

Application laboratories of the Czech Academy of Sciences



Czech Academy
of Sciences



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of Sciences

"Top research in the public interest"

"Top research in the public interest" is the motto of the Academy of Sciences Strategy, AV21, which reflects the research challenges and challenges facing today's society. Strategic programs identify these key topics and link the research efforts of a number of institutions in synergy to achieve common goals. The set of application laboratories of the Czech Academy of Sciences is also a part of this strategy and aims to extend direct contacts of the Academy of Sciences with all potential partners who can exploit the capacities, technology, expertise and knowledge that these laboratories can offer. The offer is directed both to industrial enterprises, to institution of the state administration, to the non-profit sector and, last but not least, to scientists, researchers and designers of public and private research entities both at home and abroad. The Application Labs initiative aspires to be a platform for building new contacts and partnerships. Collaboration on the basis of minor research services is usually a good starting point for following joint projects of longer term collaborative research or knowledge transfer.

The advantage of the Academy of Sciences is an emphasis on scientific excellence comparable to international standards in the areas of research of individual institutions. Research in collaboration with application partners, whether it is based on more complex projects or simple research services can always benefit from the vast amount of knowledge, experience and skills of both scientific and technical staff accumulated over many years of their research activities. Application Labs include equipment and infrastructures that have been primarily built for use by their parent institutions for their own research, but due to their nature and capabilities, their capacity can be also offered to practice. Linking to high-quality proprietary research, almost always in cooperation with renowned foreign research centers, guarantees that it represents modern and state-of-the-art technology of today.

The Academy of Sciences perceives its share of responsibility to support the competitiveness of the Czech Republic. The research services for which it offers its potential in the form of Application Laboratories are the usual starting step towards achieving long-term partnerships with both businesses and other application partners that appear to be the most effective form of application of research results in practice. According to our experience, after this first step, often more focused forms of cooperation, such as joint research projects follow.

Of particular importance in this respect is cooperation with innovative SMEs. In this context, the potential of the Application Laboratories of the Czech Academy of Sciences and its importance for building such relationships between the academic and commercial spheres can be perceived, based on mutually beneficial and long-term motivations whose application will bring a lasting benefit to the Czech Republic and its citizens. If this brochure contributes to this goal, it has fulfilled its purpose.



prof. Eva Zažímalová
President of the Czech Academy of Sciences

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HiLASE Centre

Institute of Physics of the CAS



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Expertise

HiLASE Centre combines the development of solid state pulsed lasers with the development of applications requiring high peak power. Developed and operated laser systems with short and ultra-short pulses are considered to be the most powerful laser systems in the world, according to known data. The developed laser systems provide a beam from the hard UV area through the visible spectra to the near and mid-IR light. Thanks to these laser systems, laser applications requiring very high pulse energy or high peak power, such as laser machining of resistant or composite materials, surface modifications, laser material deposition, laser reinforcement of materials, laser induced damage threshold measurement of thin optical layers & optical materials, and lasers for X-ray & EUV generation are studied and developed.



Laser Micro-machining, Processing station

Competences

- Industrial or scientific applications Feasibility studies
- Application oriented laser source development
- Development of optical and opto-mechanical components
- Research and development of novel lasers
- Laser Induced Damage threshold studies and measurement
- Laser Micro-machining of mechanical components and surface
- Maintenance lifetime improvement by laser induced shock wave
- Laser driven materials modifica-

tion and nanoparticles preparation

- Development of novel laser applications
- Beam-time rental

Target sectors and customers

- Hi-Tech innovative companies
- Manufacturers of lasers, optics and opto-mechanical components
- Engineering industry working with hard, resistant and difficult to machine materials
- Automotive and aviation industry
- Biomedical industry
- Semiconductor and electronics industry

- Industry for micro and nano machining
- Research centers and universities

References and examples of cooperation

- Damage threshold measurement of thin layers: Meopta – optika, s.r.o.
- Development and testing of optical crystals, optical materials and thin layers: Crytur, spol. s.r.o.
- Testing of thin layers for laser optical component: L.E.T. optomechanika Praha, spol. s.r.o.
- Fiber transportation technology for high energies: SQS Vláknová optika a.s.



Processing station for laser driven material hardening and maintenance life-time improvement.

- Compaction of materials for RTG generation: Rigaku Inovative Technology Europe, s.r.o.
- Development of diffractive optics: Meopta – optika, s.r.o.
- Nano-optics: API Optix, s.r.o.
- Visualization and construction of opto-mechanical components for experimental laboratory: FJFI CTU Prague; TOPTEC – Regionální centrum speciální optiky a optoelektronických systémů v Turnově
- Laser hardening and maintenance, life time improvement of construction materials for nuclear industry: Centrum výzkumu Řež, a.s.

- Laser driven particle acceleration: ELI-Beamlines
- working, a.s., Korean Electronics Technology Institute (South Korea), Axel (South Korea), Institute of photonics and electronics AS CR

- Improvement and optimization of laser processing: ŠKODA AUTO, a.s.
- Development of nanosecond 100J laser system: Rutherford Appleton Laboratory, Science and Technology Facilities Council (UK)
- Development of laser system for EUV generation: Gigaphoton (Japan)
- Development of pulsed laser system for medicine: Profiber Ne-



Micro-chip laser setup for material characterization and development of compact lasers.

Centre for Analysis of Functional Materials Project (SAFMAT)

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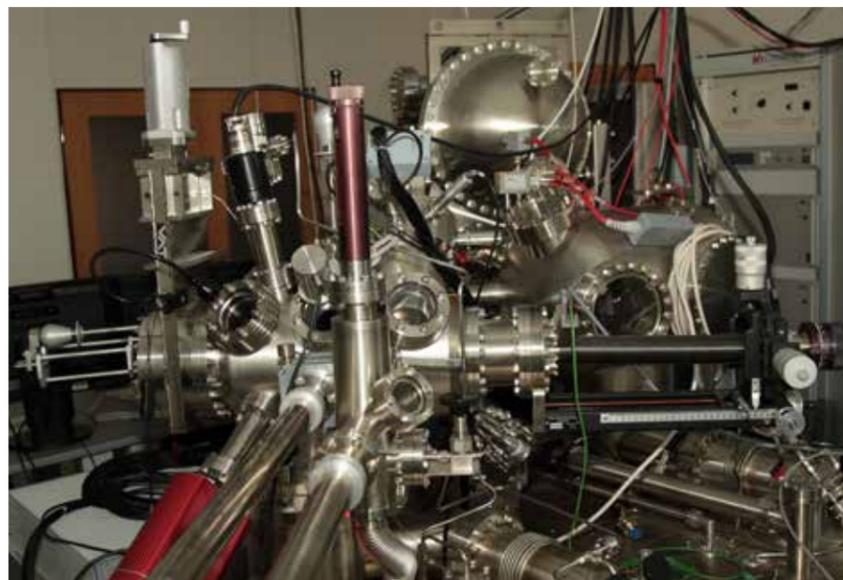
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Specialisation

SAFMAT is an infrastructural project of the Institute of Physics (FZÚ) (funded from the Operational Programme Prague – Competitiveness), by means of which modern laboratories were built. Thanks to the new laboratories, interdisciplinary research into functional materials with new, interesting physical properties for a broad spectrum of technical applications, including application in medical technology and medicine, can be conducted at the FZÚ. Its backbone consists of three modern experimental devices that enable to characterise the microstructure and chemical composition of surfaces of materials at macro-, micro- as well as nanolevels (SEM-FIB TESCAN FERA3, NanoESCA, AFM Bruker) and equipment for the study of electron paramagnetic resonance (EPR).

A scanning electron microscope with a plasma focused ion beam and



The NanoESCA instrument including a preparatory UHV chamber for analysing the chemical composition of materials in nano-dimensions

a wide variety of analysers allows displaying the surface of materials with electrons of various energy, including analysing its chemical composition, orientation, microstructure during the action of external influences, such as increased temperature or mechanical stress. The NanoESCA device combines electron microscopy and photoelectron spectroscopy. Therefore, using it, it is possible to study chemical composition and structural properties in a nanometric spatial resolution. This proves to be very attractive for a number of modern material applications in which the non-uniformity of structure and of chemical composition plays a substantial role in these dimensions. The EPR laboratory is equipped with a top-class EPR spectrometer capable of analysing the dynamics and spatial distribution of paramagnetic particles at atomic level in a random type of materials.

In addition to solid substances, the instrument also enables the analysis of gels, liquids and biological samples. This method is widely used for characterising defects in solid-state materials and for characterising some organic molecules.

The behaviour of cells in an environment with specific physical parameters (e.g. low temperature) is studied in a new atomic force microscopy (AFM) laboratory. Other experimental equipment includes ellipsometers for measuring the optical properties of volumetric materials and thin films in a broad spectral range (from UV up to far IR). Within the infrastructure, an optical lithography laboratory was built and employs the method of direct recording into photoresist by means of UV lasers with a resolution of 0.6 micrometers.



The TESCAN Fera3 scanning electron microscope with a focused ion beam for analysing the surfaces and microstructures of functional materials

The SAFMAT Centre offers the research community and industrial enterprises in the field of mechanical engineering, optics and fine mechanics, vacuum technology, electrical engineering and medical instruments and implants to make use of a part of the capacity of its top-class facilities by way of services.

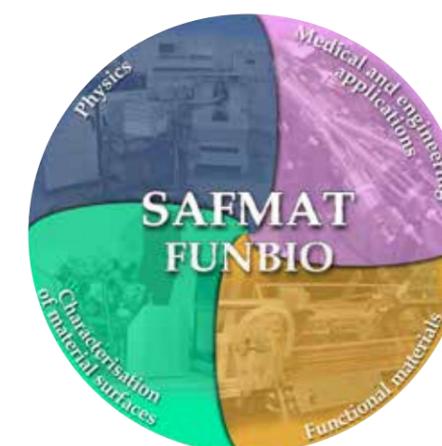
Competences

- Analysis of paramagnetic centres in materials, e.g. optical crystals, semiconductors
- Analysis of the structure of organic materials
- Characterisation of surfaces of materials or thin films
- Preparation and characterisation of thin-film materials in the conditions of an ultra-clean vacuum
- Designs of special vacuum systems for PVD technologies
- Analysis and characterisation of the real structure of crystalline materials
- Analysis of new materials for bio-

- logical and medical applications
- Characterisation of interfaces of biological and inorganic materials

Target groups

- Manufacturers of laser and scintillation crystals
- Manufacturers of semiconductor crystals
- Companies employing thin-film technologies, e.g. graphene, hard



Field specialisation of the SAFMAT project

- and metal coatings, thin-film sensors
- Manufacturers of electronics and microelectronics
- Breweries for determining the quality of hops
- Engineering and metallurgical industry
- Manufacturers using actuators and super-elastic elements with shape-memory alloys
- Manufacturers of bio-implants and biomedicine

Results

- Characterisation of defects in optical crystals – Crytur, spol. s r.o.
- Development and design of a deposition system – Institut Lumière Matière of Université Lyon 1
- Preparation and characterisation of graphene layers – University of Chemistry and Technology Prague
- Characterisation of thin-film covering of microwave components – Tesla Electrontubes, s.r.o.
- Analysis of laser welds
- Post-treatment characterisation of the surfaces of thermocouples (LINTECH/Continental)
- Design of probes for displaying magnetic particles by magnetic resonance spectrography of advanced preclinical imaging
- Drafting of methodology minimising damage during handling of haematopoietic stem and embryonic cells
- Surface layers of superelastic stents made of the NiTi alloy resistant to corrosion fatigue – ELLA-CS, s.r.o.
- Design and manufacture of springs made of the NiTi alloy for thermostatic valves – THT Polička, s.r.o.

Laboratory of nanostructures and nanomaterials (LNSM)

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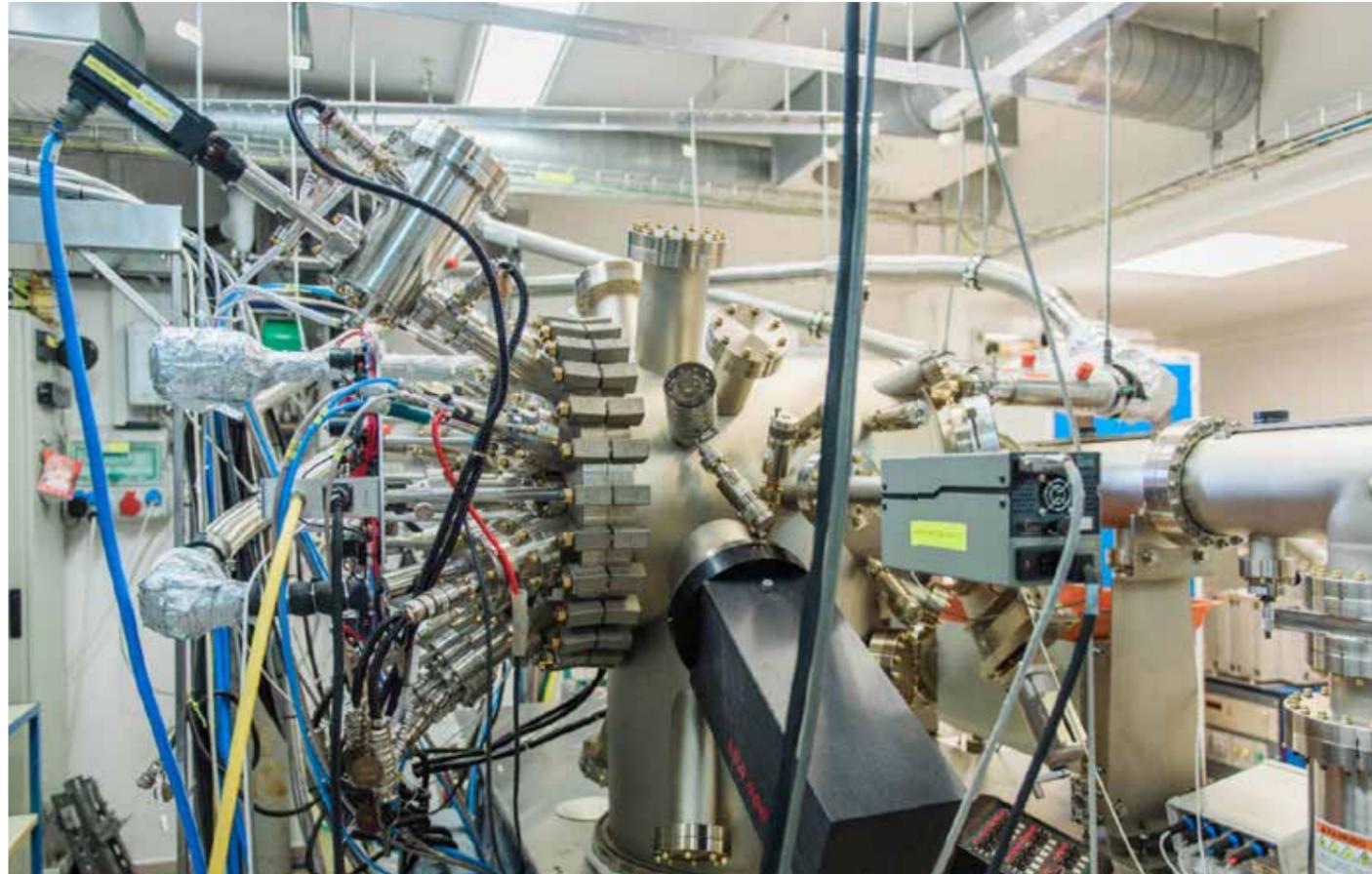
www.fzu.cz

Aims

LNSM provides unique instruments for preparation, investigation and development of a wide spectrum of inorganic nanomaterials (semiconductors, metals and nanostructured bulks) and nanostructures (nanoparticles, nanowires, junctions, monolayers and thin films). The application fields include micro- and nano-electronics, spintronics, photovoltaics, photonic structures, carbon-based thin films and nanostructures, as well as functionalized materials for biomedical implants or sensors.

Competencies

LNSM prepares epitaxial layers of compound semiconductors and spintronic materials, silicon and diamond thin films or nanostructures as well as nanocrystalline metals and oxides



Molecular Beam Epitaxy Growth Chamber (MBE)

and composites. It provides further processing into devices, including lithographic structuring and contacting. State-of-the-art characterization methods are also provided.

Target groups

Innovative companies, research and educational organizations, in particular in the fields of:

- Material sciences (semiconductors, metals, thin films and nanostructures)
- Physics (optics, optoelectronics,

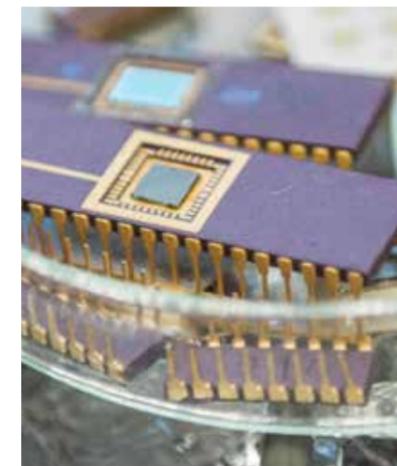
spintronics, nanostructures for energy conversion)

- Organic and inorganic chemistry, biomedicine.

Services

Highly specialized as well as multidisciplinary research by experienced researchers using state-of-the-art for:

- Molecular beam epitaxy (MBE) deposition of thin films for spintronics
- Metal Organic Vapour Phase Epitaxy (MOVPE) deposition of gal-



Produced Electronic devices



Combined Electron Beam Lithography

- lithium nitride based semiconductors
- Plasma Enhanced Chemical Vapour Deposition (PECVD) of silicon thin films and nanostructures
- PECVD deposition of nanocrystalline diamond films and nanostructures
- Microscopic analysis and imaging by Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM)
- Device preparation, by electron beam lithography or optical lithography, reactive ion etching, ion milling, contacting and device encapsulation.

References

- H2020 projects: ASPIN - Antiferromagnetic spintronics (FET OPEN) and NextBase - Next-generation interdigitated back-contacted silicon heterojunction solar cells and modules by design and process innovations (Low Carbon Economy)
- Hitachi Cambridge
- FEI Czech Republic s.r.o.
- HVM Plasma s.r.o.
- ON Semiconductor Czech Republic s. r. o. (CZ)
- CRYTUR a. s. , Turnov (CZ)
- SVCS Process Innovation, Rožnov p. R., (CZ)

Laboratories of Scintillation and Luminescent Materials (SciMat)

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The SciMat laboratories are engaged in the research and development of new scintillation and luminescent materials, both in terms of fundamental physical and chemical process and their practical application, i.e. measurement of application-critical parameters. That are of importance to application. Scintillation materials generally serve for monitoring and detecting ionising radiation with a broad range of applications, e.g. in medical imaging and radiotherapy, in high tech industrial applications and scientific instruments, safety technologies and in science as such, especially high-energy physics and nuclear physics.

Competences

- Research studies from technical literature
- Measurement of luminescence spectra in the UV-VIS spectral



A detection unit in a McPherson VUV spectrophotometer

- band in a broad temperature range of 10-800 K
- Measurement of luminescence decay on a time scale from 100 ps up to the order of minutes
- Study of defective and trapping states affecting the scintillation and luminescence mechanism by correlated experiments of optical, luminescence and magnetic spectroscopies
- Measurement of scintillation parameters – a light yield in excitation by gamma and alpha radiators; scintillation decay in excitation by gamma radiators, radioluminescence in excitation by X-ray radiation
- Measurement of absorption spectra and induced absorption, i.e. radiation damage to optical materials



An overall view of luminescence apparatus; 5000M model, Horiba Jobin Yvon

Target groups

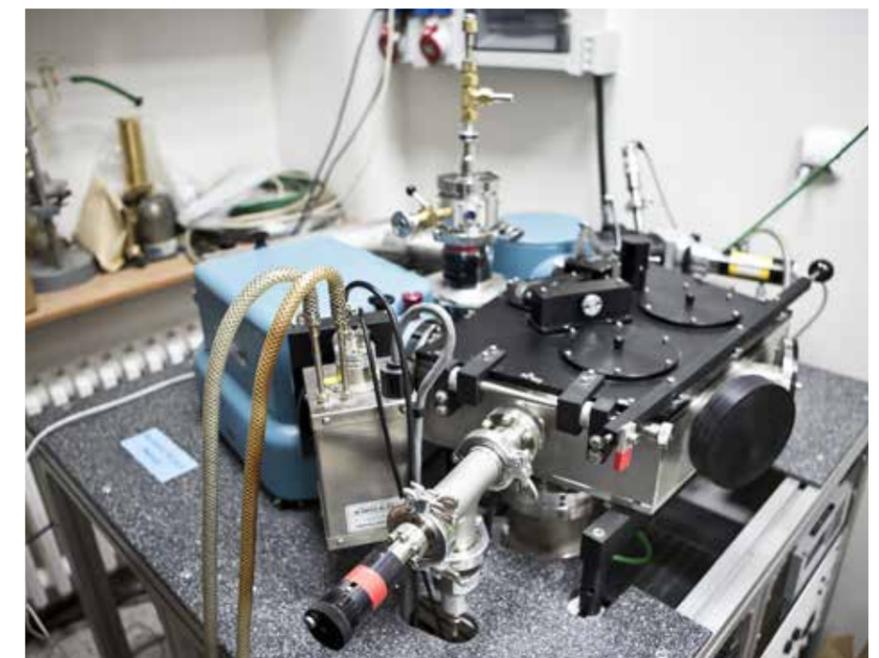
- Manufacturers of scintillation and luminescent materials
- Firms operating in the field of application of scintillators, solid-state lasers, optical sensors and lighting technology

Result

- Development and testing of scintillation monocrystals: Crytur, spol. s r. o.
- Development and testing of plastic scintillators: Nuvia a.s.
- Development and testing of fluoride monocrystals for optical and scintillation applications: Tokuyama Co.



The cryostat head of a Janis closed-cycle refrigerator



An overall view of the optical part of a McPherson VUV spectrophotometer

Regional Centre for Special Optics and Optoelectronic Systems – TOPTEC

Institute of Plasma Physics of the CAS



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Output visual inspection of the mandrel of an X-ray objective

Specialisation

The main objective of the TOPTEC project is to build, run and develop a research centre with modern equipment and an excellent scientific team that specialises in the research and development of ultra-precision optics and optical systems. The Centre is able, inter alia, to ensure an efficient transfer of knowledge into industrial practice.

The Regional Centre for Special Optics and Optoelectronic Systems (Turnov OPToelectronic Centre – TOPTEC) is a direct extension of the optics workplace of the Institute of Plasma Physics of the CAS in Turnov (formerly known as the Optical Development Workshop of the CAS). The specialisation of the TOPTEC is based on a 40 years' tradition of re-

search and development of optics at the Turnov academic workplace. The main directions of research and development include working (machining) the optical surfaces of ultra-precision elements with aspheric and freeform surfaces for optical instruments including X-ray and crystal optics, researching modern optical systems for use in super-powerful lasers, developing imaging systems, developing optical systems for applications in space, developing systems for astronomical instrumentation, automotive industry and medical purposes. Furthermore, the TOPTEC is engaged in the development of measuring and diagnostic methods, precision mechanics and systems for the active suppression of vibrations in demand-

ing measuring applications.

TOPTEC is currently the only research and development workplace specialising in ultra-precision and special optics in the Czech Republic. It cooperates with more than 80 companies all around the world and with a great number of scientific research institutions both in our country and in the EU.

Competences

The TOPTEC focuses primarily on research and development in the field of special optics and advanced optical systems. The significant asset of the Centre is its ability to offer complete services services in the above fields – from identifying the partner's needs

via basic design and detailed analyses to manufacturing, testing and subsequent installation or, where appropriate, certification of equipment. Therefore, the possibilities of cooperation offered include a number of services such as design and simulation of optical systems, precise measurement of many physical, mainly optical quantities, designs of fine-mechanical structures for use in optics, structural analyses and numerical simulations or expert examinations, expert opinions and education in the field of optics.

The TOPTEC takes part in a number of national and international research and development projects; the most prestigious ones being the implementation of space research

projects funded from ESA resources. The TOPTEC welcomes offers for cooperation in preparing and handling projects relating to both applied and basic research.

For more details see: www.toptec.eu

Target group of partners

The spectrum of our partners includes small enterprises as well as research and development centres, development laboratories and companies engaged in advanced technologies and multinational firms. Our goal is to propose propose a solution that best suits the partner's requirements.

Examples of results achieved

- Lighting optical systems based on the principle of facet optics for Siemens (design of system, implementation of prototype, optical tests, consulting in the start-up of series production)
- Aspherical plungers for intraocular lenses for MEDICEM Institute s.r.o. (design of the shape of optical area, design of technology of production of plungers, manufacture of plungers, optical tests)
- Germanium-, silicon-, ZnSe- and ZNS-based refractive IR systems or reflective IR systems
- Diffraction-limited optical systems for two laser wavelengths for Optometrics, USA (design and implementation of the system, optical tests)
- METIS – lightweight Zerodur mirrors for experiments on the Sun's orbit with an extreme requirement for microroughness (Ra

< 3 Å) and the precision of shape for ESA (cooperation in optical design, design of bearing structure, manufacture, optical tests)

- ASPIICS (Proba 3 mission) – an optomechanical system for experiments on the Sun's orbit for ESA (design and implementation of optical and mechanical parts of the lens, optical and mechanical tests)
- Design of a telescope system for the European Solar Telescope (EST)
- Crystal optics – implementation of narrow-band filters for solar research
- Mandrels for X-ray applications with minimal microroughness (~ 1 Å) for Rigaku
- SiSiC-based lightweight optical elements for ESA (design of bearing structure, design and implementation of optical surface, optical measurements)
- GaP machining technology for optical applications both in the visible and IR sphere as part of the EUREKA project
- An autonomous system for on-line evaluation of optical properties of thin films for PRECIOSA
- Analysis and optimisation of the electro-optical part of sensors of yarn properties for Rieter
- A system for visualisation of the welding process
- Producing a design of the optical parts of a RICH quartz detector allowing the identification of pions, kaons and protons within the range of their momentum of 1-4 GeV/c
- Implementation of an interferometer for the on-line measurement of the refractive index of gas in RICH gas detectors

Laboratory of Plasma Technologies for Materials Engineering

Institute of Plasma Physics



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Expertise

Department of Materials Engineering (MI) carries out applied research and development that utilizes plasma for preparation of materials and/or their surfaces. Laboratory of plasma technologies (LPT) as part of the MI department is engaged in surface modifications by plasma sprayed coatings (ceramic as well as metallic), and on the other side can prepare bulk materials by plasma sintering of powders. The so-called spark plasma sintering uses pulsed electric current and is much faster than conventional sintering.

For over 30 years, various plasma sprayed coatings have been deposited on parts delivered by our industrial partners. The coatings are sprayed



Spark plasma sintering (SPS)

where it is needed to protect the functional surface of a part against effects of extreme operating conditions, such as high temperatures and thermal shocks, corrosion, abrasion, combined thermo-mechanical loading, etc. For nuclear fusion devices, materials resistant to plasma effects are under development.

Due to a wide domestic and international collaboration the know-how is not limited only to plasma spraying, but covers all major thermal spray

technologies – HVOF/HVAF, flame spray, wire arc, cold spray, etc. For more information, see www.ipp.cas.cz/MI.

Competences

LPT is equipped with state-of-the-art technology for various types of preparation of bulk materials and deposition of diverse surface coatings. Plasma sprayed coatings are primarily made with the world unique plasma torches with the hybrid stabilization, WSP®H. This plasma spraying system was de-

veloped at our Institute and it features certain properties unreachable by other commercial plasma spray systems. Thick or larger area coatings of high quality can be prepared in a short time from both powders and suspensions.

Thanks to years of experience and the top analytical equipment, the prepared materials – bulk as well as coatings – can then be analyzed in great detail. Many of our staff either studied directly at top foreign universities or completed long-term stays at foreign laboratories. In case of specific requirements, we are able to provide contacts to a number of our domestic and foreign partners.

Key technologies

Plasma spraying (for coatings with thickness ranging from several tens of micrometers up to several millimeters):

- Plasma torch WSP®H 500 based on the water stabilization of plasma
- Plasma torch based on radio-frequency induction coupled plasma arc (RF/ICP plasma system) working in a controlled atmosphere
- Our own patented technology for production of self-supporting bodies
- SPS technology for powder sintering in a pulsed electric field – sintering temperatures up to 2400° C

Target groups

Manufacturers and research organizations with specific problems in the area of functional surface protection of industrial parts or experimental apparatus, or special needs in sintering of powder materials. We offer cooperation on the basis of joint projects

as well as in the form of contractual or collaborative research, or expertise on order.

Services offered

- Deposition of ceramic or metallic plasma sprayed coatings made in ambient or controlled inert atmosphere or at lower pressure; coatings include functionally graded materials with continuous gradation or the sandwich type
- Production of plasma sprayed self-supporting ceramic thin walled tubes and shells
- Sintering of special powders, nanomaterials and advanced composites by SPS technology
- Routine and advanced material analyses focused on characterization of plasma sprayed and sintered materials - materialography, optical and electron microscopy, porosimetry, mechanical tests (adhesion, hardness, abrasion resistance, Young's modulus), X-ray diffraction (phase analysis and residual stress), thermal measurements (DSC, DTA, dilatometry and thermal conductivity), evaluation of damage causes, etc.
- Consultations and custom development in the field of thermal spraying (selection and development of suitable materials, processing technology and methods of characterization)
- All services, including the research report, can be performed under NDA

Examples of cooperation with the industry

We cooperate with a number of domestic and foreign companies operating in the glass and ceramics industry, metallurgy, electrical engineering, agriculture and automotive and aerospace industries. For these companies, we develop or carry out the following:

- Protection of functional surfaces of exposed parts, such as glass feeders and stirrers, heating elements of furnaces and similar, against high temperature corrosion, thermal shocks, abrasion, etc.
- Routine production of thin walled ceramic tubes up to 220 mm in diameter and length up to 1500 mm
- Production of special composites with an increased resistance to plasma
- Development of decorative coatings and special sintered ceramics
- Pilot testing of usability of plasma technologies for sintering of powders (SPS method), spheroidization of various powders by plasma spraying, collaboration with producers on development of feedstock materials, etc.
- Materials analysis, such as XRD phase analysis of HVOF coatings, determination of the thermal conductivity of TBC, characterization of microstructure and thickness of coatings, measurements of coatings adhesion, evaluation of abrasion resistance of surfaces with coatings and welded layers, and the like
- Support for optimization of production processes, failure analysis, etc.

Application Laboratories of Microtechnologies and Nanotechnologies (ALISI)

Institute of Scientific Instruments of the CAS



Contact

Institute of Scientific Instruments of the CAS

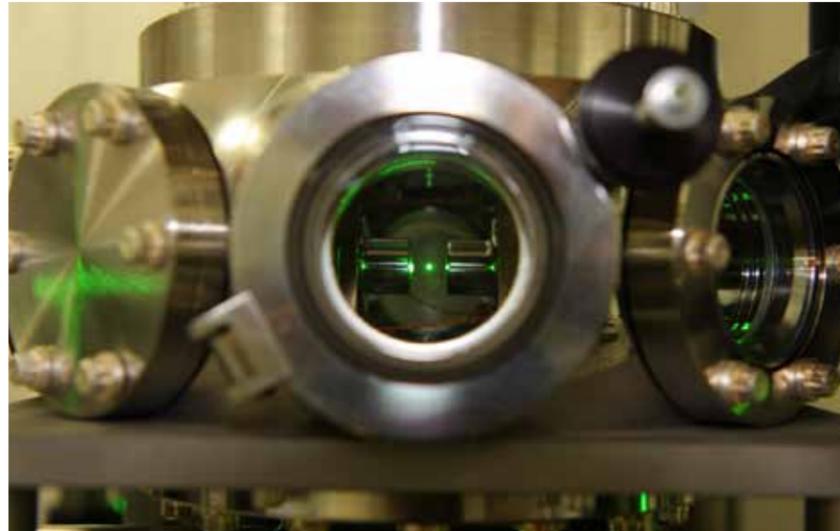
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Ion clock for quantum metrology, ultraprecise standard of time based on spectroscopy of trapped ions

Specialisation

The objective of the ALISI is to build and run a regional R&D centre with modern equipment developing diagnostic methods and technologies focusing on the microworld and nanoworld. The preparation and implementation of the project is provided by the Institute of Scientific Instruments of the CAS.

The specialisation of the ALISI is based on the tradition of the Institute of Scientific Instruments of the CAS in Brno (ÚPT), which has been successfully developing diagnostic methods and technological procedures in the field of electron microscopy, nuclear magnetic resonance, biosignal processing, special technologies and metrology for more than 60 years. The results of the scientific work of the ÚPT are utilised not only by partners operating in the region but also

beyond the borders of the Czech Republic.

Competences

Application and development laboratories of advance microtechnologies and nanotechnologies are intended for the pursuit of research activities stretching into the fields of diagnostics and technologies that employ methods of magnetic resonance, laser interferometry and spectroscopy, measurement and evaluation of biosignals, electron microscopy and lithography, electron and laser beam welding, magnetron sputtering and cryogenics to construct new instruments and systems.

