Federal Scientific Research Center

“Crystallography and Photonics”

Russian Academy of Science

(FSRC «Crystallography and Photonics» RAS)

Olga Alekseeva,

Director

Moscow, Russia

FSRC “Crystallography and Photonics” RAS

Established in 2016 on the basis of Shubnikov Institute of Crystallography on the initiative of Prof. M.Kovalchuk and Academician V.Panchenko, now the scientific leaders of the Center

Subdivisions

Shubnikov Institute of Crystallography (*IC RAS,* *Moscow*)

Institute of Photon Technologies (*IPT RAS,* *Moscow*)

Photochemistry Centre (*PC RAS,* *Moscow*)

75 years in 2018

Branches

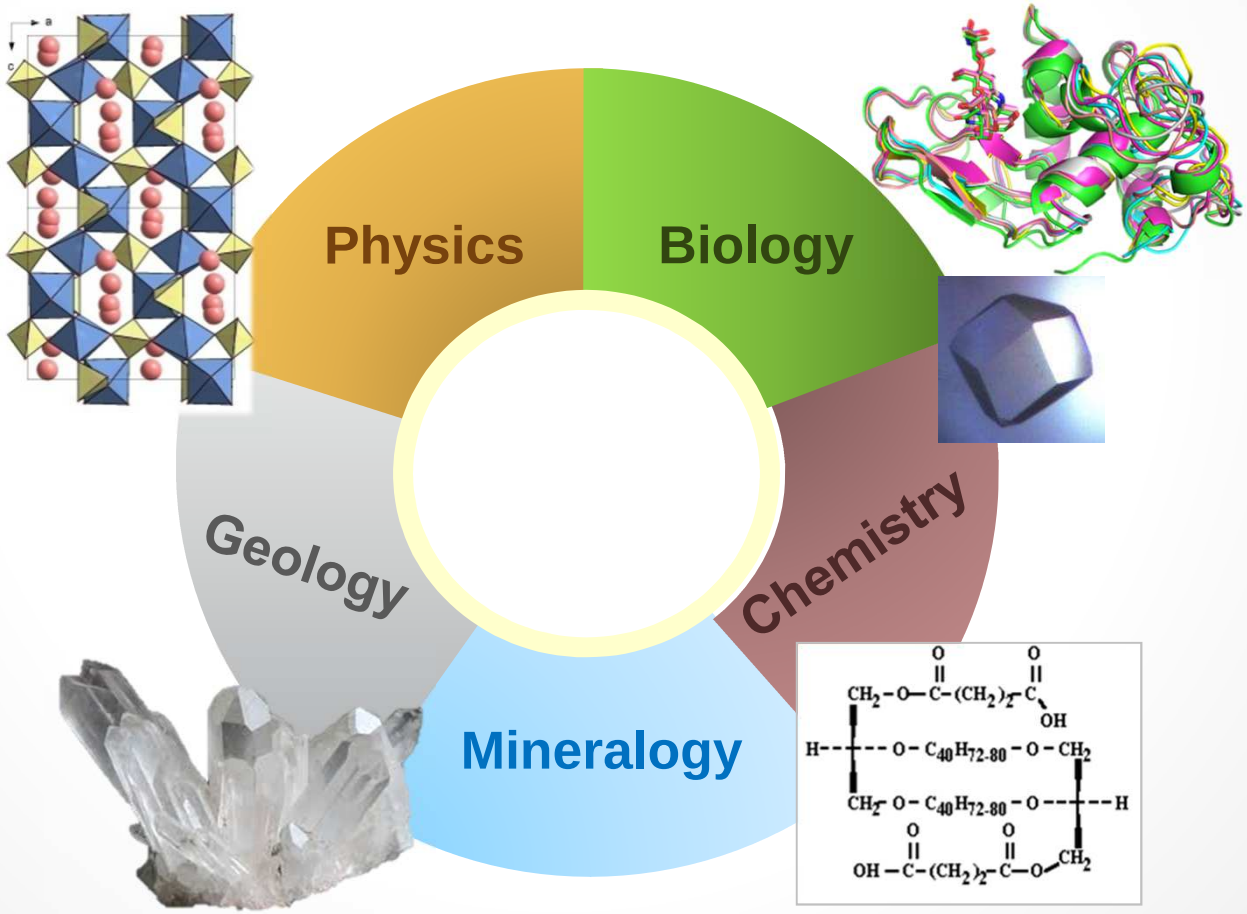
Laboratory on Space Materials Science of IC RAS (*LCM IC RAS,* *Kaluga*)

Image processing systems Institute (*IPSI RAS,* *Samara*)

Institute on Laser and Information Technologies (*ILIT RAS,* *Shatura*)

Crystallography: stages of development

Starting as the mineralogical science, crystallography became an interdisciplinary science, where the achievements of chemistry, biology, physics, and geology are mixed and complementary.



Crystallography: stages of development

Shubnikov Institute of Crystallography – research ideology that is based on the "growth–structure–properties" triad with a deep relationship between these concepts.

During 75 years our institute went the same way as the science of crystallography and now our research fields are including mineralogy, chemistry, chemical analysis, crystal growth, X-ray diffraction analysis, physical materials science and also biology and protein crystallography.

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After the merger of the Institutes the main directions of scientific research has significantly expanded:

- Crystallography, Condensed Matter Physics, Materials Science;
- Physics and Technology of Nanomaterials and Nanostructures;
- Additive Technology;
- Structure and Function of Biomolecules and Supramolecular Complexes;
- Structural Diagnostics Methods with the use of X-ray and Synchrotron Radiation, Electrons, Neutrons, and Atomic Force Microscopy;
- Space Materials Science;
- Photonics, Photochemistry;
- Laser-Information Systems and Technologies;
- Products and Technology for Medical Application, Intelligent Systems for Medicine;
- Computer Optics, Adaptive Intelligent Vision Systems;
- Radio-, Acousto-, Optoelectronics, Optical and Microwave Communication systems;
- Pharmacology: Pharmaceutical Chemistry, Biopharmacy.

