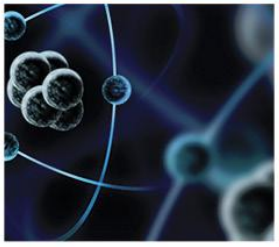
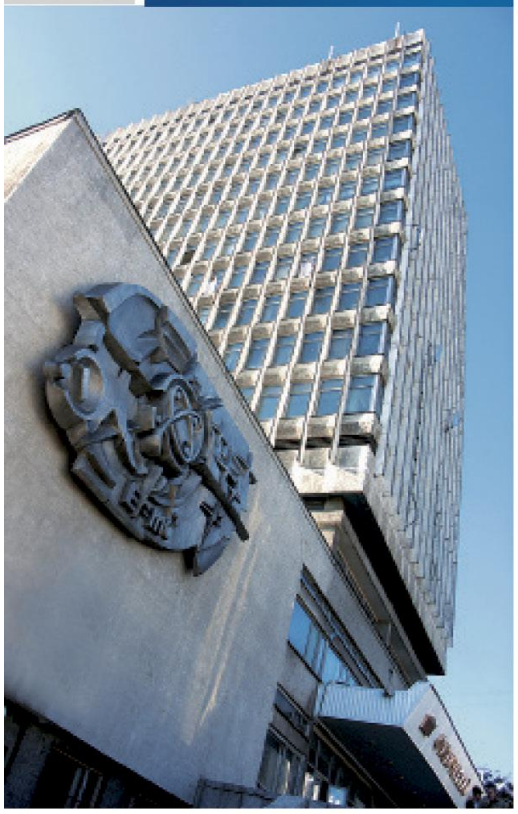
KAZAN FEDERAL UNIVERSITY

INSTITUTE OF PHYSICS



INVOLVED INSTITUTES



Scientific supervisor:
Professor Dmitrii Tayurskii
Deputy Director, Institute of Physics

Tel. +7 843 2337065
E-mail: Dmitry.Tayurskii@kpfu.ru
Skype: dtayursk

Institute of Fundamental Medicine
and Biology

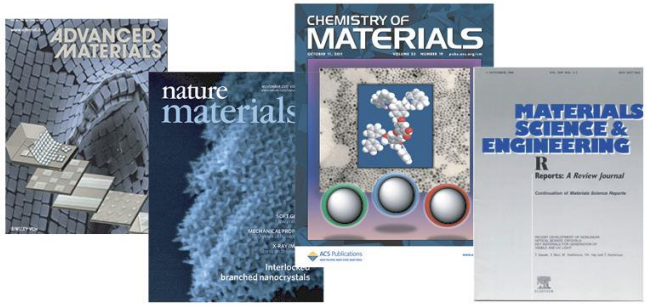
Branch of KFU in Naberezhnye Chelny,
Engineering Center

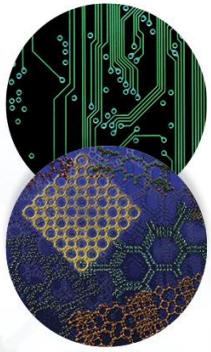
WHY MATERIALS?

MATERIALS – HISTORIC MILESTONES AND THE PHYSICAL BASIS OF CIVILIZATION

Stone Age | Bronze Age | Iron Age

THE NUMBER OF PAPERS ON MATERIAL STUDIES IS GROWING EXPONENTIALLY



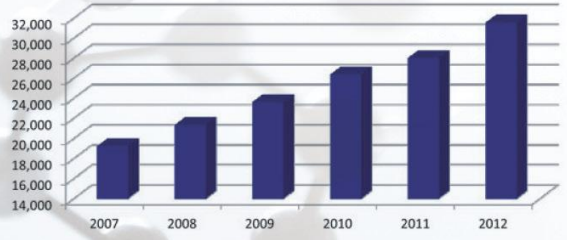


Electronic (Silicon) Age

Materials determine the historic milestones and present the physical basis of civilization. The whole mankind history is the change of "material" ages. Today the technologies for materials determine the development of all fields of industry – transport, power, natural resources, environmental safety, odern information technologies, agriculture, constructing aviation etc., the national security and success of many national programs and projects depend crucially on them.

