



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

ABSTRACT BOOK



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 1

Title: Development of crystalline 2D polymers for next-generation energy storage

Project leader: Atsushi Nagai

Contact: atsushi.nagai@ensemble3.eu

FNP programme: International Research Agendas Programme (IRAP)

Covalent organic frameworks (COFs) are a class of important porous materials that allow atomically precise integration of building blocks to achieve pre-designable pore size and geometry. Thus, various COFs can be achieved features of 2D COFs, with confined spaces in controllable 1D nanochannels, offer the possibility to trigger interactions with excitons, electrons, holes, spin, ion, and molecules. Wide structural tunability, and good electrochemical stability of the COFs have bestowed the COF-based batteries or fuel cells with various merits as following: (i) The light weight of COFs could reduce the weight of the batteries or fuel cells. (ii) The easy functionalization of the COFs structure allows it to be modified for application in batteries or fuel cells. (iii) The covalent linkages and functional groups in COFs endow the framework with high electrochemical stability. (iv) The layer-ordered porous structure of the COFs can provide fast ion transport channel and is helpful to form a homogenous Li⁺ or proton flux. (v) The designable ordered porosity could sieve anions to further improve Li⁺ transference or proton number. According to these merits, our research focuses on the development of solid electrolytes for the battery and fuel cell. Interestingly, in the Lithium-ion battery, the Li⁺ conduction is through hopping involving neighboring site within the ordered channels. In the fuel cells, the proton of acids in the COFs will be promoted to form the infinite proton networks in the COFs with water to provide a highly speed channel for proton hopping transfer, unlike generally fuel cells.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 2

Title: Collisional losses of ultracold molecules due to intermediate complex formation

Project leader: Michał Tomza

Contact: michal.tomza@fuw.edu.pl

FNP programme: FIRST TEAM

Authors: Michał Tomza

Understanding the sources of losses and chemical reactions of ultracold alkali-metal molecules is among the critical elements needed for their application in precision measurements and quantum technologies. Recent experiments with nonreactive systems have reported unexpectedly large loss rates, posing a challenge for theoretical explanation. Here, we examine the dynamics of intermediate four-atom complexes formed in bimolecular collisions. We estimate the nuclear spin-rotation, spin-spin, and quadrupole coupling constants for bialkali four-atom complexes using *ab initio* quantum-chemical methods. We show that the variation in the nuclear spin-spin and quadrupole couplings may be strong enough to couple different rotational manifolds to increase the density of states and lifetimes of the collision complexes, which is consistent with experimental results. We also reveal that the interaction-induced variation of electron spin-nuclear spin couplings may explain the recently observed long lifetime of alkali-metal three-atom complexes formed in atom-molecule collisions. Finally, we propose further experiments that could verify our predictions.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 3

**Title: Development of new resin formulations for bioprinting in DLP
and SLA technology**

Project leader: Joanna Ortyl

Contact: joanna.ortyl@photohitech.com

FNP programme: TEAM-TECH

Authors: Joanna Ortyl, Monika Topa-Skwarczyńska, Wiktoria Tomal, Maciej Pilch, Patryk Szymaszek, Andrzej Świeży, Filip Petko, Magdalena Jankowska, Patrycja Środa, Dominika Krok, Katarzyna Starzak, Paweł Niezgoda, Paweł Stalmach, Małgorzata Noworyta, Bartosz Oksiuta, Paweł Jamróż, Dawid Kiesiewicz, Weronika Wańczyk, Karolina Gałuszka, Jakub Strzała, Szymon Żydowski, Jakub Szymański, Dawid Oksiuta

Due to the continuous search for highly efficient photoinitiator systems in the production of polymer coatings and in high-speed 3D imaging technologies, a research plan has been proposed to deal with application issues extended with research aspects concerning the development of new high-performance photoinitiator-catalyst systems (PICs) demonstrating versatility by being able to photochemically initiate all types of standard photopolymerisation processes, such as cationic photopolymerisation (CP), free-radical polymerisation (FRP), thiol-ene photopolymerisation and hybrid photopolymerisation. Similar to the 3D printing technology used in industry, the medical bioprinting process uses a mechanism of precise layering of biological, biochemical and, most importantly, living cell materials together with the ability to spatially arrange the structures themselves in a specific, pre-planned manner. The project has resulted in the development of effective systems for 3D printing in 3D-DLP /SLA technology using photopolymerisation processes. Currently, formulations have also been developed for bioprinting processes to build spatial objects from biological materials.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 4

Title: RNA metabolic pathways in stem cells: interplay between splicing and translation in development

Project leader: Agnieszka Chacińska, Magda Konarska

Contact: m.ciesla@imol.institute

FNP programme: International Research Agendas Programme (IRAP)

Authors: Vladyslava Liudkovska, Kevork Wakimian, Maciej Cieřła

Embryonic stem cells (ESCs) are pluripotent cells derived from the inner cell mass of a blastocyst. ESCs have an unlimited capacity for self-renewal and the potential to differentiate into every cell type. This is achieved through rapid re-wiring of key cellular pathways during specification, that gradually restricts ESCs' plasticity and promote differentiation. The exit of ESCs from pluripotency relies on the fast gene expression shifts achieved through post-transcriptional gene regulation. This includes alternative splicing, polyadenylation, RNA modifications, differential translation or control of stability. However, dynamics of machineries maintaining RNA metabolism upon exit from pluripotency remain poorly defined. We hypothesized that specification of ESCs is maintained by regulation of expression of factors involved in RNA metabolism. Using a combination of high-throughput transcriptomic and proteomic approaches, we identify ESC-specific expression patterns of RNA metabolism-related factors, e.g. RNA-binding proteins, splicing factors, exonucleases, and enzymes impacting mRNA stability. As a model, we studied the pluripotent human H9 ESCs and their early differentiated progenies, embryo bodies (EBs). To analyze changes in transcription (total RNA) and translation (polysome-bound mRNAs) between ESCs and EBs, we performed global deep RNA sequencing. We also determined the relative protein abundances between pluripotent cells and embryo bodies by quantitative mass spectrometry. Together, we create a translation dynamics map of RNA metabolism factors during ESCs differentiation. Subsequent experiments will focus on the selected factors, to determine the relevance of their translational regulation and its effect on downstream molecular events in the context of ESCs function.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 5

Title: Compact fiber-based mid-infrared frequency comb sources for precision spectroscopy of greenhouse gases

Project leader: Grzegorz Sobon

Contact: grzegorz.sobon@pwr.edu.pl

FNP programme: FIRST TEAM

Authors: Karol Krzempek, Dorota Tomaszewska-Rolla, Aleksander Głuszek, Arkadiusz Hudzikowski, Mikołaj Krakowski, Adrian Hjältén, Matthias Germann, Aleksandra Foltynowicz, Grzegorz Sobon

The main goal of the Project is to develop novel types of compact laser systems (so-called optical frequency combs) in the mid-infrared spectral range, which will be suitable for outside-lab operation. Such sources are in demand for many applications, particularly laser spectroscopy, e.g., for fast and sensitive detection of multiple air pollutants simultaneously (especially greenhouse gases), and precision spectroscopy (high-resolution studies of broadband molecular spectra). Recently, we developed a fully functional prototype of a mid-infrared frequency comb, which covers the spectral range of 7 – 9 μm , and achieved the main milestone: we proved the applicability of our optical frequency combs to spectroscopy. The broad spectral coverage of the comb enabled us to measure low-pressure spectra of nitrous oxide (N_2O), a greenhouse gas and air pollutant; methane (CH_4), potent greenhouse gas and constituent of (exo-) planetary atmospheres, and formaldehyde (H_2CO), an atmospheric pollutant and constituent of the interstellar medium. All of them are of strong interest to atmospheric physics and astrophysics. The currently available databases of line lists of these molecules are still primarily based on traditional FTIR studies. Optical frequency comb spectroscopy offers superior frequency accuracy and precision but was hindered by the lack of comb sources in that spectral range. We measured several hundreds of line positions and intensities of these molecules, achieving unprecedented uncertainties. The accuracy of the line position determination is an order of magnitude better than what was previously available from conventional FTIR measurements. In the case of methane, the obtained data will be used to improve the global model of methane spectra. Thanks to our international collaboration with a foreign partner institution (Umeå University, Sweden), we have achieved several milestones and demonstrated tremendous progress in precise frequency comb spectroscopy.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 6

Title: Periodontal pathogens as masters of neutrophil and macrophage survival and immune responses in periodontitis