Our activities

- Utilisation of electron beams for displaying, diagnostics, lithography and welding

- Designing new sequences for magnetic resonance tomography and their utilisation for the detection of chemical changes in living organisms including humans
- Measurement of thermal radiation or absorption of materials under very low temperatures, designing cryogenic systems
- Technology of application of thin films
- Scanning and processing of biosignals in medicine
- Utilisation of laser beams for welding, spectroscopy, precision measurement of distances and refractive index of gases, for handling of microobjects and nanoobjects

More detailed information: www.alisi.isibrno.cz/upload/files/brozura-dotisk-cz.pdf

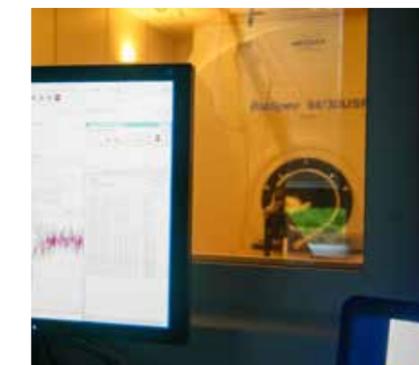
Target groups

- High tech, innovative firms
- Universities
- Research institutes

Results

- Relief structures based on the principle of diffractive optics
- Development and verification of methodology of physical realisation of optical thin films
- Analysis of the microstructure and material composition of inorganic nanoparticles
- A system for the measurement of angles on ELI handlers
- Study of dealing with measuring techniques for measuring angles with extreme resolution
- Analysis of the microstructure and chemical composition of synthetic diamond powders
- Elaboration and verification of methodology of displaying and analysing an animal model of schizophrenia by means of magnetic resonance in a field of 9.4 Tesla and gauging of a supplied sample
- Research and development of electron guns intended for electron beam welding
- Experimental determination of thermal radiation properties of surfaces of parts of instruments for operation in cosmic space
- Development of welding techniques for superalloys used in the automotive industry
- Research into detection principles and their application during the development of special detection units for electron microscopes

- Design and execution of an assembly for spectroscopy of dissociated iodine vapours
- Relief structures based on the principle of diffractive optics
- Development of heterogeneous welds of structures for special industrial fittings
- A system for defined 3D setting and monitoring of a magnetic field
- Design of a nanolithographic system based on two-photon photopolymerisation
- A module for measuring the optical spectrum in the band of 1300–1600 nm
- A draft design and pilot experimental verification of a system for measuring the straightness of firearm barrels
- Development of welding and soldering technologies for cryogenic systems



Magnetic resonance laboratories equipped with a 9.4T MR scanner Bruker Biospec 94/30 suitable for imaging mice, rats or rabbits

- Elaboration and verification of methodology of physical realisation of optical thin films with the electron vapour-deposition method

- New soldering and welding methods for new sources of X-ray radiation
- Elaboration and verification of methodology of physical realisation of optical thin films for interferometers
- Absorptivity of thermal radiation for the development of materials by superinsulation for alternating magnetic fields
- Development of welding methods for zirconium alloys intended for creep tests
- Topography of surfaces of thin polymer films
- Development of an electron gun for welding radioactive samples in a hot chamber used for the nuclear industry
- Development of a membrane heat exchanger
- Study of the microstructure of heat-resisting steels by means of slow-electron microscopy
- Development of technologies of welding heterogeneous joints for advanced forming methods
- Expert activities in cryogenics
- Microanalysis of special steels
- Development of the reference of optical frequency for the stabilisation of laser
- Design and realisation of the reference of optical frequency in the visible spectrum area
- Development and manufacture of absorption cells for spectroscopy
- Development of a measuring station for sorting ferromagnetic materials
- Research and development of permanent joints of metal materials for instrumentation using electron welding and vacuum soldering technology

Fibre Optics Laboratory

Institute of Photonics and Electronics of the CAS



Contact

Institute of Photonics and Electronics of the CAS

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Specialisation

The Fibre Optics Laboratory focuses on the design and development of special optical fibres, fibre lasers and amplifiers. It has technologies for the preparation of fibres doped with Yb, Er, Tm, Ho, technologies for fibre fusion splicing and forming, technology for writing long-period fibre gratings, know-how concerning the construction of fibre lasers in the midrange-power area (units up to tens of Watts) for the spectral bands of 1060, 1550, 2000 and 2100 nm and in the field of pulse femtosecond and picosecond fibre lasers.

Competences

- Design, development and manufacture of special fibres
- Characterisation of optical fibres (spectral attenuation, dispersion, refractive index profile, dopant concentration and so forth)



CO₂ laser for the preparation of special fiber components

- Development of fibre-optical components
- Development of CW and G-switched, Q-switched, actively and passively mode-synchronised pulse fibre lasers
- Development of fibre amplifiers
- Measurement of laser beams
- Modelling of the propagation of light and optical pulses in optical fibres and photonic structures

Target groups

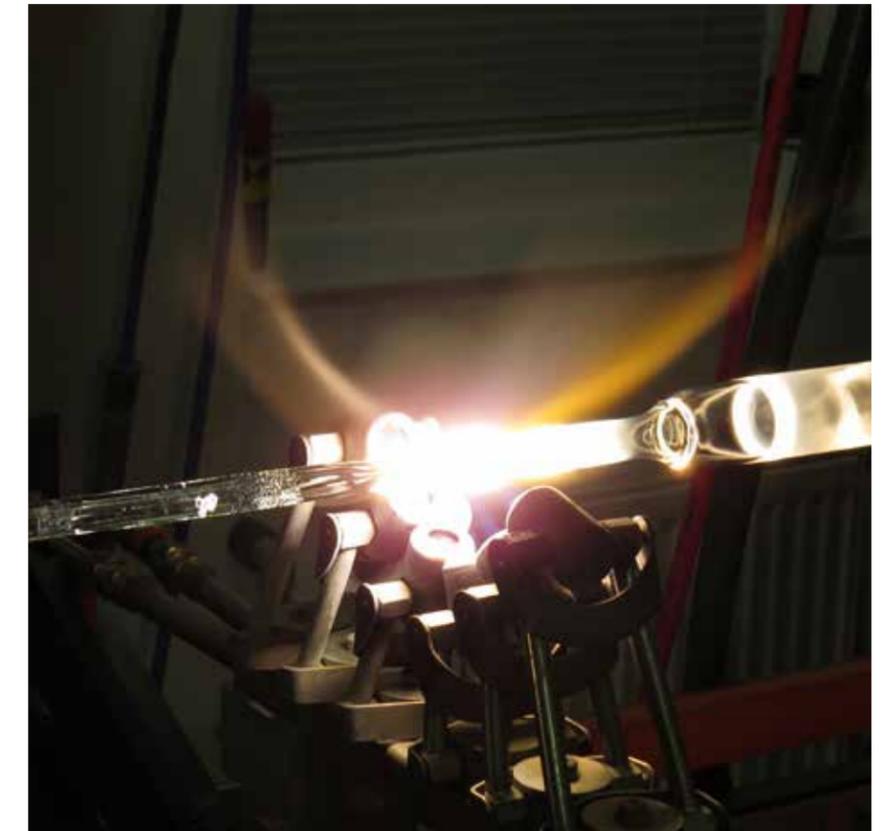
- Manufacture of fibre components
- Manufacturers of fibre lasers
- Telecommunication companies



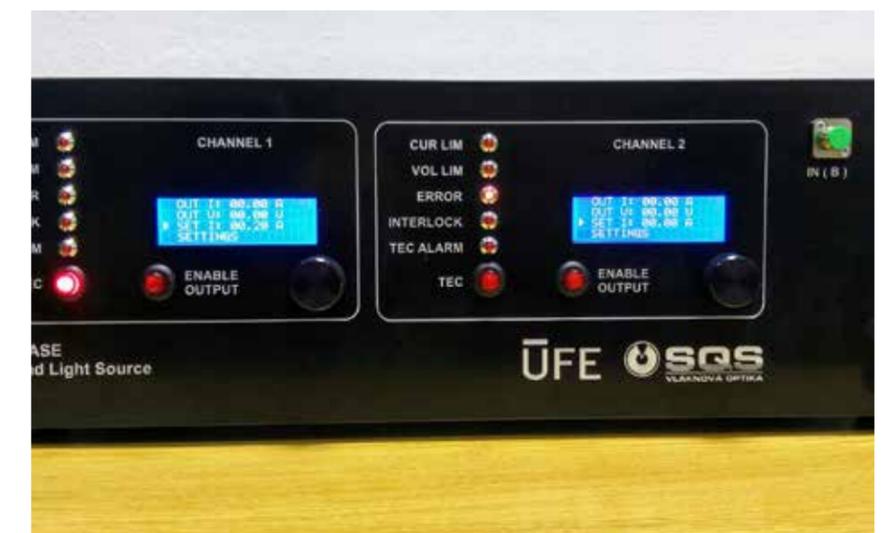
Aparatura s CO₂ laserem pro přípravu speciálních vláknových součástek a vláknových mřížek s dlouhou periodou

Results achieved, references and examples of cooperation

- Joint development of fibre components (SQS Vláknová optika a. s.)
- Joint development of fibre amplifiers (CESNET z.s.p.o.)
- Joint development of fibre sensors and wide-spectrum sources of radiation (Safibra, s.r.o.)
- Joint development of fibre lasers and generator for the middle infra-red region (Optokon, a.s.)



Pre-form for pulling the optical fibre



2000 nm-band amplified spontaneous emission source

Laboratories of Mechanics, Magnetic and Transport Properties and Structure of Materials. IPMinfra -

Infrastructure for the Study and Application of Advanced Materials

Institute of Physics of Materials of the CAS



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Competences

The activities of the Institute of Physics of Materials of the Czech Academy of Sciences ("IPM") are focused on explaining the relationship between the behaviour and properties of materials and their structural and microstructural characteristics, where the priority is the research of advanced metal-based materials, ceramics and composites in relation to their microstructure and the method of preparation. The aim of this research is the optimisation of utility properties of materials and prediction of their operational service life. IPM is adequately equipped for its extensive experimental activities. The traditional laboratories have been significantly extended through the development of the research infrastructure IPMinfra that commenced its activities in 2017. The existence of the research infrastructure creates a precondition for the use of unique devices and



methods for excellent scientific and research activities of interested users from among national and international research organizations, universities and industrial enterprises.

The specialization of the Institute has a long-standing tradition in the field of material research, reaching back to 1955 when it was founded with the aim of studying properties of metal materials. Through natural development, the research portfolio has extended also to other materials that form the basis of highly sophisticated engineering applications. At present, great attention is paid for example to the materials for safe and environment-friendly generation

of electrical energy, new generation of highly strong steel used in automobile and aviation industry, nano-materials with unique properties, high-temperature superalloys used in turbines, materials for implants used in medicine, functional materials, ceramic materials and composites. The range of expert activities also responds to current trends in the field of material engineering; a part of research capacities is for example devoted to properties of materials and components produced by means of 3D printing of metals.

Main Fields of Activities

The IPM and its research infrastructure IPMinfra focuses in particular on the research of advanced materials used in engineering applications. With its field of specialization, IPMinfra covers in particular the area of long-term mechanical tests (i.e. fatigue of materials, creep, interactions of creep and fatigue, fracture and material failures, all the above within a wide range of temperatures) and characterization of materials structure and its changes during exposure to stress.

Creep Tests and Study of Processes Occurring upon Creep Deformation of Materials

The research infrastructure of the Institute provides a unique capacity of almost 40 creep devices suitable for identification of creep characteristics, such as the time until rupture, creep rate or overall creep elongation. Both tension and compression experiments are possible, under controlled load and stress, within the temperature range from 20°C to 1,400°C.

Experimental Characterization of Fatigue Endurance of Materials, Determination of Fatigue Life and Endurance and Resistance against the Spreading of Fatigue Cracks

Fatigue laboratories offer resonance and servo hydraulic devices for determination of fatigue characteristics within the range up to 108 cycles within the temperature range from 20°C to 1,000°C. Tests can be performed under nitrogen vapour cooling. There is a device for giga-cycle high-frequency fatigue testing up to 1010 cycles, one fatigue device for combined loading, a testing device for thermomechanical fatigue.

Testing and Investigation of Strength of Materials

The laboratories allow for performing a wide range of tests determining mechanic properties of materials, such as tension tests, determination of fracture toughness within the temperature range from -196 °C to 1,200 °C, within an extensive range of loads. It is possible to use acoustic emissions or non-destructive measuring of elastic constants.

Characterization and Description of the Structure and Composition of Materials

For the purpose of describing the structure, composition and characteristics of materials, the laboratories offer devices for phase analysis of materials with high content of iron (up to 1,000 °C), an X-ray powder diffractometer, a high-resolution spectrometer for surface analysis, in-depth profile analysis and volume analysis of electrically conductive and non-conductive samples and thin layers.

There are also devices for the state-of-the-art transmission and scanning electron microscopy with EDS and EBSD detectors and two SEM microscopes with focused ion beam technology (FIB). AFM microscope can be used for imaging of object surfaces that can be placed in a standard SEM, which allows for obtaining highly valuable information combining both imaging methods.

Magnetic and Electrical Properties

There are also extensive possibilities of determining magnetic, electrical and transport properties of materials. The laboratories offer for example devices for measuring DC resistivity, AC resistivity, Hall effect, thermal conductivity, thermal capacity and measurement of magnetoresistance. The laboratories are equipped with quadrupole mass spectrometer, Mössbauer spectrometer and magnetometers.

However, the key factor for successful problem solving is the experience of the teams of excellent material science experts, who enjoy international reputation. They are capable of offering highly specialized consulting activities or of performing technical analyses associated with problems occurring in the course of engineering applications of new advanced materials.

Target Group

The target group of the offered services consists in particular of national and international research organizations, universities and industrial enterprises. At the same time, the

infrastructure capacities are offered to external users by means of open access.

The IPM laboratories and the developed IPMinfra infrastructure represent a unique environment for excellent research and development of advanced materials and for intensive collaboration with both international and domestic academic or application sphere.

Achieved Results, References and Examples of Co-operation

Experimental laboratories of IPM are fully prepared for academic co-operation or for co-operation with the application sphere. We have been co-operating on a long-term basis with various corporations manufacturing components or operating highly sophisticated devices where materials are exposed to high levels of stress during operation. These include in particular companies in the field of power industry, companies specializing in the development and manufacture of transport technology or components of transport machinery or devices, or companies manufacturing medical instruments and implants. Among the companies co-operating with the IPM on a long-term basis are, for example BONATRANS GROUP a. s., PBS Velká Bíteš, a. s., GE Aviation Czech s.r.o., ŽPSV a.s., ČEZ a. s., Hanon Systems Autopal Services s.r.o., Honeywell, ŠKODA AUTO, a.s., voestalpine Giesserei, Dentsply Sirona Prosthetics, Manoir Industries and others.

Center of Accelerators and Nuclear Analytical Methods (CANAM)

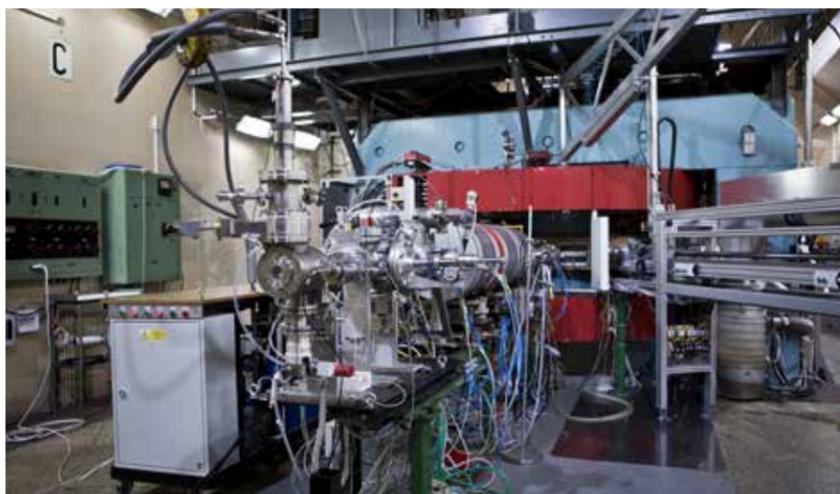
Nuclear Physics Institute of the CAS



The mission of the large CANAM infrastructure is to make use of energetic-ion and neutron beams in physics, chemistry, biology, power engineering and other fields of science. The CANAM interconnects large experimental facilities of the Nuclear Physics Institute of the CAS in Řež (NPI): an isochronous cyclotron U-120M, newly commissioned cyclotron TR-24, fast neutron generators (Laboratory of Cyclotrons and of Fast Neutrons), Tandetron electrostatic accelerator (Laboratory of Tandetron Accelerator) and equipment installed on the neutron irradiation channels of an LVR-15 research reactor (Neutron Physics Laboratory).



a) Laboratory of Cyclotrons and Fast Neutrons (LC&FNG)



The U-120M cyclotron with the target station (Be target) for the generation of fast neutrons

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Competences

The isochronous cyclotron U-120 M and newly commissioned cyclotron TR-24 are operated in the Laboratory. The cyclotron U-120M provides beams of accelerated ions (p, d, $3\text{He}+2$, $4\text{He}+2$) with energies from 6 to 50 MeV – depending on the type of particle – and external currents from units of pA up to tens of μA . In connection with target stations of fast neutron generators (FNG), the cyclotron is a unique intensive source of fast neutrons. Thanks to the broad range

of energies and currents, the accelerated beams are used by both domestic and foreign groups of researchers for a wide range of experiments of basic as well as applied research. These include particularly astrophysical experiments ($3\text{He}+2$ beam), measurement of excitation functions and nuclear data, irradiation of biological samples, testing of cosmic rays detectors, determination of radiation damage to electronic components, production of fluorescent nanodiamonds, calibration sources as well as the production of both conventional

and unconventional radionuclides for the preparation of radiopharmaceuticals. Cyclotron TR-24 provides proton beams with the energy range 18 – 24 MeV and external currents up to 300 μA . These beams will be used, in connection with the developed target stations, for the production of fast neutron fluxes with high-density (up to $2 \times 10^{12} \text{ n/cm}^2/\text{s}$) and for the production of new medical, particularly long-lived radionuclides. Also, components of accelerator technology, diagnostic elements of accelerated beams, target technology and systems for the irradiation of samples and materials are developed and manufactured in the Laboratory. The utilisation of a beam of accelerated particles that is in preparation for measuring the wear of components of combustion engines using the TLA (Thin Layer Activation) method appears to be very promising for the automotive industry.

Target groups

- Domestic and foreign scientific research institutes and workplaces, technological centres
- Nuclear medicine workplaces
- Radiopharmaceutical industry
- Biomedical engineering
- Manufacturers of electronic components
- Firms and institutions participating in space research
- Companies and institutions involved in the design and manufacture of components of thermonuclear facilities (i.e. ITER).

Our services

- Irradiation services including feasibility studies and design of experiments
- Designing target systems and target holders for the irradiation of samples and materials
- Calculations and designs of vacuum systems and apparatus
- Calculations and designs of ion-optical systems for the transport of accelerated particles
- Calculations and simulations of the movement of charged particles in combined electric (including time-variable) and magnetic fields
- Diagnostics and measurement of accelerated beams of charged particles and fast neutrons
- Production of fluorescent nanodiamonds



Ionto-optical beam-line of the TR-24 cyclotron

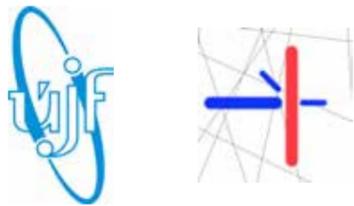
- Irradiation of biological samples
- Testing of radiation resistance
- Production of commercial and non-commercial radionuclides for the preparation of radiopharmaceuticals

Results and references

- Astrophysical experiments – Department of Nuclear Reactions of the NPI of the CAS
- Study and measurement of excitation functions and effective cross-sections of nuclear reactions – ITU Karlsruhe, Germany, TU Dresden, Germany
- Production of fluorescent nanodiamonds – Institute of Organic Chemistry and Biochemistry of the CAS, Faculty of Biomedical Engineering of the Czech Technical University in Prague, Institute of Microbiology of the CAS, Generi Bio SME ČR, Interuniversitair Micro-Electronica Centrum vzw, Belgium, University of Stuttgart, Germany, School of Medical Science, Griffith University, Australia
- Preparation of $83\text{Rb}/83\text{mKr}$ zeolite and implanted calibration sources – KATRIN and XENON project, Karlsruhe Institute of Technology,
- Irradiation of biological samples – Department of Radiation Dosimetry of the NPI of the CAS
- Testing of the radiation resistance of electronic components – ALICE project, CERN, Department of Nuclear Spectroscopy of the NPI of the CAS
- Preparation of medical radionuclides for research – RadioMedic s.r.o., ÚJV Řež, a. s., Institute of Molecular Genetics of the CAS, Envinet a. s., Advanced Cyclotron Systems Inc., European Pharmacopoeia Committee
- Commercial production of radionuclides for the preparation of radiopharmaceuticals – RadioMedic s.r.o.

Center of Accelerators and Nuclear Analytical Methods (CANAM)

Nuclear Physics Institute of the CAS



b) Laboratory of Tandetron Accelerator (LT)

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Energetic-ion beams are used to modify surface layers of solid substances and to analyse their composition and structure. Ion analytical methods (Ion Beam Analysis – IBA) possess a number of unique properties for which they cannot be substituted by other alternative procedures in the qualitative and quantitative analysis of materials. A Tandetron 4130 MC electrostatic accelerator is used for these purposes. The accelerator provides ion beams from hydrogen to gold with ion currents up to units of mA and energies from hundreds of keV to tens of MeV. The accelerator is the only one of its kind in the Czech Republic and allows, in a substantial manner, extend-



Laboratory of Tandetron – a view of beam lines with end target chambers for ion analytical methods'

ing analytical possibilities, introducing new ways of the modification of substances and the synthesis of new prospective materials and micro – and nanostructures. Broadly conceived interdisciplinary research is done in close cooperation with specialised workplaces in the Czech Republic and abroad.

Competences

The research activities focus especially on the monitoring of creation processes of thin films and layered structures with notable mechanical, electrical, magnetic, optical, chemical and biological properties and on the study of physical and chemical processes that take place in such structures during the passage of high energy charged particles. A broad spectrum of nuclear analytical methods and their use

in interdisciplinary and application areas are developed methodically in the Laboratory. Apparatus for analyses using the proton fluorescence analysis (PIXE), charged-particle elastic scattering (RBS, RBS channelling, ERDA, ToF ERDA) methods and by various nuclear reactions (PIGE, NRA) is available. Furthermore, equipment is available for the ion implantation of samples of up to 8 cm in diameter, fluence of up to 10^{16} ions per cm^2 (possible cooling by liquid nitrogen or, where appropriate, heating of the substrate to 800°C), an external beam for the irradiation of samples that cannot be placed in a vacuum, and a microbeam making it possible to focus ions to a size of less than $1\ \mu\text{m}$.

- Ion implantation – micro- and nanostructured materials for – microelectronics, optics, laser technologies, photonics, spintron-



Multifunctional analytical vacuum chamber enabling to measure X-rays and recoiled ions concurrently

- ics, biomedicine
- Use of energetic ions in the study of aerosols in the atmosphere
- Characterisation of volumetric and layered materials with notable mechanical applications
- Characterisation of materials for nuclear technologies
- Study of the element composition of archaeological artefacts
- Study of fundamental processes

- during the interaction of energetic ions with solid substance
- An external beam for the pre-defined uniform irradiation of a sample in the – applications for irradiation e.g. of living tissues for dosimetric studies
- A progressive method of preparing optical nanostructures by machining by an ion beam
- Simulation of the passage of ions through materials, the formation of defects, structural and composition changes in the synthesis of structures by ion beams
- Deposition of layers using methods of magnetron sputtering, vapour-deposition and deposition with the use of ion beams

Target groups

- Industrial development dealing with the preparation of layered structures with notable mechanical, optical or opto-electronic properties
- Characterisation of the element composition and modification of crystalline materials for the semiconductor industry
- Characterisation of materials for nuclear power engineering – industrial development of technologies for nuclear and fusion reactors
- Preparation of nanostructures and doping of materials by ion implantation for the semiconductor industry, industrial research and development in microelectronics and optics

Results and references

- Preparation of optical and optoelectronic structures - Institute

- of Chemical Technology Prague, Helmholtz Zentrum, Dresden-Rossendorf, Germany, Faculty of Mathematics and Physics, Charles University, Prague
- Microstructuring in glasses, ceramics, crystals, and 2D structures on the graphene basis – ATOMKI, Debrecen, Hungary, Institute of Chemical Technology - Prague, Institute of Physics CAS
- Use of the external beam on the air for irradiation of living cells and testing of electronics, applications in dosimetry and cosmic technologies – Dept. of Radiation Dosimetry NPI CAS, Faculty of Nuclear Sciences and Physical Engineering CTU Praha
- Control of the quality and production process of roll-type capacitors – HYDRA a. s.
- Composition of crystalline materials, content and in-depth profile of light elements, analysis of trace elements, positioning of dopants in crystals – Institute of Chemical Technology Prague, Institute of Physics CAS
- Characterisation of multi-layered systems of mechanically resistant and abrasion-resistant layers prepared in plasma reactors – HVM spol. s r. o., SHM spol. s r. o. Šumperk
- Chemical composition of zirconium layers for technology of nuclear fuel packaging material and materials for nuclear fusion – UJP Praha a. s., Institute of Plasma Physics CAS
- Study of in-depth profiles of heavy elements to characterize the diffusion of fission products in granitic rocks of the Czech massif – UJV Řež, a. s.

Center of Accelerators and Nuclear Analytical Methods (CANAM)

Nuclear Physics Institute of the CAS



c) Neutron Physics Laboratory (NPL)

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Competences

The Neutron Physics Laboratory was founded within the NPI for the purposes of neutron-physics experiments for research projects of the NPI but also for the provision of measuring time on neutron beams and of the experience of its experts to external users. Neutron channels in the LVR-15 research reactor (operated by Centrum výzkumu Řež, s.r.o. – Research Centre Řež Ltd.) are used both for material research by means of neutron diffraction and for neutron activation analysis. Analyses with the help of neutrons are carried out on a total of eight facilities and are basically divided into two circles:

- Neutron diffraction is used for studying the structure and microstructure of materials (e.g.



An SPN-100 neutron diffractometer for scanning tension in materials (left) and analytical methods for neutron in-depth profiling and prompt gamma activation analysis (right) on neutron beams in a research reactor

- advanced metals and ceramics but also archaeological artefacts) in diverse sizes, starting with an arrangement of atoms in a crystal lattice up to microscopic heterogeneities on a nano- and microscale. High permeability of the neutrons of most materials makes it possible to carry out these tests in a non-destructive manner with a large volume of materials or even in-situ under various external conditions (mechanical strain, high temperature)
- Nuclear reactions of neutrons with mass are utilised for analysing concentrations or concentration profiles of elements in substances.
- Advanced neutron and photon activation methods are used in multidisciplinary research, namely in environmental, biomedical, geo- and cosmochemical branches.

Target groups

- The target group for the services offered by the Laboratory comprises industrial enterprises, technological centres, universities and research institutions at national and international level, as well as state administration bodies.
- In the field of material characterisation, users may include firms engaged in the manufacture of components, where the material is strained during thermomechanical processing or during operation. These are, in particular, firms from the transport area (e.g. analysis of tension in the vicinity of welds), from the energy industry (e.g. the microstructure of materials in turbine components) or firms engaged in the manufacture of medical components (e.g. joint replacements).

- Analytical techniques can be used, for example, by medical companies, enterprises concerned with the environment, and also food processing companies. Expert analyses can be provided to state administration bodies as well.
- Last but not least, the facilities of the Laboratory can be used by research institutions at national or international level focusing on material sciences, geology, optics, opto-electronics and spintronics, organic and inorganic chemistry or medicine and biology. The facilities and knowledge of our experts can be used by specialised research institutions, for example when building new scientific research capacities.

Our services

- Five neutron scattering devices (SPN-100 – a device for scanning internal stresses in materials, MEREDIT – a powder diffractometer, NOD – a diffractometer for testing neutron optics, MAUD – a small-angle diffractometer, TKS-400 – a high-resolution diffractometer) can be used for the following types of specialist analyses:
- Determination of crystallographic structure and phase analysis
- Determination of magnetic structure
- Development of crystallographic or magnetic structure subjected to an external influence of temperature or pressure (in situ)
- Determination of residual stresses in metals and ceramics, e.g. in the vicinity of welds, in engineering components following thermal and

- mechanical treatment, in functionally graded ceramics; in some cases characterisation can be carried out in an entirely non-destructive manner
- Research into microstresses and deformation mechanisms in polycrystals subjected to mechanical and thermal strain
- Characterisation (ev. non-destructive) of the microstructure of precipitates and pores in metals (e.g. high-temperature alloys), ceramics (thermal barriers, superplastic ceramics) and glasses (e.g. from zirconium)
- Microstructure of polymers on rather large dimensional scales
- Testing of neutron-optical components (neutron monochromators and analysers)

Further three neutron-physics devices (T-NDP – neutron in-depth profiling, NG – prompt gamma activation analysis, NAA – neutron activation analysis) along with X-Ray fluorescence spectroscopy (XRF) can be employed for the following analytical purposes:

- Non-destructive measurement of the concentration of some light isotopes (³He, ⁶Li, ⁷Be, ¹⁰B, ¹⁴N etc) depending on the depth in areas near the surface of solid substances (to tens of μm with a resolution of ~ 10 nm). A 1D or 2D mode of measurement can be used
- Precise determination of the concentration of isotopes/elements (B, Cd, Sm, Gd, H, Cl etc) optimised for liquid or powder samples
- Monitoring of the environment – analysis of aerosols, soil, biomonitors
- Geo- and cosmochemistry: element characterisation of rocks,

- minerals, tektites, meteorites
- Geomycology: element characterisation of fungi and their substrates
- Nutrition science: determination of basic and toxic trace elements in food and beverages
- Biomedicine: determination of basic and toxic trace elements in human and animal tissues
- Material science: element characterisation of diverse materials, e.g. alloys or high tech materials that are difficult to characterise by other analytical methods
- Chemometrics: analyses for checking the accuracy of other analytical techniques, testing of homogeneity and certification analyses of reference materials that are being newly prepared
- Archaeology: analysis of metal and glass artefacts
- Analyses relating to “The Restriction of the use of certain hazardous substances in electrical and electronic equipment – RoHS (Directive 2002/95/EC)”

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User access:
<https://users.canam.ujf.cas.cz>

E-mail: useroffice@ujf.cas.cz

Microtron Laboratory – Department of Accelerators

Nuclear Physics Institute of the CAS



Contact

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Microtron MT 25 is a source of relativistic electrons (primary electron beam), secondary photon beams (bremsstrahlung) and neutrons from nuclear reactions. Electron beams are used for radiation crosslinking, radiation polymerization, and irradiation of biological samples, different types of detectors testing and for the production of NV centers in nanodiamonds. Electronic beams are also used for research in the food industry and for radiation sterilization. Photon beams are mainly used for IPAA (instrumental photon activation analysis) which determines selected elements in different materials, for irradiation of biological samples and for irradiation of PbWO₄ crystals, where the change of optical properties is measured. In neutron fields, ionizing radiation detectors are tested and electronic components are irradiated to ascertain radiation resistance. A fully automated pneumatic



The vacuum chamber of the accelerator

post was built and installed in the laboratory. This post ensures fast sample transport between the irradiation position and the HPGe detector. This system will greatly extend IPAA capabilities, as it will allow determination of the short-lived isotopes. The microtron laboratory also developed a method for the automated processing of radiographic data generated by charged particles, and an optical path for electron radiography was designed. A development of a compact spectrometer of charged energy particles takes place in cooperation with IEAP CTU. This spectrometer allows the determination of not only particle energy but also their trajec-



An adjustable beam outlet from the accelerator chamber

tory and species (electron, proton, alpha particles, etc.)

Competences

- Feasibility studies
- Irradiation services (electron and photon beams or mixed photon and neutron field) including dose determination
- Instrumental photon activation analysis
- Radionuclides production
- Radiation hardness of materials or devices testing
- Testing of ionizing radiation detectors and measuring systems
- Radiation sterilization



Celkový pohled na urychlovač mikrotron MT25

- Radiation modification of material properties (suitable irradiation can modify optical, electrical or mechanical properties)
- Radiation crosslinking and polymerization of various materials

Target groups

- Manufactures of ionizing radiation detectors
- Manufacturers of electronics and microelectronics
- Biomedical engineering
- Chemical industry
- Geochemical laboratories
- Universities and research institutes

Results and references

- Scintillation crystals testing: Technical University of Liberec
- Luminescent nanodiamonds production: Institute of Organic Chemistry and Biochemistry of the CAS, Faculty of Biomedical Engineering CTU in Prague
- Research on the effect of ionizing radiation on the durability of fish

- meat: University of South Bohemia in České Budějovice
- Chemical composition of Ti alloys for joint replacements: UJP Praha a. s.
- Determination of fluorine in apatites: The Institute of Rock Structure and Mechanics of the CAS, p.r.i.
- Radiation crosslinking of gelatin doped with hydroxyapatite for bone replacement: The Institute of Rock Structure and Mechanics of the CAS, p.r.i.
- Radiation crosslinking of cryogels suitable for subsequent cell culture: Institute of Macromolecular Chemistry of the CAS, p.r.i.
- Radionuclides production: FNSPE CTU in Prague
- Response of fast neutron detectors testing: Eurostandard CZ, s. r. o.
- Testing of position sensitive ionizing radiation pixel detectors of from the Medipix family: IEAP CTU in Prague
- Radiation polymerization and sterilization: Food Research Institute Prague, p. r. i.

