

**Science & Technology Wing  
Embassy of India  
Moscow**



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## 1. Scientists Synthesize New Material for High-Performance Supercapacitors

*Tomsk Polytechnic University news*  
15 January 2021



### Scientists Synthesize New Material for High-Performance Supercapacitors

Scientists of Tomsk Polytechnic University jointly with colleagues from the University of Lille (Lille, France) synthesized a new material based on reduced graphene oxide (rGO) for supercapacitors, energy storage devices. The rGO modification method with the use of organic molecules, derivatives of hypervalent iodine, allowed obtaining a material that stores 1.7 times more electrical energy. The research findings are published in *Electrochimica Acta* academic journal (IF: 6,215; Q1).

A supercapacitor is an electrochemical device for storage and release of electric charge. Unlike batteries, they store and release energy several times faster and do not contain lithium.

A supercapacitor is an element with two electrodes separated by an organic or

inorganic electrolyte. The electrodes are coated with an electric charge accumulating material. The modern trend in science is to use various materials based on graphene, one of the thinnest and most durable materials known to man. The researchers of TPU and the University of Lille used reduced graphene oxide (rGO), a cheap and available material.

“Despite their potential, supercapacitors are not wide-spread yet. For further development of the technology, it is required to enhance the efficiency of supercapacitors. One of the key challenges here is to increase the energy capacity.

It can be achieved by expanding the surface area of an energy storage material, rGO in this particular case. We found a simple and quite fast method. We used exceptionally organic molecules under mild conditions and did not use expensive and toxic metals,” Pavel Postnikov, Associate Professor of TPU Research School of Chemistry and Applied Biomedical Science and the research supervisor says.

Reduced graphene oxide in a powder form is deposited on electrodes. As a result, the electrode becomes coated with hundreds of nanoscale layers of the substance. The layers tend to agglomerate, in other words, to sinter. To expand the surface area of a material, the interlayer spacing should be increased.

“For this purpose, we modified rGO with organic molecules, which resulted in the interlayer spacing increase. Insignificant differences in interlayer spacing allowed increasing energy capacity of the material by

1.7 times. That is, 1 g of the new material can store 1.7 times more energy in comparison with a pristine reduced graphene oxide,” Elizaveta Sviridova, Junior Research Fellow of TPU Research School of Chemistry and Applied Biomedical Sciences and one of the authors of the article explains.

The reaction proceeded through the formation of active arynes from iodonium salts. They kindle scientists` interest due to their property to form a single layer of new organic groups on material surfaces. The TPU researchers have been developing the chemistry of iodonium salts for many years.

“The modification reaction proceeds under mild conditions by simply mixing the solution of iodonium salt with reduced graphene oxide. If we compare it with other methods of reduced graphene oxide functionalization, we have achieved the highest indicators of material energy capacity increase,” **Elizaveta Sviridova says**

The research work was conducted with the support of the Russian Science Foundation.

## **2. Addition of Lutetium-177 May Be Promising for Cancer Therapy - Joint Research Indicates**

*Ural Federal University news  
13 January 2021*

Ural and Egyptian scientists analyzed the effect of a promising radionuclide for cancer therapy.

Physicists from the Ural Federal University, the Ural Branch of the Russian Academy of

Sciences, together with colleagues from the Al-Azhar and Miniya Universities (Egypt), analyzed the effect of a promising radionuclide for cancer therapy - lutetium-177 ( $^{177}\text{Lu}$ ). To do this, they built bio kinetic models of the behavior of radionuclides in the body and calculated what doses metastases, as well as other organs and tissues, would receive. To build the models, scientists used data from many clinical and laboratory studies published in the world scientific literature.

The analysis results are presented in the International Journal of Radiation Biology.



*Scientists have attached lutetium-177 to two agents that deliver the radionuclide to the tumor.*

According to the researcher of the Department of Experimental Physics of UrFU, Hesham Mahmoud Hamed Mohamed, most of the known malignant tumors form metastases that are located in different parts of the skeleton. They deliver constant pain to the patient and significantly limit his activity, therefore, the primary therapeutic task is to relieve pain with a radiopharmaceutical. But the problem is that the drug affects not only the tumor and

metastases, but also the neighboring organs and tissues.

We needed to analyze what doses other organs would receive, except for the one that is the main target. For diagnostic drugs, this is not so critical, because the doses are small. And in therapy, a very large dose is applied to a tumor, and if the drug, in addition to the tumor, accumulates somewhere else, this may have negative consequences for the patient, ”explains Mikhail Zhukovsky, director of the Institute of Industrial Ecology of the Ural Branch of the Russian Academy of Sciences, professor of the Department of Experimental Physics of the Ural Federal University.

Scientists have found that preparations with the addition of lutetium-177 are more effective than analogues. For example, strontium-89, which has been used in therapy for many years, is relatively long-lived. Its half-life is 50.5 days. This time it is in the bones and additionally irradiates the red bone marrow, which is located nearby.

“If you need to get a large dose quickly, you have to inject a lot of the drug, and then this dose is too much for the patient. But if you introduce the drug gradually and wait until the required volume has accumulated, then it may take several weeks, which is also bad for the patient. And lutetium is short-lived, with a half-life of 6.73 days. Therefore, the dose is implemented quickly enough, ”says Mikhail Zhukovsky.

During the research, physicists studied two agents, methylene diphosphonate (MDP) and ethylenediamine tetramethylene phosphate (EDTMP), which deliver the radionuclide to the focus. Lu177 was "attached" to them.

Both preparations contain phosphorus, which ensures a high cell response (tropism) in the bone tissue. For them, scientists were the first in the world to create biokinetic models of the impact on the human body (experimental data were obtained on mice in 2008). The absorbed doses were determined for the kidneys, red bone marrow, liver, spleen, and bone surfaces.

"Analysis of published experimental data showed that  $^{177}\text{Lu}$ -EDTMP is more favorable for radionuclide therapy than other drugs, because it is more targeted - the tumor receives more dose than organs," explains Hesham Mahmoud Hamed Mohamed. “In addition, despite the fact that drugs with the addition of lutetium caused a slight depression of bone marrow function, no patient had any negative effects requiring intervention.”

According to scientists, the data published in the journal should be enough to continue the work on the development of radiopharmaceuticals with  $^{177}\text{Lu}$ . It is also possible to produce such drugs in the Urals, since lutetium-177 is produced here (although for the time being for supplies abroad).

“Despite the fact that lutetium has convenient parameters and is becoming popular in the world, it is not yet used in our pharmacopoeia. It is theoretically possible to create a base of radio-pharmaceuticals based on our own. Since we produce lutetium, there is no need to purchase it. In addition, there is a powerful school of nuclear medicine in Chelyabinsk. There are enough specialists in the field of radio-chemistry in the same "Mayak". UrFU has a Department

of Radio-chemistry, ”states Mikhail Zhukovsky.

Ural Federal University is one of the leading universities in Russia that celebrated its 100th anniversary in 2020. UrFU is located in Yekaterinburg, the capital of the World Summer Student Games 2023. The University has initiated the establishment of the Ural Interregional Research and Education Center — ‘Advanced Industrial Technologies and Materials’ and is its project office designed for solving tasks of "Science" National Project.

### 3. UrFU's Prof. Zatsepin - 'Low Radiation Doses Kill Coronavirus'

*Ural Federal University news*  
12 January 2021



*On the part of UrFU, the scientific group in these studies is headed by Anatoly Zatssepin*

Researches are conducted by university scientists together with colleagues from Uzbekistan

A team of scientists from Russia and Uzbekistan has established that low doses of radiation (for example, X-rays) can destroy the coronavirus. Experts are developing

guidelines for the use of radiation in the treatment of patients with Covid-19 and during disinfection.

“An original mechanism of the Auger destruction of the virus heredity molecule under the influence of small doses of soft X-rays was proposed,” says Anatoly Zatssepin, professor of UrFU, head of the scientific laboratory “Physics of functional materials of carbon micro- and optoelectronics”. - The essence of this pioneering idea is that a huge RNA molecule of a given virus, when it enters a human cell, is forced to strongly deform in many areas along its length. It turned out that deformed places along the RNA molecule are a thousand times more sensitive to radiation exposure than the molecules of healthy cells. From this it followed that small doses of radiation, destructive for the virus, would be absolutely safe for healthy cells. ”

The study of the radiation effect on the new coronavirus is being carried out by scientists from UrFU and the Academy of Sciences of the Republic of Uzbekistan. The study began with an idea put forward in April 2020 by a group of scientists from Uzbekistan headed by Professor Boris Oksengendler, who is also a laboratory employee at UrFU. Currently, in the course of joint research, several details of the effect of soft X-rays and even ultraviolet radiation on coronavirus have been discovered, scientists say. Experts suggest using radiation not only for treating a person and preventing diseases, but also for disinfecting objects, products and premises. A joint team of scientists from the Russian Federation and Uzbekistan is currently developing a treatment method.

“This method is designed not only for Covid-19 viruses, but also for other viruses, in particular, for its mutations. As physicists, we develop and analyze the mechanisms of

radiation exposure at the micro level, and biologists and doctors help us understand how this affects the human body as a whole. At the same time, in the light of recent events, it should be noted that no mutations of the virus that prevent the fight against it by biological methods do not at all affect the effectiveness of the radiation method according to the mechanism of Auger destruction," Zatsepin emphasized.

Scientists plan to determine whether the proposed mechanism is dominant in all possible situations or not.

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#### **4. Ural Federal University Researchers Explored Alternative Method For Producing Gold From Minerals**

*Ural Federal University news*  
11 January 2021

Researchers at the Ural Federal University have identified the mechanisms and studied the kinetics of the nitric acid oxidation of pyrite and arsenopyrite minerals, which are carriers of fine gold particles. The results obtained are important for improving the technologies of gold extraction production.

The paper was published in the journal Hydro-metallurgy with the support of the Russian Science Foundation.

Pyrite and arsenopyrite are gold carriers, as well as promising refractory ore and technogenic materials containing sulfide minerals.

Gold is a valuable resource that is not only necessary for the manufacture of jewelry, but also irreplaceable in microelectronics, scientific research, including nuclear research, in dentistry and pharmacology, in the food and other industries. In addition, gold is an essential element of the global financial system.



Metals recovery processes are one of the main sources of environmental pollution, therefore, it is extremely important to develop low-waste, resource-saving and harmless technologies. The existing scheme of most factories implies at almost all stages the production of ecologically hazardous by-products, including sulfur dioxide, arsenic compounds, cyanides and others. In view of the ongoing depletion of mineral reserves, it becomes relevant to use low-grade raw materials, which often do not lend themselves to traditional metallurgical processing methods. For example, persistent ore and man-made materials containing sulfide minerals and serving as gold carriers - pyrite and arsenopyrite - are promising.

Classical approaches involve the use of high pressure or pyrometallurgical processes, but there is also an alternative - exposure to nitric acid, which ensures high environmental safety and a high degree of gold recovery.

Russian scientists have studied the kinetics and oxidation mechanism of arsenopyrite (also called arsenic pyrite) in nitric acid media, including the effect of pyrite on the kinetic characteristics of the dissolution process. Previous studies were aimed at studying various reaction conditions: the results obtained indicate that in almost all cases the surface of solid particles is "hidden" due to the formation of a film on it (the passivation effect). Thermodynamic and kinetic properties of pyrite and arsenopyrite are similar, including similar values of solubility in aqueous media. Pyrite can have a catalytic effect when dissolving various sulfide minerals, minimizing the negative phenomenon of passivation, but so far there has been no evidence of its effect on the dissolution of arsenopyrite. Research on the mutual action of individual minerals on each other in nitric acid media can be considered pioneering, since these interactions are practically not studied.

The authors of the article conducted laboratory experiments on leaching (leaching means the transfer of one or more components of a solid material into solution) with nitric acid. To establish the kinetic characteristics of the reactions, samples were taken at regular intervals and examined using inductively coupled plasma mass spectrometry (ICP-MS), a highly sensitive method capable of determining the content of elements in low concentrations.

Experiments to study the effect of acid concentration, pyrite, and granule size were carried out at different temperatures. Its

increase from 50 to 80 ° C increases the efficiency of arsenic extraction from arsenopyrite from 68 to 83% after 1 hour of leaching with a solution of 10% nitric acid. The presence of pyrite and particle size reduction have the same beneficial effect. Probably, the influence of pyrite on leaching is related to its catalytic action at an early stage of the process. But the increase in the concentration of nitric acid was of the greatest significance: a change from 10 to 25% makes it possible to increase the degree of arsenic extraction from 77 to 97%. To compare the effect of pyrite and Fe (III) ions, similar experiments were carried out. The influence of iron, like that of pyrite, increased the yield of arsenic from 80 to 89%, but proceeded according to a different mechanism. The authors also calculated the kinetic parameters of the system, which made it possible to derive a semi-empirical equation for the process of arsenopyrite leaching.

