neuraminidase of influenza A and B viruses. The two best compounds have demonstrated high antiviral activity against all tested viral strains, including strains resistant to oseltamivir (Sup.: cand(biol.) H.Zakaryan).

A method has been developed for nanopore sequencing of mutations in the *MEFV* gene that cause familial Mediterranean fever. A patent has been obtained (Sup.: DSc(biol.) A.Arakelyan).

## **Institute of Hydroponics Problems after G.Davtyan**

### ***Major achievements***

By the mathematical modeling of the data, the linear regression equation of the moringa yield increase has been derived:  $y=161.37-1.49x$ , which shows the mathematical relationship between the plant yield and NPK ratio in nutrient solution. Thus, in the case of the nourishment of moringa plants with the nutrient solution with the ratio  $N_{43}:P_{35}:K_{22}$  atomic ratio a maximum 161.37 g/plant yield of dry leaves can be received (Sup.: cand(biol.) A.Hakobjanyan).

*In vitro* culture for saffron crocus (*Crocus sativus* L.), the best nutrient medium was 0.5 MS containing 3% sucrose, where concentrations of 1.0 mg/L BAP, 0.5 mg/L IBA and  $GA_3$  stimulated the formation of new corms. In hydroponic and soil plant raw materials of rosemary (*Rosmarinus officinalis* L.) phenolic acids formed the following descending range: chlorogenic > rosmarinic > gallic > caffeic acids, where chlorogenic acid exceeded rosmarinic, gallic, and caffeic acids by 1.4 and 1.5, 2.4 and 2.5, 2.5 and 2.8 times, respectively.

It has been shown that in the Ararat Valley in the territory of the Institute plant raw material of several vegetables and medicinal plants cultivated in hydroponics and in soil is radio-ecologically safe, since the gross  $\beta$ -radioactivity complies with the radioecological safety standards established by the World Health Organization (1000 Bq/kg). Moreover, according to gross  $\beta$ -radioactivity in hydroponics and soil, medicinal plants make the following descending range: ashwagandha (*Withania somnifera* L.) > holy basil (*Ocimum tenuiflorum* L.) > rosemary, and vegetables: hot pepper (*Capsicum annum* L.) > cicer (*Cicer srietinum* L.) > lentil (*Vicia lens* Coss & Germ.) (Sup.: corr. member S.Mairapetyan).

### ***Outcomes of applied developments***

For the first time, valuable medicinal plants, shatavari (*Asparagus racemosus* Willd.) and skullcap (*Scutellaria lateriflora* L.) have been introduced in Armenia and tested in soilless conditions. The wild edible plants *Bilacunaria microcarpa* M. Bieb. Pimenov & V.N. Tikhom. and *Falcaria vulgaris* Bernh. have been first introduced into hydroponic culture. For the first time, the pyracantha bush (*Pyracantha* M. Roem.) has also been introduced into hydroponic culture, about 60 seedlings have been grown, which have decorative value and can be widely used in landscaping of Yerevan city (Sup.: cand.(biol.) A.Tadevosyan).

From several dwarf juda tree seedlings woven seedlings have been obtained, which have decorative practical value and can be used in landscaping (Sup.: cand.(agric.) L.Hovhannisyan):

About 720 saplings of different tree-shrubs (thuja, sycamore, catalpa, juniper, oak, sophora, juda tree, silk tree, privet) and plants raw materials produced as a result of scientific experiments have been sold for about 1120,0 thousands drams (Sup.: cand.(biol.) Kh.Mayrapetyan).

Specific practical radio protective proposals have been developed for the use in hydroponics and agrocenoses. It will ensure obtaining the radio-ecologically safer plant raw material and will have ecological and sanitary-hygienic significance (Sup.: cand.(agric.) L.Ghalachyan).

## **Institute of Physiology after L.Orbeli**

### ***Major achievements***

An evaluation of the impact of the predominant components of the *Macrovipera lebetina obtusa* snake's venom to induce hemorrhage and a study of the mechanisms of their synergistic action have been performed (Sup.: DSc(biol.) N.Ayvazyan).

The indices of the protective potential of the "Diabephy" herbal collection have been identified under conditions of functional electrophysiological and microvascular disorders in the neuronal networks of the brain. The data obtained broaden the therapeutic targets of the plant collection, particularly in relation to cholinergic activity under the conditions of metabolic syndrome (Sup.: DSc(biol.) V.Chavushyan-Papayan).

The data obtained from histochemical studies of bacterial melanin (BM) indicate its antioxidant and vascular protective effects. Research conducted under the influence of galarmin in a rat model of Alzheimer's disease suggests that galarmin exhibits both vascular and neuroprotective effects (Sup.: cand.(biol.) M.Danielyan).

Examination of an alcoholic aqueous solution of "Herba Origani vulgaris" has revealed a consistent anti-inflammatory and analgesic effect at a dose of 5 mg/kg. Furthermore, it demonstrates an anti-cancer effect on the MCF-7 cell line (Sup.: cand.(biol.) A.Voskanyan).

### ***Outcomes of applied developments***

A prototype of two dosage forms of a combined analgesic and anti-inflammatory drug has been developed: an injection solution and an ointment. The ointment version has shown the most effective anti-inflammatory effect, reducing the volume of carrageenan inflammatory edema by approximately 49% after 24 hours, and does not cause allergic irritation (Sup.: cand.(biol.) A.Voskanyan).

Technologies for the production of albumin and normal immunoglobulin have been developed, and test samples have been obtained. Their compliance with international drug equivalents and the requirements of the European Pharmacopoeia has been shown. As a result, it becomes possible to produce these drugs in the Republic of Armenia (Sup.: cand.(biol.) G.Kirakosyan).

Decellularized neural scaffolds have been studied using H&E histological analysis and confocal microscopy. Successful removal of the cellular component has been observed with relative preservation of tissue structure (Sup.: V.Grigoryan).

Cultures of dorsal ganglion cells have been obtained. The scaffolds have been combined with graphene oxide and preliminary data obtained shows that they do not have a negative effect on cells (Sup.: V.Grigoryan).

To monitor the behavioral activity of laboratory animals, a preliminary version of the SFCO sensor signal processing program has been developed. A portable multimodal system for collecting

human bioelectric signals has been developed and assembled, which includes a photoplatysmogram, an accelerometer, a gyroscope and a magnetometer. The system is designed to collect multimodal information when conducting psychophysiological experiments (Sup.: cand.(biol.) A.Khachunts).

## **DIVISION OF CHEMISTRY AND EARTH SCIENCE**

*Academician-Secretary – academician L.Tavadyan*

*Scientific Secretary – cand.(tech.) L.Gasparyan*

The Division includes the Scientific Technological Center of Organic and Pharmaceutical Chemistry, the Institute of Chemical Physics after A.Nalbandyan, the Institute of General and Inorganic Chemistry after A.Manvelyan, the Institute of Geological Sciences, the Institute of Geophysics and Engineering Seismology after A.Nazarov.

The Division includes 5 academicians, 5 corresponding members and 18 foreign members.

1 general meeting, 6 committee meetings, 10 meetings of the Bureau and 2 operational meetings were held during the reporting year.

At the annual general meeting of the Division held on April 20 the reports of the Academician-Secretary, acad. L.Tavadyan, directors of the Institutes, as well as leading scientists, related to their scientific activities and achievements in 2022 were discussed.

At the committee meetings of the Division the following issues were discussed: assessment of the risk of hazardous chemical waste “Lacquer ethinol” of the “Nairit Plant” and its safe neutralization; two investment projects; 7 applications submitted in the nomination “Best scientific work”, where, according to the results of a closed secret ballot, the works of those applying from the I<sup>st</sup> to the VII<sup>th</sup> places were approved; the program aimed at creating a center for scientific and experimental laboratories; issues related to the important initiatives of the NAS RA and the sphere of scientific and scientific-technical activities in the RA .

At the meetings of the Bureau the following issues were discussed and approved: applications for the programs of basic financing of scientific and scientific-and-technical activity: “Preservation and development of infrastructure” and for state target programs for 2024; working plan for 2023; distribution of full-time and part-time postgraduate free places of the NAS RA for 2024/2025; applications for purchase of the equipment in the scope of the programs on “Improvement of saturation and modernization of the Institutes of the NAS RA” and “Maintenance, rearmament of scientific equipment, purchase of substances for scientific research, fulfillment of unforeseen urgent expenses of the Institutes of the NAS RA” for 2023. The following was discussed: forming problem councils presented by the scientific organizations of NAS RA; five year development plan for 2023-2027; initial requirements for scientific departments of scientific organizations; the draft resolution of the RA Government “On confirming the state funding procedures of scientific forms of scientific and scientific and technical activities of basic, state-target, scientific grants”; awarding research workers of the Institutes with a commemorative medal dedicated to the 80th anniversary of the NAS RA and foreign business trips of research workers of the Institutes of the Division.

