SAPERE AUDE

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FOR THE GLORY OF SCIENCE ENGLISH LANGUAGE EDITION SINCE 1958 №1 (1933) 2014

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Special Issue:

MIPT Nobel Prize Winners



Rector's column



Nikolay Kudryavtsev MIPT rector

DEAR READER,

You hold in your hands the first English edition of MIPT's magazine "For the Glory of Science." MIPT has been actively increasing its presence in the English-speaking world: we hold international conferences in English on campus, recently opened an authorized TOEFL iBT* testing center, and launched new training programs in English this academic year. This summer we also welcomed international interns from leading universities, some of whom decided to continue their education here, and we are expecting to host members of our International Board on September 27-28 of this year.

MIPT's international history spans perhaps the history of the institute itself – our founding fathers, Pyotr Kapitsa and Nikolay Semyonov, were Nobel Prize winners. Six teachers and two graduates of MIPT, Andre Geim and Konstantin Novoselov, have also received Nobel Prizes. Today MIPT graduates work in leading laboratories around the world, including in California, Manchester, Chicago, Berlin, Boston and Washington, D.C.

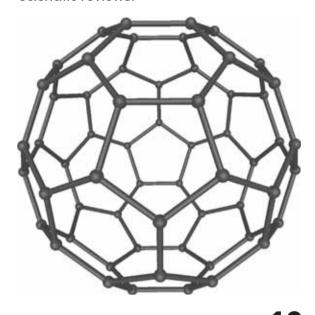
We decided to dedicate this issue, the first in a series of English-language annuals, to our history, namely the Nobel Prize winners and alumni who have left their mark on the international scientific scene. We believe that the number of such stories will increase over time.

SCIENCE AT MIPT.....

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We conduct research in various fields, including physics, astronomy, chemistry, molecular biology and medicine. In this issue we present a selection of recently published scientific reviews.

FOREIGN STUDENTS AT MIPT.....20
This summer more than 30 students from 13 countries visited MIPT for training as part of the Summer Internship 2014 program. They conducted research at our laboratories and research centers.



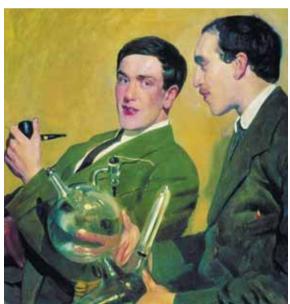


ASK A SCIENTIST

MIPT NOBEL PRIZE WINNERS 22 MIPT founding fathers, Pyotr Kapitsa and Nikolay Semyonov, were Nobel Prize winners. Six teachers and two graduates of MIPT, Andre Geim and Konstantin Novoselov, have also received Nobel Prizes. We take a look at all of them.

MIPT's press office recently presented a new section in institute communications where MIPT-based researchers answer non-specialists' questions on science.





THREE NOBEL PRIZE WINNERS .. 44 MIPT rector Nikolay Kudryavtsev shares his story of working with Nikolay Semenov, Alexander Prokhorov and Vitaly Ginzburg.

THE MAIN QUESTION OF LIFE 46

On September 1st, a new building for MIPT's lyceum for gifted children was opened. Konstantin Novoselov, 2010 Nobel Prize winner and MIPT graduate, spoke at the opening ceremony and answer some questions.

THE FATHER OF METAMATERIALS

A 1951 graduate of the Department of Physics and Technology at Moscow State University (MSU), professor at MIPT and laureate of the State Prize of the USSR, Victor Veselago, spoke with "For the Glory of Science" about his experiences during his studies at "MIPT 1.0" – the Department of Physics and Technology at MSU.

In an interview with MIPT's press service, a 1957 MIPT graduate, the head of the RMS project and the CMS project at the Large Hadron Collider, Professor Igor Golutvin spoke about his first steps at MIPT and about the progress made on the world's most exciting scientific endeavor.

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The contacts of Moscow Institute of Physics and Technology are vast and various. From Nobel Prize winners to cosmonauts, diplomats and great chess players, people from all over the world come to visit our institute. The editorial office of "For the Glory of Science" magazine offers readers an image gallery of 12 notable guests who visited MIPT in 2014.



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Scientists Come Closer to the Industrial Synthesis of a Material Harder than Diamond

Researchers from the Technological Institute for Superhard and Novel Carbon Materials in Troitsk, MIPT, MISiS, and MSU have developed anew method for the synthesis of an ultrahard material that exceeds diamond in hardness.

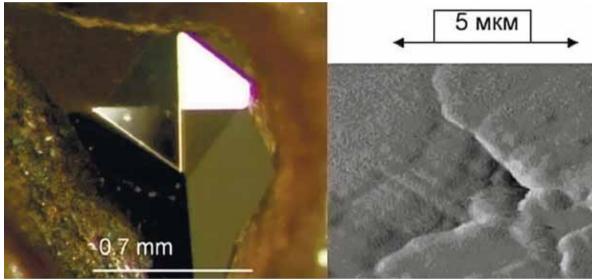


Photo of a Vickers indenter made of ultrahard fullerite. Courtesy of MikhailPopov

An article recently published in the journal Carbon describes in detail a method that allows for the synthesis of ultrahard fullerite, a polymer composed of fullerenes, or spherical molecules made of carbon atoms.

In their work, the scientists note that diamond hasn't been the hardest material for some time now. Natural diamonds have a hardness of nearly 150 GPa, but ultrahard fullerite has surpassed diamond to become first on the list of hardest materials with values that range from 150 to 300 GPa.

All materials that are harder than diamond are called ultra hard materials. Materials softer than diamond but harder than boron nitride are termedsuperhard. Boron nitride, with its cubic lattice, is almost three times harder than the well-known corundum.

1 http://mipt.ru/upload/medialibrary/6d8/162-168.pdf

Fullerites are materials that consist of fullerenes. In their turn, fullerenes are carbon molecules in the form of spheres consisting of 60 atoms. Fullerene was first synthesized more than 20 years ago, and a Nobel Prize was awarded for that work. The carbon spheres within fullerite can be arranged in different ways, and the material's hardness largely depends on just how interconnected they are. In the ultrahard fullerite discovered by the workers at the Technological Institutefor Superhard and Novel Carbon Materials (FSBITISNCM), C_{60} molecules are interconnected by covalent bonds in all directions, a material scientists call a three-dimensional polymer.

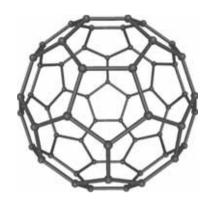
However, the methods providing production of this promising material on an industrial scale are not available yet. Practically, the superhard carbon form is of primary interest for specialists in the field of metals and other materials processing: the harder a tool is, the longer it works, and the more qualitatively the details can be processed.

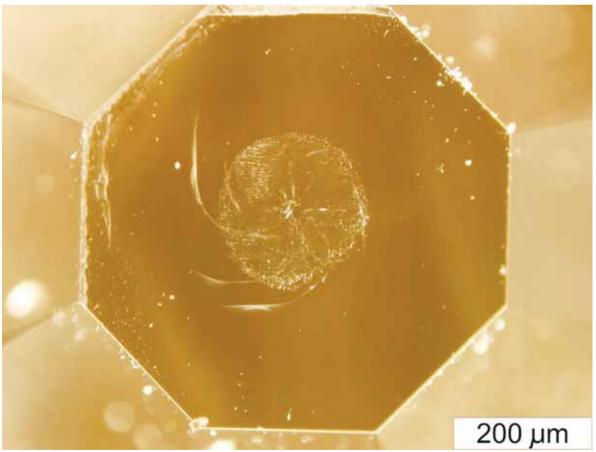
What makes synthesizing fullerite in large quantities so difficult is the high pressure required for the reaction to begin. Formation of the three-dimensional polymer begins at a pressure of 13 GPa, or 130,000 atm. But modern equipment cannot provide such pressure on a large scale.

The scientists in the current study have shown that adding carbon disulfide (CS_2) to the initial mixture of reagents can accelerate fullerite synthesis. This substance is synthesized on an industrial scale, is actively used in various enterprises, and the technologies for working with it are well-developed. According to experiments, carbon disulfide is an end product, but here it acts as an accelerator. Using CS_2 , the formation of the valuable superhard material becomes possible even if the pressure is lower and amounts to 8GPa. In addition, while previous efforts to synthesize fullerite at a pressure of 13 GPa required heating up to 1100K (more than 820 degrees

Celsius), in the present case it occurs at room temperature.

"The discovery described in this article (the catalytic synthesis of ultrahard fullerite) will create a new research area in materials science because it substantially reduces the pressure required for synthesis and allows for manufacturing the material and its derivatives on an industrial scale", explained Mikhail Popov, the leading author of the research and the head of the laboratory of functional nanomaterials at FSBI TISNCM.





Diamond anvils malformed during synthesis of ultrahard fullerite. Note the dent in the center.

MIPT-based Researcher Predicts New State of Matter

A researcher with the Department of Electrodynamics of Complex Systems and Nanophotonics, Alexander Rozhkov, has presented theoretical calculations which indicate the possible existence of fermionic matter in apreviously unknown state – in the form of a one-dimensional liquid, which cannot be described within the framework of existing models. Details are contained in Rozhkov's article in the journal Physical Review Letters, and are also available as a preprint at www.arxiv.org.

Rozhkov explained that the one-dimensional liquid state of matter is not necessarily one that can be observed with the naked eye on a macroscopic scale. The term «liquid» should be understood broadly, he said; it applies to models describing multi-particle systems with inter-particle interaction. Such models can be described as quite ordinary objects such as electrons in conductors and more sophisticated objects, such as nanotubes, nanowires or graphene sheets.

"Currently there are two general models of fermionic matter, namely fermionic liquid (for three- and two-dimensional spaces) and Tomonaga-Luttinger liquid (for one-dimensional space)," Rozhkov said. "I showed that it is possible to produce yet another state of one-dimensional matter adjusting certain interactions. This state is similar to both of these models, but cannot be reduced to either. I suggested calling it aquasi-fermionic liquid."

As follows from the proposed name, the newly found matter consists of fermions, which are particles with half-integer spin. (Spin is the quantum characteristic of a particle, while half-integer is an integer plus one-half.) According to the laws of quantum mechanics, the

behavior of substances consisting of fermions differs from that of matter consisting of bosons, which are particles with integer spin.

The difference between Bose and fermionic liquids can be illustrated with the example of liquid helium: the atom of a helium-4 isotope has a Bose nucleus, and forms of Bose liquid that undergoes Bose condensation at temperatures below 2.17 Kelvin. A Bose-condensed liquid exhibits superfluidity, for example, it can flow through any crack without meeting any resistance. Helium-3 has a fermion nucleus, and therefore forms afermionic liquid. To turn helium-3 into a superfluid one needs to cool it to 0.0025 Kelvin.

Rozhkov also noted that at low temperatures and in high magnetic fields, fermions begin to behave as if they had no spin, which simplifies their modeling, allowing a researcher to maintain sufficient accuracy.

Preliminary estimates show that the new onedimensional liquid statecan be obtained using atoms cooled to very low temperatures in magnetic traps. However, it is still too early to consider the practical application of such a system, according to Rozhkov.

¹ http://journals.aps.org/prl/abstract/10.1103/PhysRevLett.112.106403

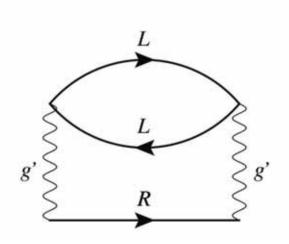


Optical tweezers

"In almost any contemporary paper, both theoretical and experimental, researchers describe the practical application of their discovery, but at this stage I would not hopetoo much for any practical application," Rozhkov said. "I found an exotic mutant different from anything currently known. And whether this can be applied in practice remains to be seen. At this moment I don't think so," said Rozhkov.

Rozhkov added that the group of researchers he works with is also looking into other low-dimensional and multi-particle systems. For example, new results were recently obtained on the possible anti-ferromagnetism in two-layer graphene-AA, and a new description for quantum dots of superconducting material was drafted.

MIPT's press service would like to thank Dr. Alexander Rozhkov for his generous help in writing this article.



The leading self-energy correction diagram. The solid lines with arrows and 'L', 'R' chirality labels correspond to the fermion propagators (http://arxiv.org/pdf/1405.4790v1.pdf)..

Signaling Pathways and Cancer Diagnosis

A group of Russian scientists, including staff members of the Russian Academy of Sciences, MIPT and the Federal Medical and Biological Agency (FMBA), used bioinformatic analysis of the activation of signaling pathways to develop a method for diagnosing and treating nine different types of cancer found in humans.



