TOPIC 1

Faculty: Faculty of Medicine
Institute/Department: Institute of Medical and Clinical Biochemistry

Title of the Topic: Translation of AFM Analysis of Tear Fluid into Clinical Practice as a Non-Invasive Tool for Personalized Diagnostics

Annotation: This study focuses on the processing of tear fluid droplets collected from both patients and healthy individuals, and their comparative, comprehensive analysis using atomic force microscopy (AFM). The primary objective is to characterize the nanoscale structure of tear fluid components and to identify potential differences associated with pathological processes. By applying AFM as a high-resolution analytical tool, the research aims to deepen the understanding of tear fluid biophysics and its diagnostic potential. The results of the AFM analysis will be used to train a neural network based on machine learning approaches. Subsequently, unknown samples will be evaluated using the trained model with the aim of distinguishing tear fluid from healthy individuals and experimental groups representing various ophthalmological, systemic, neurological, and psychiatric disorders. The ultimate goal is the translation of experimental laboratory findings into clinical practice through the development of a foundation for a novel, non-invasive, and personalized diagnostic approach.

Host professor: prof. Ing. Mária Mareková, CSc.
Email: maria.marekova@upjs.sk

Supervisor: prof. RNDr. Vladimíra Tomečková, PhD.
Email: vladimira.tomeckova@upjs.sk

Professional requirements/candidate criteria:

Processing of tear samples from patients and healthy individuals and their analysis using atomic force microscopy, with the aim of translating experimental laboratory results into clinical practice.

TOPIC 2

Faculty: Faculty of Science
Institute/Department: Institute of Chemistry, Department of Analytical Chemistry

Title of the Topic: Development of new analytical procedures in line with the requirements of sustainable development

Annotation: One of the current and important trends in contemporary analytical chemistry is the development of new procedures in accordance with the requirements of sustainable development. There are several approaches to ensure such development. These include, for example, the miniaturization of analytical techniques, i.e. the development of procedures that would allow obtaining a high-quality analytical result using significantly fewer reagents, the replacement of commonly used hazardous chemicals with safer ones, and automation. The topic is devoted to the first two of the above-mentioned methods.

Solid-phase extraction as well as liquid-liquid extraction are considered common techniques. Despite numerous disadvantages and limitations, these techniques are currently the most commonly used analytical sample preparation procedures. Various solutions have been proposed in recent years to improve these techniques and their miniaturized variations have emerged, such as solid-phase microextraction, microextraction by packed sorbent (MEPS) and pipette-tip solid-phase extraction (PT-SPE), as well as various liquid-phase miecroextraction (LPME) techniques. These improvements make it possible to significantly reduce and sometimes completely eliminate the use of organic solvents during analysis. It is necessary to emphasize the high publication and citation potential of similar research in Q1-Q2 journals. The research involves the development of new and/or improvement of existing SPE and LPME techniques for concentration and separation of target analytes in environmental and food samples in order to improve their analytical characteristics. The developed methods will be validated by the analysis of real samples.

Host professor: prof. Dr. Yaroslav Bazeľ, DrSc.
Email address: yaroslav.bazel@upjs.sk

Supervisor: prof. Mgr. Vasiľ Andruch, DSc.
Email address: vasil.andruch@upjs.sk

Professional requirements/candidate criteria:

Experience in green analytical chemistry. Experience in microextraction methods, mainly DSPE, PT-SPE, MEPS, SDME, etc. Experience with green solvents, mainly deep eutectic solvents, surfactants, etc. Experience in student supervision (defended diploma theses). Willingness to complete several (1-2 month) stays abroad.