Project leader: Maja Sochalska

Contact: maja.sochalska@uj.edu.pl

FNP programme: FIRST TEAM

Authors: Maja Sochalska, Alicja Plonczynska, Zsombor Prucsi, Natalia Zubrzycka, Agnieszka Zimny, Jan Potempa

Periodontitis is a common inflammatory disease connected with the deregulation of neutrophils and macrophages recruited to periodontium in case of a microbiota shift in the oral cavity. Bacteria *Porphyromonas gingivalis* (Pg) is among the three strains responsible for the pathogenesis of the periodontal disease. Current literature shows that Pg can manipulate the recruitment of neutrophils to the periodontium, as these phagocytes become hyperactive and secrete overload of reactive oxygen species and proteolytic enzymes that contribute to the destruction of teeth surrounding tissues. During standard infection, neutrophils have a prolonged lifespan, which is controlled by proteins belonging to the Bcl-2 family, which assures enough time for bacterial eradication. Obtained results revealed that type of lipopolysaccharide isolated from Pg (activating TLR-2 & -4), contributes to the prolonged survival of neutrophils through influence on anti-apoptotic proteins expression, including Mcl-1 protein. After treatment of neutrophils with Pg LPS, production of overload of: ROS, proinflammatory cytokine TNF α as well as neutrophil serine protease – elastase were observed. Importantly, Pg directed macrophages into the highly proinflammatory death type. Pharmacological inhibition of Mcl-1 protein expression or blocking anti-apoptotic signaling pathway (dependent on PI3K or SYK) blocked neutrophil and macrophage inflammatory responses and may be potentially used in periodontitis treatment.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 7

Title: MLK4 (Mixed-Lineage Kinase 4) as a new player in breast cancer progression

Project leader: Anna Marusiak

Contact: a.marusiak@imol.institute

FNP programme: International Research Agendas Programme (IRAP)

Authors: Dawid Mehlich, Alicja Mazan, Dagmara Dymerska, Michał Łomiak, Agnieszka Borowiec, Kamila Karpińska, Anna A. Marusiak

Breast cancer is one of the most common malignancies in women, and the development of better therapies for breast cancer patients remains a major unmet need in breast oncology. Our team identified an oncogenic function of MLK4 in breast cancer, highlighting that the inhibition of this kinase could be an effective strategy for breast cancer treatment. Mixed-Lineage Kinase 4 (MLK4) is a member of the serine/threonine kinases family. Recent cancer genomics data indicated that MLK4 is amplified and overexpressed in breast cancer, facilitating the aggressive growth and migratory potential of cancer cells. We demonstrated that MLK4 promotes triple-negative breast cancer (TNBC) chemoresistance by regulating the pro-survival response to DNA-damaging therapies. Furthermore, our new data indicated that MLK4 activates the phenotypic changes of breast cancer cells induced by macrophages, the main components of the tumour microenvironment. Using mixed co-culture of breast cancer cells and macrophages, we showed that MLK4-mediated cross-talk between these cell types promotes cancer growth and metastasis. In summary, we demonstrated mechanistic details of how MLK4 contributes to oncogenesis and resistance to chemotherapies and provided a rationale for the therapeutic targeting of MLK4 in the treatment of cancer patients.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 8

Title: Development of Conductive Fibrous Hydrogels for Neural Interfaces

Project leader: Filippo Pierini

Contact: shzargar@ippt.pan.pl

FNP programme: FIRST TEAM

Authors: Seyed Shahrooz Zargarian, Chiara Rinoldi, Yasamin Ziai,
Mohammad Ali Haghighat Bayan, Paweł Nakielski, Filippo Pierini

Recently, conductive hydrogels have been utilized as interfaces for neural electrode arrays to improve their biocompatibility and lower protein adsorption. Alas, the chronic application of such interfaces is still challenging due to their relatively low stimuli-responsive characteristics. The utilization of porous, high surface area and stimuli-responsive hydrogels may compensate for these physiochemical shortcomings, offering multifunctional properties such as low electrical impedance, better mechanical properties, and lower thickness. To this end, a conductive hydrogel with semi-interpenetrating polymer network (semi-IPN) structure comprised of poly (N-isopropyl acrylamide) (PNIPAAm)-based copolymer and polythiophene (PT) was synthesized in this work and miniaturized via a nanofabrication method to be used as a neural interface. The electrospinnability of the solution was facilitated by the high molecular weight of the synthesized PNIPAAm-based block copolymer and its narrow molecular weight distribution. A cytocompatible and degradable dendrimer was used as the crosslinking agent of the semi-IPN with ample surface groups, which allowed a dual-hardening physical and chemical gelation process. Consequently, a lowered curing temperature was necessary to attain structural robustness at molecular and macroscopic levels. The fibrous hydrogel gave water molecules rapid access to the whole material and switched on a fast responsive characteristic. Furthermore, the conductive fibrous semi-IPN displayed a lower impedance compared to the conductive bulk hydrogel. This occurrence was attributed to the formation of a large electrochemical surface area that resulted from system miniaturization. The incorporation of PT chains in the hydrogel network promoted the synergetic effect between the two components leading to the fabrication of a superior fibrous interpenetrating network neural interface with remarkable electrochemical properties.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 9

Title: Femtosecond fiber laser sources for multiphoton microscopy of human retina and two-photon vision studies in humans

Project leader: Grzegorz Soboń

Contact: dorota.stachowiak@pwr.edu.pl

FNP programme: FIRST TEAM

Authors: Dorota Stachowiak, Jakub Bogusławski, Marcin Marzejon, Zbigniew Łaszczych, Aleksander Głuszek, Arkadiusz Hudzikowski, Katarzyna Komar, Maciej Wojtkowski, Grzegorz Soboń

Femtosecond lasers have found an interesting application in the field of biophotonics, in particular in noninvasive diagnostics such as optical imaging and multiphoton microscopy, e.g. the two-photon excited fluorescent (TPEF) imaging. Additionally, the spectral tunability of the laser is very attractive for applications like non-invasive ophthalmic diagnostics with two-photon studies, where pulsed infrared light (800-1200 nm) is perceived due to the two-photon absorption occurring in visual pigments (as 400-600 nm wavelengths). As a result of our research, we demonstrate two types of laser sources. The first one is an Er-doped fiber laser prototype at TRL 9, optimized for TPEF imaging. The laser generates ultrashort pulses at 780 nm wavelength with sub-60 fs duration and >1.3 nJ of energy, with a widely tunable pulse repetition rate (1-12 MHz). The laser was installed at the IChF and integrated with the scanning TPEF microscope. After preliminary tests on ex-vivo biological samples, researchers at IChF PAN performed the first experiments with TPEF microscopy of the human eye. The excellent laser parameters enabled obtaining the world's first TPEF images of the human retina, which is a tremendous step towards developing novel diagnostic tools and applying fiber laser-based instruments in clinical and pre-clinical studies. The second laser source is an Er-doped fiber laser, spectrally shifted to the wavelength range of 1750-2140 nm, and then frequency-doubled in a second harmonic generation module. This source provides the spectral tuning range 872-1075 nm, with a pulse duration of sub-230 fs. The excellent laser source parameters allowed us to perform reliable experiments and obtain a scotopic luminance curve in a wide range of 200 nm for 2PV for 3 healthy persons. The developed technology might be beneficial for testing human vision sensitivity in case of cataract or other age-related opacifications, and achieved results have an excellent tech-transfer potential.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 10

**Title: Polymer-derived ceramics based composites as anodes for fast charging
Li-ion batteries**

Project leader: Monika Wilamowska-Zawlocka

Contact: monika.wilamowska@pg.edu.pl

FNP programme: POWROTY / REINTEGRATION

Authors: Monika Wilamowska-Zawlocka, Dominik Knozowski, Pradeep Vallachira,
Warriam Sasikumar, Magdalena Graczyk-Zajac, Grzegorz Trykowski, Gurdial Blugan

Polymer-derived ceramics (PDCs) have been evaluated as promising anode materials for lithium-ion batteries (LIBs) due to their unique properties. PDCs exhibit high capacities, stability upon charge-discharge processes and slight volume changes during lithiation. Polymer-derived silicon oxycarbides (SiOC) consist of SiO_xC_y ($x, y = 0-4$) silicon tetrahedra and a free carbon phase. The microstructure and chemical composition of SiOCs depend on a precursor type, synthesis and pyrolysis parameters and the presence of additional components, and may be easily tuned to achieve desired properties. Therefore, they may act as valuable electrochemically active matrices for composite materials. Here, we present binary and ternary composites based on SiOC, graphite and tin nanoparticles as valuable anodes for fast-charging LIBs. Incorporation of graphite into SiOC matrix has several advantages, including enhancement of the first cycle Coulombic efficiency, whereas the introduction of tin nanoparticles improves electric conductivity of the material and increased capacity values. Electrochemical characterization of the presented binary and ternary composites along with their thorough structural investigation indicate the importance of proper tailoring of their composition and structure to boost the electrochemical performance of the anodes in LIBs.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 11

