

# HIGHLIGHTS



# WELCOME

Dear Colleagues!

I am glad to present to your attention the catalog of major scientific achievements of Southern Federal University "Highlights" which includes the most cited articles of the university scientists, published in high-impact journals.

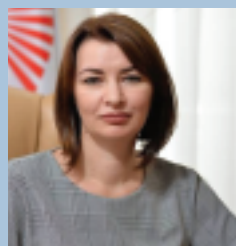
Peer reviews of these publications show that SFedU research is in line with the current trends in world science. The catalog provides a general overview of the main scientific results of Southern Federal

University research activities, achieved over a certain period of time. It also sets strategic guidelines for

further research. It is worth noting that in the total amount of SFedU fundamental and applied research the proportion of the innovation component has been increased, joint interdisciplinary research projects have been implemented in collaboration with colleagues from other universities, and new efficient technologies have been created.

It is my pleasure to invite you to participate in the implementation of joint projects and initiatives.

I hope that the presented abstracts will help to create communication platforms for effective interaction and further development of issues under consideration.



**Inna Shevchenko**  
Rector ad interim



Southern Federal University is the largest scientific, academic and innovation center in the south of Russia.

During its century-long history the University has successfully employed highly - qualified and talented professionals, leading scientists in the different fields and has succeeded in developing the-state-of-the art innovation infrastructure. Innovation activities of the University are focused on establishing partnerships with business and industry and introducing innovative technologies in the high-tech industries.

The Southern Federal University develops projects which have a strong social impact and make contribution to national and regional economic growth.

The University has successfully implemented research and education projects under the program of innovative development of state - owned corporations, has become a reference company in the development of innovation and technology cluster "Yuzhnoye Sozvezdiye", has created a small innovation zone, which includes more than 80 small enterprises, and has become a member of the national technological platforms.

**6** integrated scientific inquires

**36** intellectual fields

**74** research areas

**64** scientific schools

**300** more than 300 joint projects with world class universities

**879** publications in international collaborations

## RESEARCH AREAS



Nanomaterials, nanotechnologies, facilities and systems based on them, intellectual materials;



Marine, aviation and spacerocket equipment, radio engineering, automation and control;



Biotechnologies, living systems technologies, ecological security, the medicine of the future;



Information and telecommunication technologies, facilities and systems;



Architectural and art work, design, restoration, modernizing and creating objects of urban development, architecture, design and art;



Humanitarian technologies and models for developing human capital and tolerant socio-economic communities in a polyethnic region of Russia.

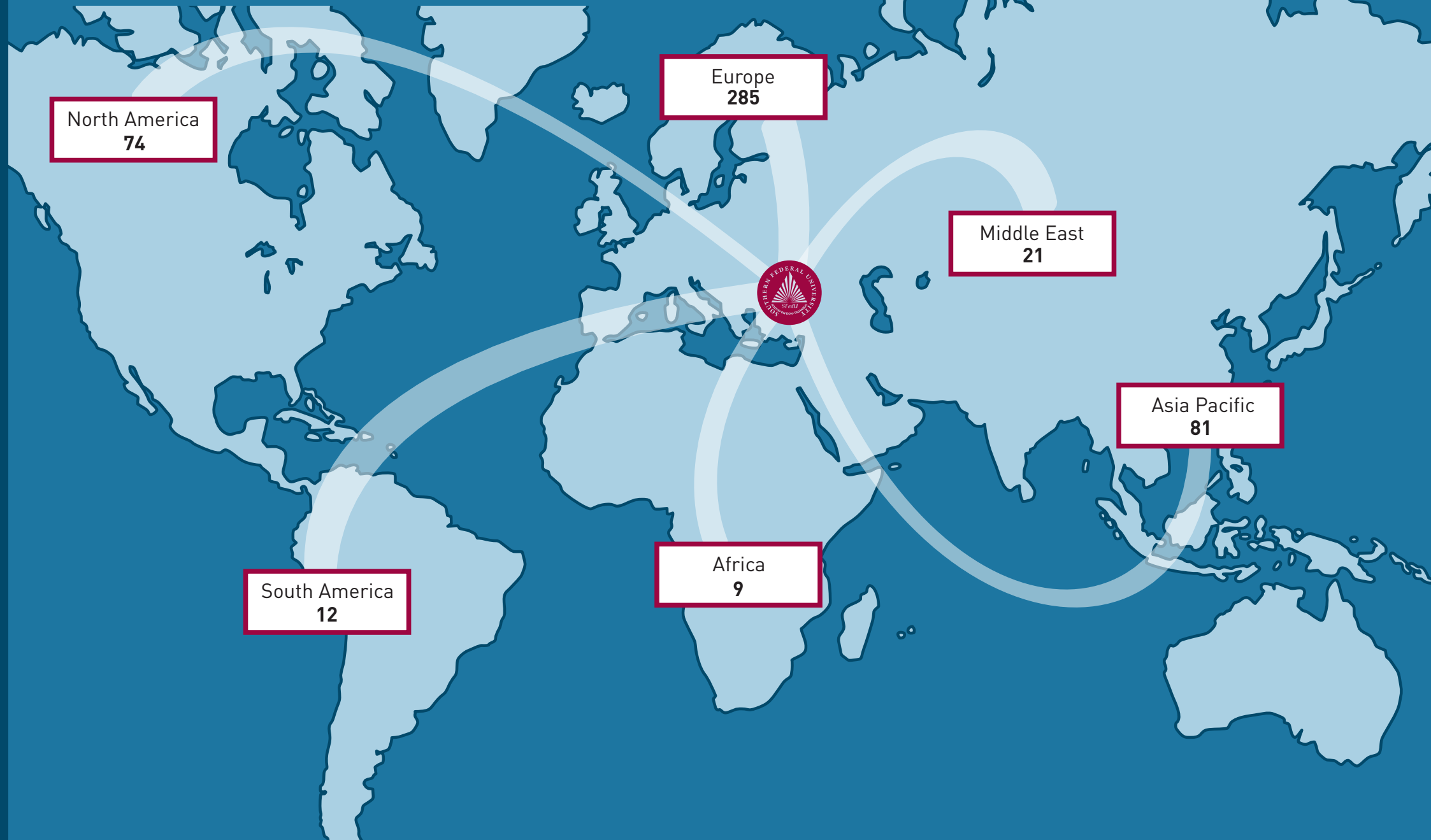


## R&D COLLABORATION

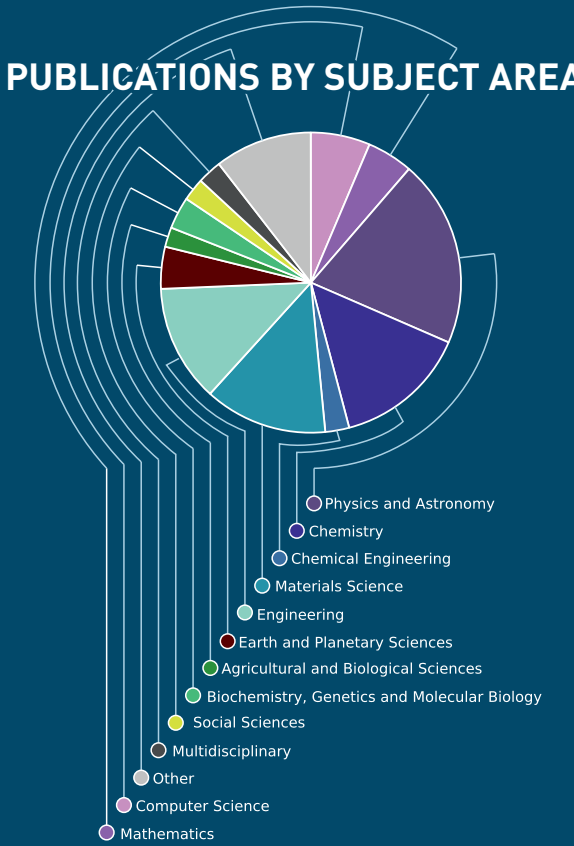
482 foreign partners

1276 publications co-authored with international partners (2010-2015)

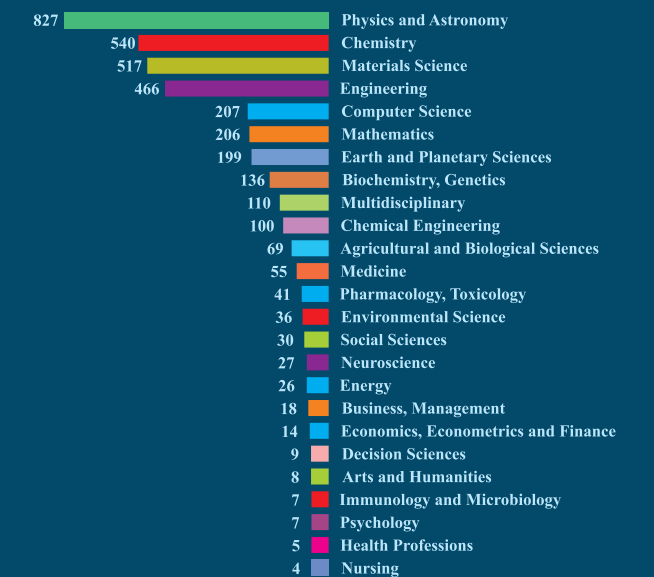
21 international group projects



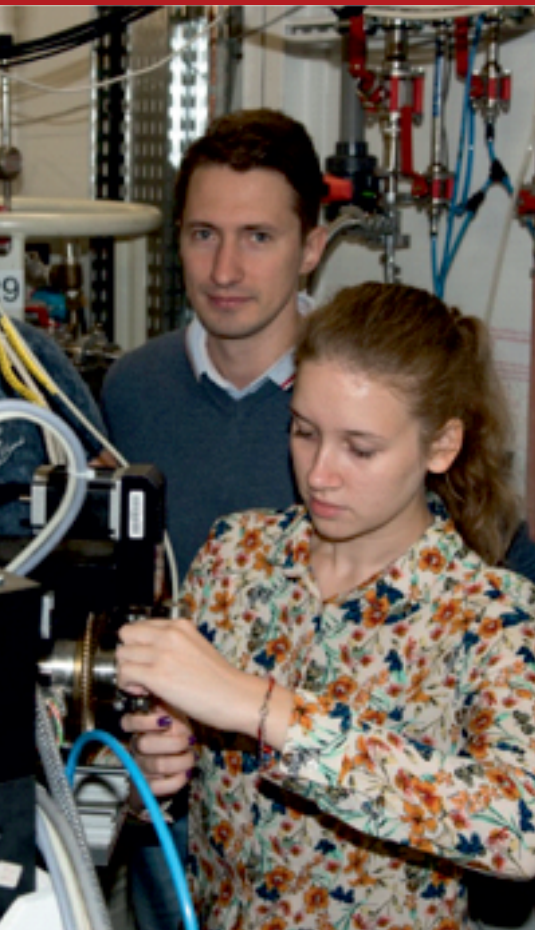
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## SFedU PUBLICATION ACTIVITY (according to Scopus database)

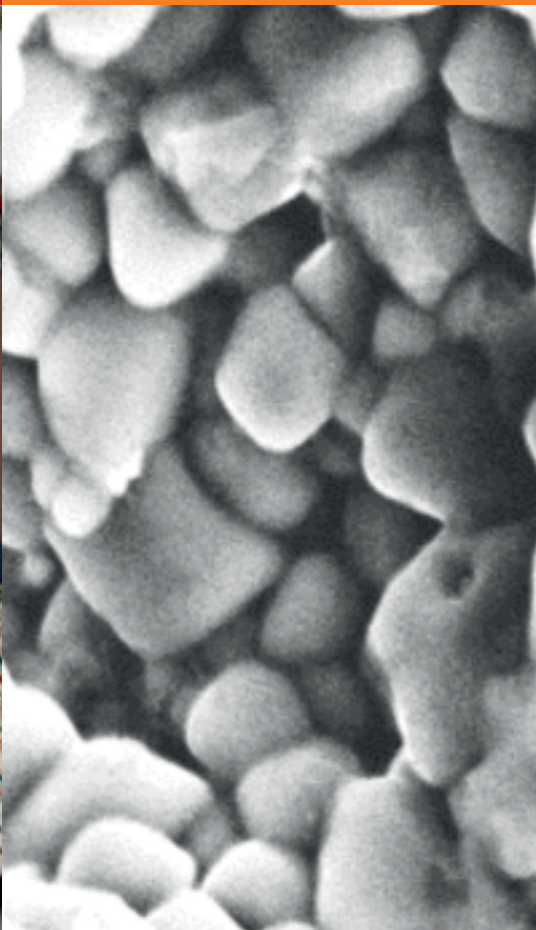


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NANOPARTICLES  
FOR THERANOSTICS  
IN ONCOLOGY  
AND ADVANCED  
NANO-IMAGING  
TECHNIQUES  
USING MEGA-  
SCALE FACILITIES**