TOPIC 3

Faculty: Faculty of Science
Institute/department: Institute of Chemistry/Department of Physical Chemistry

Title of the Topic: Sustainable transition metal electrocatalysts for hydrogen production

Annotation: The main objective of the project is to develop highly efficient catalysts based on transition metal nitrides, carbides, or borides for electrochemical water splitting. Particular emphasis will be placed on exploring simple and environmentally friendly synthesis methods, comprehensive characterization

Host professor: prof. RNDr. Renáta Oriňaková, DrSc.
Email address: renata.orinakova@upjs.sk

Supervisor: prof. RNDr. Renáta Oriňaková, DrSc.
Email address: renata.orinakova@upjs.sk

Professional requirements/candidate criteria:
- PhD degree in one of the study programs Physical Chemistry, Inorganic Chemistry, Material Chemistry, Chemical Engineering
- at least three publications in scientific journals registered in the WoS database, first or corresponding author on at least one of them,
- experience in electrochemistry

TOPIC 4

Faculty: Faculty of Science
Institute/department: Institute of Physics, Department of Condensed Matter Physics

Title of the Topic: Study of the structure and physical properties of metallic glasses far from thermodynamic equilibrium.

Annotation: The postdoctoral project aims to strengthen the research group for structural characterization of materials (leaders: Prof. Pavol Sovák and Assoc. Prof. Jozef Bednarčík), which has been gradually established at the Department of Condensed Matter Physics since 2010 through the successful implementation of EU projects (*nanoCEXmat*, *PROMATECH*), and more recently through the *MASS-PRAM* project (No. [insert number]). The group currently possesses excellent scientific infrastructure, providing strong support for advanced research. The postdoctoral researcher will contribute to ensuring the sustainability of the MASS-PRAM project and to optimizing the use of the new laboratory's X-ray facilities for structural diagnostics of metallic glasses.

A further expected contribution is the reinforcement of the group's capabilities in preparing metallic glasses for the research topic **Study of structure and physical properties of amorphous and nanocrystalline metallic glasses**. The team needs an expert capable of reactivating existing equipment for producing amorphous alloys, particularly through *melt spinning* and *mechanical alloying* methods. The project is also expected to enhance the quality and impact of the group's scientific publications in the field of structural characterization of materials.

Host professor: prof. RNDr. Pavol Sovák, CSc.
Email address: pavol.sovak@upjs.sk

Supervisor: doc. RNDr. Jozef Bednarčík, PhD
Email address: jozef.bednarcik@upjs.sk

Professional requirements/candidate criteria:

1. Completed PhD in Physics, Materials Science, Physical Engineering, or Applied Physics.
2. Research experience focused on the production of amorphous alloys, particularly using *melt spinning* and *mechanical alloying* techniques, as well as on the investigation of their structure and physical properties. Experience with Dynamic Mechanical Analysis (DMA) methodology is an advantage.
3. Proven ability to work in an international team, demonstrated by participation in a postdoctoral or research stay abroad at a university or scientific institution outside the Slovak Republic following completion of the PhD.
4. Documented experience in presenting and publishing scientific results in recognized international databases (CC/WoS/Scopus) and at international conferences.
5. Experience in peer reviewing scientific papers published in WoS or Scopus-indexed journals are also welcomed.

TOPIC 5

Faculty: Faculty of Science
Institute/department: Institute of Physics, Department of Condensed Matter Physics

Title of the Topic: Postdoctoral study in the field of development and investigation of effective, stable and cheap thin film photoelectrocatalysts for hydrogen economy.

Annotation: The world is facing a multifaceted energy and environmental crisis that poses significant challenges for the future. On the energy side, global demand continues to rise, yet the world remains heavily reliant on finite, polluting fossil fuels to meet this demand. Addressing this crisis requires a transition to renewable energy sources, and solar hydrogen production plays a key role in enabling a sustainable, low-carbon energy system out of water and sunlight. For this technology, delafossite $CuFeO_2$ (CFO) thin film is a promising material, not only possess appropriate absorption properties, suitable bandgap alignment, and relatively high conductivity, but also can be made with the atoms abundant in the earth's crust. Nevertheless, its low solar energy conversion efficiency, long-term electrochemical stability and chemical-intensive synthesis tactics critically limit its practical applications. To overcome these limitations, thus, the postdoctoral research intends to develop effective, low-cost and stable CFO thin films. Strategically, it imbeds with exploiting of synthesis-property-performance relationship that includes state-of-the-art sputtering of metal oxides and nitrides coating, scrutinizing their physicochemical properties, and conducting photoelectrochemical tests toward the development of cheap and easily scalable CFO based devices.