Title: Functional Polymers and Biomaterials for a Sustainable Future

Project leader: Alexander Steinbüchel

Contact: vignesh.kumaravel@p.lodz.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Vignesh Kumaravel, Zeinab Qazanfarzadeh, Deniz Atila,
Lekshmi Gopakumari Satheesh Chandran, Anshu Dubey

Polymers and biomaterials (PolyBioMat) group of ICRI-BioM is addressing global challenges such as greenhouse gas emissions, energy crises, infectious diseases, and environmental pollution in a sustainable way using functional/smart materials. Valorization of agro-industrial waste has a significant role in fulfilling the circular bioeconomy goals. Fabrication of packaging materials from agro-industrial waste renders a great opportunity to raise the value-added of these wastes. This strategy not only decreases waste accumulation but also causes a positive environmental impact. In dental tissue engineering, the incorporation of antimicrobial agents and the use of biomaterials meet the requirements of dental pulp restoration due to their biodegradability. On the other hand, recycled synthetic polymers match with mechanical needs for 3D-printing of hard tissue parts of teeth, while reducing the ecological footprint of humankind. The COVID-19 pandemic testified to the need for the development of antibacterial medical implants/devices through sustainable technologies to prevent infection risks. Biodegradable polymer coatings can be used with medical implants to address microbial infections and poor osseointegration without compromising bioactivity, stability, and mechanical durability. Fabrication of carbonaceous materials via the upcycling of agricultural waste is a potential strategy to engineer materials for carbon dioxide conversion into fuels. Besides, the bio-derived carbon-polymer scaffolds could also be utilized for bone tissue regeneration and contraceptives with superior durability, heat transfer, and antimicrobial features. Our findings would be of great interest to researchers in chemistry, materials science, biotechnology, and microbiology. PolyBioMat inventions would assuredly support to the development of a sustainable society with a green economy and environment.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 12

Title: The translome of the spore – translation regulation in *Bacillus subtilis*

Project leader: Agata L. Starosta

Contact: agata.starosta@ibb.waw.pl

FNP programme: FIRST TEAM

Author: Agata L. Starosta

Our lab is interested in gene expression regulation on a translational level in various bacteria. Using Next Generation Sequencing techniques to analyse transcriptome and translome (ribosome profiling) in combination with molecular biology and biochemical methods, we study how translation of mRNAs can be modulated by the ribosome itself and/or associated translation factors. We look into translational machinery and translome of the sporulating *B. subtilis*. Sporulation is a way for *Bacillus subtilis* to respond to hostile conditions like nutrient deprivation. It's highly organized process where mother cell divides asymmetrically to give a rise to a spore. Unlike vegetative division, where cells divide every 20-40 min, sporulation takes hours and can be divided into highly trackable stages. Sporulation in *Bacillus subtilis* is well described on the level of transcriptional regulation, but almost nothing is known about translation regulation of this process.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 13

Title: Dynamics and quality control of mitochondrial respiratory complexes in disease-associated stress.

Project leader: Karolina Szczepanowska

Contact: k.szczepanowska@imol.institute

FNP programme: International Research Agendas Programme (IRAP)

Authors: Hanna Salmonowicz, Mahdi S. Mahdi, Karolina Szczepanowska

Szczepanowska Lab is fascinated by mechanisms underlying the regulation of cellular metabolism. Our research focuses on the quality control and remodeling of mitochondrial respiratory complexes, a set of elaborate molecular machines critical for energy production and global metabolic fluxes. The major aim is to understand how respiratory complexes are surveilled, repaired, and turned over, particularly upon exposure to stress. Our ongoing projects spotlight the consequences of intrinsic and microenvironmental stress associated with metabolic reprogramming imposed by changes in cellular proliferation. Although respiratory complexes play an important role in carcinogenesis and cellular senescence, the two extreme traits of cell proliferation capacity, the exact underlying mechanisms remain elusive. With the help of advanced proteomic and classical biochemistry approaches, we identify the differences in the dynamics and fitness of respiratory complexes in cancer and senescent cells. Furthermore, we investigate the role of intramitochondrial protein quality control machinery in shaping respiratory chain complexes in response to these pathological conditions. Our findings will help design new therapeutic strategies raised against diseases associated with the energetic crisis and altered metabolism in our cells.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 14

Title: Core Facility for Crystallographic and Biophysical Research to Support the Development of Medicinal Products

Project leader: Krzysztof Woźniak

Contact: kwozniak@chem.uw.edu.pl

FNP programme: TEAM-TECH Core Facility

Authors: Marlena Kisiała, Maura Malińska, Jan Kutner, Monika Wanat, Daria Dawidziak, Szymon Sutula, Krzysztof Woźniak

As a result of the TEAM-TECH Core Facility grant award from the Foundation for Polish Science (FNP), we have established the Core Facility for Crystallography and Biophysics (CFCB) at the Biological and Chemical Research Centre, University of Warsaw, under the supervision of Prof. Krzysztof Woźniak. The Core Facility services are focused on the analysis of proteins and small molecule compounds leading to crystallization trials for academic and commercial users. The project enables studies of challenging biochemical, pharmaceutical, chemical and physical problems, with an emphasis on drug development. Research at CFCB is carried out in an interdisciplinary way, including both wet biology ("BIO") and chemical crystallography ("CHEM") pipelines as well as theoretical approaches. Apart from services and collaborations, postdoctoral and PhD researchers carry out their own research projects dedicated to challenging biochemical and crystallographic problems. We also develop new crystallographic methodologies. Work in Core Facility includes collaboration with other research groups and biotech/pharmaceutical companies such as : WPD Pharmaceuticals, Cellis, Leaderna Biostructures, OncoArendi Therapeutics, Pikralida, Bio-Rad, Innvigo, Chemirol, Moleculin(USA), "Grupa Azoty S.A." + a few more. We also cooperate with Dr. Sebastian Glatt (Structural Biology Core Facility, Jagiellonian University, Cracow) under the TT CF extension with focus on the commercial aspects (The Integrative Platform for Accelerated Drug Discovery – IPADD). As the first group in Poland, and one of a few in Europe, we have started electron diffraction structural studies using our Glacios ED microscope. We are open to different forms of collaborations with individual researchers, research groups or biotech/pharma companies. Acknowledgments The project is supported by FNP/EU under the European Regional Development Fund (TEAM TECH CORE FACILITY/2017-3/4, POIR.04.04.00-00-31DF/17-00).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 15

Title: Radical Ring-opening Polymerization (rROP) to prepare (bio)degradable analogues of commercially important plastics

Project leader: Christopher Plummer

Contact: christopher.plummer@p.lodz.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Christopher M. Plummer, Vishal Purohit, Marlena Pieta

The versatility and durability of plastics, coupled with their low cost of production, has resulted in an a worldwide production exceeding 335-million tonnes per year. While some polymer waste is incinerated for energy production, most is either discarded into landfill or directly into the environment. Microplastic waste is now also becoming pervasive throughout the environment and food chain, with the long-term consequences yet to be established. This situation has forced governments around the world to initiate long-term changes to their policies regarding the manufacture and use of disposable plastics. The European Union (EU) has recently ruled a ban on single-use plastic within its member states, focusing on items including plastic bags, wrappers, cutlery, plates and straws. An emerging technique to produce (bio)degradable polymers is the copolymerization of tailor-made monomers with conventional monomer feedstock. One such promising technique is “radical ring-opening polymerization” (rROP) which allows the installation of degradable linkages into the backbone of conventional free-radical polymerization (FRP) produced polymers (ca. 50% of all polymers). Discovered in 2019, a new class of rROP monomers are the thionolactones. These monomers install thioester linkages which can be more readily broken than their (oxo)ester counterparts, degrading by processes including hydrolysis, aminolysis, trans-thioesterification and oxidative hydrolysis. It is envisioned that these additional susceptibilities could assist in the environmental degradation of polymers, as nitrogen- and sulfur-containing molecules (i.e., amino acids) are ubiquitous throughout the natural environment, as are oxidation processes.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 16

Title: Filaggrin insufficiency modifies the impact of keratinocyte-derived small extracellular vesicles on CD1a-mediated T cell responses by altering provision of lipid antigens