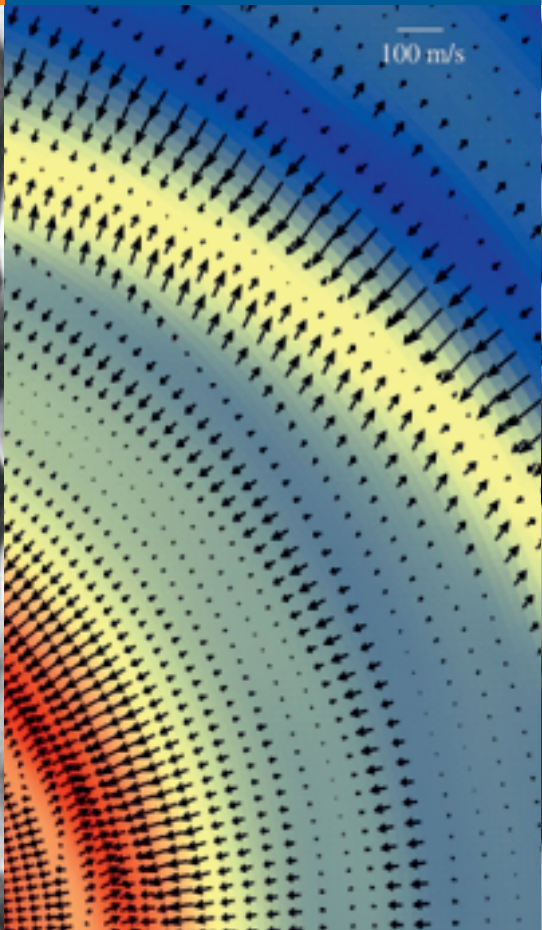
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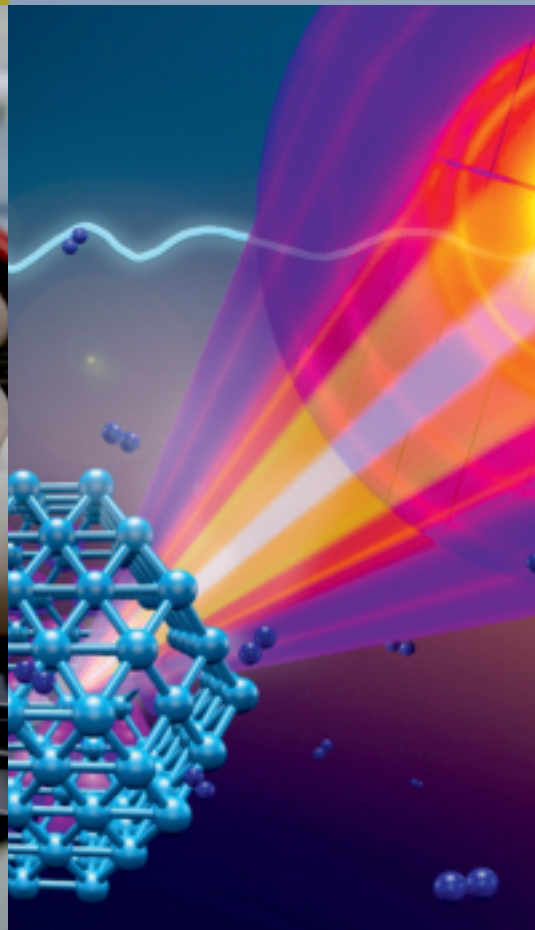
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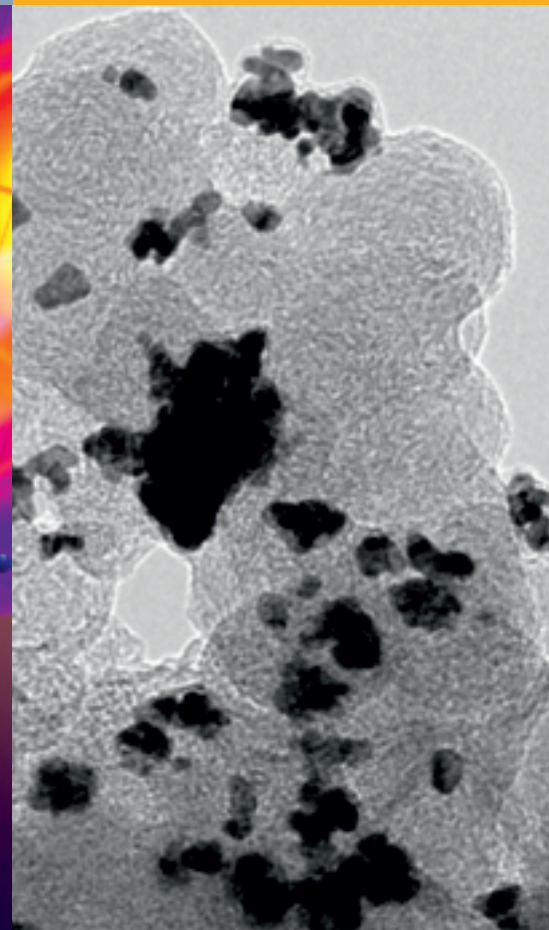
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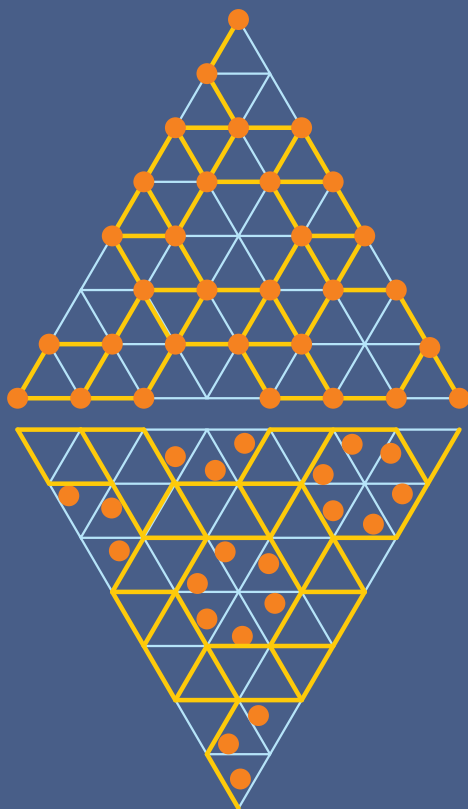
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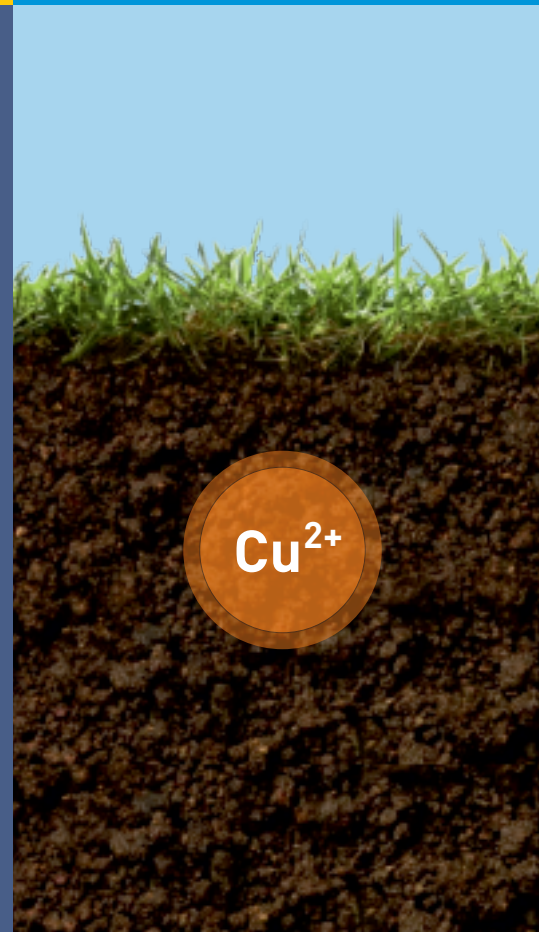
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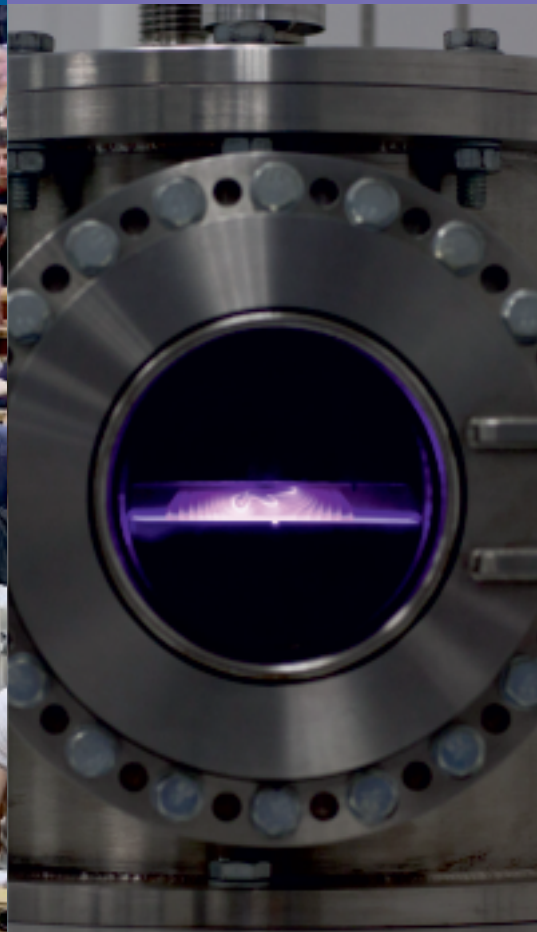
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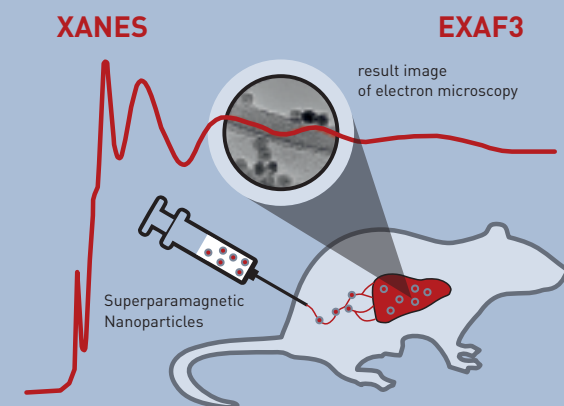




# SUPERPARAMAGNETIC NANOPARTICLES FOR THERANOSTICS IN ONCOLOGY AND ADVANCED NANO-IMAGING TECHNIQUES USING MEGA-SCALE FACILITIES

A.V. Soldatov

We developed the methods of synthesis for several classes of colloidal superparamagnetic nanoparticles in aqueous and organic media. Their physical and chemical characteristics have been studied and a comparative assessment of their toxicity has been investigated. The prospects for their use in theranostics (simultaneous therapy and diagnosis) of oncological diseases have been examined. A unique complex of non-destructive methods for studying the parameters of the local atomic, electronic, and magnetic structures of these nanoparticles with high spatial resolution using mega-scale research facilities (European synchrotron radiation facility) was used to analyze in details the interaction of these nanoparticles with tumor tissues.



Morbidity and mortality in malignant neoplasms is one of the most pressing problems both in Russia and abroad. One of the promising high-tech vectors is the use of colloidal superparamagnetic nanoparticles for targeted delivery of therapeutic agents, local magnetic hyperthermia and simultaneous therapy and diagnostics of oncological diseases - theranostics. The relevance of the study of superparamagnetic iron oxide colloidal nanoparticles (SPIONs) for theranostics is confirmed by the exponential growth of the number of scientific publications on the study of SPIONs for nano-bio-medical applications. In the course of the project, in

addition to Fe<sub>3</sub>O<sub>4</sub> nanoparticles, an investigation of gamma-Fe<sub>2</sub>O<sub>3</sub> nanoparticles was made as well. It was found that small nanoparticles are more prone to oxidation, which leads to the formation of the  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub> phase in small nanoparticles.

One of the main objectives of this project was the development and application of an advanced methodology (combining both experimental studies and theoretical supercomputer simulations) to study the characteristics of the local atomic and electronic structures of SPIONs for magnetic hyperthermia, to establish the relationship between the physical and chemical properties of these magnetic nanoparticles with their hyperthermal characteristics and the possibility of using these SPIONs for local magnetic hyperthermia. The development of this field will allow improving the method of local magnetic hyperthermia and will lead to the appearance of more accessible methods of theranostics in oncology, the development of personalized medicine and high-tech public health. The developed method allows us to separate two phases of SPIONs, (Fe<sub>3</sub>O<sub>4</sub> and  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub>) which cannot be distinguished by standard methods. Due to their biocompatibility the developed SPIONs are promising materials for the purpose of theranostics in oncology. It was shown that spherical colloidal SPIONs with an average size of about 20 nm and a narrow size distribution are one of the most effective for biomedical applications in oncology.