Host professor: Prof. RNDr. Pavol Sovák CSc.
Email address: pavol.sovak@upjs.sk

Supervisor: Doc. Mgr. Vladimír Komanický Ph.D
Email address: vladimir.komanicky@upjs.sk

Professional requirements/candidate criteria: The candidate must have experience in research in the field of electrocatalysis, fuel cells or electrolyzers . She/he must have strong teoretical and practical skills in the field of condensed matter physics, physical chemistry and materials research. The candidate must have experience in preparation of thin films by magnetron sputtering and electrodepostion. Her/his qualification must be proven by publications or pattents in the field of electrocatalysis.

TOPIC 6

Faculty: Faculty of Science
Institute/department: Institute of Physics/Department of Condensed Matter Physics

Title of the Topic: Development of core-shell magnetic nanosystems with tunable magnetic properties for tumor therapy and diagnostics.

Annotation: **Magnetic nanoparticles** represent a pivotal technological platform in contemporary nanomedicine due to their capacity to integrate therapeutic and diagnostic functionalities into a single entity, thereby fulfilling the concept of theranostics. Their unique potential lies in a multifunctional response to external magnetic fields: under an alternating magnetic field, they generate heat that can be exploited for the targeted ablation of tumor cells, whereas in the presence of strong magnetic fields, they act as highly sensitive contrast agents for MRI imaging.

A principal limitation of current nanomaterials is the mutual exclusivity of these two functions, whereby efforts to maximize therapeutic efficacy negatively correlate with the quality of the diagnostic output. The transition toward sophisticated core–shell nanostructures offers a pathway to overcome these barriers. The presented postdoctoral project focuses on the development of advanced multifunctional nanomaterials designed for innovative oncological theranostics, directly linking targeted therapy with MRI diagnostics. The research is oriented toward the design of innovative core-shell structures utilizing a combination of magnetically hard and soft phases (e.g., $CoFe_2O_4$/Mn Fe_2O_4/ a Fe_3O_4) to radically enhance heat generation in magnetic nanoparticle hyperthermia. The initial phase of the project will focus on the preparation of magnetic nanosystems via multi-step thermal decomposition, ensuring the formation of core-shell structures with high crystallinity and monodispersity. Subsequently, the surface of these nanocomposites will be functionalized with a biocompatible polyacrylic acid (PAA) coating, incorporating paramagnetic gadolinium ions. This step will yield a highly efficient and colloidally stable ferrofluid capable of providing dual (T_1/T_2) MRI contrast. The resulting system will undergo detailed analysis of its structural, morphological, and magnetic properties, including an evaluation of its cytotoxicity. In the second phase, the research will focus on the experimental verification of hyperthermic performance and the measurement of relaxometric parameters for MRI. The project will result in a fully characterized theranostic platform with a defined architecture and a thoroughly investigated synergistic effect in the fields of magnetic hyperthermia and MRI diagnostics.

Host professor: prof. Ing. Martin Orendáč, DrSc.
Email address: martin.orendac@upjs.sk

Supervisor: doc. RNDr. Adriana Zeleňáková, DrSc.
Email address: adriana.zelenakova@upjs.sk

Professional requirements/candidate criteria:
The applicant has completed doctoral studies in the field of physical aspects of condensed matter physics and material sciences with a focus on the issue of magnetic nanoparticles. The applicant must have demonstrable experience in the field of chemical synthesis of nanoparticles, measurement of magnetic properties using SQUID devices, study of the structure of nanoparticles using SEM and XRD, etc. The applicant for the post-doctoral position documents co-authorship of at least 8 scientific publications registered in WoS on the issue of magnetic nanoparticles, documents active participation in at least 5 scientific conferences focused on the issue of magnetic nanoparticles, documents research/co-research on at least 3 scientific projects with the issue of magnetic nanoparticles.