“The data obtained will allow us to deepen our understanding of the kinetic features of dissolution and the mutual influence of minerals in complex heterogeneous processes, to study their mechanisms and to reduce the probable passivation phenomena. This will supplement the fundamental principles of the oxidation processes of such materials contained in the processed raw materials of the mining and metallurgical complex of Russia and the world, taking into account environmental factors to minimize environmental pollution, ”says Denis Rogozhnikov, senior researcher at the Department of Nonferrous Metals Metallurgy, UrFU.

## 5. UrFU Chemists Synthesized Unique Chromophores

Ural Federal University news  
28 December 2020



Chromophores were first obtained on the basis of a heterocyclic system. Illustration: *Journal of Photochemistry and Photobiology A: Chemistry*.

### The chromophores can be used to create fiber-optic communication lines and sensors

International group of scientists have synthesized a series of chromophores promising to create a new class of materials with nonlinear optical properties (NLO). The staff of Institute of Organic Synthesis of Ural Branch of the Russian Academy of Sciences, Ural Federal and Strasbourg Universities (France), Universities of Rennes-1 (France) and Pardubice (Czech Republic) have worked on the creation of the materials.

Such chromophores were first obtained on the basis of a heterocyclic system - furazanopyrazine. They are push-pull systems - compounds with pronounced electron-donor and electron-acceptor parts and, therefore, with a high intensity of intramolecular charge transfer.

Such organic materials, which are characterized by significant NLO coefficients in comparison with traditional inorganic analogs, are of particular interest for use in laser systems for generating, modulating, and transmitting light radiation. In particular, materials of this kind are promising for the creation of modern fiber-optic communication lines.

“The significance of our work is that, firstly, one of the obtained compounds is characterized by high hyperpolarizability, that is, the unique ability to “change” the plane of polarization of light when exposed to an external electric field. In other words, this compound has strong nonlinear optical properties. Secondly, prior to our research, it was believed that furazanopyrazine derivatives are only suitable for the development of new energy-saturated compounds, as well as biologically active compounds capable of affecting various processes in living organisms,” explains the che Laboratory of Heterocyclic Compounds, IOS URO RAS and junior researcher at the scientific laboratory of medicinal chemistry and promising organic materials, Ural Federal University Egor Verbitskiy.

Having synthesized new compounds and studied their electrochemical, photophysical, nonlinear optical characteristics, scientists have demonstrated for the first time that the range of useful properties of this class of compounds is not limited to the above applications. They can also act as sensors for various ecotoxicants that pollute the environment, for example, pesticides (herbicides), or exhibit semiconducting properties.

We add that the research was supported by the Russian Foundation for Basic Research (project 18-29-23045mk "New low-molecular compounds for functional layers

of hybrid solar cells on a film basis"). o-leader of the research group, leading researcher at the Laboratory of Heterocyclic Compounds, IOS URO RAS and junior researcher at the scientific laboratory of medicinal chemistry and promising organic materials, Ural Federal University Egor Verbitskiy.

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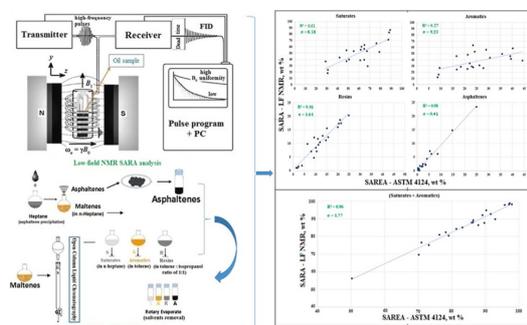
## 6. Low-field NMR relaxometry as a fast way to analyze SARA-composition of crude oils

*Kazan Federal University news*  
02 January 2021

“Currently, Russia and the world have several standard methodologies to determine light and heavy components of petroleum, such as saturated hydrocarbons, tars and asphaltenes,” says co-author, Associate Professor Mikhail Varfolomeev.

The proposed express test doesn't involve any supplements and can eliminate the

majority of human errors, according to the authors.



“That is to say, we measure our specimens without any external influence. It's a monumental time saver because of the elimination of errors and labor needed for manual analysis,” explains Varfolomeev.

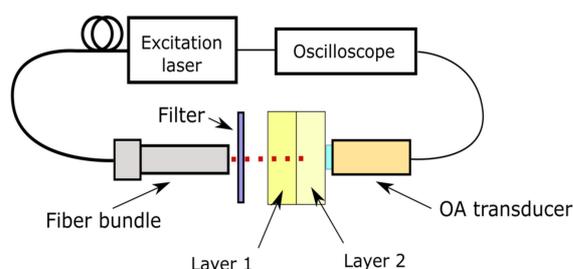
Initial tests were conducted in cooperation with Transneft, Russia's designated oil pipeline operator. So far, the researchers have learned how to determine four fractions: asphaltenes, tars, saturated hydrocarbons, and aromatic hydrocarbons.

«Asphaltenes are found in oil as solid parts, and this plays into our approach. With relaxometry, we don't observe spectra, but rather detect relaxation time and relaxation lines. Then we analyze them with regards to decrease speed. The speed depends on molecule mobility, as is well-known, petroleum is one of the most complicated compounds when it comes to the variety of molecules found in it. They all have differing relaxations speeds,» describes Associate Professor Boris Sakharov. The team plans to expand its research to test core samples.

Low-field NMR-relaxometry as fast and simple technique for in-situ determination of SARA-composition of crude oils  
<https://www.sciencedirect.com/science/article/pii/S0920410520310457>

## 7. Optoacoustic sensor measures water content in living tissue

Skolkovo Institute of Science & Technology news  
14 January 2021



Researchers from Skoltech and the University of Texas Medical Branch (US) have shown how optoacoustics can be used for monitoring skin water content, a technique which is promising for medical applications such as tissue trauma management and in cosmetology.

Too much or too little water in skin tissues can be a sign of various health problems, such as an edema (swelling caused by fluid accumulation) or dehydration, which can also have cosmetic impacts. Right now, electrical, mechanical and spectroscopic methods can be used to monitor water content in tissues, but there is no accurate and noninvasive technique that would also provide a high resolution and significant probing depth required for potential clinical applications.

Sergei Perkov of the Skoltech Center for Photonics and Quantum Materials and his colleagues decided to test whether the optoacoustic method can be used for this purpose. In optoacoustic monitoring, tissue is irradiated with pulsed light, which causes thermoelastic expansion of the target that

absorbs this light, and that target can be detected in ultrasound signals. In previous studies, optoacoustic spectroscopy has been shown to detect hemoglobin, melanin, and water, and the team decided to find out whether this method can be used both on tissue models and in vivo on real skin.

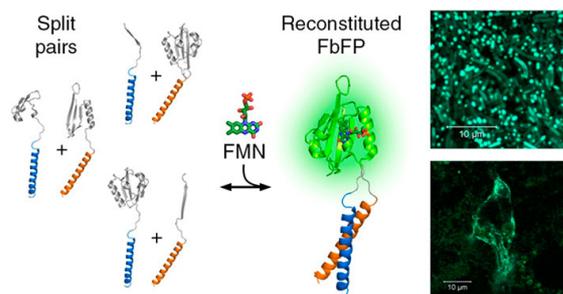
*“The OA technique is safe for clinical applications because the amount of energy absorbed by the biological tissue that is required for signal detection is relatively small. The advantage of OA technique over other optical methods is that we need to deliver laser energy only in one direction – to the absorber, and after that we detect a generated ultrasound signal that does not attenuate much in biological tissues, whilst in order to detect the signal using optical methods, a light beam has to propagate to the absorber and back (or through the whole body part),”* **Dmitry Gorin**, a Skoltech professor and coauthor of the paper, says.

The researchers built two-layered “skin phantoms” out of gelatin and milk and constructed some of them to mimic swelling under the top “epidermis” layer, using water. They also tested their optoacoustic detector on human wrists with no edema. The data they got was in good agreement with earlier published data on skin water content, and the team was able to identify optimal wavelengths for water content monitoring.

Next, the team plans to conduct similar experiments in vivo on real edema and to increase the number of different wavelengths used for OA signal generation in order to try to quantify the amount of water in different layers of the skin. This work will continue in collaboration with UTMB Galveston professor Rinat Esenaliev.

## 8. Biophysicists from MIPT have developed a new method for detecting protein-protein interactions in living cells.

Moscow Institute of Physics & Technology news



**Fig-1**

Three ways to cut the fluorescent LOV domain. Model interacting proteins are shown in blue and orange spirals. The parts of the fluorescent protein prior to interaction are shown in gray. The glowing LOV domain is shown in green. FMN (flavin mononucleotide) is a molecule that is needed to absorb and emit light. Source: ACS Synthetic Biology. Copyright (2021) American Chemical Society

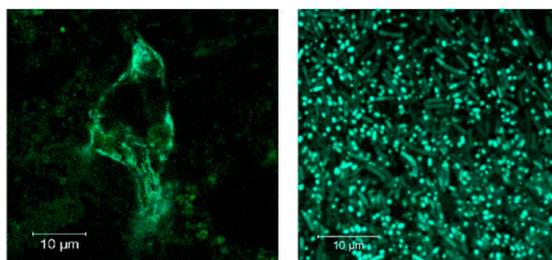
To see a specific protein in a cell, it is not enough just to look through a microscope, since the typical size of proteins is about 10 nm, which is many times less than the wavelength of visible light, and most proteins are colorless. To solve this problem, you need to somehow mark the protein of interest to us. One way is to genetically attach to it (i.e., make changes in its DNA sequence) a fluorescent protein that will glow when exposed to light of a certain wavelength. The most commonly used GFP (Green Fluorescent Protein), however, does not work under all conditions. Alternatively, so-called LOV domains can be used. One of these proteins was previously developed by

scientists from the Moscow Institute of Physics and Technology.

The task becomes more complicated if you want not only to look at one protein, but to discover the interactions of two different ones. One of the possible approaches is to use the so-called split (in English - split) proteins.

“Imagine that we split a light bulb into two parts and gave those parts to two people.

When two people come to each other (and only in this case), the light bulb will gather from two halves and start to glow. In our case, two people are two proteins about which we want to know whether they interact in the cell, and if so, in which part of it. A light bulb is a luminous protein that was divided into two parts and attached to the proteins under study,” commented Anna Yudenko, researcher at the Center for the Study of Molecular Mechanisms of Aging and Age-related Diseases, Moscow Institute of Physics and Technology. However, it is a lot of work to find such parts of the protein that, after separation, can reassemble and fluoresce. Separately, parts of the protein may be unstable or precipitate or, conversely, bind to each other too strongly. To mitigate the risks, the scientists first performed Bioinformatics analysis, which showed the best places to cut the fluorescent protein. After that, several dozen genetic constructs were created, in which DNA sequences encoding model proteins and halves of a fluorescent protein were combined. As a result, the best variants were found that gave a good signal both on bacterial cells - *E. coli* - and on cells of human neuroblastoma (Figure 2).



**Fig- 2.**

*Human neuroblastoma cell with assembled fluorescent proteins attached to two model interacting molecules that accumulate in mitochondria. Mainly mitochondria glow. (Right) bacteria in which the separated fluorescent protein has collected. Source: ACS Synthetic Biology. Copyright (2021) American Chemical Society.*

The resulting tool will allow the study of protein-protein interactions under anaerobic conditions and will provide a basis for the further development of fluorescent and optogenetic tools based on LOV domains.

## 9. Russian scientists intend to discover new elements of the periodic table

*RIA News  
9 February 2021*

Specialists of the Joint Institute for Nuclear Research ( Dubna , Moscow Region ) may start work on the synthesis of new superheavy elements of the periodic table in 2022, said JINR Director, RAS Academician Grigory Trubnikov .

"Our main task (in 2021) is to generate maximum statistics in order to understand where to look for new elements - 119th, 120th, 121st, and what properties they will have," he added.