The method draws on the bioinformatics algorithm OncoFinder, which allows for comparing the expression of all genes in a cell, in contrast to traditional molecular markers which are based on the products of expression of individual genes at the RNA and protein levels. The results of the study were published in the journal OncoTarget¹.

To diagnose cancer, doctors usually use biochemical markers that are sensitive to certain types of cancer. However, such markers haven't yet been identified for all types of tumors, and the tumor markers used in clinics are not always sufficiently sensitive.

It has been proven that some intracellular signaling pathways are actively involved in oncogenesis, while others are "silent" in transformed cells and tissues. Intracellular regulation has significant influence on metastasis, tumor invasion and resistance to drug therapy. OncoFinder quantifies the activation of signaling pathways in normal cells and in pathological specimens, including tumor cells.

The scientists studied the activation of 82 different signaling pathways, including about 2,700 genes. They were

the first to make quantitative profiles of the activation of signaling pathways in 292 samples of tumors, including bladder cancer, basal cell carcinoma, glioblastoma, hepatocellular carcinoma, lung adenocarcinoma, squamous carcinoma of the tongue, primary melanoma, prostate cancer and renal cancer.

Over 50 scientists have contributed to the development of the OncoFinder method, including the groups of Nikolai Borisov (FMBA), Alexander Aliper (Moscow State University), Sergey Rumyantsev (MIPT), Andrei Garazha(MIPT), Mikhail Korzinkin (National Research Nuclear University MEPhI), Nikolai Zhukov (PyotrHerzen clinic), Olga Kovalchuk (Alberta, Canada), Charles Cantor (Boston University), Chinsong Zhu (John Hopkins University) and Alexander Zhavoronkov(MIPT).

OncoFinder offers a wide range of opportunities and can be used to fight not only cancer but also the aging of an organism. In their previous studies, the scientists proved that OncoFinder effectively selects geroprotectors and compares different data obtained through microchipping and new-generation sequencing platforms. Data regarding the activation of signaling pathways can be used as tumor markers for different types of tumors instead of conventional gene expression biomarkers. Processing data with OncoFinder greatly facilitates the selection of a chemotherapy course and prediction of the dynamics of a disease.

 $^1http://www.impactjournals.com/oncotarget/index.php?journal=oncotarget@page=article@op=view@path[]=2358$

Unknown Form of Magnesium Carbide

An international team of researchers from the United States and France, along with the head of a state-funded "mega grant" laboratory based at MIPT, Artyom Oganov, has synthesized a previously unknown form of magnesium carbide. This material can be used for synthesizing carbon nanostructures and other compounds. Details can be found in an article published in the journal Inorganic Chemistry¹.

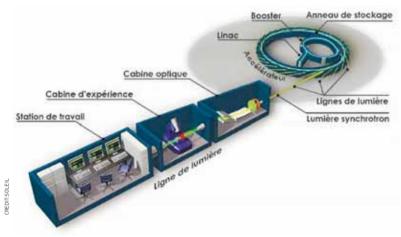
A team of researchers from the Carnegie Institution for Science (United States), Paris-Sorbonne University, the European Synchrotron Radiation Facility in Grenoble, the SOLEIL synchrotron facility (France), the State University of New York at Stony Brookin the United States, and MIPT has synthesized and studied samples of a substance named beta magnesium carbide (Mg,C,).

To synthesize the compound, the group used presses that are able to create pressures of up to several tens of GPa (hundreds of thousands of atmospheric pressures) and that can heat a sample to more than 1,000 degrees Celsius. Using X-ray analysis, NMR (nuclear magnetic resonance) and optical spectroscopy they collected data showing that this substance has a unique atomic structure.

Experiments showed that the new version of magnesium carbide retains its structure after pressure is reduced to normal and temperatures return to normal room temperatures. It is still too early to speak about any devices that could use the obtained substance, the researchers say, but they add that, nevertheless, Mg₂C₃ is a promising element for synthesizing other compounds, including various carbon nanostructures.

Chemistry and Synchrotrons

Originally intended for experiments in the field of elementary particle physics, accelerators have been an invaluable tool for research in many different areas. Turning a beam of charged particles produces X-rays, which exceeds the radiation from traditional cathode tubes (a standard X-ray source for medical equipment) by a number of parameters. Accelerators are capable of



the SOLEIL synchrotron facility

producing radiation many orders of magnitude brighter, providing record short impulses. Moreover, the radiation is monochromatic and with the required polarization.

Synchrotrons have enabled chemists to carry out X-ray diffraction analysis of samples of any nature, including both inorganic compounds and biomolecules. Modern accelerators can X-ray minerals, details of mechanisms and structures, archaeological artifacts, and determine the exact chemical composition of a sample. Furthermore, ultra short impulses of radiation allow scientists to take snapshots of certain phases of chemical reactions, "catching" short-living intermediate products.

Modern synchrotron radiation centers offer various pieces of equipment, including furnaces, presses and spectrometers.

1 http://pubs.acs.org/doi/pdf/10.1021/ic500960d

IVOLGA Looks at Greenhouse Gases

MIPT's Laboratory for the Spectroscopy of Planetary Atmospheres has come up with a high-resolution meter to gauge the concentration of gases in the atmosphere with unparalleled precision. The infrared spectrum radiometer is described in an article recently published in the journal Optics Express.

The paper¹, authored by Alexander Rodin, Artem Klimchuk, Alexander Nadezhdinsky, Dmitry Churbanov and Maxim Spiridonov, says that the new spectrum radiometer is 100 times more precise than the best available near-infrared spectrometers, and 10 times more accurate than a meter created on a similar principle recently described by NASA's Goddard Center.

Tracking down carbon dioxide, methane and other gases with simultaneous determination of their concentrations at different altitudes is necessary, in particular, for research into global warming. The vast majority of scientists do not doubt the correlation between growing temperatures on the planet and the greenhouse effect, but so far it has been impossible to positively predict future changes in global warming. A current lack of data on the distribution of greenhouse gases also compromises the forecasting and, consequently, the development of appropriate response measures. This is because in order to create a dense network of monitoring stations, many large, sophisticated and expensive spectrometers are needed.

The meter created by the Russian scientists is distinctive not only for its very high resolution, but also for its easy maintenance. The authors of the paper stress that their meter is far less susceptible to external disturbances compared with existing analogues. Its performance depends to a lesser extent on vibration, humidity and exposure to both low and high temperatures.

Alexander Rodin explained that the meter uses

the heterodyne principle, known for over 100 years. The essence of the method could be best described as follows: a received signal is added to a reference signal to form an intermediate frequency signal. Generally, it does not matter whether it's a radio wave or sunlight passing through the atmosphere, as is the case in the new meter.

The converted signal is much easier to process, namely to amplify and to filter. Moreover, when the frequency of the reference signal is sufficiently stable, extremely high sensitivity can be achieved. The only problem is that a signal of very high frequency, whether it is infrared or optical, is not so easy to add to the reference source - it must be very stable and at the same time emit radiation of high intensity.

The first heterodyne radios, operating at megahertz frequencies, were created in the early 20th century, becoming mass-produced toward the end of the Second World War; while in the terahertz sphere heterodyne devices appeared only recently. For near-infrared radiation, whose frequency is a few hundred times greater, the task of combining the signals appeared to be compounded by a number of technical difficulties.

Calculations showed that a more "touchy" device is needed for a heterodyne signal in the near infrared radiation spectrum. Even a shift of a few hundredths of a wavelength (i.e. a couple of dozen nanometers) could be critical, but eventually the researchers from MIPT and their colleagues from the Moscow-based General Physics Institute managed to create a heterodyne near-

1 http://www.opticsinfobase.org/oe/abstract.cfm?URI=oe-22-11-13825

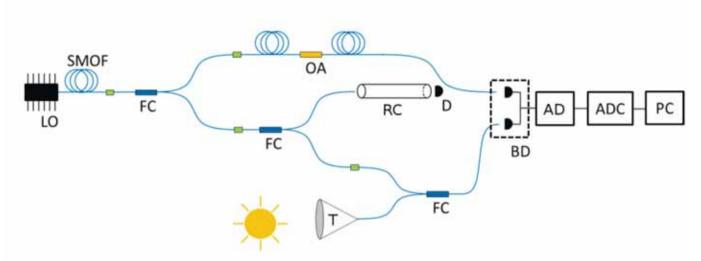


Fig. 1. A sketch of the experimental setup. LO – local oscillator, SMOF - single mode optical fiber; FC – fiber coupler; OA – optical attenuator; T – microtelescope; RC – reference gas cell; BD – balanced detector; AD- amplitude detector; ADC – analog-digital converter; PC – personal computer. Fiber connectors are shown as green boxes.

Scheme of IVOLGA

infrared detector, in which a key role was played by laser stabilization.

They used an optical system that directs a laser beam to two different points, one of them a special module for mixing it with sunlight passed through the atmosphere (i.e. the analyzed signal) and the other a cell with a pure sample of the gas to be identified. Since the gas absorbs electromagnetic waves at a specific frequency, the brightness of the radiation going through the cell indicates how far the laser has deviated from the reference frequency. And this, in turn, makes it possible to adjust the frequency of the optical oscillator, i.e. laser (the word laser is an acronym of "light amplification by stimulated emission of radiation").

New spectrum radiometers may be used at both stationary and mobile stations monitoring the atmosphere, according to the official site of the IVOLGA project, which is another abbreviation translated from Russian as "infrared heterodyne fiber analyzer."

MIPT's press service would like to thank Dr. Alexander Rodin for his generous help in writing this article.



IVOLGA

Destruction of Three Stars by Black Holes

Researchers from MIPT and the Space Research Institute of the Russian Academy of Sciences have reported registering three possible occasions of the tidal destruction of stars by supermassive black holes at the centers of galaxies.



Details are given in an article by Ildar Khabibullin and Sergei Sazonov, accepted for publication by the Monthly Notices of the Royal Astronomical Society journal (a preprint is available at www.arXiv.org).

The astrophysicists used data obtained by X-ray orbiting observatories ROSAT and XMM-Newton. The former was put into orbit in 1990 and served until 1999, when XMM-Newton took over. The two satellites gathered enough information to detect very rare events, the destruction of stars by supermassive black holes.

A star in a galaxy passes by a black hole closely enough to be destroyed once every 10,000 years. It is possible to detect the death of a star in a fairly distant galaxyas the destruction of a star generates a bright X-ray flare; it is only necessary to distinguish such a flare from other types of X-ray radiation. Because flares occur in a variety of astrophysical processes,

the task of finding stars destroyed by black holes is quite complicated.

The researchers developed a number of methods to distinguish the destruction of a star by a black hole from other occurrences. The easiest way to filter out extraneous signals is to eliminate from consideration flares in our galaxy; there is only one supermassive black hole at the center of the Milky Way, so there clearly could not have been stars that have become victims of gravity on the periphery of our galaxy. The researchers also excludedsourcesof radiation that were too large (in angular measurements) and additionally analyzed the range of objects along with the dependence of brightness on time.

Since a supermassive black hole takes just a few years to fully absorb the captured matter of a destroyed star (typically, this makes up about a quarter of its

1 http://arxiv.org/pdf/1405.5086v1

original mass), observations repeated decade later should detect significant dimming of an X-ray source. The researchers obtained sky surveydata in the 1990s and in the 2000s, so they were able to detect objects whose brightness reduced by at least tenfold.

The data led to the identification of three X-ray sources labeled1RXS J114727.1 + 494302, 1RXS J130547.2 + 641252 and 1RXS J235424.5-102053. [1RXS means that the object was first noticed during the first survey of the sky by the ROSATtelescope, and the two six-digit numbers after the letter J are angular coordinates.]

There is another object that may be a starthat has been rippedapart, but theavailable data does not allow for distinguishing it from the active nucleus of a distant galaxy. New data suggests that the destruction of stars near black holes occur once every30,000 years within the same galaxy, which agrees quite well with estimates derived from observations in the visible and ultraviolet spectral range.

The uncertainty of these estimates is quite significant since they are based on a very small number of occurrences – the full sample contains no more than two dozen "credible" X-ray sourcesregistered by various methods in different spectral bands. Progress in this area is expected to be made with the launch of the space observatory Spectrum-X-Gamma in 2016, which will be equipped with two X-ray telescopes in the soft X-ray wavelength (the Russian-German unit eROSITA) and in the hard wavelength (Russia's ART-XC). They will be used to carry out eight new legs of X-ray sky surveys within four years. The sensitivity of each shot will be several times greater than that of ROSAT.