The reports on the scientific and technical activity of the Institutes on the program “Preservation and development of infrastructure” of the basic funding and state target programs for 2023 were discussed and approved.

221 scientific articles: 193 in the peer-reviewed journals (119 abroad) and 28 in the conference proceedings (22 abroad), 145 theses (71 abroad), 7 monographs (4 abroad), 1 manual were published by the Institutes of the Division, 5 patents were obtained.

Eight Candidates’ dissertations were defended in 2023.

The Division actively took part in the discussion of the scientific results of the Institutes during the annual meetings of these organizations.

### **Scientific Technological Centre of Organic and Pharmaceutical Chemistry**

#### ***Major achievements***

Based on heterocyclic and alicyclic ketones, methods have been developed for obtaining pyrano[3,4-*c*]pyridine, isoquinoline and conjugated thieno[3,2-*d*]pyrimidines containing 2,7-naphthyridine ring. Methods for the synthesis of new derivatives furo[2',3':4,5]thieno[2,3-*b*]pyridine and pyrido[3'',2''':4',5']thieno[2',3':4,5]furo[3,2-*d*]pyrimidine systems containing excess and deficiency heterocycles have been developed. Alkylation reactions of derivatives containing a hydroxyl group in the conjugated pyridine ring have been studied. In cooperation with the

Department of Organic Chemistry of Krasnodar University, quantum chemical studies have been performed to reveal the reaction mechanism. Based on hydroxyl derivatives of conjugated pyridines, new tetracyclic conjugated heterocyclic systems have been synthesized - thieno[2,3-*b*]furo[3,2-*d*] and thieno[2,3-*b*]furo[3,2-*e*]pyridines. *In silico* studies have been carried out and biological properties of the synthesized compounds have been studied (Sup.: DSc(chem.) E.Paronikyan).

The behavior of acetylene in superbasic media, particularly in dimethyl sulfoxide solution in the presence of KOH and NaOH bases, has been studied using NMR spectroscopy. It has been determined that the  $^1J_{CH}$  spin-spin coupling constant (SSCC) of acetylene in the  $^{13}C$  NMR spectrum depends on the experimental conditions (temperature, presence of water, concentration of dissolved base). Furthermore, the disappearance of the SSCC in the spectrum, called coalescence, is observed. The phenomenon is reversible, and most likely is due to exchange processes in the medium. Quantum chemical calculations have shown the possibility of several different exchange reactions between acetylene hydrogen and the hydroxyl groups of the metal and water. The discovered phenomenon may shed light on the understanding of the mechanism of reactivity of acetylene under superbasic conditions (Sup: cand.(chem.) A.Shakhhatuni).

#### ***Outcomes of applied developments***

Some new preparative forms for the use of the pheromone of the oriental fruit moth (*Grapholita molesta*) have been created. Based on field tests dispensers with a pheromone concentration of 20 mg/ml, coated with a polymer shell, are the most effective. Some key steps in the production of the tomato moth (*Tuta absoluta*) pheromone - (3E, 8Z,11Z)-3,8,11-tetradecatrienylacetate have been carried out according to the stated three-synthon strategy  $C_5 + C_5 + C_4$ . However, the yield of the target 2-(deca-4,7-diyne-1-yloxy)tetrahydro-2*H*-pyran was 5%. At this stage of the work, another strategy for obtaining diyne has been developed and tested. First, pent-2-yn-1-ol has been obtained from propargyl alcohol; it has been converted into the corresponding 2-pentin-1-yl-*p*-toluenesulfonate by reaction with *p*-toluenesulfonyl chloride at -10°C. 1-(tetrahydropyran-2-yloxy)-4-pentine then has been reacted with ethyl magnesium bromide in THF. The condensation of an alkyne Grignard reagent and the corresponding tosylate catalyzed by a CuBr-Me<sub>2</sub>S complex has afforded 2-(deca-4,7-diyne-1-yloxy)tetrahydro-2*H*-pyran in 78% yield (Sup.: cand.(chem.) H.Sargsyan).

### **Institute of Chemical Physics after A. Nalbandyan**

#### **Major achievements**

Bidirectional complete conversion from rock-salt to spinel structure has been unraveled during spark plasma sintering of high entropy (Fe,Co,Ni,Mn,Zn)O oxides that enables to tailor magnetic and mechanical properties of high entropy materials within the required interval (Sup.: corr. member S.Kharatyan).

The methods of Fourier transformed infrared and magnetic resonance spectroscopy have shown that the studied seleno-organic compounds possess antihydroperoxide/antioxidant properties. A reaction mechanism for interaction with a model lipid hydroperoxide, cumene hydroperoxide has been proposed (Sup.: acad. L.Tavadyan).

An iron-doped tungsten carbide catalyst with high efficiency and selectivity has been synthesized by the microwave irradiation method. The catalyst has shown 100% conversion in the oxidative desulfurization of mineral oil (Sup: cand.(chem.) D.Davtyan).

### **Institute of General and Inorganic Chemistry after M.Manvelyan**

#### **Major achievements**

A new method of acid treatment for serpentine-containing ore (Mg(Fe))<sub>6</sub>[Si<sub>4</sub>O<sub>10</sub>](OH)<sub>8</sub> has been developed and optimal parameters of the treatment ensuring a high yield of magnesium compounds from serpentine minerals have been determined. The dependence of magnesium yield on the mineralogical composition of the rock, temperature and processing time has been determined. It

has been revealed that both chrysotile and lizardite provide higher magnesium yields than antigorite does (Sup.: DSc(chem.) N.Zulumyan).

The regions of glass formation and phase diagrams in  $\text{Al}_2\text{O}_3\cdot\text{MeO}/\text{MeF}_2\text{-B}_2\text{O}_3\text{-SiO}_2$  (Me-Mg,Ca,Sr,Ba),  $\text{BaV}_2\text{O}_5\text{-MeB}_2\text{O}_4\text{-MgF}_2$  (Me-Zn,Cd) systems, and the stages of glass crystals synthesis by a directional crystallization technique have been studied. IR-transparent glasses, heat-resistant, glass-crystalline and semiconductor glasses have been developed. Based on  $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2\text{-Fe}_2\text{O}_3\text{-MenFm}$  (Me-Mg,Ca,Al) system, binders with different hardening rates have been developed (Sup.: DSc(tech.) N.Knyazyan).

A high-temperature phosphate packing material for precision casting has been obtained using  $\beta$ -cristobalite synthesized from  $\beta$ -quartz at  $1100^\circ\text{C}$  in the presence of mineralizers. The solidification start of resulting mixture is 9 minutes, a compressive strength is 6.1 MPa. In addition, the product has a smooth surface and is easily removed from the mold of chrome-nickel alloys (Sup.: cand.(tech.) K.Grigoryan).

#### ***Outcomes of applied developments***

A slow-acting complex fertilizer containing phosphorus, iron, calcium, magnesium, active (water-soluble) silicon, *etc.* has been obtained from phosphorus-containing diatomite rocks of the Sisian basin. The use of the synthesized fertilizer has resulted in a significant improvement observed in the agrochemical parameters of soil and crops (Sup.: cand.(tech.) K.Grigoryan).

Fluorosilicate system-based glass with high transparency in the IR range for use in night vision devices has been developed. Directed crystallization has been synthesized with a nanocrystalline structure and a low expansion coefficient (15-30·10<sup>-7</sup>K<sup>-1</sup>), transparent sitals, as well as semiconducting fusible glass based on divalent metal borvanadates for applications in microelectronics. High-speed binders based on the  $\text{CaO-Al}_2\text{O}_3\text{-SiO}_2\text{-Fe}_2\text{O}_3\text{-MeFn}$  (Me-Mg,Ca,Al) system have been developed for restoration of buildings (Sup.: DSc(tech.) N.Knyazyan).

### **Institute of Geological Sciences**

#### ***Major achievements***

Detailed geochemical, geochronological ( $\text{U-Pb}$  and  $^{40}\text{Ar}/^{39}\text{Ar}$ ) study of magmatic and metamorphic rocks of South Armenian Block (SAB) have firmly revealed that they are of Gondwanan origin and rifting from the north-eastern margin of Gondwana occurred in Early Triassic times with the opening of the Neo-Tethys Ocean. New paleogeodynamic model for SAB evolution in Mesozoic times has been proposed. Mafic alkaline OIB-like sills in the Late Devonian sedimentary cover in the Arpi (south central Armenia) and Negram (south Nakhichevan) areas, dated at  $\sim 246$  Ma are products of asthenospheric melting beneath the SAB. A mafic P-MORB-like intrusion at Khor Virap, dated at  $\sim 234$  Ma, reflects melt derivation from a more depleted, shallower mantle source and demonstrate presence of wide-scale mafic volcanism on the SAB. Andesitic dykes in the Late Devonian sedimentary cover in the Arpi ( $\sim 117$  Ma) and Negram ( $\sim 104$  -126 Ma) areas exhibit a “subduction-related” (north-east subduction) geochemical signature (Sup.: DSc(geol.) Kh.Meliksetian).