The results obtained in the course of the project create a basis for the development of novel promising biocompatible magnetic nanoparticles and allow us to evaluate the possibilities of their use for local magnetic hyperthermia of tumor tissues. The experience gained during the implementation of the project allows research organizations in the field of nano-bio-medical technology to provide a new and effective method for nano-characterization of colloidal magnetic nanomaterials for theranostics in oncology.



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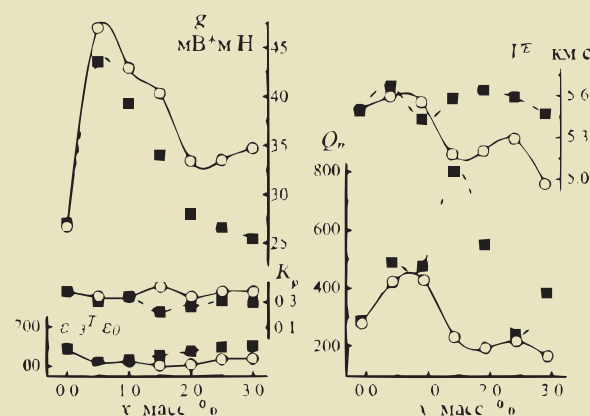
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Lastovina, T.A., Budnik, A.P., Polyakov, V.A., Soldatov, A.V. Magnetic structural properties of maghemite nanoparticles obtained with the use of different stabilizers, *Journal of Structural Chemistry*, 2017, V. 58, pp 1391–1396. DOI: 10.1134/S0022476617070162

## FROM INTELLIGENT MATERIALS AND ENVIRONMENTALLY FRIENDLY TECHNOLOGIES – TO HIGHLY SENSITIVE MICROWAVE TECHNOLOGY, ULTRAHIGH-TEMPERATURE DEFECTOSCOPY

S. Prosandeev, I. P. Raevski, S. I. Raevskaya, A. Malashevich, H. Chen, L. Bellaiche

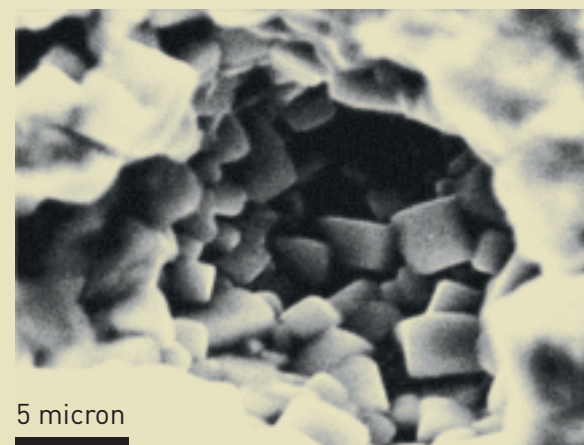
There have been developed composite ferroelectric (magnetic) active materials which do not contain toxic elements, based on the modified (over - and stoichiometrically simple and combined dopants, including rare earth ones) metaniobates alkali/alkaline earth metal, bismuth ferrite and serial ecologically safe technologies of their development with target parameters (low dielectric permittivity, high piezosensitivity, mechanical Q-factor, piezo anisotropy) for microwave applications, defectoscopy, storage devices; for processing and transmission of large amounts of data information.

There has been performed stepwise optimization of the structure formation of alkali/alkaline earth metals niobates and of bismuth ferrite, and within the framework of affordable industrial technology there have been made undoped, high density, and non-compromising the integrity and effects of desquamation samples, the composition of which corresponds to formulas  $(1-x) \text{Na}_{0.54}\text{K}_{0.46}(\text{Nb}_{0.9}\text{Ta}_{0.1})\text{O}_3 - x\text{LiSbO}_3$  ( $x = 0.02-0.06$ ), modified (super- and stoichiometrically) by simple ( $\text{MnO}_2$ ,  $\text{CuO}$ ,  $\text{NiO}$ ), combined ( $\text{MnO}_2+\text{NiO}$ ,  $\text{Bi}_2\text{O}_3+ \text{Fe}_2\text{O}_3$ ) and other oxides, and  $\text{BiFeO}_3/\text{REE}$ ,  $\text{Sr}_2(\text{Ca}_2)\text{Nb}_2\text{O}_7$ , with additives.



There has been defined the change of the kinetics of phase formation and the nature of recrystallization processes (from the solid phase to the liquid phase) with the introduction of some dopants, which is associated with the formation of low-melting eutectic, a manifestation of Hedvalla, the development of crystal-chemical disorder and anion-deficiency. The transformation of the phase pattern upon the introduction of  $\text{NiO}$  is explained by the high stereochemical activity and the emissivity of  $\text{NiO}$  (II). The growth of the mechanical Q-factor and piezosensitivity against the background of a decrease in the dielectric permittivity, losses, and electrical conductivity in modified ceramics is due to the formation of anion-deficient anion-redundant environments of increased ferririgidity.

Simultaneous formation of "hard" and soft ferroic properties during doping with Mn and Cu oxides is associated, on the one hand, with the enhancement of the covalence of Mn-O and Cu-O bonds, the formation of anion vacancies, the formation of a finely grained structure (Fig. b) and, on the other hand, with a decrease in the homogeneous strain parameter.



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Abubakarov A.G., Pavelko A.A., Sadykov H.A., Verbenko I.A., Shilkina L.A., Konstantinov G.M., Shevtsova S.I., Dudkina S.I., Andryushina I.N., Reznichenko L.A. Influence of  $\text{CuO}$ ,  $\text{MnO}_2$ ,  $\text{NiO}$ ,  $\text{Bi}_2\text{O}_3$ , and  $\text{Fe}_2\text{O}_3$  modifiers on the crystalline structure and electrophysical properties of  $(\text{Na}, \text{Li}) \text{NbO}_3$  solid solutions // *J. Materials Science*. 2017. V. 52. No. 4. P. 2142-2157.

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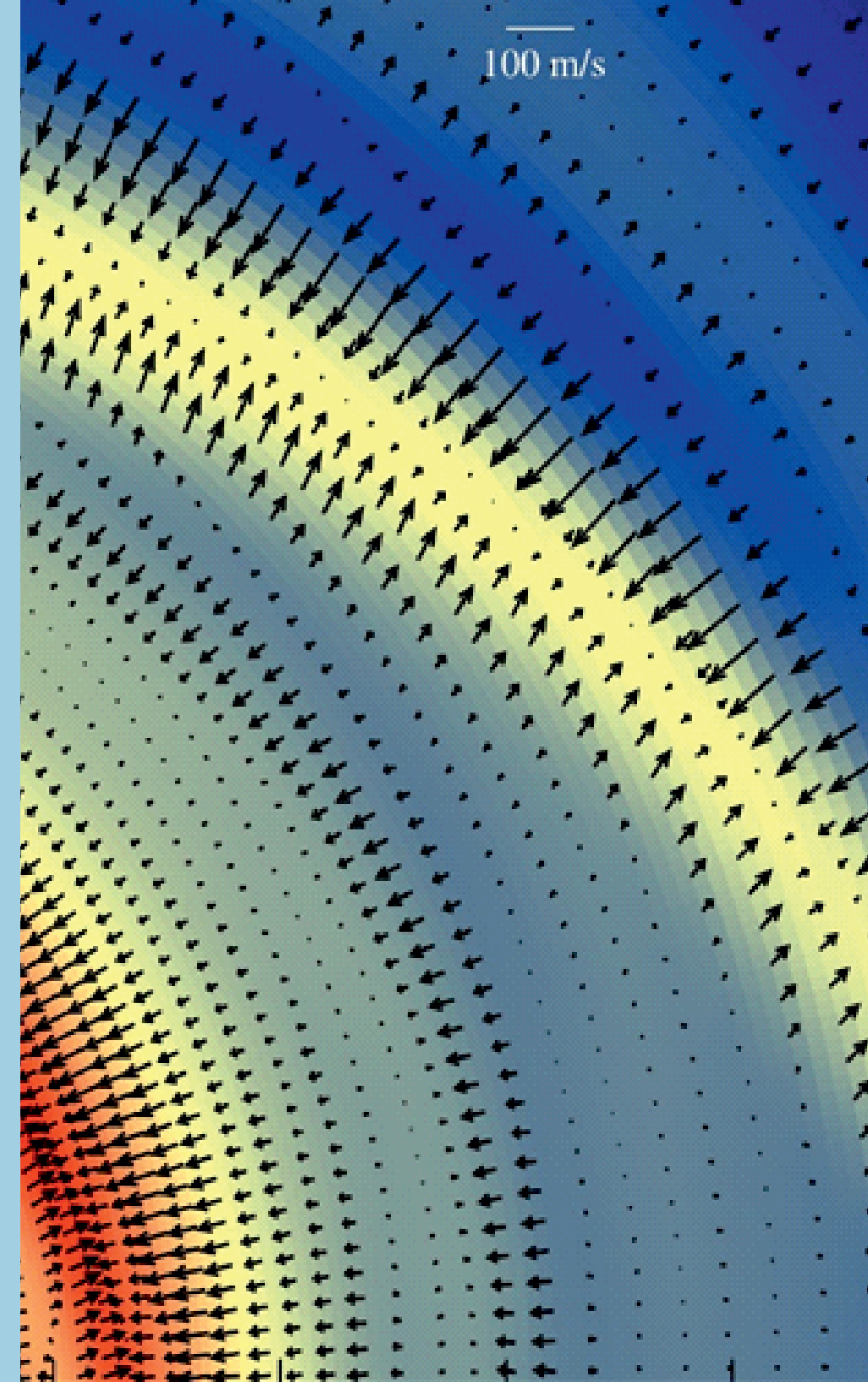
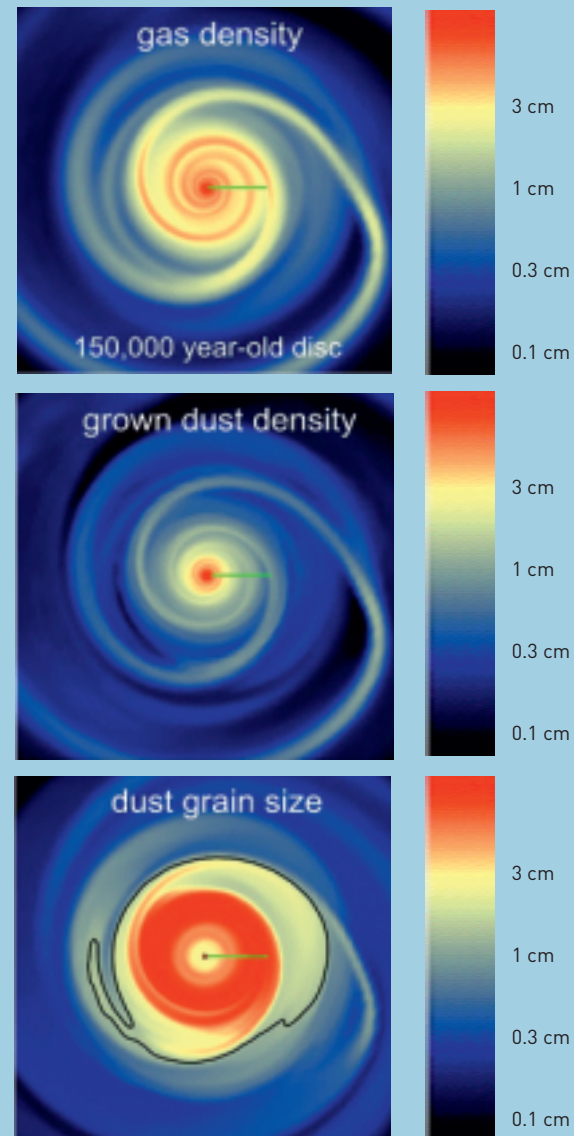


## WHEN DO PLANETS STAR FORMING?

E. I. Vorobyov

The quest for our origins inevitably leads to the question of how and when planets come into existence. We know that planets form in circumstellar disks of gas and dust owing to dust growth from sub-micron particles to kilometer-sized planetesimals. The lifetime of circumstellar disks, a few million years, is rather short by cosmic scales. Therefore, it is important that the planet formation process starts as early as possible. Until recently, it was thought that dust growth commences in relatively advanced stages of disk evolution – in so-called protoplanetary disks with a typical age of one million years. However, the recent spectacular images of HL Tau, a star with a much younger circumstellar disk, has revealed the presence of disk features, such as rings and gaps, that are typical of advanced stages of dust growth. These disk features imply that the process of planet formation is coeval with the process of disk and star formation.