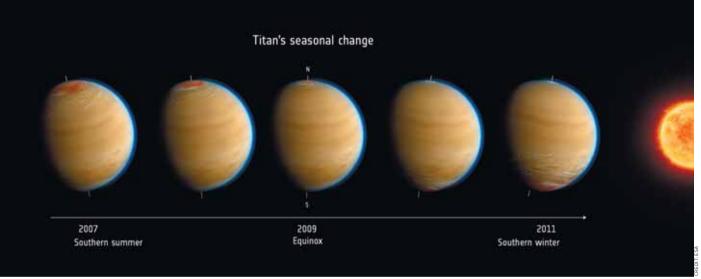
Researchers estimate that several hundred such occurrences will be registered annually with the help of Spectrum-X-Gamma. This will not only allow them to more accurately measure the average frequency of such occurrences in the universe, but also to examine in greater detail the interaction of supermassive black holeswith surrounding objects.



XMM-Newton

MIPT-based researcher models Titan's atmosphere

A researcher from MIPT, Prof. Vladimir Krasnopolsky, who heads the Laboratory of High Resolution Infrared Spectroscopy of Planetary Atmospheres, has published the results of the comparison of his model of Titan's atmosphere with the latest data.

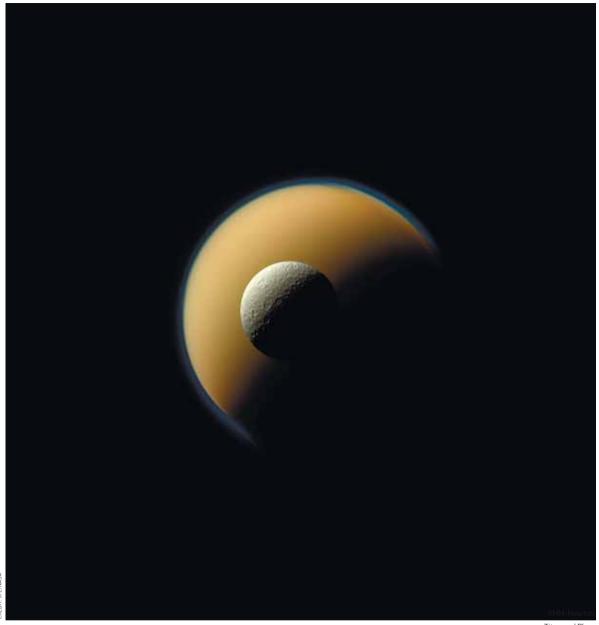


Titan's seasonal change

The article in the journal Icarus compares the chemical composition of Titan's atmosphere with parameters predicted by a mathematical model. The atmosphere of Saturn's largest moon was described by a model that took into account the presence of 83 neutral molecules and 33 ions and 420 different chemical reactions between them. Despite the fact that Titan is located much further from the Sun than the Earth and that radiation flux coming from the Sun to the moon is 100 times less, the intensity of UV rays is enough to spur photochemical reactions in the upper layers of Titan's atmosphere.

The data regarding the composition of Titan's atmosphere, which is 1.6 times denser near the surface than the Earth's air, was obtained from several sources, the main of which was the Cassini orbiter. It was equipped with a number of gauges, including ultraviolet and infrared spectrometers and equipment for studying the ions that were drawn into space. Within ten years in Saturn's orbit, a plasma complex and a mass spectrometer designed specifically for this research project gathered enough data to compare it with mathematical models.

In addition to Cassini, part of the data was obtained



itan and Rhea

using the IRAM ground submillimeter telescope and the Hershel infrared space observatory. Data onthe distribution of aerosol particles in Titan's atmosphere was received from a unique space capsule, Huygens, which landed on Titan for the first time in the history of mankind and sent the first photos of its surface.

Comparing this data with the previously developed model, Krasnopolsky showed that the theoretical description of Titan's atmosphere matches the reality quite accurately. There are discrepancies, however, but they are caused by inevitable measurement errors – so far the concentrations of many substances are approximate.

The most important thing is not the absolute matching of specific parameters but the correctness of the general model of chemical processes.

"The coherence of the model with reality means that we can correctly tell where different substances go from Titan's ionosphere and where they come from," Krasnopolsky said.

Krasnopolsky is considered a leading global expert on the atmosphere of celestial bodies of the solar system. He has participated in the creation of spectrometers for a variety of spacecraft, including the legendary Voyagers and the first Soviet interplanetary probes.

Ask a Scientist: What Makes Interstellar Flights Impossible?

MIPT's press office recently presented a new section on the institute's communications: Ask a Scientist. In this section, MIPT-based researchers answer non-specialists' questions on science.



Our reader Nikita Agueyev asks: What's the main problem of interstellar travel? To answer this question, we'll need to write a long article, although it all boils down to just one symbol: c.

The speed of light in vacuum, or c, is about 300,000 km per second, and light cannot exceed it. Consequently, one can't get to the stars faster than in a few years. Light takes 4.243 years to travel to Proxima Centauri, and no spacecraft will be able to travel faster. If you add the time required to accelerate and decelerate with more or less acceptable conditions for a human, you'll get about ten years. That's how long it'll take to travel to the nearest star.

This period is already a significant obstacle in itself, even apart from the question of how to accelerate to speeds close to the speed of light. There're currently no spaceships which allow a crew to live independently in space for so long –astronauts currently living in spaceare constantly brought fresh supplies from Earth. Usually, a discussion about the problems of interstellar travel would

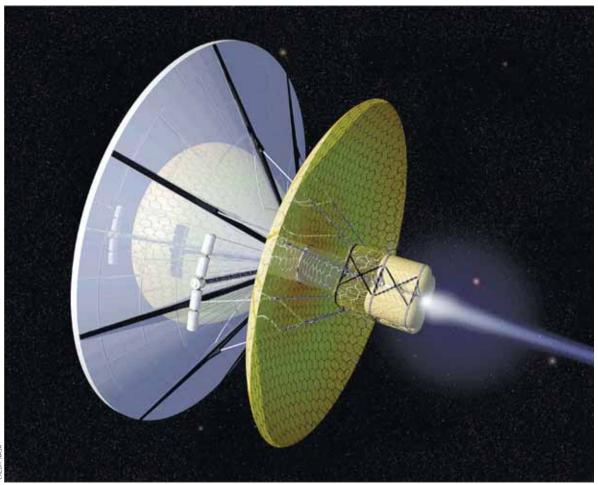
start with more fundamental issues, but let's start with the day-to-day problems.

Even half a century after Gagarin's flight, engineers have been unable to come up with a properly working washing machine or shower for a spaceship, and toilets designed to work in the conditions of weightlessness break at the ISS quite often. A flight to Mars (22 light minutes instead of 4 light years) already sets a nontrivial task to plumbing designers. So a journey to the stars will require inventing a toilet and a washing machine with a 20-year guarantee.

Astronauts will also need to take enough water for washing and drinking or reuse it. Likewise, they'll need to take care of air and food reserves. Food will probably need to be grown onboard. Experiments to create a sustainable ecosystem have already been conducted on Earth, but the conditions are still very different from those found in space; at least, for instance, there is gravity on Earth. Mankind can turn the contents of a chamber pot into clean drinking water, but in this case it's necessary to be able to do so in zero gravity and without a truckload of filter cartridges.

Washing your socks and protecting yourself against intestinal infections may seem banal constraints for interstellar flights, but any traveler will tell you that the trivia like uncomfortable shoes or indigestion can become a threat to life.

Solving even basic household problems requires a no less serious technological base than the development of new space engines. On the Earth, a worn gasket in the toilet tank can be bought in a shop for a couple of rubles, but on a ship travelling to Mars it'll be necessary to have a stock of all these parts, or to have a 3D printer



 $\label{eq:abstraction} A \ Bussard \ Ramjet, one of many possible methods that could serve as propulsion for a starship.$

to produce them from universal plastic raw materials.

In 2013, the United States Navy took up the issue of 3D printing after assessing the time and cost of repairing military equipment by traditional methods. They concluded that printing a gasket for a helicopter that was taken out of production ten years ago is easier than ordering one from a warehouse on another continent.

One of the closest associates of Sergei Korolev, Boris Chertok, wrote in his memoirs, 'Rockets and People,' that at one point the Soviet space program faced a shortage of plug contacts, and reliable connectors for multi-core cables had to be developed separately.

In addition to spare parts for the equipment, food, water and air, astronauts will need power. The engine and avionics will need enough power, so it'll be necessary to solve the problem of its source. Solar panels won't work, just because of the distance from the Sun during a flight. Radioisotope generators, which supply energy for the Voyagers and New Horizons, can't provide enough power

for a large manned spacecraft, and we still don't make full-fledged nuclear reactors for space.

The Soviet program for nuclear-powered satellites was marred by the collapse of Cosmos-954 in Canada, as well as a number of other less dramatic failures. In the U.S., similar projects were scrapped at an even earlier stage. Now Russia's Nuclear Agency and Space Agency are going to resume research in this field, but such projects will be for short-haul flights rather than long travels to other stellar systems.

Perhaps instead of a nuclear reactor interstellar ships will use tokamaks. There was a free-attendance lecture at MIPT this summer about how difficult it would be to at least correctly identify the parameters of fusion plasma. By the way, there is a quite successful project ITER on Earth. Even freshmen have a good chance of joining the work on the first experimental fusion reactor with a positive energy balance.

What to fly on?

For the acceleration and deceleration of a starship, conventional rocket engines just won't work. Those familiar with the course in mechanics, which is given at MIPT in the first semester, can calculate how much fuel a rocket would need to go at least 100,000 km per second. For those who aren't familiar with the Tsiolkovsky rocket equation, we can give you the result – the mass of fuel tanks would have to be significantly larger than the mass of the solar system.

It's possible to reduce the amount of fuel by increasing the speed at which the engine produces the working fluid, gas, plasma or else up to a beam of elementary particles. Currently, plasma and ion engines are used for flights of automatic interplanetary stations in the solar system and for the correction of the orbits of geostationary satellites, but they have a number of drawbacks. In particular, their propulsion thrust is very low, and they can't give a ship acceleration of a few meters per second squared.

MIPT's vice-rector is one of the recognized experts on plasma jet engines. The Fakel design bureau makes such engines, which are used to correct the orbits of communication satellites.

In the 1950s, there was the project Orion, through which an engine was developed that would use the momentum of a nuclear explosion, but it was far from becoming a ready-made solution for interstellar flights. A project for an engine that uses a magnetohydrodynamic effect, which means accelerating a ship through interaction with interstellar plasma, is even less developed. Theoretically, a spaceship could "suck up" plasma inside and throw it back, creating jet thrust, but then another problem arises.

How to survive?

Interstellar plasma is primarily protons and helium nuclei, if we take the heavy particles. When moving with velocities of the order of hundreds of thousands kilometers per second, all these particles gain the energy of megaelectronvolts or even tens of MeV – as many as are products of nuclear reactions. The density of the interstellar medium is about 100,000 ions per cubic meter, which means that within a second one square meter of the ship's casing will be exposed to 1,013 protons with the energies of tens of MeV.

One electronvolt (eV) is the energy acquired by an electron when moving from one electrode to another with a potential difference of one volt. That's the energy

of quanta of light, and UV quanta with greater energy can damage DNA molecules. Radiation or particles with the energies of MeVare typical for nuclear reactions and, moreover, are able to cause them.

Such exposure corresponds to tens of joules of absorbed energy (assuming that all the energy is absorbed by the casing). This energy will come not just in the form of heat; it may partially go to the initiation of nuclear reactions in the material of the ship with the formation of short-lived isotopes. Simply put, the casing will become radioactive.

Part of the incident protons and helium nuclei can be deflected by the magnetic field; you can also protect astronauts from radiation by a complex shell of many layers, but these problems haven't been solved yet. In addition, fundamental questions like "what kind of material is least likely to be destroyed by radiation" would be coupled to specific in-flight problems such as "how to remove four screws in a compartment with a background radiation of 50 millisievert per hour."

During the most recent repairs of the Hubble telescope, astronauts initially failed to remove four bolts that held a camera. After consulting with their colleagues on the Earth, they replaced a wrench that had a torque limitation with an ordinary one but then had to apply brute force to use it. The bolts finally budged, and the camera was successfully replaced.

Are there any work arounds?