#### ***Outcomes of applied developments***

Formulas for predicting synthetic seismograms and accelerograms for 8 different inhomogeneous two-layer foundations and curves of their changes over time have been obtained, depending on the seismic order of the foundation layers, the magnitude of the earthquake, and the distance from the fault line during a future earthquake (Sup.: acad. E.Khachiyan).

The study, commissioned by the Ministry of Environment, on description, mapping, data analysis of geological and volcanological features and desertification process within the bounds of “Hatis Volcano” geological monument has been undertaken. Evaluating the geological-volcanic features of the Hatis volcano has formed the basis for presenting an assessment of the scientific value and touristic potential of the “Hatis volcano” monument. In this process, 13 geosites have been identified and incorporated into the conservation zones of three sites. A comparative research

analysis of relief changes resulting from earthworks has also been conducted (Sup.: DSc(geol.) Kh.Meliksetian).

A high-resolution digital elevation model of the Ararat valley (5 m) has been built based on digitized isohypses from large-scale (1:10,000, 1:25,000) topographic maps of the Valley. The optimal places for accumulation of drainage water in the Ararat Valley for their reuse for irrigation have been determined by comparing DEM with satellite images and vector layers of water bodies and infrastructure.

A GIS model of the water balance of Kasakh River basin has been compiled based on the data on precipitation, surface runoff, evaporation and digital elevation model. The values of the water balance components of individual sections of the river and drainage basins of tributaries have been calculated. The impact of climate change on the components of the water balance has also been assessed using the UN IPCC RCP8.5 scenario for the periods up to 2040, 2070, 2100. The results can be used for more effective planning of water resource management and water use in the river basin.

A quantitative assessment of the impact of municipal wastewater on the ecological state of Lake Sevan has been carried out. It has been found out that about 338 tons of nitrogen and 65 tons of phosphorus are discharged into Lake Sevan annually, which contributes to the active blooming of the lake (Sup.: cand. (tech.) A.Arakelyan).

As a result of the analysis of existing methods and systems for assessing the risk of forest fires, forecasting and warning about fire outbreaks, a methodology applicable to the territory of Armenia has been developed (Sup.: cand.(geol.) G.Avetisyan).

For the first time, the vertical accuracy of digital elevation models with global coverage (ALOS, ASTER and SRTM) has been analyzed and assessed for the territory of the Republic of Armenia. It has been concluded that for studies covering the entire territory of Armenia, it is preferable to use the ALOS digital elevation model (DEM), in the case of specific forested or built-up areas - SRTM, and in the case of coastal areas of Lake Sevan - SRTM or ASTER (Sup.: H.Uloyan).

The sen2r library of the R software environment has been installed and configured on the Geoinformatics lab's server, which allows to download automatically Sentinel-2 images and its derived indexes for a selected area (Sup.: N.Tarasyan).

## **Institute of Geophysics and Engineering Seismology after A. Nazarov**

### ***Major achievements***

Tectonic activity in the collision zone of the Eurasian and Arabian plates has been described using seismic 2D tomography (Sup.: cand.(geol.) J.Karapetyan)

An analysis of the focal mechanisms, seismic moments and spatial distribution of the epicenters of earthquakes with magnitude  $M \geq 5$  that occurred in the Tauro-Caucasus region for the period from 2005 to 2022 has been carried out. It has been demonstrated that various forms of anomalous manifestations of seismicity had preceded and accompanied the strongest earthquakes in the region (Van 10/23/2011,  $M_w=7.2$ , Agar 08/11/2012,  $M_w=6.4$ , Diyarbekir 01/24/2020,  $M_w=6.8$ ). It has been revealed that the regional seismic deformation processes, at spatiotemporal discretion, have a migration character from east to west and outline the Arabian plate from the east to the Zagros, forefront Urmia-Bitlis-Erzrnka and western Erznka-Eastern Anatolian suture zones (Sup.: cand.(phys.-math.) E.Geodakyan).

From the time series of average long-term and current values of quantitative parameters of the seismic regime ( $A_{10}, \gamma, \sum n, \sum E$ ), anomalous time intervals of exceeding the background and fluctuation values of the corresponding characteristics have been identified. It has been revealed that, having high efficiency, the parameters ( $\gamma, \sum n$ ) for the period 2016-2022 sensitively responded to the processes of changes in local field stresses in the disjunctive node of the Lag-Agdam and Kechut faults in the form of spatially concentrated epicenters of seismic events. Based on a retrospective analysis, these identified anomalous manifestations have been identified as harbingers of the processes of preparation and occurrence of Dmanisky 2016, Tashirsky 2019 and Metsavan 2022 earthquakes (Sup.: B.Sahakyan).

The distribution of earthquake epicenters ( $M_s \geq 3.5$ ) on the territory of Armenia and adjacent territories in space and time has been analyzed and compared with the tectonic movements of the territory. The focal mechanisms of these earthquakes have been calculated and analyzed. It has been revealed that almost all solutions (varieties) of focal mechanisms are present in the specified area and are compared with the main deep faults with a high degree of accuracy (Sup.: cand.(geol.) A.Gevorgyan).

#### ***Outcomes of applied developments***

A digital three-channel seismic data logger has been developed. The circuit design and printed circuit board of previous designs have been completely redesigned. Printed circuit boards are made in an industrial manner, which increases operational reliability.

A program has been developed for the Raspberry PI microcomputer, which allows reading data from an analog-to-digital converter with subsequent recording of the results to a hard drive, as well as transmitting this data via the Internet (Sup.: H.Shahparonyan).

A comprehensive power supply system has been designed (with the ability to charge with a voltage of 100 V) using modern lithium-ion batteries to carry out deep electrical exploration work (Sup.: S.Shakhparonyan).

Modernized seismic stations IGES-006 of national production have been designed and installed at seismic stations in Vladikavkaz and Makhachkala (Sup.: cand.(geol.) J.Karapetyan).

A new version of a vertical-pendular sensor has been developed, providing a wider range of periods (Sup.: A.Gasparyan).

## **DIVISION OF ARMENOLOGY AND SOCIAL SCIENCES**

*Academician-Secretary - academician Yu.Suvaryan*

*Scientific Secretary - A.Melkumyan*

The Division includes the Institutes of History, the Institute of Oriental Studies, the Institute of Arts, the Institute of Archaeology and Ethnography, the Institute of Economics after M.Kotanyan, the Institute of Language after H.Acharyan, the Institute of Literature after M.Abeghyan, the Institute of Philosophy, Sociology and Law, Shirak Center for Armenian Studies, “Armenian Encyclopedia. Publishing House”.

The Division includes 6 academicians and 15 corresponding members.

In 2023 3 general meetings of the Division were held.

At the annual general meeting held on April 4 the report of academician Yu.Suvaryan on “The main results of scientific and scientific-organizational activities of the Division for 2022” was discussed and approved. The following scientific reports were presented: “Azerbaijan: Historical-Demographic Examination”(academician A.Melkonyan); “The Latest Archaeological Researches of the Eastern Shores of Lake Sevan” (A.Bobokhyan, DSc(hist.)).

At the general meeting held on June 29 the candidacies of H.Vorskanyan, cand.(phil.) and M.Manucharyan, cand. (phil.) were nominated for the vacant positions of the directors of the Institute of Literature after M.Abeghyan and the Institute of Economics after M.Kotanyan. It was decided to submit the candidacies for consideration to the Presidium of NAS RA with a positive opinion.

At the general meeting of the Division held on August 31 the issues on guaranteeing the candidacies of V.Katvallyan, DSc(phil.) and academician A.Melkonyan for the vacant positions of the directors of the Institute of Language and the Institute of History were considered. It was decided to submit their candidacies for consideration to the Presidium of NAS RA with a positive opinion.

During the reporting year 21 Bureau sessions were held..

The following issues were considered and approved: the working plan of the Division for 2023, the applications for the program of basic financing of scientific and scientific-technical activities ”Preservation and development of infrastructure”, current reports on realization of the mentioned project in 2022, the reports on the mentioned project during 2022, as well as the current reports on realizing of the mentioned project in 2023, the applications on post-graduate students’ entrance exams, the process of writing the first volume of the first book of “Armenian History”, issues on increasing the efficiency of the scientific organizations of the Division and the results of the work aimed at internationalization of scientific journals, formation of professional councils at the Division, the 2023 budget programs (“Maintenance of scientific equipment, re-equipment, acquisition of materials for carrying out scientific experiments and fulfillment of unforeseen urgent expenses” and “Re-equipment of NAS RA system organizations”) of the scientific organizations of the Division, as well as other scientific and organizational issues. On December 25 the reports on scientific and scientific-organizational activities of the Bureau and scientific organizations during 2023, as well as the personal staff of the Scientific Council of the Institute of History were considered and approved.