The development of the existing technologies and the creating of the new ones are impossible without new, multifunctional and smart materials. It is already possible today to create the materials specific for solving some problems. The success in the creation of smart materials opens practically unbounded market for the necessary products. Airplanes invisible for radar detection, artificial bones, solar cells, computer memory, modern sensors – all of them are connected with the functional materials the properties of which are determined and are controlled during the design process.

JOURNAL OF MATERIALS SCIENCE CITATIONS



UNIQUENESS OF KFU

EPR spectrometer for W- and X-band Bruker Elexsys 680 in the Federal Center for the Shared Facilities

The unique infrastructure for new materials studies has been built last years at KFU. It is the first in Russia laboratory for computer design of new materials on the basis of innovative software package from Materials Design ®, laboratory for chemoinformatics, joint research laboratory KFU-RIKEN with a leading world institute for material science – Institute for Physical and Chemical Studies RIKEN, Japan. The Federal center for the shared facilities for physical-chemical investigations and the International center for magnetic resonance should be mentioned as well.

Opening ceremony for the Joint Research Laboratory KFU-RIKEN in May, 2012

The existing at KFU the rich infrastructure of scientific studies, the unique scientific experience of KFU allow today to develop the synthesis and investigations of such materials like

- new functional and smart materials
- materials for quantum technologies
- materials for biomedicine
- new catalytic materials
- polymer composite materials
- drug delivery systems

Participants of the International Workshop "2D Electrons on Liquid Helium and Quantum Information", 3-7 May, 2014

THE UNIQUENESS of the realization at KFU of the above mentioned studies consists in the choice of the studied objects, in the variety of the used approaches and of experimental methods for solving the problems.

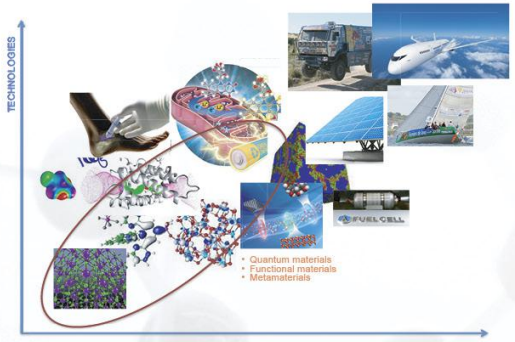
THE UNIQUENESS of the choice of the studied matter is an attribute especially for materials for quantum technologies and functional materials – quantum phase of matter, interface between solid substrate and quantum fluids, 2D systems of electrons and ions on and beneath of quantum fluids, thin film heterostructures, low-dimensional systems etc. For a number of them KFU is the one from only few Russian and world scientific centers.

Powder X-ray diffractometer Bruker D8 Advance

THE ORIGINALITY of advanced materials studies at KFU is the integrated approach – computer design of new materials, their synthesis and a wide set of experimental methods for their characterization with a feedback to improve modeling and synthesis methods.

Optical floating zone furnace for the crystal growth of oxide compounds, Crystal Systems Corporation, Japan