TOPIC 7

Faculty: Faculty of Science
Institute/department: Institute of Physics / Condensed Matter Physics Department

Title of the Topic: Nature of multiferroicity and spin transitions in complex oxide materials with a perovskite structure

Annotation:
Complex oxide materials with a perovskite structure are unique materials with a great application potential, in which multiferroicity plays an important role. The only known multiferroic material, which merges proper ferroelectricity and magnetism at room temperature,

is $BiFeO_3$. Some of our previous studies of substituted $BiFeO_3$ (with Sc or Cr) and solid solutions of their non-magnetic analogues show interesting phenomena, such as conversion polymorphism. As a continuation of research on this topic, rare-earth orthochromites $RCrO_3$ (R = rare-earth ion) are promising materials that show symmetry-forbidden multiferroicity with a field-induced polarization. They feature exotic low-temperature magnetism like spin-reorientation phase transitions, large magnetocaloric effect, and are very promising as magneto-optical materials. The postdoctoral researcher with previous experience in this topic will be involved in the study of physical properties of pure and substituted rare earth orthochromites $RCr_{1-x}Fe_xO_3$, including possible spin-reorientation transitions induced by high external magnetic fields. New results should expand modern understanding of the nature of multiferroicity and spin transitions in such materials.

Host professor: prof. Ing. Martin Orendáč, DrSc.
Email address: martin.orendac@upjs.sk

Supervisor: doc. RNDr. Erik Čižmár, PhD.
Email address: erik.cizmar@upjs.sk

Professional requirements/candidate criteria:
The candidate is required to have previous experience in the topic of multiferroism, in magnetic measurements, powder diffraction techniques for structural analysis, and knowledge of crystal growth is welcome. The minimum scientometric requirements: 5 papers in Scopus/WoS (3 as first author), 7 SCI citations.

TOPIC 8

Faculty: Faculty of Science
Institute/department: Institute of Physics/Department of Biophysics

Title of the topic: Thermodynamic characterization of the transitions between ferryl intermediates of cytochrome c oxidase

Annotation: Coupled electron and proton transfer plays an essential role in energy conversion in living systems and is considered a key process in the cellular respiration. One of the two mechanisms, utilized by membrane-bound respiratory enzyme complexes, in the conversion of potential energy of electron transfer to the transmembrane electrochemical proton gradient, is proton pumping. This phenomenon, which was discovered in cytochrome oxidase (CcO), terminal complex of the cellular respiratory chain, remains one of the most important unresolved problems of the contemporary molecular bioenergetics. The proton pumping in CcO is driven by the free energy released during the redox transitions of the ferryl intermediates of the catalytic center of this enzyme. However, a direct and complete determination of the thermodynamic properties of the transitions and the identity of certain ferryl forms is still missing. In recent years, the group led prof. Jancura and Dr. Fabian has introduced direct calorimetric measurements characterizing the formation and transition of the ferryl intermediates into the study of energy conversion in CcO. The main aim of this postdoctoral project is to determine the thermodynamic characteristics of the transitions of ferryl forms and confirm the presence of plausible radical(s) in certain ferryl states. These goals will be achieved by combining isothermal titration calorimetry (ITC), electron paramagnetic resonance spectroscopy (EPR), density functional theory calculations and our innovative approaches.

Host professor: prof. Mgr. Daniel Jancura, PhD.
Email address: daniel.jancura@upjs.sk

Supervisor: prof. Mgr. Daniel Jancura, PhD.
Email address: daniel.jancura@upjs.sk

Professional requirements/candidate criteria: The applicant should be a successful graduate of PhD. studies in one of the following study programs: Biophysics, Biochemistry, Physical Chemistry, Chemistry. Experience in the field of research of respiratory chain enzymes, ideally the terminal complex of this chain, cytochrome oxidase. He should be proficient in various spectroscopic methods (UV-Vis absorption spectroscopy, fluorescence, time-resolved spectroscopy), calorimetric techniques (DSC, ITC), biochemical methods (e.g. chromatography) or have experience with quantum-chemical calculations.