During 2023 the following periodicals were published: “Historical-Philological Journal” (3 issues), “Journal of Armenian Studies” (3 issues), “Bulletin of Social Sciences” (3 issues), as well as the electronic journal “Fundamental Armenology” (in English, 2 issues). The Institute of Language after H. Acharyan published the periodical “Language and Linguistics” (1 issue), “Jahukyan Readings” (2 issues), the Institute of Literature after M.Abeghyan published the periodical “Journal of Literary Studies” (2 issues), and the Institute of Arts - the periodical “Journal of Art Studies”(2 issues)..

133 books (8 abroad), 17 textbooks and handbooks, 1088 articles, including 736 in peer-reviewed scientific journals (153 abroad) and 352 in conference proceedings (130 abroad), as well as 240 abstracts (72 abroad) were published by the researchers of the scientific organizations of the Division.

31 international and 58 local conferences were successfully held.

Director of the Institute of Archaeology and Ethnography of NAS RA, Arsen Bobokyan, was elected a corresponding member of the German Archaeological Institute (DAI), Berlin.

## **Institute of History**

### ***Major achievements***

Within the framework of the theme “Armenia and Armenians in the modern period. The Armenian question and the Armenian Genocide” (Sup.: DSc(hist.) K.Khachatryan) as a result of international cooperation an article devoted to the problems of Soviet nation-state building on the example of Soviet Armenia and Artsakh was published in the journal “Oriental Studies” (Scopus, Q1), with a high rating in the framework of monitoring and evaluation. The authors of the article highlight specific facts that the Armenian SSR and the Nagorno-Karabakh Republic were national entities with many signs of statehood, on the basis of which in September, 1991 two independent Armenian states emerged: the Republic of Armenia and the Republic of Artsakh.

The collection of reports of the scientific and practical conference dedicated to the Artsakh problems presents analyses, articles and proposals for their solution in the complicated geopolitical situation around Artsakh and the Republic of Armenia.

## **Institute of Oriental Studies**

### ***Major achievements***

In the framework of the programme “Eastern sources of the ancient, medieval and new period about Armenia and the Armenians”, “Armenia and the problems of political, social, cultural and ethnic history of Turkey, Iran, Caucasus and Arabic countries of Mashriq”, “International relations in Near East, Eastern Asia, South Caucasus and the Republic of Armenia” (Sup.: DSc (hist.) R.Ghazaryan) the history of Urartu has been published under the authorship (co-authored) of Y.Ghrekian in the fourth volume of “The Oxford History of the Ancient Near East”, which presents in detail the history of Urartu from the origin to the fall, the structure of the state, its administrative, economic and military organization, pantheon, as well as issues related to chronology and ethnic issues. The study is particularly important due to the fact that this publication represents an unprecedented phenomenon in the Armenian scientific reality, and for the first time a study by an Armenian scholar finds a place in such popular scientific publications as Oxford or Cambridge publishing houses.

Important results have been obtained in the research on Ałuank (Albania), which is of great importance not only from the scientific but also from the strategic point of view, in particular, the scientific publications “Armenian sources on the introduction of christianity to Caucasian Albania and Albania's relationships with Armenia” and “The Ethnic situation in antique and medieval Caucasian Albania” are devoted to the history, ethnic problems and religious issues of the ancient and medieval period of Ałuank (Albania), this topic has become part of the Azerbaijani state policy of outdating its own history and presenting itself as an autochthon and heir to the historical and cultural heritage of Ałuank (Albania) over the last almost hundred years. The studies have been published by major publishing houses (“Brill”, “De Gruyter”) included in international scientific indexing databases with a wide audience.

### ***Outcomes of applied developments***

The Institute has actively participated in the implementation of scientific and applied activities with the involvement of diplomatic and scientific circles of different countries, especially Middle Eastern states, and an attempt has been made to form platforms of scientific and public diplomacy.

Scientific events have been organized with the involvement of the ambassadors of Armenia and Middle East countries, diplomats and other representatives of state agencies. Scientific conferences have been organized, such as the conference dedicated to the tenth anniversary of initiative “One Belt and One Road”, as well as the conferences “South Caucasus: Current challenges to stability and security” and “Armenian communities of Arab Middle Eastern states: Modern trends and transformations”

The publication of the first volume of the Kurdish language textbook by T.Amryan (co-authored with V.Voskanian) is of particular importance.

One of the important achievements is the publication of two issues of the peer-reviewed periodicals “Bulletin of the Institute of Oriental Studies” and “Contemporary Eurasia”. This is important for the dissemination of Armenian orientalist thought, popularization of objective studies related to Armenian studies. The periodicals are published in English, one third of the articles have been presented by foreign researchers. The periodicals are included in such well-known international databases of scientific information as ErihPlus, DOAJ, Dimensions and others.

## **Institute of Archaeology and Ethnography**

### **Major achievements**

The sub-project “Excavations and study of archaeological sources of ancient and old Armenia” has recorded important achievements in the field of research of ancient societies and populations of the Armenian Highlands. The works of the Armenian-Japanese expedition in Lernagog-1 site (Armavir region) have shown that at the turn of the 8th-7th millennia BC a community lived there, the inhabitants of which mastered early animal husbandry and the technique of building mud-brick houses. This is one of the first settlements of early herders known not only in Armenia, but also in the entire region. In this sense, the excavations of Lernagog-1 are of great importance in the research of the first sedentary communities of the Ancient World. The data obtained from the excavations of the Armenian-German expedition of the capital Artashat are also significant, they shed new light on the various cultural, economic and political processes taking place in the capital of ancient Armenia, reveal the extensive trade connections on the Silk Road. At the foot of the 17th hill of Artashat a monumental civic structure of the 2nd century AD has been excavated, which is unique in its engineering and functionality. Its foundation and destruction are directly connected with the political developments in the capital and throughout Armenia. The results of field researches, biometric and anthropometric laboratory analyzes have been published in high-ranked journals (Sup.: cand.(hist.) A.Bobokhyan).

Achievements of strategic importance have been recorded in the field of internationalization of Artsakh's cultural heritage problems by the scientific research groups “Study of Artsakh's historical and cultural heritage” and “Applied anthropology”. In particular, the trilingual (Armenian, English and Russian) academic platform <https://monumentwatch.org/> has been launched, which presents the cultural heritage of Artsakh to the world, monitors its current state, responds to cases of Azerbaijani vandalism (Sup.: DSc(hist.) H.Petrosyan). In addition, the descriptions of the official lists of monuments of Soviet Azerbaijan and the cultural policy of the Azerbaijani authorities in Artsakh (and Nakhichevan) were acquired and researched from the Moscow archives (Sup.: cand.(hist.) H.Kharatyan).

The Department of Ethnography has recorded the most important result in popularization of the cultural heritage of Armenia. At the 18th Intergovernmental Session of the UNESCO on Convention towards the safeguarding of intangible cultural heritage the application “Gyumri Blacksmithing Tradition” was registered and included in UNESCO Intangible Cultural Heritage list (Sup.: cand.(hist.) A.Tadevosyan).

### ***Outcomes of applied developments***

The “Applied Anthropology Group” has successfully implemented various research and analytical programs focused on the preservation and transformation of identity of ethnic, religious, linguistic, and social groups. The group has conducted investigations into the social, political, cultural, and ideological factors, as well as into anthropological regularities and policies shaping individual, societal and collective memory. The group has presented its professional findings to the Government of the RA and the Ministry of Education, Science, Culture, and Sport (Sup.: cand.(hist.) H.Kharatyan).

A trilingual (Armenian, English and Russian) academic platform, <https://monumentwatch.org/>, has been launched by the participants of the subprogram “Study of the historical and cultural heritage of Artsakh” in collaboration with international partners. It presents cultural heritage, monitors its current state, and responds to cases of Azerbaijani vandalism (Sup.: DSc(hist.) H.Petrosyan).

One of the most significant achievements is the launch of the interactive website “100 archaeological sites of Armenia” (<https://ama100.am/>), created in collaboration with the American University of Armenia (Sup.: cand.(hist.) V.Vasilyan).

Exhibitions have been organized based on the museification of archaeological artifacts in Gyumri (“The Mystery of the Soil: Shirak, Results of Armenian-German Excavations”), Ijevan (“Geghovit-2 Cave”), Vanadzor (“Wine Festival”, “Museum Night”), and Yerevan (“The Phenomenon of Pithos Burials”, HMA).

The Institute has participated in technology exhibitions such as Digitec Expo and EXPO “BanUGorts-2023”.

Projects for restoration and museification of the excavated castles Dashtadam and Tavush have been implemented based on the excavations. These projects also provide educational opportunities for local communities and schools.

A program for the inclusion of the Tirinkatar archaeological site in the preliminary list of UNESCO World Heritage has been presented to the Ministry of ESCS. The project has been approved, and relevant work is currently underway. The application “Traditions of Blacksmithing in Gyumri” has been included in the UNESCO List of Intangible Cultural Heritage.

The Institute has organized two international summer schools: the “Archaeological Summer School in Artanish” in collaboration with the University of Halle and the “Museum from the Field: Archaeological Summer School in Vedi” in partnership with the University of Hong Kong.