In science fiction (often more fiction than science) interstellar flights are carried out through "subspace tunnels." Formally speaking, the Einstein equations describing the geometry of space-time depending on the distribution of mass and energy do allow for something like that. However, the amount of energy required for such a travel is even more depressing than the estimates of the amount of rocket fuel for a flight to Proxima Centauri. You'll not only need a great deal of energy, its density will have to be negative.

The question of whether it's possible to create a stable and large wormhole is tied to fundamental questions about the structure of the universe as a whole. One of the unsolved problems is the lack of physical gravity in the so-called Standard Model, a theory describing the behavior of elementary particles and three out of four fundamental types of physical interactions. The vast majority of physicists are quite skeptical about the possibility of "jumping through hyperspace" in the quantum theory of gravity but, strictly speaking, no one prohibits you from looking for a workaround.

International Workshop

Structure and Functions of Biomembranes

Moscow Institute of Physics and Technology, Dolgoprudny

Registration 10th August

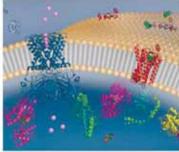
Abstract Submission 1[™] September

http://biomembranes2014.ru biomembranes2014@mipt.ru

29 September - 3 October, 2014













Membranes...

Research on biological membranes occupies a central position in cellular and molecular biology. Biomembranes form very complex, dynamic and heterogeneous structures, in both space and time, critical for cellular function. Membrane proteins are involved in transport of ions and nutrients, signal transduction and energy conversion, and their malfunctions often result in numerous serious diseases, such as Alzheimer's, Parkinson's, diabetes, cancers, heart failure and others. While membrane proteins represent roughly one-third of the proteins encoded in the human genome, about 60-70% of modern drugs target these proteins, emphasizing their crucial value for pharmacology and medicine. Biological membranes are also a focus of intense investigations in soft matter and theoretical physics.

And Methods for their studies...

X-ray and neutron scattering, NMR, electron microscopy, mass-spectrometry and single molecule fluorescence spectroscopy are key methods to study structural aspects and functional mechanisms of membrane proteins at time resolutions from femtoseconds to minutes, and spatial scales from atoms to whole organisms. The last few years have brought multiple breakthroughs in instrumentation and technologies, enabling the pursuit of new directions and paradigms in a variety of fields including studies of biological membranes.

A major goal of this Workshop is to provide up-to-date information about key advances in the diverse research fields related to biomembranes including XFEL. World-leading scientists in structural biology, biophysics and soft matter from different countries will share their knowledge and expertise on several of the hottest topics in modern science.

A special emphasis will be given to publicity of the scientific activities at MIPT and its partners within the 5TOP100 program. The Workshop is intended to promote efficient scientific co-operations between MIPT and world-leading laboratories, and to attract students and young scientists to participate in this program.

Keynote Speakers:

- Ernst Bamberg
- Max Planck Institute of Biophysics, Germany
- Ray Stevens
 - The Scripps Research Institute, USA; iHuman Institute, China

Invited Speakers:

- Georg Büldt (Russia)
- · Vadim Cherezov (USA)
- Igor Chizhov (Germany) · Norbert Dencher (Germany)
- Rouslan Efremov (Belgium)
- Martin Enhelhard (Germany)
- · Thomas Gensch (Germany) · Sergei Grudinin (France)
- · Gerhard Gompper (Germany) · Valentin Gordeliy (France)
- Karl-Erich Jaeger (Germany)
- Vsevolod Katritch (USA)
- Leonid Sazanov (UK) Vasily Studitsky (USA)
- · Dieter Willbold (Germany)
- Marat Yusupov (France)

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Neurocomputers, Nano-Orbiters and Xtallography: Foreign Students at MIPT

This summer more than 30 students from 13 countries have come to MIPT for training in the scope of Summer Internship 2014. They have conducted research at our laboratories and research centers.



Gustavo Rios and Mike Kalomeni with Prof. Alexander Rodin

Guests from École Polytechnique Fédérale de Lausanne performed design work for the installation of a greenhouse gas meter developed at MIPT, a Chinese team became familiar with USPEX at Prof. Artem Oganov's Crystallography lab and Prof. Alexander Galushkin, the head of the Neurotechnology lab at MIPT, took on seven students from Vietnam, Bulgaria and Poland.

The interns shared their impressions with MIPT's press service.

«I lived in La Paz before I turned 18,» told Gustavo Rios. «In high school, while on summer vacation, I traveled to the USA and visited the John F. Kennedy Space Center. It was such an awesome and impressive experience for me, seeing those rockets and satellites with my own eyes, that I realized learning about space is what I wanted to do. Then, when I finished school I applied for a scholarship to the Simón I. Patiño Foundation. I explained to them my desire to study aerospace engineering in order to take part in the Bolivian space program and so I came to Ecole Polytechnique. Mike Kalomeni (another student from École Polytechnique) and I met in our first year. We have been working on microsatellites and this summer our research supervisor, who knows Prof. Rodin of MIPT, suggested that we do an internship here at Phystech, because his recently invented greenhouse gas meter could be mounted on one of our satellites and that seemed very interesting to us.»

Prof. Alexander Rodin said that he was satisfied with the outcome of our joint work. «The greenhouse gas meter, developed at MIPT, has been successfully combined with a nano-satellite, constructed with the help of our interns from École Polytechnique.»

Nine young scientists from China have recently begun doing an internship at MIPT Crystallography lab. During their training at MIPT, the students will become familiar with USPEX, an original method of computational materials design created by Prof. Artem Oganov.

«We deal with the problems of alternative energy sources, photovoltaics and thermoelectricity,» said Chen Pengcheng. «The search for new compounds in these fields would take too long and would be very difficult if we didn't use computer simulation and only did experiments.»

«I am proud of the fact that our laboratory has attracted a record number of students for this Summer Internship 2014,» said Prof. Artem Oganov. «And I look



MIPT students and foreign interns who performed training at Prof. Oganov Crystallography lab

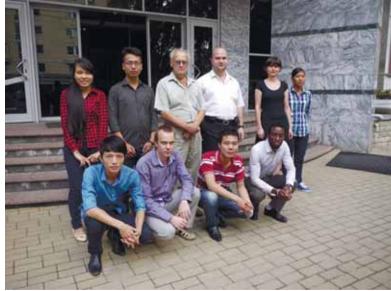
forward to developing cooperation with universities all over the world, and especially with Tsinghua University, in order to introduce my methodology to a maximum number of young scientists.»

«3D modeling is not just the creation of an object in a virtual environment; it's a much broader and more interesting area,» said Anna Lorent, Czestochowa University of Technology. «Through my research project, I create 3D images based on two-dimensional scans obtained through X-ray computed tomography (CT). There is, however, a problem in doing this: the more accurate the image we want to get, the greater the dose of X-ray radiation the patient is exposed to. With low levels of radiation, images look smudgy. The main objective of my research project is to create accurate 3D models of human organs from fuzzy two-dimensional scans. Our university has a long history of cooperation with MIPT's Department of Cybernetics, and I hope the results of our joint work will soon be used in new X-ray scanners.»

«Technical University of Sofia and Professor Galushkin's laboratory are researching memristors, a special class of electronic devices that have memory,» said Stoyan Mihailov Kirilov from Bulgaria. «Their functionality was described in the early 1970s, but it was only recently, in 2008, that we were able to make a nano-scale memristors of 50 by 50 nm. In fact, we're on the threshold of creating a neurocomputer, comparable to the size of the human

brain, and the awareness of this inspires us to continue our research.»

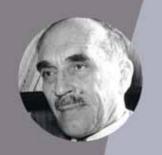
The head of the laboratory Prof. Alexander Galushkin emphasized that all interns had in depth knowledge and were highly motivated for training. «I am pleased to present the achievements of our Institute to those who are really interested in cutting edge cybertechnology,» he added.



The Head of Neurotechnology lab Prof. Alexander Galushkin and international interns

MIPT Nobel Prize Winners

1956



Nikolay Semenov The Nobel Prize in Chemistry

Prize motivation: "for their researches into the mechanism of chemical reactions" **Field:** chemical kinetics, physical chemistry

1958



Igor Tamm The Nobel Prize in Physics

Prize motivation: "for the discovery and the interpretation of the Cherenkov effect"

Field: electromagnetism

1962



Lev Landau The Nobel Prize in Physics

Prize motivation: "for his pioneering theories for condensed matter, especially liquid helium" **Field:** condensed matter physics, superfluidity

1964



Aleksandr Prokhorov The Nobel Prize in Physics

Prize motivation: "for fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based on the maser-laser principle" Field: optical physics, quantum electrodynamics

Andrei Sakharov The Nobel Peace Prize

Role: Soviet nuclear physicist

Field: human rights



1975

Pyotr Kapitsa The Nobel Prize in Physics

Prize motivation: "for his basic inventions and discoveries in the area of low-temperature physics"

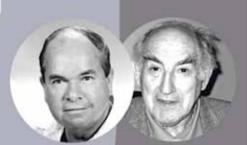
Field: condensed matter physics



1978

Alexei Abrikosov, Vitaly Ginzburg The Nobel Prize in Physics

Prize motivation: "for pioneering contributions to the theory of superconductors and superfluids" Field: condensed matter physics, superconductivity, superfluidity



2003

Andre Geim, Konstantin Novoselov The Nobel Prize in Physics

Prize motivation: "for pioneering contributions to the theory of superconductors and superfluids" Field: condensed matter physics, superconductivity, superfluidity

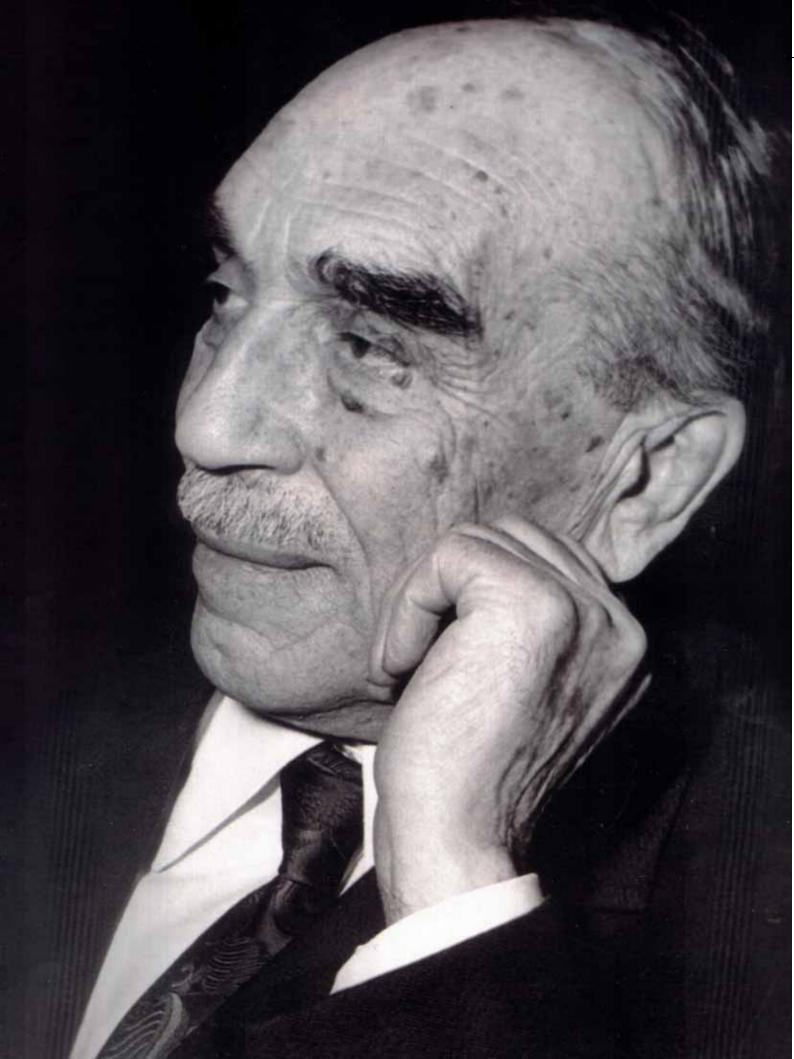


2010

Nikolay Semyonov

3 april 1896, Saratov, Russian Empire – 8 april 1984, Moscow, USSR Nobel Prize in Chemistry 1956