Project leader: Danuta Gutowska-Owsiak

Contact: danuta.gutowska-owsiak@ug.edu.pl

FNP programme: FIRST TEAM

Authors: Adrian Kobiela, Weronika Hewelt-Belka, Joanna E. Frackowiak, Lilit Hovhannisyan, Aleksandra E. Bogucka, Rachel Etherington, Artus Piróg, Irena Dapic, Susanne Gabrielsson, Sara J. Brown, Graham S. Ogg, Danuta Gutowska-Owsiak

GOALS: Filaggrin (FLG) is critical for structural, antimicrobial and immunological functions of the skin barrier; all these being linked to keratinocyte differentiation. FLG insufficiency is prominent in atopic dermatitis (AD), asthma and hay fever. Small extracellular vesicles (sEVs) carry proteins, nucleic acids, lipids and other mediators as messengers between cells, distant tissues and organs. FLG insufficiency affects multiple cell functions; we investigated its impact on the sEVs, and the involvement of keratinocyte-derived sEVs in the process of antigen presentation to immune cells (T cells). **RELEVANCE/IMPACT:** Understanding of the impact of sEVs secreted by FLG-insufficient keratinocytes is important for proposing novel therapeutic and preventive strategies for allergic manifestations. **SCIENTIFIC CHALLENGES:** Antigen-specific T cell responses to lipids are difficult to study and we are the first to show that sEVs may participate in those. **RESULTS:** We found that sEVs constitute a source of antigens for lipid-specific CD1a-mediated antigen presentation pathway, and activate or block T cells upon release of lipids. We also found that sEVs secreted by FLG-insufficient cells have different content of lipids and this affects the response that we observe from antigen-specific T cells reacting to the components of the sEV membranes. **DISCUSSION:** Filaggrin insufficiency remodels the lipid compartment of keratinocytes which has an impact of the communication between the epidermis and immune cells. We believe that this has importance locally in the skin, but may also impact on processes elsewhere in the body, such as inflammation in the lungs or nasal mucosa.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 17

Title: Multiapplicability of OLED emitters

Project leader: Przemyslaw Data

Contact: Przemyslaw.Data@gmail.com

FNP programme: FIRST TEAM

Authors: Paola Zimmermann Crocomo, Massimiliano Sipala, Aleksandra Nyga, Ivan Gusev, Jaijanarthan Lingagouder, Marli Ferreira, Przemyslaw Data

Every new generation of lighting was formed by a solution that gave a more efficient and easier to handle (not particularly cheaper) electric light source. Nowadays, lighting is dominated by LEDs, nevertheless, like with displays, OLEDs are nearby trying to take over the market. From the viewpoint of emission mechanisms, there are two types of emitters: fluorescence and phosphorescence emitters. Fluorescence emitters are the first generation of electroluminescence emitters for OLEDs, but they are restricted by the upper limit of internal quantum efficiency (IQE) of 25% due to spin statistics. The phosphorescence emitters are more efficient and used in OLED-based displays. The main problem with phosphorescence emitters is that they are organometallic complexes comprising very expensive and rare heavy metals such as Ir and Pt. The search for all-organic TADF (Thermally Activated Delayed Fluorescence) and RTP (Room Temperature Phosphorescence) emitters is conducted to overcome this problem. Both of the processes allow to harvest of 100% of the energy used for excitation, and those processes are opposite to each other. Moreover, fragile aspects of the charge transfer state allow us to not only control those processes in one molecule but also to observe both processes at the same time. The slight energy difference between those states gives an opportunity to use OLED emitters as sensors as well, only a little change in temperature, humidity, and oxygen content can cause the switch between emissive states. Finally, the deep understating of the charge transfer phenomena allowed us to predict which OLED emitters can be used as efficient singlet oxygen release layers (antimicrobial layers). Control and understanding of the excited states and charge transfer process result in many new OLED emitters applications.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 18

Title: Multifunctional quantum devices for metrology, quantum information processing and communication

Project leader: Konrad Banaszek

Contact: m.parniak@cent.uw.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Michał Parniak

The first generation of quantum devices were brought by many brilliant ideas, where for example atomic systems could be used to enhance quantum communication (via quantum repeater protocols) or enhance sensing of very weak signals. Working on those systems for the past 20 years has brought significant progress in controlling the quantum matter and information. Certainly one example of advanced quantum devices are quantum computers - while they cannot be practical yet, they do provide complex computational capabilities via an extraordinary level of control. In our research we use those control capabilities to create completely new, next-generation quantum devices, which allow sensing, communication and processing within one systems in order to gain greater advantage. For example, we used a multifunctional quantum-memory processor to demonstrate a quantum-enhanced super-resolution spectroscopy protocol [M. Mazelanik et al., Nature Communications 13, 691 (2022)] for very narrowband light. Our new systems, which we developed also within the QOT project, involve Rydberg atoms, that allow SI-traceable sensing of microwave fields as well as enhance the space of possible quantum operations. Our advances also stretch towards quantum optomechanical systems, as part of my work within the team in Niels Bohr Institute in Copenhagen. I would like to outline recent progress and future plans that strive to combine creation of practical quantum devices and simultaneous progress in the fundamental ground-breaking research.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 19

Title: Targeted protein degradation in Escherichia coli using CLIPPERS

Project leader: Maria Górna

Contact: mgorna@chem.uw.edu.pl

FNP programme: FIRST TEAM

Authors: Matylda A. Izert, Maria M. Klimecka, Anna Antosiewicz,
Patrycja Szybowska, Remigiusz Serwa, Maria W. Górna

Targeted Protein Degradation is a new exciting approach to drug discovery that relies on degradation of disease-causing proteins, typically via the ubiquitin-proteasome pathway. The urgent need for next generation antibiotics could be answered by this type of drugs, but a different degradation pathway must be used in bacteria since they lack the ubiquitin-proteasome system. We present our invention, the Clp-Interacting Peptidic Protein Erasers (CLIPPERS) which are chimeric peptides that recruit the ClpXP protease to knock down target endogenous proteins in Escherichia coli. CLIPPERS show antimicrobial activity when directed against essential proteins and can be used as tools to study protein function and to validate antimicrobial drug targets.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 20

Title: Innovative sub-THz sensors developed within the CENTERA project

Project leader: Wojciech Knap

Contact: mvaleri@unipress.waw.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Valeri Mikhnev, Grzegorz Cywiński, Thomas Skotnicki, Wojciech Knap

THz radiation possesses specific and unique properties. Exploitation of these properties enables sensing features undetectable in visible light nor in X-ray inspection. In the CENTERA project we have conceived a variety of innovative sensors working around 24GHz and 80GHz frequencies. We will present a sensor aimed at detection of an almond in a candie, a sensor of moisture content in plastics, an universal dielectric coating sensor capable of nondestructive thickness measurement without necessity of calibration, a sensor capable of measuring impurity level in gasoline, etc. In the next step those sensors will be upgraded to higher frequencies such as 0.3 THz and 0.6 THz, which are expected to offer still more sophisticated and accurate measurements. All these subTHz and THz sensors are developed in view of demonstration of practical and society important THz waves applications.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 21

Title: A heterotypic assembly mechanism regulates CHIP E3 ligase activity

Project leader: Wojciech Pokrzywa

Contact: wpokrzywa@iimcb.gov.pl

FNP programme: FIRST TEAM

Authors: Aniruddha Das, Pankaj Thapa, Ulises Santiago, Nilesh Shanmugam, Katarzyna Banasiak, Katarzyna Dąbrowska, Hendrik Nolte, Natalia A Szulc, Rose M Gathungu, Dominik Cysewski, Marcus Krüger, Michał Dadlez, Marcin Nowotny, Carlos J Camacho, Thorsten Hoppe, Wojciech Pokrzywa

CHIP (C-terminus of Hsc70-interacting protein) and its worm ortholog CHN-1 are E3 ubiquitin ligases that link the chaperone system with the ubiquitin-proteasome system (UPS). CHN-1 can cooperate with UFD-2, another E3 ligase, to accelerate ubiquitin chain formation; however, the basis for the high processivity of this E3s set has remained obscure. Here, we studied the molecular mechanism and function of the CHN-1–UFD-2 complex in *Caenorhabditis elegans*. Our data show that UFD-2 binding promotes the cooperation between CHN-1 and ubiquitin-conjugating E2 enzymes by stabilizing the CHN-1 U-box dimer. However, HSP70/HSP-1 chaperone outcompetes UFD-2 for CHN-1 binding, thereby promoting a shift to the autoinhibited CHN-1 state by acting on a conserved residue in its U-box domain. The interaction with UFD-2 enables CHN-1 to efficiently ubiquitylate and regulate S-adenosylhomocysteinase (AHCY-1), a key enzyme in the S-adenosylmethionine (SAM) regeneration cycle, which is essential for SAM-dependent methylation. Our results define the molecular mechanism underlying the synergistic cooperation of CHN-1 and UFD-2 in substrate ubiquitylation.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 22