Trubnikov explained that the so-called relativistic effects, which are a consequence of the theory of relativity, strongly influence the chemical properties of superheavy elements. "The relativistic effects affect in such a way that, according to the periodic law, it should be a gas, and it behaves like a metal. And it is very interesting what is outside of Oganesson - element 118, the heaviest element at the moment," added the JINR director .

|   |            |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |    |    |
|---|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|
| 1 | H          |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     | He |    |
| 2 | 3          | 4   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |    | 10 |
|   | Li         | Be  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |    | Ne |
| 3 | 11         | 12  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |    | 18 |
|   | Na         | Mg  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |    | Ar |
| 4 | 19         | 20  | 21  | 22  | 23  | 24  | 25  | 26  | 27  | 28  | 29  | 30  | 31  | 32  | 33  | 34  | 35  | 36 |    |
|   | K          | Ca  | Sc  | Ti  | V   | Cr  | Mn  | Fe  | Co  | Ni  | Cu  | Zn  | Ga  | Ge  | As  | Se  | Br  | Kr |    |
| 5 | 37         | 38  | 39  | 40  | 41  | 42  | 43  | 44  | 45  | 46  | 47  | 48  | 49  | 50  | 51  | 52  | 53  | 54 |    |
|   | Rb         | Sr  | Y   | Zr  | Nb  | Mo  | Tc  | Ru  | Rh  | Pd  | Ag  | Cd  | In  | Sn  | Sb  | Te  | I   | Xe |    |
| 6 | 55         | 56  | 72  | 73  | 74  | 75  | 76  | 77  | 78  | 79  | 80  | 81  | 82  | 83  | 84  | 85  | 86  |    |    |
|   | Cs         | Ba  | Hf  | Ta  | W   | Re  | Os  | Ir  | Pt  | Au  | Hg  | Tl  | Pb  | Bi  | Po  | At  | Rn  |    |    |
| 7 | 87         | 88  | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 |    |    |
|   | Fr         | Ra  | Rf  | Db  | Sg  | Bh  | Hs  | Mt  | Ds  | Rg  | Cn  | Nh  | Fl  | Mc  | Lv  | Ts  | Og  |    |    |
| 8 | 119        | 120 | 121 | 122 |     |     |     |     |     |     |     |     |     |     |     |     |     |    |    |
|   | Лантаноиды |     | 57  | 58  | 59  | 60  | 61  | 62  | 63  | 64  | 65  | 66  | 67  | 68  | 69  | 70  | 71  |    |    |
|   | Актиноиды  |     | 89  | 90  | 91  | 92  | 93  | 94  | 95  | 96  | 97  | 98  | 99  | 100 | 101 | 102 | 103 |    |    |
|   |            |     | La  | Ce  | Pr  | Nd  | Pm  | Sm  | Eu  | Gd  | Tb  | Dy  | Ho  | Er  | Tm  | Yb  | Lu  |    |    |
|   |            |     | Ac  | Th  | Pa  | U   | Np  | Pu  | Am  | Cm  | Bk  | Cf  | Es  | Fm  | Md  | No  | Lr  |    |    |

All elements heavier than uranium are obtained in nuclear reactors or with the help of accelerators when nuclei of other elements collide. And scientists synthesize superheavy elements only at accelerators by bombarding targets from transplutonium elements with heavy ions. When the nuclei of the target and the "projectile" merge, the nucleus of a superheavy element appears for a short time.

Till today, scientists from different countries have obtained a number of superheavy chemical elements ending in element 118. The greatest contribution to the achievement of these results was made by Russian specialists from JINR under the leadership of the outstanding world scientist Academician Yuri Oganessian. The 118th element is named "oganeson" in his honor.

Earlier, Oganessian did not rule out that in the future, as new superheavy elements are synthesized and their properties are studied, the periodic table may change its current familiar form.

Now, in the largest nuclear physics centers in the world, work has actually begun on the synthesis of the 119th, 120th and 121st elements, which is called the "big race". Dubna intends to be the first to receive new elements. At JINR, a unique by world standards scientific facility is operating - the so-called "Factory of Superheavy Elements". Its central part is a charged particle accelerator - the DC-280 cyclotron. Thanks to this new technique, the efficiency of experiments on the synthesis of superheavy elements is greatly increased. In December 2020, this "factory" began a cycle of experiments on the synthesis of superheavy elements.

"I think ... for six months or a year, we would have accumulated statistics on superheavy elements, which all mankind to turn out the last 20-30 years in all laboratories around the world - from Japan to America Is not This achievement reinforces exactly.? Russia is not just in the forefront, but in the first place in this Physics ", - said Trubnikov.

## **10. Scientists have discovered a new exotic particle with the help of the Large Hadron Collider**

*Kurchatov Institute news  
02 March 2021*

Scientists from the Kurchatov Institute - ITEP as part of an international research group discovered a new exotic particle during the LHCb experiment at the Large

Hadron Collider. She was named X (4740). This particle is a tetraquark, that is, it consists of four quarks. In the course of the study, its mass and intrinsic width were measured - parameters that provide a key to understanding the nature of tetraquark states. The analysis that led to the discovery of X (4740) was carried out by specialists from the Kurchatov Institute - ITEP Ivan Belyaev, Viktor Egorychev and Tatiana Ovsyannikova. The results of this work have been accepted for publication in the Journal of High Energy Physics.

The researchers found that the new exotic particle decays into two mesons. The first is a bound state of charmed and anti-charmed quarks, while the second is composed of strange and anti-strange quarks. Thus, X (4740) contains four quarks. The existence of tetra- and pentaquark states was predicted back in the 60s of the last century, and only in the last decade these theories have received a large number of experimental confirmations.

"Until now, the structure of the tetraquark has not been definitely established. Some theoretical models adhere to the idea that these particles consist of pairs of different mesons temporarily bonded together like a molecule. Others view the tetraquark as a single coherent system of four particles ," explained the co-author of the work, scientific Tatyana Ovsyannikova, an employee of the National Research Center Kurchatov Institute - ITEP " The discovery of new types of tetraquarks and the study of their properties will help to get a more complete picture of these exotic components of the subatomic world ."

According to scientists, the most important result of the work was the measurement of the main parameters of the particle X (4740). Its mass is  $4741 \text{ MeV} / c^2$  , and its own

width is about 53 MeV. To obtain these characteristics, experts analyzed the data collected in the LHCb experiment for the period from 2011 to 2018. After upgrading the Large Hadron Collider, scientists plan to carry out an additional measurement of the quantum numbers of the state X (4740). This study will allow theorists to come closer to understanding the nature of tetraquarks in general and the new particle X (4740) in particular.

For reference:

The LHCb (Large Hadron Collider beauty) experiment is one of the four main experiments at the Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN). Here, experts are looking for an answer to one of the most important questions of modern high-energy physics - what processes allowed matter after the Big Bang to be preserved in the form in which we observe it. **These studies will help to understand why anti-matter disappeared during the evolution of the Universe.**

### **11. No package needed: biopolymers - instead of plastic**

*Rusnanonet news, 05 February 2021*

Twenty minutes of work and more than a hundred years in the trash heap is, on average, the "life cycle" of a plastic bag. **Scientists of South Ural State University in collaboration with colleagues from India propose a new material based on starch.** In the future, it may replace polyethylene and plastic. Due to the plant base, the new material decomposes without leaving any residue.

"Today, there is a steady trend towards an increase in the volume of municipal solid

waste due to an increase in the number of packaging products, - explains Doctor of Technical Sciences Irina Potoroko . "It has been calculated that the average use time of a polyethylene bag is about 20 minutes, and its decomposition time is over 100 years."

The solution to the problem of MSW accumulation, according to the university professor, is rooted in reorientation to degradable materials that do not harm the environment. They can be used not only in everyday life or in the food industry, but also in such areas as cosmetology, pharmaceuticals and medicine.



The project began with the development of methods that make it possible to obtain a material called a bio-polymer from a mixture of potato starch, plasticizer and solvent. Foreign colleagues rely on corn starch, but the Chelyabinsk residents preferred potato starch - an inexpensive, affordable raw material. Practice has shown that "potato film" really turns out to be transparent, plastic, and serves as a good alternative to plastic bags.

Another area of scientific research is the production of a biodegradable polymer based on pectin, which is extracted from waste at the stage of starch production. Resource-saving technologies may interest processors of agricultural raw materials. Scientists say that each product must have its

own Eco-friendly film and set about developing containers for storing liquid products from an edible degradable bio polymer.

## 12. How to protect satellite's "brain" from cosmic radiation

*Rusnanonet news*  
04 February 2021



Scientists have proposed a new material for creating power electronics that can be installed in orbiters. This semiconductor based on gallium and aluminum oxides is better able to withstand the effects of cosmic radiation. The article was published in the journal *Acta Astronautica*.

The planet Earth is surrounded by artificial satellites of various purposes: scientific, military vehicles, communication satellites. In 2020, the public organization "Union of Concerned Scientists" numbered almost 2,800 working vehicles in near-earth orbit. New ones are launched every year. When designing them, engineers must take care of placing all the necessary devices in a small object, as well as protecting the equipment from solar radiation.

"On Earth, we are protected by our atmosphere, which absorbs or reflects most of the influences coming from space. But as soon as we leave the atmosphere, everything falls directly into us. For example, ion beams," explains **Dmitry Bauman**, professor at the Faculty of Laser Photonics and Optoelectronics at ITMO University. - If we bombard an electronic device with high-energy ions, the material will ionize, parasitic charges will appear in it, which will affect the operation of the device. Perhaps they will even lead to its destruction. The second harmful factor that we meet in space is harsh electromagnetic radiation that can penetrate a variety of shields and harm electronics. "

In any satellite, there are a lot of electronic devices - with their help, operators control the operation of the devices: they change the angle of inclination of solar batteries, control the orbit, take pictures, transmit and receive messages. Great efforts are being made to protect these devices from solar radiation, and **protective coatings are** invented. This wastes not only money and resources, but also useful weight when launching the launch vehicle. Therefore, engineers and scientists are constantly looking for the most efficient and compact solutions.

### When protection is the material itself

Scientists **from ITMO University** and **NPO Special Materials** have jointly proposed a new semiconductor material, which itself is more resistant to the harmful effects of cosmic radiation. Potentially, it can be used to create electronics for spacecraft.

In search of such a material, scientists paid attention to semiconductors with the widest possible band gap. The wider the band gap of a semiconductor material, the higher its resistivity and, as a rule, the higher voltages

it can withstand. As it turned out, this indicator also affects the resistance to radiation.

Scientists began experimenting with gallium oxide ( $\text{Ga}_2\text{O}_3$ ), a well-known semiconductor material. However, as it turned out in the course of work, the optimal material is  $(\text{Al}_x\text{Ga}_{1-x})_2\text{O}_3$ .

"This is such a solid solution, - says **Dmitry Bauman**.- Aluminum is not an impurity, it is embedded in the crystal lattice instead of gallium atoms. Somewhere there is gallium, somewhere aluminum, it is a mixture of gallium oxide and aluminum oxide. "

### Three in one

As a result of experiments, scientists have obtained a more resistant material that works better in radiation conditions. However, as it turned out, the advantages of their development do not end there.

"In the works of various researchers, other advantages of the binary material in comparison with pure gallium oxide have been revealed. For example, it has been found that it has much higher electron mobility, which is good for any semiconductor, says **Dmitry Bauman**.- The higher the mobility, the faster the material reacts to external influences, the faster the device will work. Another example: solar-blind photodetectors made of  $(\text{Al}_x\text{Ga}_{1-x})_2\text{O}_3$  produced a photocurrent ten times higher than that of pure gallium oxide detectors, which significantly improves the performance of the device. "

Thus, the new material can potentially be used for new spacecraft.

However, scientists do not exclude that it can be applied to terrestrial devices that operate in conditions of an increased background radiation.

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### 13. Scientists have synthesized an antibacterial drug based on silver nanoparticles that is safe for the body

*Rusnanonet news 04 February 2021*



International research team of NUST MISIS, Moscow State University Lomonosov and other Russian universities, as well as Dankuk

University (South Korea) presented a drug based on silver nanoparticles, which showed the absence of cytotoxicity for living cells. In the future, it can be used as a new generation antibiotic.

Silver nanoparticles ( AgNPs ) are currently the most studied antimicrobial nanomaterials. However, their use in biomedicine is still limited due to the availability of data confirming the toxicity of nanosilver. It is associated, first of all, with the development of oxidative stress in mammalian cells. This is a pathological process of cell damage that occurs as a result of an excessive amount of free radicals in living tissues.

The solution to the problem can be the modification of the surface of silver nanoparticles due to synthetic or natural compounds that have zero or low toxicity in relation to the human and animal body. Thus, a silver nanoparticle with antimicrobial properties is "packed" in a protective shell that does not harm cells.

The results of assessing the effect of such a drug on a living organism were presented by scientists from NUST MISIS together with colleagues from Moscow State University, Lomonosov and other Russian universities and Dankuk University (South Korea).

"We used a simple technology to obtain silver nanoparticles 30-60 nm in size, stabilized by miramistin (benzyl dimethyl [3-myristoylamine 3-monohydrate) -propyl] ammonium chloride) - a well-known active ingredient of many antibacterial drugs, - said one of the co-authors of the work, a senior researcher of the department FTSiVTM NUST MISIS Alexander Gusev .