For most of these scientific areas the use of synchrotron radiation source is very important and gives new unique research opportunities.

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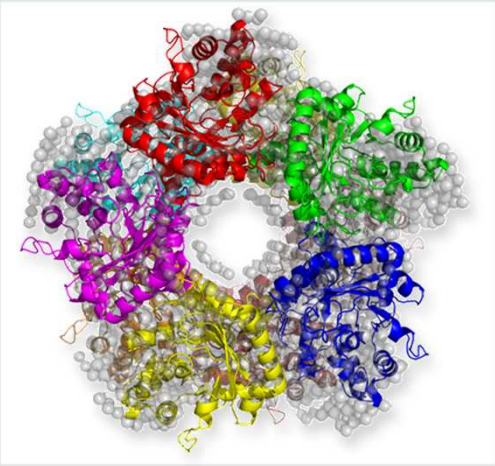
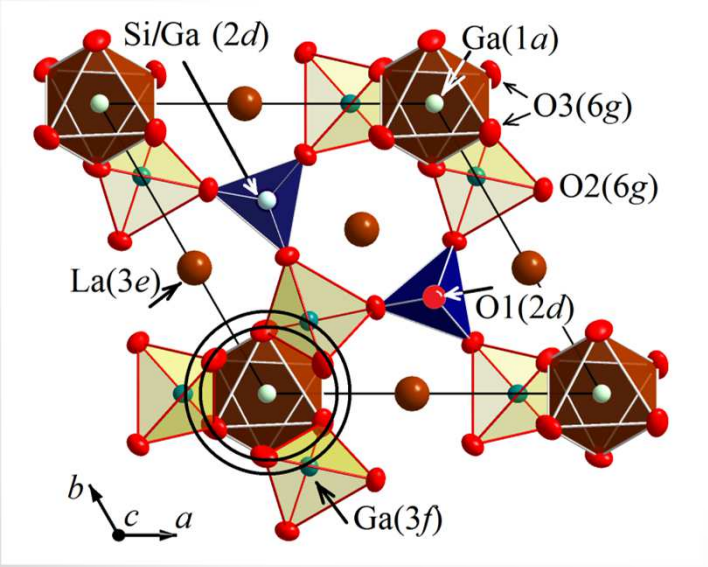
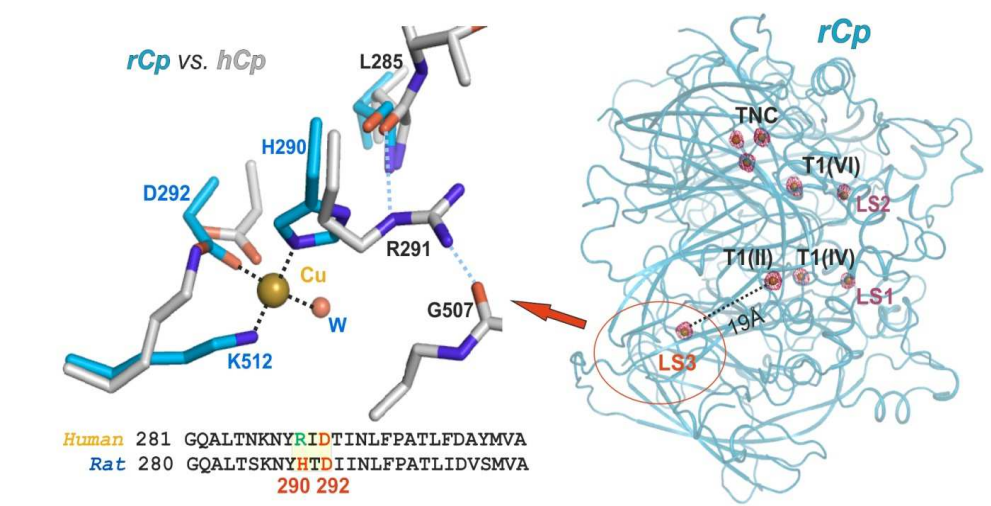
Scientific research

1. **Methods for diagnostics of inorganic, organic and bioorganic materials, nanostructures using X-ray, synchrotron radiation and electrons: Development and Application**