Through lectures and seminars, the Institute has actively participated in numerous international and republican events, including the “International Day for Monuments and Sites” and the “European Archaeology Days”.

The Institute periodically publishes journals, including the “Proceedings of the Institute of Archaeology and Ethnography” and the “Armenian Humanities Journal”.

## **Shirak Centre for Armenian Studies**

### *Major achievements*

Within the framework of the theme “Archaeological and historical-ethnographic studies of Shirak-3” (Sup.: cand.(hist.) A.Hayrapetyan) the excavations in the area of the Bronze Iron Age fortress-settlement of Jradzor have been resumed. The defensive wall on the western slope of the castle was the focal point of the main force concentration. The horizontal outline of the castle wall was sketched out after the collapsed stones were cleared away. At the excavation site, remnants of a cult pillar with a hexagonal cut in basalt have been discovered. Most of the material excavated consists of fragments of Early and Late Iron Age shells. The current appearance of the castle has inevitably resulted from centuries of use and restoration.

A Bronze Iron Age fortress system has been found on the Ashotsk plateau. These defensive structures varied in size and were connected by ramparts that were between 1.5 and 2 metres wide. Unfortunately, the areas have survived as islets because they are inhabited and used for agricultural purposes. The “pathways” of pile stones discovered on the same plateau are especially fascinating. These complexes are dispersed throughout the villages of Ashotsk, Hartashen, and Zuygaghbyur. Based on initial observations, it appears that we deal with mega-complexes of archaeology, the true significance of which has not been determined yet.

Reconnaissance work has been conducted in the cemetery of Hartashen community of Shirak Province. Aerial photography has been taken, and a model and an orthophoto plan of the cemetery have been created. Research has been carried out in the castle and cemetery of Ketik. Based on the conducted research, it can be hypothesized that the tomb No. 21, which once contained the remains of a two-wheeled cart, belonged to the Late Bronze Early Iron Age fortress of Ketik, which was in charge of overseeing the mountain pass connecting the Ashotsk plateau along with the Shirak field. On the castle grounds, aerial photography has revealed the remnants of a road-like structure.

## **Institute of Language after H.Acharyan**

### ***Major achievements***

Significant results have been achieved in the direction of studying the relationship between Grabar and dialects. Within the framework of the theme “Issues of historical development of the Armenian language” (Sup.: cand.(phil.) G.Mkhitaryan) correspondences of a number of realities typical of Grabar have been observed in the Artsakh dialect, as well as marks of some pre-Grabar phenomena in the dialect, which indicate the use of the Armenian language in Artsakh since ancient times. Research provides material for clarifying some issues of both the dialectal Armenian language and the history of the Armenian language, for highlighting the peculiarities of the development of different grammatical categories. Expressions of a number of thematic groups of vocabulary at different stages of the Armenian language development have been studied. The meanings, structure and features of expression of lexical units have been described. The study of thematic groups of vocabulary has been carried out using modern linguistic approaches and methods. The interpretation of lexical units as various forms of expression of objective reality has cognitive significance.

Within the framework of the theme “Study of Armenian Dialects” (Sup.: DSc(phil.) V.Katvalyan) remarkable results have been achieved in the direction of synchronic research of Armenian dialectal units and features. The study of Armenian dialects has been supplemented by a study and description of the Surmali, Severeke, Basen, and Nakhichevan dialects, and a general description of the dialectal speech of the Shirak Region has been presented. Significant observations have been done regarding the phonetic systems of individual dialectal units. Much work has been done in the areas of identifying and describing the semantic and word-formation realities of vocabulary, as well as the study of lexico-thematic groups. Interesting observations have been done regarding the verbal system and syntactic realities of modern dialectal language.

### ***Outcomes of applied developments***

On the occasion of the 80th anniversary of the foundation of NAS RA as well as of the Institute, within the framework of the topic “Issues of historical development of the Armenian language” (Sup.: cand.(phil.) G.Mkhitaryan), a collection “Episodes of Armenian history (V-VII centuries)” has been published. It presents events recorded in the works of Armenian historians that have been of decisive importance for the history of our people. The book, which has parallel versions of Grabar-Ashkharabar, has both cognitive and educational significance.

Within the framework of the topic “Study of Armenian Dialects” (Sup.: DSc(phil.) V.Katvalyan) about 500 dialectal versions of Tumanyan’s fairy tale “The Liar” have been digitalized, included in records made in the last quarter of the last century and at the beginning of the 21st century as part of the project of collecting materials of the Dialectological Atlas of the Armenian language. The book being prepared for publication has great scientific, educational and cognitive significance.

Within the framework of the topic “Issues of studying and standardizing the modern Eastern Armenian and Western Armenian languages” (Sup.: cand.(phil.) T.Asoyan), dictionaries of neologisms of the Eastern and Western Armenian branches of the modern literary Armenian language have been prepared for publication.

## **Institute of Literature after M.Abeghyan**

### ***Major achievements***

Within the framework of the project “History of Armenian literature and theory of literature” (Sup.: DSc(phil.) V.Devrikyan,) cand.(phil.) H.Vorskanyan) the monography “Армения и армяне в записках европейских путешественников. Легенды и предания эпохи раннего христианства” has been published. The monograph disseminates unexplored material from the history of the Armenian cultural heritage summarized in the travel records of several European authors who visited Armenia in the 11th-18th centuries. The author of the monography (cand. (phil.) G.Karagyozyan) has translated and presented ten legends and narratives from French, English, Latin, Italian, and German. The material recorded by European travelers has a significant scientific importance from the perspective of a novel and systematic understanding of the historical path of the Armenian nation and

its cultural heritage since these travel records enable to restore some Armenian traditions that exist orally but are not preserved in written form in Armenian sources.

Within the scope of research dedicated to Artsakh, the work “The Armenian origins of Artsakh and refuting of Azerbaijani fake “Albanology” (Sup.: cand.(phil.) V.Yeghiazaryan) has been published, in which the existence of the Gorozchuni, Parachuni, Khachyan and Khaghbyan noble dynasties of Artsakh has been substantiated based on the primary source study. References to Artsakh and Artsakh people in ancient Armenian literature based on the systematic approach have been highlighted. Comprehensive information about Artsakh and its regions has been provided, and the Azerbaijani forgery - to present Armenian famous cultural figures as Albanians, has been thoroughly refuted and exposed.

#### ***Outcomes of applied developments***

The 8<sup>th</sup> volume of Avetik Isahakyan’s complete collection of works (14 volumes) has been published. The volume includes continuation of the partial manuscripts and notes of the second version of the novel “Usta Karo and Orte Harut” by representing the content via three thematic subgroups: Usta Karo in Ani, Usta Karo in Gyumri and Bagran’ pilgrimage.

The 1<sup>st</sup> volume of Yeghishe Charents’ collection of works (13 volumes) has been published. It summarizes Yeghishe Charents’ poetic legacy of 1912-1922. Three of 15 new poems have not been included in any Charents’ collection previously. The omissions and errors in preceding editions have been corrected including word misreading, punctuation, spelling questions, and annotations.

The materials of the local conference “H.Tumanyan’s 100th death anniversary” have been collected and prepared for publication. The articles of this collection shed light on Tumanyan’s fruitful activities by presenting his national-political thinking and individuality features, his way of perception of the reality.

“Literature. A textbook for the 7<sup>th</sup> form of secondary schools” has been published.

#### **Institute of Economics after M.Kotanyan**

##### ***Major achievements***

Within the framework of the theme “Protection of the environment and natural resources as a guarantee of sustainable development of RA” (Sup: cand.(econ.) M.Manucharyan) it has been revealed that over time, large-scale, long-term intentional and unintentional influences, both external and internal, cause significant damage to national security, at the same time posing a great threat to the environment. Intentional impact is basically ecological aggression in various manifestations. It is usually considered within the military component of national security. In this context, a decoupling method has been proposed to quantify the relationship between economic growth, resource consumption and environmental pollution, which makes it clear whether economic activity is effective in minimizing environmental damage. The following has been justified: the development of adaptation to predicted climate changes and the creation of appropriate capacity, the transition to a circular economy that can restore natural systems and increase human well-being, which will also contribute to the solution of global problems, which must be committed by the government. Emphasizing the role of ecological security in the system of ensuring national security, guarantees have been developed to include it in the sphere of social values. In other words, ecological security should be guaranteed like military security of the state. From a legal point of view, the right to a socially guaranteed minimum of ecological security should be universal and equal for all.

Within the framework of the theme “Prospects of the development of the mining industry and the possibilities of developing measures aimed at obtaining the final products in the Republic of Armenia” (Sup.: cand.(econ.) Y.Hakobyan): a package of implementation measures aimed at obtaining final mining products in the Republic of Armenia has been developed; as a result of the analysis of international experience from the point of view of sustainable mining industry, the scope of legislative changes has been justified; the relationship between resilience and productivity in the mining industry has also been revealed, the priorities of the sector's development have been specified.