TOPIC 9

Faculty: Faculty of Science
Institute/department: Institute of Physics, Department of Theoretical Physics and Astrophysics

Title of the Topic: Spin Transport and Spin-Current Generation in Altermagnetic Materials

Annotation: Modern society increasingly depends on advanced information and communication technologies whose continued progress is fundamentally limited by our understanding of quantum phenomena in materials. Addressing these limitations requires sustained fundamental research that can uncover and control novel quantum effects with direct technological relevance. The proposed project aims to meet this need by exploring emergent quantum properties in a newly identified class of magnetic materials.

Until recently, magnetic systems were primarily classified as either ferromagnets or antiferromagnets. However, recent theoretical predictions, later verified experimentally, have revealed that collinear magnetic structures in certain crystals can give rise to the emergence of a fundamentally new type of magnetic order referred to as altermagnetism. Altermagnets can be viewed as a distinct class of materials that combine key features of both ferromagnets and antiferromagnets: they possess zero net magnetic moment, similar to antiferromagnets, while simultaneously exhibiting spin-split electronic band structures characteristic of ferromagnets.

This unique combination offers major advantages for spintronics applications. Altermagnets retain essential ferromagnetic functionalities while avoiding drawbacks associated with net magnetization, such as stray magnetic fields, and remain compatible with semiconducting platforms. Moreover, they exhibit intrinsically ultrafast spin dynamics in the terahertz regime, making them highly attractive for next-generation information technologies. As a result, altermagnets are emerging as promising candidates for magnetic random-access memory (MRAM), spin-based logic devices, and optoelectronic applications. Their fast response, low-power operation, and tunable electronic structure could enable a new generation of energy-efficient technologies surpassing current information and communication systems.

One of the most important open questions is how altermagnets respond to external electric fields and whether they can generate robust spin-polarized currents suitable for practical spintronic functionality. Spin transport is essential for confirming genuine altermagnetic behavior, yet it remains largely unexplored both theoretically and experimentally. In particular, the generation of pure spin currents -- a key requirement for electrical spin injection into non-magnetic materials and device integration -- has not yet been demonstrated.

The proposed post-doctoral project aims to establish unambiguous theoretical protocols to disentangle genuine altermagnetic signatures, with particular emphasis on resolving recent controversial interpretations of similar response signals arising from relativistic effects such as the spin Hall effect. Central to this effort is the use of state-of-the-art density functional theory (DFT), which provides a quantitatively accurate and material-specific description of electronic structure, enabling direct and reliable comparison with experimental observations. These first-principles calculations will be combined with advanced transport approaches, including nonequilibrium Green's function (NEGF) methods and the Kubo formalism, to achieve a predictive and experimentally relevant understanding of spin-current generation and the spin-splitter effect in altermagnets.

This project will contribute to the development of next-generation spintronic materials and devices and aligns with the key research objectives of the European M-ERA.NET consortium ALTMAG, which brings together six leading European research laboratories with the ambition of transforming altermagnetic concepts into practical technologies.

Host professor: prof. RNDr. Michal Jaščur, CSc.
Email address: michal.jascur@upjs.sk

Supervisor: RNDr. Martin Gmitra, PhD.
Email address: martin.gmitra@upjs.sk

Professional requirements/candidate criteria:

- PhD degree in condensed matter physics, materials science, or a related field
- A proven track record in spintronics, magnetic materials, and spin transport phenomena
- Strong background with demonstrated expertise in electronic structure calculations, especially density functional theory (DFT)
- Experience with first-principles computational packages such as Quantum ESPRESSO, VASP, OpenMX, SIESTA or similar electronic structure codes
- Experience with spin-dependent quantum transport methods such as nonequilibrium Green's functions (NEGF), Kubo formalism, or related approaches
- Programming skills for scientific computing (Python, MATLAB, Fortran, C/C++)
- Experience with high-performance computing (HPC) environments is an advantage
- Good communication skills in English and ability to work in an international research environment

TOPIC 10

Faculty: Faculty of Science
Institute/department: Institute of Biological and Ecological Sciences/Department of Zoology

Title of the Topic: Patterns of morphological, ecological, and genetic diversity in relict communities of soil oribatid mites (Acari: Oribatida) along microclimatic gradients at ice caves