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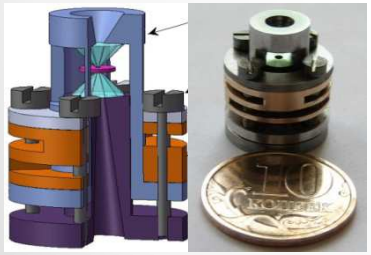
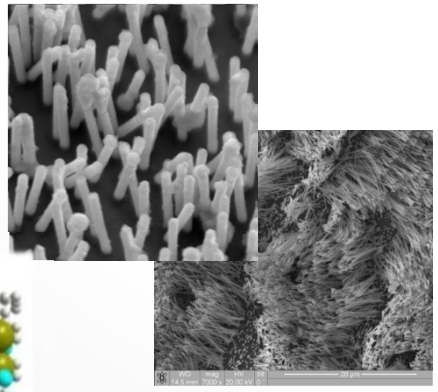
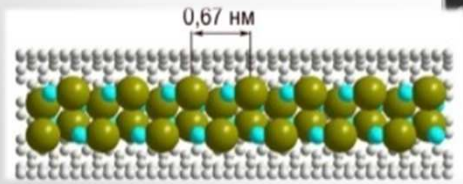
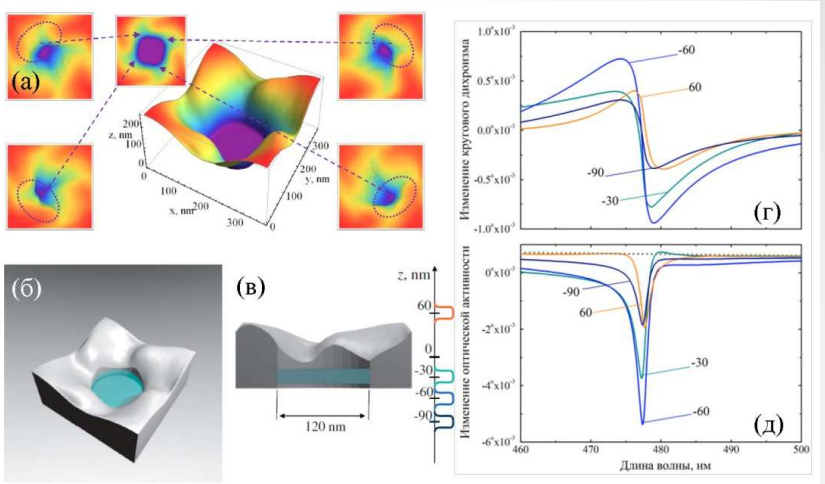
Scientific research

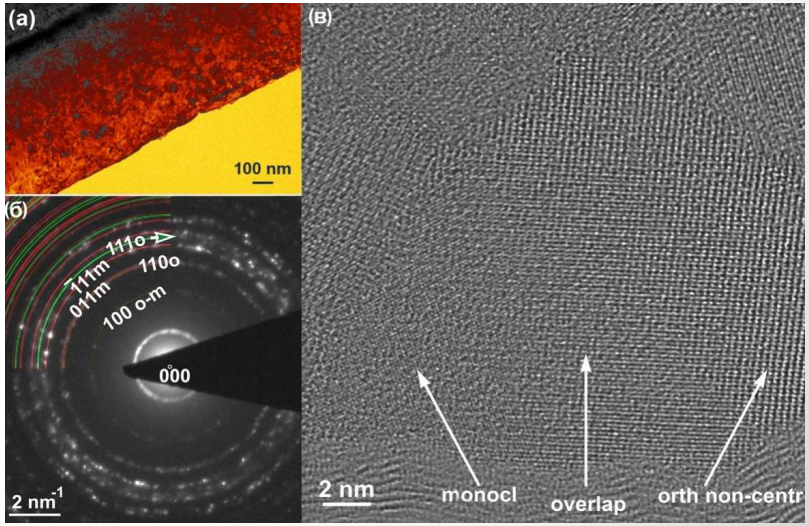
2. **Studies of the structure and properties of nanomaterials using electrons and atomic force microscopy.**
3. **Processes of formation of crystalline materials, their defective structure and properties, including that at the extreme conditions of low and high temperatures; high and ultrahigh pressures.**











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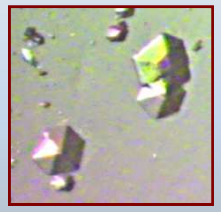
Crystallization in space

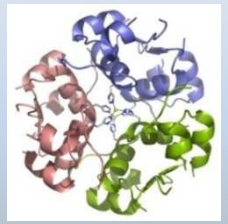
man-controlled or automatic

– since 1976 till now

From inorganic crystals to proteins

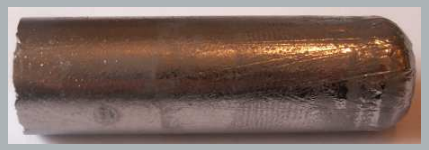
Proteins





Crystals and structure of
gene engineering insulin (1,6 Å)

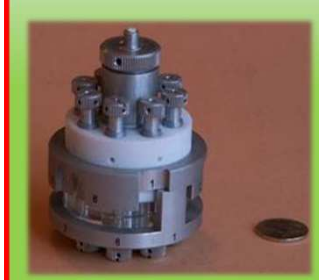
Semiconductors



GaSb<Te>

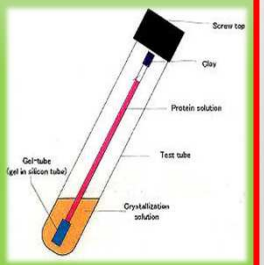
«Crystallization micro-vat» program

Development of the equipment for crystal growth in space



Unit-1

Unit-3



JAXA

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Design and manufacturing of Stations for Kurchatov synchrotron radiation source

for:

- Protein Crystallography – „Belok“(Protein)
- Liquid/air Interfaces (Langmuir)
- X-ray crystallography and material science (XCMS)
- X-ray topography and tomography (X-TOM)
- X-ray diffraction analysis (XDA)

Under the scientific leadership of Prof. M. Kovalchuk

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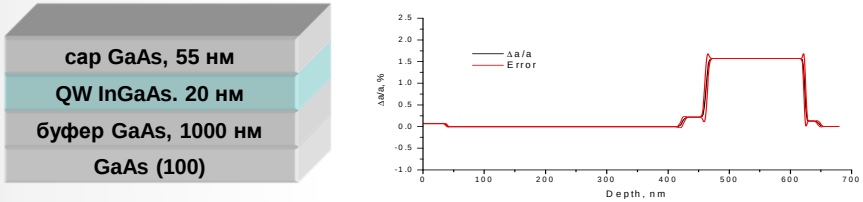
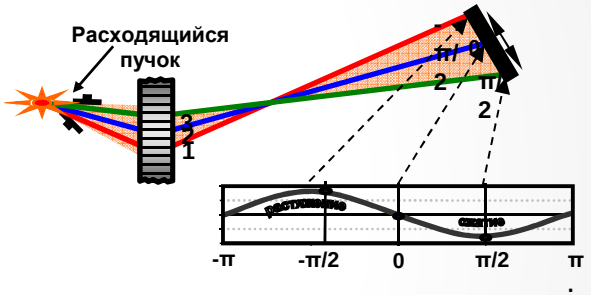
Shubnikov Institute of Crystallography IC RAS