- Nikolay Semyonov is one of MIPT's founders.
- Semyonov is the only Russian Nobel Prize winner in chemistry for the time being.
- In 1922, together with Pyotr Kapitsa, he proposed a way to **measure the magnetic field** of an atomic nucleus.
- In his youth, during the Russian Civil War, Semyonov was enlisted into the White Army. He **served as a horse breeder** in the artillery battery for about a month.
 - During his life Semyonov published only around 50 original articles.
- In 1931 he organized the Institute of Chemical Physics, which he led for more than half a century.
- At MIPT he was at the head of the united base organization of Chemical Physics, appointed by the institute. He was also one of the founders of the Chemical Physics faculty, whose legacy continues to this day in both the Department of Biological and Medical Physics and the Department of Nano-, Bio-, Information and Cognitive Technologies.
- •On the famous double portait of Pyotr Kapitsa and Nikolay Semyonov by Boris Kustodiev, the two of them are seen early in their careers, without any honours or prizes. By the end of their lives, between the two of them, they had **two Nobel Prizes, four Hero of Socialist Labour titles and fifteen Order of Lenin decorations**.



lgor Tamm

26 june 1895, Vladivostok, Russian Empire – 12 april 1971, Moscow, USSR Nobel Prize in Physics 1958

- Igor Tamm was an MIPT professor.
- Tamm shared the Nobel Prize with two colleagues, **Pavel Cherenkov** and **Ilya Frank**. Cherenkov, together with **Sergey Vavilov**, described the unusual electromagnetic radiation emitted when a charged particle passes through a dielectric medium at a speed greater than the phase velocity of light in that medium (Vavilov-Cherenkov radiation). Frank understood the nature of this phenomenon and set up a theory explaining it in cooperation with Tamm.
- In his youth Tamm was more **interested in politics and Marxism than in science**. However, his fate was determined by a meeting in Odessa with the outstanding physicist Leonid Isaakovich Mandelstam, who later became his research advisor.
- It was Tamm who discovered the future physicist and father of the Soviet hydrogen bomb (and MIPT professor), **Andrei Sakharov**.
- Tamm's granddaughter, **Marina Tamm**, teaches inorganic chemistry at MIPT's Chemistry department.
- Igor Tamm is the author of the term "phonon" the name for a quasiparticle, the quantum of the vibrational motion of atoms in a crystal.
 - He is also one of the early authors of the cascade theory of cosmic ray showers.
- One of Tamm's first scientific papers was on the investigation of the theory of relativity. This work was highly appreciated and accepted for publication by **Albert Einstein** himself..
- During his internship in Germany Tamm became friends with **Paul Dirac**, one of the creators of quantum mechanics.
- Besides the Nobel Prize, Tamm was honored with the highest of all Soviet titles –
 Hero of Socialist Labor.

Lev Landau

22 january 1908, Baku, Russian Empire (now Azerbaijan) – 1 april 1968, Moscow, USSR Nobel Prize in Physics 1962

- Lev Landau was **one of the first professors of the MIPT's** section of Theoretical Physics.
- Landau won the Nobel Prize for his theory of superfluidity of helium **16 years earlier than Pyotr Kapitsa**, who was awarded with the Prize for discovery of the phenomenon itself.
- At the age of 14, he matriculated at Baku State University, **studying in two departments** simultaneously: the Departments of Physics and Mathematics, and the Department of Chemistry.
 - Landau's scientific advisor was **Niels Bohr** whom he regarded as his only teacher.
 - Fellow academics called Landau briefly just "Dau".
- Landau invented the **Physicists Rating Scale**. According to this logarithmic scale a 1st class physicist has done 10 times more than a 2nd class. In the Landau's opinion the one and only "rank-free" physicist was Einstein who was awarded with a 0.5 class by Soviet scientist. Landau attributed himself at first to the 2.5 class, then to the 2nd, then to the 1.5 class.
- Range of Lev Landau's scientific interests was very wide. The well-known saying asserts that "**there were no closed doors** for Landau in the huge building of the XX-century physics".
- Landau developed also his own theory of happiness. According to it, everyone must be happy. "Landau-style" formula of happiness includes **love**, work and communication.
- Landau has created a strong school of theoretical physicists. It was necessary to pass the "Landau's theoretical minimum" nine theoretical examinations to consider yourself admitted in this school.

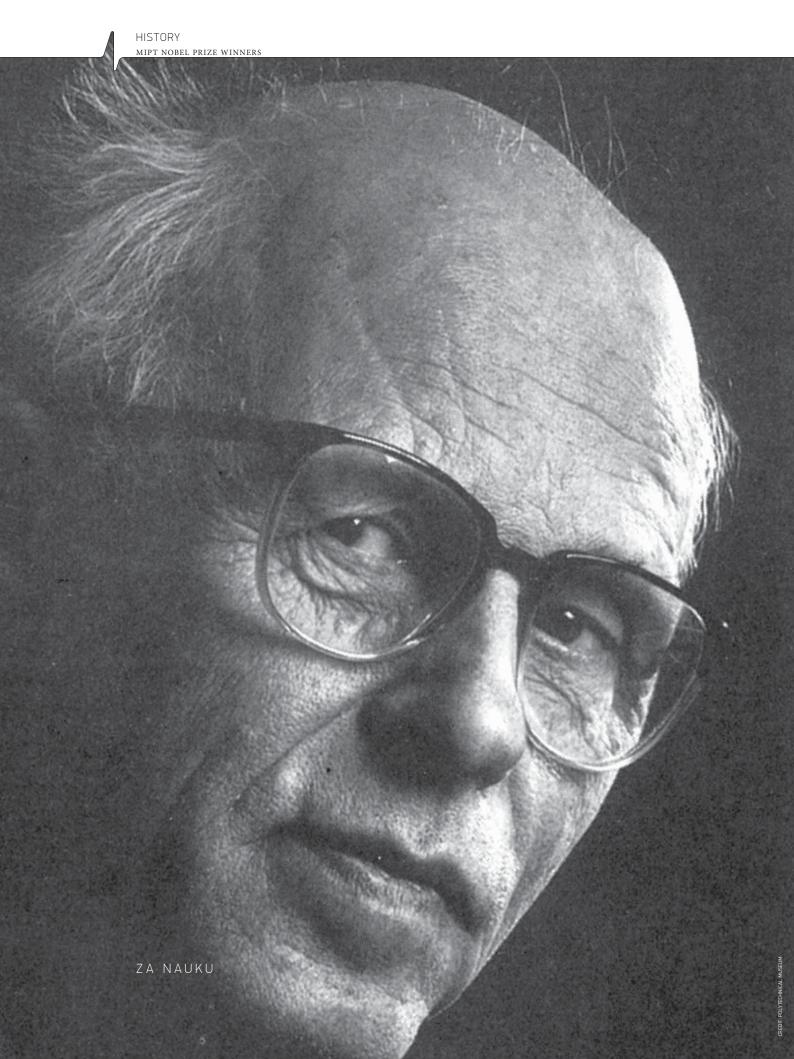




Alexander Prokhorov

11 july 1916, Atherton, Australia – 8 january 2002, Moscow, Russia Nobel Prize in Physics 1964

- Alexander Prokhorov was a **MIPT professor**, the founder and the head of the section of Laser Physics.
- His Nobel Prize in physics Prokhorov shared with his doctoral student **Nikolay Basov** and American physicist **Charles Hard Townes**.
- Interestingly, Alexander Prokhorov and Nikolay Basov haven't created the first laser in the world, neither the first maser. The first laser was constructed in 1960 by Theodore Harold Maiman, and the first maser in 1953 by Charles Hard Townes. But Prokhorov and Basov were the **first who formulated the principles of quantum amplification and generation.**
- The first seven years of his life Prokhorov **spent in Australia**. His parents-revolutionaries had fled from the persecution of the authorities to the Green Continent
 - In 2012 an Aeroflot Airbus A-321 aircraft was named after Alexander Prokhorov.
- In 1982 Prokhorov founded the **General Physics Institute** of the Russian Academy of Sciences, which is named after him nowadays. He served as its director for more than 20 years.
- Prokhorov was a chief Editor of the **Great Soviet Encyclopaedia** the Soviet analogue of Encyclopaedia Britannica.



Andrei Sakharov

21 may 1921, Moscow, RSFSR – 8 april 1989, Moscow, USSR Nobel Peace Prize 1975

- Andrei Sakharov was a MIPT professor.
- Sakharov was one of two Russian Nobel Peace Prize laureates.
- His scientific adviser was another MIPT professor and Nobel Prize winner in physics, **Igor Tamm**.
- Andrei Sakharov got a C in relativity theory, taking the examination from professors Tamm and Leontovich. Late at night after that Tamm made a call to Leontovich and said that they were wrong and Sakharov was right on the exam. In this way Sakharov **became a Tamm's student.**
- **The authorship of Tokamak** toroidal plasma reactor providing controlled fusion belongs to Sakharov and Tamm. The future demonstration reactor of ITER project is arranged in a similar way.
- In 1953 at the age of 35 Sakharov was elected as academician of the USSR Academie of Sciences, **bypassing the rank of corresponding member.**
- Sakharov is reputed as one of the **hydrogen bomb fathers**. It was his scheme "Sakharov's layer cake" that obtained a practical implementation.
- It is considered that in his article "**The World in Half a Century**", published in 1974, Sakharov predicted the development of the Internet.
- In 1970s he became one of the three founders of **The Committee on Human Rights in the USSR**. In 1980 he was arrested for his human rights work and sent to internal exile in the city of Gorky, now Nizhny Novgorod, a city that was off-limits to foreigners. He returned from exile only in 1986.



Pyotr Kapitsa

9 july 1894, Kronshtadt, Russian Empire -8 april 1984, Moscow, USSR Nobel Prize in Physics 1978

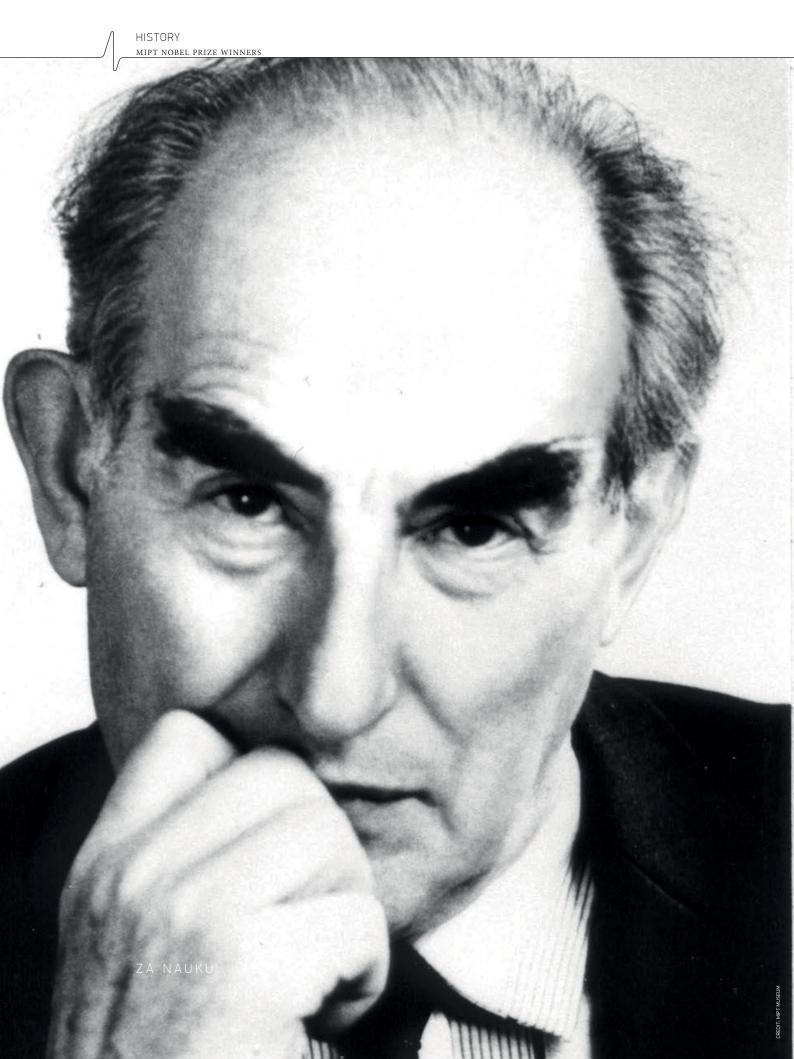
- Pyotr Kapitsa is one of MIPT's founders.
- The **nickname "Crocodile"** was given to Ernest Rutherford specially by Kapitsa, his distinguished student.
- Kapitsa shared his Nobel Prize, awarded in 1978, with **Arno Allan Penzias** and **Robert Woodrow Wilson**, who were awarded for discovering cosmic microwave background.
- Kapitsa received his Nobel Prize for discovering of superfluidity of liquid helium **exactly 40 years after** the publication of the corresponding article in the journal Nature.
- Pyotr Kapitsa not only discovered the phenomenon of superfluidity itself but also coined the **term** in the scientific community.
- Kapitsa was an excellent chess player and won the Cambridgeshire County championship in chess.
- Anna Krylova, Kapitsa's second wife, was the daughter of an outstanding mathematician, mechanician, naval engineer and academician, **Aleksey Krylov**.
- **Both of their sons** made significant contribution to the history of science. Sergei Kapitsa became a physicist and MIPT professor. He was also the host of the popular scientific TV show "Evident, but Incredible" for 39 years. Their other son Andrey Petrovich Kapitsa grew into a famous Antarctic explorer and geographer.
- The now-famous double portrait of Pyotr Kapitsa and Nikolay Semyonov by Boris Kustodiev (see cover) depicts Semenov at age 25 and Kapitsa two years older. It is said that the two young men came to Kustodiev by their own accord and asked him to paint their portrait, alleging as their reason that he usually does portraits of famous people, and they would be famous some day without fail.