According to Gusev, the aim of the study was to assess the toxicity of the drug to the small intestine and liver of mice when it was administered through the gastrointestinal tract.

"The animals received a dose of 0.8–7.5 mg / kg in the acute form and 0.05–2.25 mg / kg in the subacute form of experiments, Gusev concluded . "The absence of significant entero- and hepatotoxic effects after a single exposure was found using dosages less than 4 mg / kg."

Surface modification of silver nanoparticles, according to the developers, is a powerful method to improve their bio compatibility. Bactericidal "shells" with zero or low toxicity are the most promising stabilizers,

their use, among other things, will minimize the risk of microbial resistance to silver-based materials.

Currently, the team continues a series of experiments within the framework of solving a large-scale task of obtaining new nano structured antibiotics of a wide spectrum of action that are not addictive.

The research result is presented in the international scientific journal Nano materials .

#### **14. Quantum tunneling in graphene brings the era of wireless terahertz technologies closer**

*Rusnanonet news*  
04 February 2021



Physicists from the Moscow Institute of Physics and Technology with colleagues from the Moscow State Pedagogical University and the University of Manchester have created a highly sensitive terahertz radiation detector based on the tunneling effect in graphene.

The sensitivity of the device is already superior to commercially available analogs based on semiconductors and superconductors, whPosted in Research and Development , Organizations News.

The transmission of information in wireless networks is based on the transformation of a continuous high-frequency wave into a sequence of segments - bits of information. This technique is called radiation modulation. To transmit information faster, it is necessary to increase the modulation frequency. However, in this case, it is necessary to synchronously increase the frequency of the carrier radiation. If the usual FM radio uses signals at frequencies of hundreds of megahertz, then the carrier frequency of the Wi-Fi transmitter is already about five gigahertz, and for mobile transmission systems of the 5G generation this frequency reaches twenty tgigahertz. This is far from the limit, and a further increase in the carrier frequency promises a proportional increase in the data transfer rate. However, picking up signals with frequencies of hundreds of gigahertz and higher is becoming more and more difficult.

The basic receiver used in wireless data transmission systems consists of a weak-signal amplifier based on a transistor and a demodulator that "pulls" the useful bit sequence from the microwave signal. This scheme, which originated in the era of radio and television, becomes ineffective at frequencies of hundreds of gigahertz desirable for mobile systems. The fact is that most of the existing transistors do not have time to recharge at such a high frequency.

The "evolutionary" way to solve the problem is to increase the speed of the transistor. Most of the specialists in the field of nanoelectronics work in this direction. A "revolutionary" way of solving the problem was theoretically proposed in the early 1990s by physicists Mikhail Dyakonov and Mikhail Shur and implemented - including by a group of authors in 2018. This way consists in giving up the signal amplification by the transistor and abandoning the demodulator. The transistor remains in the circuit, but its role is now different. It itself converts the modulated signal into a sequence of bits or voice information due to the non-linear relationship between current and voltage.

In their current work, the authors have proven that terahertz signal detection is very effective in a special type of transistor called a tunneling transistor.... To understand its work, it is enough to recall the principle of an elector-mechanical relay, where the supply of current to the control contacts leads to a mechanical connection of two conductors and the appearance of a current. In a tunneling transistor, applying voltage to the control contact - the gate - leads to the connection of the energy levels of the source and channel, which, in turn, also leads to the flow of current. A distinctive feature of the tunneling transistor is its very strong sensitivity to the control voltage. After all, even a small "detuning" of energy levels is enough to interrupt the quantum-mechanical process of tunneling. And even a small voltage at the control gate is able to "connect" the levels and initiate the tunneling current.

"The idea of a strong reaction of a tunneling transistor to low voltages has been known for about fifteen years," says Dmitry Svintsov, one of the authors of the study, head of the 2D materials optoelectronics laboratory at the Center for Photonics and 2D Materials at the Moscow Institute of Physics and Technology. - However, it was known only among scientists dealing with low-power electronics. Before us, no one realized that the same property of a tunneling transistor could be applied in terahertz detector technology. Georgy Alymov and co-author of the study were lucky to work in both areas. Then we realized: if the transistor opens and closes well at a low power of the control signal, then it should also pick up a weak signal "out of the air" well.

The created device is based on two-layer graphene, a unique material in which the position of energy levels (more strictly, the band structure) can be controlled using an electric voltage. This allowed the authors to switch between the modes of classical and quantum tunneling transport inside one device with just a change in the polarities of the voltage at the control contacts. This capability is extremely important for an accurate comparison of the detecting properties of classical and quantum tunneling transistors.

The experiment showed that the sensitivity of the device in the tunnel mode is several orders of magnitude higher than that in the classical transport mode. The minimum signal distinguishable by the detector against the background of noise already competes with that of commercially available

superconducting and semiconductor bolometers. However, this is not the limit: the sensitivity of the detector can be further increased in "clean" devices with a low concentration of residual impurities. The developed theory of detection, tested by the current experiment, shows that the sensitivity of the "optimal" detector can be a hundred times higher.

"The current characteristics give rise to great hopes for the creation of fast and sensitive detectors for wireless communications," says the author of the work Denis Bandurin, at the time of the work - a researcher at the University of Manchester and the Center for Photonics and Two-Dimensional Materials of the Moscow Institute of Physics and Technology, - but more importantly something else: a new area for applications is opening transistors with high switching slope for detecting terahertz radiation. And this area is not limited to graphene and is not limited to tunnel transistors. We expect that with the same success a remarkable detector can be created, for example, based on an electrically controlled phase transition. Graphene here turned out to be just a good launching pad, just a door, behind which is a whole world of exciting new research."

The results presented in this paper are an example of a successful collaboration between several scientific groups. The authors note that it is precisely this format of work that allows them once again to obtain world-class scientific results. For example, earlier the same team of scientists demonstrated how waves in the electron sea

of graphene can contribute to the development of terahertz technologies

"In the era of rapidly developing technologies, it is becoming increasingly difficult to achieve competitive results, - says the author of the study, Georgy Fedorov , deputy head of the laboratory of nanocarbon materials at MIPT. "Only by combining the efforts and experience of several scientific groups can we successfully perform the most difficult tasks and achieve the most ambitious goals, which we will continue to do."

### **15. Chemists have come up with a way to design metalloenzyme inhibitors**

*Rusnanonet news, 05 February 2021*



Scientists have figured out how to get highly reactive analogs of natural molecules (rapicons and funicons) in the laboratory. Substrates based on these molecules, in turn, can become a synthetic basis for new bioactive compounds.

In fact, scientists have proposed a new, "soft" and convenient way to carry out reactions using simple starting compounds. Based on these starting compounds, it will be possible to create a whole class of complex (heterocyclic) systems for effective and safe antiviral drugs .

An important feature of the compounds is the ability to introduce a diketoacid fragment into various classes of compounds. This fragment is responsible for biological activity through coordination with metalloenzyme coenzymes (metal cations). It is these organic compounds that are able to block the virus when the viral DNA is inserted into the DNA of the host cell. The class of such drugs also includes modern HIV drugs.

"One of the important reactions for the search for compounds with antiviral activity involves the preparation of polycarbonyl structures. This approach is used as one of the key steps in industrial methods for the preparation of the most advanced HIV integrase inhibitors, dolutegravir and bictegravir. Usually this reaction is carried out using strong bases - "hard" enolization. With the "hard" method, the range of products obtained is limited, side reactions are possible, - says Dmitry Obydenov, associate professor of the Department of Organic Chemistry and High-Molecular Compounds of the Ural Federal University... "We have discovered for the first time that the acylation of enamionodions can be carried out under conditions of " mild "enolization using acids as catalysts. Thanks to this, we have obtained the synthesis of a wide range

of oxypyrones with different structures. At the same time, it was possible to completely eliminate the side reaction. "

One of the effective methods for creating modern medicinal compounds is the use of chemically active and relatively simple molecules ("building blocks"). These molecules provide access to a wide variety of related heterocyclic structures. Very often, this role is played by polycarbonyl compounds (diketones and triketones). It is to these classes of substrates that 4-pyrones belong. Such compounds are actively used in synthetic practice and for the preparation and development of medicinal compounds such as dolutegravir and bictegravir. But, despite the high attractiveness of these "building blocks" for the design of molecules, they remain hard-to-reach substrates.

"The 3-hydroxy-4-pyrones obtained by us are chemically very active molecules, they have wide possibilities for functionalization, but they also contain the necessary pharmacophore, - says Dmitry Obydenov . "Therefore, on their basis, it is possible to construct complex organic molecules of various structures, interesting from the point of view of their biological activity."

Thus, scientists have developed a new convenient method for obtaining valuable chemical compounds, which are analogs of natural pyrons and a synthetic basis for the design of new bioactive molecules. In the future, on the basis of these molecules and compounds, it is possible to obtain drugs for the treatment of human immunodeficiency virus.

The study was supported by the Russian Science Foundation (project no. 18-73-00186). The results are published in the journal *Synthesis* .

## 16. Energy from sunlight will help to cleanse water from pollution

*RIA Novosti news, 19 January 2021*



A new model of the structure of compounds with photocatalytic properties was developed by scientists from the National Research Nizhny Novgorod State University named after N.I. Lobachevsky (Lobachevsky University). According to the authors, the results of the study open up new possibilities for using the energy of sunlight to clean water from organic pollutants.

The ingress of organic pollutants into wastewater - cyclic aromatic carbon, pesticides, phenol, poly chlorinated biphenyls - is a particular by-product of human economic activity. These chemicals and compounds negatively affect the ecosystem and, as a result, human health.

Today scientists around the world are working to improve the efficiency of water purification systems, including by the method of photocatalytic decomposition of organic poisons and chemicals. Photocatalysis is the acceleration of a chemical reaction due to the interaction of a special substance - a photo-catalyst - with incident light. Some photo-catalysts, when absorbed by light, contribute to the oxidation of organic matter, which is used for waste-water treatment, the researchers noted.

According to them, today titanium dioxide TiO<sub>2</sub> is used on an industrial scale for these purposes - it is cheap to manufacture, but it reacts to visible light in a relatively narrow range, which significantly reduces its efficiency.

Scientists at Lobachevsky University synthesized a number of substances and experimentally established their photocatalytic properties.

“We were able to establish the characteristics of compounds belonging to the structural type of  $\beta$ -pyrochlore and proposed a new structural model, based on which we predicted and synthesized new tellurium-containing compounds. The photocatalysts we have obtained on this basis, on the one hand, meet the criteria put forward to the band structure of the material for carrying out the corresponding reactions, and on the other hand, they are chemically stable in aqueous solutions and organic solvents, which will allow them to be used for a long time,” she commented Diana Fukina, Junior

Researcher, Laboratory of High-Purity Materials Technology, Research Institute of Chemistry, Lobachevsky University.

Researchers have theoretically established which reactions will be able to photocatalyze the resulting materials by determining their band structure - the relative position of the valence band and the edges of the conduction band. The results of the measurements were verified in an experiment with the substance methylene blue: two of the four obtained compounds - CsTeMoO<sub>6</sub> and RbTe<sub>1.5</sub>W<sub>0.5</sub>O<sub>6</sub> - successfully decompose the dye with a decomposition rate of about 100 and 50 percent in 8 hours, respectively, the scientists said.

According to Fukina, the obtained compounds allow working in the visible range of light, that is, directly using the energy of sunlight to initiate the start of photocatalytic oxidation reactions. When using such materials in countries with high solar activity during the day, additional electricity costs will not be needed to activate the process, as is the case with titanium dioxide.

“Scientists around the world are struggling to improve the efficiency of the photocatalytic process in various ways. For example, there is a way to modify titanium oxide by adding silver - the activity increases, but the production process immediately becomes more expensive and complex. In the case of our compounds, let some reagents be more expensive than titanium oxide, but the synthesis process is quite simple, and modifications are not required. Therefore,

now, although complex at first glance in composition, but simpler from the point of view of synthesis, compounds without precious metals seem more attractive," explained Fukina.

The scientific group continues a detailed study of the mechanism of the processes of photo-catalytic decomposition of organic matter using the compounds already obtained. This will make it possible to understand how it is necessary to modify the compounds, under what conditions and in relation to which processes their efficiency will be maximum.

### **17. Russian scientists have developed a method that will make it possible to more efficiently explore the lunar soil without landing**

*Saint Petersburg State University news*  
19 January 2021



Scientists at St. Petersburg University and Moscow State Technical University of Civil Aviation have developed a new method for studying the lunar soil, which makes it possible to more effectively study the

composition of rocks at a distance. It is based on the developments started back in the Soviet era that have been on the shelf for almost 40 years.