Application Dosimetry Laboratories (ADL)

Nuclear Physics Institute of the CAS



Contact

Nuclear Physics Institute
of the CAS

Department of Radiation Dosimetry

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Sampling of atmospheric $^{14}\text{CO}_2$



Transfer of C-14 to a chemical form suitable for the measurement of activity

The aim of the ADL is to provide the users with expert knowledge and experience in the field of radiation protection and ionising radiation dosimetry, to conduct research and development of ionising radiation along with associated applications of ionising radiation in medicine and industry.

The specialisation of the ADL is based on the tradition of the Department of Radiation Dosimetry, the former Institute of Radiation Dosimetry of the CAS in Prague, which has been successfully developing methods of microdosimetry and dosimetry using both active and passive radiation detectors, environmental dosimetry including new procedures for the determination of radionuclides in sam-

ples of the environment for nearly 70 years.

Competences

The research subjects concentrate especially on understanding the effects of low radiation doses, characterisation of the transfer of ionising radiation energy on a nanometric and micrometric scale, research into cosmic radiation, study of anthropogenic effects in nature, radiocarbon dating and so forth. We have unique instrumentation and laboratory premises at our disposal, in particular:

- A laboratory for low-background measurements of and work with radioactive materials

- A radiocarbon dating laboratory with the international code CRL
- A secondary calibration laboratory for gamma radiation
- A laboratory for molecular and cellular radiobiology
- Sources of ionising radiation
- Liquid scintillation spectrometers
- A high-speed optical microscope intended for scanning and digitalisation of large areas, the only of this kind in Europe
- Active and passive radiation detectors for measurements in mixed radiation fields

Target groups

The target group for contract research is represented by industrial enterprises, university workplaces,

state authorities, technological centres and research institutions at national and international level. Another target group comprises entities the workers of which may be exposed to the effects of ionising radiation – namely healthcare facilities, nuclear power plants or air transport companies.

Results achieved, references and examples of cooperation

- Verification of dosimetric systems
- Irradiation of samples to a precise dose
- Studies oriented to the environmental effect of humans in the present and in past times:
 - a) occurrence of radionuclides in the environment surrounding

- nuclear power plants and in background reference areas,
- b) combustion of fossil fuels and an increase in CO₂ concentration in the atmosphere,
- c) transport of CO₂ and other chemical forms of carbon in the environment,
- d) in cooperation with institutions focusing on archaeology and geology: changes in the environment in past times and the associated man-nature relation,
- e) possibilities of employing analytical methods as part of interdisciplinary research (for example, use in ADL developed methods for monitoring radionuclides in the process sections of nuclear power plants)

- Determination of the personal dose equivalent of a flight crew
- Determination of linear energy transfer spectra in beams and fields of ionising radiation
- Determination of the content of low-energy beta radiators in samples of the environment (in particular, ¹⁴C and, further, ³H, ⁸⁵Kr, ⁹⁰Sr, ⁸⁹Sr) and development of associated analytical methods
- Sample dating in the radiocarbon dating laboratory with the international code CRL
- Determination of radiation damage by DNA methods to agarose and polyacrylamide electrophoresis
- Determination of radiation damage to cell lines

The Aerodynamics laboratory

Institute of Thermomechanics of the CAS



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Specialisation

The Aerodynamics laboratory in Nový Knín, situated about 30 km south of Prague, offers several wind tunnels for experimental research relevant to power engineering and environmental engineering. The wind tunnels are configurable to handle various testing needs.

The aerodynamics facility hosts two laboratories: the Laboratory of Internal Flows conducts systematic research on transonic fluid flows in narrow channels, axial and radial turbine and compressor blade cascades or steam valves, focusing on aerodynamic optimization and aeroelasticity. The Laboratory of Environmental Aerodynamics studies turbulent flows and dispersion of pollutants in the surface



Technician Antonín Zajíček inspects the blade cascade model before mounting into the aerodynamic tunnel

layer of the atmosphere using a specialized boundary-layer wind tunnel.

Competences

The Aerodynamics laboratory was built in 1960s and over the years it has been expanded and modernized to provide our researchers with cutting-edge experimental equipment. It has been serving mainly our power engineering industry, however, more recently it has also been serving government authorities, municipalities and companies interested in studies of dispersion of dangerous substances and air pollutants in the atmosphere.

We offer the following research competences:

- Optimization of flow channels and turbomachinery parts
- Research of flow of compressible and viscous fluid, including in mini-channels and relatively narrow channels
- Research of aeroelasticity
- Calibration of pressure probes (including multi-hole) for subsonic and supersonic flow
- Design and calibration of new research methods for air pollution studies
- Studies of dispersion of accidentally and deliberately released

- hazardous substances in urban, industrial or rural environments
- Assessment of the influence of the landscape on the dispersion of pollutants
- Validation of numerical studies

Results

The following are examples of our recent studies conducted either as part of national and international basic and applied research projects or as part of contract research:

- Optimization of flow parts of two 1,000MW turbines in the Temelín

nuclear power plant (in cooperation with Doosan Škoda Power). The optimization helped to increase the output power of each power plant block from 1,000 MW to 1,050 MW without increasing the nuclear fuel consumption.

- Development of ultra-long blades of the last stage of a high-performance steam turbine (cooperation with Doosan Škoda Power).
- Aerodynamic optimization of transonic steam valves for high-performance steam turbines (for Doosan Škoda Power).
- Aerodynamic measurements of transonic axial compressor blade



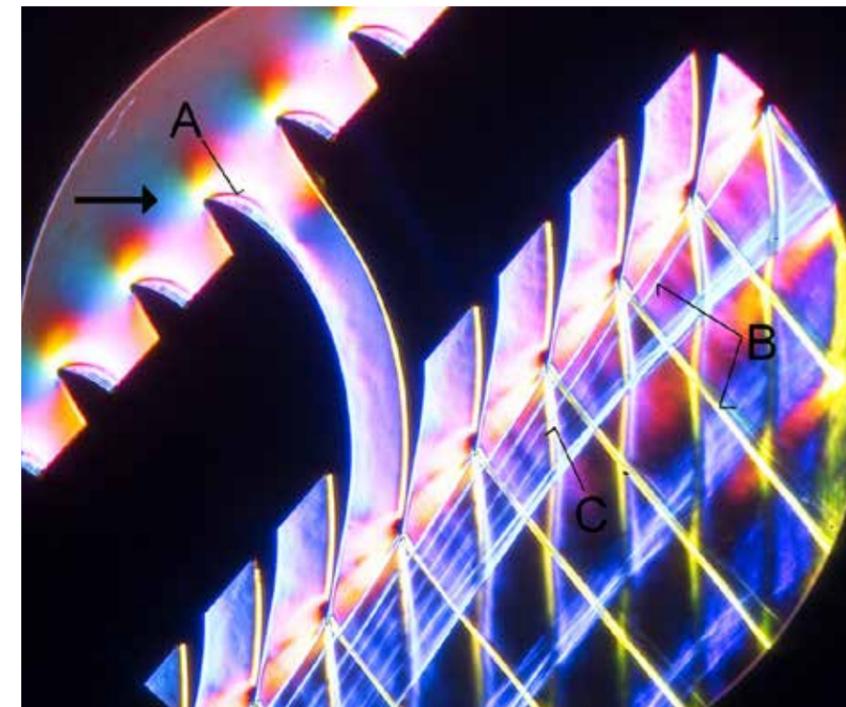
Visualization of the flow above the model of the city of Pardubice inside the wind tunnel

profiles (for Doosan Heavy Industries, South Korea).

- Dispersion of traffic pollution in the streets of Hannover.
- Experimental study of accidental release of chlorine gas from the Synthesia chemical plant in Semtín and from the railway station in the city of Pardubice.
- Experimental study of deliberate releases of hazardous gas in Prague's Old Town square.
- Experimental study of coal dust dispersion from the open-cut coal mine Libouš in the Chomutov region.

Target Groups

- Manufacturers of turbomachinery and internal combustion engines
- Aviation industry
- Government authorities, municipalities and companies interested in studies of dispersion of dangerous substances and air pollutants in the atmosphere



Transonic flow field in the blade cascade model of the root section of the impeller of the last stage of a high-performance steam turbine designed by Doosan Škoda Power in Pilsen. The exit Mach number is 1.7. We see a flow field visualized using the colour Schlieren method at off-design conditions. The large positive angle of attack (30°) results in flow separation on the suction sides of the profiles (A). We see, among other things, a system of exit shock waves (B) and wakes (C) downstream of the cascade.

Laboratory of Applied Informatics

Institute of Computer Science of the CAS,



Contact

Institute of Computer Science
of the CAS

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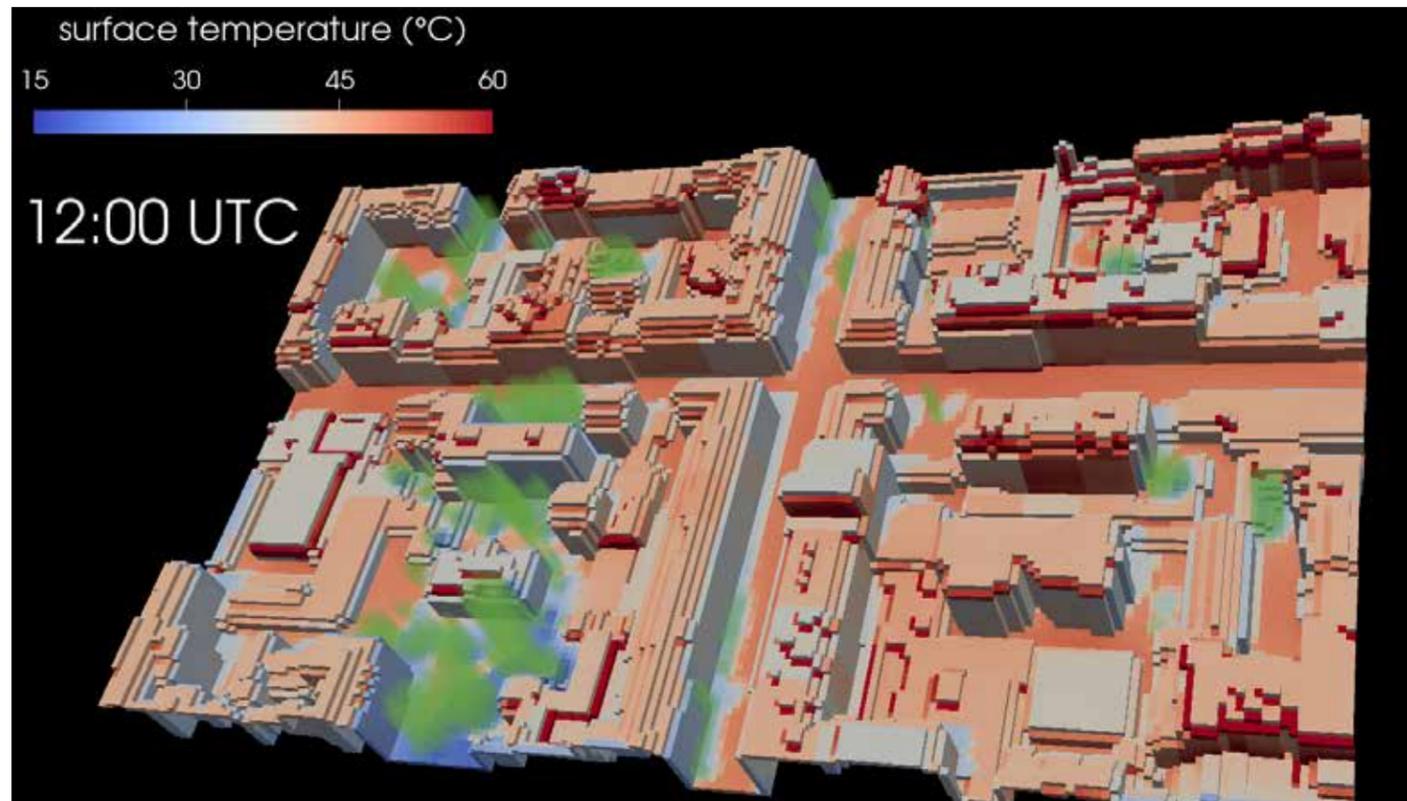
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Competences

Volume and complexity of data that is used in day-to-day life is increasing rapidly and both private companies and public institutions have to tackle the challenge of using the data in effective and beneficial manner. This area is well aligned with the field of research of Institute of Computer Science. The role of Laboratory of Applied Informatics is to provide the platform that brings together state-of-the-art research and practical needs of applied sector. The laboratory is dedicated to real-world testing of new scientific results that belong to selected fields of computer science and collected know-how and experience is used to transfer the knowledge into applications. Working with real-world data is the next step for application of new algorithms and



Simulated urban scenario for Prague districts - Praha-Holešovice and Praha-Dejvice

methods. This usually means that a number of issues has to be solved that are not present in previous basic research. Close collaboration with partners from the applied sector is required to move scientific results closer to applications that respect particular needs and technical constraints given by application domain.

The key areas of competence of the laboratory include:

- Analysis and modelling of complex systems using methodology for both linear and non-linear analyses
- Selected applications of large-scale computing, including parallel processing on HPC (high perfor-

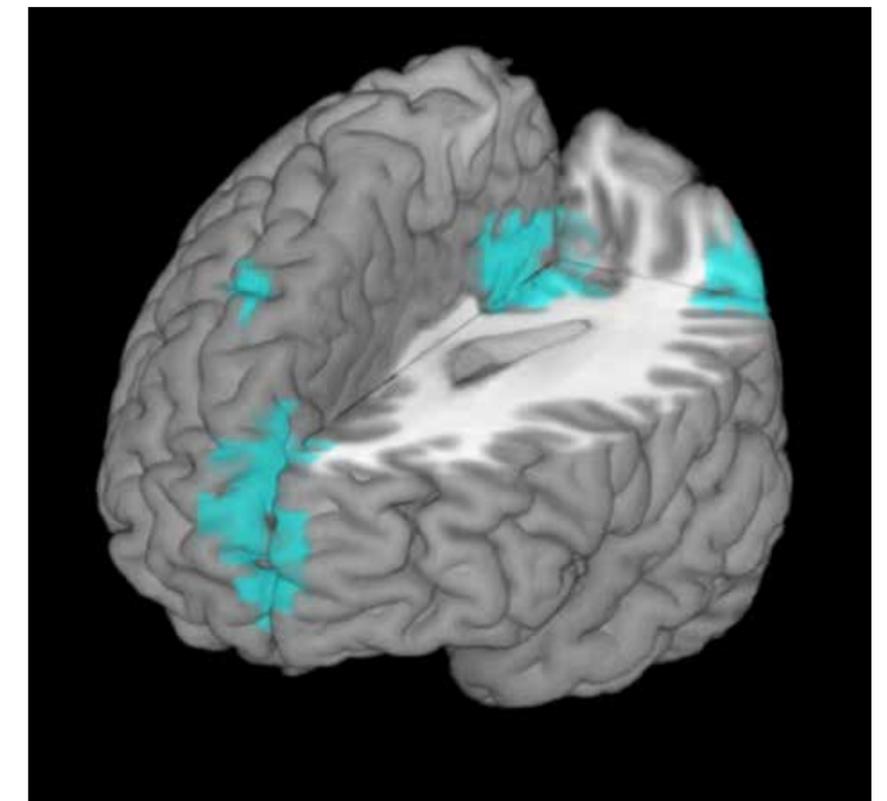
- mance computing) clusters
- Methods of artificial intelligence – machine learning in particular (including artificial neural networks) computed using heterogeneous multiprocessor systems and GPU architectures with possibility to use processing on cloud platforms
- Statistical analyses of complex data, statistical modelling, development of inference procedures, statistical experiment design

Application domains

There is universal demand that goes across application domains for better data processing that is able to extract

vital information and that helps to understand the data. This leads to very wide spectrum of past and present collaborations – from commercial application of analyses of brain activity captured by neuroimaging technique to application of machine learning in cybersecurity. However, the fields of application that are the most significant, with repeated applications of scientific results and with long-term collaborations are:

- Energy – for example statistical modelling of natural gas consumption aimed to accounting applications, or application of models, and satellite and meteorological data



Processing and analysis of brain activity – neuroscientific typology of television programmes

- for estimation of energy production from solar photovoltaics
- Environment – for example application of heat comfort models in high spatial resolution for urban planning or data analyses for air quality observation network
- Transportation – for example processing of traffic data from toll gates for free parking capacity estimation

End users

Our know-how and experience is interesting to any companies and institutions that have to process large volumes of data and usual and easy-

to-access methods are not sufficient. Typical problems in data processing include – data volume, data complexity, and also lack of in-house knowledge of more sophisticated state-of-the-art methods (that fall into domain of mathematical statistics, or artificial intelligence). The wide portfolio of our partners thus include technological companies, companies and institutions active in various fields of research and development, global corporations that want to stay in touch with recent advances and know-how of various fields of computer science, and also government and municipal institutions.

Water Technology Laboratory

Institute of Hydrodynamics of the CAS



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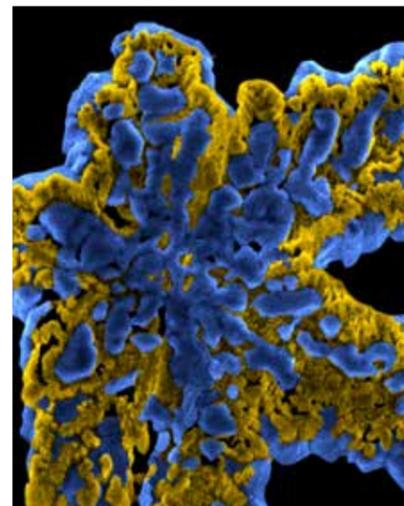


Jar test – Optimization of coagulation

Competences

The Water Technology Laboratory conducts research focused on the optimization of water treatment (algal organic matter – AOM; micropollutants – pesticides, halogenderivates, etc.) and on the description of reaction mechanisms. Our fields of interest include: coagulation (interactions of pollutants with hydrolytic product of coagulants; the influence of physical and chemical factors); formation, characterization and separation of aggregates (physical-chemical parameters, the impact of hydrodynamic forces, sedimentation, filtration); adsorption of micropollutants onto activated carbon (modelling of the processes, competitive adsorption);

mechanisms of disinfection by-products (DBPs) formation. Additionally, we also perform advanced analysis of polluting substances present in water (the content and characterization of organic compounds, surface charge measurements, elemental analysis of liquid samples, concentration of micropollutants, etc.). The laboratory not only conducts basic research, but is also capable of designing or optimizing water treatment technologies.



Aggregate formed through the interaction between organic matter and Fe particles

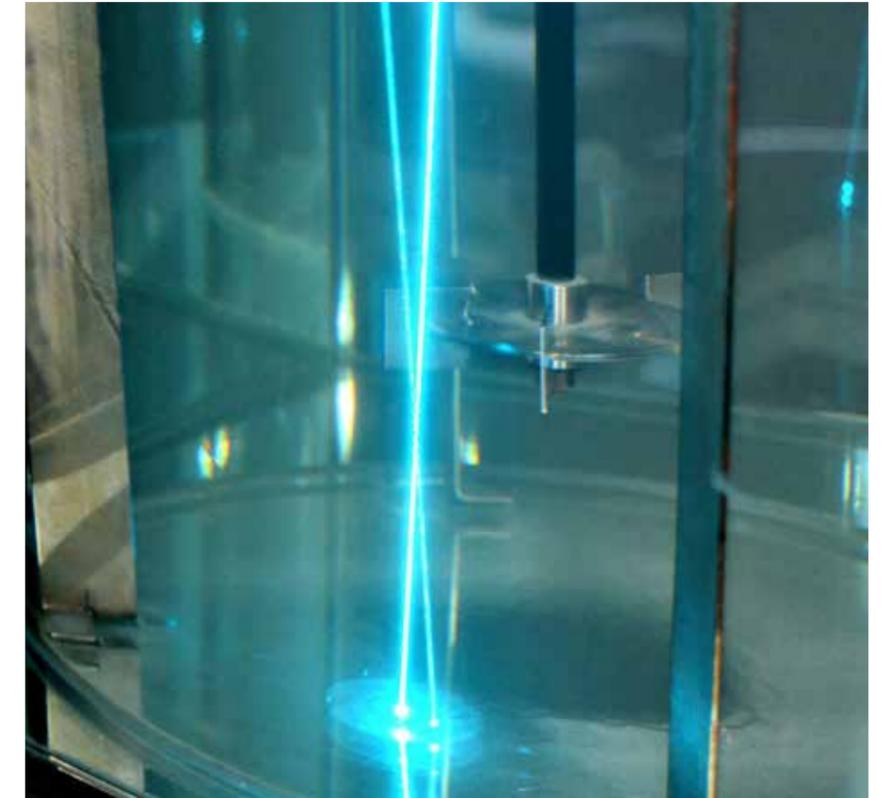
Target groups

The recipients of our services are mainly water management companies (operators of drinking water and wastewater treatment plants), developers and manufacturers of devices for water treatment and also any other entities involved in the field of water pollution or treatment technologies.

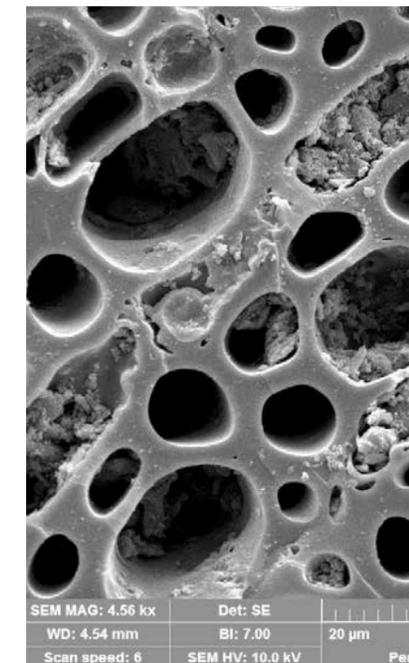
Our services

We are able to provide the following services:

- Laboratory analysis of water samples (the content of organic carbon – toc, doc and nitrogen – tn; spectrophotometric (icp-oes, uv-vis) and chromatographic (hp-sec/hplc with dad/rid/fluorescent



Mixing in water treatment - measurement of velocity field



Structure of granular activated carbon

- detection; gc-ecd/ms) measurements)
- Water treatment technology design (homogenizing mixing; aggregation mixing; separation processes – sedimentation, filtration, flotation, membrane processes; adsorption onto activated carbon) based on the raw water parameters
- Optimization of processes at water treatment plants (pH conditions, the type and dose of coagulant, mixing time and intensity – jar tests; alteration of filtration cycles; set-up of adsorption unit)
- Technological audits of drinking water treatment plants
- Training and consulting activity in

- the field of water treatment (staff training, preparation of project proposals preparations, etc.)
- Optimization of micropollutants (pesticides, cyanobacterial toxins) adsorption onto activated carbon

Rheology Laboratory

Institute of Hydrodynamics of the CAS, v. v. i.



Contact

Institute of Hydrodynamics
of the CAS

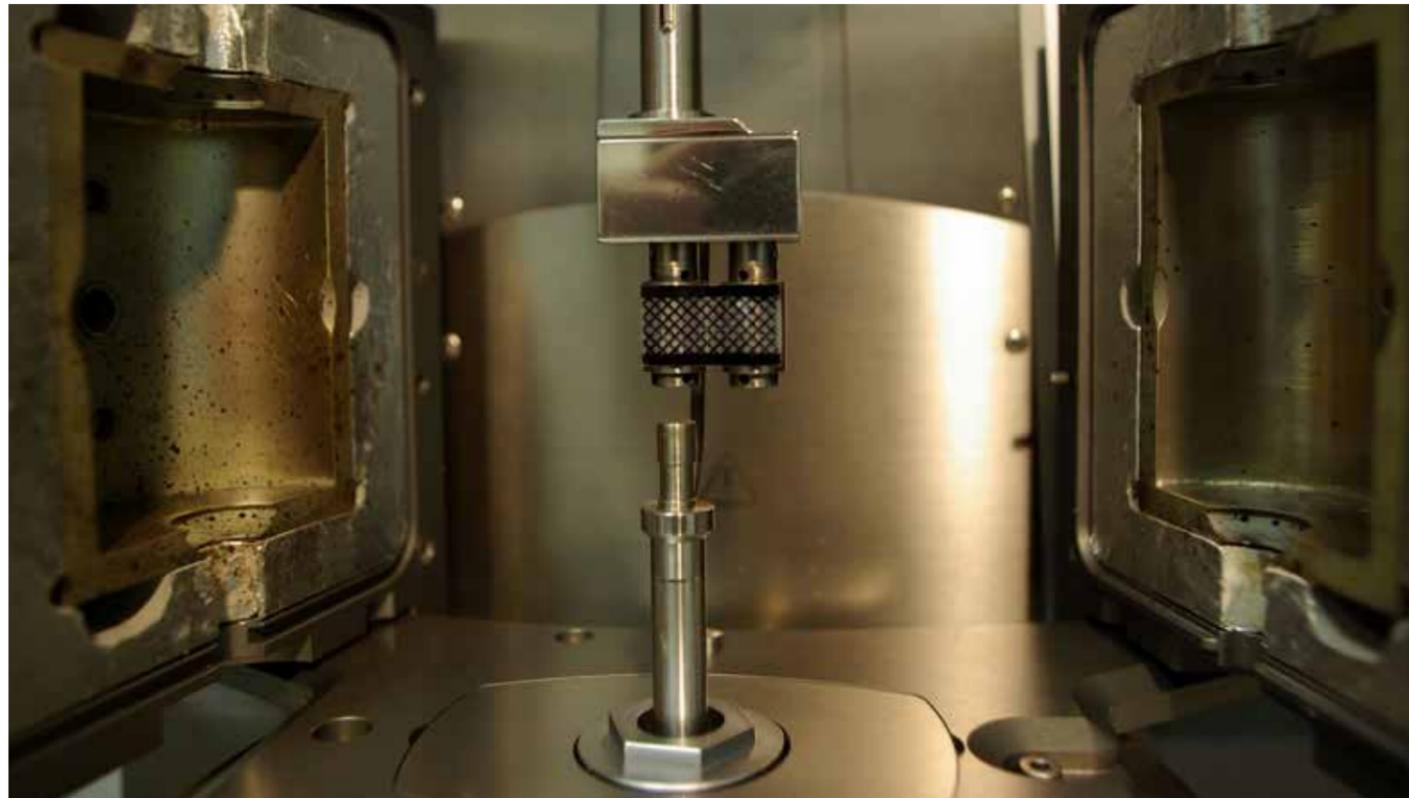
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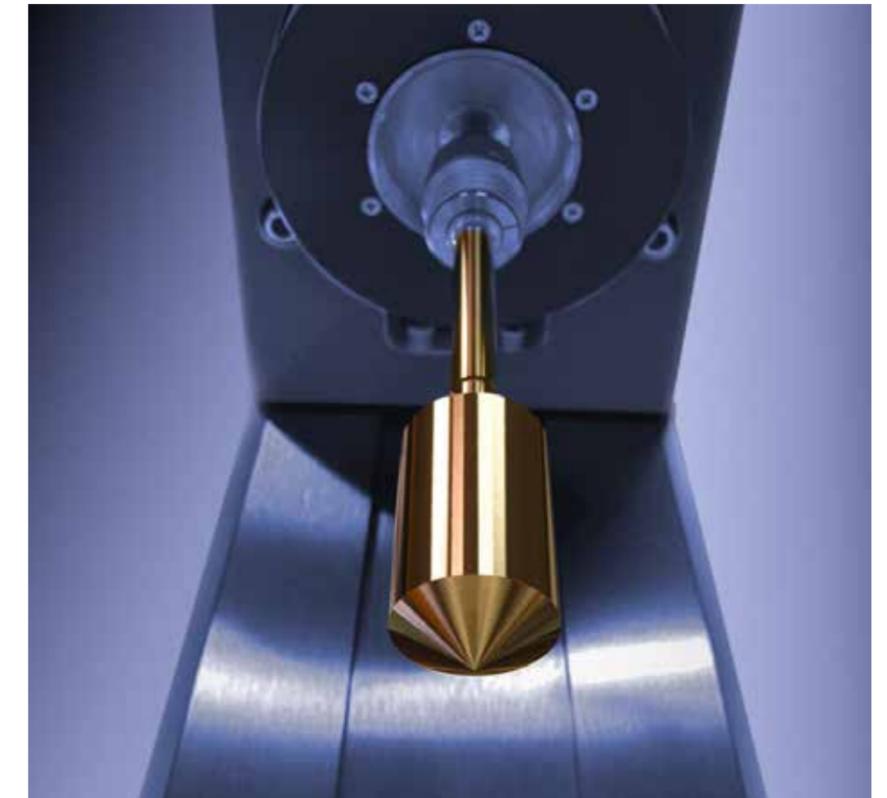
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Sentmanat extension rheometer in-built in an Anton Paar rotational rheometer with an illustrative polymer sample



The concentric cylinder arrangement of the rotational rheometer

Competences

A group dealing with rheometry (characterization of non-Newtonian materials) has a long-term experience both in academic (frequent contributions to renowned international journals) and applied (analysis of concrete industrial materials) spheres.

Target Groups

Target groups are represented by industrial companies, technological centres and research institutes interested in characterization of non-Newtonian materials, i.e. the organizations dealing with polymer

processing, cosmetics and food technology.

Experimental Equipment

- Rotational rheometers (Anton Paar MCR 501, Anton Paar MCR 702) equipped with various geometries (plate-and-plate, cone-and-plate, concentric cylinders) and rheological cells (the electrorheological one of a type plate-and-plate but also with concentric cylinders; the magnetorheological one of a type plate-and-plate equipped with precise measurement of intensity of magnetic field and temperature). An in-built part of the tempe-

- rature oven is a camera enabling continuous recording of the chosen characteristic including elongational viscosity using a Sentmanat Extensional Rheometer). A precise Peltier system for temperature setting (up to 200 °C) can be used as well
- A two-piston capillary rheometer (Rosand RH 2200) is equipped with four dies (with diameters (0.5, 1.0, 1.5, 2.0 mm) and five pressure transducers. For measuring of suspension characteristic it is possible to use conical dies
- Using thermal and cooling presses it is possible to prepare material samples of required dimensions from raw polymer pellets, emul-



Rotational rheometer Anton Paar MCR 501 with an oven up to 400 °C and in-built camera

- sions and suspensions can be prepared using vibrating shakers, magnetic stirrers and sonicators
- For analysis of nanofibrous materials there is applied a scanning electron microscope VEGA 3 (producer Tescan), for determination of their hydrophilic or hydrophobic properties a device See System E

Services at Disposal

Rheological analysis of materials of these types:

- Polymer melts
- Polymer solutions and suspensions
- Cosmetic emulsions
- Food materials, etc.

Rheological analysis is understood in the sense that not only shear but in the case of polymer melts an elongational viscosity can be determined as well. Measurements relating viscous and elastic components (loss and elastic moduli) can be carried out as well. Temperature can be increased up to approximately 400°C. These characteristics can be also measured in the electric and magnetic fields.

Analysis of materials processed by an electrospinning method from the viewpoint of rheology including hydrophilic and hydrophobic characterization.

Centre of Excellence Telč

Institute of Theoretical and Applied Mechanics of the CAS



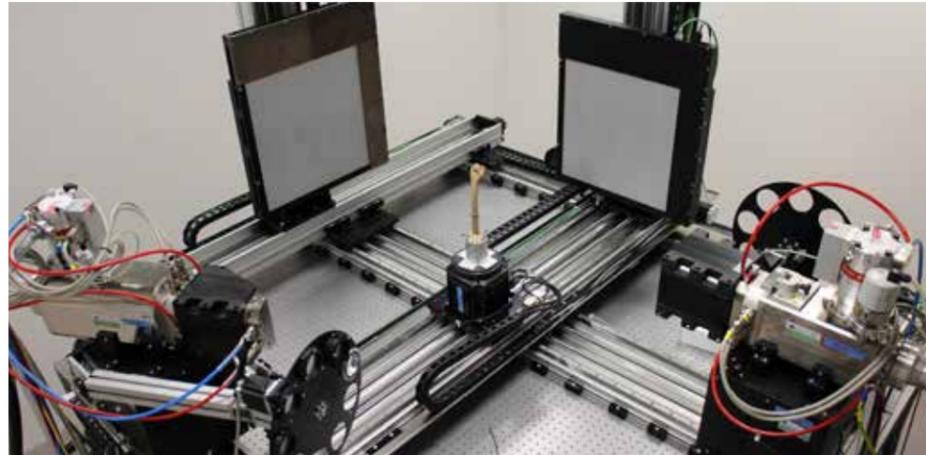
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Specialization

The Centre of Excellence Telč (CET) is part of the Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences. It was established as an European research infrastructure for the interdisciplinary research of cultural heritage funded by the European Union and Czech Republic as part of the Operational Programme "Research and Development for Innovations" for 2007-2013.