Numerical hydrodynamics modeling performed at the Research Institute of Physics, Southern Federal University, has confirmed the recent observational findings and demonstrated that micron-sized dust can grow to meter-sized boulders via collisional sticking at the very early stages of disk evolution known as the protostellar stage. The net mass of boulders can reach as much as hundreds of Earth masses in 100-thousand-years old disks. The boulders drift towards the star, which alleviates the process of planet formation in the inner regions of circumstellar disks. The boulders can also accumulate in the spiral density waves, which traverse through the disk, thus making planet formation possible through the bulk of the circumstellar disk. The results of this study will be published in the peer-reviewed journal "Astronomy & Astrophysics".



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Vorobyov E.I., Akimkin V., Stoyanovskaya O., Pavlyuchenkov Y., Liu H. B. The early evolution of viscous and self-gravitating circumstellar disks with a dust component. // *Astronomy & Astrophysics*, Forthcoming article. Received: 01 August 2017 / Accepted: 18 January 2018.

## PROBIOTIC TECHNOLOGIES FOR INDUSTRIAL POULTRY FARMING

V.A. Chistyakov, M.L. Chikindas, A.V. Usatov, I.V. Gorlov, Z.V. Komarova, M.A. Mazanko  
E.V. Prazdnova, M.S. Makarenko, Y.V. Denisenko

Probiotic spore-forming bacteria of the *Bacillus* genus are able to release into the culture medium substances with antioxidant and DNA-protective activity. Three preparations of such microorganisms, produced according to the solid-phase technology developed in SFedU are tested in conditions of industrial poultry farming. The effects of stimulation of egg production of Highsex brown hens have been recorded, as well as the slowing down of reproductive aging.

For the experiment, 8 groups of day-old chicks of the parent herd of the cross "Highsex brown" (hatching August 25, 2016) were formed: 4 groups of hens 70 heads each and 4 groups of roosters with 7 heads each. Groups were formed as follows: control, I, II and III - experimental. The control group receives a standard diet, the preparations of probiotic strains are introduced into the experimental group diet (group I based on the *Bacillus subtilis* strain KATMIRA 1933, group II on the basis of the strain *Bacillus amyloliquefaciens* B-1895 and group III on the basis of *Bacillus subtilis* KATMIRA1933 and *Bacillus amyloliquefaciens* B-1895). Doses of administration of probiotic supplements containing not less than 109 CFU/g of viable spores amounted to 0.1% of the diet.

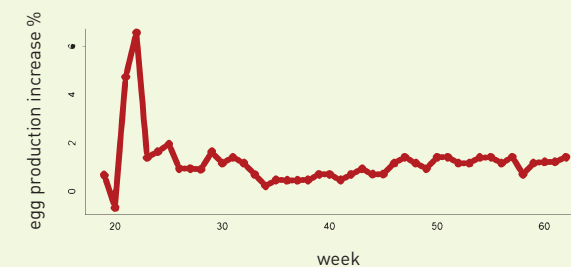
In the first 100 days of the experiment, it was already noted that the introduction of drugs in the diet leads to an increase in the live weight of birds and a decrease in the conversion rate of feed. Further studies showed that the drugs used demonstrate a stimulating effect and egg production. The productivity of chickens throughout all the experimental period (19-62 weeks) was high and corresponded to the breed standard, however in experimental groups the egg rate of laying hens exceeded the control. The results of the most effective of the tested drugs are shown in the figure. The registered effect of stimulation was statistically significant (Wilcoxon test,  $p = 6.3 \times 10^{-9}$ ). It was also found that not only the egg production is stimulated in the high-intensity periods typical for Highsex brown, but also the

extension of this period. Thus, the effect of slowing the reproductive aging of chickens was revealed.

Parameters of quality of eggs obtained from hens from experimental groups were higher or did not differ from those for control. The results of egg laying in the incubator showed the best result in the 1st test group, where the chick's output exceeded the control by 2 - 3%. A higher incidence of chicks in experimental groups was obtained by increasing the fertilization of eggs and reducing the number of embryo deaths during the first 7 days of incubation, as well as by increasing the fertilizing capacity of the sperm. The breeding roosters of the experimental groups exceeded the control birds by the volume of the ejaculate, the concentration of spermatozoa in the ejaculate and the total number of spermatozoa in the ejaculate. The number of morphologically abnormal cells in the ejaculate of the roosters of the experimental groups decreased.

Analysis of DNA stability parameters of control and test groups showed that the mitochondrial DNA of the latter has a statistically significantly lower number of lesions. Apparently, this phenomenon is the fundamental basis of the observed physiological effects.

In conclusion, we have to note that the results obtained create prerequisites for the widespread introduction of elements of "organic" poultry farming into industrial practice. At the same time, high indicators of economic efficiency can be achieved without unnecessary "chemicalization" of production.



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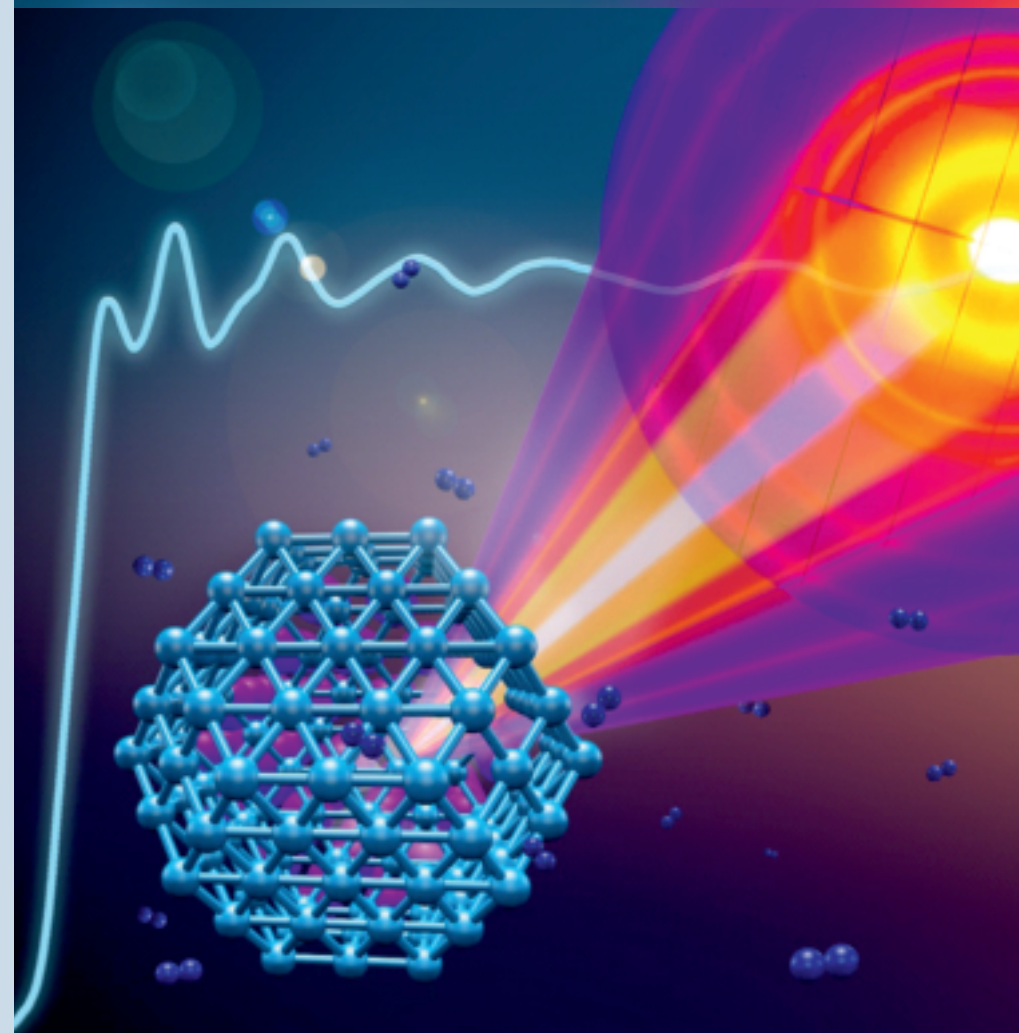
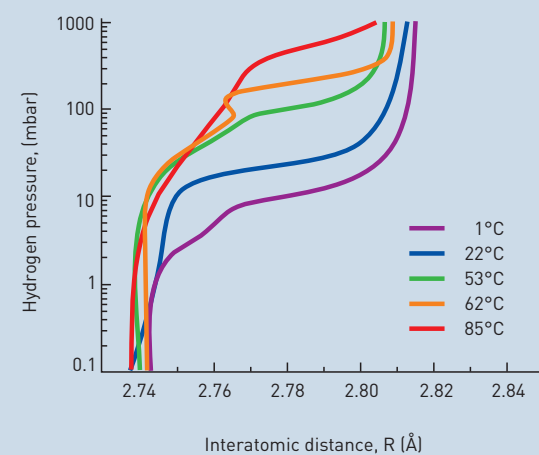
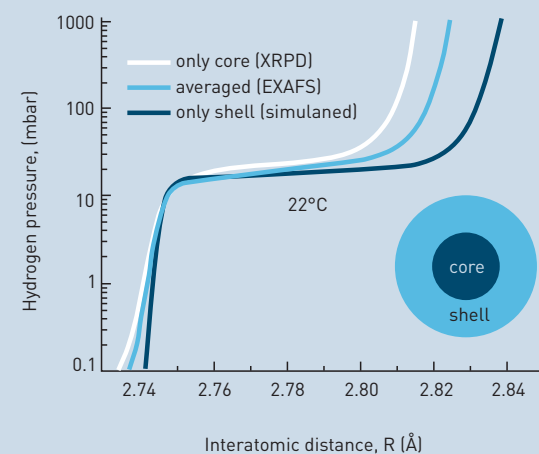
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# CORE-SHELL STRUCTURE OF PALLADIUM HYDRIDE NANOPARTICLES: FIRST EXPERIMENTAL EVIDENCE

Aram L. Bugaev, Alexander A. Guda, Kirill A. Lomachenko, Alexander V. Soldatov, Vladimir P. Dmitriev, Jeroen A. van Bokhoven, Carlo Lamberti

Palladium nanoparticles are used in the industrial scale in a number of important catalytic reactions in the petrochemical industry. Investigation of palladium hydride phase is a key topic in many experimental and theoretical works. Researchers of the Smart Materials Center of SFedU in collaboration with University of Turin, ETH Zurich, Chimet S.p.A. and European Synchrotron Radiation Facility have performed an advanced experimental investigation applying synchrotron-based techniques to provide the first evidence of the core-shell structure of palladium hydride nanoparticles. Such structures have been predicted before by theoretical simulation, however, no direct experimental proof has been presented so far. This research work combined modern experimental techniques with advanced theoretical modeling of X-ray absorption and X-ray diffraction data. The obtained results have been published in *The Journal of Physical Chemistry C* and were promoted at the Journal Cover (volume 121, issue 33).



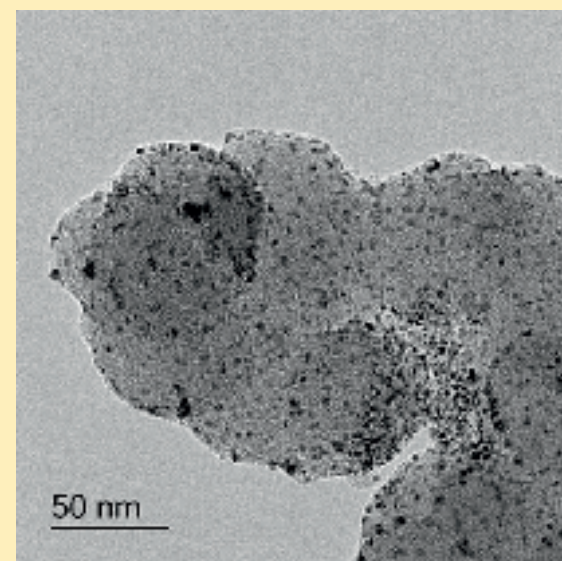
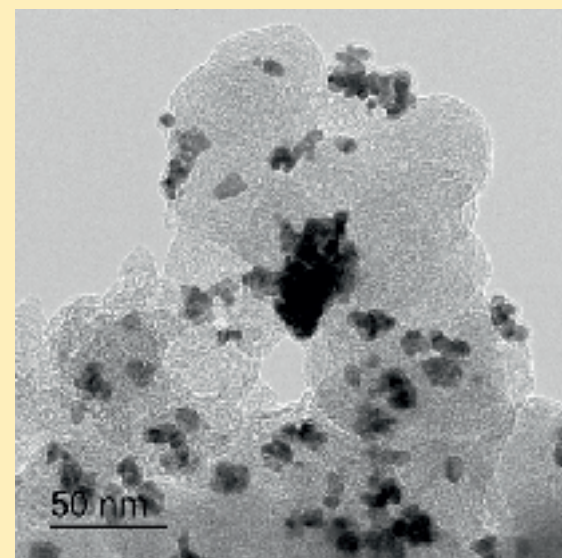
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Which was promoted at the cover of the 33rd issue (2017) of *The Journal of Physical Chemistry C*.