### *Outcomes of applied developments*

Within the framework of the theme “Protection of environment and natural resources as a guarantee of sustainable development of RA” (Sup.: cand.(econ.) M.Manucharyan) the following priorities have been distinguished.

Due to the increase in water pollution from industrial, domestic and other uses, the increase in demand for water use, as well as the existing and projected reduction in water resources due to climate change, secondary water use becomes necessary and relevant, especially to meet the irrigation needs of the Ararat Valley and in order to reduce pressure on Lake Sevan and various sectors of the economy. Adaptation measures to climate change include growing heat- and drought-resistant crops, hail nets, field protection forests, improving water supply systems, planning and storing water resources, managing and maintaining watersheds, increasing green areas, applying sun protection measures, sustainable use of natural resources, conservation of biodiversity, etc. The implementation of measures to mitigate the effects of climate change is very important for Armenia, therefore the development of adaptation to projected climate changes and the creation of corresponding capacity is extremely necessary.

Considering the issue of transition from a linear economy to a circular economy, it should be noted that the most important difference between these two forms is that the circular economy is closed-loop, unlike the linear economy, which does not involve the reuse of primary products and waste for further processing. The main goal of a linear economy is maximum profit, not conservation of nature and the environment. The goal of the circular economy is environmental balance, that is, sustainable environmental management is applied to achieve a long-term and efficient cycle of use of goods and services. The above proposal will create enormous opportunities to modernize production and introduce industrial innovations that ensure annual productivity growth.

In order to prevent pollution of Lake Sevan, it is recommended to build a sanitary protective layer 100-200 m wide around the Kechut and Spandari reservoirs in order to eliminate the quantitative increase in emissions of pollutants discharged into Lake Sevan from the Arpa, the Vorotan rivers, and from the catchment basins of the Kechut and the Spandari reservoirs, and also the introduction of restrictions on economic activities within the boundaries of the sanitary district of “Jermuk” mineral waters. The “Jermuk” nature reserve is located within these same boundaries. Maintaining the regime of the reserve will prevent the entry of nutrients and toxic substances of anthropogenic origin into the lake.

Within the framework of the theme “Prospects of the development of the mining industry and the possibilities of developing measures aimed at obtaining the final products in the Republic of Armenia” (Sup.: cand.(econ.) Y.Hakobyan) the following has been suggested: measures to increase the investment attractiveness of the mining industry, some directions and measures to introduce innovations based on the study of international experience, the implementation and application of which can contribute to the innovative development of the industry; a new methodology for calculating the amount of mineral rent in the Republic of Armenia.

Within the framework of the theme “Conceptual approaches to strategic planning and the need to develop national policy” (Sup.: cand.(econ.) E.Matevosyan) it has been suggested to adopt a methodological document (decision, law, methodology) on strategic planning in the Republic of Armenia, which will regulate and coordinate state policy measures in the field of strategic planning aimed at preserving the national interests of the Republic of Armenia, ensuring socio-economic development and national security, determination of long-term development goals, identification of strategic national priorities, as well as the main ways and tools for achieving them.

Within the framework of the theme “The Armenian model of economic growth and its socio-economic consequences” (Sup.: cand.(econ.) Sh.Poghosyan) it is recommended to create an environment by gradually increasing the share of industry sector in the GDP structure, as well as to diversify the service sector, contributing to the expansion of modern information services, to ensure the growth of competitiveness of domestic companies in the international markets, to attract investments from advanced foreign companies, as well as to implement the effective fiscal policy of the government in the conditions of current economic developments, the establishment of a knowledge-based economy to form an institutional environment, production, scientific-technological and human capital potential.

Within the framework of the theme “Development prospects of the innovative economy of RA in the context of digital transformations” (Sup.: cand. (econ.) S.Dallakyan) a hypothetical model for the development of a tourism cluster has been developed, including the tourism infrastructure of the Republic of Armenia, historical, cultural, winemaking, marketing and other opportunities.

Within the framework of the theme “The labor market as a policy for the prosperity of the business environment” (Sup.: cand. (econ.) T.Parsadanyan) it has been proposed to organize training programs and courses in the field of ICT to solve employment problems, especially for the low-income population. To increase the workforce in the energy sector, it is necessary to develop an energy development plan for the Republic of Armenia with detailed stages and a real period of development, which will bring clarity to the labor market, as well as in the formation of professions. About 200 small hydroelectric power plants operating in Armenia are staffed by young people living in surrounding villages who do not have sufficient knowledge about the operation of hydroelectric power plants, as a result of which hydroelectric power stations do not always operate in an efficient mode, and equipment often breaks down. It is necessary to organize local training courses, which will improve the efficiency of hydroelectric power plants and solve many environmental problems.

### **Institute of Philosophy, Sociology and Law**

#### ***Major achievements***

Within the scope of the topic “Philosophical, socio-political and legal issues of the Armenian society (history and modernity)” (Sup.: cand. (pol.sciences) E.Ordukhanyan) research has been conducted in four scientific directions: philosophy, sociology, law and political science.

The most important results, covering also the context of interdisciplinary research, include the analysis of current issues related to the theory and history of Armenian philosophy, the historical and theoretical issues of law, the legal-philosophical issues of Armenian statehood, the study of key socio-political processes and current challenges in RA, South Caucasus and nearby regions, taking into account the new geopolitical and demographic shifts and changes.

Among the obtained results, it is important to highlight: the study of the works of L.Shant, M.Ormalyan, and M.Mamuryan, prominent figures of Armenian philosophical and political thought of the late 19th and early 20th centuries; the dictionary of French-Armenian legal terms (about 35,000 words and expressions, which is the first voluminous professional dictionary in the field of law in our reality; the publication of the 4th, 5th and 6th editions of “Treasure of Armenian political thought and Armenia’s political history”, where the issues of Armenian geostrategic thought, the internal and external folds of the Armenocide and the “Armenian Crossroads” have been presented and comprehensively examined within the framework of Armenian political thought; the comprehensive research on the development of the parliamentary governance system in the Republic of Armenia, the development of the concept of constitutional reforms, taking into account the effective international experience and the characteristics of RA.

The most important scientific results have been published in monographs, in the articles which figure in the list of scholarly periodicals acceptable to the RA Supreme Certifying Committee as well as in the journals included in the prestigious international WoS and Scopus scientometric databases.

#### ***Outcomes of applied developments***

The newly created research group on Internationalization of Law and Comparative Legal Studies is actively involved in the work of the RA Constitutional Reforms Professional Committee. The head of given research group is the chairman of that Committee.

In the context of the comprehensive cooperation agreement signed between the Institute and the Constitutional Court of the RA, joint theoretical and applied scientific-research and expert works have continued.

Some scientific results of the Department of Political Studies, related to regional security issues and conflict resolution, have been regularly presented to the relevant RA state structures, the researchers of the Institute have regularly presented their analyzes and proposals on the organization of legal and political life of the state in the public field.

In order to popularize the Institute and its fundamental scientific directions, two series of lectures have been videotaped, which had thousands of views on the Institute's YouTube channel.

The scientific journal founded by the Institute (“The POLITNOMOS. Journal of Political and Legal Studies”) is published in English and accepts scholarly papers related to political science, law, political and legal philosophy.

## **Institute of Art**

### ***Major achievements***

Within the framework of the basic project “Complex study of the Armenian Art” ( Sup.: DSc (arts) A.Asatryan) the study of contemporary art has continued. For the first time, a comprehensive study of the creative path, performing activities, choirmaster and conducting art of Ohannes Tchekidjian has been carried out, his exceptional contribution to the development of Armenian choral art has been presented, and the performing features of the choral and conducting art of Ohannes Tchekidjian have been revealed.

As part of the study of new and contemporary Armenian art, the creative activity of the architect Hovhannes Kajaznuni ( Sup.: DSc(arch.) L.Dolukhanyan) has been studied, articles and archival documents relating to his professional activities have been introduced into scientific circulation.

### ***Outcomes of applied developments***

Within the scope of the project “Development and publication of educational-methodological literature for Music and Art schools” (Sup.: corr.member A.Aghasyan) the third, concluding volume of the first non-translated, Armenian narrated three-volume teaching manual “Art History: Visual Art” has been published. This volume presents the major trends and schools of the XX century Western visual art, as well as a brief history of Russian and Armenian visual art of the mentioned period.

Within the framework of the basic project “Complex study of the Armenian Art” (Sup.: DSc(arts) A.Asatryan) the study and evaluation of the life, creative legacy, performing, musical and public activity of the prominent Armenian composer Aram Khachaturyan has continued. The results of the studies have been presented at the International scientific conference “Aram Khachaturyan – 120”, which has become an important phase in international Khachaturyan Studies.