The Centre of Excellence Telč is equipped with a unique infrastructure for expert research as well as development and verification of advanced methods for diagnostics, enhancement of life of structures and their components, preventive protection and pres-



Roentgen tomograph TORATOM with two adjustable perpendicular axes and two X-ray tube/detector pairs. The device is used for tomography with a resolution down to 1 μm and is protected by European patent No. 14002662.6

ervation as well as long-term sustainable use of both cultural heritage and existing building stock. The Centre operates the following facilities:

- **Climatic and wind tunnel "Vincenc Strouhal"**, which is designed as an enclosed circuit with wind speed regulation and possibility to control a number of weather parameters - cyclic changes in temperature in a range of ±5°C, various intensity of rainfall (both rain and snow) and radiant heat radiation. For this purpose, the tunnel is equipped with two measuring chambers. The aerodynamic section is used for the study of static and dynamic effects of wind using down-scaled models of structures, buildings or landscape or using real-sized structural elements. The climatic section is used for experiments simulating combinations of effects of wind with weather impacts
- **Laboratory of Roentgen and Neutron Radiography**, micro- and nano-

- tomography with high resolution
- **Set of physical, chemical and biological laboratories** for complex material analysis and study of their degradation, durability and options for preventive protection or preservation
- **Laboratory for diagnostics of materials and structures**, equipped with a mobile unit with a number of world-class diagnostic instrumentation for field measurements

Competences

- The laboratories are staffed with top-class experts, who fulfil their tasks from the initial analysis of the problem through a complex solution design and its experimental verification up to a comprehensive interpretation of results for the client. For example, ITAM CET is a partner of the newly built European Research Infrastructure for Heritage Science (E-RIHS)

Examples of selected services

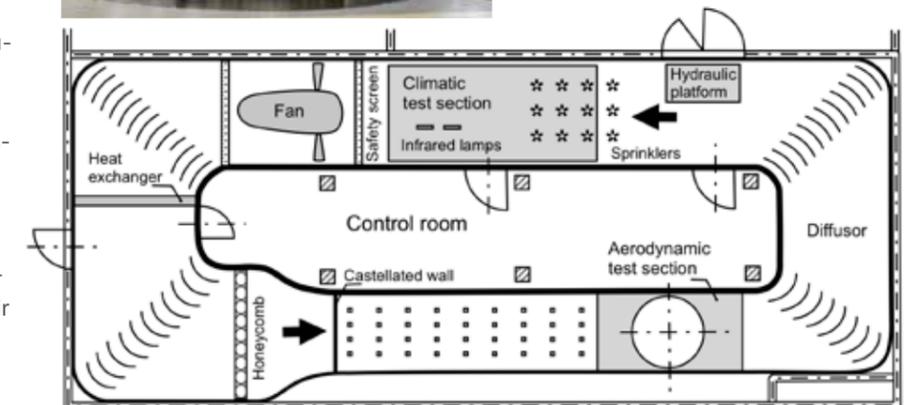
- Measurement and simulation of wind pressure on buildings or sets of buildings with complex shapes
- Measurement of aerodynamic instability of bridges, poles and towers
- Simulation of stratified air flow
- Study of well-being in public premises, sports facilities etc.
- Simulation of water penetration, measurement of efficiency of hydrophobic surface protection
- Study of frost deposit development on bridge cables and their impact on the bridge aerodynamics
- Micro-tomography of complex structures under load (bones, composites)
- Complex measurement of porosity of inorganic composites and their fracture properties
- Complex physical/chemical and biological analyses of historical materials, assessment of their condition and proposals for preservation or preventive protection
- Measurement of nanoindentation characteristics
- Measurement of thermal expansion
- Tests of material degradation under various climatic loads in the climatic wind tunnel Vincenc Strouhal and in climatic chambers
- Field diagnostics of condition of wooden structures including measurement of strength using a patented miniature press
- Diagnostics of condition of buildings affected or damaged by natural disasters and proposals for their preventive protection or recovery measures
- Estimates of impacts of mass tourism or development projects on cultural heritage;

Target groups

- Architects, design and manufacturing companies in civil and mechanical engineering
- Manufacturers of building materials
- Manufacturers of diagnostic instrumentation, software producers
- State institutions and public administration bodies responsible for management and implementation of care for cultural heritage
- Owners and managers of historical buildings
- Institutions responsible for planning of research programmes, creation of strategies, support for research and education in the field of cultural heritage etc.
- Standard-setting and normative bodies, state testing
- Research institutes and universities

Results and references

- Heritage care procedures, certified methodologies, utility designs, reports and expert opinions in the field of protection and preservation of cultural heritage as well as existing building stock. References and examples of cooperation: National Heritage Institute, Museums & Galleries, Academy of Fine Arts in Prague, Metropolitan Chapter of St. Vitus in Prague etc., Aqua, obnova staveb s.r.o., GEMA ART GROUP a.s., Stavební huť Slavonice, s.r.o., IBZ Freiberg, Fraunhofer Institut WKI Braunschweig, FRUP Litomyšl, Institut of Archeology of the CAS, UCT Prague, FCE CTU Prague, Automotive Lightning a.s., HESS TIMBER GmbH, INRECO, s.r.o., ALLCONS Industry, s.r.o., NANO PLM + s.r.o., AZ - Pokorný s.r.o., BAUSYSTEM Kft., Bilfinger Babcock CZ s.r.o., EXCON a.s., GEFOS a.s., Noliac Ceramics s.r.o., SDS EXMOST spol. s r.o., WPC - WOOD-PLASTIC, a.s., IBZ - Salzchemie GmbH & Co.KG, Sobriety, s.r.o., VCES a.s., WISTERIA s.r.o.



View of the Climatic Wind Tunnel laboratory and its layout
 Visualizations and flow processes are regulated from the control room

Central Laboratory for Experimental Mechanics

Institute of Theoretical and Applied Mechanics of the CAS



Contact

ITAM of the CAS

Prosecká 809/76

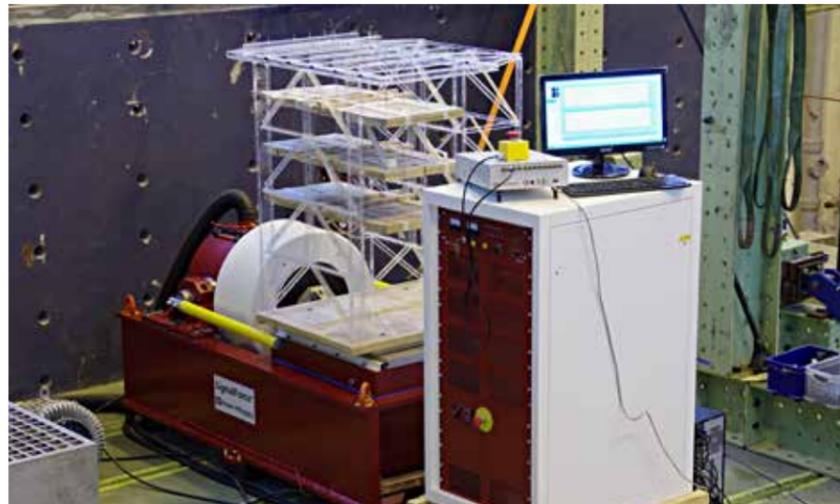
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Vibration bench with a model of industrial boiler steel structure - study of dynamic properties

Competences

CLEM disposes of unique instrumentation infrastructure, which - thanks to the modular system of hydraulic actuators - allows implementation of multi-axial structural tests; moreover, the lab owns several loading frames with a capacity of 500 kN for various material tests. CLEM is equipped with two vibration tables for simulation of seismic loads and support walls for dynamic and fatigue tests. Furthermore, CLEM's employees work on the development of instruments applicable both in laboratory and on in-situ structures (examples include a portable driver unit for fast load testing of bridge structures).

With its application laboratories, ITAM offers a wide research potential. Highly qualified scientific staff is a matter of course.

Examples of services offered

Central Laboratory for Experimental Mechanics

- Loading tests of structures and their parts, determination of dynamic characteristics and vibration amplitudes of structures, measurement of both static and dynamic strain, design of dissipative devices
- Dynamic safety assessment
- Measurement of micro-vibration and technical seismicity in endangered areas and determination of human exposure to undesirable mechanical vibration
- Organization and implementation of dynamic loading tests for bridges, footbridges and structures
- Specialized calculations and numerical solutions

Laboratory of Optical Methods

- Development of unique measuring and loading instrumentation for digitalisation of surfaces, e.g.

assessment of their 3D shape, colouring and roughness

The Fracture Mechanics and Fatigue Laboratory

- Safety, integrity and operational reliability of pipe systems and other thin-walled systems (determination of fracture toughness and other mechanical parameters of materials, assessment of fatigue behaviour, determination of critical defect size, determination of impact toughness, assessment of safety and residual life of defective pipeline system, assessment of impacts of defects in welds, corrosion fatigue, etc.)
- Material fatigue (due to mechanical loading, chemical action and combinations of impacts, etc.)
- Fracture mechanics
- Material research (creep properties, hydrogen embrittlement, corrosion fatigue etc.)
- Safety research

Laboratory for Analysis of Particulate Media

- Extensive material analyses, e.g. moisture and water soluble salts content in masonry, composition and description of material microstructure (chemical and phase composition, granularity, porosity), sorption properties of construction materials, diagnostics and monitoring of wooden structures, study of effects of preservative materials and technologies

Expert activities:

- Economics: Real estate valuation
- Power industry: Transformation, fracture and reliability of power

industry structures (steel piping, reservoirs, poles etc.)

- Civil engineering: Structural analysis, dynamics, defects and faults, renovations, tests and accidents in residential, public, industrial and utility facilities
- Healthcare: Biomechanics of hard tissues (bones and joints) and their replacements

Target groups

- Universities, research institutions
- Companies in commercial sector
- Public administration bodies
- Clerical organizations
- Project partners in national and European projects among universities, research institutions and companies

Results, references and examples of cooperation

- Resolution of nonlinear system vibration and development of calculation methods for EXCON, tests of new material for heritage preservation for NANO PLM +, tests and diagnostic measurements for study of historical structures (e.g.

diagnostics of Marian Column in Letohrad, of wooden structures of the Wallachian Open Air Museum in Rožnov pod Radhoštěm, of historical buildings in Prague, Telč, Hradec Králové, study of dynamic characteristics of structures, long-term measurement of static and dynamic displacements on transmission poles, dynamic test of the new Troja Bridge, aerodynamic loading assessment of Leeds (GB) power plant). Within the work on research projects, the Institute obtained many national as well as European patents; examples include equipment for field tests of strength and deformability of in-built wooden elements.

Other examples of cooperation:

Pražská plynárenská, a.s., Škoda Auto, a.s., Transgas, a.s., Metrostav a.s., Institute of Physics of the CAS, National Heritage Institute, Ministry of Industry and Trade, Ministry of Transport, České radiokomunikace, a.s., EXCON a.s., Tension analysis of roof bearing rods (e.g. Sazka aréna, Strážkov underground station)



Basic dynamic load test is usually carried out prior to commissioning the bridge. It aims at the determination of the initial dynamic stiffness of the structure and vibration amplitude upon passage of testing vehicles. The picture shows an example of measurement on the Troja Bridge

Laboratory of X-ray computer tomography

Institute of Geonics of the CAS



Contact

Institute of Geonics of the CAS

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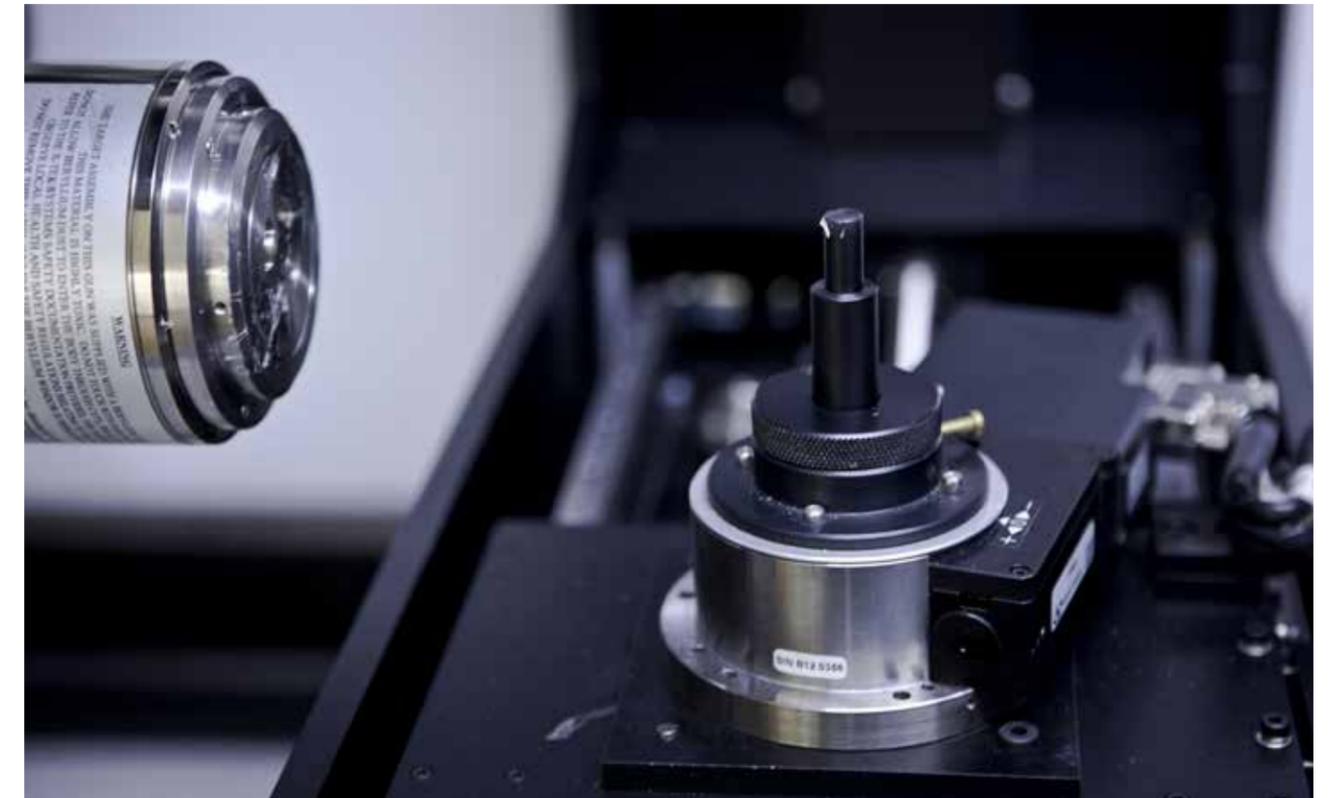
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The XT H 225 ST X-ray CT system



The XT H 225 ST X-ray CT system, transmission X-ray source with a rotary stage for samples under analysis

Competences

The Laboratory of X-ray computer tomography was established in 2012 within the framework of the Institute of Clean Technologies for Extraction and Use of Energy Resources, based on an agreement among VŠB TU Ostrava, Faculty of Mining and Geology and a partner Institute of Geonics of the Academy of Sciences of the Czech Republic. The importance of the workplace lies above all in the possibility of non-destructive way of analysis and study of internal construction and time-space changes in different types of geomaterials in relation to the influence of external factors. The workplace is equipped with the two X-ray micro-focal industrial

computed tomography systems XT H 450 2D/3D and XT H 225 ST, reconstruction software by NIKON Metrology NV and visualization software VGStudio Max.

Basic technical specification of the laboratory equipment

- Tomograph XT H 450 2D/3D is a system with max. operating voltage and power output of X-ray source: 450kV/450W, X-ray focal size at 200W/600W: 80µm/300µm, max. weight, average and height of the scanned samples: 100 kg/ca. 0,6 m/ca. 0,8 m, max. X-raying thickness of the analysed samples: 395kg/m², max.

- X-raying thickness of the analysed samples: 395kg/m², X-ray detectors (16 bit contrast resolution): flat panel (400x400mm, 200µm per pixel, 4 mil. pixels), line detector (400 µm per pixel, 2 000 pixels)
- Tomograph XT H 225 ST is a system with max. operating voltage and power output of X-ray source: (reflex. Mode): 225kV/225W, max. operating voltage and power output of X-ray source (transmission mode): 180kV/20W, X-ray focal size (reflex. mode/transmission mode): <3µm/<1µm, max. weight, average and height of the scanned samples: 50kg/ cc.0,35m, max. X-raying thickness

- of the analysed samples: 237 kg/m², X-ray detectors (16 bit contrast resolution): flat panel (400x400mm, 100 µm per pixel, 16 mil. pixels)

Target groups

Target groups for contract research are industrial enterprises, technology centres and national or international research institutions. Another target group can be, for example, project partners from both the university and industrial and application environments, institutions active in the field of geomaterial research in relation to their internal structures.

Our services

The laboratory can provide the following expert analyses:

- Research and analysis in the field of surface and spatial density of the inhomogenities, non-destructive research of structure and content of rocks, geomaterials, composites, building and construction materials
- Visualization of the interior structure of materials
- Study of other types of materials (steel, alloys, biological materials, etc.) Control of equipment, machines and their components
- Research on the character of the

- failure, defects and the formation and propagation of cracks in the studied materials
- Using the tomographic data analysis software, we offer the possibility of co-ordinate measurement of the geometric shapes of the analysed objects
- Investigation of the pore space of rocks, the character of penetration of fluids into the porous, disrupted environment
- Radiography - taking x-ray images

Water Jet Workplace

Institute of Geonics of the CAS
Institute of Clean Technologies for Mining and Utilization of Raw Materials
for Energy Use



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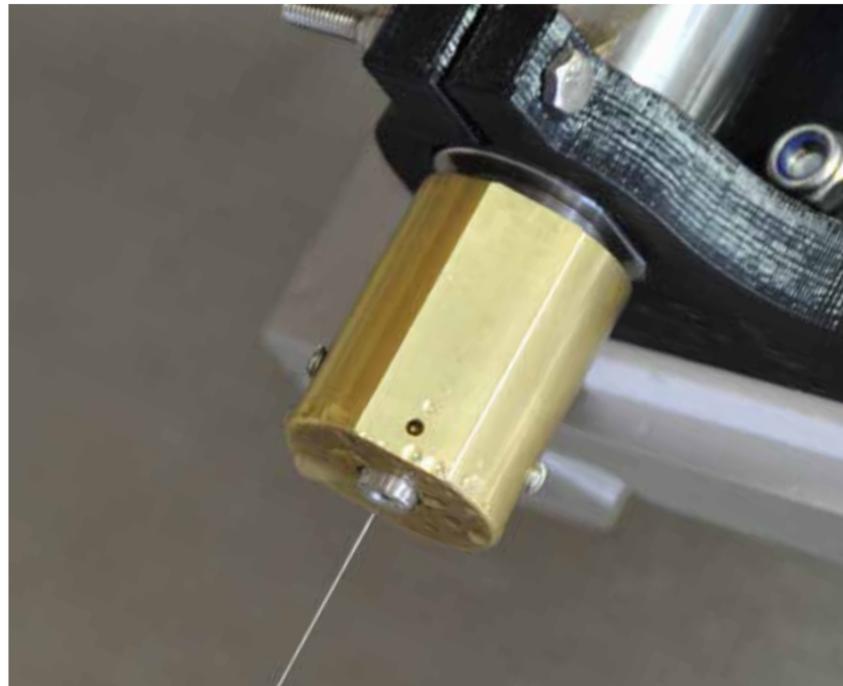
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Prototype of a water jet cutting head for medical applications

Specialisation

The Water Jet Workplace at the Institute of Geonics of the CAS has been systematically built since 1985. The important impulse for its development was a project of the Operational Programme Research and Development for Innovations – Institute of Clean Technologies of Mining and Utilization of Energy Raw Materials dealt with in cooperation with the VŠB- Technical University of Ostrava, within the framework of which the equipment of the Workplace was supplemented by new pumps, water jet manipulators and measuring instruments. Research activities of the Workplace concentrate on intensifying the effects of high-speed water jets, on the interaction of water and abrasive jets with

materials and on the development of new areas of utilisation of high-speed water jets in machining, in medical applications and for ultrafine grinding and disintegration of materials.

Competences

The Workplace offers precision cutting by a water and abrasive jet, testing of surface treatments, removal of surface layers, cleaning by pulsating water jets, disintegration of particles by water jets, visualisation, measurement and evaluation of flow, numerical modelling of flow and stress calculations, analysis of the size of particles, measurement of surface characteristics, pressure tests and expert consultations with top experts including the preparation of projects

and proposals for their implementation. To this end, the Workplace is equipped with high-pressure plunger pumps Hammelmann HDP 253 (maximum working pressure 160 MPa, maximum flow rate 67 l/min) and Hammelmann HDP 254 (maximum working pressure 260 MPa, maximum flow rate 40 l/min), PTV75-60 high-pressure pump with two pressure multipliers (working pressure from 40 MPa to 415 MPa, maximum flow rate 7.8 l/min at 415 MPa), AMU-2500 Abrasive Suspension Jet unit, ABB IRB 6640-180/2.55 Master robot for manipulating the cutting head of a water jet, X-Y PTV WJ202-2Z 1xPJ – 2D cutting table with a tilting cutting head, specially designed for water-jet cutting, a system for the visualisation and measurement of flow velocity-

-fields (2x PIV Imager Pro X 2M CCD camera with accessories, NL 135-15 PIV two-pulse laser with accessories and optics for the creation of a light section, high-speed cameras High-SpeedStar 3G CMOS and Phantom v2011 with accessories, control computer with DaVis software), a notebook-based measuring system with a DAQ National Instruments (16-bit) measuring card and LabView Full Development System software, FRT Micro Prof optical profile meter, Keyence VHX 5000 mobile digital microscope with accessories, Fritsch Analysette 22 NanoTec particle size laser analyser and a computing system for flow modelling equipped with CFD ANSYS software.

Target groups

The Workplace offers cooperation both on the basis of joint projects and contract research to domestic and foreign academic and research institutions as well as industrial enterprises and firms engaged in the research, development and utilisation of high-speed water jet technology throughout the spectrum of their applications (cutting, machining, rehabilitation of structures and buildings, cleaning, removal of coatings and deposits, hydrodemolition, mining, abrasive materials, applications in medicine, food industry and other special waterjetting applications, high-pressure technology, safety aspects etc.).

Results

As part of research oriented to intensify the effects of high-speed water jets, an original method of genera-



A kerf created by rotating pulsating high-speed water jet in granite massif (Erlich quarry, locality Žulová)

ting a pulsating fluid jet by means of an acoustic generator, which is patent-protected in the USA, Australia, Czech Republic and by a European patent with validation in 20 states and has been used in the form of an exclusive licence agreement with a renowned German manufacturer of high-pressure equipment – Hammelmann GmbH. The Workplace has also participated, in cooperation with the Military Technical Institute of Armament and Ammunition (MTIAA) Slavičín, in the development of technology of disposal of the solid propellant of SS-23 missiles. Based on the results of laboratory and field tests, a technological procedure has been developed for cutting the charge and creating a fine ground mixture of the charge in water by means of high-speed water jets. The procedure was then applied by the MTIAA when disposing of all the SS-23 missiles that were in the arsenal of the Czech army.

Furthermore, for example, a draft was drawn up of technology of waste-free disposal of explosive charges placed in boreholes for seismic research within the built-up area of the municipality of Halenkovice, based on the use of high-speed water jets for the safe uncovering and subsequent removal or destruction of these explosive charges.

In cooperation with the German partner ANT AG, the Workplace is involved in the development and testing of the unit for generating an Abrasive Suspension Jet.

Years of experience in the field of flow modelling are utilized in the development of a new abrasive cutting head working on a completely different principle in cooperation with the PTV Ltd. in Hostivice, the Czech manufacturer of high-pressure equipment. Techniques for other technological operations performed by water jet technology (such as turning, milling) and for modification of surface properties of materials (peening) were developed and improved.

Laboratory of mechanical and transport processes in rocks

Institute of Geonics of the CAS



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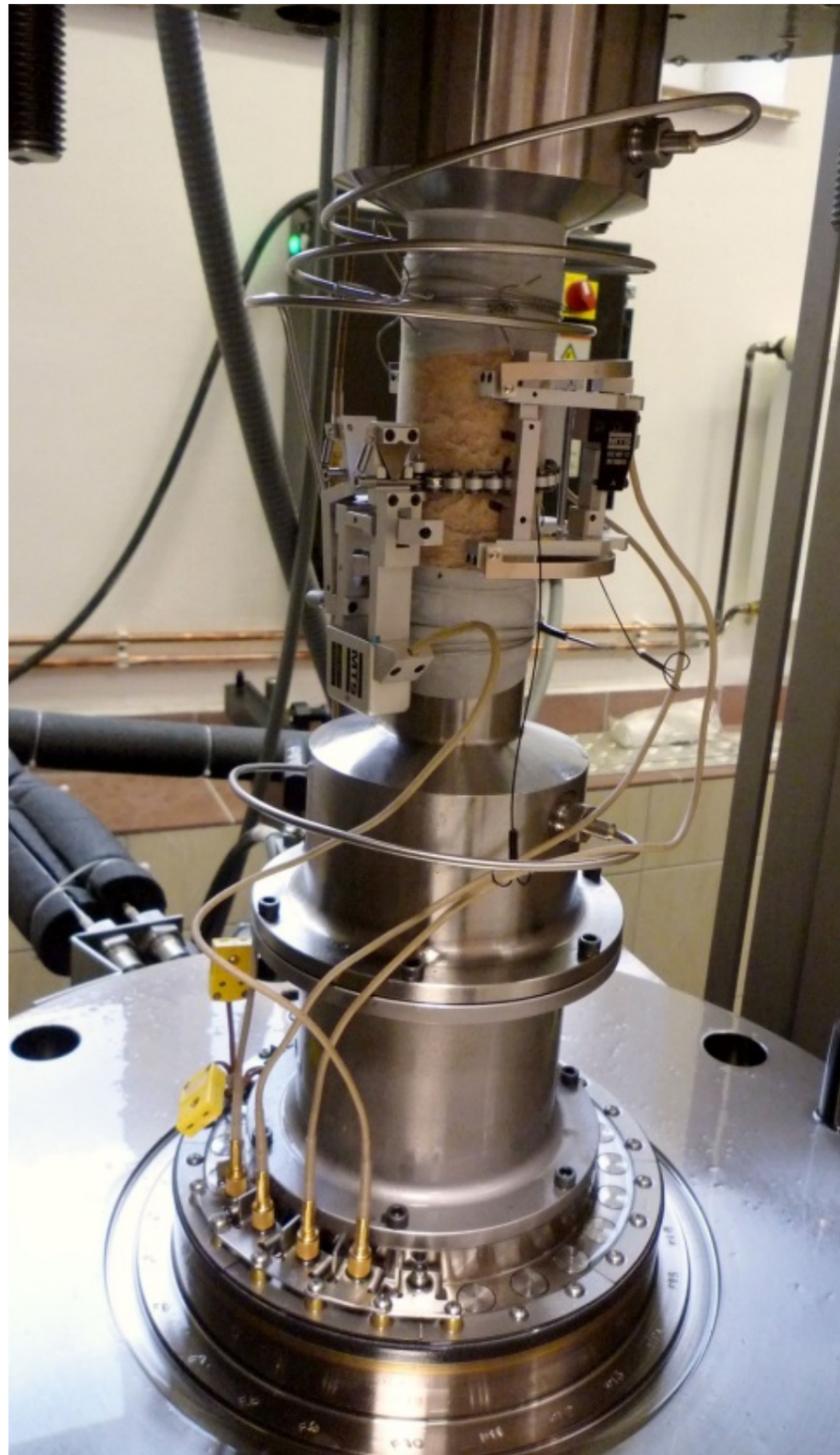
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Competences

The laboratory has long been dealing with mechanical behaviour of rocks and other geomaterials under various physical conditions and with physical interactions of rock materials with fluids. The laboratory conducts a comprehensive research and testing on physico-mechanical properties of rocks, specific geomaterials (e.g. rocks and soils modified by polymer grouts, alkali-activated materials, or others), and selected building materials. Furthermore, changes in the permeability of rocks in the deformation process, as well as rock fracturing processes and the character of crack propagation are studied.



Setup for triaxial test of rock sample exposed to pore water pressure

Key devices

- Servo-hydraulic loading system (MTS Systems Corp.) for testing strength and deformational properties of rocks, equipped with a hydraulic actuator of axial loading (max force 2,6 MN, frame stiffness 10,5 GN/m)
- High-pressure triaxial cell furnished with intensifiers of in-chamber and pore pressures (max pressures 140 MPa), with cascade control of temperature during the loading (up to 200 °C) and with accessories for measuring permeability of rocks to water and other inert liquids
- ZWICK 1494 mechanical press (max force 600 kN)
- KTK 100 Karman's triaxial cell with possibility of permeability measurements in deformation process (confining pressure up to 50 MPa)
- FP 10 mechanical press for testing tensile strength of rocks
- FPZ 100 mechanical press for testing uniaxial compression strength, splitting tensile strength, flexural and shear strength, and fracture toughness (CB test) of rocks
- Micro Hardness Tester (CSM Instruments) with measurements of micro-indentation Young modulus

Our services

- Determination of strength and deformation parameters of rocks and other geomaterials under uniaxial and triaxial states of stress
- Uniaxial compression or tension tests, Brazilian test (indirect tension), bending and shear tests
- Triaxial tests: standard triaxial testing (including determination of



Multipurpose servo-hydraulic loading system with triaxial cell

- failure envelope), special multiaxial tests (specific conditions and evolution of loading including axial extension tests), creep and relaxation tests, cyclic loading tests (separation of plastic and elastic strains), analysis of limit states (strain driven tests)
- Analysis of stress-strain characteristics, determination of standard mechanical moduli (Young modulus, Poisson ratio, bulk modulus, compressibility etc.) or special parameters for particular constitutive models
- Determination of fracture toughness of rocks
- Measurements of microhardness and micro-indentation Young's modulus
- Measurements of gas permeability of rocks under triaxial state of stress
- Assessment of physical interactions between rocks and water (dynamics of water absorption and evaporation)

- Preparation of geomaterial test specimens by drilling and cutting
- Professional consultation and expertise

Target groups

Target groups for cooperation are industrial as well as academic institutions focusing on the use of rock mass, either as a source of mineral raw materials and energies (mining, oil and gas extraction, geothermal energy) or as an environment for building underground structures (tunnels, fuel and energy storage systems, repositories of industrial and radioactive waste, etc.). We also offer cooperation to partners from the field of geotechnics, to producers of building stone and aggregates, to companies engaged in processing of geomaterials, building materials development and application, or to monument care institutions.

Laboratory of identification and characterization of geomaterials

Institute of Geonics of the CAS



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Competences

The laboratory has long been engaged in a comprehensive material research on rocks and minerals, energy raw materials, modified geomaterials and selected building materials. The basic research area is characterization of geomaterials in terms of their structure, mineralogical composition and chemico-physical properties using spectroscopic and microscopic methods (infrared and Raman spectroscopy; optical, confocal and infrared microscopy), and methods of thermal analysis and physical sorption of gases. Clay minerals and their use in the preparation of advanced composites and nanocomposites with specific properties represent another important field of research.