Development of X-ray diagnostics of inorganic, organic, bioorganic materials

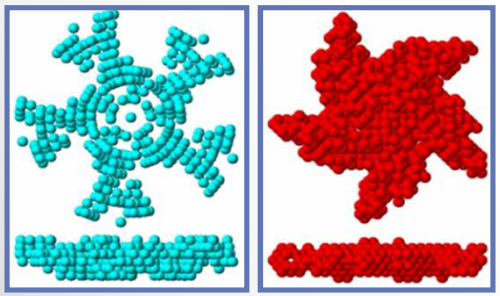
X-ray diagnostics of multilayer systems
Reflectivity and grazing angle diffraction



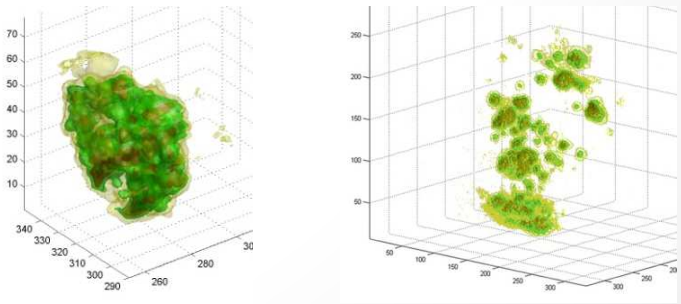
X-ray optics based upon crystals with acoustic vibrations
Focusing , l scanning, stroboscopy



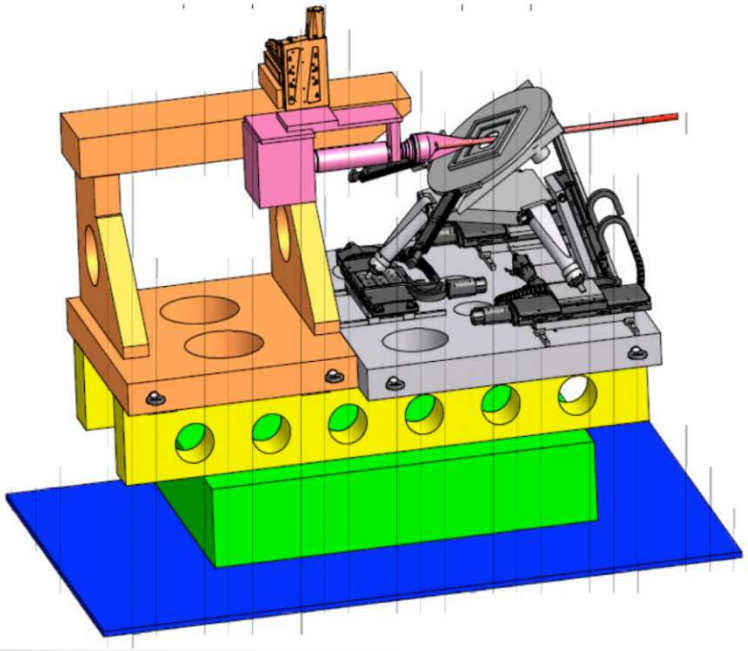
Small angle scattering
Methods & Soft for data management



X-ray micro topo-tomo-graphy
Equipment and methods



Epiphysis:
a – normal,
b– alcohol dependent.



Ultra fast X-ray imaging of scientific processes with on-line assessment and data-driven process control

Each full scan per 30 мsec.

<u>In collaboration with:</u>
Prof. Marc Weber, Prof. T. Baumbach,
V. Altapova, D. Hänschke,