Within the scope of implementing interdisciplinary research, the international academic conference “William Saroyan and Art” has been held, for the first time the issue of interrelations between art and literature has been discussed, exemplified by Saroyan's oeuvre. Saroyan's literary legacy has been explored from the perspective of art, and the author's contribution to visual art and music has been assessed.

## INTERNATIONAL SCIENTIFIC-EDUCATIONAL CENTER

### *Major achievements*

In the internationalization process of the Center (ISEC NAS RA) active growth has been noted regarding partner organizations and international mobility. In particular, 17 agreements on international and foreign cooperation, memoranda and contracts with various universities, scientific and other organizations have been signed.

During the cooperation, the Center has placed basic departments in scientific and production organizations and companies represented by Instigate CJSC and Engineering Association NPO. The Department of “Aerospace Engineering” is located in the Engineering City, and the Department of "Computer Science and Autonomous Systems" is located in the "Instigate" Group of Companies.

Observing the current challenges in the field of high technologies and engineering, as well as studying and evaluating the current needs of the labour market, available jobs and opportunities for further development, the Center, together with the Engineering Association, has developed and is implementing a new Master's program “Aerospace Instrumentation”. At present, the fields of space technology and activities are rapidly developing worldwide, providing solutions to national security, disaster prevention, climate change monitoring, rational use of land resources and a number of other issues. The aim of the Master's program “Aerospace Instrumentation” is to train specialists with valuable knowledge in the field of aerospace systems and future technologies, which will further contribute to the development of the target industry in the RA and create jobs for specialists. Master's program “Information Systems Development” is aimed at conducting project-oriented research within the framework of real projects received from the state and companies approved by “Instigate” CJSC. The training is conducted based on an actual project using online materials, and practical work is carried out by conducting research within the framework of the project.

The Center has continued the publication of the scientific periodical "Katchar", included in the list of Armenian scientific periodicals guaranteed by the Science Committee of the RA, as well as the scientific journal “In the World of Science”. In the reporting year, the teaching staff has published one textbook (recommended by the Ministry of Education, Science, Culture and Sports of the RA), 46 scientific articles, 7 of which are published in scientific periodicals included in the databases of “Scopus” and “Web of Science”.

### *Outcomes of applied developments*

Computer classrooms at the Center have been technically equipped with computers, projectors, loudspeakers and interactive screens. Media equipment for the ISEC NAS RA Media Laboratory has been purchased; a film booth has been equipped and opened. ISEC NAS RA has updated the Moodle environment, which is the basis of the distance learning platform (website: <https://vle.sci.am/>) and other system software. ISEC NAS RA has participated in the following Erasmus+ capacity-building programs:

- within the framework of the project “Reforming Doctoral Education in Armenia in Line with Needs of Academia, Industry and Current EU Practices (ARMDOCT)” a visit to Lyon has been organized on French experience and the intra-university rules for organizing joint educational programs of doctoral studies and the third level of higher education have been studied. Together with Eurasia International University, a joint postgraduate educational program has been developed under the common title “Sustainable Development”, as well as the documents necessary for its launch. A cooperation agreement has been signed between the two universities. The media laboratory created within the framework of the project has been launched.

- within the framework of the project “Development of Aquaculture and Fisheries Education for Green Deal in Armenia and Ukraine: from education to ecology (AFISHE)”, a study of similar educational programs has been conducted, a meeting with employers has been organized, educational outcomes and a training program for the joint Master Program “Fishery” has been developed, a project coordination meeting has been held in Nitra, Croatia. The project will create a scientific and educational laboratory and other infrastructures necessary for implementing research-based education. 10 units of computer and laboratory equipment have been purchased for the laboratory that will be created within the project. ISEC NAS RA working group, together with the National

Agrarian University of Armenia, has developed a new master's degree program based on the NAS RA Scientific Center of Zoology and Hydroecology, thereby contributing to research education in the Republic of Armenia. The teaching staff has been selected to work in the joint educational program; work has begun on developing educational materials. Obtaining a license for the joint educational program "Fishery" is underway. Thanks to the AFISHE project, an industry network of aquaculture and fisheries will be created between Armenia, Ukraine and European countries. This project will serve as a platform for joint educational and research activities in aquaculture and fisheries, which will contribute to the development of environmentally sound approaches and activities per the UN Sustainable Development Goals and the EU Green Deal.

In the current year, two professors from the University of Tuscia (Italy) have delivered lectures at the Department of Jurisprudence. The management and teaching staff of the Center paid working visits to Northern Macedonia, Italy, France, Croatia, Poland, Bulgaria, Albania, and the Russian Federation and also participated in training programs, youth forums and conferences in Armenia and abroad. About 20 international and interuniversity agreements and memorandums of cooperation have been signed.

In order to ensure the process of involving the Center in the ranking tables of the best universities, professors from the Diaspora are involved in the educational process.

- In the first semester of the 2023-2024 academic year, Lilit Hovhannisyan, a researcher at the Institute of Biotechnology and Molecular Biology in Gdansk (Poland), will teach the subject "Molecular Microbiology" at the Department of Molecular and Cellular Biology online.

- In the first semester of the 2024-2025 academic year, Hripsime Gevorgyan, researcher and lecturer at Freiberg University of Mining and Technology (Germany), will deliver the subject "Physical Volcanology" online at the Department of Geology.

- In the third semester of the 2023-2025 academic year, Professor Taniel Danielyan from the University of Lille (France) will deliver the subject "Development of professional communication skills" (in English) at the Department of Geology, ISEC NAS RA. Professor Danielyan is Deputy Director of the well-known Evo-Eco-Paleo laboratory in Europe, as well as Director of the IRePSE Institute on Environmental Sciences (Institut de Recherches Pluridisciplinaires en Sciences de l'Environnement).

## **NATIONAL BUREAU OF EXPERTISE SNPO**

### ***Major achievements***

Since 2019 the Organization has been publishing a scientific periodical entitled "Armenian Journal of Forensic Expertise and Criminalistics", in the year under review the 9th and 10th (anniversary) issues of this publication were published.

Work has been carried out aimed at improving the practical activities of forensic experts through innovation in technical solutions and methodological support, in line with modern global scientific achievements. In particular, the Leica RTC360 laser scanning system has been complemented by the Cyclone 3DR software, which has made it possible to carry out construction, technical and environmental expert studies in the field using a laser scanner, in order to obtain scientifically based, reliable values of the volumes of extracted and accumulated rocks. This software also makes it easier to calculate the geometric characteristics of buildings and facilities (building length, width, area, volume, etc.).

The latest generation "Regula" 4307 video spectral comparator with software enabling 3D modeling, automatic comparative search and identification of seals and stamps has been purchased.

Modern ultra-sensitive analytical equipment - liquid chromatograph combined with triple quadrupole mass spectrometer has been put into operation. It has allowed to start production of toxicological studies of biological objects with determination of foreign substances in urine and blood. For the first time in RA, with the help of the developed and implemented modern scientific method, qualitative and quantitative studies of narcotics, psychoactive substances and drugs entering the body from the outside, i.e. in hair, nails, sweat, saliva, have been started.

The theoretical knowledge and practical skills of the Organization's experts for all 28 types of expert examinations carried out by the Organization have continued to improve, enabling more than 16,000 expert examinations to be carried out with scientifically sound results. Experts of the Organization have also participated in conferences, seminars, master classes, proficiency tests and other relevant events organized in 2023 by the working groups of the European Network of Forensic Science Institutes (ENFSI).

The Organization has continued its research aimed at the development and implementation of new methods and techniques in certain areas, work has continued to replenish databases in subject areas. The organization has co-organized 4 foreign international conferences, memorandums of cooperation have been signed with the Republican Center of Forensic Expertise of Uzbekistan (RCFE) and the Institute for Handwriting Sciences (HIS) of Switzerland.

The active participation of leading experts from the Organization in the TOPCOP project, coordinated by the European Police College (CEPOL) and supported by Europol, has continued.

### ***Outcomes of applied developments***

In the accounting period within the framework of the procurement contract for provision of services for the needs of the state, forensic expertise in the quantity of 12931 have been carried out. Within the framework of the criminal procedure legislation the Organization has conducted expert examinations in 28 expert types, including 111 expert subtypes and technological directions. The departments of the Organization in the reporting period on the basis of decisions of courts have taken 156 examinations, within the framework of civil proceedings - 20 examinations, within the framework of administrative proceedings - 1 examination, based on court decisions in cases of bankruptcy - 105 examinations, within the framework of the public procurement agreement "On the provision of services for public needs" with the Prosecutor's Office of the Republic of Armenia, as well as on the basis of contracts concluded with individuals and legal entities within the framework of civil law relations - 167 expertises.

## STATE TARGET PROGRAMS

### **Creating Cloud Computing Environment for the Solution of Scientific and Applied Problems**

*Coordinator V. Sahakyan, cand. (phys.-math.), Institute for Informatics and Automation Problems*

The program aims to address the problems of natural sciences (hydrometeorology, ecology, seismology, biology, and medical genetics) and develop a cloud infrastructure using the possibilities of national research e-infrastructure.