SETSYS TG-DTA/DSC 24 thermal analyser with mass spectrometer (Setaram Instrumentation)

Key devices

Instruments for infrared and Raman spectroscopy

- NICOLET 6700 FT-IR spectrometer with NICOLET NXR FT-Raman module (Thermo Fisher Scientific)

- NICOLET iN10 FT-IR microscope (Thermo Fisher Scientific)

Instruments and software for microscopy and image analysis

- NIKON Eclipse 80i optical polarization and fluorescence microscope

with MÄRZHÄUSER Scan-24-410 motorized scanning stage

- NIKON Eclipse LVDIA-N optical polarization microscope
- OLYMPUS BX 50 optical polarization and fluorescence microscope
- OLYMPUS LEXT OLS 3100 laser confocal microscope
- NIKON SMZ25 and NIKON SMZ2T stereomicroscopes
- Image processing and analysis systems: NIS Elements (Nikon), LUCIA Vitrinite, LUCIA Concrete (Laboratory Imaging, Ltd.) and Matlab Image Processing Toolbox

Instruments for thermal analysis

- SETSYS TG-DTA/DSC 24 thermal analyser with mass spectrometer (Setaram Instrumentation)
- SETSYS 12 thermal analyser (Setaram Instrumentation)
- Izomet 2104 – device for measuring thermal conductivity and specific heat capacity of geomaterials

Instrument for measuring specific surface area and pore size distribution in geomaterials by gas physisorption methods

- ASAP 2026 surface area and porosity analyser (Micromeritics)

Equipment for preparation of analytical samples

- FRITCH „Pulverisette 5“ laboratory planet mill - agate, ZrO₂
- FRITCH „Pulverisette 1“ jaw crusher + „Pulverisette 13“ disc mill
- DISCOPLAN-TS device for automatic cutting and grinding of mineralogical samples (Struers)
- BUEHLER SimpliMet XPS1 mounting press for preparation of microscopic polished sections



Microscopic preparation (rock thin section) in transmitted light of NIKON Eclipse 80i optical microscope

Our services

- Analysis of composition, structure, thermal stability, corrosion states and physico-chemical changes in geomaterials and building materials (optical and IR microscopy, image processing and analysis, IR and Raman spectroscopy, TG-DTA/DSC thermal analysis)
- Technical mineralogy and petrography
- Coal petrography (maceral analysis, vitrinite reflectance)
- Measurement of thermal properties of geomaterials (specific heat capacity and thermal conductivity, TMA)
- Measurement of specific surface area and pore size distribution in materials by gas physisorption methods
- Analysis of tendency of metallurgical by-products towards volume changes
- Analysis of condition and probable origin of historical building materials

- Professional consultation and expertise

Target groups

Target groups for cooperation are industrial as well as academic institutions, whose activities are related to the use of Earth's crust, especially in the field of engineering geology, geotechnics, and building materials. We also offer cooperation to partners from the field of extraction and processing of raw materials, metallurgy and materials engineering, underground engineering, civil engineering, highway and railway construction, or to monument care institutions.

Road weather forecast

Institute of Atmospheric Physics of the CAS



Contact

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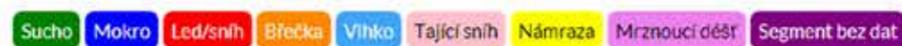
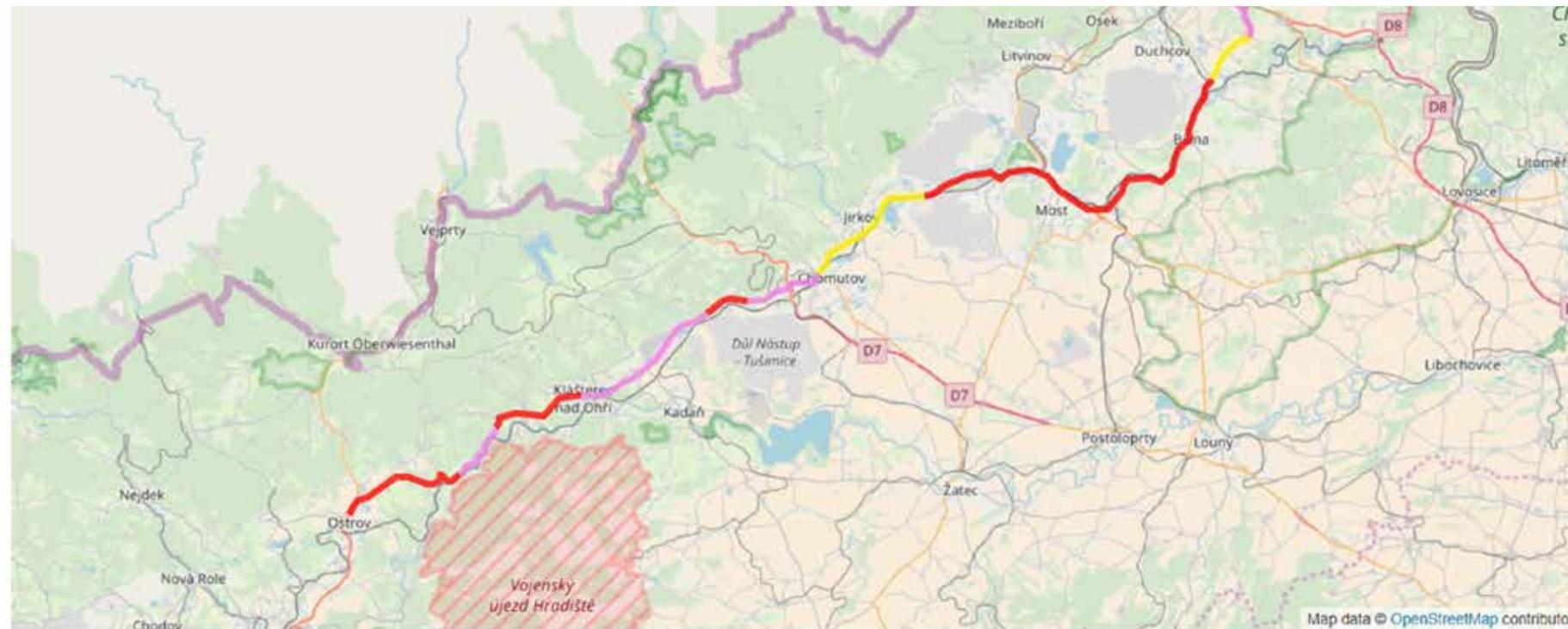
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Road weather hazards can be mitigated only by a timely forecast of the weather phenomena that affect the road traffic. A timely forecast enables the road maintenance (deployment of machinery, application of anti-icing agents, etc.) being efficient, which reduces or even eliminates negative weather impacts. Efficient road maintenance not only increases the traffic safety and smoothness but also has a significant economic and environmental effect due to minimized consumption of anti-icing agents.

Competences

Department of Meteorology at the Institute of Atmospheric Physics (IAP) deals with the atmospheric research



Example of the line forecast for 17 December 2017, 21:40 CET. The forecast was issued at 20:00 CET

focused on methods of weather forecast. Currently one of the main streams of our applied research is road meteorology, namely the development of forecasting methods of the road surface temperature and condition. In this activity, we have a key collaboration with the Czech Hydrometeorological Institute (CHMI) as well as with the users of our research outcome, presently with the Road and Motorway Directorate of the Czech Republic, Technical Administration of Roadways of the Capital City Prague, and the company ChanGroup.

We have developed a forecasting system, which is based on the phy-

sico-mathematical model of the heat conduction in the road and of the energy balance on its surface (FORTE). The model, owned by IAP, uses the road weather station data and the forecast output of the numerical weather prediction model ALADIN, operated by CHMI. The result of this successful project (TA01031509 „Road condition forecasting system for the Czech Republic“, Technology Agency of the Czech Republic) is a prognostic line, which is in operation in CHMI. We continue improving the FORTE model. In the project ICEWARN, supported by the Operational Programme Prague – Growth Pole of the Czech Republic, we focus on the me-

thod of a continuous line forecast for the road network in Prague. Our plan is an application of the ensemble method that we have developed for the road weather forecast. In contrast to the existing deterministic forecasts, the ensemble method enables uncertainty estimation and a probability forecast. We plan to make the forecasts more accurate for the lead time 0-3 hours by using the radar data on precipitation as well as the satellite data.

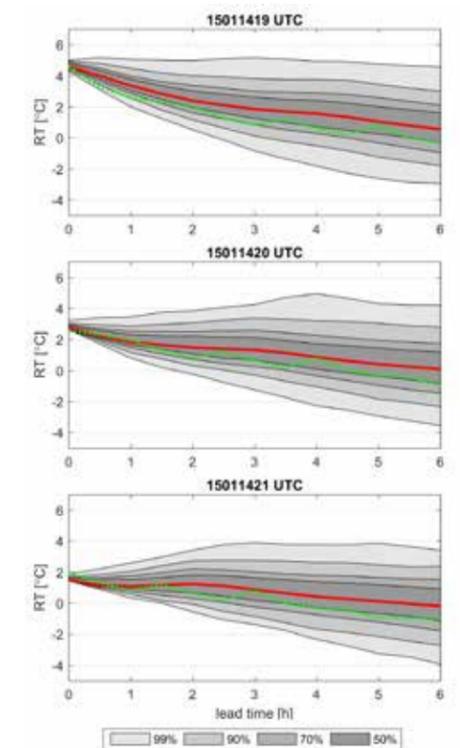
Target groups

- Technical administration of roadways
- Transport companies
- Public administration bodies

Recent results

- Forecasting system METRo-CZ, which is based on the forecast model for the road surface temperature and condition developed in collaboration with CHMI, is in operation since the end of 2014. It provides forecasts for the points where the road weather stations are located on the highways and on the 1st and 2nd class roads in the Czech Republic (except for the capital city of Prague)
- Continuous line forecast of the surface temperature and condition for part of the road I/13 and for the road I/8 between Teplice and the mountain border crossing Cínovec is a result of our joint pilot project

with CHMI and the company ChanGroup, aimed at modification of METRo-CZ for a continuous forecast. The on-line forecast is open to the public at www.changroup.cz/forte



Ensemble forecast of road surface temperature for the position of road weather station Damičice in dependence on the lead time in hours. The red and green curves show the deterministic forecast and observed data, respectively. The grey areas denote the ranges for 99%, 90%, 70% and 50% probabilities that the road surface temperature will be within the range denoted. The forecast start times are indicated in the graph titles in a year, month, day and hour (2 digits) format



NanoEnviCz represents the unique research infrastructure which interconnects the top scientific research teams in the area of environmental and material sciences. The primary objective of this infrastructure is to provide the services and expertise including development and synthesis of new nanomaterials, their complex chemical and structural characterization, tuning their functional properties for new applications with respect to reduction of potential negative risks on environment. Multi-disciplinary research groups include scientists from the field of physics and solid state chemistry, material and environmental engineering and biological and medical science originating from three institutes of the Czech Academy of Sciences – J. Heyrovsky Institute of Physical Chemistry, Institute of Inorganic Chemistry, and Institute of Experimental Medicine and three universities – Palacky University in Olomouc, Technical University in Liberec and



J. E. Purkyne University in Ústí nad Labem. This provides highly qualified base for top specialized services, which are offered to other research and industrial subjects in the Czech Republic as well as abroad.

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a) J. Heyrovsky Institute of Physical Chemistry of the CAS

Competences

The research of HIPC in the frame of RI NanoEnviCz is focused on i) design and synthesis of new multifunctional nanomaterials for environmental protection, ii) heterogeneous catalysis for environment protection and iii) effective photocatalytic technologies. Research in the field of new nanomaterial synthesis covers preparation of nanomaterials of varying dimensionality and nature, including nanopowders, colloids, nanocomposites, nanofibers, thin films, etc. in an amount range up to hundred grams, varying modification of their

structure and surface. Moreover, it offers complex chemical and structural characterization of nanostructured materials, determination of their activity, thermal stability and magnetic, electronic, electrochemical and transport properties. It also includes computational modelling of structural properties of nanomaterials and their reactivity with the aim to use this knowledge for optimization of new material synthesis parameters. The development of new heterogeneous catalysts is carried out with respect to the use of these nanoparticles for degradation of pollutants in water, soil and air or for abatement of pollutants from industrial processes and automotive transport. New nanostructured materials with photocatalytic activity are developed in different forms (powder or thin layers) as a possible material for photocatalytic degradation of pollutants in environ-

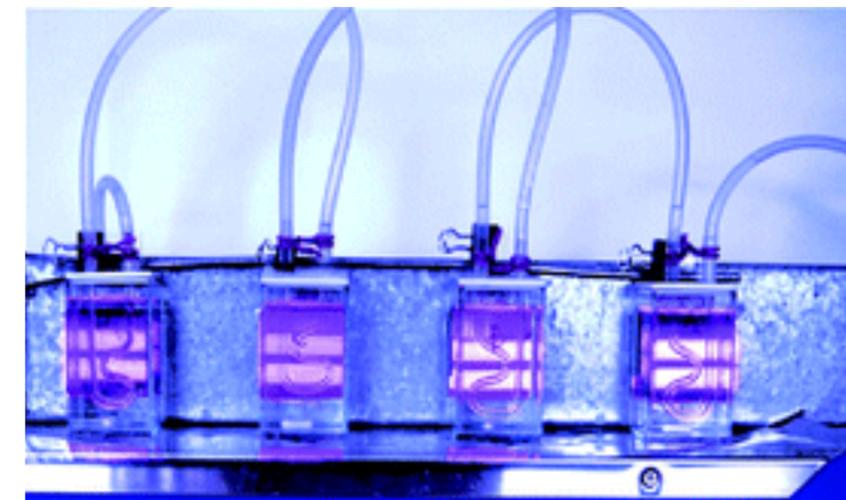
ment. These photocatalysts can be used for direct water splitting and as photoelectrodes for solar cells including functional barrier coatings for both dye-sensitized and perovskite solar cells.

Services

- Equipment and technology for preparation of different types of nanomaterials with high purity, in adequate amount and in various composition and with defined properties
- Preparation of very thin layers of nanomaterials by lithography methods in clean room
- Complex chemical and structural characterization of nanomaterials using state-of-the-art techniques (spectroscopy and microscopy with high resolution)
- Testing of functional properties of



Reactor for liquid phase nanomaterial synthesis and testing catalysts and kinetic measurements



Set of reactors for photocatalytic purification of water

nanostructured materials in the area of sensors, photoelectrochemistry, heterogeneous catalysis and environmental photocatalysis

Final users

- Universities and research institutions focused on material and environmental research
- Organizations interested in environmental protection
- Industrial companies using processes on the basis of catalysis
- Automotive industrial companies dealing with exhausted fumes control
- Energetic industry focused on renewable sources of energy

Results and collaboration

- Degradation and removal methods of antibiotics from aqueous matrices, University of Chemistry and Technology, Prague
- Optical fiber sensors with Bragg gratings and graphene layers, Czech

- Technical University in Prague
- Microfabrication of single crystalline samples for resistivity and ac susceptibility measurement, Charles University, Prague
- Synthesis of hierarchical zeolites for advanced hydroisomerization catalysts, University of Pardubice
- Effect of the simulated accelerated weathering on performance of the functional coatings, Advanced Materials-JTJ, s.r.o
- Characterization of hydrophobic magnetic nanoparticles for incorporation into spin hybrid systems, Institute of Physics of the Czech Academy of Sciences, v. v. i.
- Consolidants of porous materials with enhanced penetration ability or multifunctional properties, Universidad de Cadiz, Spain
- Photocatalytic activity of porous multiwalled carbon nanotube-TiO₂ composite layers for pollutant degradation, Chim ParisTech, France



b) Institute of Inorganic Chemistry of the CAS



Coordinator IIC

Ing. Petra Ecorchard, Ph.D.

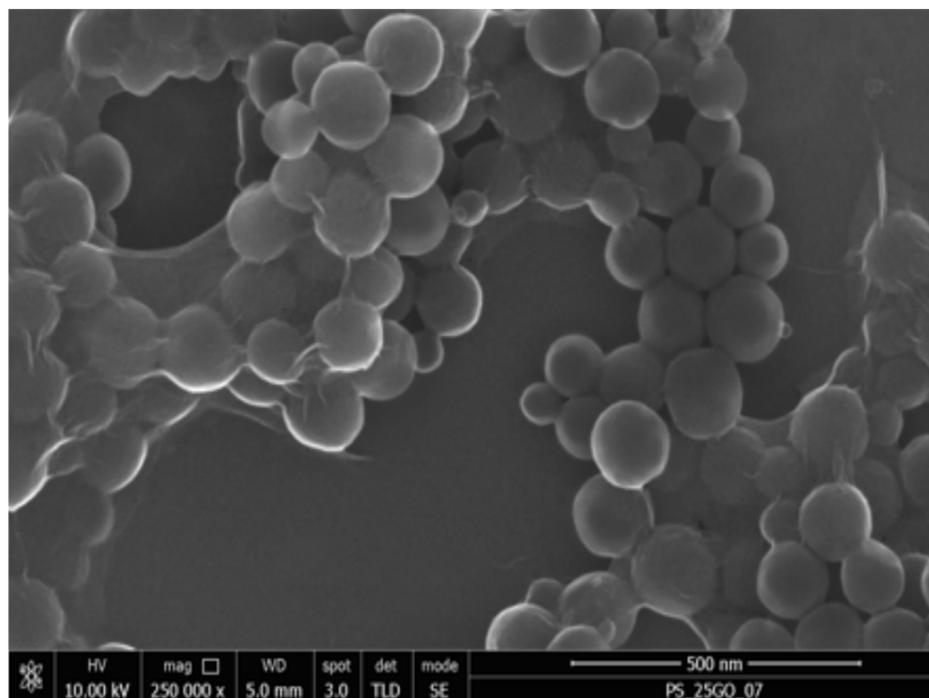
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Competences

The new efficient technological processes based on nanotechnologies are developed for the capture and degradation of pollutants from air, water and soil. The development of new nanotechnologies is also related to the preparation and study of new sorbents, filtering media and (photo) catalysts based on the nanofibers, metal oxides, nanocomposite materials used to reduce or completely degrade pollutants. New types of sensors using nanoparticles are developed to improve the specificity of pollutant detection. The attention is paid to the preparation of naturally based nanomaterials in which synthesis is optimized to be environmentally friendly. Thanks to the work on these materials, the researchers have gained experience not only with material preparation, but also with the methods of their characterization or testing. As a result, we can offer ex-



Sorbent of radionuclides based on the polymer matrix containing graphene oxide as an active component

perience within the NanoEnviCz infrastructure together with our equipment, which is needed to monitor the degradation processes or to characterize nanomaterials. The applicants interested will receive rapid and flexible response to their research. The applicants, who do not have the proper equipment or experience in the field, can contact us and in the case of successful results, a long-term cooperation can be established. More information can be found on the website of the infrastructure, where the Institute of Inorganic Chemistry of the Czech Academy of Sciences is abbreviated by the acronym UACH. The selection of the individual methodologies can be chosen from the complete offering list. It is possible to

combine the instruments and methodologies across all Institutes listed within the NanoEnviCz. We offer a simple and fast way to a targeted result.

Services

Characterization of nanomaterials:

- AFM Bruker Dimension Icon (UACH1)
- HRSEM FEI NanoSEM 450 (UACH4)
- HRTEM JEOL JEM 3010 (UACH10) + preparation of sample (UACH11-13)
- Determination of particle size distribution by a Malvern laser analyzer (UACH3)
- Surface area and Pore Size Analyzer Beckman Coulter SA3100 (BET) (UACH5)
- FTIR spectroscopy + DRIFT Thermo

- Nicolet NEXUS 670 (UACH8)
- DXR Raman microscope Thermo Scientific (UACH9)
- XRD powder diffractometer PAN-alytical XPertPRO (UACH14)
- TA-MS Setaram Setsys Evolution 1750 (UACH15)

Techniques for the preparation of nanomaterials:

- Supercritical Drying Procedure (UACH6)

Techniques for photocatalytic degradation in liquid and gas phases:

- Detection by UV/VIS spectrophotometer CoulorQuest (UACH2)
- GC-MS JEOL JMS – Q1000GC Ultra-Quad (UACH7)

The instruments of the IIC are identified described at website www.nanoenvicz.cz (UACH in brackets).

Targeted groups

National and international research institutions/universities/companies dealing with:

- Sorption nanomaterials
- Reactive sorbents for degradation of pesticides and highly toxic substances
- Microbial filters / membranes
- Nanomaterials to eliminate of radioactive contamination
- Iron-based nanoparticles for the treatment of groundwater, wastewater and capture of heavy metals
- Environmental decontamination
- Active nanoparticle surfaces

Investigate materials and cooperations

- Properties of mixed oxides used as catalysts for oxidation processes,

- Bulgarian Academy of Sciences, Bulgaria (use UACH3,4,5,9)
- TiO₂ with graphene oxide, Uppsala University, Sweden (use UACH1,4,7)
- Measurement of precursors, Faculty of Science, University of Ostrava (use UACH4,5, 15)
- Two-dimensional materials, University of Pardubice (use UACH10)
- Study of racemates and enantiomers of organic compounds, Institute of Organic Chemistry and Biochemistry of the CAS (use UACH1)
- Metal oxides and mixed metal oxides, Institute of Chemical Process Fundamentals of the CAS (use UACH10)
- Sulphur-doped covalent triazine-based organic frameworks, Faculty of Science, Charles University (use UACH2,5)
- Natural sediments, comparative materials for environmental purposes, Faculty of Science, Charles

- University (use UACH14)
- Thin layers of semiconducting material, AFM topology measurement, Institute of Organic Chemistry and Biochemistry of the CAS (use UACH1)
- TiO₂ microscopic measurements, other characteristics, University of Chemistry and Technology Prague (use UACH14,15)
- Measurement of carbides and ferrites, Institute of Inorganic Chemistry of the CAS (use UACH10, 14)
- Extruded alloys, alloy powders, University of Chemistry and Technology Prague (use UACH12)
- TiO₂ preparation and microscopic treatment, Faculty of Natural Sciences, Comenius University in Bratislava (use UACH11)
- Mixed iron oxides, Council of Scientific & Industrial Research, India (use UACH10)
- Photocatalytic degradation, University of Pardubice (use UACH2)



HRSEM FEI NanoSEM 450 (High-Resolution Scanning Electron Microscope)



c) Institute of Experimental Medicine of the CAS (IEM)



Coordinator IEM

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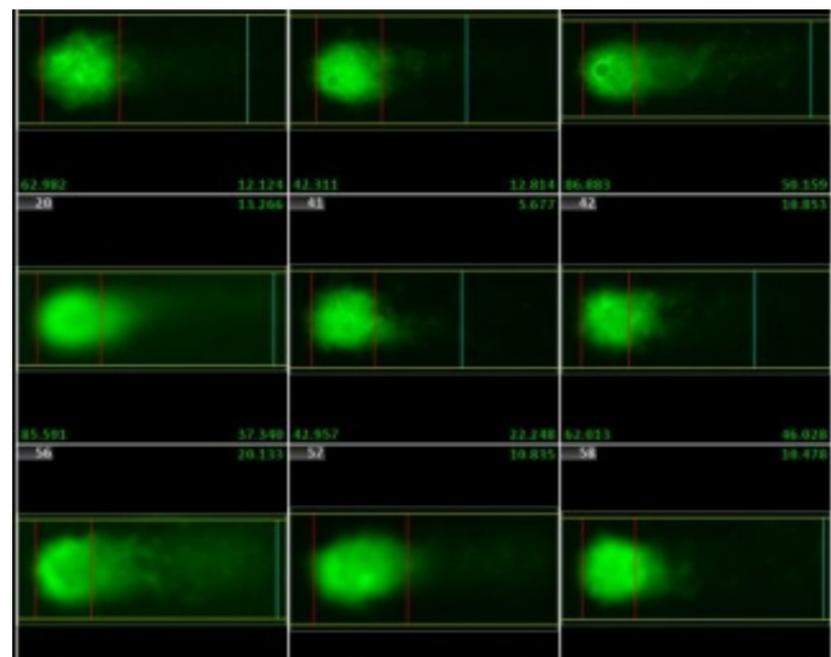
www.iem.cas.cz/cs

Competences

Nowadays, great attention is paid to development and production of nanomaterials used in environmental protection (remediation, removal of combustion products) and in various industrial areas such as power engineering, electrical engineering, pharmacy, biomedicine, etc.). Responsible handling of nanomaterials, toxicity assessment, health and environmental risks should be an integral part of development of new nanomaterials (NM). This applies in particular to nanomaterials that enter the environment, as well as to professional exposure to nanomaterials during their production and application. The timely identification of these risks at the nanomaterial development stage represents the best approach for applying the latest “safe-by-design” nanoscience principle. This approach is based on an objective assessment



Metafer Slide Scanning System version 3.11., MetaSystems GmbH (Comet assay) for analysis of genotoxic potential of nanomaterials



Evaluation of genotoxicity of nanomaterials by Comet Assay method (Single Cell Gel Electrophoresis)



Analysis of genotoxicity of nanomaterials by Comet Assay method (Single Cell Gel Electrophoresis)

- material and fungal toxicity, biocidal effects, ecotoxicity, global assessment of effects on environment and human health.
- ZetaSizer Nano System for physico-chemical characterization of nanoparticles (new instrument)
- Fully equipped laboratory of nanotoxicology for working with cell cultures (new)
- SpectraMax Multimode Plate Reader for analysis of cytotoxicity and oxidative damage of biomolecules induced by nanomaterials (NM)
- Metafer Slide Scanning System for analysis of genotoxic effects of NM (Fig. 1)
- Fluorescence Microscope for cytogenetic analysis after the application of nanomaterials (NM)
- iScan System, MiSeq System – toxicogenomic analyses after exposure to nanomaterials (NM)
- Fast Real-Time PCR System – analysis of gene expression changes of selected genes after exposure to nanomaterials (NM)

of ecotoxicological properties (nanoparticles, the generation of predictive models of environmental impact of nanomaterials, and the use of these models to design environment-friendly nanomaterials. The Institute of Experimental Medicine affords offers an opportunity for training in characterization of physico-chemical properties of nanoparticles and, in particular, their interaction with biological systems in terms of possible adverse effects.

Services

- Complex analysis of the health and environmental risks of different nanomaterials and novel materials in vivo and in vitro by toxicity tests such as cytotoxicity, genotoxicity, cell membrane interactions, bac-

Final users

- Universities and Research Institutions
- Bioengineering Industry
- Chemical and Food Industry
- Pharmaceutical Industry

Results and collaboration

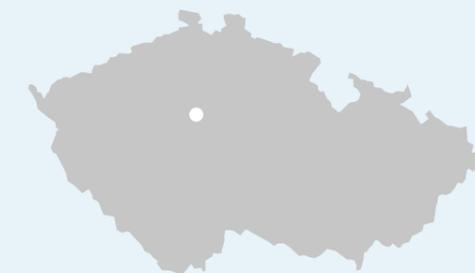
- STAMI (Norway), In vitro transformation of human lung epithelial cells with diesel exhaust particles and tobacco smoke carcinogens
- Technical University of Ostrava, Comparison of potential cytotoxic and genotoxic effects of manufactured nanoparticles in model human cell lines A549 and THP-1
- J. Heyrovsky Institute of Physical Chemistry, Academy of Sciences of the Czech Republic, Cytotoxicity of nanomaterials used for renovation of historical monuments



Human bronchial epithelial cells (BEAS-2B)

Joint Laboratory of Solid State NMR Spectroscopy IMC CAS and JHIPC CAS

Institute of Macromolecular Chemistry of the CAS,
Jaroslav Heyrovský Institute of Physical Chemistry of the CAS,



Contact

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Professional focus

The Joint Laboratory of Solid State NMR Spectroscopy of today has a unique device that is the Bruker Avance III HD 500 WB /US NMR solid state NMR spectrometer equipped with four radio frequency channels and a full range of measuring probes. This allows a detailed structural analysis of practically all materials including inorganic crystalline and amor-

The mission of the Joint Laboratory of Solid State NMR Spectroscopy is to seek and find the patterns and relationships between the dynamics of molecules, the structure of matter, its macroscopic and useful mechanical or physical properties. The members of this laboratory are the Institute of Macromolecular Chemistry of the CAS and Jaroslav Heyrovský Institute of Physical Chemistry of the CAS.



phous substances, minerals, glass, natural and synthetic polymers, gels, soil samples or biological materials. Many of the unique properties of these materials have their origins in the local arrangement of atoms and molecules, which in the case of many systems can be described at atomic level almost exclusively by solid state NMR. It is not just a static distribution of atoms and molecules, which determines the behavior of living and non-living matter. This micro-world is in constant motion, and here NMR spectroscopy enables very accurate description of the amplitudes and

frequencies of these movements. These are the internal motions that determine not only the mechanical properties of a wide range of polymeric substances (toughness, elasticity) but also the bioavailability of the pharmaceutically active compounds.

Competences

Pharmaceutical research: The pharmaceutical industry is forced to look for effective quality control procedures for both feedstocks and finished products. Developing a new generation of medications also requires

a detailed insight into their structure. For these purposes, a combined experimental-computational approach NMR crystallography is developed and applied in our joint laboratory to enable effective monitoring of the production of the pharmacological products, an easy and safe identification of admixtures (polymorphs), and a detailed description of the crystalline structure of the pharmaceutically active compounds even when obtaining the X-ray diffraction data is impossible.

Building Materials and Environmental Issues: In our laboratory we also carry out research on advanced single-component geopolymers and modified cements. We study the re-processing of waste materials and high tonnage dusty waste products, and perform deep analysis of aluminosilicate-based sorbents for heavy metal fixation.

Advanced polymeric materials and nanocomposites: Another focus of our laboratory is study of the formation, structure and properties of organic-inorganic hybrids, as well as determination and regulation of interfacial interaction in polymeric nanocomposites based on thermosets and thermoplastics containing inorganic nanoparticles. The properties of advanced polymer systems, that display a well-defined response to external stimuli, derive from a strictly defined hierarchical architecture in which the structural features on the surface, the phase interface between the "intelligent" polymer system and the surrounding environment, play a dominant role.

Organic Matter, Soil Samples, Fo-

ssils: Solid state NMR spectroscopy offers a unique and surprisingly detailed view of the structure and processes that occur in organic matter, soil material, or fossils. Exploration of the structure of coal, humic acids or various organic residues is one of the traditional directions of structural analysis conducted in the joint laboratory.

Catalytic Systems: The possibilities of solid state NMR spectroscopy and advanced physical analyzes in the development of catalytic systems for industrial applications are very broad and extensive. Thus, the experts in the joint laboratory have a vast knowledge potential that can be utilized in the development of new catalysts for both acid catalyzed and redox processes based on aluminosilicate lattice materials, silicate- and alumina-based support systems, both as a study of carrier/matrix and in terms of the structure and location of active centers.

Target groups

- Industrial companies
- Universities and colleges
- Research organizations
- State control bodies

Examples of collaborative results achieved in applied research

- Research of Alginate Particles for Cell Transplantation - Veterinary and Pharmaceutical University of Brno
- Piperidine derivatives of boronic acid, their unique structure and extensive polymorphism - Teva Pharmaceuticals CR, s.r.o
- Research on the structure of hybrid nanomaterials for transport and

- controlled release of drugs ("liquid-solid" systems) - Ratiopharm GmbH
- Structural characterization of food pigments - Research Institute of Organic Syntheses a.s.
- NMR characterization of resins - Research and Testing Aerospace Institute, a.s.
- Research of styrene-butadiene rubbers - Cray Valley Czech s.r.o.
- Polycarbonate Systems Research - GEA Heat Exchangers a.s.
- Polysaccharide structure research - Contipro Biotech s.r.o.
- Soil and Fossil Residue Research - Institute of Environment, UK, Prague
- Study of the Structure and Mechanism of the Flowering of Historical Wax Seals - Institute of Chemical Technology of Restoration of Monuments, ICT Prague
- Catalysts for the elimination of N₂O and NO_x from process gases in the production of nitric acid, Euro Support Manufacturing Czechia, s.r.o.
- Synthesis of Zeolite SSZ-13, Unipetrol R & D Center, a.s.
- Synthesis of rich zeolite silicon with a controlled aluminum structure in the grid, Unipetrol R & D Center, a.s., Support Manufacturing Czechia, s.r.o.
- Synthesis of zeolite aggregates with unique properties, Unipetrol R & D Center, a.s., Support Manufacturing Czechia, s.r.o.
- Structural characterization of raw materials for the production of catalysts, Support Manufacturing Czechia, s.r.o.
- Development of catalysts for the evaluation of petrochemical products, Support Manufacturing Czechia, s.r.o.

Otto Wichterle Innovation Centre of Polymer Materials and Technologies

Polymer Materials and Technologies

Institute of Macromolecular Chemistry of the CAS



Contact

Polymer Materials and Technologies

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Professional focus

Research and development of new polymer systems with controlled structure and properties.

The key activities include development of polymer materials for applications in technologies and products with a high added value, which requires combination of top-level basic research and targeted research and development. An equally important characteristic is the transfer of new findings from basic research to the application sphere, implementation and assessment of results and intellectual property. An example is the licence production of total replacements for the hip and knee joints by the Beznoska company based on patent No. 297 700 with follow-up im-



Laboratory for the development and processing of polymer materials

plementation of results of the awarded TA CR project TA01011406. In December 2017, Ekoplant launched semi-operating manufacturing of biodegradable scent repellents based on utility models 30634 and PV 2017-166. A process for recycling of polyurethane waste based on patent No. 301,686 is being developed for implementation on an industrial scale. In addition, specialised laboratories offer their free capacity of advanced instrumentation for implementation of contractual research and expert assessments, particularly in the assessment of utility properties of polymer materials and prediction of their lifetime in application environments, including specific environments (e.g., chemically aggressive, living tissue).