Alexei Abrikosov

born on **25 june 1928**, Moscow, USSR **Nobel Prize in Physics 2003**

- Alexei Abrikosov was a **MIPT professor in 1972-1976**. He headed the section of Theoretical Physics
- His Nobel Prize in physics Abrikosov shared with the other MIPT professor, Vitaly Ginzburg and American physicist Anthony James Leggett.
- Both Abrikosov's parents were **well-known Moscow pathologists**. His father was the head of the Department of Pathological Anatomy of the First Moscow Medical Institute, and mother the chief dissector of the Kremlin hospital.
- Alexei Abrikosov's scientific adviser was the legendary Nobel laureate, MIPT professor **Lev Landau.**
- Abrikosov was a corresponding member of the Russian Academy of Sciences and The National Academy of Sciences in USA.
- The ring-shaped (toroidal) vortices of a superconducting current in a superconductor, discovered by Abrikosov, now are known as **Abrikosov vortices**.
- •It was Abrikosov who discovered the **new type of superconductors** so-called type-II superconductors.



Vitaly Ginzburg

4 october 1916, Moscow, Russian Empire – 8 november 2009, Moscow, Russia Nobel Prize in Physics 2003

- Vitaly Ginzburg was **a MIPT professor**, the founder and the head of the section of Problems of Physics and Astronomy.
- His Nobel Prize in physics Ginzburg shared with the other MIPT professor, Alexei Abrikosov and American physicist Anthony James Leggett. It is the third Phystech's Nobel Prize, dealing with the phenomenon of superfluidity (two others belong to Lev Landau and Pyotr Kapitsa).
- As well as Andrei Dmitrievich Sakharov, Ginzburg was a doctoral student of Igor
 Tamm the Nobel laureate and MIPT professor.
- Ginzburg is one of the authors of the Theory of Superconductivity, which contains in its title surnames of three MIPT professors and Nobel laureates. It is called **Ginzburg-Landau-Abrikosov-Gor'kov** (GLAG) theory.
- Ginzburg was a consistent atheist and fought all his life against the mixing of religion and science. He set up a **Commission to Combat Pseudoscience** and the Falsification of Scientific Research in the Russian Academy of Sciences
- During the World War II he survived the severe winter of 1942, so later he often joked about how **surprising is his love of low temperatures**, that allow superconductivity and superfluidity to develop.



Sir Andre Geim

born on **21 october 1958**, Sochi, USSR **Nobel Prize in Physics 2010**

- Andre Geim is one of two **MIPT's graduates**, who won the Nobel Prize. He **graduated** from the MIPT's department of General and Applied Physics in 1982.
- In 1975 Geim applied to the Moscow Engineering Physics Institute, but on account of his German ethnicity he wasn't admitted in the institute, dealing with the nuclear project.
- He is a first scientist who won **both a Nobel Prize and an Ig Nobel Prize**, which is given for unusual or trivial achievements in scientific research as a parody of the Nobel Prize. Geim's Ig Nobel was earned by his experiment with a live frog's levitation.
- Andre Geim has enviable sense of humor. He named his favorite hamster, **H.A.M.S. ter Tisha**, co-author in a 2001 research paper.
- December 31st of 2011 Geim was made a Knight Bachelor for services to science by the Queen's Elizabeth II decree. He thus can duly to be called a Sir.
- It wasn't long between the publication about graphene in Science and winning the Nobel Prize: **six years**. Quite a short interval, according to the award's statistics.
- Geim takes a great interest in **mountain tourism**. He climbed Elbrus, Kilimanjaro and other mountains higher than 5000 meters.
- In 2003 Geim has become a creator of **Gecko tape**. Its principle of operation is similar to that by which geckos can stick to the steep walls or ceiling.

Sir Konstantin Novoselov

born on 23 august 1974, Nizhny Tagil, USSR Nobel Prize in Physics 2010

- Konstantin Novoselov is one of two **MIPT graduates** to win the Nobel Prize. He was awarded jointly with Andre Geim for the discovery of graphene, a new form of carbon.
 - Novoselov the youngest Russian Nobel Prize winner.
- He **graduated with honors** from the MIPT's Department of Physical and Quantum Electronics in 1997.
- Graphene was discovered using **ordinary Scotch tape**. As it turns out, adhesive tape allows the detachment of a single layer of carbon atoms from graphite. This layer is graphene. It has unique properties: if one were to make a hammock using graphene, the hammock would weigh less than a milligram but **would be able to bear a 4-kg cat**.
 - Novoselov publishes in English using the short version of his name "Kostya".
- In 2014 he took 2nd place in the Discovery section of **National science photography** competition.
- On December 31, 2011, Novoselov was made a **Knight Bachelor** by decree the Queen Elizabeth II. He now has an absolute freedom to add the title "Sir" to his name. In November 2010 he become a Knight Commander of the Order of the Netherlands Lion.
- As of June 2014, his published works have been cited more than **70,000 times** by the scientific community.

Working With Three Nobel Prize Winners

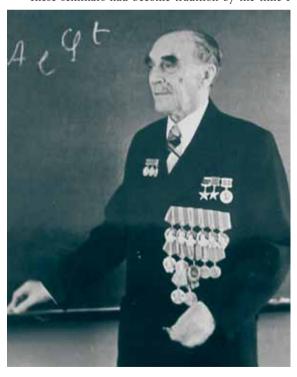
MIPT rector Nikolay Kudryavtsev shares his story of working with Nikolay Semenov, Alexander Prokhorov and Vitaly Ginzburg.

Nikolay Semyonov

As both an undergraduate and postgraduate student, I worked at MIPT's Department of Chemical Physics specializing in combustion and condensation systems. My choice of specialization was influenced by Nikolay Semyonov, who was director of the institute and head of the department. Semyonov used to come over to MIPT. I was at that time a junior student, not yet working at the institute.

At the Department of Chemical Physics we had annual cross-departmental seminars, where, basically, students were matriculated. They would start with a speech by a leading scientist from a partnership section and continue with a matriculation ceremony. Half of the audience consisted of departmental staff, and the other half of students in various years of study.

These seminars had become tradition by the time I



finished my first year, but the appearance of Semyonov at one such seminar attracted a lot of attention, and we all turned up to listen. He spoke about the chain reactions for which he received his Nobel Prize, about the atomic bomb, how it had been made at the Institute of Chemical Physics and how he had taken a very active part in it. That speech had a very big impression on me, and I joined the Institute of Chemical Physics of the Russian Academy of Sciences.

Semyonov established a tradition at the institute – he regularly met with undergraduates and postgraduates at MIPT, Moscow State University and the Moscow Institute of Physical Engineering. He held half-an-hour-long meetings several times a year, asking students how things were going, whether there were any difficulties and if anything could be improved.

Alexander Prokhorov

I personally became acquainted with Nobel Prize winner Alexander Prokhorov, who founded the Department of Problems of Physics and Energetics, after I had already been working as Rector for several years. There are three MIPT partnership sections at the Institute of General Physics of the Russian Academy of Sciences, and Prokhorov approached his work in a principled manner and with a great sense of responsibility. He wanted to keep the sections fully in his view so that the fate of every student would pass through his hands. This, of course, was a fine idea, but unfortunately it created a few practical difficulties: he was already getting on in age, didn't come in to the institute every day, and, therefore, decisions that were important for the students - transfer to other sections, student admissions and withdrawals - were sometimes drawn out. But the heads of these three departments, although they did not say it out loud, were a bit afraid to approach Prokhorov with a proposal to change procedures in the department. They were very worried that he'd be upset if approached with this question. So they proposed that the initiative come from MIPT.



At the time, the Department of Problems of Physics and Energetics was headed by Sergei Gordyunin. We had an idea that Prokhorov would work as the scientific advisor for all three sections and, thus, be responsible for strategic issues, an area where his say, his vision and his authority would be very important. Other questions regarding the internal life of the departments would be left to the heads of the section and their deputies. I came to Prokhorov with this suggestion. He met me very warmly, asked about MIPT, and we discussed science - we were close in scientific terms. Eventually, I nevertheless plucked up the courage to make our proposal. And he accepted it to my great relief! I, of course, didn't expect things to turn out like this. Then he asked where the heads of the sections were. I replied honestly and told him that they were afraid of him. He laughed, told his secretary to call them, got out a bottle of cognac and glasses and said: "Well, Nikolai Nikolaevich has come to me with a very useful proposal, why did you not raise this with me before?"

After that, we spoke again on several occasions and I was very satisfied with our joint work.

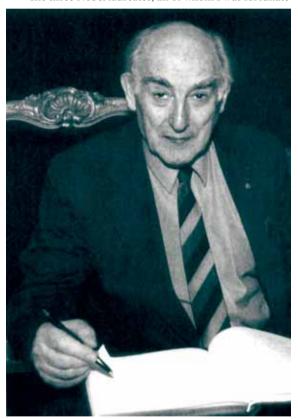
Vitaly Ginzburg

Vitaly Ginzburg headed a partnership section at MIPT. I first met with him when I was already Rector. We visited him several times at the Physics Institute of the Russian Academy of Sciences to discuss the work of the section. He was already a legend and had young theoretician colleagues who were successfully working at the section; he created a very good school. I invited him to MIPT several times, but he was already getting on in age, and a journey to Dolgoprudny would have been very

difficult for him. But he was always working with the students at his department and headed it very successfully.

At that time in his life he was thinking a great deal about reforming the Russian Academy of Sciences, discussed the issue with us and spoke about the role of MIPT. He believed that science and education should be very close. He published very good articles on this theme in Poisk (Search) newspaper and other media. To the depths of his soul, he worried about the situation in the academy and in Russian science. He noticed the problems long before things got so bad, and he tried to do something about it. He was also very concerned about the influence of clericalism on Russian society. I got the impression that, although he didn't deny the usefulness of the church, he viewed it only as an element of psychotherapy, a useful element. But when this element of psychotherapy began to touch the very basis of scientific knowledge, as a scientist he could not accept it.

The three Nobel laureates, all of whom I was fortunate



to know, were united by one thing: they all held MIPT in high regard.

The Main Question of Life and the Universe

On September 1st, a new building for MIPT's lyceum for gifted children was opened. Konstantin Novoselov, 2010 Nobel Prize winner and MIPT graduate, spoke at the opening ceremony and answer some questions.



What is the purpose of science? What should the process of scientific cognition lead to?

It's a very difficult question. <...> I set a goal for myself, first of all, to enjoy the research I do and try to learn something new every day, or maybe every week. And then all this knowledge adds up like bricks in the building of our understanding of the world. Will it eventually become a monolithic building, or be several separate buildings in different areas? I don't know. It's likely to become one building, but it's still very far ahead.

A curved smartphone with graphene parts

What has been done in Russia to build on your discovery of graphene and what are its application prospects?

I should point out that I'm a scientist, not a promoter of graphene. Whether or not something comes out of it is, frankly, none of my business. My job is science. I take interest in new experiments that we carry out with graphene, so I do them. In three years from now I may become keen on something else, and I'll switch easily. In fact, this is happening now – I spend only about 30% of my time on graphene.