Title: SorLA limits anti-inflammatory actions of glioma-associated microglia/macrophages and can be targeted to prevent glioma growth

Project leader: Anna Malik

Contact: ar.malik@uw.edu.pl

FNP programme: HOMING

Authors: Paulina Kaminska, Mateusz Jakiel, Magda Bakun, Michal Draminski, Tomasz Obrebski, Magdalena Fliszkiewicz, Bozena Kaminska, Michal Dadlez, Michal J. Dabrowski, Anna Malik

VPS10P domain receptors are intracellular sorting receptors, primarily recognized in neuronal cells, where they direct protein cargo (i.e. growth factors, extracellular matrix components, signaling receptors) to their distinct subcellular localizations. Emerging evidence suggests that VPS10P receptors can play important roles also in non-neuronal cells, including microglia. Those innate immune cells of central nervous system (CNS) acquire diverse functional properties depending on the pathophysiological context. Glioblastoma (GBM) is characterized by infiltration of glioma associated microglia and macrophages (GAMs) which stimulate angiogenesis, suppress immune response against tumor, and promote its invasiveness. Mechanisms underlying such properties of GAMs still remain poorly understood. A recent study shows that SORL1, a gene encoding SorLA (a member of VPS10P receptors family), is highly expressed in GAM's. We hypothesised that SorLA can play a key role in phenotype polarization of GAMs thereby influencing their pro-tumorigenic properties. The goal of our studies is to evaluate the impact of SorLA on reprogramming of GAMs, characterize factors involved in regulation of SORL1 expression, identify SorLA targets in microglia and assess the consequences of SorLA depletion on glioma progression.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 23

**Title: Functional dissection of IGH enhancers and enhancer RNAs
in B-cell lymphomas**

Project leader: Agnieszka Dzikiewicz-Krawczyk

Contact: krawczyk@man.poznan.pl

FNP programme: FIRST TEAM

Authors: Marta Kasprzyk, Weronika Sura, Wojciech Łosiewski, Marta Podralska,
Marta Kazimierska, Tomasz Woźniak, Natalia Rozwadowska,
Agnieszka Dzikiewicz-Krawczyk

Characteristic feature of B-cell non-Hodgkin lymphomas (NHL) are recurrent translocations juxtaposing an oncogene (e.g. MYC) with the immunoglobulin heavy chain (IGH) enhancers: E μ and 3' regulatory regions (3'RR1, 3'RR2). Survival and proliferation of many B-cell lymphomas depend on the expression of the translocated oncogene. The function of IGH enhancers in normal B-cell maturation is well established, while the precise mechanisms of their involvement in oncogene expression and lymphomagenesis are yet to be determined. Our goal is to identify functional elements in the IGH enhancers and transcribed enhancer RNAs (eRNAs), which are essential for oncogene expression and B-cell lymphoma cell growth. We designed a sgRNA library densely covering the IGH enhancers and performed tiling CRISPR interference screens in three NHL cell lines. Our results revealed three 500-700 bp regions, one in the E μ and two in the 3'RR enhancers, whose targeting profoundly inhibited NHL cells growth. In parallel, we performed chromatin-enriched RNA-Seq in lymphoma and normal B cells, which confirmed eRNA transcription from the essential enhancer regions. We validated eRNA expression in a large panel of NHL cell lines and in patient-derived samples. Inhibition of the transcription from the essential enhancer regions led to downregulation of MYC and reduced fitness of several B-cell lymphoma cell lines. Presence of B-cell receptor on cell surface was affected by targeting the E μ enhancer but only slightly by inhibiting the 3'RRs. This indicates that the observed effect can be mainly attributed to the regulation of oncogene expression by IGH enhancers. We are performing rescue experiments with MYC overexpression to further confirm this findings. Our current challenge is to establish whether the very act of transcription or the eRNA transcripts themselves are important. To this end we are working on eRNA knockdown.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 24

**Title: Unravel mosaics - novel approaches in post-zygotic variation research
in 3P-Medicine Laboratory**

Project leader: Jan Dumanski

Contact: mab@gumed.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Arkadiusz Piotrowski, Jakub Mieczkowski, Natalia Filipowicz

The overarching aim of the program in 3P-Medicine Laboratory is beyond state-of-the-art analyses of a poorly explored area of postzygotic mutations (PZMs) that can predispose to various diseases. During four years of our study we gathered a comprehensive cancer-oriented collection of over 42000 samples from 3500 donors with 7 diagnoses. Based on that we have realized several projects to study PZMs in civilizational diseases implementing novel laboratory approaches including Duplex sequencing, scRNAseq, and spatial transcriptomics. Our recently published results demonstrate that structural chromosomal aberrations and clearly pathogenic point variants in crucial breast cancer driver genes are frequent in the normal mammary glandular tissue that remains after breast-conserving surgery. This finding was obtained using targeted resequencing and confirmed with an ultra-sensitive Duplex sequencing method. Extensive studies of cancer and Alzheimer Disease in the context of Loss of Chromosome Y (LOY) showed its coexistence with clonal hematopoiesis of indeterminate potential (CHIP) and allowed identification of LOY-associated transcriptional effect (LATE) in sorted leukocytes subfractions. Our unit also implemented 10x Visium spatial transcriptomics that combines transcriptomics with morphology and allows us to examine novel modes of gene expression regulations. In our recent manuscript we proposed to increase the accuracy of the cell recognition and results of the spatial transcriptomic profiles by application of innovative Consecutive Slices Data Integration (CSDI) for postmortem brains. The findings of our projects allow us to find the most relevant mutation from the predisposition point of view, provide new insights in early disease mechanisms and reveal new biomarkers.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 25

**Title: Topological Transition in (111)-oriented Pb(1-x)Sn(x)Se Epilayers
Probed by Spin-Resolved ARPES**

Project leader: Tomasz Dietl

Contact: wojto@magtop.ifpan.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Bartłomiej Turowski, Aleksandr Kazakov, Rafal Rudniewski,
Tomasz Sobol, Ewa Partyka-Jankowska, Tomasz Wojciechowski,
Marta Aleszkiewicz, Wojciech Zaleszczyk, Magdalena Szczepanik,
Valentine Volobuev, Tomasz Wojtowicz

The helical spin texture on the surface of topological crystalline insulators (TCI) makes these materials attractive for application in spintronics [1]. Topological crystalline insulators based on the narrow gap lead-tin chalcogenide IV-VI semiconductors provide a unique platform for studying topological phase transitions as a function of external perturbations [2]. In this work, spin-polarization and electronic structure of surface states of (111)-oriented Pb(1-x)Sn(x)Se TCI epitaxial films with both trivial and topological compositions x were examined by angle- as well as spin-resolved photoemission spectroscopy (SR-ARPES). RHEED and AFM were used to prove high surface quality of MBE-grown samples and XRD and EDX-SEM techniques were used to determine Sn films' content. E(k) ARPES spectra and spin-resolved energy dispersive profiles were recorded in photon energy range of 50-90 eV. The topological-to-normal transition manifested by the opening of the band gap was investigated as a function of Sn content and temperature. In addition, it was shown that the opening of the gap can also be induced by deposition of a transition metal (TM) on the layer surface. In the latter case, the gapping of the surface states is caused by a change in the composition of the surface, rather than magnetism. An important finding of our study is that helical spin polarization occurs not only for samples with topological composition, but also for trivial samples (with an open band gap). The observed spin polarization reaches a value of 30% for the in-plane spin component and is almost absent for the out-of-plane component. We believe that our work will pave the way for the application of surface states of not only topological but also normal insulators based on lead-tin chalcogenides in spin-charge conversion devices.