Leading specialists have taken participation in the program from the Institutes for Informatics and Automation Problems, the Institute of Geophysics and Engineering Seismology after A.Nazarov, the Institute for Physiology after L.Orbeli, the Institute of Molecular Biology, the International Scientific and Educational Centre and the Ministry of Environment of RA.

Research has been carried out in the direction of the cloud environment expansion and development of cloud service based on machine learning technologies. In particular, the Kubernetes (k8s) cluster has been expanded, and a set of specialized containers (pods) has been developed for processing Earth remote sensing data in a chosen direction. A scalable platform compatible with cloud High-Performance Computing (HPC) resources and data warehouses has been created. Furthermore, a serverless architecture and a corresponding script package have been designed for executing HPC workloads, and these are available on Github (<https://github.com/imastio/shoc>). Building upon the efforts of previous years, where machine learning methods were employed and a consistent direction was maintained, an assessment of climate change has been conducted on both regional and global scales. The development of a remote sensing image processing and storage system based on open data cubes has continued. Works have been undertaken to improve data compression techniques with the aim of increasing data management efficiency. Following experiments, the Zstandard compression method and the Dask software framework have been selected as the optimal solutions, resulting in a reduction in both the volume of stored data and the time of transmission over the network.

In the field of meteorology the ongoing research encompasses a range of activities, including the analysis of climate and climate change in Armenia and the South Caucasus, the assessment of drought conditions in Armenia using satellite observations and meteorological station data, and the modeling of hazardous weather conditions through the utilization of the Weather Research and Forecasting (WRF) digital weather forecasting model.

In the field of environmental protection, endeavours have been initiated to advance state-of-the-art software for the regulation of atmospheric emissions and to formulate an evaluation methodology for emissions from motor transport.

In the domain of seismology, the development of a seismic system operating within the <2 Hz frequency range has been undertaken. This system is designed to assess the technical condition (vulnerability) of buildings. The electronic subsystem of the recording system, the associated software package, and the overall automatic sourcing system have been successfully crafted. The system is currently undergoing calibration in our laboratory.

In the field of biology, efforts have continued in the computer modelling of complex systems. Specifically, the ongoing work involves modelling the lipid bilayer/transmembrane integrin complex biological system. Resources have been assessed with a focus on energy efficiency. Additionally, by adjusting various parameters of the software package, attempts have been made to optimize the trade-off between speed and energy consumption

In the field of medical genetics, efforts have been directed towards creating an Armenian atlas of cancer genomes and conducting pan-cancer research on the mechanisms of telomere length maintenance.

The results achieved during the implementation of the state target program have been published in 25 articles.

## **Development of Geochemical Maps to Ensure Sustainable Agricultural Development and Food Safety**

*Coordinator L.Sahakyan, cand. (geogr.), director of the Center for Ecological-Noosphere Studies*

Soil survey of a regional scale has been conducted in Lori region. 158 samples have been collected and analyzed to determine the contents of Cr, V, Ti, As, Zn, Cu, Co, Fe, Mn, Ba, Pb, Ca, K and Mo as well as indices of  $\alpha$ - and  $\beta$ - activity. A relevant database has been compiled, the studied indices have been mapped. As a result it has been established that the specificities of spatial distribution of the studied indices are mainly due to geological basement, soil types, and location of ore deposits. Moreover, Cu, Ca, Pb, Ba and Cr play a key role in spatial distribution and geochemical peculiarities of chemical elements under study and formation of geochemical association.

Exceedances of MAC set up by the RA have been established in case of Cr, As, Zn, Cu, Mn, and Pb. Neither mono-elemental nor multi-elemental noncarcinogenic health risks to adults have been identified. Mono-elemental noncarcinogenic risk to children health has been registered in the case of Fe, Pb, Mn, As и Co. The regionwide noncancerogenic risk to children health was mainly due to Fe, Mn, Co and Pb. Exceedance of the allowable level of life-time carcinogenic risk has been identified only in the case of Pb in one sample. In the frames of this target program, electronic geochemical atlases of agricultural soils of all the studied regions have been produced as supporting information when making decisions.

### **Factors of the Armenian gene pool stability**

*Coordinators A.Arakelyan, DSc(biol.), director of the Institute of Molecular Biology, L.Yepiskoposyan, DSc(biol.)*

Within the framework of the project the presence of genetic variants in the Armenian population has been documented, as well as their types and frequency have been determined based on the sequencing data of 30 complete genomes and 50 complete exons.

### **Practical (commercial) grade titanium based alloys synthesis by Hydride Cycle method**

*Coordinator D.Mailyan, cand.(chem.), Institute of Chemical Physics after A.Nalbandyan*

The technological process of synthesis of alloys Ti-23Zr-25Nb,  $\gamma$ - TiAl, Ti<sub>3</sub>Al, TiAl<sub>3</sub> by hydride cycle (HC) method has been studied. The required amount of initial titanium, zirconium and niobium hydrides has been synthesized using the self-propagating high-temperature synthesis (SHS) method. At all stages of the technological process, the characteristics of the initial and final materials have been determined: hydrogen content, phase composition, microstructure, thermal effects. X-ray phase analysis have shown that the phase composition of the Ti-23Zr-25Nb alloy contains two phases -  $\alpha$  (HCP, 194: P6<sub>3</sub>/mmc) and  $\beta$  (BCC, 229: Im-3m). The crystal lattice parameters of the phases have been determined: for  $\alpha$ - phase - a = 0.310451 nm, c = 0.489659 nm, for  $\beta$ - phase - a = 0.331091 nm. The interaction of the synthesized Ti-23Zr-25Nb alloy with hydrogen in the SHS mode has been studied. It has been shown that cylindrical, compact, solid samples without preliminary grinding can interact with hydrogen during SHS process, as a result of which the Ti-23Zr-25Nb alloy absorbs 2.78 wt.% hydrogen. At hydrogen pressure P(H<sub>2</sub>) = 2 MPa, the combustion temperature of the alloy was T = 540°C. Thermal stability and hydrogen hydride desorption of the synthesized alloy have been studied by DTA. It has been shown that hydrogen desorption occurs due to two thermal endo-effects at temperatures of T = 362 °C and T = 855 °C.

The synthesis of aluminides TiAl<sub>3</sub> and Ti<sub>3</sub>Al by HC method proceeds according to the following reaction mechanism:  $x\text{TiH}_2 + (1-x)\text{Al} \rightarrow \text{Ti}_x\text{Al}_{1-x} + \text{H}_2\uparrow$ , where x = 0.25, 0.75. Alloys with a single-phase tetragonal structure TiAl<sub>3</sub> and a single-phase hexagonal structure  $\alpha_2$ - Ti<sub>3</sub>Al have been obtained. As a result of studying the synthesis of Ti-Al alloys, combining mass change curves and differential thermal curves, as well as identifying intermediate and final materials, it has been confirmed that the formation of aluminides synthesized by the HC method occurs through the solid-phase diffusion mechanism.

The above-mentioned technological developments may provide the basis for industrial applications and be of commercial interest.

**Development of radiation-resistant and protective from laser location glassy and composite materials**

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The presented topic has been carried out jointly with the Alikhanyan National Scientific Laboratory. Research has been carried out in the direction of obtaining silicates, various types of glasses and composite materials by high-temperature, hydrothermal methods from RA rocks (perlite, tuff, nepheline syenite, feldspar, diatomite, etc.)

A microwave (MA) method of obtaining cadmium and bismuth silicates has been developed, as well as various glass mixtures based on bismuth silicate.

The physicochemical and optical properties of both silicates and glasses have been studied. In the Alikhanyan National Scientific Laboratory, the radiation stability of the obtained materials has been studied under proton radiation conditions before and after heat treatment; Diffusion reflectance properties have been studied before and after proton irradiation with an intensity of  $10^{14}$  P/cm<sup>2</sup> in the wavelength range from 200 to 1000 nm.

It has been found that elements with a large atomic mass reduce the intensity of radiation more strongly than elements with a light atomic mass. Based on the results of the calculations, the ranges of stable glasses for the processing of applied vitreous and glass-ceramic materials have been highlighted in the systems.

**The main directions of the comparative study of the Armenians in their own and other national environment: challenges and prospects of the research**

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Important results have been recorded within the project "The Main Directions of Comparative Research of the Armenians in Their Own and Foreign Environment: Problems and Perspectives of the Study". This project has been realized through the state targeted-program funded by the Scientific Committee of RA (2021-2025). The institute's research group cooperates with scientific centers of 13 countries (Russia, Belarus, Kyrgyzstan, Lebanon, Kuwait, Great Britain, Germany, France, Portugal, Belgium, Czech Republic, Ukraine, USA) on relevant issues. As a result of the research, it has become possible to create a theoretical and comparative background for interpretations on integration of Armenian communities. Based on the analysis of the materials obtained, expert proposals have been made to various departments of RA. As a result of this research a collection of articles in English has been published in Prague.