# MANAGEMENT BY NUCLEATION & GROWTH OF PLATINUM NANOPARTICLES IN THE PROCESS OF THEIR LIQUID PHASE SYNTHESIS

A.A. Alekseenko, V.E. Guterman, N.Y. Tabachkova, O.I. Safronenko

Low-temperature fuel cells with a polymer membrane (LTFC) are ecological and universal systems that convert the energy of the chemical reaction directly into electrical energy. The need for such devices is growing every year, and the scope of their application is rapidly expanding. One of the key components of the LTFC is catalytically active materials, from which porous catalytic layers are formed on both sides of the polymer membrane. It is in these layers that electrochemical reactions occur that "produce" electric current. Precious platinum or some of its alloys demonstrate greatest catalytic activity among all known materials. The desire to save the precious metal in combination with the need to increase the platinum surface area in the electrode layers led the researchers to obtain nanostructured supported catalysts consisting of platinum nanocrystals anchored to the surface of the carrier material particles, typically carbon materials (soot, nanotubes, nanofibers, graphene, etc.). The smaller the size of such nanoparticles, the greater the surface area which corresponds to one and the same amount (mass) of platinum in the electrocatalyst. At the same time, infinitely decreasing the size of nanoparticles is meaningless, since in this case platinum begins to lose its catalytic activity. Thus, researchers came to the idea of the existence of an optimal size of nanoparticles, which provides sufficiently high catalytic activity and platinum surface area simultaneously. It was also found that nanocrystals of different shapes, faceted by different types of facets, may have different activity in the electrochemical reactions taking place in the LTFC.



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# MASS EXTINCTION OF THE EARTH BIOTA 240 MILLION OF YEARS AGO

Dmitry A. Ruban

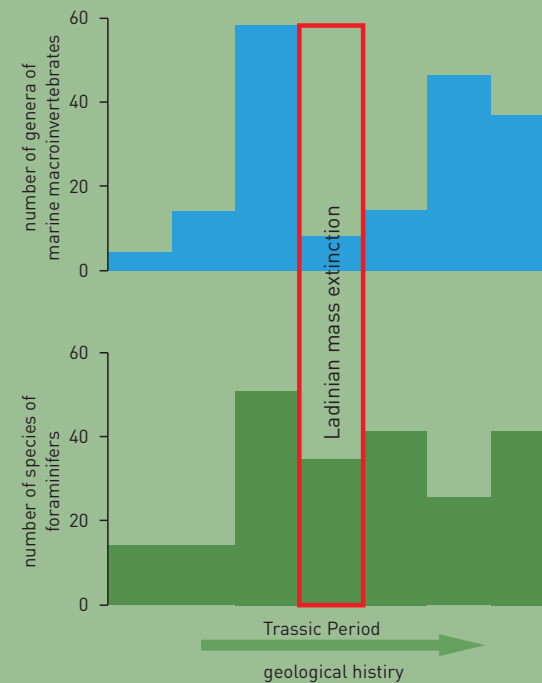
Global synthesis of palaeontological data allowed D.A. Ruban to formulate idea of a new mass extinction of the Earth's biota. This catastrophe occurred about 240 million of years ago. Importantly, the evidence of this event is found in the southwest of Russia. The results of this project have been published in the world best journal in geology (according to SCImago).

Mass extinctions were terrible catastrophes in the history of Life. Geologists and palaeontologists have been studied them for decades. The most famous mass extinctions occurred in the end of the Permian Period (245 million of years ago) when up to 90% of living creatures went extinct because of voluminous volcanic eruptions and in the end of the Cretaceous Period (65 million of years ago) when dinosaurs on the land and ammonites in the sea disappeared forever. There were also some other events of the same kind in the geological history. Studying them has remained one of the "hot" research topic for the contemporary geologists and palaeontologists. But how complete is our knowledge? May be there were other biotic catastrophes that specialists "missed" in their research? The new investigation of D.A. Ruban has permitted to give positive answer to this question.

The Ladinian is the second stage of the Middle Triassic epoch. This stage took place about 240 million of years ago. Available reconstructions of the diversity dynamics of fossil organisms across the entire Triassic allow to propose the Ladinian biotic crisis. Focus on particular groups of fossil organisms provides more intriguing information. In fact, the global number of genera of ammonoids, brachiopods, and tetrapods declined significantly (by 1.1–2.5 times) during the Ladinian, as did the number of species of conodonts. The origination rate of bivalves also decreased during the Ladinian. The only land plants were apparently unaffected. In the southwest of Russia, representative outcrops of Triassic rocks can be found. Palaeontological data from them

imply significant decline in fossil diversity in the Ladinian.

This article shows that the Ladinian biotic evolution deserves closer attention by specialists in mass extinctions. Further research should be aimed at high-precision diversity reconstructions and incorporating/integrating more palaeontological data for more fossil groups from additional regions. Achieving these tasks will require collection of new detailed paleontological and geological data.



The influence of the Ladinian mass extinction on various groups of fossil organisms and the possible mechanisms of this event.

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Ruban D.A. 2017. Examining the Ladinian crisis in light of the current knowledge of the Triassic biodiversity changes. *Gondwana Research*, 48, 285-291.

WoS, Scopus, IF[2016]=6,959,  
SJR[2016]=4.227, Q1  
№ 1 journal for Geology (SCImago)

## WHY DO SYRINGE-LIKE NANOMACHINES WORK EFFICIENTLY?

S. B. Rochal, D. S. Rochal

We have shown that when a syringe-like nanomachine is triggered, contraction and twisting of the outer sheath occurs in such a way that it again becomes commensurate with the inner tube. The commensurability found is biologically expedient, since it significantly reduces the energy of interaction between protein nanotubes, and the corresponding energy gain increases the torque of the inner tube and the efficiency of the nanomachine.

Cells of living organisms widely use biological nanomachines: complex or simple systems with size less than ten millionth of a meter. Nanomachines are also used by viruses, which are the form of life that are unable to breed outside the host cell, into which they need to somehow penetrate. Millions of years of evolution led to the emergence of special structures that help a virus to put its genetic material (DNA or RNA) inside the infected cells. The most successful were syringe-shaped devices consisting of two protein tubes: one is inserted into another. With the contraction of the outer cylinder, the inner one pierces the membrane, and information molecules are injected into the cell.

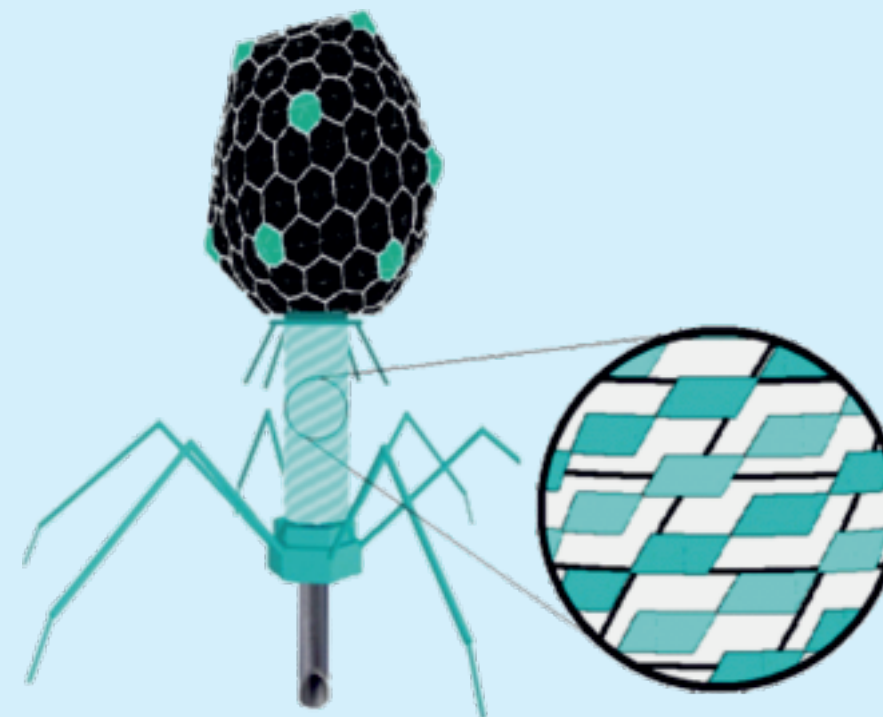
Although in general this mechanism has been known for several decades, relatively accurate data on the structure of two such systems: the bacteriophage T4 (virus, which attack bacteria) and the protein pyocin R2 (the main "weapon" of the *Pseudomonas aeruginosa*) have only been obtained in the last couple of years. Bacteriophage T4 uses a syringe nanomachine to inject viral DNA into its prey. The R-type pyocin proteins, on the contrary, do not inject any substance into the cell, but destroy it, making a "hole" in the shell and disrupting the electrochemical equilibrium. We have constructed a simple model based on the example of bacteriophage T4 and pyocin R2, which explains the structural and operational features of syringe nanomachines.

Two tubular organelles of nanomachines: hollow "sword" and its cover work together harmoniously,

ensuring successful penetration into the cell. After the contact with the victim's membrane surface, the outer tube, formed by slightly twisted spirals, undergoes restructuring - it contracts and shortens. At the same time, a hard "sword" hidden under the outer tube starts to play its significant role: it is exposed and pierces the cell membrane. The structural transformation associated with this mechanism preserves a certain relation (which is called commensurability) between the symmetries of the inner and contracted outer tubes. For the first time this relation was found in our article [1].

Any work requires energy, and all systems can operate only using their internal "savings", which cannot be completely spent. This principle is also true for a syringe nanomachine. The extended state of the sheath has the greatest internal energy. The hidden inside "sword" affects the geometry of the contraction process, causing the system to move to the state with minimal energy and to do a great work. We have found a beautiful and simple principle [1] according to which the parameters of the outer tube (distance between protein rings and angular shift between them) are changed when the nanomachine operates. The appearance of commensurability reduces both the energy of interaction of the "sword" and sheath and the internal energy of the system. The obtained gain allows "sword" to increase force piercing the cell membrane, making the nanomachine work more efficient.

Investigation of the structure and functioning principles of the syringe nanomachine used by bacteriophages is important for antibiotic therapy, especially in the case when harmful microorganisms are resistant to traditional antibiotics. In addition, bacteriophages are the promising vector (nanocontainer) to transfer DNA sites in genetic engineering. We believe that discovered by us structural phenomenon of molecular nanomachines can be observed in other similar, but still poorly studied nanoobjects.



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## SYMMETRIES, WHICH ARE HIDDEN IN VIRAL SHELLS

S. B. Rochal, O. V. Konevtsova

Static and dynamic symmetries of various viral shells (capsids) were investigated. It is shown that in many capsids these symmetries are not reduced to the conventional point one, but in addition include the essential hidden components. It is explained by the fact that viral shells self-assemble from identical proteins, which tend to form equivalent environments in the resulting assemblies. Understanding the structural peculiarities of the viral shells can help in the creation of effective antiviral strategies.