Competencies

- Research and development of thermoplastics-based materials (including biodegradable materials and plastics manufactured from renewables) and technologies for their processing as melt; relationships between composition, mechanical, thermal and rheological properties of plastics, their blends and composites
- Analysis of the supramolecular structure of solid polymer systems (morphology, microscopy), development of the phase structure in melt
- Assessment of mechanical properties of polymer materials in different conditions using standardised tests or tests simulating product

- stress. Optimisation of properties by targeted structure control
- Testing of the lifetime of plastics under conditions simulating specific applications, formulation of stabilisation systems and addi-



In addition to standardized tests, the Centre also develops new types of examinations



The Centre is equipped with a technology capable of processing high-abrasion materials and special materials at high temperatures (up to 450 °C)

- tives for targeted lifetime control. Development and optimisation of recycling procedures
- Development of polymer semiconductors and study of their optoelectronic properties
- Research and development of new polymer materials and membranes required for the development of equipment for electricity storage and elimination of environmental burden

Target groups

Basic and targeted research institutions of the Czech Academy of Sciences and universities; research and development departments of companies in the area of development and processing of polymer materials, advanced technologies, organic electronics and photonics; institutions and industrial entities requiring expert knowledge and testing in materials research and description of material properties, recycling and processing of plastics.

Our services

- Consulting on applications of polymer materials
- Technical support to optimisation of processing procedures
- Development of new polymer materials with targeted control of properties
- Development and optimisation of recycling procedures
- Testing of the lifetime of plastics for specific applications
- Formulation of stabilisation systems and additives for targeted plastics lifetime control
- Assessment of morphology, thermal and mechanical properties of polymer materials
- Measurement of electric and photoelectric properties of polymer materials
- Development and description of polymer membranes for gas and vapour separation
- Development and description of ion exchange membranes
- Licensing and know-how
- Professional seminars and training



Contact

Centre of Bio-Medical Polymers

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Viewing cells through a confocal microscope using the FLIM method



Transmission electron microscope for cryoscopic measurements

Professional focus

Development of methodological approaches playing a key role in targeted biomaterial research and helping overcome the barrier between the level of findings achieved by chemical and engineering research and that required for application of biomaterials in biology or medicine.

Competencies

- Description of primary responses of cells to contact with a polymer biomaterial or macromolecular system carrying biologically active substances or structures and application of molecular biology techniques for monitoring the

- mechanisms of such responses
- Specific microscopic techniques such as laser confocal microscopy and low-vacuum electron microscopy, possessing sub-micron resolution required for studying morphological characteristics of polymer gels and supramolecular polymer structures in states that can be expected in biological organisms
- Application of highly sensitive radioisotope techniques for quantification of the active components of polymer systems in biomaterials and focus on preparation and description of radionuclide polymer systems and their application in therapy and diagnostics

Target groups

In addition to our own research and joint projects with basic research institutions of the Czech Academy of Sciences and universities domestically and abroad, we offer qualified collaboration with the industry, development laboratories and clinical institutions.

Our services

- Methodological and analytical support to biopolymer testing using cellular systems
- Testing and evaluation of new polymer materials applicable in medicine or other disciplines
- Implementation and optimisation

of new approaches to studying properties of biopolymers in in-vitro systems

- Statistical processing of biological data
- Radiolabeling of low-molecular-weight and macromolecular substances
- Employment of sensitive and selective radioanalytical methods for polymers
- Collaboration on the development of radiopharmaceuticals and their medicinal forms
- Collaboration on the development of polymer materials for radionuclide techniques for health and the environment
- Study of the morphology (supramolecular structure) of polymer systems





Contact

Polymer Sensors

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Quartz microbes with energy dissipation analysis



Spectroscopic ellipsometer

Professional focus

Research into the behaviour of polymers at interfaces between various types of materials and between the material and the surrounding environment, particularly that of biological systems. Application of findings in the development and preparation of functional interfaces applicable in designing sensors, photocapacitors, composite materials of high utility value, new medicinal forms and biomaterials for tissue engineering. Application of bioactive polymer layers in preparation of biosensors providing fast detection of biomarkers and pathogens in biological fluids (blood, plasma, serum, food, water).

Competencies

- Research and development of new polymerising techniques that lead to controlled architecture of polymer layers
- Physico-chemical analysis of polymers and polymer layers using state-of-the-art equipment (XPS, spectroscopic ellipsometer, NMR imaging)
- Research into interactions between polymer surfaces and complex biological fluids and development of biosensors
- Electrochemical synthesis of semiconductor polymers and study of their properties

Target groups

Basic and targeted research institutions of the Czech Academy of Sciences and universities; research and development departments of companies engaged in the development and preparation of tissue substitutes, separation techniques and biotechnologies, and optical biosensors; institutions and industrial entities requiring expert knowledge and testing in materials research and description of surfaces as well as institutions and companies applying semiconductor polymers.

Our services

- Development of modern controlled polymerisation methods, preparation of functional molecular layers
- Comprehensive surface description using state-of-the-art instrumentation
- Structural analysis of advanced polymer systems
- Study of interactions between tested surfaces and biological environments (blood, plasma, serum)
- Research into interactions between/among biomacromolecules
- Application of polymer layers for development of biosensors
- Electrochemical synthesis of semiconductor polymers
- Synthesis of short peptides and nucleotides



XPS spectrometer

Centre for Biorefining Research (BIORAF)

Institute of Chemical Process Fundamentals of the CAS



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The Competences Centre for Biorefining Research (BIORAF), which was formed with the support of the Technology Agency of the Czech Republic in 2012, falls under green chemistry projects and specialises in the comprehensive utilisation of biomass using environmentally-friendly procedures. The set goal is directed at obtaining feedstuffs, food supplements, fertilisers, biopolymers and biofuels of higher generations from materials of plant and animal origin.

The BIORAF project

- It creates an interdisciplinary centre with a high innovation potential for the sustainable exploitation of renewable resources and aspires to take the leading position in the biorefining area in the Czech Republic in the years to come



Waste-free technology of utilising recycled water for the growth of microalgae

- It utilises biomass of animal and plant origin including algae
- It interconnects the private sector with experts from various scientific branches (e.g. biology, analytical chemistry, enzymology, chemical, biochemical and material engineering etc)
- The principle of the BIORAF project is the interconnection of enterprises producing various biologically usable waste substances so that waste from one production specific to a given producer can be used as a valuable raw material for another production process

Competences

The specialisation of the Centre follows from the interconnection of experts in various scientific areas – plant biosciences, algology, ana-

lytical chemistry, enzymology, microbiology, chemical and biochemical engineering, material engineering (biocomposites) and experts in assessing the life cycle with the private sector. All the teams composed of renowned scientists have top equipment in the above branches including the possibility to verify the technology on a magnified scale as well as analyses in accredited laboratories. The BIORAF Competences Centre is able to investigate topics concerning e.g.:

- Ensuring sustainable sources of biomass that does not compete with the use of agricultural land in the food industry
- Development of new, advanced environmentally-clean processes for biorefining biomass to obtain products of high market value, increasing market possibilities and creating new job opportunities



Chlorella vulgaris with omega-3 fatty acids for feeding purposes

- Verification of new, promising technologies on demonstration and pilot units in order to commercialise the products developed
- Design and verification of new technological procedures for utilising biomass of animal and plant origin, including algae

Target groups

The target group includes entities from both the commercial and research sphere interested in issues concerning the following topics:

- Finding and identification of new, highly efficient and selective microbial strains with significant hydrolytic activity against plant and animal proteins including keratins, against animal tissues and fats, lignocellulosic materials, polysaccharides, starch and cell walls

- Research in the area of identification and isolation of new hydrolytic enzymes against plant and animal tissues
- Research into new types of accelerators of the growth of plants and microalgae and research into and identification of new types of microalgae with a high content of biologically active substances
- Research into new separation methods with high selectivity, in particular membrane ones for the separation of bioactive substances from microwave-based liquid media for the accelerated separation of bioactive substances from solid, very resistant matrixes and into extraction techniques for the separation of bioactive substances
- Research into new types of bioreactors for the cultivation of

- microorganisms
- Research into new, highly sensitive and selective methods for the identification and quantitative determination of biological substances in animal and plant material, enabling also rapid screening of new types of biologically active substances

Results

- For the first two years of existence of the BIORAF Competences Centre, two patents have been granted to members of the consortium and two more have been filed, and two prototypes and two utility designs concerning the issues specified below have been developed:
- Strains of unicellular algae capable of growing on contaminated glycerol, technology of cultivation and technology of production of algae biomass for feeding purposes from glycerol
- A photobioreactor for cultivating microalgae and an algae-based food supplement
- Inulin from Jerusalem artichoke tubers and inulin-based products
- Large-area production plantations of energy crops and certification of cultivation procedures for selected crops, extracted bioactive substances from biological materials
- Hydrolysis and fractionation of lignocellulosic materials
- An alternative fuel based on waste of plant origin
- Isolation of carbon dioxide from biogas by means of membrane separation

Department of Aerosols Chemistry and Physics

Institute of Chemical Process Fundamentals of the CAS



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Specialisation

The Laboratory of Chemistry and Physics of Aerosols is engaged in the study of chemical and physical properties of atmospheric aerosols, the behaviour of aerosols in an indoor environment, the preparation of composite nanoparticles through the aerosol process, the kinetics of the nucleation and growth of atmospheric systems and emission samplings of aerosol particles under increased temperatures and pressures. As necessary, new aerosol instrumentation is developed for solving given tasks. Considering that the Institute specialises in chemical engineering and related branches, the workers of the Laboratory are able to assess tasks being performed from a process point of view, i.e. to understand the dynamics of processes under observation and to



Aerosol particle counters – the brain of a set-up for measuring the efficiency of filters

predict the behaviour of systems being observed upon changes in conditions (e.g. during an accident).

Competences

We have been engaged on a long-term basis in the sampling of aerosol (i.e. airborne) particles from both outdoor and indoor environments including situations where there are temperatures and pressures at the sampling place that are different from atmospheric ones. We can perform samplings of these particles both online, i.e. with a very fast analysis of the samples, and off-line (on filters or sorted by size into impactors with subsequent physical or chemical analysis) based on the customer's requirements. In samples taken we determine the concentration of particles and their size distribution. For

size-distributed samples we are able to determine the composition of individual size fractions. We are equipped with a set of aerosol spectrometers and counters working on the basis of several physical principles: diffusion, electrostatic, condensation, aerodynamic and optical, which enables us to select the most suitable type of analysis for a given task. The head workers of the Laboratory have many years of experience with aerosol technologies and are constantly in close contact with the latest scientific findings in the branch.

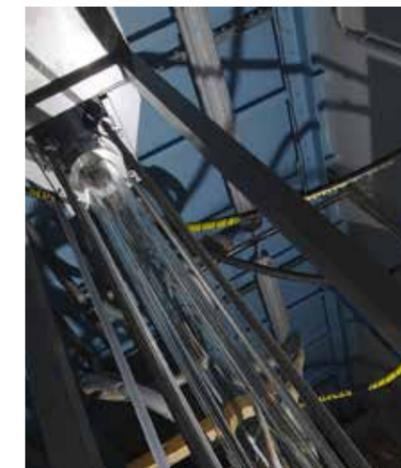
Enumeration of key instruments

- **c-TOF-AMS aerosol mass spectrometer** (Aerodyne, USA), which makes it possible, with a time resolution under one minute,

to determine the size and basic chemical composition of aerosol particles in the size range of 50-500 nanometres

- **SMPS 3936NL scanning mobility particle sizer** (TSI, USA). This aerosol spectrometer determines the size distribution of aerosol particles in the size range of 3-1000 nanometres
- **APS 3321 aerodynamic particle sizer** (TSI, USA) is an aerosol spectrometer determining particle-size distribution in the size range of 500 nanometres up to 20 micrometres
- **Diffusion battery** (TSI, ICPF) measures particle-size distribution in the range of 3-300 nanometres.
- **OPS 3330 optical particle sizer** (TSI, USA) determines particle-size distribution from 300 nanometres to 10 micrometres
- **BLPI Berner low-pressure cascade impactor** (Hauke, Austria) allows separating particles into 10 size classes from 25 nanometres to 10 micrometres for subsequent chemical and physical analyses
- **SDI small deposit area cascade impactor** (FMI Finland) allows, in a similar way, separating particles into 12 size classes from 45 nanometres to 13 micrometres with an advantage for elementary analysis using the PIXE method
- **Condensation particle counter** (TSI, USA) – in several versions with detection and determination of the concentration of particles from 3 nanometres to 3 micrometres
- **A11 particle size magnifier** (Airmodus, Finland) – a two-stage condensation particle counter with a lower detection limit of 1.2 nanometres

- **OC-EC Analyzer organic and elementary carbon analyser** (Sunset, USA) makes it possible to determine the concentrations of several fractions of organic and elementary carbon on the basis of their various volatility.
- **NAS nanoparticle sampling device** – (TSI) an electrostatic separator of nanoparticles for taking samples for electron microscopy



A condensation chamber for the study of acid rain

Target groups

Firms that, for some reason, need to ascertain the presence, concentration or composition of aerosol particles in operation or to find a place of escape of particles from operating equipment. Firms that manufacture filters and personal protective equipment or that want to verify the functionality of these devices. Firms engaged in the manufacture of nanoparticles, national organisations monitoring air quality.

Services offered

- Determination of the efficiency of aerosol filters depending on the size of particles
- Testing of the efficiency of personal protective equipment
- Operational measurement of aerosol (nano-) particles
- Measurement of the size distribution of aerosol particles in spray
- Determination of the chemical composition of aerosol particles depending on their size
- Emission and pollutant samplings of aerosol particles and analyses thereof
- Development of aerosol instrumentation
- Generation of nanoparticles using the CVD method, e.g. for inhalation experiments

References

- Czech Hydrometeorological Institute
- ČEZ a.s.
- ELMARCO s.r.o.
- Pardam s.r.o.
- Preciosa a.s., Plant 14
- PRECHEZA a.s.
- SPUR a.s.
- National Institute for Nuclear, Chemical and Biological Protection, public research institution
- National Radiation Protection Institute, public research institution
- Occupational Safety Research Institute, public research institution
- Brno University of Technology

Applied Laboratory of Cell Therapy and Tissue Engineering

Institute of Experimental Medicine of the CAS



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Research Focus

The main goal of the laboratory is development and preclinical testing of new therapeutic methods based on modern therapies (stem cells, biomaterials) for application in tissue engineering and regenerative medicine.

The cell therapy research is focused on stem cells efficiency and safety (mesenchymal, fetal, and induced pluripotent stem cells) of their application in the treatment of ischemia, neurodegenerative diseases, spinal injury, severe ocular surface damage



Work in clean spaces



Fluorescent microscopy analysis

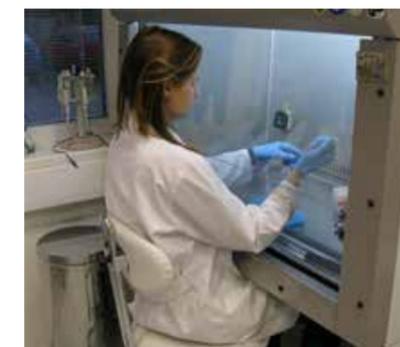
and other experimental models. The material research of the laboratory focuses on the development and testing of biocompatible functionalized nanofibres with controlled release of substances, such as drugs, growth factors, and other bioactive molecules. Furthermore, 3D biodegradable scaffolds are being developed. The scaffolds are mainly designed for cartilage, bone, and skin regeneration. They are "tailor-made" with the required degradation time and release of the compounds at the desired site of action. In collaboration with the Institute of Physics of the CAS, the laboratory focuses on development of low-temperature plasma treatment for the use in veterinary and human medicine.

Competences

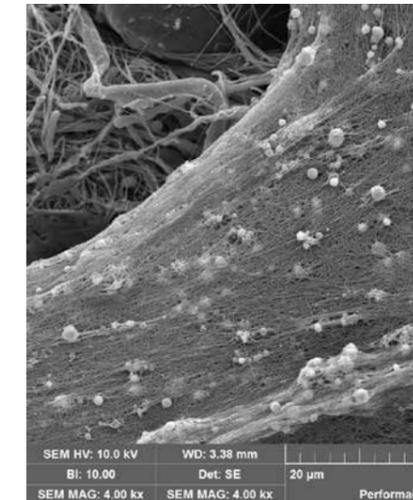
- Culture of human mesenchymal stem cells from different source (bone marrow, adipose tissue and umbilical cord) and their secretomes for preclinical applications
- In vitro testing of cytotoxicity of the materials using cell culture, e.g. mesenchymal stem cells, osteoblasts, chondrocytes, keratinocytes, melanocytes, and fibroblasts
- Fabrication and characterization of nanofibers with controlled release of bioactive substances (drugs, growth factors, and others)
- Preparation of composite foams and hydrogels with controlled drug delivery
- Material characterization of the fabricated scaffolds
- In vivo testing of modern therapies using animal models of mouse, rat, rabbit, and miniature pig

Target groups

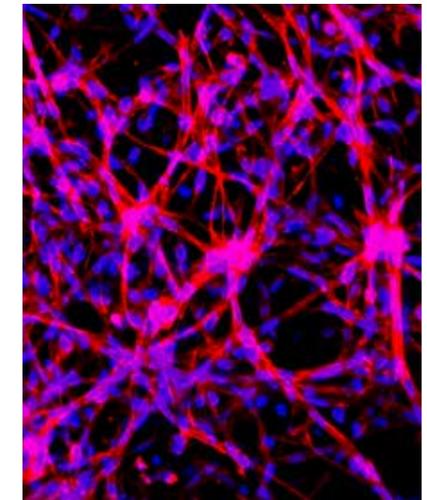
- Research and clinical institutes
- Manufacturers of drugs, materials and devices for medical application
- Companies in the field of food industry, cosmetics and food supplements



Work in cell culture box



Nanofibers with adhered platelets visualized using scanning electron microscopy



Fluorescent micrograph of stem cells growing in the three-dimensional biomaterial

Achievements, References & Collaboration

The laboratory has long-term experience in cell therapy and tissue engineering, resulting in a number of publications in journals with impact factors. At the same time, it is the originator of several patents and utility models.

- Patent file No. 302699 – Process for producing nanofiber-based nanopellets
- Patent file No. 306217 – Low-temperature plasma source with possibility of both contact and contactless application and process for preparing sandwich structure for such a source
- Patent file No. 306800 A device for storage, transport and application of stem cells
- Patent file No. 307053 3 D collagen porous composite carriers for accelerated bone regeneration

- Utility model No. 30686 A variable kit for cultivation of cell structures in cultivation plates
- Utility model No. 30612 3D composite gels for controlled cell differentiation under in vitro conditions
- Utility model No. 20346 Net enriched with nanofibers of polycaprolactone or a mixture of polylactic acid and polyglycolic acid or polyvinylchloride with adhered liposomes

The laboratory is involved in the EA-TRIS infrastructure and has long-term cooperation with Nanoprogres, z.s.p.o. cluster, Bioinova s.r.o. and Student Science s.r.o.

Centre of Preclinical Testing (CPT)

Institute of Physiology of the CAS



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Professional Focus

Basic research, which is the main focus of the institutes belonging to the Czech Academy of Sciences (CAS), may sometimes produce results that lead to the development of potential pharmaceuticals. Current status of development of these substances at most of the CAS institutes still has potential for improvement. New discoveries frequently end up in scientific publications, a patent application is rarely issued. Such situation reduces the applicability of new discoveries in clinical practice. Interest of pharmaceutical companies in collaboration on new discoveries depends on results of preclinical testing. The results



Beckmann Biochemical Analyzer

of these tests enable to select the projects, which fulfill key acceptance criteria, i.e. low toxicity, reproducible results, required pharmacokinetics, etc.

In some cases the new compounds cannot be used due to their side effects, e.g. for their toxicity. Only preclinical studies can give the answer whether the new finding, or even its partial result has a potential for future clinical application. The performance of preclinical studies also serves as an important criterion for evaluation of research project and can initiate possible change to current approach.

The goal of the Centre of Preclinical Testing (CPT) is to offer comprehensive service to research groups within the CAS, but also to universities and commercial subjects. CPT can per-

form high quality and effective preclinical testing. CPT aims to contribute to easier transfer of results of basic research into clinical practice. The Institute of Physiology of the CAS (IPHYS) functions within the CPT as the Good Laboratory Practice (GLP) certified Test Facility for studies on small laboratory animals (it is certified by the State Institute for Drug Control). The other involved institutes within CPT (Institute of Molecular Genomics -IMG - Czech Center for Phenogenomics, Institute of Animal Physiology and Genetics-IAPG - Center PIGMOD, Institute of Biotechnology-IBT) act as the Test sites. These sites have also established quality system compatible with the GLP rules.

Competences

Test facility and Test sites within CPT have long term experience with toxic-

city studies under OECD (Organisation for Economic Co-operation and Development) and ICH (The International Conference on Harmonisation) guidelines. These studies are being performed both on small laboratory animals, and on minipigs. CPT performs studies successfully for customers from within the CAS and also for commercial subjects.

Starting in January 2017, the Test Facility at IPHYS is GLP certified by State Institute of Drug Control (SÚKL). This enhances the quality and scope of its services.

Basic specification of utilized equipment

CPT utilizes the capacity of equipment for basic research. It owns high quality premises for lab animals housing, including husbandries for Specific Pathogen Free (SPF) animals. Premises for lab animals are equipped with high performance HVAC providing visualization of process states and with independent temperature and humidity sensors. There are high tech devices and lab equipment in CPT, which serve for the preparation of application forms of the test items, for evaluation of hematological parameters in the blood of animals (hematological analyzer scil Vet abc Plus+), evaluation of biochemical parameters in the plasma or other biological matrices (biochemical analyzer Beckmann Coulter AU480), determination of residues of active substances in plasma of tested animals (analytical system LC/MS/MS Thermo Fischer Scientific Q Exactive PLUS). There

are numerous devices used for histopathological evaluation, e.g. automatic vacuum tissue processor Leica ASP6025, tissue filling system Leica, fully motorized rotational microtome Leica RM2255-FU, microscopes Zeiss and Leica, automated system for processing histological samples Ventana Symphony and Axio Scan Z1 for scanning and storage of final histopathological colored slides.

The CPT also has a well-equipped operation unit for minipigs.

Target Groups

CPT offers its service to both academic institutes and to commercial partners (pharmaceutical companies, small innovative firms focused on biotechnologies and development of pharmaceuticals).



Mass spectrometer Thermo Fischer Scientific

Our Services

The Center provides the following tests and services:

- Toxicity studies, including toxicokinetic studies of promising chemical or biological agents on model animals – rodents and non-rodents (test systems: mouse, rat, guinea pig, rabbit, minipig) in compliance with ICH and OECD guidelines (e.g. skin irritation tests, acute and chronic toxicity, MTD, DRF studies).
- Bioanalytical, hematological and biochemical testing of samples taken from animals during toxicity studies (determination of active substance in plasma or other biological matrices. Measurement of common hematology parameters and biochemical parameters based upon need of sponsors)
- Development and validation of bioanalytical methods for various test systems and biological matrices
- Determination of metabolites in tissues and other biological samples
- Histopathological evaluation of tissues from test animals
- Pharmacological studies on xenografts (nude mice), including Patient Derived Xenografts -PDX
- Studies for determination of the therapeutic window
- Cardiology diagnostic tests on animal models – electrocardiogram (ECG), blood pressure measurement, cardiac imaging (Echo)
- Synthesis, characterization and certification of chemical substances, development of formulations for drug application

Biotechnological Pilot Plant

Institute of Microbiology of the CAS



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Biotechnological Pilot Plant

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www.mbucas.cz/vyzkum

mikrobiologie/biotechnologicka-hala

Professional focus

The Biotechnological Pilot Plant is focused on the development of pilot aerobic and anaerobic fermentation technologies in the field of technical microbiology and the design and testing of subsequent isolation and purification processes leading to a bioproduct making. It is necessary to obtain a relevant knowledge of the growth kinetics and production of the used microbial producers to achieve satisfactory results in the development of the pilot biotechnology. Therefore we perform engineering process analyses and create process models. We also deal with the development and the implementations of



Cross-flow filtration: universal unit Alfa Laval M39/M3.8 for microfiltration, ultrafiltration,

nanofiltration a reverse osmosis



Bioreaktor Bioengineering NLF 30

control and monitoring systems in the field of bioreactor engineering.

Competences and offered services

- Development of pilot technologies preparing microbial products using supplied microbial producing strains
- Handling of natural, genetically modified and pathogenic organisms (BSL 2)
- Preparation and optimization of volume pre-steps of the pilot cultivations - Up-Stream-Processing.
- Submerged fermentation technologies in bioreactors 5 - 1000 L (working volume) using batch and fed-batch mode under aerobic and anaerobic conditions

- Development of the isolation and purification processes (Down-Stream-Processing) in the pilot scale corresponding to the bioreactors
- Optimization of the cultivation media, fermentation processes and DSP
- Scale-up of the fermentation processes and DSP

Technological equipment

- Inoculum preparation equipment, inoculation box, incubators, tempered shakers
- Submerged bioreactors type CSTR:
 - 2x Chemap working volumes 3-5 a 6-10 L
 - 1x Bioengineering working volume 12-20 L
 - 4x Bioengineering working vo-

- lume 25-50 L
- 2x Bioengineering working volume 100-200 L
- 1x Bioengineering working volume 450-1000 L
- Instrumentality for Down-Stream-Processing:
 - Centrifugation: tube centrifuge Pennwalt Sharples - up to 5 kg of the sediment; disk-bowl centrifuge Alfa Laval BTPX 205, continuous; drum centrifuge Alfa Laval K212, up to 50 kg of the sediment
 - Disintegration and homogenization: french-press APV Rannie 10.38, 60 L/h, 1000 bar
 - Filtration: vacuum suction filters; cross-flow filtration: universal units Alfa Laval M39/M3.8 a M20 for microfiltration, ultrafiltration, nanofiltration a reverse osmosis
 - Spray drying: driers Niro Atomizer Minor (4 l/h) and Anhydro Compact (up to 20 l/h)
 - Lyophilization (freeze drying): modernized unit Frigera LZ-45 (batch up to 27 L)
- Cooling and freezing box, steam sterilizers, powerful liquid cooling system, filtration air conditioning, decontamination sump

Target groups

Target groups include domestic and foreign commercial and academic subjects who intend to realize the development of a biotechnological process feasible in our Pilot Plant. The current technical equipment would be extended temporarily by renting other facilities.

- Researchers from the Institute of Microbiology and from other

- institutes of the CAS who are interested in transferring their biotechnological application research into a pilot scale.
- Bearers of original microbial technologies developed in a laboratory scale who need the transfer into a pilot scale and a preparation of the technologies for a realization of production.
- Those interested in a realization of unit operations (see technological equipment) and complete biotechnological productions in the pilot scale.
- Owners of microbial strains possessing a market potential.

Application areas

- Human and veterinary medicines
 - antibiotics, vitamins, carriers, vaccines, biologically active compounds, proteins, immunostimulants, probiotic cultures, bacterial lysates
- Nutrition and feeds
 - proteins, polysaccharides, lipids, enzymes, nutritional supplements, pigments
- Enzyme technology
 - detergents, enzymes for pharmacy, food and feed industry
- Environmental biotechnologies
 - decontaminations of waters and soils, biodegradable plastics
- Biorefinery
 - biogas, agricultural waste treatment
- Agriculture
 - auxiliary plant products, soil amendments, biological fertilizers, wine yeast cultures

The PIGMOD Centre (Pig Models of Disease)

Institute of Animal Physiology and Genetics of the CAS



Contact

Institute of Animal Physiology and Genetics of the CAS

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Proteomics metody:

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Microscopy:

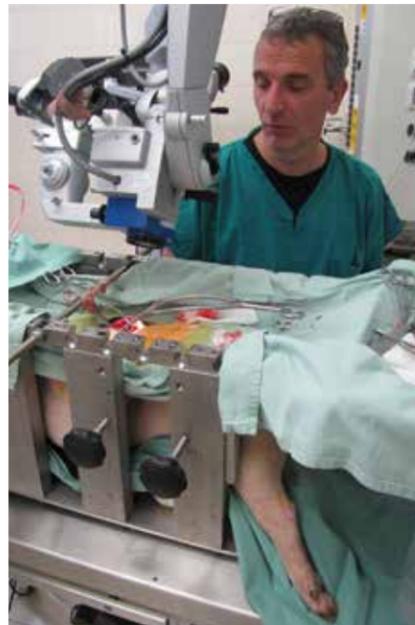
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Focus

The PIGMOD Centre (Pig Models of Disease) was established at the Institute of Animal Physiology and Genetics with a support of the European structural funds under the Operational Programme "Research and Development for Innovations". The main goal of the PIGMOD Centre is to bring together the research teams focused on the translational biomedical re-



Minipig spinal cord surgery

search. Currently the Centre research covers three basic areas:

- Neural system disorders – Huntington's disease, amyotrophic lateral sclerosis (ALS), traumatic spinal injury and macular degeneration (retinal disease)
- Cancer research, focused mainly on malignant melanoma
- Disorders of DNA damage response – compromised chromosomal integrity in oocytes and early embryos and its influence on fertility, and DNA damage response in neurodegeneration and aging

The mechanisms underlying these disorders are studied using biochemical, molecular biology and proteomic methods, and new disease models are developed and used for testing potential treatments. The developed disease models are offered to part-

ners in applied research sphere for the testing of novel therapies, with a focus on long term safety and other approaches not practical in small model organisms, such as rodents.

Competences

The PIGMOD Centre is composed of three laboratories:

Laboratory of cell regeneration and plasticity disposes with fully equipped operating theatres, animal housing and postoperative care facilities allowing advanced surgical experiments on minimipigs. Available models include transgenic Huntington's disease minimipig, minimipig line with a hereditary disposition to malignant melanoma, model of traumatic spinal injury and control minimipigs available for development of novel surgical approaches (laparoscopy, endoscopy, mini-invasive surgery) and testing of potential treatments (cell and gene therapy, novel biomaterials).

- Laparoscopy (XION GmbH) and endoscopy equipment (Olympus endoscopy tower with video processor, CV-170 OPTERA light source and video gastroscope GIF-Q165)
- Eye surgery equipment - the ophthalmic surgery microscope (Hi-R NEO 900A, Haag-Streit), phaco-emulsifier/vitreotome (R-Evolution CR, Optikon), ophthalmic green laser (Merilas 532α, Meridian) and optical coherent tomography (OCT) (Optovue, iVue)
- X-ray imaging (ARCADIS Varic Gen2, Siemens Healthcare, s.r.o.)
- Neurosurgery equipment, including stereotactic frame and injector (Neurostar)



Proteomic analysis on QTRAP5500 mass spectrometer (Sciex)

Laboratory of DNA integrity is equipped with an environmental controlled Leica TCS SP5 confocal microscope with three PMT and two HyD detectors. HyD detectors provide high sensitivity essential to minimize photodamage of imaged cells. This allows for long term live cell confocal microscopy experiments.

Laboratory of applied proteome analyses is equipped for analysis of protein composition of complex biological samples by mass spectrometry and antibody based methods.

- Sciex TripleTOF 5600+ mass spectrometer coupled to Eksigent nanoLC 425 liquid chromatography for the whole proteome untargeted (shotgun) proteomics, including SWATH MS
- Sciex QTRAP 5500 + mass spectrometer coupled to Eksigent na-

noLC 425 liquid chromatography for targeted proteomics using SRM (selected reaction monitoring)

- Multiplex xMAP immunoanalyzer Luminex 200
- BD FACS Aria flow cytometer and sorter
- Equipment for 2D electrophoresis including DIGE
- 2D HPLC for protein fractionation

Target groups

Basic and applied research biomedical institutions, clinical institutions and R&D departments of companies with a need for large animal model experiments. Groups with interest in microscopic analysis of live cells and in proteomic analysis of biological samples.