MULTISCALE STUDIES AT KFU

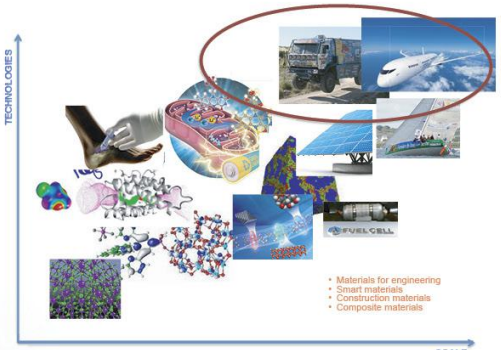


QUANTUM TECHNOLOGIES

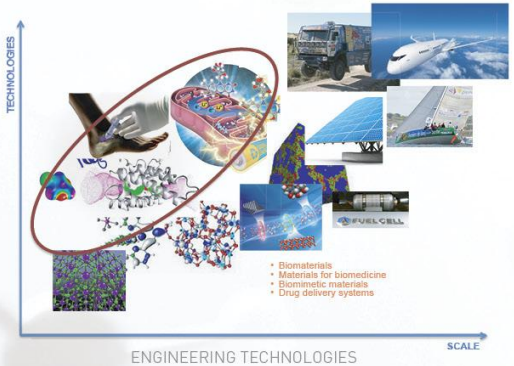
CHEMICAL TECHNOLOGIES

To make a breakthrough in computer design of new materials and to create innovative systems one must use the concept of multiscale modeling. It should connect the structure of the matter on the quantum level (electronic structure) with the characteristic times about femtoseconds and the macroscopic classical behavior on the times of years and even of tens of years.

This concept has to be built as the merging of the "bottom-up" and "top-down" approaches. The description, understanding and the forecast of such multiscale and multiphysical phenomena is the very important scientific problem, the key problem for the safety and wealthy of the modern society.



BIOTECHNOLOGIES



ENGINEERING TECHNOLOGIES

CENTERS AND LABORATORIES

NMR-spectrometer Bruker Avance 500

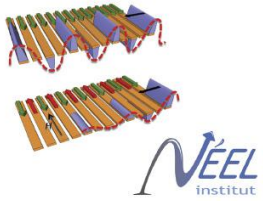
NMR-spectrometer Bruker Avance IIITM with two tomography sensors allowing to study small animals (mouses)

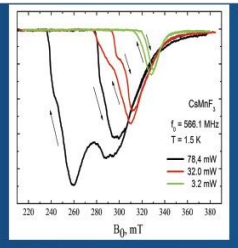
The main activities are:

- Structure determination of biologically active peptides and drugs in solution and in a complex with model membranes by high-resolution NMR
- Development of MR imaging methods in researches of small animals
- Spin superfluidity in condensed matter
- Synthesis of nanomaterials and the development of magnetic resonance methods to characterize them
- The development of new approaches, problem-oriented techniques and technologies based on the NMR spectroscopy with magnetic field gradient to solve fundamental and applied problems

Scientific supervisor: Professor Albert Aganov Director, Institute of Physics

Team leaders: Prof. Yu. Bunkov (Neel Institute, France) and Prof. M. Tagirov





LABORATORY FOR SPIN SUPERFLUIDITY AND NON-LINEAR MAGNETIC RESONANCE

The following subjects are the main interest of:
- physics of magnetically ordered coherent states, dynamics of magnons, prototypes for magnonics
- transport phenomena in superconductors
- coherent magnetic dynamics in ferrites and ferrite films

CENTER FOR QUANTUM TECHNOLOGY

The fields of our studies are:

- New materials for quantum technology
- Synthesis and research of functional heterostructures superconductor-ferromagnetic, superconducting spintronics
- Transport, spectral and magnetic properties of new materials with strong correlations

Physical Properties Measurement Systems PPMS-9, Quantum Design, USA

Today the problem of quantum computer is not only a great scientific problem but has also some image nuance which important for the positioning of the university on the world scientific arena. From the scientific point of view the creation of quantum computer is many facets task. The questions of long-time quantum memory, prototyping of cubits as well as the development of quantum calculation algorithms play here important role. Also the design of new devices for quantum teleportation and quantum cryptography is crucial for quantum informatics.

At KFU the unique situation has been created when the scientists work together actively in magnetic resonance researches, in quantum optics, in the synthesis of new materials. It makes the real basics to promote KFU into the leading center in the field of quantum technologies. The existing scientific programs, joint projects and studies give the bright evidence for a high level of Kazan researchers for solving such problems. Today in the Center for Quantum Technology, founded only in 2013, there are already several ambitious projects under development in close co-operation with the leading world centers: the synthesis of room-temperature superconductors, the design of qubit on the basics of planar Josephson junctions, the one-electron transistor in 2D electron system on the liquid helium.