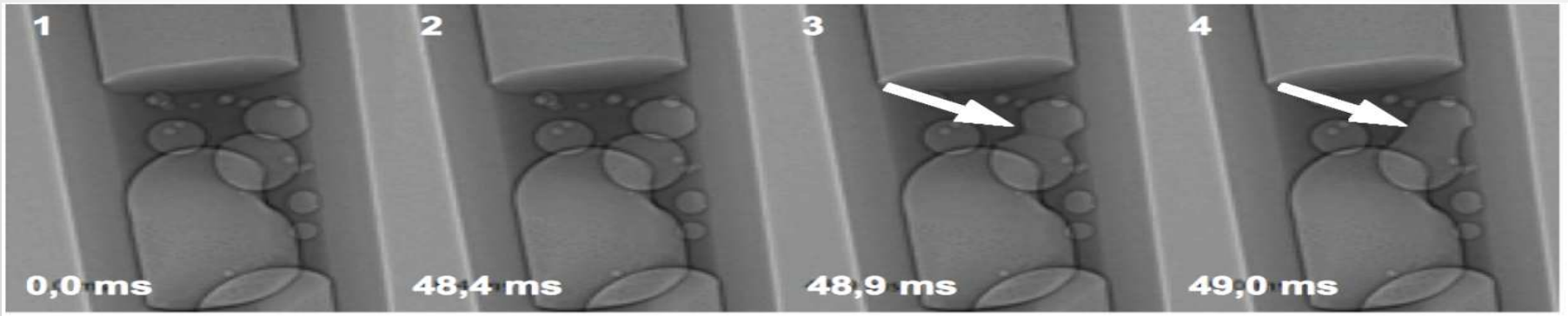


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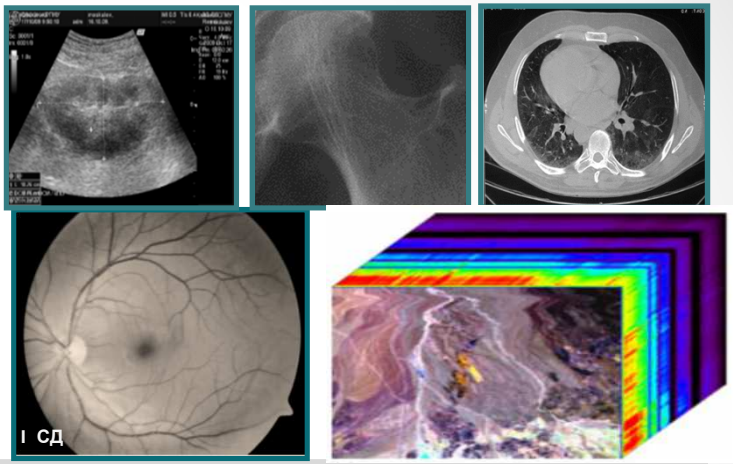
Image Processing Systems Institute IPSI RAS

Scientific research

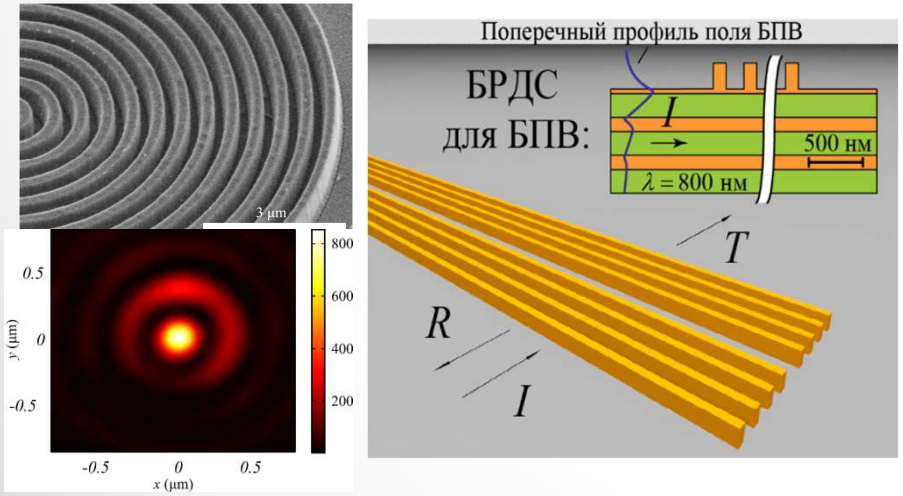
1. Computer optics, nanophotonics, optical information technologies

2. Systems for image analysis and pattern recognition

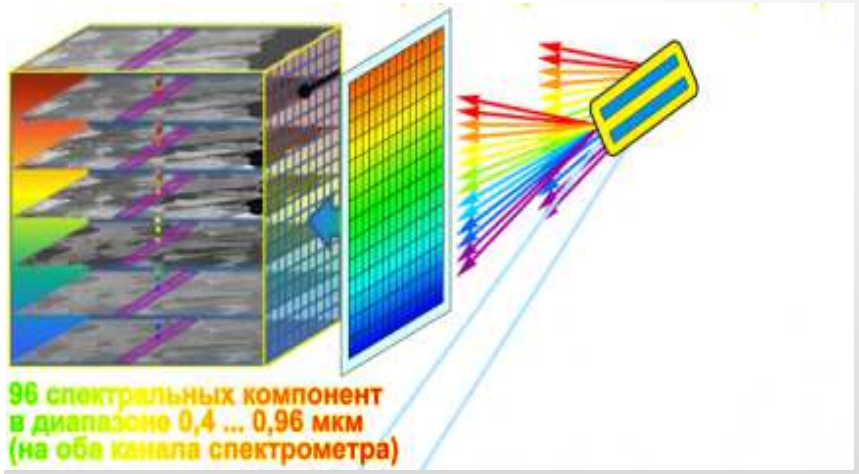
3. Geoinformation technologies



Processing of medical images and analysis of Big Data



Creation of nanophotonics components for light control



Development of hyperspectrometers for remote sensing of the Earth

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Institute of Photon Technologies IPT RAS

Scientific research

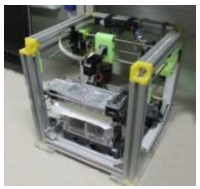
- Additive technologies for medicine.
- Optical data communication for supercomputers.
- Upconversion nanoparticles for medicine and photonics applications.
- Smart laser system for cardiosurgery.
- Supercritical fluid technologies.

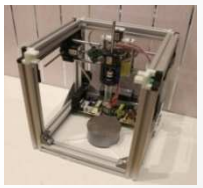
Equipment developed at the IPT RAS

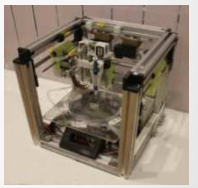
Smart laser cardiosurgery system

Spectroscopic refractometer for the refractive index measurements of liquids and solids.

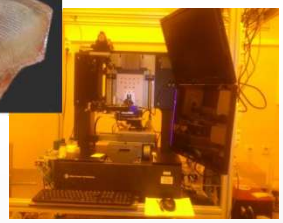
Universal mini laboratory for the physical and chemical process study in supercritical fluids.







Systems for the biocompatible and bioactive bulk structure synthesis.



Laser system for 3D polymer micro- and nanostructures formation.