Services offered

- Testing of new therapeutical approaches from novel surgical techniques to cell and gene therapies on large animal model
- Toxicity studies (including toxicokinetics) of potential chemical substances using minimipigs
- Design and execution of live cell microscopy experiments, including image analysis
- Design, execution and analysis of complex proteomic experiments

Results, references and previous collaborations

- Creation of transgenic minimipig model of Huntington's disease: collaboration with CHDI Foundation, Inc., USA
- Testing of experimental gene

- therapy for Huntington's disease using miRNA gene silencing with AAV vector mediated delivery for uniQure Inc., Netherlands
- Development of unique sub-pial vector delivery technique for uniQure Inc., with cooperation with UCSD San Diego, USA
- Development of new surgical approaches for implantation of biomaterials for bone, cartilage and skin repair (1st Medical faculty, Charles University in Prague, Institute of Rock Structure and Mechanics, AZV project 15-25813A; Beznoska s.r.o., Student Science s.r.o., Military University Hospital Prague)
- Development of pig models of human digestive tract diseases (esophageal stricture, colonic anastomosis, stenosis and leak) and their therapies (AZV projects 16-27653A and 16-31806A, IBD Comfort, ISCARE)
- Model of traumatic spinal cord injury, its treatment using neural precursor transplantation and analysis of proteome changes in response to neural tissue damage: collaboration with UCSD San Diego and Neuralstem, Inc., USA
- Establishment of Test Site (TS) for studies in Good Laboratory Practice (GLP) mode: collaboration with Institute of Physiology of the Czech Academy of Sciences
- Development of mass spectrometry assay for simultaneous quantification of cell processes: collaboration with ETH Zurich, Switzerland

Genetic analysis of breeds and lines of economically important fish species

Laboratory of Fish Genetics

Institute of Animal Physiology and Genetics, of the CAS



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Professional focus

The activities of the Laboratory of fish genetics (LGR) focuses in particular on the study of clonal reproduction and polyploidy in fish and amphibians. Over the long term, the phenomenon of hybrid unisexual vertebrate animals is studied on the model hybrid complexes of loaches of the genus *Cobitis*, crucian carp of the genus *Carassius* and synklepton of water frogs *Pelophylax esculentus*. The laboratory focuses on detailed description of such a model for a general understanding of how clonal vertebrates originate, how dynamics and cohabitation of clonal and sexual individuals are maintained and how they play an evolutionary role in natural populations. The laboratory has conducted a detailed analysis of the fish of the genus *Cobitis* extended



Collection of blood from bred common carp of the Žďárský lysec breed

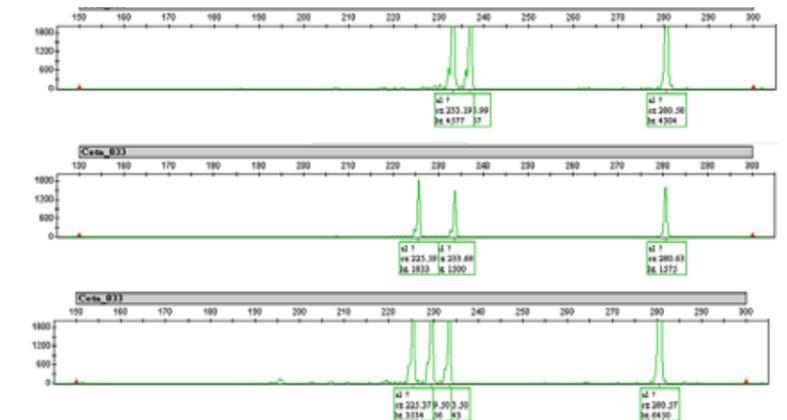
in Europe, presents findings about the species and hybrid diversity, their way of reproduction, which is sperm-dependent sexual parasitism, including experimental modelling of this type of reproduction. It also characterises molecular phylogeography and phylogeny of these forms proving reciprocal, polyphyletic and repeating origin of clonal lines, including the ability to change the host type on which they act as parasites. Mathematical modelling technique is also used to study the coexistence of sexually and clonally reproducing forms and their physiological differences. The laboratory also focuses on detailed phylogeographic study of fish in Mediterranean Europe for recognition of the origin of our populations. In the laboratory conditions, clonal and polyploid fish were successfully created experimentally by simple cross-breeding, without cellular manipulation, demonstrating clonal reproduction and explaining the origins of polyploidy as a causal result of inter-species hybridisation and elimination of the conservational

mechanism of meiosis. This is the first such successful experiment concerning interspecies hybridisation after a long 80 years since description of the first clonal vertebrate in the world. For the result called Clonal vertebrates: discovery, mechanisms, biodiversity and reconstruction on a model of loaches, the Laboratory of Genetics of Fish received an award from the Czech Academy of Sciences in 2012. Another major activity of the laboratory is in cooperation with colleagues from the Faculty of Fisheries and Water Protection at the University of South Bohemia the study of hybrid and ploidy diversity of sturgeon species with the aid of genetic methods. The ploidy series of individual sturgeons was reconstructed from the level of 120 to 420 chromosomes, and in relation thereto the laboratory began intensively engaging in research of genomes of archaic forms of fish (gar gars, bowfins, lungfish). Besides other focuses of research (e.g. Molecular cytogenetics and cytogenomics of fish), the laboratory is intensively

involved in the National programme of genetic resources of economically important fish species, including carp, tench, whitefish, trout, sturgeons - analysis of genetic parameters of tenches and populations for which the laboratory has accreditation from the Czech Ministry of Agriculture. It uses tools and equipment intended for evolutionary and biological studies also for applied research - the project of genetic characterisation of Czech breeds of carp (ROZE) Strategy AV21.

Competencies

The Laboratory of fish genetics ÚŽFG is according to Act No. 154/2000 Coll., as amended, authorised to verify the origin of fish and in cooperation with FROV JU Vodňany conducts genetic analyses for fish farmers within the programme of conservation of genetic resources of fish in accordance with the specified law. A whole series of carp raised in the Czech Republic are currently described, which show different morphometric characteristics induced by long-term selection and adaptation to local conditions. Although the carp is naturally the most important focus of the studies, they are also focused on other species of economically important fish, such as the tench, the brown trout, the rainbow trout and whitefish. The formation of new genetic methods and the description of genetic characteristics enable deeper analysis of population-related genetic structures of breeds and lines. This provides a professional basis for protection of the gene pool and breeding of carp in particular. Since expert activity has been done by LGR since 1995, the basic characterisation of breeds and lines



Example of variability of the genetic characteristics - micro satellites - for the river trout

of carp and other species of fish in the Czech Republic via multiple genetic characteristics is already available, but a sufficient amount of data and clear studies about intra- and inter-population variability is still lacking. Based on a decision by the Czech Ministry of Agriculture with case number 69017/2017-MZE-17253, LGR is curator of the gene bank of economically important fish species included in the National programme of conservation and use of genetic sources of animals important for food and agriculture.

Target groups

Fish farmers associated in the Fisheries Association of the Czech Republic and applicants for grants under Act No. 32/2011 Coll., on improvement of farmed animals and the programme of genetic sources.

Results and outcomes

In view of its expert knowledge and activities, LGR over the long time has been monitoring the genetic

structure of breeds and lines of carp specified in the programme of gene resources and in the Act on improvement. During this activity, LGR has collected samples and data from various generations of available regional and commercially used breeds of carp and other important fish species and has created:

- A gene bank of samples of selected regional and commercial breeds of carp
- A database of known genetic markers characterising individual selected breeds of carp and other fish species
- Seminars have been held for farmers about the importance of maintaining biodiversity within breeds of carp for sustainable farming and further development and improvement of species.
- An Atlas of Genetic Diversity of Czech Carp is being prepared for the domestic and foreign fish farming public.

Application Laboratory for Agricultural Research

Institute of Experimental Botany of the CAS



Contact

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Competences

The Application Laboratory for Agricultural Research is the first laboratory at the Czech Academy of Sciences to link scientists with breeders and farmers. It was established under the Food for Future Program of the Strategy AV21 in February 2017 and is located at the Centre of Plant Structural and Functional Genomics of the Institute of Experimental Botany in Olomouc. The main objective of the Laboratory is to facilitate the transfer of the latest results and methods of fundamental and exploratory research to plant breeders and agricultural industry in general. The Laboratory has the



ambition to play an important role in the efforts to secure enough food for the growing human population at global level and contribute to food quality and self-sufficiency at national level. A key task in these efforts will be to support breeding new crop varieties adapted to the changing climate and to drought, in particular. The new generation of crops should be also resistant to diseases and pests friendly agricultural practices.

Target groups

- Organizations involved in breeding crops as well as utility and ornamental plants
- Companies involved in seed propagation and seed production
- Agricultural companies and farmers
- Professional organizations involved in quality control of food production and their impact on human health
- State authorities responsible for testing new crop varieties and su-

- supervising the use of agrochemicals
- Ministries and authorities dealing with legislation related to agriculture and food industry
- Local governments interested in adapting agricultural production to changing societal and environmental conditions
- Citizen initiatives, foundations and organizations promoting environment-friendly agriculture and healthy nutrition

Our activities

Genome analysis in main crops

We are a world-recognised workplace for sorting of plant chromosomes and downstream applications, including sequencing and data analysis in main crops. We have developed original methods that have helped to break down complex genomes of wheat, barley and pea. The results of our research have been published in prestigious international scientific journals Nature and Science. We also par-

ticipate in projects aiming at cloning genes underlying important agronomic traits, including disease resistance.

Development of DNA markers

We have extensive experience in developing a wide range of DNA markers / probes for high-throughput genotyping and population screening. Our Centre serves as a global genotyping centre for some crops.

Organization of specialized workshops

We routinely prepare scientific conferences, professional seminars and workshops, including practical demonstration of selected methods.

Professional consultation

Our experts are engaged in comprehensive research of heredity in plants. That is why we are able to offer or mediate consultations in various areas of genetics and genomics.

Custom analyses

We can analyse your samples using state-of-the-art instruments and methods. The most common are flow cytometry and ploidy determination in particular, cytogenetic analysis, genotyping using different types of DNA markers and NGS sequencing.

Sequencing of DNA and RNA

We routinely sequence DNA and RNA samples. Individual samples may be processed by the Sanger method. Genomic projects are addressed primarily by Illumina technology using MiSeq and HiSeq sequencers.

Bioinformatics analysis

We process, store, and analyse the

sequencing data of your samples according to your requirements. The Laboratory is well-equipped for the analysis of large volumes of sequence data and management.

Genome editing

We perform targeted genome editing using the CRISPR / Cas9 method. We design the so-called "guide" RNA (gRNA) for the target sequence and we can prepare and verify vectors for plant transformation.

Technical equipment

The laboratory is fully equipped for a wide range of DNA analysis methods. These include instruments for the new generation of sequencing methods (MiSeq, Illumina) and Sanger sequencing. The laboratory also uses IRYS (BioNano) optical mapping system. Processing of large amounts of NGS data and their storage enables high-capacity server, data storage and relevant bioinformatics tools. We also use flow cytometry (FACSria SORP-Becton Dickinson flow sorter and Partec PAS Flow Cytometer),

fluorescence microscopy and high resolution microscopy. The ability to handle a large number of samples is facilitated by the use of a wide range of automated and robotized devices.

Results

We successfully collaborate on a number of projects, including:

- Characterization of interspecific hybrids of fescues and ryegrasses by flow cytometry
- Determination of genomic composition of Festulolium cultivars by molecular-cytogenetic methods (GISH)
- Development and use of DNA chip for genotyping of fescue, ryegrass and their hybrids
- Production of dihaploid lines in maize
- Identification of female papaya seedlings by PCR
- Ploidy determination in petunia hybrids
- DNA analysis of algae
- Professional consultation on fruit tree genomics



Apple breeding with a focus on disease resistance

Institute of Experimental Botany of the CAS



Contact

Institute of Experimental Botany of the CAS

Station of apple breeding for disease resistance

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Ing. Radek Černý

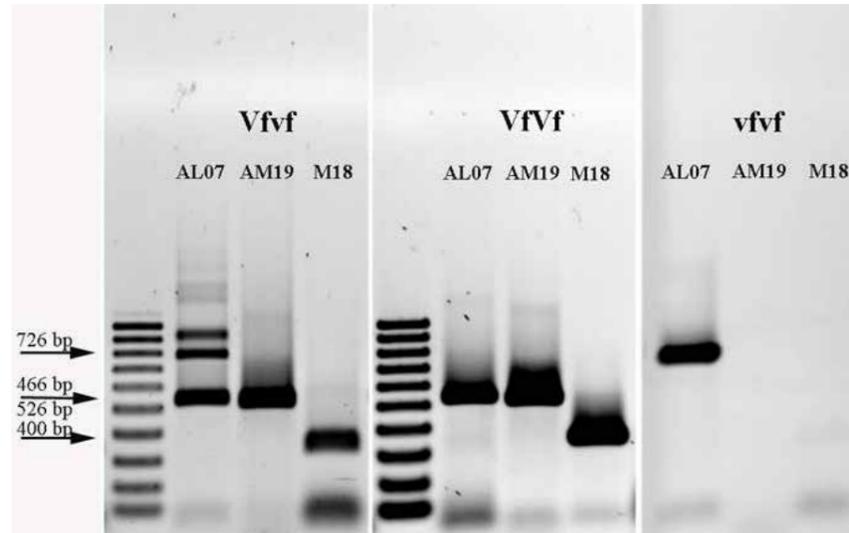
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Professional direction

Program of the Station of apple breeding for disease resistance, IEB CAS, v.v.i. is focused on resistance to apple scab, the most serious disease of commercial varieties. Scab protection requires dozens of chemical sprays during vegetation that are financially and labor-intensive and can adversely affect the environment. The commercial use of new resistant varieties will significantly reduce these chemical sprays against fungal diseases. In the past, the monogenic resistance caused by the Vf gene from the wild species *Malus floribunda* was predominantly used for the breeding of resistant varieties. At present, sources of scab resistance on a polygenic basis are used for this purpose. Previous experience has shown that this type of resistance is more permanent than that of the monogenous type Vf,



Markers for characterization of resistance in breeding material

which has already been overcome by new fungus races in some commercial apple-growing areas.

The breeding program is based on molecular methods of identification and analysis of genetic basis of resistance and implements so-called genetic markers for characterization of resistance in breeding material. In addition to disease resistance, new varieties must meet strict requirements for the cultivation properties, particularly fertility and fruit quality, in terms of appearance, taste, firmness and brittleness of the flesh, shelf life and durability during manipulation. Thus, selected newly bred cultivars are tested from above standpoints in the Czech Republic and especially abroad in research centers and business partners. Commercially promising varieties are legally protected by the Community Plant Variety Rights in the European Union and by

the US plant patent. They are grown predominantly under conditions of organic and integrated production; licensing contracts are concluded for their multiplication and sale.

The most successful variety of the IEB from the commercial point of view is the Topaz variety and its red mutant Red Topaz. In the past years, Topaz was the best-selling European variety with scab resistance, planted over an area of over 1 000 hectares, with annual sales of approx. 400 thousand trees. Varieties with a potential for broad application according to the global marketing concept are already present among IEB breeding results. The implementation of such a model under the leadership of companies in the US and Germany for UEB 32642, known under the trademark OPAL®, which is registered in more than 40 countries, is the most advanced. OPAL® was already rated "Excellent"



The most successful variety of the IEB from the commercial point of view is the Topaz variety and its mutant Red Topaz

by an extensive survey among consumers conducted by Perishables Group in the USA in 2009. In addition to the legal protection already granted in the European Union and the United States, this variety has been applied for legal protection a number of other countries such as Argentina, Australia, Brazil, Chile, South Africa, Canada, Morocco, Mexico and New Zealand.

One of the newest IEB variety, the Bonita, is being promoted in Europe. Its name comes from Portuguese for "beautiful" which suggests that the variety is characterized by attractive red color and good economic characteristics. Over 600 thousand trees of this variety were planted especially in South Tyrol during last three years.



In the last few years, the Bonita variety found commercial success in several European regions, especially South Tyrol

Competences

- Breeding apple tree for disease resistance and improved economic performance
- Testing the apple new breeding with a perspective for commercial use
- Ensuring and making available intellectual property through legal protection
- Preparation of license agreements, commercialization of results

Target groups

- Research institutions
- Nurseries and horticultural businesses
- Fruit orchards
- Marketing companies for the commercialization of new varieties of the IEB
- Food and sales chains- companies focusing on healthy nutrition and organic products

Results

In cooperation with international business partners, we are successful in commercial implementation of legally protected varieties of apple trees grown in the IEB. The annual sales of trees reach more than 1.2 million worldwide, with the gradually increasing license revenues reaching almost CZK 9 million in 2016. The goal of the application laboratory is to make the results available to interested target groups. Offer includes:

- Newly breed varieties of apple trees at IEB
- IEB apple varieties with polygenic resistance to scab
- Legal protection of new varieties of the IEB apple tree
- Commercial use of ieb apple varieties through licensed reproduction
- Presentation of results at professional conferences, seminars and trade fairs

Laboratory of Experimental Phycology and Ecotoxicology

Institute of Botany of the CAS



Contact

Institute of Botany of the CAS

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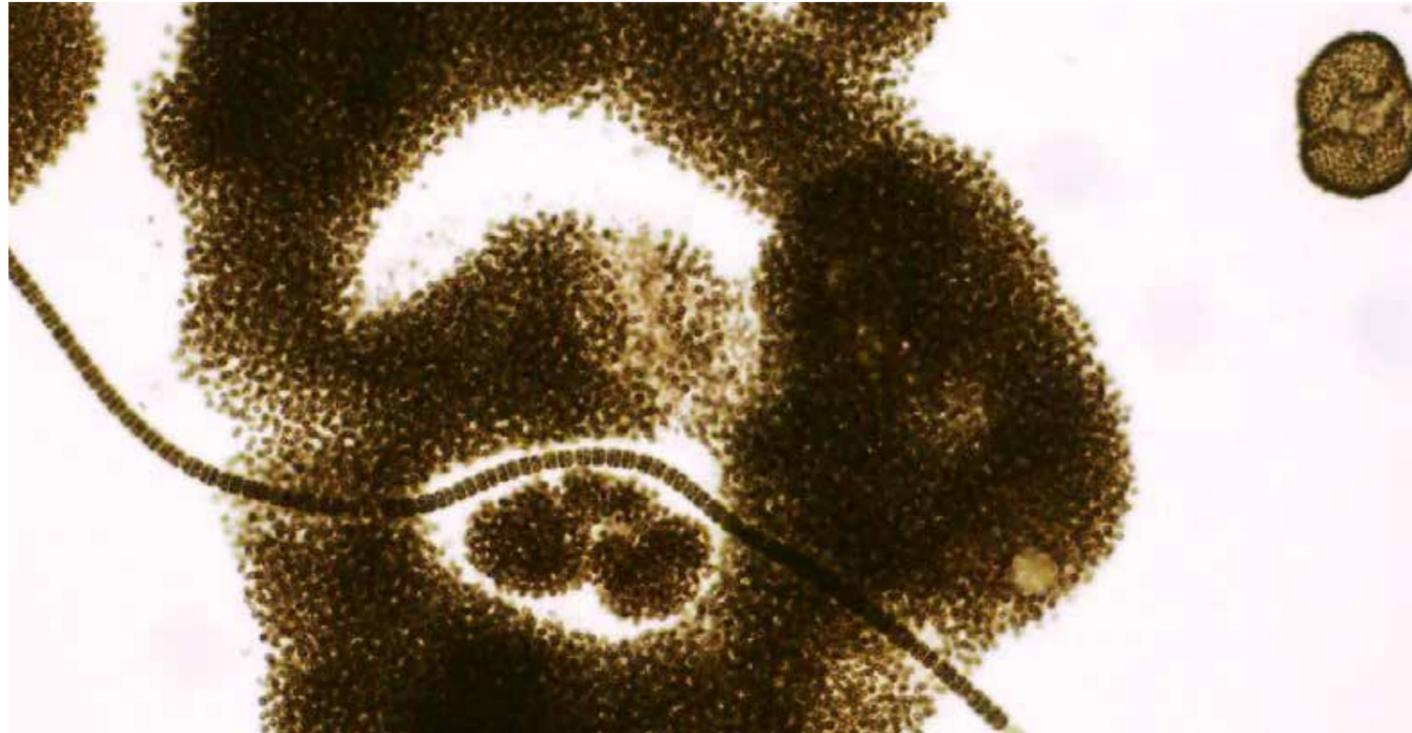
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Cyanobacteria under light microscope



Cyanobacterial water bloom

Professional qualification

The Laboratory of Experimental Phycology and Ecotoxicology deals with water quality problems, toxic compound detection and development of technologies for toxic compounds and phosphorus removal from waste water, surface and drinking water treatment.

The laboratory also specialises in detection methods, quantification and preventive measures for cyanobacterial water blooms, including methods for cyanobacteria and its toxins removal from natural reservoirs and drinking water.



Cyanobacterial water bloom sampling

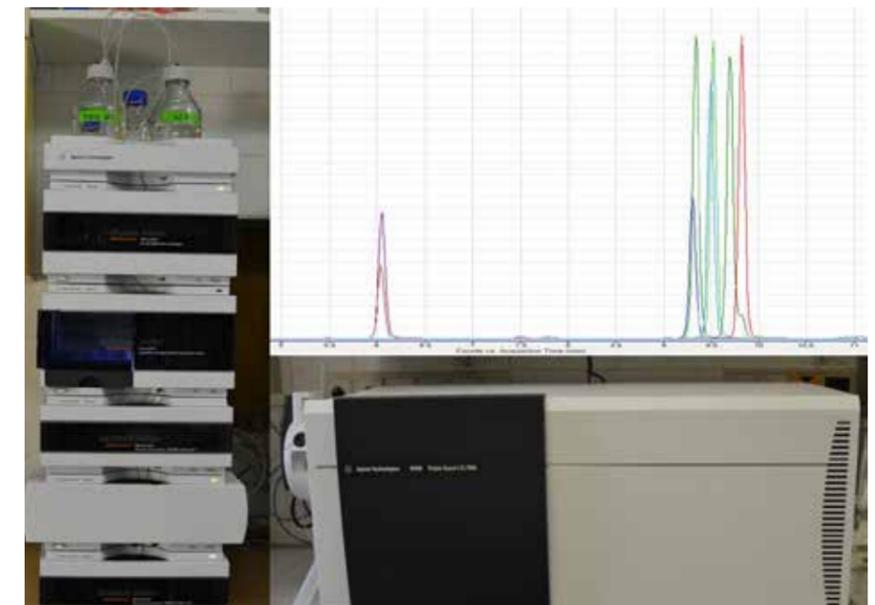
Target groups

Cities, municipalities, state and local administration, consulting and implementation companies for swimming biotope, water authorities and public health authorities, water supplies-sewerage authorities.

Our services

- Analysis of microcystins, saxitoxins and other cyanobacterial toxins
- Analysis and quantification of cyanobacterial water bloom biomass
- Measure proposals against cyanobacterial water bloom development
- Trace analysis of pharmaceuticals, estrogens, pesticides using LC-MS/MS

- Ecotoxicological evaluation
- Consultancy for water and wastewater treatment technologies and reduction of cyanobacterial water bloom development, analysis of cyanobacterial toxins
- New environment-friendly technologies for wastewater treatment
- Consultancy on water quality management using relations of water organisms and microorganisms and their establishment without chemicals in swimming biotopes



Device used for trace analyses of pharmaceuticals, estrogens or pesticides

Laboratory of Flow Cytometry

Institute of Botany of the CAS



Contact

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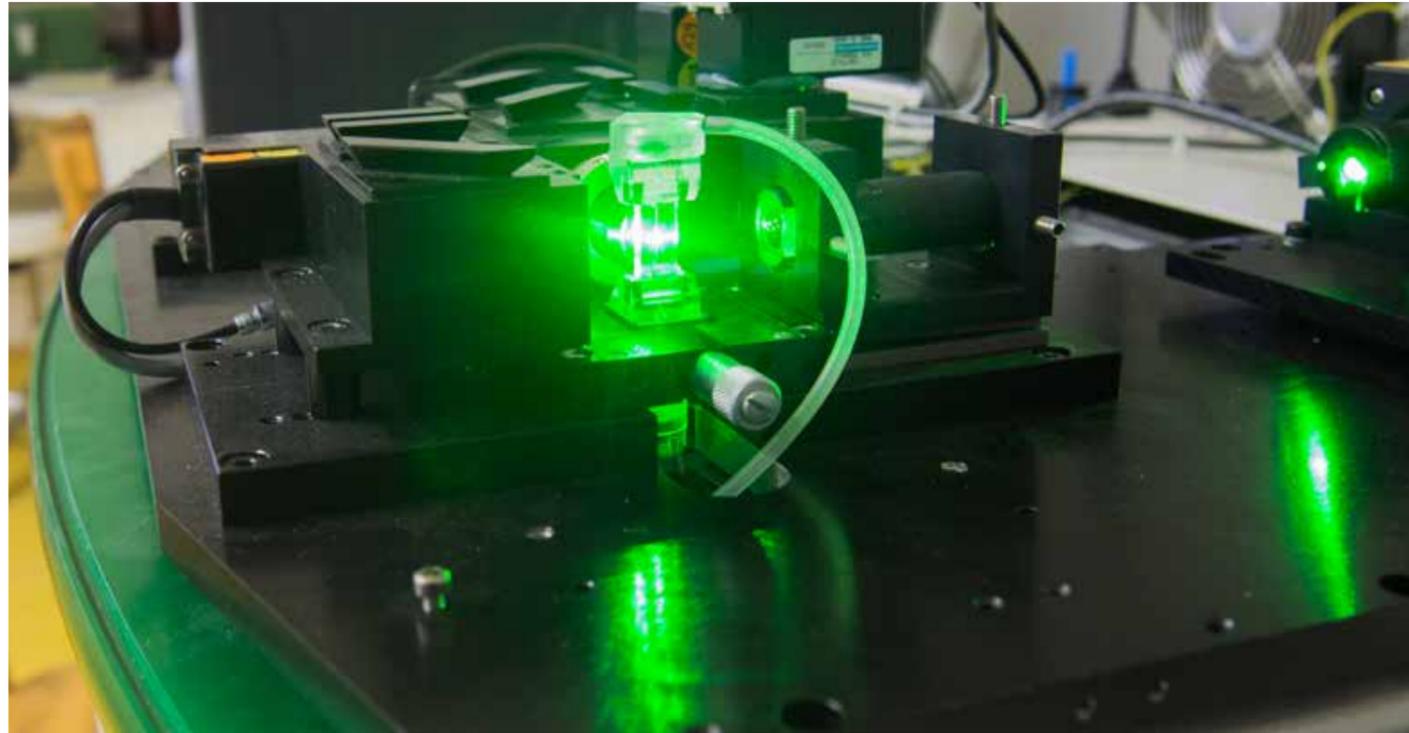
Laboratory:

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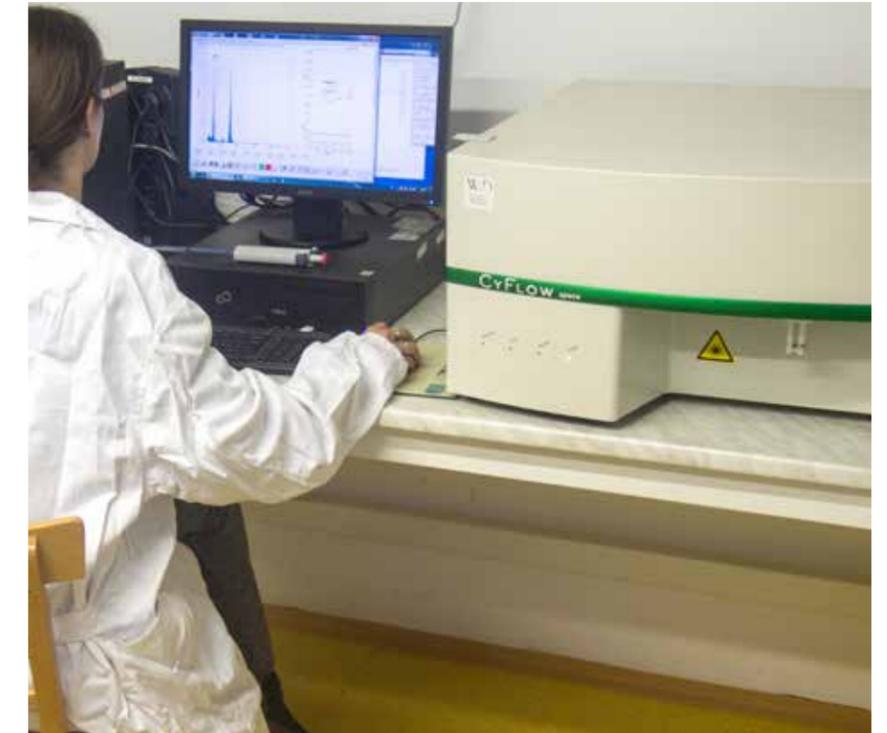
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Flow chamber represents "heart" of each cytometer where fluorochrome binded to plant nuclear DNA are excited



Every single cytometer is capable to run dozens of samples per day and operates independently

Competences

The Laboratory of Flow Cytometry of the Institute of Botany of the CAS is one of the leading subjects in the field of evolutionary history of polyploid complexes. This task is studied at various levels of research interest – starting interactions within and among populations, evolution of newly emerged polyploid taxa and formation of entire genera. Among the main topics that are addressed in our facility belong cytotype screening at various spatial levels spanning from population to continents, gene-flow detection between ploidy levels, analysis of whole-genomes traits for biosystematics and taxonomic purposes, flow cytometric seed screening for reproductive mode de-



The Laboratory of a Flow Cytometry provides scientific background and equipments for analysis of huge amount of samples

tection and progeny ploidy analysis, both inter- and intra-cytotype hybrids detections, etc.

The substantial part of our competences is "know-how" in methodology of flow cytometry analysis of plants, organization of practical workshops for pre- and post-graduate students, providing our services to interested parties outside of the academic sphere (including commercial subjects), and provision of guidance and assistance in plant flow cytometry.

Target groups

All academic subjects, research groups, plant growing facilities, commercial

subjects, etc. with no access to needed equipment and with without an access to the necessary equipment and with a lack of know-how in the field of plant flow cytometry.

Our services

The laboratory was founded to fulfill demands arising from research needs within the Institute of Botany, but special attention was also paid to the establishment of a broad network of international cooperation both on academic and non-academic basis. The facility is equipped with by five flow cytometres of German producer Partec GmbH and supports these services:

- Population targeted ploidy screening at various spatial scales including capacity for huge amount of samples (hundreds per day)
- Minority cytotype detection in supposed ploidy uniform populations
- Homoploid and heteroploid hybrids detection in situ or in experimentally emerged plants
- Nuclear genome size estimation at various taxonomic levels
- Whole-genome estimation of AT-GC content
- Assessment of reproduction mode based on seed screening of plants with developed endosperm.

The laboratory also provides data analysis if requested by customers.

Laboratory of Paleoecology

Institute of Botany of the CAS



Contact

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Focus and scope

The Laboratory of Paleoecology studies vegetation dynamics of last ten thousand years and the interaction between human societies and nature. The main research scope is long-term development of ecosystems in Central Europe, past human impact on the environment and future trajectories



Mapping of tundra vegetation in the vicinity of a pollen deposition monitoring site in the Abisko national park

under the ongoing climate change. The extensive pollen monitoring network enables precise interpretation of fossil pollen record. Paleoecological research of the Institute of Botany has more than half century long tradition. The Laboratory of Paleoecology is situated at two work sites: Brno and Průhonice.

Competences

The laboratory processes paleoecological material sampled from Quaternary sediments of peat bogs, lakes and tufa formations, but also from archaeological excavations and recent surface sampling. Paleoecological samples prepared in our laboratories are subsequently macroscopically

and microscopically analysed using identification literature, our Reference Collections of Pollen Preparations and Seeds and high quality microscopy techniques.

In particular, we prepare and process samples of:

- Fossil and recent pollen
- Pollen for analysis of honey
- Microscopic and macroscopic charcoal
- Plant macroremains
- Diatoms (Bacillariophyceae) and chlorococcal green algae (Chlorophyceae)

Target groups

- Universities and research institutions dealing with e.g. ecology, history, archaeology, geology, forestry and hydrobiology
- Government organizations (nature protection – bioindication)
- Beekeepers (melisopalynology)
- Allergologists (aerobiology)



Preparation of a paleoecological profile for transportation into a laboratory



Microscopic analysis of diatoms using Image analysis

Laboratories for Water, Soil and Plant Material Analyses

Institute of Botany of the CAS



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High-Resolution Continuum Source Atomic Absorption Spectrometer ContrAA 700 (Jena Zeiss) with possibility to change quickly from flame technology to graphite furnace technology

Focus and scope

The Institute of Botany of the CAS currently operates at three work sites. The work sites differ slightly in their focus - in Třeboň, the focus is on natural water analyses, whereas in Průhonice it is on soil analyses. All three laboratories provide analyses on external orders, mainly for university centres, institutions for environmental protection and other organizations of the Czech Academy of Sciences. The broad range of analyses provided by our laboratories is enabled by modern equipment that we constantly complete and update according to the current needs. The laboratories work program includes not only service activities but also the implementation and modification of new methods as well as consultations and expert assistance for university students.

Competences

The Laboratories offer primarily water, soil and plant material analyses ranging from pH measurement to determination of different nutrients or trace elements. For calcium, magnesium, potassium and other macro- and microelements, the overall and available nutrient content is determined. In case of nitrogen, its different forms can be determined, which is important for ecology and agricultural sciences. Typical tasks include comparison analyses of soils and plant biomass from the same locality to monitor transport of nutrients and trace elements. Apart from macronutrients, the laboratories determine content of several trace elements that cause contamination in soils and plants.



Detail of the nebulizer and the injection module SFS 6 of the Atomic Absorption Spectrometer ContrAA 700 (Jena Zeiss)

The methods used in the laboratories are compatible with international ISO standards, but in cases when monitoring is dependent on consistency with previous sampling, we adhere to the original methods. However when the monitoring is dependent on consistency with the previous sampling, then we adhere to the original methods.

Target groups

Research institutions as well as commercial subjects dealing with environmental protection, ecology, agriculture, climatic change etc.