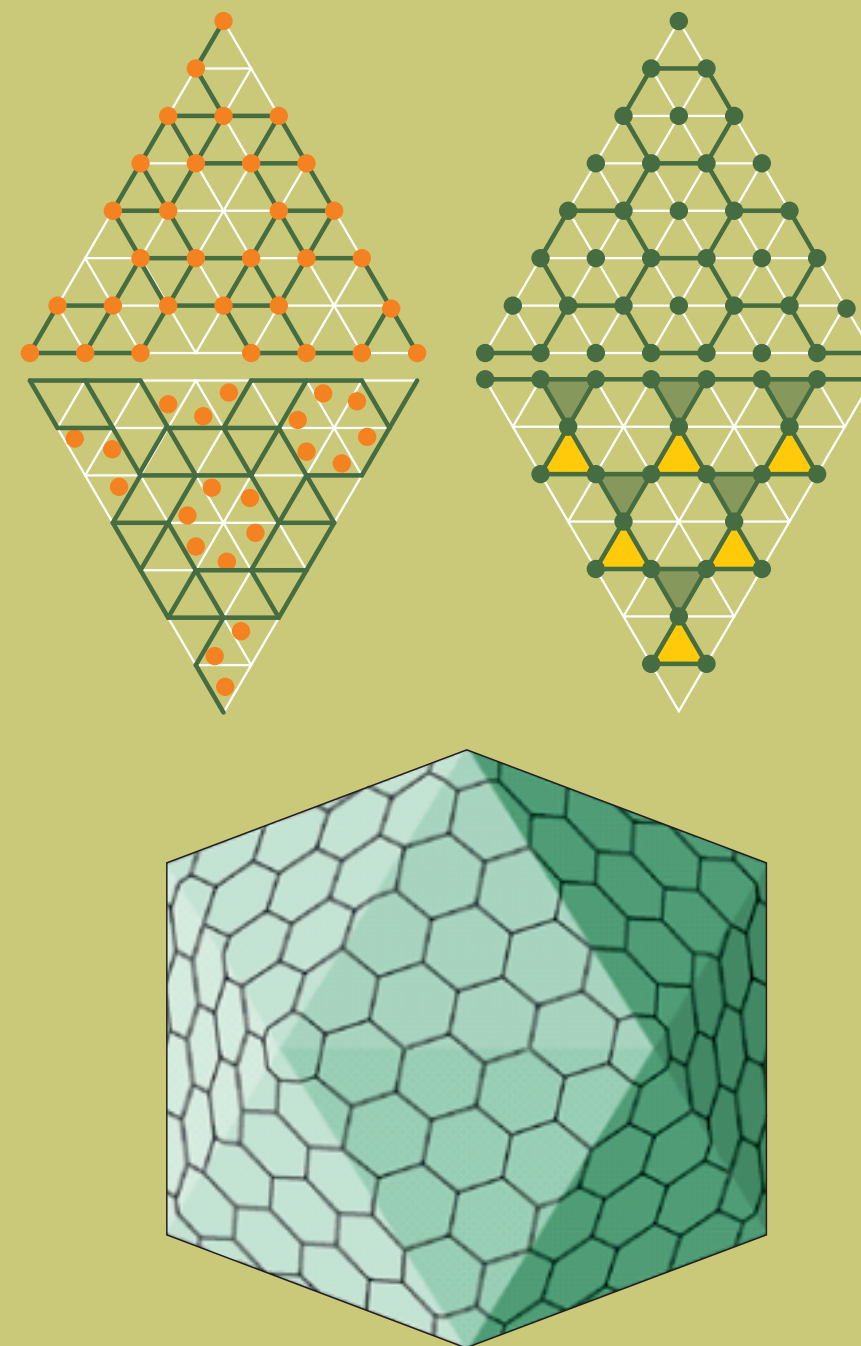
Symmetry, which in the 20th century became the fundamental basis for the exploration and formulation of the fundamental principles of non-living nature, is extremely important for understanding the processes of self-assembly and maturation (giving rise to virus ability to infect the host cell) of viruses that are intermediate between living and non-living objects.

In the work [1] we presented a detailed study of the hidden static (geometric) and dynamic symmetries of the viral protein shells. The first of them is related to the local order of the proteins that form the capsids. To explain the structural peculiarities and to reveal the hidden geometric symmetry of large and giant viral shells, we use and generalize the geometric model of Caspar and Klug [2], which underlies the modern virology. As is known, the paradigmatic CK model treats the capsid shell as a regular icosahedron, smoothly covered with a specific planar hexagonal structure composed from hexamers. Just as it is impossible to sew a dress without undercuts, planar crystalline structures cannot remain defect-free on a curved or polyhedron surface. The curvature-induced defect is called a disclination and corresponds to a sector cut out of the planar order. However, one deleted sector is not enough, and in the final analysis, it is necessary to design a net of a suitable polyhedron, with which one can transfer the planar order onto the shell. We show that for the capsid modeling in the framework of the CK mapping scheme, several symmetrical periodic motifs

with hexagonal translational symmetry can be mapped onto the icosahedron surface. We have found a very limited number of hexagonal patterns that in principle could correspond to the local order of proteins in viral shells. These structures are deduced from the primitive hexagonal lattices due to its unit cell multiplications by 3, 4 and 7 and are shown on the top of the figure. The performed analysis shows that the hidden symmetry of protein organizations in a wide variety of large and giant viruses with icosahedral shape can be understood in terms of the simple hexagonal tilings listed above [1].

The hidden dynamical symmetry of capsids (which is also considered in [1]) manifests itself in the maturation processes occurring at the final step of the virus self-assembly. These processes are extremely important since they enable the mature viruses to acquire the ability to infect the host-cell. The maturation of any viral shell is characterized by significant correlated changes in its structure. The shape of the shell very often varies from spherical to faceted, and sometimes hexamers, which are deformed in the procapsid, recover a more regular shape. Analyzing the dynamic symmetry of the bacteriophage P22 viral shell, we demonstrate that the collective critical modes responsible for the protein reorganization during the procapsid maturation are approximately equivalent to the normal modes of the isotropic spherical membrane with  $O(3)$  symmetry. Furthermore, we establish the relationship between the dynamic symmetry of the P22 procapsid and the protein arrangement regularities that appear only in the mature capsid.

The importance of studies of the structural and symmetry features of viral capsids is due to several factors. First, the viral shell protects the genome, which will either be successfully transported, and then penetrate and infect the host-cell, or drug therapy will disrupt one of the steps of this process. Second, the obtained results can be applied in other areas of nanotechnology.



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D.L.D. Caspar and A. Klug, *Cold Spring Harbor Symp. Quant. Biol.*, 1962, 27, 1

# CHEMICAL FRACTIONATION OF COOPER IN SOIL AND ITS IMPLICATION FOR RISK ASSESSMENT

T. M. Minkina, D. G. Nevidomskaya, A. V. Soldatov, Yu. S. Podkovyrina, S. S. Mandzhieva

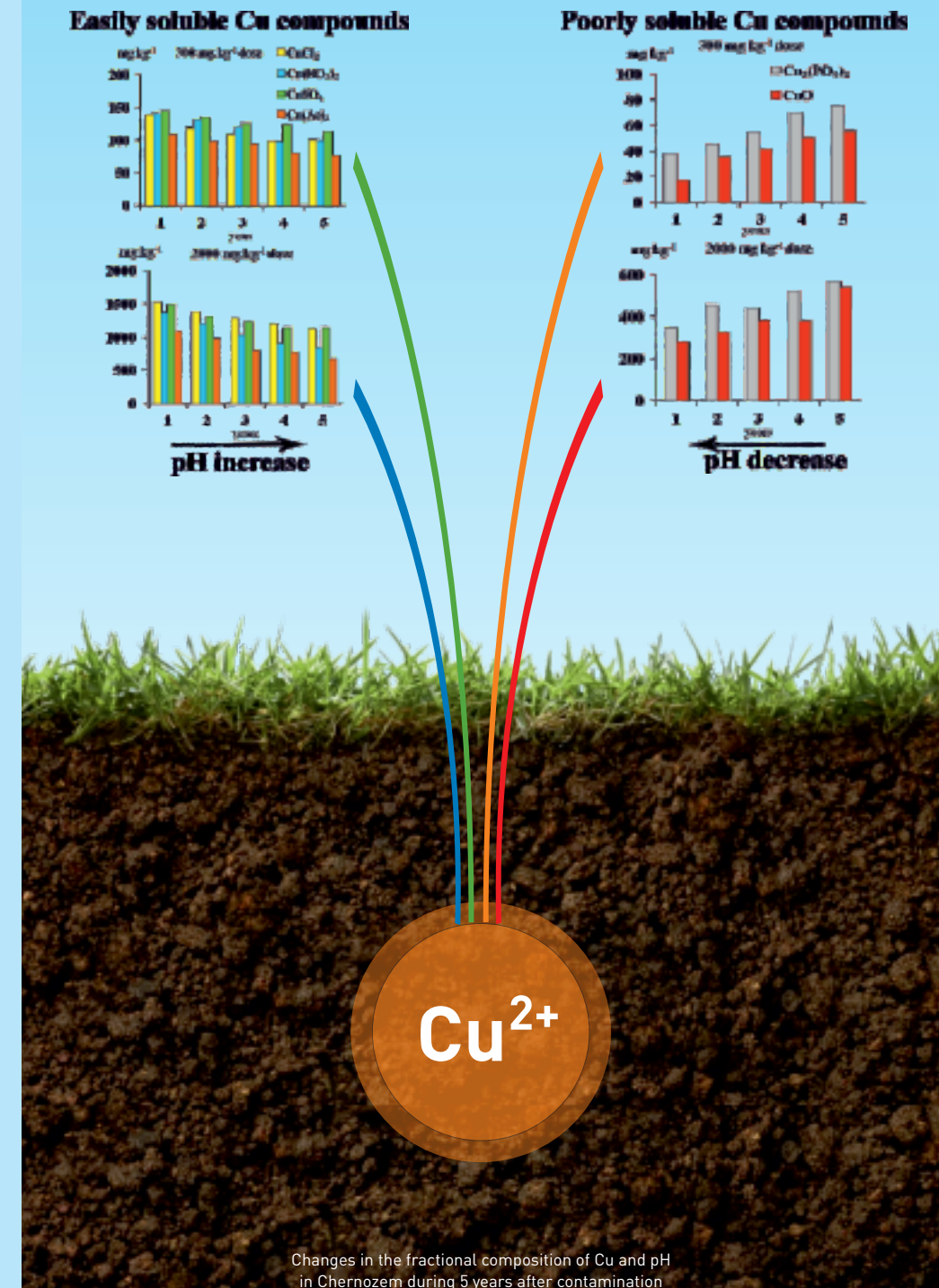
The regularities of Cu stabilization in soil contaminated with easily soluble (acetates, nitrates, sulfates, chlorides) and poorly soluble (phosphates and oxides) metal compounds in a five-year incubation experiment were studied. The indicators of risk assessment were changes in the level of Cu mobility and pH soil with time.

Anthropogenic activities throughout the world are responsible for heavy metal contamination in soil. Heavy metals are regarded as serious pollutants of soil because of their bioavailability, toxicity and environmental persistence. Bioavailability is defined as the portion of a pollutant in the soil that is available for uptake by soil organisms and/or plants. The mobility and bioavailability of metals strongly depend on their chemical forms. The easily soluble compounds entered to the soil with industrial emissions are represented, first of all, by salts of mineral acids, and the poorly soluble compounds are mainly represented by oxides and phosphates. The easily soluble forms can effectively react with soil components, while the poorly soluble forms are subject to dissolution due to further transformation. Therefore, the metal oxides and phosphates in the soil should induce a lower environmental hazard per unit of metal mass than easily soluble salts. Their residence time is directly related to the mobility and bioavailability of heavy metals in soils. Stabilization implies the formation of strongly bound compounds of heavy metals due to their interaction with components of the soil solid phase, which reduces the mobility of metals and their availability to living organisms. Of special importance are studies of the stabilization features of Cu compounds in soils, because Cu is simultaneously a physiologically active microelement and a metal. Its excess, as well as deficiency, has a negative effect on living organisms. Copper has a high technophilicity and is used in different industries. The wide application of Cu implies an increase in its production and related

inevitable contamination of soils with this metal.

A 5-year-long model experiment was established to study the stabilization of anthropogenic Cu compounds in Chernozem. The uncontaminated soil (1 kg) was placed in plastic pots with a ceramicsite drainage layer on the bottom. Different Cu compounds were then separately added to the pots: acetates, nitrates, sulfates, chlorides, phosphates, and oxides at concentrations of 300 and 2000 mg Cu kg<sup>-1</sup>. These salts are the main forms in which metals entered in the soil from anthropogenic sources. Contaminated soil was exposed at room temperature and natural lighting for 5 years. The collection of soil samples for analysis was performed every year. Parallel extractions were employed to study the mobile Cu forms (Minkina et al., 2018): (1) exchangeable Cu form; (2) organically bound forms and complex compounds of Cu together with its exchangeable forms. 3) Cu bound to amorphous compounds and carbonates. The concentrations of the metal in complex and specifically sorbed compounds were calculated from the difference between the concentrations in extracts (2) and (1), (3) and (1). The sum of the exchangeable, complexed, and specifically sorbed forms represents loosely bound compounds (LBCs). They are the most important from an ecological viewpoint and are capable of entering adjacent areas and plants.

Changes in the Cu LBC content in the soils contaminated with easily soluble and poorly soluble metal are shown in Fig. 1. The Cu LBC content decreases over time in the soils contaminated with easily soluble Cu compounds and increases in the soils contaminated with poorly soluble Cu compounds. The decrease in the fixation strength of Cu by the soil over time is due to the gradual dissolution of metal phosphates and oxides in the soil solution.