Methods for remote sensing of the lunar soil have existed for several decades. These are the so-called passive methods - gamma-spectral, neutron-spectral and X-ray fluorescence. All of them are based on the study of the naturally excited radiation of the surface rocks of the Moon from the orbit of its artificial satellite. And although the methods existing today have helped to achieve significant success in the study of lunar rocks, they all have certain drawbacks.

Scientists say that the main disadvantage of passive methods of remote sensing is the low intensity of natural streams of characteristic radiation from lunar rocks. A person cannot increase the intensity, let alone control these flows. It is also extremely difficult to improve these methods: one can neither increase the spatial resolution of the results obtained - maps of the composition of rocks, nor increase the number of determined elements, nor increase the accuracy of determining their content. For example, the most popular - X-ray fluorescence - method depends on solar flares, which last for a very short time, and they can only be predicted three days in advance.

The author of the study, Professor of the Department of Physical Mechanics, Faculty of Mathematics and Mechanics, St. Petersburg State University, Doctor of Physics and Mathematics Evgeny Kolesnikov: Fundamentally new

opportunities can be opened only by the transition to the use of active methods of remote elemental analysis based on spectrometry of characteristic radiation of rock-forming elements artificially excited in the surface layer of the soil.

The scientist conducts various research in this direction with his research group, and the last work was published jointly with the associate professor of the Department of Electrical Engineering and Aviation Electrical Equipment of the Moscow State Technical University of Civil Aviation, Candidate of Physical and Mathematical Sciences Alexander Zelensky (formerly a graduate and postgraduate student of the Department of Physical Mechanics of St. Petersburg State University). "At present, the results of our research are again becoming relevant in connection with a sharp increase in activity in the study of the natural satellite of the Earth. Along with Russia and the USA, Europe, China, India and Japan are now participating in the study of the Moon. An important place in modern research, as in the past, belongs to the study of the elemental composition of the surface rocks of the Moon," says Alexander Zelensky.

The method, developed by scientists from St. Petersburg State University and Moscow State Technical University of Civil Aviation, is based on the spectrometry of characteristic X-ray radiation (CRR) of lunar rocks. Researchers propose to artificially excite this radiation in the surface layer of the lunar soil with an electron beam: a special complex of equipment creates a beam and directs it to

the area of interest on the lunar surface, and then, based on the analysis of the recorded X-ray radiation, determines the elemental composition of the rocks of this area. As a result, detailed maps of the composition of the lunar surface rocks can be quickly generated.

The whole process will have to be carried out on one spacecraft, in a circum-lunar orbit, passing at an altitude of about 40 kilometers above the lunar surface.

The choice of the optimal type of characteristic radiation and the method of its excitation is dictated by the necessary requirements for the parameters of the system: it must determine the content of elements of interest to scientists in lunar rocks from a considerable distance and, at the same time, be able to be compactly located in the lunar orbit. The method developed by scientists meets all these requirements.

"The main advantage of our proposed system, in comparison with other active systems for remote elemental analysis - for example, based on the use of beams of neutral hydrogen atoms, is the relatively low energy of the probing beam electrons: from several tens of keV (for elements of the beginning of the periodic table) to hundreds of keV (for elements in the middle of the table). In addition, large values of the CXR excitation cross sections make it possible, at relatively low levels of the probe beam current, to create, in the orbit of the system carrier, flows of characteristic X-ray radiation of lunar rock elements with an

intensity sufficient for their reliable recording against the background of the bremsstrahlung of the beam electrons excited simultaneously with CXR also background fluxes of X-rays of natural origin "- explains Evgeny Kolesnikov.

With the help of the method developed by scientists, it will be possible to compile more detailed and accurate maps of the surface rocks of the Moon for both light (magnesium, aluminum and silicon) and heavy (calcium, titanium, iron) basic rock-forming elements, determine the relationship of relief forms with elemental composition, and also the composition of the rocks of individual areas of the lunar surface of scientific interest.

A more effective study of the lunar surface is necessary not only to enrich our knowledge of its nature, but also - in the long term - to build bases on the moon and begin its industrial development.

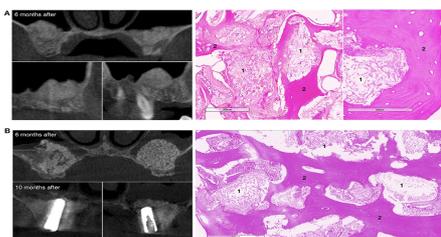
Note that Russian science began to study the possibilities of studying the lunar soil remotely - from the orbit of the Moon - more than half a century ago. In the 1960s – 70s, this area was successfully developing both in the USSR and in the USA. In the Soviet Union, the Research Institute of Mathematics and Mechanics of Leningrad State University played a significant role in the development of possible principles for constructing promising systems for remote sensing of lunar rocks. However, in the 1980s, the lunar programs were suspended and many beginnings in this area remained on paper, and then went to the archive.

Today, the improvement of methods for studying the lunar surface is again becoming relevant. Not only Russia and the United States, but also many other countries are now studying the Earth's satellite. The developments of the 1970s and 1980s, as Evgeny Kolesnikov notes, do not differ ideologically from those proposed by the scientists of St. Petersburg. "We can say that in our case the new is the well forgotten old. This study was based on the long-term developments of the laboratory of physical mechanics of the Research Institute of Mathematics and Mechanics of St. Petersburg State University, including the results of a 1982 handwritten work deposited at VINITI, written by me together with A.P. Kuryshev, a senior researcher at NIIMM. In that work, we showed for the first time that this method can be used in practice," says Evgeny Kolesnikov.

## **18. Results of clinical trials of the world's first gene-activated material published**

*Russian Science Foundation news  
10 February 2021*

Successful clinical trials of the world's first gene-activated material for bone augmentation before dental implants and for the treatment of patients with bone injuries have been carried out. This is the result of 10 years of joint work of several research teams.



The journal *Frontiers in Bioengineering and Biotechnology* published the results of clinical studies of the gene-activated material "Histograft", developed by the company "Histograft" in collaboration with the Human Stem Cell Institute (HSCI) and the Institute of Metallurgy and Materials Science. A.A. Baikova (HAVE). The results of experimental and clinical studies were supported ( 1 , 2 ) by the Russian Science Foundation.

“Gene-activated material is a substance (matrix) compatible with the body with constructs from the genes of those compounds (factors) that lead to bone growth. Such constructs can be introduced into the implant material ( in vivo gene therapy ) or into multipotent mesenchymal stromal cells, which are then implanted on matrices (ex vivo gene therapy). Among the gene-activated materials are also tissue-engineered products containing cells, where constructs with therapeutic genes have been introduced, ”explained the press service of HSCI.

Material "Histograft" - granules of octacalcium phosphate. It is one of the calcium phosphates that the authors of the article previously identified as a possible precursor of bone mineral components, capable of facilitating the specialization of

young bone cells, and as an effective scaffold for cell delivery. The granules are coated with plasmid DNA molecules with the gene for vascular endothelial growth factor (VEGF), a signaling protein produced by cells to stimulate the growth of blood vessels.

Granules serve as a matrix for the formation of bone tissue, and DNA enhances blood supply and regeneration of bone tissue in the surgical area.

Roszdraznadzor issued a registration certificate for the material in 2019. In April 2020, the company began manufacturing and introducing the product into clinical practice.

The mechanism of action of the new material has been confirmed in the laboratory. A clinical study on 20 patients showed the safety and high efficiency of the material in jaw bone grafting. Observation of patients (for about a year), examination of bone sections under a microscope revealed a relatively rapid formation of their own (native) bone tissue.

“This unique translational study has brought together 10 years of joint work of several scientific teams ... An important stage has been passed, but there is still a lot of work and new variants of gene-activated materials that we are developing. Today, Histograft, in cooperation with HSCI and IMET, continues to develop materials containing DNA of growth factors, and plans to introduce into clinical practice gene-activated products in the form of a gel, a membrane and personalized implants made using 3D

printing technologies," said the director of the company "Histograft", the practicing maxillofacial surgeon Ilya Bozo.

### 19. TPU scientists suggest using carbon dioxide for useful chemistry

*Russian Science Foundation news  
26 February 2021*



Scientists of Tomsk Polytechnic University (TPU), together with colleagues from Czech universities, have proposed a new way of utilizing carbon dioxide (CO<sub>2</sub>) from the atmosphere using plasmon energy; their method involves the production of organic compounds from CO<sub>2</sub>, which are used in various fields, including the creation of drugs, the TPU website reported on Friday.

The increase in the level of carbon dioxide in the atmosphere is a global environmental problem. Usually, the solution focuses on measures to reduce CO<sub>2</sub> emissions. An alternative option is to use carbon dioxide, which is already in the atmosphere, for beneficial chemical transformations, the polytechnics explain.

*"Researchers have found a way to use atmospheric carbon dioxide to make cyclic carbonates. These are organic compounds that are used as electrolytes for lithium-ion batteries, green solvents, and in the creation of drugs," the report said.*

The press service explains that scientists have succeeded in synthesizing carbonates under the influence of light and at room temperature, while traditional methods involve synthesis at high pressure and temperature. In the experiments, the scientists used gold nanoparticles with grafted organic molecules of a nitrogenous base and obtained cyclic carbonates by the interaction of carbon dioxide and the initial substances – epoxides.

*"Gold nanoparticles have a plasmon effect. The question of the mechanisms of plasmon chemistry itself is a hot scientific topic. A number of our previous articles have been devoted to this area of research. Control experiments allowed us to assume that the excitation of a plasmon on particles leads to the transfer of energy to captured CO<sub>2</sub> molecule without heating," TPU scientist Olga Guselnikova is quoted in the message.*

It is noted that research and experiments have demonstrated that the reaction can be carried out directly using air without additional purification or concentration of CO<sub>2</sub> under normal conditions under the influence of light. "And this always ultimately makes the synthesis easier and more environmentally friendly," - said in the message.

It is specified that the study was carried out by Tomsk polytechnics together with scientists from the University of Chemistry and Technology of Prague and the University of Jan Purkyně (Czech Republic) with the support of the Russian Science Foundation (RSF).

## 20. World's highest-latitude muon telescope built

*Russian Science Foundation news*  
26 February 2021



Employees of the Polar Geophysical Institute (PGI) with the support of the RSF has created and put on continuous registration the world's highest-latitude muon telescope for registering secondary cosmic rays.

Muons are elementary particles with a negative electric charge; they are born in the Earth's atmosphere as a result of interaction with the atmosphere of cosmic rays. This muon telescope records muons with energies from 250 MeV, as well as electrons, positrons with energies of 3-5 MeV from

directions that are not accessible to most devices on Earth.

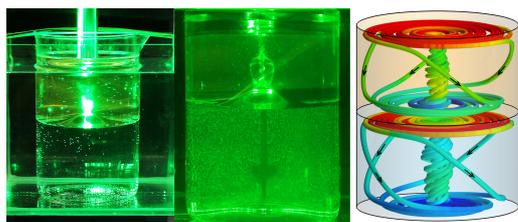
The muon telescope data will be used to assess the radiation situation in the Earth's atmosphere and near-Earth space, and to study the effect of cosmic rays on climatic processes.

A similar muon telescope will be installed on the Spitsbergen archipelago, at the PGI Barentsburg observatory.

## 21. Siberian scientists have investigated a process called "vortex domino"

*Russian Science Foundation news*  
26 February 2021

Vortex mixing is a common method of intensifying processes in chemical and bioreactors. Employees of the Institute of Thermophysics named after S.S. Kutateladze SB RAS, studying vortex hydromechanics, obtained interesting results in this area. In particular, during the search for the shape of the flows that are optimal for the growth of culture in vortex bioreactors, an interesting and impressive structure was found that mimics the strong vortices observed in the atmosphere and ocean, which can be called "vortex dominoes". Articles about this have been published in the ranking journals on fluid mechanics: *Physics of Fluids* (1, 2, 3) and *Physical Review Fluids*.



An important and intriguing fact that Siberian scientists have discovered is that a converging spiral flow in the upper fluid above the interface forms a diverging spiral motion of a denser fluid below the interface. The discovered effect of centrifugal sliding of one rotating fluid on the other requires a revision of the results of calculations of two-fluid rotating flows, performed under the condition of the continuity of the velocity and shear stress at the boundary of two media.