[1] C. H. Li, et al., Nat. Nanotechn. 9, 218 (2014). [2] P.S. Mandal, et al., Nat. Commun. 8, 968 (2017).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 26

Title: Bioactive coating materials designed for bone tissue engineering

Project leader: Andrzej Trochimczuk, Agnieszka Sobczak-Kupiec

Contact: agnieszka.sobczak-kupiec@pk.edu.pl

FNP programme: TEAM-NET

Authors: Agnieszka Sobczak-Kupiec, Dagmara Słota, Wioletta Florkiewicz,
Magdalena Bańkosz, Agnieszka Tomala, Anna Drabczyk,
Sonia Kudłacik-Kramarczyk, Bożena Tylińczak

The project goal is to develop a composite bioactive coating material designed for bone tissue engineering. For this purpose, polymeric materials like polyvinylpyrrolidone and polyethylene glycol, ceramics - hydroxyapatite as well as collagen were chosen for the composition. Such a coating can be used to cover other implants, e.g. composite or polymeric, providing better attachment of the implant with surrounding tissues. However, the innovation of the developed approach is the modification of the samples with additional active ingredients such as drug and protein growth factors. Modification with the drug - clindamycin enables the use of the biomaterial developed under the project as a carrier for the active substance. Using HPLC technique, the release kinetics of the drug over 14 days were confirmed and determined. The protein growth factors selected for modification were vascular endothelial growth factor (VEGF) and transforming growth factor beta (TGF- β). VEGF is responsible for the formation of a network of blood vessels, thus ensuring better implant engraftment into the surrounding tissues. TGF- β , on the other hand, has anti-inflammatory effects, as well as controlling proliferation and differentiation in most cell types. Protein release was determined by ELISA. What is also important is that the developed biomaterials were subjected to incubation studies during which no degradation was observed in simulated physiological fluids. In addition, the safety of the developed coatings was confirmed by cytotoxicity and in vivo tests. The developed biomaterial exhibits great potential for both treatment and application. So far, no such solution with similar parameters and composition has been found in the available literature.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 27

Title: Ultra-pure photosensors for Dark matter search and Medical application

Project leader: Leszek Roszkowski

Contact: masayuki@camk.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Iftikhar Ahmad, Azam Zabihi, Masayuki Wada

We develop ultra-pure photosensors based on Silicon Photo Multipliers (SiPMs) for experimental searches for new physics beyond the Standard Model, such as dark matter direction and neutrino-less double beta decay. We also apply the same technology to medical devices based on SiPMs, such as a Positron Emission Tomography (PET) scanner. This ultra-pure photosensor enables us to search for the elusive signal from dark matter particles, which are hypothetical particles never detected so far. The discovery of dark matter will cause revolutionary change in our understanding of our universe. With specific readout integrated electronics, SiPMs are suitable for PET scanners. For our applications, the time resolution of the signal from SiPM plus the integrated electronics is important as well as the radio purity of the sensors. In collaboration with INFN Torino, the University Cagliari, and Princeton, we will measure the time resolution in liquid argon. We are targeting to achieve a time resolution of <100 ps.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 28

Title: Towards Quantum Technologies in Quantum Resources Group

Project leader: Marek Kuś

Contact: korzekwa.kamil@gmail.com

FNP programme: TEAM-NET

Authors: Oliver Reardon-Smith, Alexssandre de Oliveira Junior, Roberto Salazar, Fereshte Shahbeigi, Kamil Korzekwa

Recent progress in experimental control over noisy intermediate-scale quantum (NISQ) systems may soon bring the advent of new technologies, whose operation will be based on purely quantum effects and that will be able to overcome current limitations of electromechanical systems and information processors. The general goal of the Quantum Resources Group is to develop a theoretical framework underpinning quantum technologies by identifying quantum resources (i.e., components of quantum theory that can provide an advantage over the best classical performance), characterising them, and finding optimal ways to use them in experimental setups with realistic constraints. In this presentation we will demonstrate our most important results so far that revolve mainly around quantum computing and quantum thermodynamics. This includes designing, implementing, and testing a state-of-the-art classical simulator of universal quantum circuits (in collaboration with IBM); discovering a novel quantum advantage allowing one to use less memory while implementing certain information processing and thermodynamic tasks than what is needed classically; and developing mathematical tools to capture coherent thermodynamic processes and thus directly investigating the role played by quantum coherence in decreasing free energy dissipation. Finally, we will also discuss our current struggles and the avenues for future research in the years to come.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 29

Title: Spatial organization of FGF receptor 1 by multimeric ligand assemblies – towards modulation of cellular signaling and precise drug delivery via FGFR1

Project leader: Łukasz Opaliński

Contact: lukasz.opalinski@uwr.edu.pl

FNP programme: FIRST TEAM

Authors: Natalia Porębska, Marta Poźniak, Kamil Jastrzębski, Agata Knapik, Marta Miączyńska, Łukasz Opaliński

Fibroblast growth factor receptor 1 (FGFR1) is a cell surface receptor that together with extracellular fibroblast growth factors (FGFs) transduce signals through the plasma membrane, regulating angiogenesis, embryogenesis, tissue repair and metabolism. Aberrant FGFRs-FGFs signaling leads to the severe developmental disorders and cancers. In the current model FGF binding triggers FGFR1 dimerization and activation. The cellular consequences of FGFR1 clustering into larger oligomers have not been explored so far. The objective of the project was to elucidate how FGFR1 clustering into oligomers of various architectures on the cell surface influences function and cellular trafficking of the receptor. We developed multimeric ligand assemblies (MLAs) specific for FGFR1 of distinct 3D structures. We have shown that oligomerization of ligands, independently of applied scaffold, results in largely increased affinity of MLAs for FGFR1, alters kinetics of signals transduction and promotes FGFR1 endocytosis by simultaneous engagement of clathrin-dependent and clathrin-independent endocytic pathways. We used the superior features of MLAs for the development of highly selective and highly potent cytotoxic conjugates of well-defined molecular architectures that effectively kill cancer cells overproducing FGFR1. Summarizing, in this project we have demonstrated that ligand-induced alterations in the spatial organization of FGFR1 may serve as an attractive tool to fine-tune cellular signaling and cell physiology. Furthermore, enhanced binding of FGFR1 and elevated endocytosis of MLAs can be used in precise anti-cancer medicine for effective and selective drug delivery into cancer cells.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 30

Title: Inflammation during early development changes the psychosocial behavior of adult mice

Project leader: Leszek Kaczmarek

Contact: k.protokowicz@nencki.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Karolina Protokowicz, Iwona Sirocka, Leszek Kaczmarek

The development of the nervous system is strictly organized in time. Due to the complexity and fragility of this process, any aberration may lead to abnormal brain functioning. Collectively, disorders that affect the nervous system development are called neurodevelopmental disorders (NDDs). NDDs characterized by altered psychosocial behavior, such as Autism spectrum disorder or schizophrenia are considered to have a multifactorial etiology. It is, however, believed that inflammatory reactions may be among their causes. The aim of this study was to evaluate changes in psychosocial behavior of adult mice treated with lipopolysaccharide (LPS) early in life. LPS injections are commonly used to mimic bacterial infection in animal models. In terms of onset of exuberant synaptogenesis, postnatal day 7 (P7) in mice corresponds with the second trimester of pregnancy in humans. On P7, mouse pups of both sexes were injected either with LPS or physiological saline (12 animals per group). After 3 weeks, behavioral tests were conducted. To evaluate anxiety levels in various conditions, a self-grooming test (SG), marble burying test (MB), and elevated plus maze (EPM) were used. The learning pace of animals has been tested in the IntelliCage system. The sociability of mice has been assessed with the Eco-HAB (EH) cage system and Three Chamber test (3Ch). Additionally, applied behavioral tests allowed the evaluation of animals' activity. Mice after the LPS treatment were less anxious (EPM $p=0,0412$; MB p .



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 31

Title: Generation of high-resolution map of chromatin contacts mediated by CTCF and cohesin in human genome using HiChIP approach

Project leader: Dariusz Plewczyński

Contact: d.plewczynski@cent.uw.edu.pl

FNP programme: TEAM

Authors: Karolina Jodkowska, Zofia Tojek, Michał Łażniewski, Dariusz Plewczyński

Human DNA, with a total length of about 2 meters, is spread over 23 chromosomes, which are tightly packed in a cell nucleus about 10 μ M in diameter. The way the chromatin is packed is related to the functions the cell performs in the organism. A major international scientific initiative such as the 1000 Genomes Project has made it possible to detect structural variants that occur within 26 human populations from around the world. Significantly, structural variants such as deletions, duplications, inversions, insertions, translocations can potentially be located in areas of the genome where structural elements are present and thus alter chromatin organization. As a consequence, cell functions can be disrupted, which in some cases can lead to human diseases. One of the main goals of our project is to study the relationship between the three-dimensional structure of chromatin in the cell nucleus and changes in the linear sequence of the human genome on a population scale. To this aim we have generated high resolution CTCF chromatin interaction maps for three families (mother, father and a daughter) from 1000 Genome Project using HiChIP approach. Our data indicate that CTCF chromatin interactions as well as chromatin contact domains (CCDs) are conserved between the lymphoblastoid cell lines analyzed. We have also detected a set of chromatin interactions mediated by cohesin for the members of Yoruban family. We are currently working on integration of 3D chromatin structure information with the structural variants data and on their comparison between the cell lines.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 32