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Institute on Laser and Information Technologies ILIT RAS

Scientific research

1. **Development of equipment and technologies for 3D synthesis of complete details from different materials.**
2. **Development of technologies for laser synthesis of new nanomaterials and nanostructures for nanophotonic and electronic.**
3. **Development and production of high power laser systems and new laser technologies for production and medicine.**
4. **Development of methods for computer modelling of different process in laser technologies.**

Last model of laser system for cardio surgery

LS-350/500

LS-250

LS-120

Created in ILIT RAS equipment for laser stereolitography production

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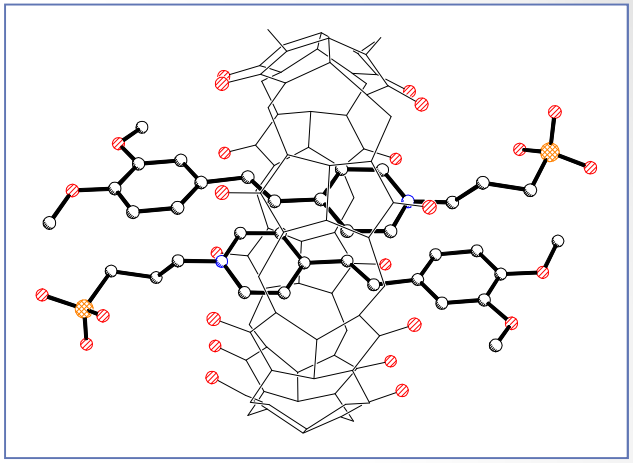
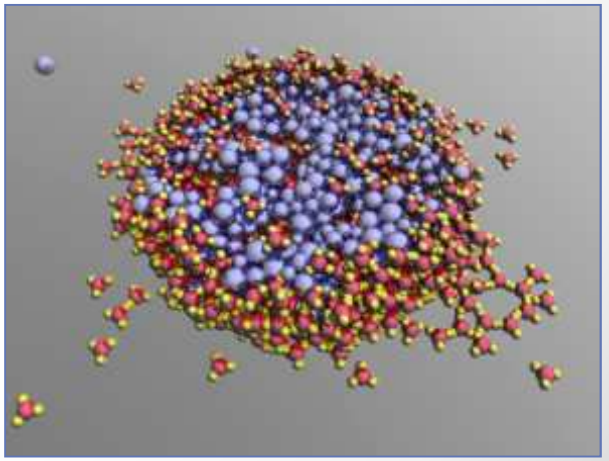
Photochemistry Centre PC RAS

Scientific research

1. Development of materials and devices of photonics based on supramolecular architectures.
2. Investigation of self-organization principles of molecules and nanoparticles.
3. Photonics and photochemistry of supramolecular architectures.
4. Design of molecules able to create the composite supramolecular architectures by the self-organization.



Supramolecular architectures



Nanoparticles

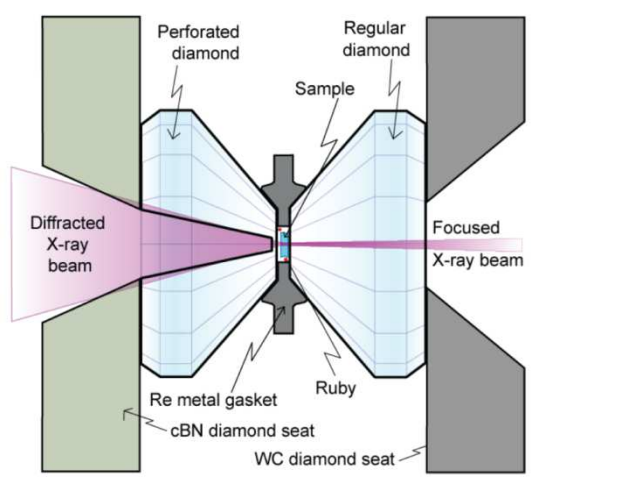
Single crystal and powder X-ray diffraction, including conditions of external fields, high pressures, high and low temperatures

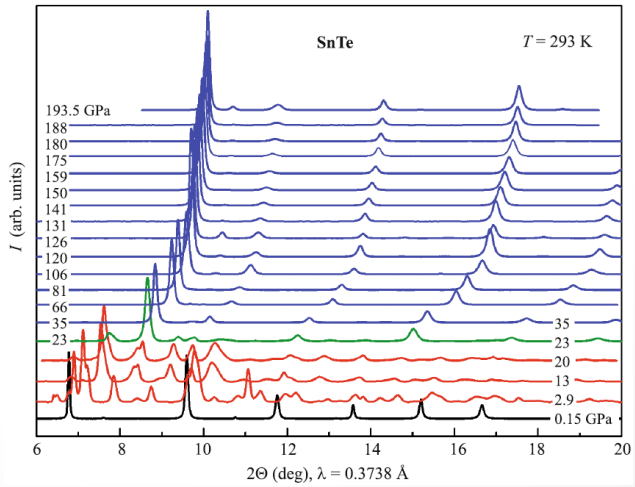
Beamline requirements:

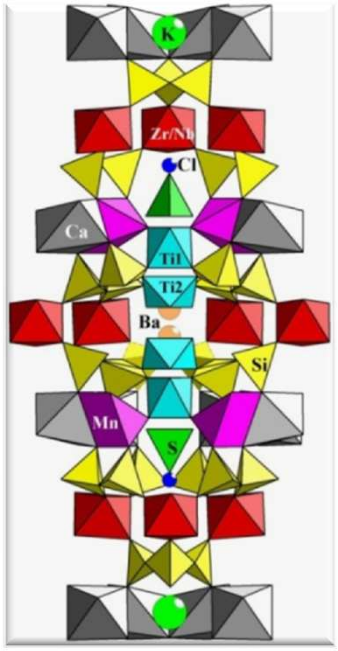
- Energy range 6.0 - 90.0 keV
- Monochromatic beam ($\Delta E/E \sim 10^{-4}$)
- beam size min/max: 5-1000 μm