It is known that vortex motion is one of the basic states of a moving medium. Despite the centuries-old history of hydrodynamics, which dates back to the works of Leonardo da Vinci, Evangelist Torricelli and Isaac Newton, many problems still remain unresolved. This primarily refers to vortex flows. Natural vortices have different structures and scales in the thickness of the medium and near the free surface, where they coexist and interact with waves of different nature. Moreover, some vortex structures, such as eddies on the surface of rivers, lakes, seas and oceans, tornadoes or tornadoes, can be observed with the naked eye, while others - spiral galaxies, large-scale atmospheric circulations, ocean currents and vortex motion in the vessels of biological organisms - require special recording equipment.

Although the existence of various types of vortices in contact with a free surface, such as a vertical Rankine vortex (whirlpool) or Helmholtz semirings (behind a bluff body), has been known for a long time, important issues of vortex generation, their metamorphosis and the transfer of matter and energy by them require deeper analysis and understanding.

Chemical, pharmaceutical, biological and other processes depend on the properties of the vortex motion and change with varying the structure and degree of swirling of the flow. In both natural and technical currents, the core of the vortex can suddenly expand sharply, and the axial velocity can be reversed. This phenomenon, called vortex decay, is of interest to scientists for its important applications and the seemingly mysterious nature of vortex decay. For example, in an airplane with delta wings, this phenomenon can cause a sudden change in lift and drag, which is undesirable. On the other hand, the decay of the vortex stabilizes the flame and reduces harmful emissions in vortex burners, weakens the tornado by expanding its funnel, and also improves mixing of components in vortex biological and chemical reactors.

A useful model of a bio-reactor is a vertical cylindrical container filled with two immiscible liquids, the movement of which is caused by the rotation of the upper disc (lid). Simple geometry and isolation from external disturbances make this model very convenient for experimental and numerical studies. In particular, it makes it easier to

study the nature of the decay of a vortex and other interesting phenomena (sliding between fluids, hysteresis and the appearance of a large number of circulation cells), which this motion turns out to be rich in.

The studies of the vortex motion near the interface between two liquids were carried out by the IT SB RAS scientists in a cylindrical container made of transparent plexiglass. It was filled with two immiscible liquids: a 67% aqueous solution of glycerin (heavy liquid) and sunflower oil (light liquid). The densities and viscosities of both constituent liquids used in the experiment were determined at room temperature (22.6 C) and were kept constant during observations. A significant difference in the density of the upper and lower media provided a stable interface. The vortex motion of liquids was created by the upper disk, which rotated at a controlled angular velocity, while the other walls of the container were stationary. The rotation of the disc was generated by a stepper motor.

At the lid, the centrifugal force pushed the adjacent liquid (oil) from the axis to the periphery, generating a meridional circulation: the oil descended at the side wall to the interface, there it spirally converged to the axis, where it returned to the vicinity of the lid. This centrifugal circulation caused anticentrifugal circulation in the lower liquid: convergence to the axis at the interface, immersion at the axis to the bottom, there is a spiral divergence to the side wall and rise along the wall to the interface. Such a two-toroidal vortex

structure (already favorable for mixing) exists at the slowest rotation.

As the twist increased, there were striking changes in the flow topology. As a result of the competition between mass centrifugal forces and viscous friction forces, a new cell with centrifugal circulation appeared at the interface in the lower liquid. It originated in the center of the interface and grew downward. It was found that numerical calculations contradict this experimental scenario of a change in the flow structure. The calculated and experimental results were in good agreement in the upper liquid, but were diametrically opposed in the lower one. In contrast to the experiments in the calculations, a new cell with centrifugal circulation developed near the bottom and grew upward, reaching the interface at the axis. Further analysis showed that sliding was observed in the experiments: the radial velocity at the interface experienced a jump, changing the magnitude and even the direction.

Although the experimental and numerical scenarios for the formation of centrifugal circulation in the lower fluid were radically different, the final result was almost the same: a strongly swirling ascending jet was formed in both fluids at the axis, and the entire flow assumed the structure of a miniature two-story tornado. It was found that (with a certain choice of fluids and the ratio of their volumes) with an increase in swirl, the decay of a vortex (swirling paraxial jet) occurs either in the upper or in the lower fluids, and sometimes in both. In the latter case, a meridional current structure

appears that resembles a domino die “one-one” (hence the name “vortex domino”). In addition, the phenomenon itself can be called the domino effect, in which the vortex motion of one medium (adjacent to a rotating disk) initiates the vortex motion of another medium,

With a further increase in the rotation of the disk, a significant deformation of the interface occurred and the transfer of angular momentum through the interface increased. Above the latter, there was still a converging, and below it, a diverging spiral motion. Under such conditions, concentric circles with a radius equal to the radius of the vortex funnel appeared in the axial region. This structure was noticeable up to the appearance of pulsations in the flow, destruction of the interface and mixing of liquids.

Unlike known examples of sliding (in a rarefied gas, on a rough surface and created by surfactants), in this new case, the sliding discovered by Siberian scientists is caused by centrifugal force. This slip (the detailed mechanism of which has not yet been disclosed) is of fundamental importance, since the calculations of two-fluid rotating flows obtained under the condition of continuity now require revision.

Vortex flows of two immiscible liquids, in addition to technological processes, are present in nature. There is a stable stratification of fluids of different densities and salinity observed at the confluence of the waters of the North and Baltic Seas, as well as the Mediterranean Sea and the Atlantic Ocean. It is possible that the mechanism of

"vortex dominoes" will help to better understand such phenomena as the sudden appearance of eddies and other vortices at the interface of immiscible liquids and gases.

Now let us dwell in a little more detail on the impressive process of the two-story vortex decay - the simultaneous appearance of axial cells with anti centrifugal circulation and with a local reversal of the axial velocity direction near the centers of both the upper and lower fluid. This process occurs when the twist is reinforced. In the upper liquid, the meridional circulation transfers the angular momentum from the rotating cover down along the side wall and then to the axis at the interface. In the lower fluid, centrifugal circulation transfers angular momentum from the rotating upper fluid downward along the side wall and then to the bottom axis. In both fluids, the converging motion causes the "ballerina effect" - an increase in angular velocity when approaching the axis. An ascending swirling jet is formed in both liquids and, figuratively speaking,

The pressure on the axis of the vortex is less than on the periphery (to balance the centrifugal force). Therefore, an increase in the angular velocity leads to the appearance of zones of low pressure near the intersection of the rotation axis with the bottom (in the lower liquid) and with the interface (in the upper liquid). The low pressure in these zones draws in the surrounding fluid and thereby reduces and partially reverses the velocity on the downstream axis. As a result, cells with anticentrifugal circulation are formed near the centers of both liquids - a

double vortex disintegration occurs and a “vortex domino” structure appears.

Summing up, we can say that in the research carried out by the scientists of the IT SB RAS, such new phenomena as sliding on the interface, a two-story tornado and a double decay of a vortex forming a "vortex domino" were discovered and studied.

With regard to the practical application of these new results, they can be useful, for example, for improving technologies, where the multiplicity of cells and their location in the "vortex domino" enhances mixing, which is beneficial, for example, for biological and chemical processes. The new knowledge indicates how to achieve this: place the growing crop in a lower liquid, which is driven by an upper medium (liquid or air), propelled by the rotation of the lid. This study can help determine not only the optimal flow pattern, but also the optimal rotation speed, ensuring gentle and effective mixing of ingredients without direct mechanical contact with the solid swirl device. Thanks to this, the biological culture is not destroyed.

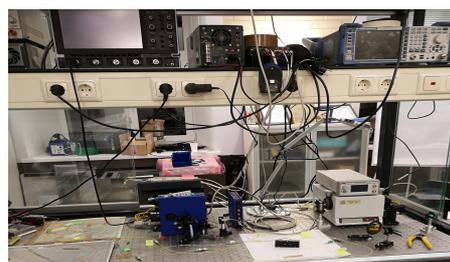
In addition, the results of the work of Siberian thermal physicists are also important for further fundamental research, since the discovered effect of centrifugal sliding requires a revision of the calculations of two-fluid rotating flows obtained under the condition of continuity of the velocity and stresses at the interface between the liquids. Another area of application is modeling the elements of the atmosphere - ocean system, which lead to the appearance

of a two-story tornado (miniature in the laboratory), and for modeling vortex motion at the interfaces between two media of different densities: for example, sea waters of different salinity or gas conglomerates of different densities in outer space.

The study was carried out as part of the work on the project of the Russian Science Foundation (grant 19-19-00083 , supervisor, Doctor of Technical Sciences, Professor of the Russian Academy of Sciences Igor Vladimirovich Naumov, the main executor, Doctor of Physics and Mathematics Vladimir Nikolaevich Stern) on the topic "Fundamental research for the creation of two-fluid centrifugal mass and heat exchangers ".

## **22. A complete laser model has been created. It will help in studying the "fingerprint" of molecules**

*RSF News, 25 February 2021*



For the development of pulsed laser technology, Russian scientists described in detail the operation of a fiber laser based on transitions of the rare earth element thulium. The accuracy of the model was confirmed by creating a setup with a given pulse duration

of about 331.7 femtoseconds. Now, being able to predict the parameters of the generated pulses, scientists can design devices with extreme performance by optimizing the parameters of the model. The research was supported by the Presidential Program of the Russian Science Foundation (RSF)

Ultra-short pulse lasers are used in many fields of science, technology and medicine, with their help it is possible to obtain coherent radiation in different spectral ranges, that is, laser pulses of shorter duration open up opportunities for varying the frequency of the converted radiation in a wider range.

The intensive development of short-pulse lasers has been going on for more than two decades. To obtain fundamentally new results, it is necessary to put as much energy as possible in the shortest possible pulse. The next generation of laser systems uses ions of rare-earth metals, in particular thulium, which belongs to the yttrium subgroup of heavy lanthanides, to generate radiation. The authors of the discussed work are developing a technology for creating fiber thulium lasers that emit short pulses at a wavelength of the order of 1.9 micrometers. Such lasers are used to generate coherent radiation in the mid-infrared range (2–20  $\mu\text{m}$ ). Here are the characteristic absorption lines of a large number of chemical compounds, which are also called "fingerprints of molecules". Using a source like this, it is possible to determine ultra-low concentrations of various substances (toxic compounds, atmospheric gases, bio-markers of diseases,

and others). It will be useful in the diagnosis of diseases, environmental monitoring, control of toxic substances in production, in scientific research. Any medium can be the object of analysis: gas, liquid, human tissues and other complex substances.

At the moment, researchers are faced with the task of obtaining the shortest possible pulses attainable for thulium lasers. Modern laser systems are very complex, and in such a search, a simple enumeration of the parameters does not allow achieving the desired result. The goal is achievable only with a complete mathematical model. The theory of propagation of ultra-short pulses in optical fibers is well known; however, insufficient attention has been paid to a complete description of the thulium laser in the scientific literature. Scientists from the Bauman Moscow State Technical University presented a detailed mathematical model developed by them that describes the behavior of radiation in their laser device. The model showed good accuracy when compared with experimental data. For example, lasing with pulses of 331.7 femtoseconds was obtained in the experiment. In this case, the error in the predicted duration was 5.4%, the spectrum width was 4.7%, and the energy error was 22.9%. The magnitude of the model error and ways to reduce it are also discussed in detail in the article.

Scientists' work on obtaining shorter pulses continues, with new results planned to be presented this year at the CLEO Europe conference .

The Institute of Photonic Technologies of the University of Aston (Great Britain), the Scientific and Educational Center "Photonics and Infrared Technology" of the Bauman Moscow State Technical University (Moscow), the Scientific Center for Fiber Optics named after E. M. Dianov of the Russian Academy of Sciences (Moscow) took part in the work.

### 23. KAMA-1 is the first Russian electric car developed on the basis of digital twin technology

*St. Petersburg Polytechnic University news*



#### ***KAMA-1 is the first Russian electric car developed on the basis of digital twin technology***

The electric car received the working name "KAMA-1" and became the first experimental model of a small-sized electric car of the M1 category (passenger cars) in Russia, oriented towards mass production, developed at the university on the basis of its own technologies for creating and using digital twins (Digital Twins) and science-intensive platform solutions.

The technology for the development of digital twins and CML-platform solutions act as a driver and integrator for the application of the system ("family") of end-to-end digital technologies of the Smart Design & Engineering class :

- Digital design (Computer – Aided Design, CAD),
- Mathematical and computer modeling (Simulation & Modeling, S&M, Simulation & Analysis, S&A),
- Verification and validation (Verification & Validation, V&V),
- System Engineering (SE) and Model Based System Engineering (MBSE),
- Computer and supercomputer engineering (Computer-Aided Engineering, CAE; High Performance Computing, HPC – CAE),
- Digital engineering (Digital Engineering, DE),
- Virtual tests, virtual benches and virtual polygons, as well as
- Artificial intelligence, blockchain, big data, etc.