Title: Macrophage-based, tumor drug delivery as treatment for solid cancer

Project leader: Tomasz Rygiel

Contact: trygiel@imdik.pan.pl

FNP programme: TEAM-TECH

Authors: Agata Braniewska, Marcin Skórzyński, Zuzanna Sas, Ilona Marszałek, Damian Strzemecki, Magdalena Król, Tomasz P. Rygiel

Hemoglobin (Hb) is a physiological protein with a primary function as an oxygen or carbon dioxide transporter. On the other hand, free hemoglobin that is released from red blood cells could have a harmful effect by generating reactive oxygen species and it must be rapidly sequestered. We found that macrophages can uptake large quantities of free Hb independently of the previously described mechanism via the CD163 receptor. Importantly, after the Hb uptake macrophages transfer a large fraction of the Hb to the neighboring cells. To a large extent, this process is conducted by the production of extracellular vesicles. Using this knowledge, we applied Hb as a drug carrier. We developed a Hb-drug conjugate that could be used in cancer therapy. Hb-drug conjugate was loaded into macrophages, that served as live drug nanocarriers. Such prepared cells were effective in cancer cell killing in co-culture cell assays in vitro. Importantly, Hb-drug-loaded macrophages were effective in the therapy of the mouse dispersed breast cancer model, showing a significant reduction of cancer growth. Building on these findings, together with our consortium partner Cellis [Ltd.] we are developing a platform of therapeutic macrophage carrier cells as therapy for solid tumors.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 33

Title: Virtual Reality Simulator for Fetoscopic Spina Bifida Repair Surgery

Project leader: Przemysław Korzeniowski

Contact: p.korzeniowski@sanoscience.org

FNP programme: International Research Agendas Programme (IRAP)

Authors: Przemysław Korzeniowski, Szymon Płotka,
Robert Brawura-Biskupski-Samaha, Arkadiusz Sitek

Spina Bifida (SB) is a birth defect developed during the early stage of pregnancy in which there is an incomplete closing of the spine around the spinal cord. The growing interest in fetoscopic Spina Bifida repair, which is performed in fetuses who are still in the pregnant uterus, prompts the need for appropriate training. The learning curve for such procedures is steep and requires excellent procedural skills. Computer based virtual reality (VR) simulation systems offer a safe, cost-effective, and configurable training environment free from ethical and patient safety issues. However, to the best of our knowledge, there are currently no commercial or experimental VR training simulation systems available for fetoscopic SBrepair procedures. We propose a novel VR simulator for core manual skills training for SB-repair. An initial simulation realism validation study was carried out by obtaining subjective feedback (face and content validity) from 14 clinicians. The overall simulation realism was on average marked 4.07 on a 5-point Likert scale (1 - 'very unrealistic', 5 - 'very realistic'). Its usefulness as a training tool for SBrepair as well as in learning fundamental laparoscopic skills was marked 4.63 and 4.80, respectively. These results indicate that VR simulation of fetoscopic procedures may contribute to surgical training without putting fetuses and their mothers at risk. It could also facilitate wider adaptation of fetoscopic procedures in place of much more invasive open fetal surgeries.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 34

Title: Supramolecular materials designed for fundamental studies and energy conversion technologies

Project leader: Piotr Kaszynski

Contact: piotr.kaszynski@chemia.uni.lodz.pl

FNP programme: TEAM

Author: Piotr Kaszynski

The presented research program deals with systematic development of rationally designed unique self-organizing molecular materials forming fluid supramolecular structures (liquid crystalline phases) with potential applications in energy harvesting, energy storage and information processing. In this context, the project is focused on the synthesis and comprehensive analysis with a wide range of physical methods of two classes of rationally designed liquid crystalline materials exhibiting: a) paramagnetism, facile photo-generation of charges and their transport in external fields, and b) anisotropic transport of Li⁺ and Na⁺ ions. The main structural elements of these new supramolecular materials are π -delocalized benzo[e][1,2,4]triazinyl radical and inorganic boron clusters, which provide the key properties of the investigated materials. Judicious choice of substituents in these building blocks permits the control of molecular properties and, consequently, affects bulk behavior of the materials. The significance of this research program lies in the addressing of current technological needs by developing broad classes of organic paramagnetic semiconductors, photoconductors, and electrolytes, and detailed understanding of their structure-property relationships (both molecular and macromolecular). From this point of view this research will make significant contributions to basic knowledge in several areas of science, while the resulting materials are attractive for applications in the fields such as solar energy harvesting, molecular electronics, and electrolytes for ion batteries.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 35

Title: Exploration of the neuronal architecture of working memory using human single-neuron activity

Project leader: Leszek Kaczmarek, Ewelina Knapska

Contact: j.kaminski@nencki.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Katarzyna Paluch, Mikołaj Magnuski, Władysław Średniawa, Olga Matysiak, Monika Służewska-Niedźwiedź, Wojciech Fortuna, Katarzyna Smarzewska, Paweł Tabakow, Harish Babu, Jan Kamiński

Neurons are fundamental - structural and functional - blocks of the brain. Because of that our progress in understanding neuronal mechanisms stems from recording activity of these specific cells. Unfortunately, opportunities to record activity of human neurons are extremely rare. This is a significant obstacle to our quest for understanding neuronal mechanisms underlying cognitive processes unique to humans. In this project we try to utilize a rare opportunity to record a single-neuron activity during surgical procedures when a direct access to the human brain is necessary for treatment. We focus our work on higher cognitive functions, especially Working Memory (WM) that constitutes the basis of our mind. In collaboration with neurosurgery clinics in Poland and the USA we tested the neuronal correlates of WM buffers and executive control of WM. Our preliminary analysis shows that stimulus specific persistent activity could be a mechanism of maintaining information in WM buffer no matter if item is currently in the focus of attention or not. The unattended content previously was postulated to be coded with activity silent mechanisms, and our result is the first argument, in this hotly debated topic, showing direct evidence of persistent activity of single human neurons for unattended WM items. Furthermore, we explored how information about task sets is being coded and maintained by executive control of WM. Our observations of neuronal activity in Medial Frontal Lobe suggests that task sets are coded using unstable dynamic activity. This dynamic activity could be a key component for flexible human behavior. Together, these results for the first time shows comprehensive view of neuronal architecture of WM using direct measurement of human neuronal activity.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 36

Title: Quantum Machine Learning Group

Project leader: Marek Kuś

Contact: z.puchala@iitis.pl

FNP programme: TEAM-NET

Author: Zbigniew Puchała

With increasing complexity and inter-connectivity in the modern world the ability to solve optimization problems becomes indispensable. However, these problems are intrinsically hard to resolve as they usually require searching over an astronomically large spaces of possible solutions. The most promising idea to overcome these difficulties could rely on quantum computers, annealers such as the D-Wave 2000Q chip, in particular. In principle, such machines could solve a variety of (hard) optimization problems (almost) “naturally” by finding low energy eigenstates. Quantum machine learning is a field of research and engineering that focuses on employing quantum information and computation for learning from data. Such intrinsic features of quantum mechanics as linearity, randomness, superposition and entanglement can be naturally employed to process data using quantum resources. Many classical machine learning techniques use linear algebra and probability theory as their foundations therefore there exists a natural mapping between mathematical theory of machine learning and two first features of quantum mechanics. The poster will contain the results in the area of quantum machine learning obtained by the group: - Translation of business problems to quantum annealing architecture, we will show the specific industry problems which was analyzed. - New schemes for benchmarking and certification for quantum operations. - Learning of quantum operations, especially results concerning learning of quantum measurement apparatus.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 37

Title: Monte Carlo calculations of Curie temperatures of (Y/Gd)(Fe/Co)₂ pseudobinary system