The development of practical applications of graphene started four years ago. Now it's widely used in composite materials. Graphene is a very light and durable material, so it's used in tennis rackets, golf clubs, etc. <...> It's also used in electronics, for example, in cell phones. In a couple of generations, for instance, iPhones will be curved, which will require strong, conductive, flexible, thin and transparent materials. Graphene is one such material, so now engineers are preparing this kind of application, and

in some countries you can already buy a phone with a graphene screen.

As for the development of Russian research, we cooperate with our friends from Russia, in particular, from Chernogolovka. There is some work going on, but I don't know anything about its industrial application, though I think it's only a matter of time.

Science in Russia

What problems do scientists face in Russia?

Low rating and low public appreciation for their work. The public is no longer aware of how much it owes to scientists and engineers; these professions are devalued, which demotivates people from working in science. Why this happened and how to deal with it is a different question.

How would you like to see Russian science?

I'd like to never see such questions brought up. Seriously. Because science is one. I have a number of colleagues from a dozen countries, with whom I carry out joint research projects, and we never think that someone is promoting British, Chinese, Ukrainian or Russian science. I work with the best scientists, and where they are at the moment makes no difference to me. Unfortunately, such questions arise in Russia, and it's a sign that the situation in science is not the best. As soon as Russian science becomes part of global science, such questions will become irrelevant.

Is there anything special about MIPT students, graduates and teachers?

I guess the main thing about them is that they brave challenges. They believe that there are no unsolvable problems. If there's a problem that appears infinitely complex, someone from MIPT will be the one to break it down into components, solve them individually, then put it back together and deliver the correct answer. This applies not only to physics, chemistry or biology, but many other areas as well. I've seen it in business and sociology.

Daily life

What helps you pursue science? Maybe you sleep a lot or, conversely, too little? Do you play sports? Do you have a hobby?

I love sleeping. Eight hours a day would be great, but it seldom is the case, though I'd like it to be.

First, it's love for science that helps one pursue it. <...> Second, it's an opportunity to be in touch with intelligent and interesting people: colleagues, students, postgraduates... They sometimes put questions that are very difficult to answer, like you did today.

As for a hobby, I try to hike in the mountains sometimes, I play football with my students every Friday, plus we try to diversify our lives – we may go to a concert or just hang out together, talking about something else. Also, I'm trying to do projects at the intersection of art and science. I work with several artists from Manchester, London and China. It also brings an interesting flair to my pursuit of science.

What prompted you to study physics intensely at school?

I'm positive that there are no untalented people, so I'm 100% sure that almost every person can be given a push, and he will understand that he does something better than others. Luckily, I was given such a push. I don't know how this happened but teachers encouraged me to participate in school Olympiads, they told me about MIPT's extramural school, gave me free access to the physics classroom – probably because my parents were sick of washing the kitchen after my experiments. Gradually it developed into a sort of attachment to this subject, and two years before graduating from high school I knew I was going to apply to MIPT, there was no question about it.

Did you want to become a great scientist as a child? Did you believe that someday you'd win a Nobel Prize?

I didn't think about the prize. I tried not to think about it till the last moment. The 1985 Nobel Prize winner in physics Klaus von Klitzing once told me, "Kostya, if you think about the prize, you'll never get it." I managed to throw these thoughts out of my head, and I pulled it off.



Among the graduates and lecturers of MIPT there are many legends. One person with whom we spoke can be considered a legend even amongst Nobel Prize winners (although he is not a prize winner, he has been nominated several times). He is a leading physicist, who more than 40 years ago predicted the existence of metamaterials. which are developing dramatically in the 21st century. A graduate of the Department of Physics and Technology at Moscow State University (MSU) in 1951, professor at MPTI, a laureate of the State Prize of the USSR, Victor Veselago, who heads the laboratory of magnetic materials in the department of strong magnetic fields at the General Physics Institute of the Russian Academy of Sciences. spoke to "For the Glory of Science" about his experiences during his studies at "MIPT 1.0" - the Department of Physics and Technology at MSU.

Why did you choose MIPT?

I chose MIPT on a completely non-scientific basis. During my last three years at school, I was a radio ham, and managed to reach quite a high level of success. I realised that after finishing school, I wanted to enrol at an institute where I could continue to study radio technology. I began by visiting those institutes – the Institute of Communications, Baumann, Aviation – so that I could understand what they studied and how things were run.

But I also wanted to find a place close-by – even by then Moscow had become a large city. I lived in Presnya and to travel to the Baumann institute in Lefortovo was difficult.

Things turned out well. I had looked at all the institutes, and then, quite accidentally, one of my classmates brought me a booklet in which there was a prospectus for a new department at MSU, PTF – the future MIPT. There was one important detail – entrance tests at MIPT began not on the 1st of August as everywhere else, but on July 1st. I decided this was what I needed; if I didn't pass, then I could apply to another university. This was the reasoning behind my application to MIPT.

I'll say it again: the idea of physics never occurred to me, I was preparing myself to be a specialist in radio-engineering. I did not know that there was such a thing as scientific work, even though my mother worked at MGU as a lecturer of foreign languages in the Department of History. I did

not even think about joining the Physics department.

How did you enrol? Tell us about your exams.

You had to pass nine exams for MIPT. The first was written algebra. I turned up, tried to solve at least something and got a "2" (F). I'd failed and thought "I did the right thing, on the 1st of August I'll enrol somewhere else". When on the next day I went to get my documents back, I met with the President of the Admissions Committee, Boris Solonouts, and told him I wanted to collect my documents. In reply, he asked me what I was doing the day after, as he thought I would have nothing going on. I confirmed that I hadn't as I had failed. "You, know, you should turn up for the next exam" he told me.

I turned up and on the next exam received a "5" (A) – after all, I had been well taught and finished a sufficiently elite school, the 135th.

Actually I received a "2" on the first exam because we were all seated far apart from each other in the large Physics Auditorium at the Department of Physics at MGU. I felt like a grain of sand in space, and felt out of sorts. I was ill-prepared psychologically for the use of new terminology.

The rest of the exams went fine: in the end, I received seven "5"s and a "4" in German. For some reason the chemistry examiner took a liking to me; during the chemistry exam he told me that MIPT needed people like me, and that he would talk about me separately. put in a good word for me.

What did he say, did he say anything in general?

Well, later there was an interview at which there were five very serious figures, one of whom was a General of Communication Troops, which I could tell by his uniform. He began to question me. He was interested in why I had enrolled in his speciality, radio physics. I told him that I was a radio ham and that I wanted to continue this activity. He asked me what had been the last device I had built. I replied that I had made a four-valve super-heterodyne all-wave radio receiver.

The discussion then centred on which valve I had used to amplify the sound. He then asked why I had decided to use this one. I laid out all the parameters of the valve. It was nice to speak as equals. And on the next day I saw my name on the list of enrolled students.

How hard was it to study at MIPT?

Studying at MIPT was very hard. You should remember it was 1947. The war had ended only two years earlier. They were very hungry times, the first time I ate till I was full was in 1953.

But the most difficult part was the study itself. The first lecture was on physics. There were lectures twice a week. Academic Kapitsa taught what he called experimental physics and Academic Landau taught what he called theoretical physics. If Kapitsa's lectures were clear and understandable, Landau's took the biscuit. Do you remember the book by Landau and Livshitz? He covered the first three quarters of this book about mechanics in the first lecture.

I walked down the corridor after this accident and decided that I would have to leave, because I did not understand anything. In the department there were four people from the school where I was taught, and one of them was a gold medallist. I asked him what he thought of the lecture and heard that he would leave – he also understood nothing. And so I decided that if even a gold medallist understood nothing, then that meant the problem was not with me.

And then the following happened. The Deputy Dean of FT, Solonouts, who played a big role in setting up the early MIPT came through the door and demanded a talk with our student front liners, whose parade uniforms were covered with battle medals from one shoulder to the other.

What they discussed with Solonouts I don't know, but then I saw the following scene – Solonouts went up to Landau, who was walking the corridor and said: "Lev Davidovich, can you come in for a minute?" Just by gesturing with his finger, Landau obediently followed him into his office. Solonouts was a mere Candidate of Physical and Mathematical sciences and formally held the modest post of lecturer in the Mathematics department. But he was afraid of no one and the academics had to "keep this in mind".

I do not know what Solonouts and Landau talked about, but at the next lecture Landau reread his lecture and spread the same three quarters of the book "Mechanics" over several lectures.

As it happens Solonouts saved me on another occasion. I received a "2" from Landau on one exam, and should then have travelled to the Crimean Radio Observatory for my practice. At that time there was a rule that "we don't carry dead wood". But Solonouts pulled rank and freed me from the requirement of the failed exam, which I later passed in the Autumn.

Can you describe a normal day at MIPT in 1947?

I lived in Moscow, got up at 6 o'clock, sat on a trolleybus or tram and went as far as Savyolovsky Station, where I caught a train to MIPT. The train was pulled by a normal steam engine, it wasn't electric. According to the timetable it left Moscow at 42 minutes past. In the winter it was terribly cold in the carriages, although it's true that in some you could find a stove with a bucket of coal. You could throw coal in the stove and warm up.



But you had to get in the right wagon.

Arriving at MIPT, first there would be a lecture, then seminars, then we would prepare for our classes in the superb library. They even had foreign journals there. At eight in the evening we went through the cold to the station "Dolgoprudnaya" - "Novodachnaya" did not exist then. We would reach home at 11 or 12 in the evening, and that went on every day for 4 years.

Incidentally, on the 1st of September 1947 when there were only two lectures and no seminars, we went to "Dolgoprudnaya" to discover that the next train to Moscow would only arrive in three hours.

There weren't many girls at MIPT, so the competition to be with them was high. Of course, there were other surrogate methods tried, such as evening meetings with students from the teaching college. In short, what saved us from paying too much attention to girls were hunger and the very high study load.

Did anything interesting happen during exams? Was there anything in particular?

We had a course in resistance of materials; the lectures were given by Professor Feodosiev, a leading specialist in this field. I didn't attend these lectures, even though resistance of materials is well known to be a difficult science. As the exam approached, I, of course, did not know anything.

So I turned up at the exam, picked a task card and sat down after having missed the whole course. As it happened I knew all of Feodosiev's questions and also the right answers. With this baggage in tow I received a "3".

My next meeting with Feodosiev was more than two decades later, in 1974, when we were both receiving the State Prize at the Kremlin. We received our prizes, and I went up to him and said, "Professor, you probably don't remember, but I am one of your students, and I am very pleased that we could receive this honour together". To which Feodosiev replied: "I remember you. You knew nothing, missed the whole course and got a "3"".

We did "practical soldering" with Alexander Prokhorov, the future inventor of lasers and masers and a 1964 Nobel laureate. This was for our laboratory work cycle; one day a week we soldered electrical circuits. At the end of the practical, there was an exam in soldering: we had to solder a given device, each one different, with a limited number of electronic valves. I had to do a particularly difficult type of oscillograph, taking up ten valves.

I tried for a long time but I couldn't get less than 12 valves. In the end I took a couple of valves for the drawer in the desk, hooked them up with two fine wires and hid them under a bundle of others, called Alexander Mikhailovich over and said: "Here, look – everything's working and with just ten valves". That was how I passed that exam. I decided to tell my lecturer how I managed to deceive him not long before he died, in the 1990s. I recall that we had a very good laugh about this.



If you were to write a code of honour for MIPT, what points would you include?

The usual. What do we have in the ten commandments? Don't kill, don't go with the wife of your best friend (even though everyone wants to). There's no need for a special code, it is sufficient enough to have ordinary human decency.

It's necessary that at MIPT, doing is more important than money. At MIPT they taught us one important principle – a phystech graduate can do anything. If they told me now to learn Chinese, I would do so even in the ninth decade of life. This is also a very important feature of MIPT.

How would you define the mission of MIPT?

I wouldn't want to talk about today's MIPT but there is one very important thing. The "MIPT System" in the form that it took from the very beginning is as much a

national achievement as Pushkin or the Tretyakov Gallery. It exists irrespective of the state of MIPT today, and to what degree the system is used today or is adopted by other universities. But it has shown its viability that it can deliver results, has provided a huge impulse to the development of the country and has given the country hundreds of outstanding scientists and brilliant technical specialists, who are prepared to do anything to get the job done.

My classmate, Nikolai Karpov, who from 1987 to 1997 was Rector of MIPT, told me that there had been a meeting organised somewhere abroad by the Ministry of Foreign Affairs of representatives of different companies working in that country. Out of the ten participants, eight were MIPT graduates. I think that's a very good illustration of the mission of MIPT.