Sample enviroments:

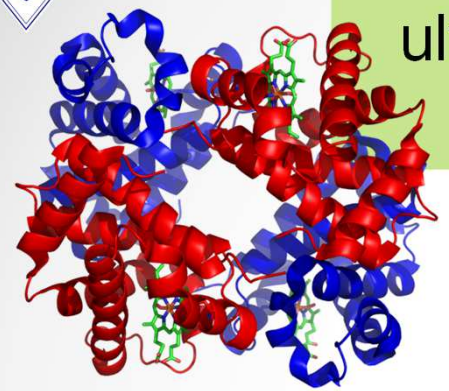
- Cryo/heating
- Temperature range 5 K to 1000 K
- Magnetic and electric fields application system
- High pressure up to 500 Gpa







Macromolecular crystallography
ultra-high resolution structure analysis and micro-crystallography



Study of structural aspects, interaction and functioning of various proteins and their complexes

X-ray diffraction, time resolving protein crystallography

Infrastructure - user laboratories:

- Samples preparation room
- Samples cryostorage
- Crystallization plates storage

Beamline requirements:

- energies 5-20 keV
- monochromator
- beam size: 4.0 × 5.0 μm^2
- Detector with readout time ~0.3sec
- X-ray fluorescence detector

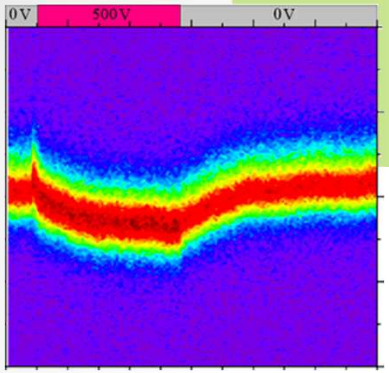
Sample enviroments:

- Cryocooler
- Automatic sample changer

Software:

for semi-automatic data collection (automatic crystal centering, data autoprocessing_

Real crystal structure dynamics under external influences



Time-resolved studies of real structure behavior in functional crystals (piezoelectrics) under external electric field

Time-resolved double- and triple-axis diffraction and spectroscopy

Sample enviroments:

- Cryo/heating
- Magnetic field application system
- High pressure

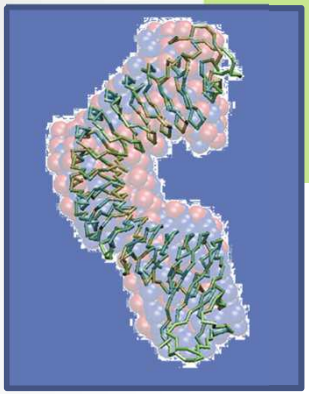
Infrastructure - user laboratories:

- Sample preparation equipment

Beamline requirements:

- energies 3-20 keV;
- monochromatic beam ($\Delta E/E \sim 10^{-4}$);
- fast (ultrasonic resonators or bending crystals) X-Ray optics
- beam size min/max: 20-1000 μm
- detectors: point, linear, 2D;
- multichannel analyzer
- sample holder with possibility of applying electric field

Small-angle X-ray scattering for nanotechnology, molecular biology, biomedical applications



Study of structural aspects, interaction and functioning of various proteins; structural nanodiagnostic of the nanomaterials.

SAXS; in-line size-exclusion chromatography (SEC)-SAXS; the in-vacuum and in-air setups; anomalous SAXS; time-resolved SAXS environments.

Beamline requirements:

-energies 4-20keV
-monochromator Si 111, multilayer for high flux
-beam size: 0.2 × 0.1 mm^2
-fast pixel detectors (Dectris)

Infrastructure - user laboratories:

-sample preparation and characterization (SPC)
-sample storage
-user laboratory

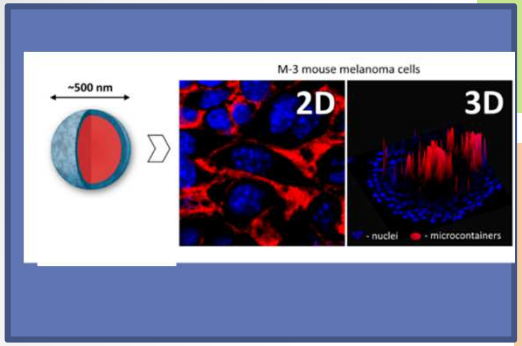
Sample enviroments:

-temperature control
- measurement cells for in-vacuum and in-air measurements
-automatic sample changer
-the in-air setup

Software:

- automation of SAXS experiment
- automated data processing and analysis

Polymer capsules for entrapment of hydrophobic and hydrophilic bioactive substances



Biocompatibility and biodegradability
Low toxicity and immunogenesity
High stability within a broad pH range

Layer-by-Layer technique
Ultrasound treatment
Emulsification

SAXS, WAXS

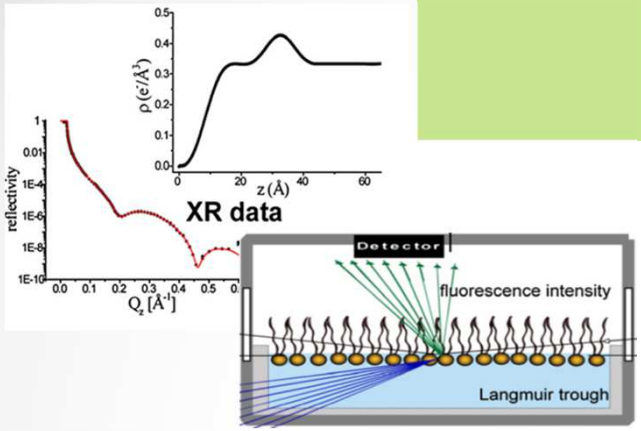
Infrastructure - user laboratories:

-Shaker
-Centrifuge
-Ultrasonic device
-Microscopy

Sample enviroments:

-In-air setup
-Automatic sample changer
-Cryo

Soft condensed matter on liquid/air interfaces



Study of organic and bioorganic layered systems formation on the liquids surface, biomembrane modeling - protein interactions with lipids ets.