Annotation: Progressive climate warming has been a reality over the past two decades, leading to the retreat and disappearance of permanent ice deposits in ice caves of the temperate zone. Entrance zones of these caves create unique environments with inverted zonation of microclimate and vegetation, representing microrefugia for cold-adapted soil organisms. Climate change therefore poses a direct threat to local populations of highly specialized and adapted organisms. The aim of the postdoctoral position will be the study of soil oribatid mites (Acari: Oribatida) using a modern integrative approach combining morphological and molecular data. The research will be conducted at selected ice caves in the temperate zone across the Carpathians, Alps, Dinaric Mountains, and the Caucasus Mts. The expected outcome will be an assessment of genetic variability and distribution patterns of ecological groups in selected oribatid mite species inhabiting microclimatically contrasting habitats of cave entrance zones, which will contribute to a better understanding of their molecular phylogeny and the historical evolution of genetic lineages in the postglacial period within a broader geographical context. At the same time, the research will help to clarify the role of these habitats in maintaining high α-diversity of soil fauna. It is expected that the results of this study may directly contribute to the urgent need for conservation of these rare habitats and their biological communities.

Host professor: prof. RNDr. Ľubomír Kováč, CSc.
Email address: lubomir.kovac@upjs.sk

Supervisor: prof. RNDr. Ľubomír Kováč, CSc.
Email address: lubomir.kovac@upjs.sk

Professional requirements/candidate criteria:
1. PhD. in Biology or related disciplines, such as Zoology and Ecology
2. Advanced knowledge on ecology of soil and subterranean fauna, with a focus on oribatid mites (Acari: Oribatida).
3. Practical skills in taxonomical identification of oribatid mites (Acari: Oribatida) based on morphological criteria.
4. Practical experience in molecular biology techniques and genetic data analysis.
5. Scientific publications dealing with the ecology and genetics of soil and cave fauna.
6. Strong personal motivation in development of scientific career.
7. Assistance and research activities during the field wo

TOPIC 11

Faculty: Faculty of Science
Institute/department: Institute of Biology and Ecology / Department of Zoology and Animal Physiology

Title of the Topic: Anthropogenic alteration of lowland wetlands and biological responses of amphibians and reptiles

Annotation: Several lowland areas of Central Europe have undergone extensive landscape transformations in the post-war period (e.g. drainage and land reclamation, channelization of formerly dynamic rivers, agricultural intensification, and habitat fragmentation), while the biological responses (adaptations) of water-associated amphibian and reptile taxa and communities remain poorly understood. Using the East Slovakian Lowland as a model area, an in-depth survey of water-dependent herpetofauna (amphibians and selected reptiles [grass snakes of the genus *Natrix* and the European pond turtle *Emys orbicularis*]) will be conducted through intensive field sampling employing environmental DNA (eDNA), complemented in selected species by the study of morphological and genomic-level processes (e.g. gene expression and DNA methylation). The aim is to identify overall species richness at selected sites in relation to wetland desiccation, landscape changes driven by anthropogenic activities, and historical geographic and landscape data. For selected species, adaptive processes will be investigated, including adaptations to hypoxia as a proxy factor model-linked to ongoing climate change. The obtained results will also be analysed with respect to potential migration corridors, as well as biodiversity and conservation hotspots.

Host professor: prof. RNDr. Ľubomír Kováč, CSc.
Email address: lubomir.kovac@upjs.sk

Supervisor: prof. RNDr. Marcel Uhrin, PhD.
Emailová adresa: marcel.uhrin@upjs.sk

Professional requirements/candidate criteria:

- Holder of a doctoral degree (third level of higher education) in ***environmental science and ecology*** and/or ***life sciences***, with a focus on herpetological research
- Authorship and/or co-authorship of at least three scientific publications indexed in the Web of Science (WoS) databases
- Applicants for the postdoctoral position must be no more than five calendar years after completion of their doctoral degree as of 30 September of the relevant year of the call announcement (this period does not include maternity or parental leave, civilian or military service, or other objectively justified interruptions of professional practice)