57th MIPT SCIENTIFIC CONFERENCE

DEDICATED TO THE MEMORY OF PYOTR KAPITSA ON HIS 120TH BIRTHDAY

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Our Man in CERN

On August 8, a 1957 MIPT graduate, the head of the RDMS project and the CMS project at the Large Hadron Collider, Professor Igor Golutvin, turned 80. In an interview with MIPT's press service, Golutvin spoke about his first steps at MIPT and about the progress made on the world's most exciting scientific endeavor.

How did you end up at MIPT and how did you learn about it?

In 1951, Moscow schools received an order to send the best students to a private faculty of physics and technology at Moscow State University. To enroll, you had to have a special recommendation from the Education Department of Moscow and the Komsomol. No other institute had such a prerequisite.

In addition, there were no advantages for high school graduates with golden medals; they had to take four exams like everyone else. Moreover, this department had a special set of exam subjects, namely physics in writing, oral physics and mathematics in writing and oral mathematics. If you received a five [an A] on the first exam, you were exempted from the second, oral exam.

I applied, got fives for my written works and enrolled. I applied at the Department of Physics and Technology of Moscow State University, and when I started to study, it was renamed as Moscow Institute of Physics and Technology – the institute opened almost immediately after the department was closed.

What was MIPT like then?

Everything was different. You can take a commuter train to Dolgoprudny now, but at that time there were only occasional steam locomotive trains going to that town. I remember they had wheels of more than a meter in diameter. The town was very difficult to reach, so everyone – even the Muscovites – lived in the dormitory.

The schedule was very tough: we started at 10 am and wouldn't finish before 8 pm – 10 pm.

During the first three years we were given lectures in mathematics and physics of the highest level – nowhere

else was it like this. Much attention was paid to theoretical physics. Those were our main subjects. And after the second year they began sending us on practical internships.

What was training like?

It was very hard to study. But our work was really rewarding, and we had great teachers, such as mathematician Sergei Nikolsky and physicist Grigory Landsberg. They made the strongest impression on me.

Some of the outstanding researchers held seminars for us. The selection principle was like this: they invited people from a strong research team and they came to Dolgoprudny for one day and worked with a group of students. Also, of course, the experience I got at the basic training chair was invaluable.

Did you take up particle physics immediately?

At that time, there wasn't even a term like that; this science was born in front of our very eyes. My first employer, which I joined in 1954, was what is now known as Concern Almaz-Antey. It was there that I actually learned electrodynamics and statistics. I applied for the Structure of Matter course, it was called course #1, but then I switched to the so-called course #4. It was a secret course; no one knew what it was about. I didn't know either until I came with a sealed envelope to the address written on it. I came to KB-1, or "P.O. Box 1323"; that was the name of Almaz then. They took two photos of me – from the front and in profile, with a board on my head – like pictures of criminals, and I started working. And then I had these pictures on my ID.

What did this design bureau do?

The bureau was set up in 1950 for a very ambitious task – to protect Moscow against a potential nuclear attack.







The task was put like this: even if 1,000 jets are sent to Moscow, each of them must be shot down at least with three missiles. So we had to secure 100 percent protection.

There were two chief designers at the bureau, Sergo Beria (Lavrentiy Beria's son) and Vladimir Kuksenko. And both had one and the same deputy, Alexander Raspletin, after whom the concern was named later.

I was lucky to be taken on to a very good, advanced laboratory headed by Vitaly Chernomordik. I am very proud to have had this experience, because it was there that I learned what collective work on a large project is. This experience helped me at CERN.

As a result of Raspletin's work, so-called defense rings were set up around Moscow. They are now equipped with the most modern complexes S-300 and S-400. I'm very proud of these years and the work that I did at KB-1.

It was there that my first scientific paper came out in 1955. But it was a secret one, so I learned about it not long ago, when I saw a list of articles in a book dedicated to Raspletin's centennial anniversary. It was very pleasant and honorable. In 1957-1958 KB-1 had all academic problems solved, I was bored there and I focused on physics, or, more specifically, on the branch that later became particle physics.

How was it started?

There was this subject, nuclear physics. And particle physics was started here, in Dubna, by people like Vladimir Veksler, whose group I joined after Raspletin's. I worked with him for 8 years, up to his death. First it was called high-energy physics, then the physics of elementary particles, and then, when we realized that the particles are not so "elementary," it got the name "the physics of particles."

How did you start working at CMS?

I worked at CMS from the very outset, from the project's planning stage, I was one of the originators of this project. There were only a few people working on it then, and now there're about 3,000. When the project passed the approval stage, more and more countries and institutions began to join it, and responsibilities began to be redistributed among them. Michel della Negra, the project manager, whom I knew well, offered me to supervise two sections, hadron calorimeter and muon chambers.

Those are parts of the front area of the detector, where radiation and intensity are the greatest, it's the most difficult part of the project. I thought the Joint Institute for Nuclear Research and our partners were capable of doing it, and I agreed.

How did you manage to find the funds for this work in such difficult times, the mid-90s?

After we approved the plan, I had to draft an estimate.

It turned out that we needed about \$10 million. Of course, a special agreement was needed to disburse such a sum, but there was no such agreement between Russia and CERN at that point yet. It so happened that Vladimir Kadyshevsky, then director of the Institute, worked at CERN.

He happened to be the right man at the right time and in the right place. Thanks to Kadyshevsky the right decision was made, and the agreement was signed. That's how our story began.

Who manufactured parts for the detector along with Dubna?

The chambers were made for free here in Dubna, but we had to buy copper and scintillators for calorimetry. I established cooperation with Belarus and with the Northern Navy, where NIKIET worked, headed by Vladimir Smetannikov. It made reactors for the nuclear program. In Belarus, there was the Center for Particle Physics and MZOR (Minsk October Revolution Plant), headed by Mikhail Kriyomaz. It made machines.

We had a very difficult task: it was necessary to process copper plates for calorimeters with the accuracy of 50 microns for 3.5 meters. Our contractors did their task very well.

How did the name RDMS appear?

At first everyone called our collaboration project FSU (Former Soviet Union); it was a standard name. I was really upset with this name and convinced Michel della Negra to change it. I told him that if it's a new business, we can't start it with references to the past.

Thus this abbreviation RDMS (Russia and Dubna Member States) appeared. RDMS brought together all members of the international organization of the Joint Institute for Nuclear Research. Now, 20 years later, we can say for sure that RDMS met its goals, when the collider was built and when it started operations.

We all worked to make a great discovery, and we made it – we've seen the Higgs boson. This discovery makes me proud. It changes our understanding of the structure of matter and of the world. And I'm sure it'll bring more results in the future.

Now that the Higgs boson has been discovered, what are the plans for the collider? Hasn't the project exhausted itself?

We can see the horizon not just for the next run of the collider, not only for a run after the second modernization stage, but for 30 years to come.

It's a unique project: it has never happened that so many generations of physicists grew up in one place, spent all their lives in it and transferred their experience to the next generation. And, of course, we'll look for physics beyond the Standard Model, we'll try to find manifestations of supersymmetry.

There is only one recipe for this – increasing power. We understand that visible matter, all that we associate with our ideas about the macrocosm and microcosm, makes up less than 5% of the Universe. The rest – dark matter and dark energy – is terra incognita.

Physics is once again becoming an experimental science – we'll see what we can observe.

The LHC has great prospects. Studies held in recent years have shown that it's possible to install superconducting magnets and dipoles in this tunnel, raising the power to 31 TeV, which will turn the LHC into a high energy collider.

Moreover, researchers are discussing the possibility of increasing the power to 100 TeV (although not in the same tunnel), using this machine as an injector.

What are your immediate plans?

You see, CMS was designed 20 years ago. It was made based on the latest achievements of science and technology, we oriented ourselves towards the methods and technology that were yet to be created, but it's been 20 years since then. CMS is a detector, full of electronics, which is developing particularly rapidly and changes drastically every three years. This means we can improve the detector significantly now.

And now we're going to start working with much greater intensity than before; we need to collect a lot more data. Thus, even radiation will be incomparably greater. In addition, proton collisions will become more frequent. This means that they will overlap and will need disentangling.

This is why we need faster systems, faster detectors. We are currently working on an upgrade of the detector. We stopped it 18 months ago, and will reactivate it in the spring of 2015.

Right now we're in the first phase of the upgrade, and it's clear what to do. But we are planning for the second leg of the upgrade: next time the detector will be stopped in 2018, also for a couple of years; after that upgrade the accelerator will operate at the same power, but at intensities greater by an order. This means we'll be able to accumulate a lot more data, more by an order.

Right now I'm working on the second leg of the upgrade, and by the end of this year we should be ready with a project of upgrading flank hadron calorimeters. We need to show what benefits it'll give and how it should be undertaken. These ideas are now being tested in Tashkent, Minsk, Kharkiv and Dubna.

Story by Alexandra Borissova

MIPT Guests: By the Dozen

The contacts of Moscow Institute of Physics and Technology are vast and various. From Nobel Prize winners to cosmonauts, diplomats and great chess players, people from all over the world come to visit our institute. The editorial office of "For the Glory of Science" magazine offers readers an image gallery of 12 notable guests who visited MIPT in 2014.



The Ambassador of the Republic of the Union of Myanmar, Wu Ting Yu, came on April 15th, during the Burmese New Year, to celebrate the holiday with students and teachers from his country who study and work at MIPT.



On April 8th, Magnus Carlsen, the current world chess champion, had a game of multi-board chess on 13 boards, of which 3 ended in a tie.

On April 29th, the head of the Main Military Medical Department of the RF Ministry of Defense, Alexander Fisun, visited MIPT's specialized laboratories, where he had a look at the institute's latest developments in the field of military medicine



On July 30th, the head of the Federal Biomedical Agency, Vladimir Uyba, and MIPT Rector Nikolay Kudryavtsev signed an agreement of collaboration between the FMBA of Russia and MIPT.

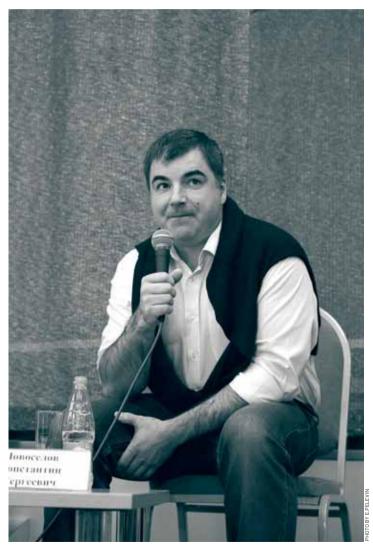


On June 3rd, the Mayor of Moscow, Sergey Sobyanin, took part in laying a capsule with a message to descendants in the foundation of MIPT Technology Park, currently under construction.





Along with the Mayor, Nikolay Nikiforov, RF communications minister, took part in the ceremony of laying the message to descendants.

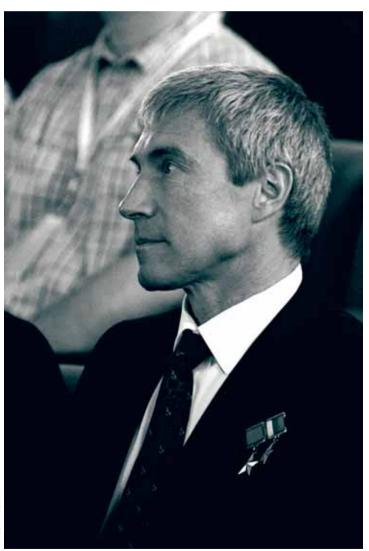


On September 1st, a new building for MIPT's lyceum for gifted children was opened. Konstantin Novoselov, 2010 Nobel Prize winner and MIPT graduate, spoke at the opening ceremony.

Andrey Vorobyov, the Governor of Moscow Region, also took part in the opening of MIPT's lyceum.



Sergey Krikalyov, the eminent Russian cosmonaut, Hero of the Soviet Union and Hero of Russia, who has made six space flights and who is the absolute record holder of time spent in space, often visits MIPT.



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On May 29th, Michael Levitt, a 2013 Nobel Prize winner in chemistry, gave a lecture at the international conference "PhystechBio".



A day later **Robert Huber**, a 1988 Nobel Prize winner in chemistry, gave a lecture at the conference.



On July 9th, Dirk Van Den Berg, TU Delft President, visited MIPT as the head of the Delft University delegation. He has previously served as Secretary-General of the Ministry of Foreign Affairs of the Netherlands, Permanent Representative of the Netherlands to UNO in New York and Ambassador of the Netherlands to China.