RIKEN

国立交通大學 National Chiao Tung University

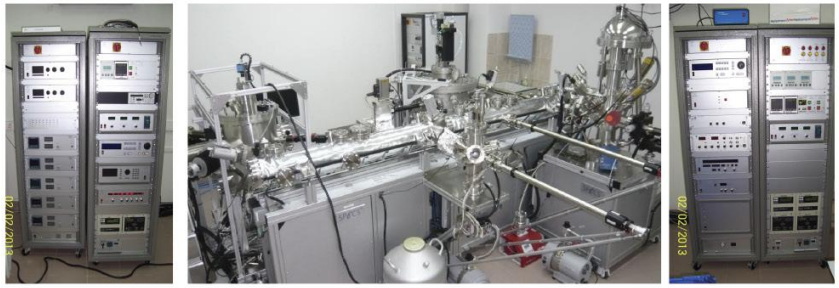
OIST Okinawa Institute of Science and Technology Graduate University

universität innsbruck

Aalto University School of Science and Technology

ИФТТ РАН ISSP RAS

Key scientific partners of the Center for Quantum Technology

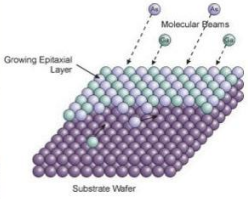


Ultra-high vacuum deposition and analysis system from SPECS and BESTEC (Germany)

LABORATORY FOR SYNTHESIS AND ANALYSIS OF THIN-FILM STRUCTURES

Synthesis and analysis of thin-film heterostructures combining dissimilar and antagonistic materials like ferromagnetic and superconducting metals, metals and insulators, superconductors and semiconductors, etc.As a result of interaction between ultrathin layers on the level of quantum mechanics, these artificial materials possess unusual and intricate properties which could not be found in Nature.
These metamaterials are searched for novel device physics.

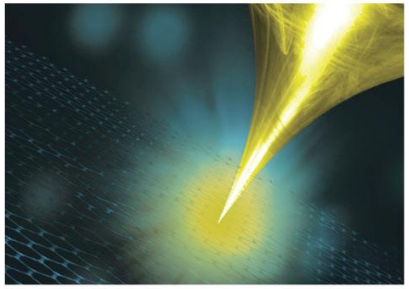
Team leader: Prof. L. Tagirov



Laboratory for synthesis and analysis of thin-film structures

Expected results:
- Ultrathin-film heterostructures exhibiting giant magnetoresistance
- Thin-film bilayers for studying the inverse proximity effect between antagonistic superconductivity and magnetism
- Ultrathin-film palladium-iron and copper-iron multilayers for Josephson junctions physics (weak link metamaterials)
Ultrathin-film Josephson structures realizing superconducting memory functions

Scanning probe microscope combined hybrid optical microscope NTEGRA SPECTRA, NT-MDT, Russia



LABORATORY FOR PHOTONIC METAMATERIALS AND NANO-SIZED DEVICES

Main goals of studiea are:
- Plasmonic waveguides
- Photonic crystals
- Single photon light sources
- Light nanofocusing
- Energy transport in metamaterials
- Light trapping devices
- Plasmonic heterogenous sensors

Also we are interested in the following research works together with the leading Russian company for nanofabrication equipment NT-MDT :
- Optimization and standardization of optical nanoantennas
- Calibration samples for Tip-Enhanced Raman Spectroscopy/ Surface-Enhanced Raman Spectroscopy Thermo cantilevers for Atomic Force Microscopy
- Atomic Force Microscopy cantilevers with embedded photonic crystals
- Graphene-based Micro Electro-Mechanical Systems