- Grazing incidence X-ray diffraction (GIXD)
- Grazing-Incidence Small-Angle X-ray Scattering (GISAXS)
- X-ray reflectometry (XRR)
- X-ray Fluorescence at Total Reflection (TXRF)
- X-ray standing wave under total external reflection conditions (XSW)

Infrastructure - user laboratories:

- Samples preparation room, including Langmuir trough
- Chemical room with cryostorage

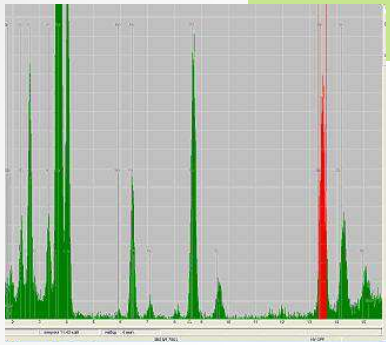
Sample enviroments:

- Langmuir trough for liquids and films (with cover)
- Gas-flow equipment

Beamline requirements:

- energies 5-25 keV
- monochromator
- Optical scheme ride X-ray at water surface
- beam size: 4.0 × 5.0 μm^2
- 1D and 2D Detectors
- X-ray fluorescence detector

μ-X-ray fluorescence analysis:
qualitative/quantitative analysis, mapping and tomography



Study of element composition in inorganic, organic and bioorganic objects and elements distribution in bulk or near surface

Infrastructure - user laboratories:

- Samples preparation room

X-ray diffraction, time resolving protein crystallography

Beamline requirements:

- energies 5-40 keV
- monochromator
- beam size min/max: 0.5*0.5/500*500 μm^2
- 1D/2D detectors
- X-ray fluorescence detectors

Sample enviroments:

- Sample chamber for air/low vacuum
- Sample holder with 3D moving and rotating

Software:

for semi-automatic data collection (spectra collection point-by-point during mapping and tomography)

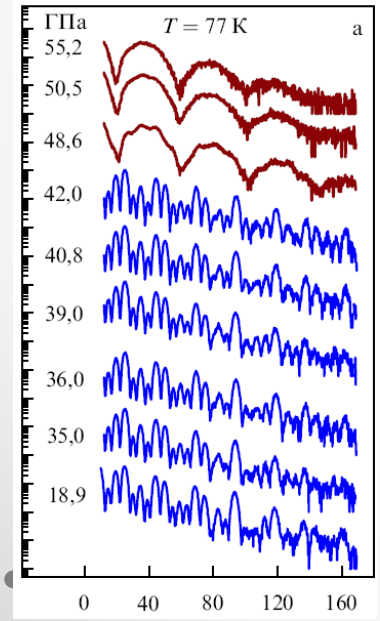
Nuclear Resonance Methods under the High Pressures and Low Temperatures in Magnetic Field

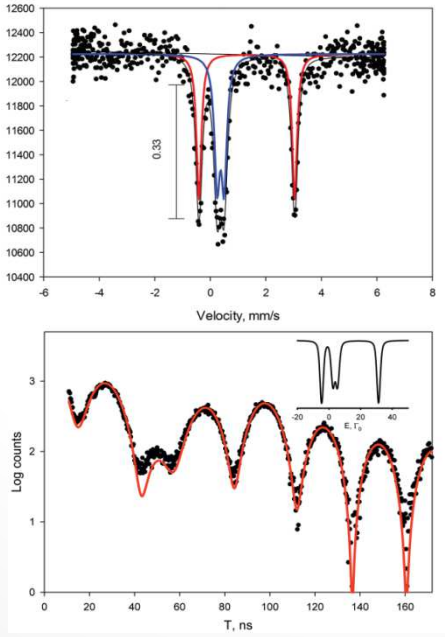
Search for new materials and study of their properties for the power engineering and conversion, high-temperature superconductivity, electronics and spintronics, geophysics and etc

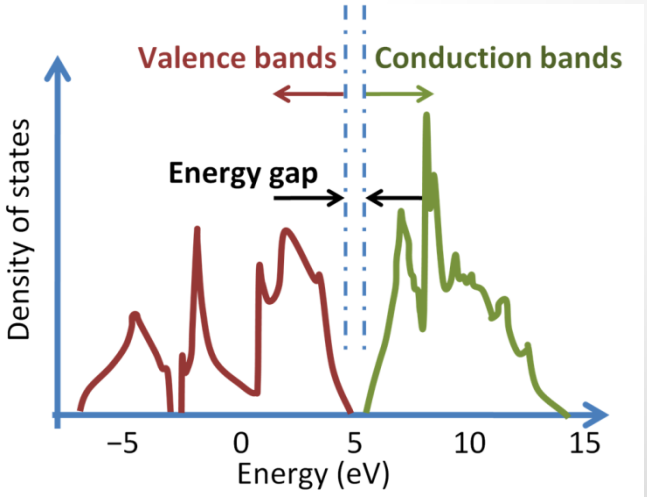
NFS – Nuclear Forward Scattering (hyperfine interactions)
SMS – Synchrotron Mossbauer Spectroscopy (hyperfine interactions)
NIS – Nuclear Inelastic Scattering (local phonon DOS)

Beamline requirements:

- Energy range 7.0 - 80.0 keV
- Temperature range 2 K to 650 K
- Magnetic field to 9 T







Thank you for attention