It is the integration of these advanced digital technologies and the rational balancing of 20,000+ characteristics of the Matrix of Requirements, Targets and Resource Limitations in terms of style, external aerodynamics, rigidity, strength, passive safety, vibroacoustic comfort, kinematic, elastokinematic and dynamic characteristics of suspension, electrics and electronics, controllability and stability of an electric vehicle made it possible to automate the most complex creative process - the process

of developing high-tech high-tech products , providing the ability to generate previously unavailable solutions on a systematic and regular basis - “solutions beyond the knowledge, experience and intuition of the general designer”.

Smart Design & Engineering tools developed by the employees of the CompMechLab ® SPbPU Engineering Center allowed, within the framework of the KAMA-1 project, to carry out all the necessary virtual tests, simulate and virtually "measure" any technical characteristics of the product throughout the entire life cycle with detailed consideration of the physical and mechanical characteristics materials and features of technological processes.

Within the framework of the KAMA-1 project, this approach provided

- a significant reduction in the cost of the development process,
- a significant reduction in labor costs for the development of an electric vehicle in comparison with world leaders, and
- more than halving the duration of work on the production of a serial sample.

Electric vehicle "KAMA-1" is developed on the basis of its own CML-platform solutions :

- CML-Bench™ - Digital platform for the development and use of digital twins - development has been underway since 2014, three years later, in 2017 the first version of CML-Bench™ was awarded the prestigious National Industrial

Award of the Russian Federation "Industry" - "industrial Oscar "(in fact, for a defining contribution to the development of bodies in the project" Cortège "/ Unified modular platform of the AURUS car line);

- CML-CAR™ - A demonstration platform for cross-market and cross-industry "end-to-end" digital and advanced manufacturing technologies - development has been underway since 2006 for vehicles, since 2017 - for electric vehicles. In 2018, the CML-CAR™ demonstrator platform was demonstrated to Russian President Vladimir Putin ;
- CML-EV™ - A universal modular platform for the development of a range of electric vehicles for various consumer needs - development has been underway since 2018. The CML-EV™ platform enables the simultaneous development of an entire electric vehicle lineup that meets international certification requirements - from compact city electric vehicles to urban 18-meter electric buses.

As a result of the project, 79 new scientific and scientific-technical results were obtained . 6 objects of intellectual property are registered :

- Industrial design "Small-sized city electric car";
- Industrial design "LED headlight of an electric vehicle";
- The program for the automated search for the optimal inner section

- of the front side member of the body in terms of the passive safety indicators of the vehicle in frontal impact;
- Industrial sample "Car dashboard with a hidden indicator block";
  - Program for processing the results of calculated checks of the sagging of the car door;
  - A program for the automated processing of the results of calculated checks of low-speed impacts to the rear of the car.

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## 24. A Russian Strain: Covid-19 found to have mutated 18 different times in one person, with some never seen before

*RT News*  
12 January 2021

A Russian woman with a malignant lymphoma, who battled Covid-19 for five months, was found to have 18 different mutations of the virus inside her body. She first caught it in April and last tested positive in September.

The revelation was made last week, when Russian scientists published their research on Virological, a discussion forum for analysis and interpretation of virus molecular evolution and epidemiology. Contributors from four universities and one hospital analyzed the woman's genome and found two of the Danish 'mink mutations,' as well as one recently discovered in the UK.

With so many changes, what was found could be classed as its own strain.

According to Nikolai Kryuchkov, an immunologist who spoke to the Moscow daily MK, Covid-19 changes rapidly in persons with weakened immune system.

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The 47-year old patient, who at the time was undergoing chemotherapy, would fit into this category.

"Experts have noticed that the rate of mutation in the organisms of weakened people is several times higher than the rate in the normal human population," he said.

Another expert, genomic engineering specialist Pavel Volchkov, noted that the Covid-19 found in the woman has similarities to the much-feared British version, and also has its own unique characteristics.

"The new variant of the coronavirus found in Russia belongs to the same group as the British 'strain,'" he told Moscow newspaper Izvestia. "They have common mutations. But there are also new ones."

"We are looking forward to our country discovering a Russian strain with altered properties. If they already exist in Britain, in South Africa, in Brazil – there are strains here," he said. "[Russia] is much larger. A new strain should have been identified long ago."

## 25. Artificial intelligence has learned to turn text into comics



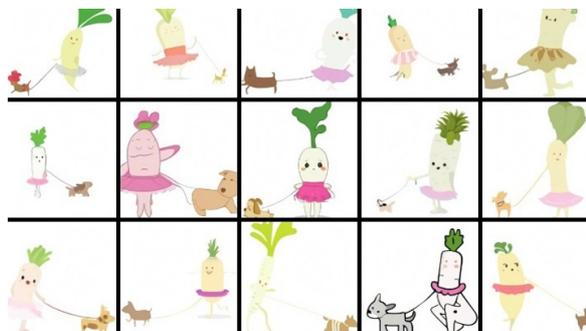
*Pic-1: Images of a female mannequin in a black leather jacket and a golden pleated skirt, generated by the GPT-3 neural network with the DALL module • E.*

The new artificial intelligence system could draw a harp-shaped snail or a tutu-shaped radish walking a dog. It is enough to ask her about it.

The novelty was developed by specialists from the OpenAI company. They have added a new module called DALL · E to their renowned GPT-3 neural network.

As a reminder, the GPT-3 system continues the text started by the user's phrase. In particular, it works well as a chatbot that answers questions. Another application of the same technology is creating a "custom writer". For example, a client might ask, "Tell me about how a dog saved a child in a fire." The computer will generate a story on this topic, quite similar to the creation of a person. Biophysicists from MIPT have developed a new method for detecting protein-protein interactions in living cells. The results of the work were published in the journal ACS Synthetic Biology.

DALL · E module extends GPT-3 capabilities. Now she can draw pictures according to the user's verbal description.



*Pic-2: Images of a small daikon radish in a tutu walking a dog, generated by a GPT-3 neural network with a DALL module • E.*

For example, he might ask him to draw a female manneBiophysicists from MIPT have developed a new method for detecting protein-protein interactions in living cells. The results of the work were published in the journal ACS Synthetic Biology.

The plots of the paintings can be both realistic and completely fantastic. For example, this is how a small daikon radish in a ballet tutu looks like in the view of artificial intelligence, walking a dog.

## 26. Vernadsky project



*Agreements on the creation of ten “Vernadsky” consortia are signed.*

At the XI Congress of the Russian Union of Rectors, the President of the RSR Academician V.A. Sadovnichy proposed a **project to create regional scientific and educational consortia “Vernadsky”**, uniting a leading university, several regional universities and research institutes and socially oriented federal and regional business.

It is advisable to form such consortia in the priority areas of development of the regional economy and taking into account the existing scientific schools of regional institutions of higher education. This initiative was supported by the President of the Russian Federation V.V. Putin and approved by the delegates of the XI Congress of the Russian Union of Rectors.

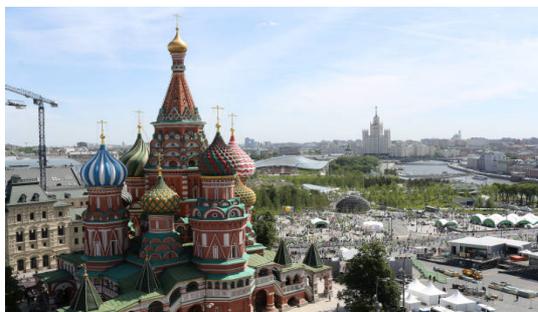
**The Vernadsky project** is to enhance the role of universities in the scientific, technological and socio-economic development of Russian regions.

**PURPOSE-** the formation of scientific and educational consortia that integrate the capabilities of leading universities, academic institutions, scientific organizations, high-tech companies of the country and the region for the socio-economic and innovative development of regions, the effective use of advanced achievements of education, science and technology.

**TASKS:**

1. Strengthening the unity of the all-Russian educational space;
2. Creation of centers for training qualified personnel, taking into account the requirements of the digital economy and the tasks of regional development;
3. Using the innovative and scientific infrastructure of leading universities in the
4. Interests of developing the human resources of the regions.

## Russia declares 2021 as the year of Science & Technology



### The government approved a plan of events dedicated to the Year of Science and Technology

More than 85 federal events will be held as part of the Year of Science and Technology in Russia. One of the key ones will be the launch of a new production of a vaccine against coronavirus at the Chumakov Scientific Center.

The plan also provides for the opening of a site for the production of recombinant drugs on the basis of the St. Petersburg Research Institute of Vaccines and Serums and the launch of the most powerful tokamak in Russia (thermonuclear reactor) T15-MD, for which they are preparing at the Kurchatov Institute.

Much attention this year will be paid to the popularization of science and modern technologies. So, in May in Russia the multimedia project “100 Questions to a Scientist” starts. Everyone will have the opportunity to ask their question to leading Russian scientists on the Yandex.Q platform.

The most interesting questions and answers will be published on the Internet.

In addition, open lectures by distinguished and young scientists will be held in Russian cities throughout the year. They will talk about their projects in the field of advanced medicine, space exploration, ecology, security, and artificial intelligence. The lectures can also be watched remotely - online broadcasts are provided for all speeches.

Also, in the Year of Science and Technology, it will be possible to sign up for an excursion to advanced laboratories and see how experiments are going on. Scientists will show how high-tech equipment works and talk about their research.

As a reminder, at the initiative of Russian President Vladimir Putin, 2021 was declared the Year of Science and Technology. The main objectives of the project are to attract talented youth to the field of science and technology and tell about the scientific achievements of Russian scientists.

The plans highlight strong Private Public partnership to promote Science and Technology and integrats all stakeholders for significant outputs throught the year, leading to promote STI interventions for societal and economic benefits. Thr program is divided into two parts:-

**(a) Major Federal Events/Inaguration**

**(b) Major Competitions/Events.**

## (a) Major Federal Events/Inauguration

| No | Event Title  | Event Period           | ORGANIZATION RESPONSIBLE FOR EVENT   |
|----|--|------------------------|--|
|    | Competitions / ongoing events  |                        |  |
| 1  | Forum «Lomonosov»  | February - March 2021  | Lomonosov Moscow State University  |
| 2  | X High-Tech Week and technology entrepreneurship for school children                                 | March 2021             | <ul style="list-style-type: none"> <li>• RUSNANO Group</li> <li>• Rosatom State Corporation</li> <li>• State Corporation «Roscosmos»</li> <li>• Sberbank's Investment Fund " «Contribution to the Future»</li> <li>• PJSC « RusHydro»</li> </ul>   |
| 3  | Track "Science" of the All-Russian competition « Leaders Of Russia»                                  | March - September 2021 | <ul style="list-style-type: none"> <li>• ANO « Russia-the Land of Opportunities»</li> <li>• Coordinating Council for Women's Affairs</li> <li>• youth in science and education</li> <li>• Members of the Presidential Council of the Russian Federation</li> <li>• Federation for Science and Education</li> </ul> |
| 4  | Summit of Young Scientists and Engineers « Big Cities challenges for society, the state and science» | April 2021             | « Talent and Success Foundation»<br>NTU « Sirius»  |
| 5  | Union State Award Ceremony in the field of Science and Technology                                    | April 2021             | Ministry of Education and Science of Russia  |
| 6  | International Engineering University « CASE-IN»championship  | April - June 2021      | Ministry of Education and Science of Russia  |
| 7  | XXIX All-Russian Festival « Russian Student's Spring»  | April - June 2021      | Ministry of Education and Science of Russia  |
| 8  | Victory Train «Science in the Great Patriotic War World War II»                                      | April-December 2021    | Ministry of Education and Science of Russia<br><br>JSC « RUSSIAN RAILWAYS»   |
| 9  | Program « Train of science in the metro»   | April-December 2021    | ANO « National Priorities»   |
| 10 | All-Russian competition « Digital Breakthrough»  | April-December 2021    | ANO " Russia-the Land of Opportunities»<br><br>Ministry of Finance of Russia   |
| 11 | All-Russian Science Festival   | April-December 2021    | Lomonosov Moscow   |