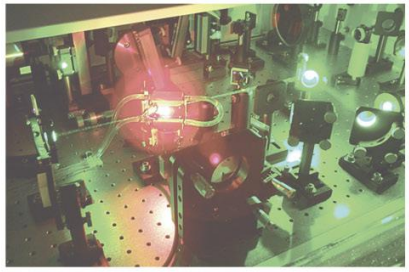
Team leader: Prof. Ildar Gabitov
Arizona University, USA

NT-MDT
Molecular Devices and Tools for Nano Technology

LABORATORY FOR FEMTOSECOND LASER PHYSICS

At the femtosecond spectroscopy laboratory the experimental investigations in several research fields are performed. The aim of the nonlinear property studies of the composite materials formed by the metallic nanoparticles embedded into various dielectric media is to determine the values of the nonlinear coefficients as well as to find out the timescales and the physical origin of the processes that govern the observed dynamics. Investigations of the ultrafast magnetization transients via the time-resolved magnetooptical Kerr effect in ferromagnetic nanostructures (nanoparticles, mono- and multilayer thin films) is a field closely related to the development of a new generation of fast high-density information storage devices. Performing the studies of nonradiative decay of the electronic excitations in the strongly correlated electron systems we gain an insight to the peculiar excited states, the paths, timescales and the processes involved.

Femtosecond laser system, Coherent Inc., USA: it includes oscillator Micra-5 (wavelength 800 nm, pulse duration after compression less than 15 fsec), regenerative amplifier ELite USP (wavelength 800 nm, pulse duration 35 fsec, pulse energy 1.5 mJ), optical parametric amplifies OPeRa Solo



Team leader: Dr. S. Nikitin
Deputy Director, Institute of Physics

CENTER OF COMPOSITE MATERIALS

We are working for the development of functional polymeric composites such as:
- Filled polymeric materials for wide application area
- Gradient materials with various operational properties
- Polyelectrolytes and their metal complexes for biomedicine

Scientific supervisor:
Prof. Rustem Amirov

We are going to get new polymer materials on the basis of thermoactive polymers (epoxy, polysulfones etc) perspective for automotive, aviataion and space industies.
We are going to synthesize and to study the physical-chemicla properties of new polymer nanocomposites on the basis of thermoplastic polymers (polyethylen, polypropylen etc.) and non-organice components (layered silicates, carbon etc.)
We are going to propose the new methods for the synthesis of new nanocompoiste catalysts on the basis of the layered silicates

UNIVERSITÀ DI PISA

Rheometr DHR-2 used for development of new epoxy composites

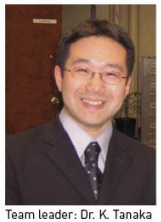
Minispec MQ20 - instrument for investigation of magnetic properties of metal-containing polymeric materials

Dielectric spectrometer Novocontrol BDS Concept 80 (Germany) allows to measure the parameters fo new functional composite materials in the wide frequency range 0.003 mHz - 3 GHz, at various external pressures 0-3000 MPa and temperatures -160 o C - +400 o C

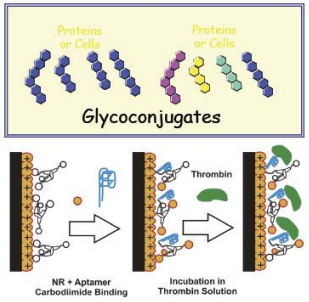
BIOFUNCTIONAL CHEMISTRY LABORATORY

We are developing the glycoconjugates which selectively target the specific organs & tumors in live animals. For this goal, we are synthesizing various natural and unnatural glycan molecules, conjugating onto proteins & cells, and systematically performing PET and fluorescence imaging in live animals.

We can develop several glycoconjugates for three years, which selectively target the specific organs and tumors in live animals. These will be used in near future as a new category of the imaging tracers of diagnostic, i.e., Positron Emission Tomography (PET) tumor diagnosis.



Team leader: Dr. K. Tanaka
RIKEN, Japan



PET or Fluorescence Imaging in live animals

Bruker Avance-400 NanoBay NMR spectrometer

DNA SENSORS LABORATORY

We develop DNA sensors based on new hybrid materials for the detection of disease biomarkers, pharmaceuticals, environmental pollutants and food additives.