Changes in the fractional composition of Cu and pH in Chernozem during 5 years after contamination

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# OXYGEN SYNTHESIS IN THE MILKY WAY GALAXY

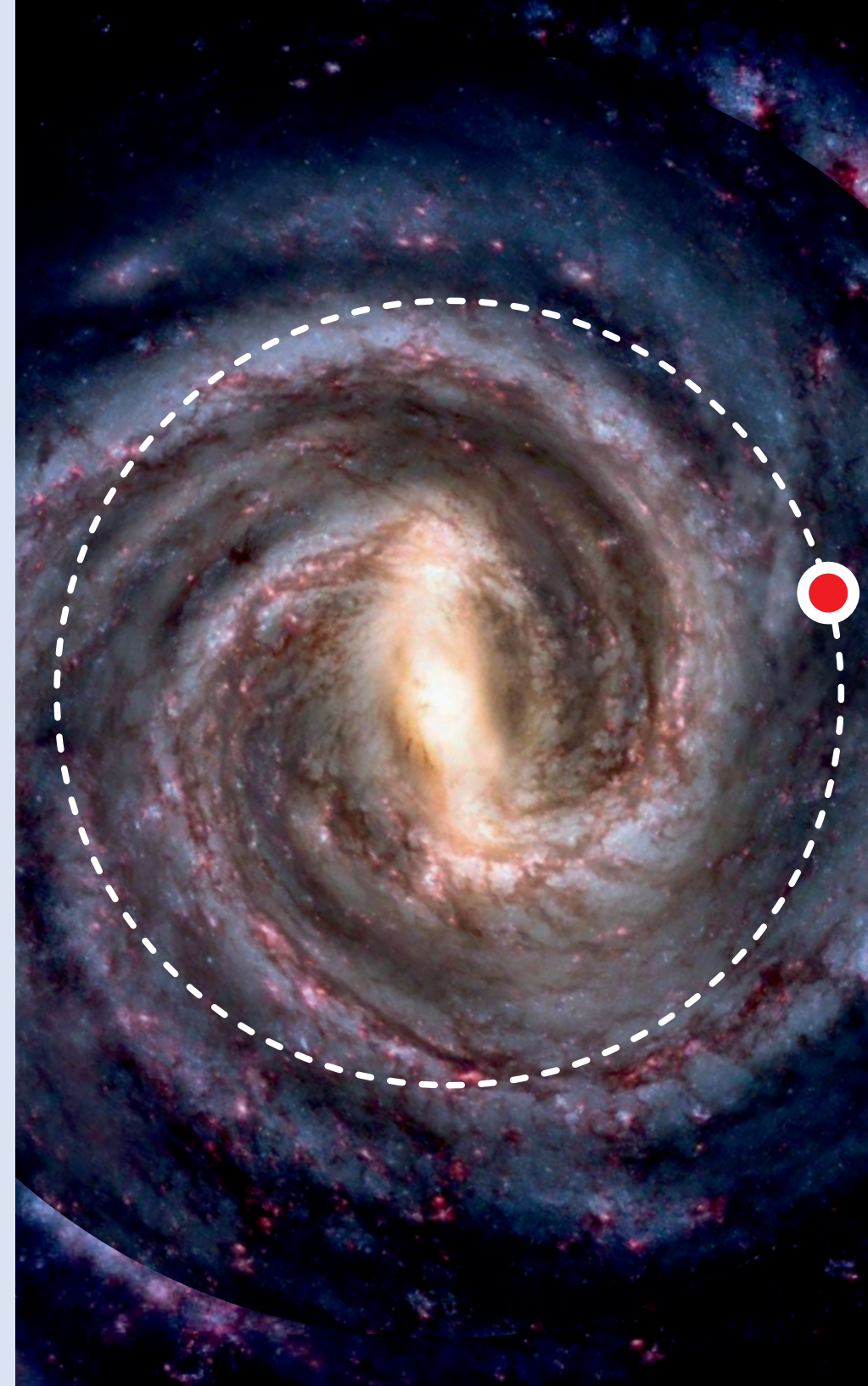
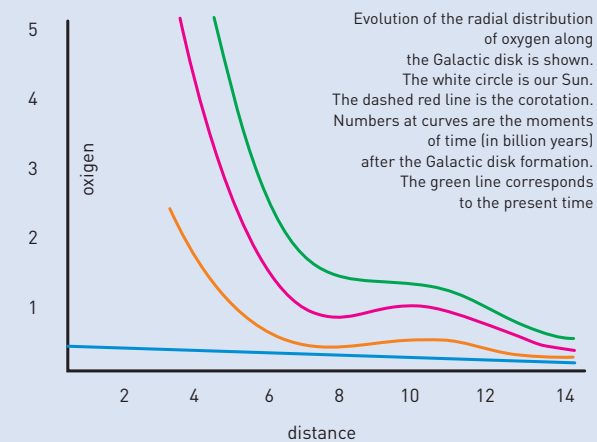
Yu. N. Mishurov

We discuss a connection between the structure of the Milky Way Galaxy and the oxygen synthesis. The special location of solar system in the Galaxy - near the so-called corotation - is due to the features of the processes in the corotation vicinity, in particular, the solar system could not be formed before a sufficient amount of oxygen had been synthesized in the Galaxy.

Like many others, our galaxy Milky Way was born several hundred million years after the birth of Universe. At those times, the matter of the Universe consisted mainly of a mixture of hydrogen and helium with a small admixture of some light first elements from Mendeleev's table. The following elements, like carbon, nitrogen, oxygen and others (they are called as heavy elements), did not exist in the nature at all. They were synthesized at the galactic stage when stars began to form. The massive stars are the sources of heavy elements up to radioactive ones. It is worthwhile to notice that heavy elements play a key role in the observed diversity of World around us. In particular, there would not be planets (including our own Earth) which surfaces consist of solid substances. As a consequence Life could not be arisen since the above three heavy elements form the basis of organic matter. In this connection, the problem of heavy elements synthesis in space conditions represents one of the central areas of astrophysics. An analysis of the spectra of cosmic objects gives information about their chemical composition. This is perhaps the most extensive area of researches in observational astrophysics. At the turn of the last millenniums significant progress has been achieved in precision and reliability of the data on content and abundance of heavy elements over the Galactic disk. These new results enable us to draw the extremely unexpected conclusions about the World around us.

It is naturally to begin the studies with features of

oxygen synthesis in the Galactic disk. The fact is that, the only sources of oxygen are the exploding supernovae stars of the so-called type II (hereafter SNe II). Their progenitors are massive stars with masses on the order of magnitude more than the solar one. They happen to be rapidly evolving objects: their lifetime (from birth to explosion) is several tens of millions of years, which is very small by the standards of the Galactic disk whose lifetime is about 10 billion years. Such stars are not only born in certain regions of the galaxy but they spend all their lives approximately in the same place where they were born. These peculiar areas (besides the galactic center) are the spiral arms of galaxies. The fact is that the density of the galactic matter is strongly increased in the arms. Therefore they are the favorable birth places for the SNe II progenitors (see Fig. 1). Low massive stars, like our Sun, are also born in spiral arms, but they are long-lived objects, and during their lifetime (of the order of several billion years) are scattered throughout the Galactic disk. In addition, such stars do not produce heavy elements (our Sun synthesizes only helium). For this reason, the distribution of oxygen in the Galaxy is only determined by the peculiarities of SNe II location.



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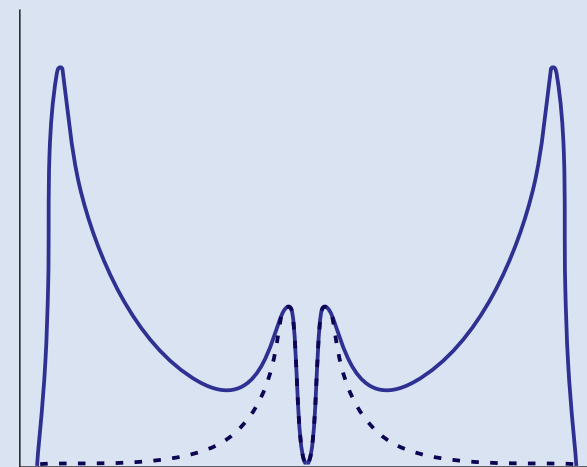
# ON VERIFICATION OF THE BASICS OF CLASSICAL ELECTRODYNAMICS

V. S. Malyshevsky

The problem of electromagnetic radiation emitted from a system under an instantaneous change of its state has been discussed in a scientific community for quite a long time. These issues are interesting mainly due to their fundamental nature related to the basics of classical electrodynamics. This is most clearly demonstrated in the rapidly developing recent concept of 'half-dressed' charges [1, 2], those which temporarily lose their equilibrium electromagnetic field. This concept has already helped to elegantly explain the Landau-Pomeranchuk-Migdal effect [3, 4] and the Ternovskii-Shul'ga-Fomin effect [5], which was recently confirmed in an experiment [6]. Physical systems in which such effects may occur can be, for example, ones with an instantaneously changing electric dipole moment, instantaneously accelerated or decelerated charge, or rapidly changing (fluctuating) charge. When speaking about alternating charge, we naturally assume that part of the system charge stops its motion and stays in the medium, while the total charge of the entire system remains constant. An example of the last processes may be the formation and ensuing disappearance of excess electrons in a nuclear electromagnetic cascade or the loss and capture of electrons by accelerated multiply charged ions in a medium. Changes in the parameters of such systems are always followed by the emission of electromagnetic waves.

The most convenient object to conduct measurements on is the multiply charged ions accelerated to relativistic velocities and having one or two residual electrons on their shells. Such ions will lose their electrons soon after entering the medium. Backward electromagnetic radiation will have characteristic features which are absent for radiation process without electron loss. Some calculated results are given in Fig.1 (spectral-angular density of radiation in dimensionless units) . The narrow maxima of the backward radiation in the X-ray range along the interface are related to the effect of total external reflection.

Summing up, we can conclude that the charge exchange Processes of accelerated multiply charged ions in a medium Lead to some characteristic features in the accompanying Electromagnetic radiation. Physically, this effect is connected to the appearance of an additional contribution to the radiation Yield from the electrons, which are captured or lost by a multiply charge ion in the medium. As follows from the performed analysis, this contribution is similar to that of instantly started or stopped charges. Therefore, we can give an affirmative answer to the question «Is it possible to measure the electromagnetic radiation of an instantly started charge?» Detailed experimental investigations of the considered Phenomena will give an opportunity to study the characteristics of electromagnetic radiation emitted by instantly starting or stopping charges.



Angular distribution of the backward radiation in the X-ray spectral region for argon relativistic ions, as they enter a gold film in the cases of fully ionized ions (dashed curve) and singly ionized ions (solid curve)



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## THE FORMATION OF PATRIOTISM IN THE PERIOD OF THE FIRST WORLD WAR

E. Yu. Leontyeva, A. N. Leontyev, I. N. Bogdanova

The period of the First World War is the time of provincial newspapers active development. The newspapers have become the most important mean of the development of values of patriotism. The purpose of the article is to analyze the daily press of the district city Tsaritsyn, which covered the military events, the work and ceremonies of religious organizations and confessions, the local charitable activities, the mobilization activities, and the loyalty manifestations.

The numerous definitions of patriotism are united by the phrase "love for the Motherland, for the Homeland". This feeling was formed spontaneously for a long time, but at a certain stage of the society development, the possibility of its purposeful development emerged. The period of the beginning of the 20th century and the First World War is characterized by the development of the local and provincial press, which played the leading role in the provision of information about the current events and could act as a mean of the development of patriotism.

The research is based on a number of sources, the most important of which are the collections of the issues of the "Tsaritsynsky Vestnik" newspaper from July 1914 to February 1915, the "Volgo-Donskoy Kray" newspaper from September 1911 to February 1915, and the calendar-reference book "All Tsaritsyn", 1911 year.

The entire press of the district town Tsaritsyn during the period of the First World War began was full of the military operations reports. Often it was the scattered information received from different cities in the world. But this information formed the average viewer about the events taking place in the military arena. At the same time, the local press was an important mean of the development of patriotic and loyal feelings. The pages of the newspapers did not contained decadent moods: even the news "from the battlefields" were

optimistic and expressed the confidence in the imminent defeat of the enemy. The press actively covered the activities of religious organizations of all faiths, provided the information about the church services, processions and prayers for the glory of Russian weapons and the victory. The newspapers published the detailed information about the manifestation of the loyal sentiments and full support for the actions of the Sovereign. The authorities' response caused a flurry of enthusiasm, which was always shown in the newspapers.

All kinds of charitable activities were presented in the press widely; they involved all segments of the population from the prosperous industrialists to young children. The mobilization readiness of the society and the patriotic eagerness of the younger generation in its aspiration to get to the front and defend the Motherland were highlighted precisely. The newspapers of the district town Tsaritsyn, published during the period of the beginning of the Great War, effectively implemented the function of propaganda and formation of appropriate patriotic values. At the same time, the newspapers either reported the residents about the expected and occurring events or established the "feedback", informing about the results and reactions of the city population, which makes the newspapers a valuable historical source



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## THE FACTORS OF THE SPREAD OF EXTREMISM IN THE REGIONS OF THE SOUTH OF RUSSIA

A. V. Serikov, A. V. Bedrik

The research is aimed at the revealing of the role of two factors influence on the distribution of the extremist attitudes and aggressive behavior practices in the South of Russia (the ethnostatus disproportions in the region and the strengthening of the dynamics of the population migration). The authors argue that the transition to a polysubject model of the implementation of national and migration policies is a necessary condition for the overcoming the interethnic conflict in Russian society.