Our services

- Determination of total carbon and nitrogen in soil and plant biomass (possibly of sulphur as well) and of total organic carbon in soil (TOC)



Elemental Analyzer NC 2500 (Carlo Erba) used for determination of total carbon and nitrogen

- Determination of element content in soil extracts, decomposed biomass and water samples (ca 20 elements including macroelements as well as microelements) using atomic absorption spectrometry with flame and graphite furnace technology; Atomic Absorption Spectrometer ContrAA 700 (Jena Zeiss) is equipped with a continuum radiation source and a high-performance optics allowing to measure elements even at very low concentrations
- Photometric analyses of phosphorus in soil extracts and decomposed biomass and soil
- Particle size distribution analyses of a broad range of suspension samples using Laser Particle Sizer A-22 Micro-Tec plus (Fritsch)
- Determination of cations in waters using ion chromatography (Na, K, Ca, Mg)
- Determination of anions in waters (ammonia ions, nitrates, nitrites, phosphates, chlorides, sulphates, total N and P)
- Photometric or turbidimetric analyses of ions in waters and extracts (nitrates, nitrites, phosphates, ammonia ions, sulphates)
- Determination of pH, electric conductivity and salinity of waters and soil extracts
- Decomposition of soils, sediments, substrates and plant biomass within determination of analyte content
- Determination of cation exchange capacity, exchange acidity, water content and content of combustible substances and carbonate content in soil samples volumetrically

Application laboratories and infrastructure of the Global Change Research Institute (CzechGlobe)

Global Change Research Institute of the CAS



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CzechGlobe is a top center of research and development. The work of the CzechGlobe Center focuses on the issue of ecological sciences, namely the issue of global change (GC), which in its essence and possible consequences goes beyond the basic thematic segments: the atmosphere - the ecosystem - the socio-economic system. GC has become an environmental, sociological and technical problem of today with a global reach, and consequently its solution requires profound expertise. The developed infrastructure of the CzechGlobe Center is rather expensive and unique. Therefore, it is essential that it is used as efficiently as possible by top foreign experts involved in the development of new techniques and methodologies (through open access), by local experts from joint workplaces and other research institutions or by students of Master and Doctoral study programmes for whom GCRI is the holder of an extended accreditation. The scientific focus of the CzechGlobe Center is based on the tradition of the Institute



Impact experiments focusing on the assessment of global change impacts on plants are carried out at various levels, from young plants in laboratory conditions (growth chambers) up to full-grown trees in field experiments (image shows poplars grown in containers)

of Systems Biology and Ecology of the CAS in Brno (ISBE), that focuses on the research of fluxes of carbon and other substances in ecosystems, ecophysiology, photosynthesis and technologies used in the development of specialized scientific instruments. The results of the research work of the CzechGlobe Centre are used by partners working not only in the region but also beyond the borders of the Czech Republic, for example within the framework of within the framework of the European Research Infrastructure Consortiums ESFRI, of which the Centre is a Founding Member: ICOS (research on greenhouse gas fluxes), ANAEE (cooperation within multifactorial experiments in different ecosystems), EUFAR (cooperation in the use of Remote Sensing Infrastructure) and newly also ACTRIS, eLTER and DANU-BIUS.

Core elements of the Center's Infrastructure

• Atmospheric Station

The Atmospheric Station Křešín near Pacov in the Bohemian-Moravian Highlands serves as a national monitoring point of both the occurrence and remote transmission of greenhouse gases, selected pollutants and basic meteorological characteristics. The station consists of a 250-metre-high meteorological mast, at whose various height levels atmospheric concentrations of greenhouse gases (CO₂, CH₄, CO, N₂O, SF₆), pollutants (tropospheric ozone, gaseous mercury, aerosols), basic meteorological characteristics (air temperature, pressure and humidity, wind speed and wind direction) as well as the height of the

atmospheric boundary layer are monitored. This facility is part of a network of atmospheric stations within the European Research Infrastructure ACTRIS and ICOS. Its location in close proximity to observatory Košetice and other CzechGlobe research infrastructures makes the atmospheric station significant on both the Czech and European scale

• Network of ecosystem stations

The network of ecosystem stations (Bílý Kříž, Štítná, Třeboň, Křešín near Pacov, Rájec, Lanžhot, Domanínek) focuses on monitoring, quantification and evaluation of carbon fluxes in basic ecosystems of the Czech Republic. These measurements are based on meteorological masts with eddy covariance technique and sensors for monitoring meteorological elements. All seven ecosystem stations are equipped, in accordance with ICOS protocol, with instrumentation for measuring fluxes of greenhouse gases (CO₂, N₂O and CH₄), water and energy between terrestrial ecosystems and the atmosphere, basic climatic characteristics, CO₂ profile, spectral reflectance, and transpiration fluxes in trees

• Systems of long-term impact experiments

The results of the experiments allow us to evaluate interactions between the influence of global climate change impacts and independent environmental factors in terms of the impact on plant physiology, production processes, plant metabolism and adaptation mechanisms in



Metabolomic profiling as well as target analyses of organic molecules can be carried out thanks to the state-of-the-art gas and liquid chromatography equipment supplemented by high-resolution mass spectrometers (Orbitrap ionisation source)

plants. They are carried out in a pavilion of experimental techniques in Brno where there is a phytotron hall with a cluster of growth chambers (phytotrons) allowing automatic regulation of atmospheric composition, temperature, air humidity, and intensity and spectral composition of light. In addition, a world-unique field system of cultivation chambers (open-top chambers) is built in Domanínek near Bystrice nad Pernštejnem. These open-top chambers, together with existing cultivation lamellar mini-domes at Bílý Kříž, enable long-term cultivation of model plant vegetation under regulated environmental conditions

• Airborne remote sensing laboratory

For process imaging of the carbon cycle, a station for collection/reception and processing of airborne and satellite FLIS (Flying Labora-

tory of Imaging Systems) data has been built. The laboratory — as the only research center in the Czech Republic — owns an aerial carrier Cessna Caravan equipped with spectroradiometers for capturing reflected solar radiation in the spectral range of 400 – 2,500 nm, a single-band thermal sensor, GPS sensors, gyro-stabilization frames, a system for controlling sensors during flight, and a supporting ground laboratory. The Airborne remote sensing laboratory processes and analyzes — among other things — hyperspectral data for private and public sector partners as well

• Central physiological, isotopic and metabolomic plant laboratory

On the premises of the CzechGlobe Center in Brno, a pavilion of experimental techniques, including

Application laboratories and infrastructure of the Global Change Research Institute (CzechGlobe)

Global Change Research Institute of the CAS



a central physiological, isotopic and metabolomic laboratory for the study of carbon assimilation processes has been built. The laboratory of ecophysiological studies is equipped with a set of portable instruments for ecophysiological measurements (gasometric systems, fluorometers, spectroradiometers) and stationary analytical instruments (spectrofluorimeter, Raman spectrometer). The isotopic and metabolomic laboratory is equipped with a complete system of two-dimensional gas chromatography with a mass detector for volatile and easily derivatizable metabolites, high pressure liquid chromatography with a mass detector for assessment of non-volatile metabolites, and an isotope-ratio mass spectrometer for determining the ratios of stable isotopes in both gaseous and solid samples of the soil-plant-atmosphere system and isotope ratios in selected metabolites. The laboratory is also equipped with a thermogravimetric analyzer

- **Incubator of application outcomes**
The Centre's application activities focus on transferring findings from basic research in the field of photosynthetic microorganisms (cyanobacteria and algae) to technologies for the production of third generation biofuels or other valuable substances utilizable, for example, in the pharmaceutical or chemical industry. These technologies are based on biological sequestration of carbon, i.e. on the exploitation of the potential of cyanobacteria and algae to transform



Growth chambers used for experiments assessing the global change impacts allow, in addition to regulating basic parameters such as air temperature or humidity, changing the concentration of carbon dioxide or the spectral composition of light

solar energy while capturing CO₂ from air or directly from combustion gases. The Incubator of application outcomes developed in collaboration with the spin-off company PSI in Drásov, transfers the research results into industrial practice in the form of prototypes of developed or modified devices and technological procedures. In order to achieve these goals, the Incubator is now putting into operation a laboratory photobioreactor system, culturing chambers for the maintenance of culture and basic laboratories for photoautotrophic microorganisms, a large-scale photobioreactor for large-scale cultivation and a high-capacity system for cell sorting according to production symptoms

- **Team of socio-economic studies**
For the needs of researching the socio-economic dimension of global climate change there is a team dealing with the GCC socio-economic aspects. Within the research and

application cooperation (e.g. with public administration authorities), various statistical and econometric models for integrated evaluation of socio-economic impacts of global climate change are applied. They include interactions between the society and ecosystem services affected by global climate change (e.g. the so-called ecological footprint). These evaluations make it possible to both predict the impacts of mitigation and adaptation measures on ecosystem services, economic performance, and other economic indicators, as well as propose optimized solutions of these measures

- **Experimental, educational, information and demonstration center**
A technical, administrative and training center has been opened at the Domanínek experimental site. The center serves as a technical and laboratory facility for experiments with fast-growing woody plants



The isotope laboratory is used to evaluate the natural discrimination of stable isotopes C, N, H, O. The discrimination is, for example, an indicator of the efficiency of plant's utilization of water or the type of photosynthetic metabolism

for biomass production, as well as for multifactor field experiments in the OTC. It also serves as a training center for students, business professionals, consultants, state administration and local government employees, and members of the scientific community interested in the topic of renewable resources

Target groups

- Hi-tech, innovative companies
- Universities
- Research institutions
- Public administration authorities

Examples of results achieved from cooperation with in applied research

- Optimization of culture conditions for growth of commercially significant Haematococcus algae with a focus on the production of astaxanthin (pigment with antioxidant effects)

- Research and implementation of a specific large-scale data collection using hyperspectral and multispectral airborne and remote sensing technique of the Czech Globe Center
- Models forecasting the production of electrical energy from photovoltaic and wind power plants based on numerical weather prediction
- Analysis of the content of organic carbon and nitrogen in agricultural soils
- Digital thematic maps of selected vegetation indices of stands
- Study on subsidies with a negative impact on biodiversity from the perspective of Strategic goal 3 of the Strategic Plan 2011-2020
- Analysis of the implementation of the National biodiversity strategy in the Czech Republic 2005-2015
- Application of Raman spectroscopy in the identification of algal lipid bodies - beta-carotene quantification
- Calibration of hyperspectral image data

- Equipment for measuring emissions of gases released by plant stands or by soil especially in places with fluctuating water levels
- Portable meter for measuring stand reflectivity
- System of compound operational forecasts of the production of electrical energy from renewable (atmospheric) sources. The system allows flexible planning and revision of real-time production plans based on
 - a) available current meteorological data and its expert evaluation by meteorologists / climatologists in the outlook from tens of minutes to several days in the future and
 - b) real-time feedback on the currently measured production from photovoltaic and wind power plants

Public Opinion Research Centre (CVVM)

Institute of Sociology of the CAS



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The CVVM conducts 10 regular and a number of extraordinary surveys every year

Area of Expertise

The Public Opinion Research Centre (CVVM) at the Institute of Sociology, Czech Academy of Sciences, works on practical and theoretical issues relating to public opinion and research on public opinion, research methodology in the social sciences, and the analysis and interpretation of data at political, economic and social level. Within the frame of their specialisations, the centre's researchers focus on public opinion as a social phenomenon and analyse specific problems in the field. The centre has 15 permanent staff who have the ability to perform all the tasks necessary to conduct complete sociological research and the interpretation of research. The centre has its own network of interviewers that is large and widespread enough (approx. 350 interviewers) to perform both population-wide and specialised surveys. For research on specialised topics the centre works with other experts within the Institute of Sociology

and professionals in the commercial, public or academic sphere.

Target groups

The Public Opinion Research Centre prepares expert reports and analyses and conducts data collection for its clients, including state administration (e.g. ministries, the Occupational Safety Research Institute/ Výzkumný ústav bezpečnosti práce, and the Czech Statistical Office/ Český statistický úřad), non-profit and commercial organisations, research bodies, and universities (almost all the top universities in the Czech Republic – e.g. Charles University, Masaryk University, Palacký University), both in the country and abroad. It is also involved in international cooperation with public opinion research agencies in the Central European Opinion Research Group (CEORG).

Outcome

Long-term and continuous study named 'Czech Society' (Naše společnost) is a key project of applied research that the CVVM has been working on. Ten surveys annually are conducted within the framework of the project. That the centre works on, as part of which it conducts ten surveys annually. These are public opinion polls conducted on a representative sample of the Czech population aged 15 and over and approximately 1000 respondents take part in each survey. The survey questionnaire's omnibus structure makes it possible to cover a great variety of topics ranging from politics, civic participation, and security, to opinions on the EU, NATO, and other institutions, a whole spectrum of economic issues, unemployment, global issues, value orientations, social policy, education, and several dozen other topics. The CVVM has unique time series on most of these subject areas and uses them to conduct in-



Regular inclusion of thematic blocks of questions makes it possible to monitor social phenomena in the long term

depth analysis. The basic outcomes are then published as press releases (approx. 100 media hits a month); analysts at the CVVM use them as resources for making comments in the media, and they also appear in the annual reports of government ministries, and so forth.

In addition to this project, the CVVM also works on various other projects for different types of clients. In 2016 and 2017 these included, among others, the following projects:

- **Media Literacy of the Population of the Czech Republic**
 - Client: Institute of Communication Studies and Journalism, Faculty of Social Sciences, Charles University
 - Research to map media literacy and opinions on the media among the Czech population
- **Generation What?**
 - Client: Czech Television
 - CVVM worked with Czech Televi-

sion on a unique project to map the attitudes, opinions, and lifestyles of young people between the ages of 18 and 34

- **Socio-spatial Disadvantages of Populations in Peripheral (Marginalised) Regions**
 - Client: Institute of Sociology, Czech Academy of Sciences
 - The research focused on the life circumstances, opportunities, and strategies of people living in peripheral rural regions and com-



Research reports dating back as far as 1946 can be found in the CVVM archives

pared them the situation of populations in other regions. It also analysed disadvantaged groups of inhabitants in peripheral areas and looked for the factors that have an influence on disadvantages

- **The Quality of Working Life in the Czech Republic in 2016**
 - Client: Occupational Safety Research Institute
 - The research examined the importance of individual aspects of employment and how satisfied the Czech population is with aspects of employment
- **An Analysis of the Position of Migrants in Prague**
 - Client: Prague City Hall
 - The research surveyed third-country foreign nationals who have been residing long term in Prague and examined in depth their needs, barriers to their integration, and their social status
- **Post-election Study 2017**
 - This was a unique post-election study on the elections to the Chamber of Deputies of the Czech Parliament that was carried out, among others, for the Faculty of Social Studies, Masaryk University in Brno, and Palacký University in Olomouc and focused on the voting behaviour of Czech voters
- **The Image of the Czech Statistical Office among the Czech Public 2017**
 - Client: Czech Statistical Office
 - The research surveyed the Czech public's view of the Czech Statistical Office and awareness of the kinds of work that the Czech Statistical Office performs

SHARE project (Survey of Health, Ageing and Retirement in Europe)

Economics Institute of the CAS



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Competences

The Economics Institute of the Czech Academy of Sciences (NHÚ), public research institution, is a participant in a joint workplace with the Centre for Economic Research and Graduate Education of the Charles University (CERGE) and closely cooperates with the Faculty of Social Sciences of the Charles University in Prague. The NHÚ pursues the scientific research into economic theory at macro- and microlevels, public finance, econometrics, economic integration, labour economics, market structure and organisation, international trade, international finance, environmental economics, health economics, experimental economics, transition economy and other areas that are asso-



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ciated with the transition to market economy and entry into the EU. An important scientific task of the NHÚ is creating studies on the Czech economy and an active participation in the life of the Czech economic community.

The NHÚ is a coordinator of the scientific infrastructure of the SHARE (Survey of Health, Ageing and Retirement in Europe) in the Czech Republic. The SHARE project consists in the creation of an all-European longitudinal data file that includes persons aged 50+ and their families. The main topics of this multidisciplinary research on more than 120,000 respondents from all EU countries (plus Switzerland and Israel) include: demography, family and social networking; education; health and healthcare; employment and pension; income,

consumption, property; help and finance in a family; housing; activities; life history; quality of life; the course of the last year of life in the event of death etc. The outcome comprises a unique, freely available data file providing information on the state, history and development of Czech and European societies. The SHARE is the largest international scientific project and research infrastructure of the EU in social sciences. It helps governments and research workers understand the consequences of demographic changes and prepare optimum measures for public finance, labour market, health or the pension scheme.

Target groups

The NHÚ offers help in processing and interpreting the data of the



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SHARE project, analyses of individual topics and mediates access to the SHARE project data. For many years a new portal with simplified access to the data of the research infrastructure easy SHARE has been available to the research public and students, and it newly allows group utilisation of the data for teaching at universities. The investigation team cooperates with researchers and pedagogues of universities in preparing courses and offers practical assistance in utilising the data in teaching.

The SHARE infrastructure makes it possible to compare the effects of various social security systems (for example, the pension scheme and healthcare system) on the quality of life, economic position, retirement, social and work participation of middle-age people and seniors etc.

Thanks to SHARE, thus, it is possible to perceive Europe as an experimental laboratory with various systems, reforms that change over the course of time. By means of the data of the SHARE infrastructure, researchers can monitor these changes, draw conclusions about the behaviour of people and recommend them for use in the formulation of optimum government policies in individual countries.

Results

The SHARE research infrastructure is currently the only long-term longitudinal survey (monitoring the same persons for many years) in the Czech Republic. In 2017, the SHARE research infrastructure successfully finished the sixth wave of data collection on a sample of more than 6,000 respondents who took

part in the previous survey waves in 2006/7, 2008/9, 2010/11, 2012/13, and 2014/15. The SHARE scientific infrastructure will welcome further persons interested in placing their own questions into the SHARE questionnaire.

The SHARE research infrastructure has been cooperating in the long term with the panel surveys on ageing Health and Retirement Study (USA), English Longitudinal Study of Ageing (UK). Panel surveys on ageing are carried out based on the SHARE research infrastructure in a number of other countries. These collaborations are essential for the further international compatibility of the SHARE research infrastructure and are of great benefit to comparing the population ageing process across countries with a different level of economic, social and institutional development.

The SHARE research infrastructure cooperates with the state administration of the Czech Republic, the Research Institute for Labour and Social Affairs, Ministry of Labour and Social Affairs, Czech Republic Government Council for Senior Citizens and Population Ageing and with a number of research institutions and universities. In addition to the academic sphere, the European Commission is the biggest user of the data of the research infrastructure: DG ECFIN uses the data of the SHARE research infrastructure for long-term projections of expenditure on pensions and healthcare, DG SANCO for health indicators, and DGEMPL for measures in the area of active ageing, inter alia, retirement and adjustment of pensions.

IDEA: Institute for Democracy and Economic Analysis at the Economics Institute of the CAS

Economics Institute of the CAS



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Analyses of the consequences of public policies

The quality of government in democratic countries with market economies depends upon the systematic evaluation of the goals, consequences, costs and returns of public policies. The Czech Republic has much still to work on in this area. Economic, social, educational and other public policies are often insufficiently backed up by good quality analyses and applied empirical research. The result is that these policies are often based on shared impressions, ideological whims and the priorities of certain interest groups. Those wishing to discuss the policies, whether in an expert or civic setting, often find it hard to obtain good relevant analytical materials. IDEA is an independent academic think tank focusing specifically on

the analysis, evaluation and proposition of public policy. IDEA studies are based on modern economic theories and models, advanced methodologies and a broad set of data and information sources. IDEA recommendations arise from analyses based on facts, data and interpretations that are unencumbered by any ideology.

The tax, social and education systems IDEA's key professional focus areas include assessment of the aims and consequences of the tax and benefits system on incomes, employment and unemployment, individual consumption, and families. Typical research topics include for example the taxation of incomes from employment and self-employment, the taxation of high incomes, the impacts of reforms to direct taxation and social benefits, the impacts of parenthood on employment and incomes, the consumption

behaviour of individuals and households, predictions of employment and unemployment, the impacts of joint taxation for married couples, and an international comparison of the population's participatory behaviour.

The aging population topic is closely related to other topics, such as comparative analyses of pension systems and employment among the elderly, the economic impacts of changes to the statutory retirement age, the consequences of divorce for incomes in old age, the employment and unemployment of older people, work during retirement and senior citizens' incomes.

Within the economics of schooling and education, IDEA investigates teachers' pay, the economic and social impacts of educational policies, and selectivity in the education system, among other topics.

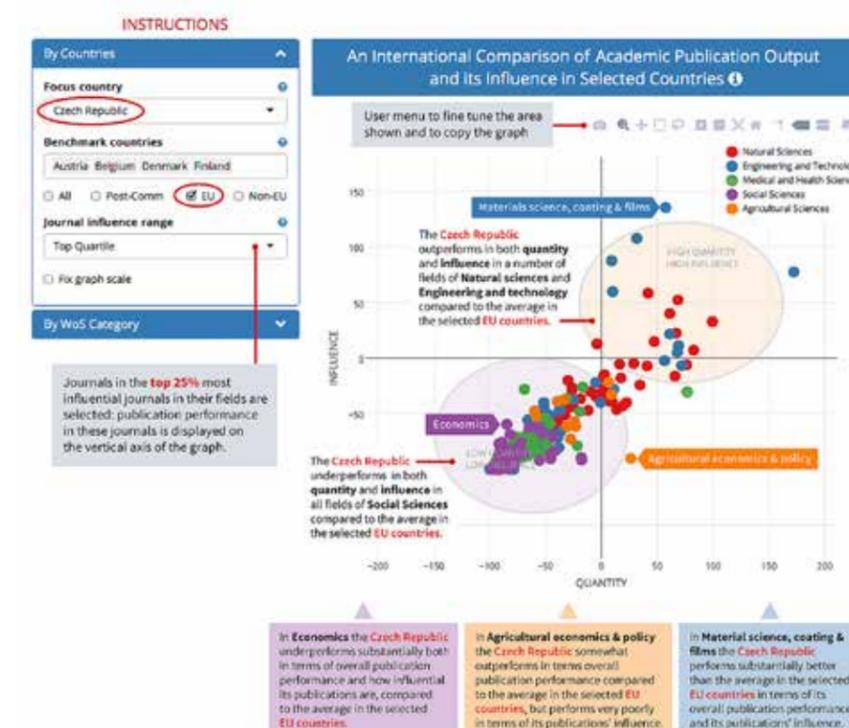
Research and innovation

Research and innovation (R&I) are key factors for the economic and social development of any country. For them to be successful, however, there must be a good system of management, adequate funding, and effective public R&I policy. To support the informed management of the R&I system on all levels, IDEA produces public analytical and informational on-line tools, and carries out empirical research in R&I fields. This includes studies of the structure and dynamics of research publication output and its quality, the behaviour of entities within the R&I systems, and the impacts of R&I financing programmes. IDEA's research and analysis offers answers to the following types of questions:

- How does Czech basic research perform in international bibliometric comparisons?
- What kind of publication output do Czech research institutions produce in individual fields, in terms of their quality, relevance and reception?
- What gender differences exist in research publication output?
- What forms do collaboration and technology transfer take at the organizational and individual levels?
- What are the returns on company expenditures on R&I?
- What impacts do R&I have on the real economy?
- Why don't foreign investors and smaller firms develop more R&I activities in the Czech Republic?
- To what extent does public support for R&I motivate firms to increase their R&I activities?
- Are grants or tax deductions more effective for R&I?



IDEA is a think tank of the Economics Institute of the Czech Academy of Sciences



- To what extent, and how, should innovation policy be regionalized?

Publications and recommendations

IDEA carries out research on a selection of important topics of its own choosing, as part of larger research projects, and also as ad-hoc studies requested by private and public institutions. Based on our findings from our analyses and research, we often formulate and explain expert advice relevant to the area of public policy concerned. IDEA's results and fin-

dings are communicated to professionals, the general public and the media in the form of freely available studies, seminars, discussion forums and even retrospective online videos of the latter events. Our professional studies are also sent directly to public policy makers in the relevant areas.

IDEA is part of the Czech Academy of Sciences' AV21 Strategy, for which it is the coordinator of the social sciences programmes "Effective public policy and contemporary society" and "R&I analyses".

Database infrastructure for digital humanities

Institute of Philosophy of the CAS



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Aim and focus

The Institute of Philosophy of the Czech Academy of Sciences runs a number of digital scholarly databases that cover a wide range of disciplines. Many of these databases (see the Results section below) are also part of the DARIAH-CZ Research Infrastructure, which is planned as a new addition to the Czech Republic's Research Infrastructure Roadmap and a distributed national node of the pan-European DARIAH-EU network for digital humanities.

Competences

The Institute of Philosophy employs specialists from fields relevant to the study of antique, medieval and early modern thinking and other areas (e.g., classical studies or comeniolo-



gy). In the case of specific topics, the databases cooperate with other experts from the Institute of Philosophy, as well as with experts from the wider academic sphere, both domestic and foreign. Other competences include expert opinions, education and consultation in relevant areas (see list of databases below).

Target audience

The target audience consists mainly of university students of humanities and researchers in related disciplines (history, philosophy, literary science, philology, theology, librarianship and archival science) at universities and research institutions. A non-aca-

demic public (for example, secondary school students) is also an important part of the users.

Results

The main output is freely accessible digital databases (over 7000 visits per month), which are continuously updated, expanded and cooperate with many domestic and foreign institutions. For example, the following databases are freely available to users:

- **Bibliography of Foreign-Language Printed Bohemica 1501–1800 (BFPT)**
BCBT is a database mapping printing production of foreign-language



Visualization of the correspondence of Jan Amos Comenius (EMLO database) using Palladio service

Bohemia by the end of the 18th century. At present, the database contains about 27 thousand records

- **Czech medieval sources on-line (CMS)**
The CMS on-line database publishes significant editions dedicated to Czech medieval history. At present, 750 volumes are available and more than six volumes are added per month
- **Dictionary of Medieval Latin**
The current version of the database contains the first two parts of the Medieval Latin Dictionary with minor corrections compared to the printed version published in 1977–1992 by the Academia Publishing House
- **Collection database of Classical Tradition and Czech Culture (A–C)**
This collection database includes:

A. Database of Ancient Drama

To this date, the database contains information about 500 productions on Czech stages, which contain 2500 bibliographic items in total, including fulltext links

B. Classical Heritage in Czech Art and Architecture

The aim of the database is complete documentation and a comprehensive analysis of the ancient heritage in the art culture of the Czech lands from the beginning to the present

C. Classical Culture in Epigraphy of Czech Lands

The database documents and analyzes the ancient heritage in the epigraphic culture of the Czech lands from the first inscriptions to the present

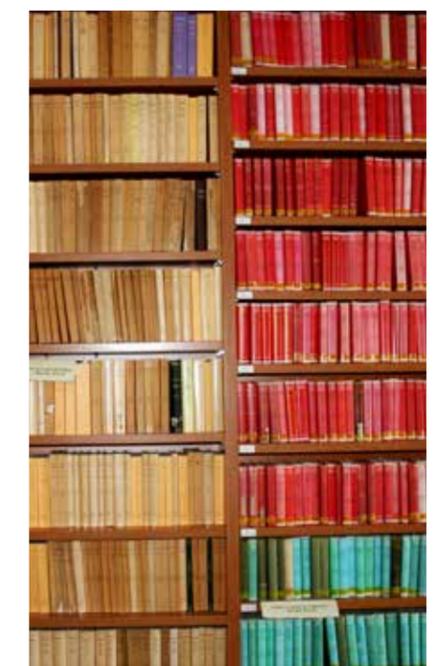
• The Jan Patočka Archive Bibliography

The AJP bibliography includes all the published texts by Jan Patočka from the first journal article from 1928 to the present. It also includes a complete inventory of secondary literature on Patočka's philosophy

The Institute of Philosophy also cooperates with the international database:

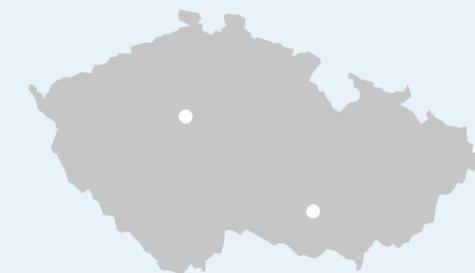
• Early Modern Letters Online (EMLO)

The section handled by the Institute of Philosophy includes the correspondence of Jan Amos Comenius (over 560 letters), Philip Jacob Sachs of Löwenheim (over 140 letters) and Amanda Polan of Polansdorf (roughly 320 letters) and others



Archaeological Information System of the Czech Republic (AIS CR)

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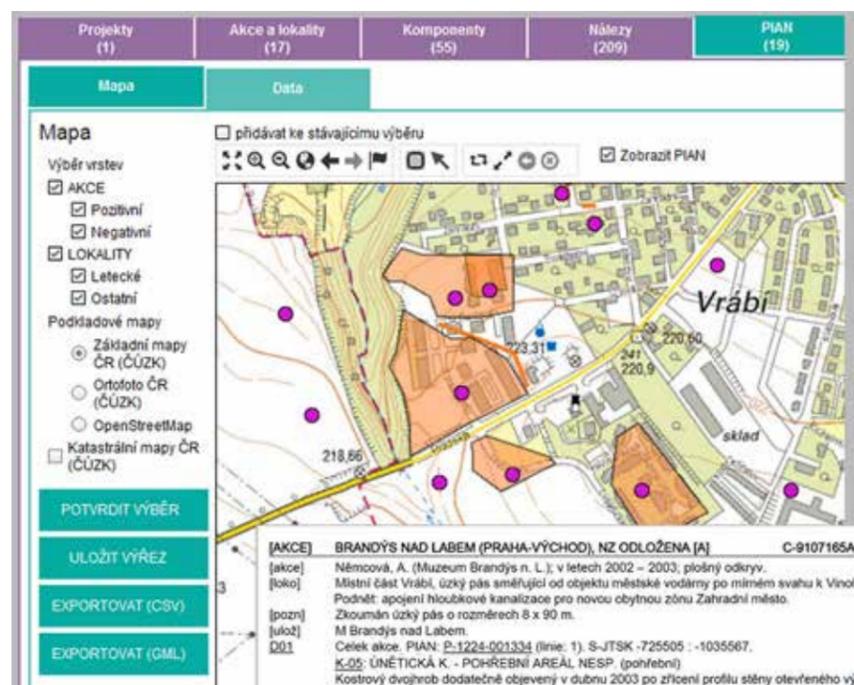
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Specialisation

Although the field of archaeology in the Czech Republic generates large amounts of data, until recently the practitioners and academics have not had sufficient tools for a comprehensive analysis and assessment of that data that would also allow the management of data acquisition and quality control. Thanks to work carried out in recent years, various information systems dealing with archaeological fieldwork have been integrated into a single platform – the Archaeological Map of the Czech Republic – along with other services designed as part of the AIS



Archaeological Map of the Czech Republic is a core of the AIS CR infrastructure

CR research infrastructure. The long-term aim of AIS CR is to integrate a system of archaeological fieldwork administration with a database of fieldwork results and other information on archaeological heritage, while providing tools for making all of that information available to the public. As part of the process of developing this infrastructure, information on so far unarchived fieldwork results is collected, revised and/or edited in order to save this important data that would otherwise be irretrievably lost.

Competences

AIS CR provides its user community with a complex, interlinked and accessible set of information on archaeological heritage and the

historical landscape, a digital archive of documents, access to maps, supplementary platforms for mining information and the presentation of data on archaeological resources in the CR. Several substantial changes have been achieved through AIS CR. These mainly concern: (i) defining a dynamic information flow model for archaeological fieldwork; (ii) implementing persistent identifiers for archaeological fieldwork events, sites and all other objects in the information system (documents, bibliographies, geospatial units); (iii) assembling data from across the Czech Republic under a single data model and a unified digital environment; (iv) maximising data accessibility for both the professional and general public.



An example of aerial image made available by AIS CR (Prague-Kralovice hillfort)

Target groups

AIS CR serves not only the research community, but also administrative and commercial sectors and the general public, thus contributing to the strengthening of national and cultural identity and the preservation of national cultural values. It provides information on archaeological projects, fieldwork events and sites (project documentation, preliminary reports, site reports, photographs, maps, plans, expert reports, specialised metadata and more) and secure access to information required for archaeological fieldwork and research and education in historical disciplines. Both administration offices and archaeological institutions are provided with access to information on fieldwork and its results. Developers and investors can use AIS CR to predict the existence of archaeological sites in their areas of interest.

The work performed by AIS CR has been positively reflected in several areas:

- Scientific research (experts, university students)
- Archaeological heritage management (field archaeologists, heritage managers, museum workers)
- Public accessibility to Czech cultural heritage (public researchers, people engaged in history, tourists)
- Spatial planning that helps construction and industrial developers save on costs (developers, public administration)
- Methodical and technological progress under the framework of Digital Humanities (multidisciplinary environment)

Achieved results

Currently, basic information on all planned, ongoing and completed fieldwork projects/events and their results is being registered in the AIS CR

databases. The AIS CR team is also involved in finishing the revision of existing datasets, retrospectively amending previously unrecorded information, incorporating data from field surveys and creating new user services. Another priority is to increase the compatibility of AIS CR with other information resources (both national and international) and to strengthen international collaboration.

AIS CR tools and services:

- Archaeological Map of the CR (www.archeologickamapa.cz)
- Digital Archive of the AMCR (<http://digiarchiv.amapa.cz>)
- Prague Archaeological (www.praha-archeologicka.cz)
- Archaeological Atlas of the CR (www.archeologickyatlas.cz)
- Archaeology Online (www.archeologieonline.cz)

Notes

Notes

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