We investigate of specific DNA interactions and biorecognition processes based on DNA and its artificial derivatives (aptamers, DNAzymes) on the transducer interface modified with nano- and mesostructured materials

Our expected results:
Synthesis and exploration of new biorecognition materials based on DNA and aptamers and nano- and mesoporous materials

The development of DNA sensors with extended sensitivity and selectivity for the detection of DNA recognizing molecules, i.e., drugs, cancer biomarkers, genotoxicants, food additives etc.
Real samples testing, DNA sensors validation and application

Team leader: Prof. T. Hianik
Comenius University, Slovakia

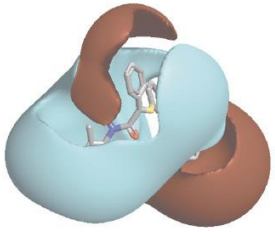
Electrochemical analyzers Autolab PGSTAT, CHI 440B, SPR Analyzere Esprit, screen printer DEK 248

UNIVERSIDAD COMPLUTENSE MADRID

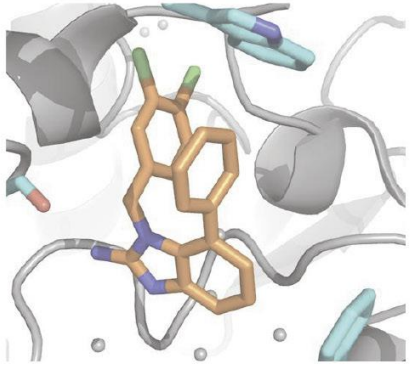
LUND UNIVERSITY

LABORATORY OF CHEMOINFORMATICS

Team leader: Prof. A. Varnek
University of Strasbourg, France



Our main goals are:
- computer-aided design of new reactions, materials and biologically active molecules in collaboration with experimental laboratories of KFU
- support of teaching of chemoinformatics and molecular modeling at undergraduate and graduate levels.



We have:
- 24-core computational server
- "Gaussian" software for quantum chemical calculations
- ChemAxon set of programs for chemoinformatics
- 128-core computational cluster for advanced computing (quantum chemistry, molecular modelling, chemoinformatics)
- Software for drug design: MOE and Schrodinger

ROYAL SOCIETY OF CHEMISTRY

ChemSpider

inte:ligand
Your partner for in-silico drug discovery.

BioSolve

CONSTRUCTION OF NEW LABORATORY BUILDING FOR THE CHEMICAL INSTITUTE

02,2014

04,2014

03,2014

05,2014

CENTER FOR SMART AND FUNCTIONAL MATERIALS

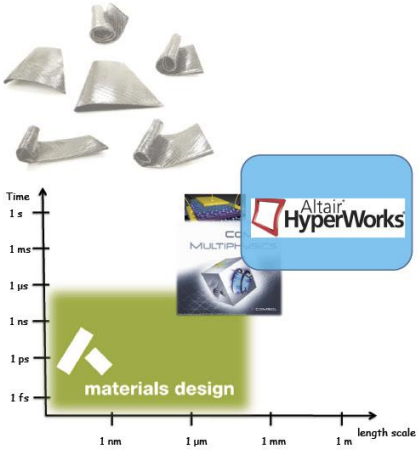
The goal of the Center is the design and study of advanced smart materials with programmable properties, technologies of their processing. The fields of our studies are:

- bulk nanomodified materials for the details in machine and heavy industry
- "smart" materials
- new technologies for processing of bulk nanostructured materials
- intellectual system for design of new materials with the given properties and for the technologies of their processing

Single crystal X-ray diffractometer Bruker Kappa Apex Duo

Teaching class in the Branch of KFU in Naberezhnye Chelny

Team leaders:
Prof. A. Vinogradov (Osaka City University, Japan)
Prof. R. Valiev, Ufa, Russia



The variety of simulation software for the multiscale modeling and design of new materials in Kazan Federal University