The main findings of the research:

Despite the actions of the federal authorities aimed at the neutralizing the ethnic factor in regional politics, the informally reproducible ethnic hierarchy systems that prevent the possibility of public self-realization of the representatives of certain ethnic communities are preserved. In addition, the politicization of the migration discourse causes the extension of the interethnic segregation in the regions receiving migrants. In spite of the fact that the migration factor itself does not have a significant impact on the socio-economic, criminogenic or ethno-demographic systems in these communities. The fragmentation of public and scientific discourse about the promising areas of Russian national policy modernization reduces the overall effectiveness of the measures to prevent the extremism, makes them formalized, and focused on that part of the society that does not belong to the risk group in inter-ethnic aggression.

In Russia and in the South of Russia, the institutional conditions for the spreading of extremist behavior forms and the escalating of the inter-ethnic violence still remain. It is due to the persistence of the latent contradictions between different ethnic components of Russian society.

The main ethnic contradictions in the region are related to the continuing ethno-territorial approach to the peoples' national self-determination in Russia. This approach is implemented through the asymmetric model of the federal system, in which along with the

administrative-territorial entities there are the national-territorial entities: republics, autonomous district, autonomous regions. This model provokes the reproduction of the ethnostatus hierarchy in the national entities of Russia, which is aggravated by the informal social practices of ethnic representation in regional and local government. Such social inequality is a factor of interethnic tension and an incentive migration motive for the Russian-speaking population of the ethnic entities, especially for young people.

At the same time, a new round of territorial reform, the unification of the entities and the de-ethnisation of Russian federal model contain even more conflict potential taking into account the modern conditions. Such actions can provoke the growth of the protest moods, the escalation of the latent level of tension, the split of the ethnic regional elites loyal to the federal center nowadays. At the present stage the rejection of any projects of reorganization of the federal system is the most appropriate both at the level of the Russian Federation constituent entities and federal districts, and at the level of municipal entities.

Another group of contradictions is related to the peculiarities of the development of migration processes in the South of Russia: both internal and external. They require not declarative but practical implementation of a polysubject model of migration policy, which should replace the monocentric model. This model is based on the civil potential of Russian society and the subsidiarity principle, which allows to solve social problems of migration at the lowest level or the most remote from the center level where the solution is the most effective. In this case, the central government should play a subsidiary (prescriptive) role, rather than a subordinate (directive) role, solving only those tasks that can not be effectively implemented at the municipal/local level.

The basic actors of the polysubject model of migration policy are the local host community in the form of municipal government bodies and the civil society

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## "INVESTMENT POWER" OF THE APPEARANCE IN VARIOUS CONTEXTS OF LIFE ACTIVITY OF MODERN YOUTH

V. A. Labuskaya

The goal of the research is a systematic socio-psychological study of the value of the appearance, its "investment power" among Russian youth, satisfaction, concern for it, evaluation functions and self-assessments of the appearance in interpersonal and intra-group interaction. The development of domestic social - psychology of the appearance, taking into account the Russian realities, the peculiarities of the formation of Russian youth, is the search for answers to questions about the role of the appearance in the sphere of education; in the context of career achievements, employment of young people; in the sphere of interpersonal, romantic relationships; in the context of child-parent relations, etc.

Theoretical, empirical analysis and generalization of data on the impact of socio-cultural, socio-psychological, economic, gender-stratification, subjective factors on the significance, satisfaction, appearance, evaluation and self-assessment of the appearance in the youth environment indicate, that we have dealing with emotionally-saturated phenomena, included in the value-semantic sphere of young people [V.A. Labunskaya, I. I. Drozdova, T.A. Shkurko]. Significance and emotional score of the appearance actualizes the experience of concern with its appearance, appearance leads to increased anxiety, depression, to the formation of a special phenomenon of "fear of assessing the appearance", if it is given a special «investment power». The negative contribution of the appearance to the self-schema helps to increase the sensitivity to deviations in the appearance in relation to a certain norm, changes the style and way of life. Increasing the importance of social, interpersonal relationships in the youth environment leads to an uncritical attribution to the appearance of the "Investment power", responsibility for well-being or ill-being. Young people are in the field of "pressure" of social - cultural standards, standards of attractive appearance, which are replicated by various media.

Namely, young people's perception of his include the appearance of their assessment of the appearance of the surroundings, significant Others, family members. Along with this, the impression is that in today's society "artificially" overestimated the importance of appearance, addictive more youth Wednesday. It should be noted that in recent decades, in Western economic and social psychology, studies are increasingly emerging in which the appearance of a person (beautiful, attractive - ugly, unattractive) is seen as the basis for discrimination in the workplace [D.V. Pogontseva]. Practically, there are no systematic studies or works that consider the influence of the appearance of applicants for a position on the Russian labor market. Does this mean that the appearance, as a criterion for selection, is on the periphery of employers' attention? Practice, for example, of Russian castings for participation in advertising campaigns, allows to answer this question negatively [V.A. Labunskaya]. Discussion of this problem within the framework of the round table "Lookizm in management and professional activity" led to the conclusion that it is necessary to study this type of discriminatory practice as combined with other types of discrimination, especially, with sexism, age discrimination, ethnic discrimination. In addition, this type of discriminatory practice, following other forms of discrimination, acquires the features of "masked", concealed discrimination. In this connection, it becomes urgent to search for indirect manifestations of Lookizm. The task of training cadres solving the issues of youth employment should include information about the manifestation of Lookizm. Given the contradictory results on the influence of the gender factor on various assessments of the appearance, a special study was conducted in which the influence of the gender factor was considered in connection with ethnic identity and concern, satisfaction with the appearance.



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## HIERARCHICAL MATERIAL TECHNOLOGIES BASED ON HYBRID CARBON NANOSTRUCTURES INTENDED FOR MEMS AND PHOTOVOLTAICS

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Technologies are intended for hierarchical materials based on nanocrystal films and hybrid carbon nanostructures used in MEMS for sensors of fire early detection and prevention systems; gas analysis systems on plants and factories; gas sensors, photosensors, solar cells etc.

### Technical details:

Gas sensor characteristics based on nanocrystal films ZnO and hybrid carbon nanostructures;  
Sensitivity rate for gases  $160 \pm 2\%$  (concentration ranges 100-1000 ppm);  
CO (purity 99,99%);  
NO<sub>2</sub> (purity 98%);  
NH<sub>3</sub> (purity 98%);  
Operating temperature range is 30°C to 200°C.

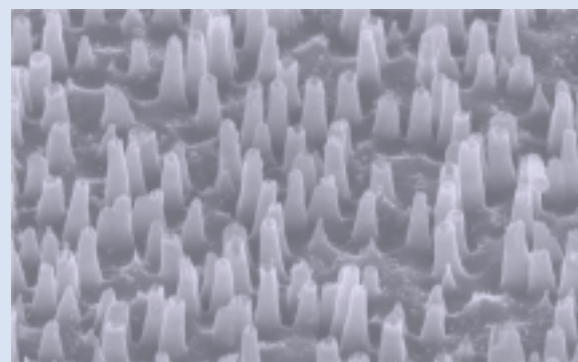
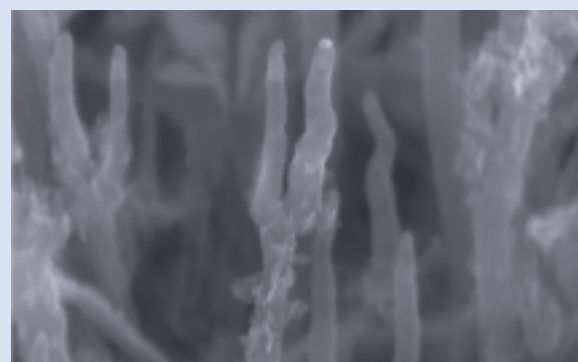
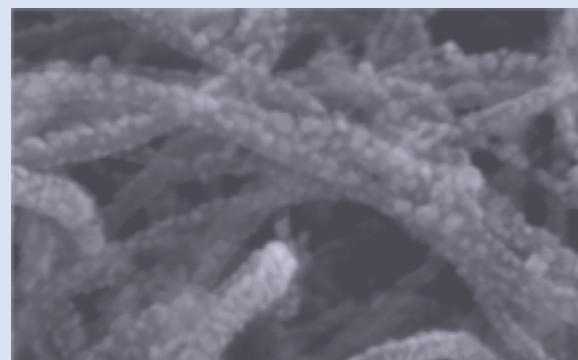
The sample of gas sensor with a sensitive element made of hierarchical material films based on nanocrystal films and hybrid carbon nanostructures has lower temperature, higher response rate, stable parameters and sensitivity, lower cost at mass production and lower electricity consumption.

### Application:

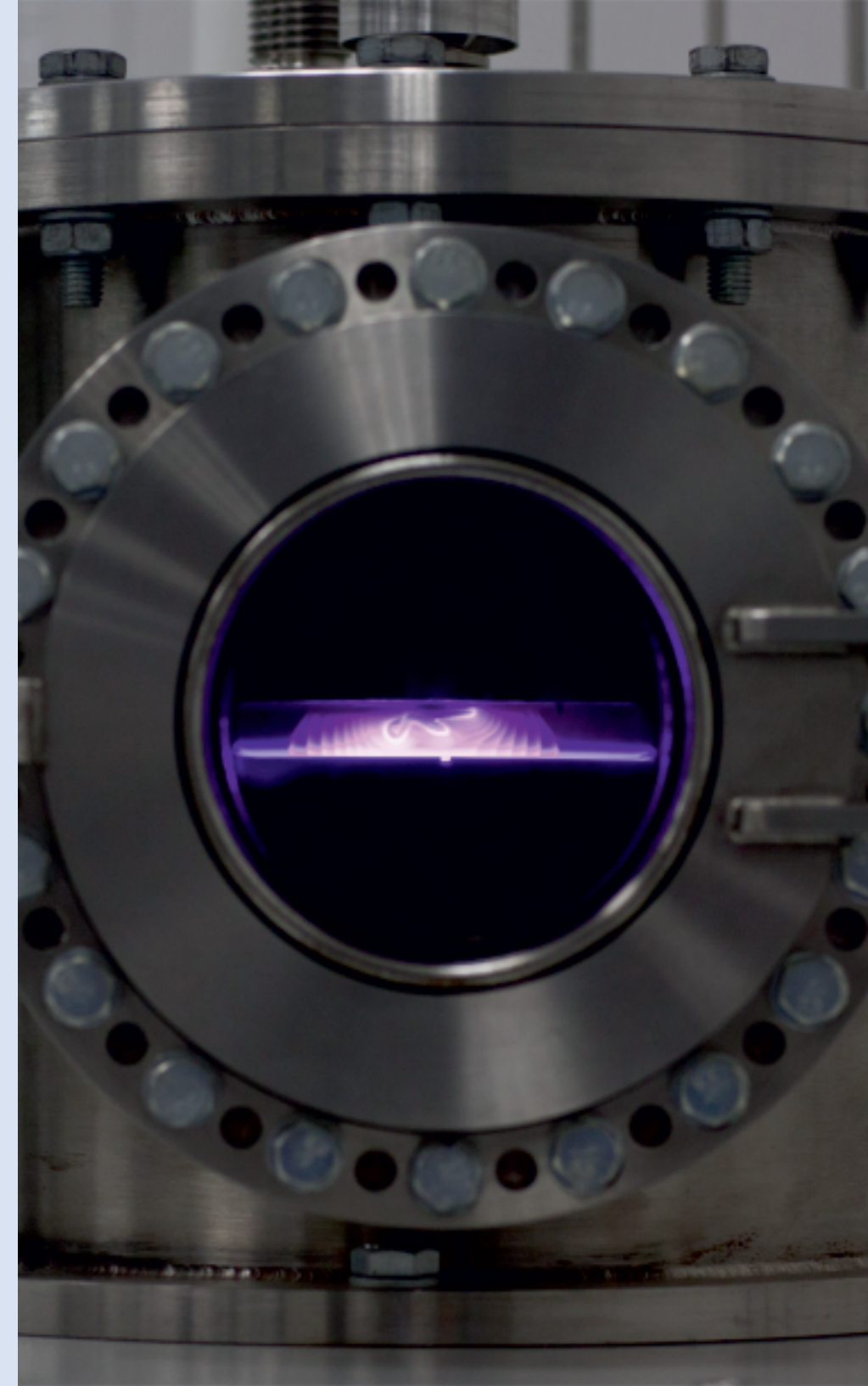
early fire detection and prevention systems;  
mobile gas analysis systems;  
gas analysis systems at factories and plants, overwater and coastal oil platforms, office spaces etc.

Patents for inventions: №2400462, 2009.; №88187, 2009.; №241789, 2009.; №87568, 2009.; №102847, 2010.; №2380109, 2008.; №102813, 2010.; №110866, 2011.; №2431597, 2011.; №2478563, 2009.; №144097, 2013.; №133312, 2013.; №148262, 2014.; №146081, 2014.;

Researchers developed lab and technological regulations for hierarchical materials based on nanocrystal films and hybrid carbon nanostructures. Construction and technology draft documents were developed as well as a sample of high power sensitive gas detection sensor based on hierarchical materials.



SEM-image of hierarchical materials based on hybrid carbon nanostructures



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