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|    | « NAUKA 0+»   |                       | State University  |
| 12 | All-Russian Student Olympiad « I'm a professional»  | April-December 2021   | Ministry of Education and Science of Russia   |
| 13 | IV Innovative St. Petersburg Medical forum  | May 2021              | Ministry of Health of Russia  |
| 14 | All-Russian Robotics Festival «Mercurochrome»   | May 2021              | Ministry of Emergency Situations of Russia  |
| 15 | Russian High Technology Week  | June 2021             | <ul style="list-style-type: none"> <li>• JSC « Expocentre »</li> <li>• Chamber of Commerce and Industry Russian Federation</li> <li>• State Duma Committee</li> <li>• Federal Assembly of the Russian Federation</li> <li>• Federation for Education and Science</li> </ul> |
| 16 | Presentation of the achievements of Russian scientists at the St. Petersburg International Economic Forum-2021, Eastern economic forum-2021 | June - September 2021 | <ul style="list-style-type: none"> <li>• Roscongress Foundation</li> <li>• Ministry of Economic Development of Russia</li> <li>• Ministry of Industry and Trade of Russia</li> <li>• Ministry of Education and Science of Russia</li> </ul>                                 |
| 17 | The cycle of All-Russian events aimed to support women scientists in Russia   | June - October 2021   | Federation Council of the Federal Assembly Russian Federation   |
| 18 | VI International Conference on Quantum Technologies ICQT 2021   | July 2021             | Russian Quantum Center Rosatom State Corporation  |
| 19 | Russian Creative Week dedicated to Year of Science and Technology   | July 2021             | Roskultcenter   |
| 20 | Design and educational intensive training for teams in the field of end-to-end technologies «NTI Archipelago (2021)»                        | July 2021             | University 2035 NTI Platform  |
| 21 | International Industrial Exhibition «Innoprom»  | July 2021             | Ministry of Industry and Trade of Russia  |
| 22 | Presentation of achievements of Russian scientists as part of the event of the International Aerospace Salon «MAKS-2021»                    | July 2021             | State Corporation «Rostec»  |
| 23 | All-Russian competition of Young Technological specialist   | July-December 2021    | Ministry of Education and Science of Russia   |

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| 24 | Presentation of achievements of Russian scientists within the framework of the International military-technical forum «Army-2021»   | August 2021                 | Defense Ministry of Russia   |
| 25 | International Railway Salon space 1520 « PRO//Movement.Expo»  | August 2021                 | JSC " RUSSIAN RAILWAYS»  |
| 26 | International Forum technological development «Technoprom»  | August 2021                 | Government of the Novosibirsk Region   |
| 27 | International Scientific and Technological Forum for Convergent and Nature-like Technologies  | September 2021              | SIC " Kurchatov Institute»   |
| 28 | Eastern Economic Forum  | September 2021              | Roscongress Foundation   |
| 29 | International Competition for Artificial Intelligence intelligence among children   | September 2021              | PJSC " Sberbank of Russia»   |
| 30 | International Sports Forum "Russia is a sports power", within the framework of the forum scientific conference with international participation "Physical culture and sports activity of the population for increasing life expectancy" | September - October 2021    | Ministry of Sports of Russia   |
| 31 | All-Russian Interdisciplinary Olympiad of school children «National Technological Academy Olympiad»   | September 2021 - April 2022 | NTI Circle Movement<br>Ministry of Education and Science of Russia               |
| 32 | Russian Agro-industrial Exhibition «Golden autumn»  | October 2021                | Ministry of Education and Science of Russia<br>Ministry of Agriculture of Russia |
| 33 | International Forum « Russian Energy Industry week»   | October 2021                | Ministry of Energy of Russia   |
| 34 | X International Congress « Sports, Human, Health»   | October 2021                | Ministry of Sports of Russia   |
| 35 | All-Russian Forum « Science of the Future-Science Of youth »  | October 2021                | Ministry of Education and Science of Russia                                      |
| 36 | « Open Innovations Forum»   | October 2021                | « Skolkovo Foundation»   |
| 37 | All-Russian Scientific Forum «Science and Technology universities»  | October 2021                | Government of the Nizhny Novgorod Region   |
| 38 | Popularization of the achievements of the Russian Federation in the field of science  | October 2021-March 2022     | Ministry of Industry and Trade of Russia   |

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|    | and technology at the World universal exhibition "EXPO-2020" (Dubai, United Arab Emirates)   |                              |   |
| 39 | Russian National Award «Student of the Year»   | November 2021                | Ministry of Education and Science of Russia<br>ANO «Russia-The Land of Opportunities»   |
| 40 | VI International Arctic Forum "Arctic the territory of the dialog"   | November 2021                | Roscongress Foundation  |
| 41 | A series of events on artificial intelligence and data analysis «AI Journey» and «AI Journey Junior»   | November 2021                | PJSC «Sberbank of Russia»   |
| 42 | National exhibition «Vuzpromexpo»  | December 2021                | Ministry of Education and Science of Russia<br>Ministry of Industry and Trade of Russia |
| 43 | All-Russian competition of youth author's projects and projects in the field of education, science and culture technologies aimed at socially economic development of Russian territories «My country - My Russia» | December 2021                | ANO "Russia-the Land of Opportunities»<br>Ministry of Education and Science of Russia   |
| 44 | International Scientific and Practical Forum «Russian Health Week-2021»  | December 2021                | Ministry of Health of Russia  |
| 45 | Creation of new international laboratories on the basis of universities with the support of Sber in the following areas HTP  | during the whole year (2021) | PJSC «Sberbank of Russia»<br>Ministry of Education and Science of Russia                |
| 46 | Multimedia popular science project «Science in 360-degree format»  | during the whole year (2021) | Russian Science Foundation  |
| 47 | "Young Professionals" Championship (WorldSkills Russia)  | during the whole year (2021) | ANO "Development Agency professional skills (Worldskills Russia)»                       |
| 48 | Student scientific expeditions «Floating university»   | during the whole year (2021) | Ministry of Education and Science of Russia   |
| 49 | Science Film Festival  | during the whole year (2021) | Ministry of Culture of Russia   |

## b) Major Competitions/Events

|    | Event Title  | Event Period           | ORGANIZATION RESPONSIBLE FOR EVENT  |
|----|--|------------------------|---|
|    | <u>The most significant federal events</u>   |                        |   |
| 1  | Multimedia project "100 questions to scientists»   | March 2021             | ANO " National Priorities»  |
| 2  | Opening ceremony of the production site for the production of a vaccine against COVID-19 on the base of "The Federal State Budgetary Institution "M. P. Chumakov FNCRIP RAS" | March 2021             | Ministry of Education and Science of Russia   |
| 3  | Launch of the "Baikal-GVD neutrino telescope"  | March 2021             | Joint Institute for Nuclear Research  |
| 4  | Events for creative universities and representatives areas of creative industries ArtScience   | March-December 2021    | Ministry of Culture of Russia   |
| 5  | Creating an online calendar of scientific achievements in Russia, " Not a day without science»   | March-December 2021    | ANO " National Priorities»<br>Ministry of Education and Science of Russia   |
| 6  | The project " Science is near»   | March-December 2021    | ANO " National Priorities»<br>Ministry of Education and Science of Russia   |
| 7  | Special event dedicated to physics start-up of the T-15 MD tokamak   | April 2021             | SIC " Kurchatov Institute"  |
| 8  | Solemn laying of the foundation stone (construction) two scientific research vessels and the launch of an open Competition for assigning the name to outstanding scientists  | April - June 2021      | Ministry of Education and Science of Russia<br>Ministry of Education of Russia  |
| 9  | Thematic scientific shifts in summer schools Children's and student camps, All-Russian Scientific and Technological Competition projects "Big Challenges»                    | April - September 2021 | Ministry of Education and Science of Russia<br>Talent and Success Foundation»<br>NTU<br>" Sirius" Regional centers for identification and support for gifted children created by Sirius models» |
| 10 | Themed proms: - All-Russian Student Graduation "With Science in your heart» All-Russian School Graduation  | June - July 2021       | Ministry of Education and Science of Russia<br>Ministry of Education of Russia  |
| 11 | Siberian Ring of Photonic Factors Special event dedicated to Center for Interdisciplinary Research   | July – Sep 2021        | Ministry of Education and Science of Russia<br>Ministry of Education of Russia  |
| 12 | Technosreda Festival at VDNKH  | August 2021            | Ministry of Education and Science of Russia   |
| 13 | International Cyber Tournament "Battle for Science"  | August 2021            | Ministry of Education and Science of Russia   |
| 14 | All-Russian open lesson on the Day of Knowledge " Modern Russian Science»  | September 1, 2021      | Ministry of Education and Science of Russia   |
| 15 | Popular science reality show " Mind Games"   | September 2021         | Ministry of Education and   |

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| 16 | A solemn event dedicated to the beginning of construction of a key new construction site of technological platform of nuclear power - a power unit with a unique reactor installation BREST -OD -300           | September - November 2021 | “Rosatom” State Corporation  |
| 17 | Launching of the scientific research center the vessel “Pioneer-M”   | September - December 2021 | Ministry of Education and Science of Russia<br>United Shipbuilding Company corporation   |
| 18 | Grand opening of the Polytechnic Museum after reconstruction   | September-December 2021   | Ministry of Culture of Russia  |
| 19 | Establishment of the National Center for Physics and Mathematics in Sarov, Nizhny Novgorod region  | October 2021              | “Rosatom State Corporation”  |
| 20 | Skolkovo Nobel Forum   | November 2021             | ANO “Skolkovo Forum”   |
| 21 | All-Russian festival dedicated to 100th anniversary of the Kruzhok Movement  | November 2021             | Ministry of Education and Science of Russia NTI Kruzhok Movement   |
| 22 | Awards “For Loyalty to Science - 2021”, aimed to promote scientific achievements   | November 2021             | Ministry of Education and Science of Russia  |
| 23 | Celebrations dedicated to the 310 <sup>th</sup> birth anniversary of the first Russian scientist-naturalist M. V. Lomonosov  | November 2021             | Lomonosov Moscow State University  |
| 24 | Opening of the Research and Production Complex Federal Center for Brain and Neurotechnology FMBA of Russia, including production site for the production of cellular products and viral drugs (GMP production) | November - December 2021  | FMBA of Russia   |
| 25 | International Congress of Young Scientists. Closing ceremony of the Year of Science and Technology   | December 2021             | Roscongress Foundation<br>Coordinating Council for youth Affairs in science and education<br>Members of the Presidential Council of the Russian Federation<br>Federation for Science and Education |
| 26 | The first session of the full acceleration cycle on derived beams of the “NICA” complex (experimental program BM@N)  | December 2021             | Joint Institute for Nuclear Research   |
| 27 | Special events dedicated to 75 <sup>th</sup> launching anniversary of the first F-1 nuclear reactor  | December 2021             | SIC “Kurchatov Institute»  |
| 28 | Russian Scientific and Technical Congress “Directions of national scientific research-Technology breakthrough 2030”  | December 2021             | Federal State Budgetary Institution, “Russian Academy of Sciences”<br>ANO “Agency for Strategic Research initiative”   |

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| 29  | Celebrating the 60th anniversary of the first human flight into space   | during the whole year (2021) | State Corporation "Roscosmos"<br><br>Lomonosov Moscow State University<br><br>VOD "Volunteers of Victory" Innovation Promotion Fund Geoscan Group of Companies  |
| 30  | Competition of student scientific communities   | during the whole year (2021) | Ministry of Education and Science of Russia   |
| 31  | The project "Science- Territory of Heroes»  | during the whole year (2021) | ANO "National Priorities" Ministry of Education and Science of Russia   |
| 32  | Promotion "On the edge of science": excursions and lessons for children students, public speeches on the topic the main achievements of Russian science and technology  | during the whole year (2021) | Coordinating Council for Women's Affairs youth in science and education<br>Members of the Presidential Council of the Russian Federation<br>Federation for Science and Education Ministry of Education and Science of Russia Research |
| 33  | Opening of new objects of scientific and technological infrastructure, including: - opening of the Center for Manufacturing and nano-biotechnologies as part of the FNCC FHM FMBA Of Russia - opening of a research and production complex for the production of recombinant drugs on the basis of              | during the whole year (2021) | Ministry of Education and Science of Russia Talent and Success Foundation»<br>NTU "Sirius" FMBA of Russia Federal executive bodies authorities  |
| 34  | Russia's Issuance of commemorative coins and state symbols postage stamps dedicated to the Year of Science and Technology   | during the whole year (2021) | Central Bank of Russia<br>Digital Ministry of Russia<br>JSC "Marka"   |
| 35  | Discovery of carbon polygons and initialization the project for the creation of an international Arctic station "Snowflake", the beginning of the project-survey work   | during the whole year (2021) | Ministry of Education and Science of Russia<br>Government of the Yamal-Nenets Autonomous District<br>Government of the Mumansk Region   |
| 36. | Presentation of the main results and directions activities of world-class Scientific and educational centers, world-class Scientific centers, Centers of Competence of the National Technology Initiative on priorities<br><br>Strategies of scientific and technological development of the Russian Federation | during the whole year (2021) | Ministry of Education and Science of Russia   |