RESEARCH AND EDUCATIONAL CENTER OF COMPLEX PHYSICS SYSTEMS

AN INTERNATIONAL PROGRAM IN THE EMERGING FIELD OF COMPLEXITY

Aiming at the training of elite scientist-manager able to model and simulate complex materials and nanostructures, within the framework of innovative research projects in the field of nanotechnology, energy, environment, life sciences, natural resources and infrastructures

A multidisciplinary teaching staff and scientific committee including researches and teachers acting in Russia and Europe

Scientific supervisor:
Prof. A. Alain Le Méhauté (France)

The Diploma of Master in Materials Engineering (France) issued for Kazan student A. Petrova

PEDAGOGICAL OBJECTIVES AND CHALLENGES FOCUSED ON TRANSDISCIPLINARY COMPETENCIES

Through face to face courses and e-learning, specialized seminars, numerical and experimental practical work, case study, individual projects or small group projects, the training scheme will allow the students:

- to discover the challenges and the applications of sciences of complexity
- to supply and to reinforce their knowledge in mathematics and scientific computing
- to initiate themselves to work out in the field of complex materials and nanostructures
- to practice to work pro actively in disciplinary and multidisciplinary team to create, innovate or develop business
- to learn how to design, to control and to evaluate innovative scientific projects, to develop skills in opportunities management and valorization of research result

in collaboration with ISMANS, France

Rector of Kazan Federal University, Prof.I.Gafurov, Director of the Branch of KFU in Naberezhnye Chelny Prof. M. Ganiev and Prof. Le Méhauté at the Altair European Conference, Torino, Italy, April 2013

STUDY PROGRAMS

WE PROPOSE A VARITE OF EDUCATIONAL PROGRAMS IN MATERIAL SCIENCE

BACHELOR DEGREE (4 YEARS)

Institute of Physics: Physics, Radiophysics, Technical Physics, Nanotechnology and Microsystem Technics, Biotechnical Systems and Technologies, Management of Innovations

Butlerov' Institute of Chemistry: Chemistry (Inorganic Chemistry, Organic Chemistry, Analytical Chemistry, Physical Chemistry, Chemistry of High-molecular Compounds)

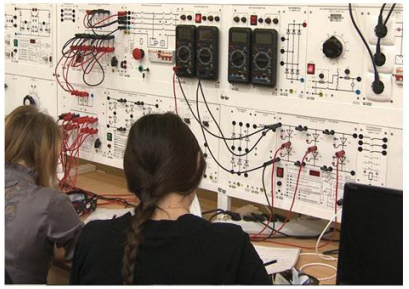
5-year Education Degree (Specialist)

Butlerov' Institute of Chemistry: Fundamental and Applied Chemistry (Inorganic chemistry, Ogranic chemistry, Analytical chemistry, Physical chemistry, Chemistry of High-molecular Compounds)

Institute of Fundamental Medicine and Biology: Medical biophysics

The Branch of KFU in Naberezhnye Chelny: Automatization of the technological processes

MASTER DEGREE (2 YEARS)



Institute of Physics: Physics (Theoretical Physics, Physics of Condensed Matter, Optics and Photonics, Physics of Complex Systems), Radiophysics (Physics of Magnetic Phenomena, Quantum Radiophysics), Technical Physics, Management of Innovations

Butlerov' Institute of Chemistry: Chemistry (Oil Chemistry and Catalysis, Chemoinformatics and Molecular Modeling, Chemistry of Supramolecular Nano- and Biosystems)

The Branch of KFU in Naberezhnye Chelny: Mechanical engineering, Technological Machines and Equipment, Mechanical Engineering for Power Industry, Material Science and Technology of Materials)

PhD Degree (3-4 years)

Physics: Condensed Matter Physics, Theoretical Physics, Optics, Technical Physics

Chemistry: Inorganic Chemistry, Analytical Chemistry, Organic Chemistry, Physical Chemistry

OUR INTERNATIONAL PARTNERS