Project leader: Mirosław Werwiński

Contact: werwinski@ifmpan.poznan.pl

FNP programme: HOMING

Authors: Mirosław Werwiński, Bartosz Wasilewski

In this work we computationally investigated the pseudo-binary Laves phase system $Y_{1-x}Gd_x(Fe_{1-y}Co_y)_2$ spanning between the YFe_2 , YCo_2 , $GdFe_2$, and $GdCo_2$ vertices. While the vast majority of the $Y_{1-x}Gd_x(Fe_{1-y}Co_y)_2$ phase diagram is the ferrimagnetic phase, YCo_2 along with a narrow range of compositions around it is the paramagnetic phase. We presented results obtained by Monte Carlo simulations of the Heisenberg model with parameters derived from first-principles calculations. For calculations, we used the Uppsala atomistic spin dynamics (UppASD) code together with the spin-polarized relativistic Korringa–Kohn–Rostoker (SPR-KKR) code. From first principles, we calculated the magnetic moments and exchange integrals for the considered pseudo-binary system, together with spin-polarized densities of states for boundary compositions. Furthermore, we showed how the compensation point with the effective zero total moment depends on the concentration in the considered ferrimagnetic phases. However, the main result of our study was the determination of the Curie temperature dependence for the system $Y_{1-x}Gd_x(Fe_{1-y}Co_y)_2$. Except for the paramagnetic region around YCo_2 , the predicted temperatures were in good qualitative and quantitative agreement with experimental results, which confirmed the ability of the method to predict magnetic transition temperatures for systems containing up to three different magnetic elements (Fe, Co, and Gd) simultaneously. For the $Y(Fe_{1-y}Co_y)_2$ and $Gd(Fe_{1-y}Co_y)_2$ systems, our calculations matched the experimentally-confirmed Slater–Pauling-like behavior of TC dependence on the Co concentration. For the $Y_{1-x}Gd_xFe_2$ system we obtained, also in agreement with the experiment, a linear dependence of TC on the Gd concentration. In addition, on the example of $Y_{0.8}Gd_{0.2}Co_2$ ferrimagnet, we showed the possibility of predicting the non-trivial behavior of the temperature dependence of magnetization, confirmed by comparison with previous measurement results.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 38

Title: A smart adaptive mechanism in your eye that you were not aware of last year

Project leader: Wiesław I. Gruszecki

Contact: wieslaw.gruszecki@umcs.pl

FNP programme: TEAM

Authors: Wojciech Grudzinski, Rafal Luchowski, Renata Welc, Maria Manuela Mendes Pinto, Alicja Sek, Jan Ostrowski, Lukasz Nierzwicki, Pawel Chodnicki, Milosz Wieczor, Karol Sowinski, Robert Rejdak, Anselm G. M. Juenemann, Grzegorz Teresinski, Jacek Czub, Wieslaw I. Gruszecki

The fact that the human eye can function effectively in both very low and very high light levels reflects its fantastic evolutionary adaptive abilities based on physiological regulatory mechanisms. One such mechanism is the well-recognized opening and contraction of the pupil of the eye. Unfortunately, this mechanism is relatively slow (minute timescale) and does not fully protect the rod-shaped photoreceptors responsible for color and precision vision, that are located in the very central part of the retina, because the pupil narrows to a diameter of approx. 2 mm. In the course of our research, we discovered the activity of another very smart regulatory mechanism in the retina of the human eye. This mechanism (called "molecular blinds") is modulated by light intensity, acts at the molecular level on a submillisecond time scale, and acts as a natural photochromic filter [1]. The active elements of the "molecular blinds" are molecules of lutein and zeaxanthin, yellow xanthophyll pigments present in the macula of the human retina. We have shown that the triggering mechanism of this adaptive mechanism is based on the reorientation of xanthophylls in biological membranes, induced by light-driven trans-cis molecular reconfiguration [1]. These studies seem to be particularly important in the light of reports that a colorful diet (including zeaxanthin and lutein) prevents AMD (age-related macular degeneration). So, the described mechanism may play a crucial role in providing protection against AMD. The discovery was the result of the activities of an international research team established to implement the project "Xanthophylls in the retina of the eye" financed by the Foundation for Polish Science (TEAM / 2016-3 / 21). References: 1. Rafal Luchowski, Wojciech Grudzinski, Renata Welc, Maria Manuela Mendes Pinto, Alicja Sek, Jan Ostrowski, Lukasz Nierzwicki, Pawel Chodnicki, Milosz Wieczor, Karol Sowinski, Robert Rejdak, Anselm G. M. Juenemann, Grzegorz Teresinski, Jacek Czub, and Wieslaw I. Gruszecki: "Light-Modulated Sunscreen Mechanism in the Retina of the Human Eye", J. Phys. Chem. B 2021, 125, 6090–6102.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 39

Title: Atomic magnetometry with Kalman Filters

Project leader: Konrad Banaszek

Contact: k.dilcher@cent.uw.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Klaudia Dilcher, Jan Kołodyński

Information inference from noisy systems is a focus of interest of various research and engineering disciplines. In 1960, Rudolf E. Kalman published a paper on an optimal filtering technique for systems described by linear dynamics and measurement models whose noise statistics is Gaussian [1]. In particular, this so-called Kalman Filter constitutes a way to construct an estimator that allows one to optimally extract the signal encoded in the system dynamics while minimizing the average mean-squared-error, despite the dynamics and measurement all undergoing uncontrolled independent stochastic fluctuations. In opposition to previously known algorithms, Kalman Filters do not require a full history of all previous steps. Because of this the technique can be used for real-time data analysis. In this work, we applied the described methods for magnetic field inference from an atomic sensor with optical read-out. Such sensors are widely used in magnetometry both within and beyond the classical limit, achieving precision comparable to cryogenic methods. The linear Kalman Filter has been applied to such systems before [2, 3]. The usability of this technique is very limited though, as the magnetic field obeys a highly non-linear dynamics in most regimes. This suggests that using the Extended Kalman Filter as well as other non-linear Kalman Filtering techniques can greatly improve the estimator beyond the linear regime. In this work, we simulate an output of such a sensor and show that in fact the magnetic field can be successfully estimated in real-time with the non-linear methods. [1] R. E. Kalman, A New Approach to Linear Filtering and Prediction Problems, Journal of Basic Engineering, vol.81, 1960. [2] Ricardo Jiménez-Martínez et. al Signal Tracking Beyond the Time Resolution of an Atomic Sensor by Kalman Filtering, PRL, vol. 120, 2018 [3] Jia Kong et. al Measurement-induced, spatially-extended entanglement in a hot, strongly-interacting atomic system, Nature Communications vol. 11, Article number: 2415, 2020.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 40

Title: Seemingly identical cells function distinctively: origins and consequences

Project leader: Michał Komorowski

Contact: m.komorowski@sysbiosig.org

FNP programme: FIRST TEAM

Authors: Piotr Topolewski, Karolina Zakrzewska, Jarosław Walczak,
Karol Nienałtowski

The same signaling stimulus can induce variable outcomes among the same cell type in a group of cells or tissue, prompting the notion that signaling is influenced by random biochemical reactions, or molecular “noise.” We generated multinuclear cells to explore whether heterogeneity in the cellular response to cytokines (the signaling molecules of the immune system), was the result of stochastic noise or of cell-to-cell variability in molecular content of cells. Our results suggest that molecular phenotypic variability makes by far the dominating contribution, and the impact of the molecular “noise” is limited. Thus, outwardly identical cells appear as a continuum of molecular phenotypes generating a repertoire of different signaling outcomes of individual cells. Further, we examined what is the consequence of the variable signaling outcomes on the efficacy of signaling inhibitors, including approved drugs. We observed that drug concentrations that result in nearly full inhibition of the average response might leave majority of cells with fully active signaling. Besides, we found that inhibitors that have similar efficacy of inhibiting population average may have considerably different efficacy of fully inhibiting signaling in single-cells, which highlights that the variability of molecular phenotypes should be accounted for in the preclinical drug development.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 41

**Title: Molecular Astrophysics Laboratory: Star-Forming Regions
in the Outer Galaxy**

Project leader: Agata Karska

Contact: agata.karska@umk.pl

FNP programme: FIRST TEAM

Authors: Agata Karska, Marta Sewiło, Lars Kristensen, Will Fischer, Miguel Figueira, Marcin Gawroński, Maciej Koprowski, Ngan Le, Mateusz Ogrodnik, Mariusz Tarnopolski, Alya Azman, Sebastian Maćkowski, Sebastian Meszyński

Stars like our Sun are born in dense, cold cocoons of dust and gas in the so-called star-forming regions. The best probes of these elusive sites are molecules, whose presence and abundances are the key to understanding physics and chemistry of star formation processes. With the advent of new, powerful telescopes it becomes possible to detect molecules even in the very far-away galaxies, but the interpretation of observations is hampered by the lack of spatial resolution and sensitivity of the instruments. In our project, we aimed to characterize star-forming regions in the outer Galaxy, where conditions are significantly different from the Solar neighborhood. For example, these regions contain much lower fraction of heavy atoms ('low metallicity'), which is typical for distant, young galaxies from the early Universe. Specific results of our project include (i) the identification of young stars in the outer Galaxy using novel techniques and multi-wavelength observations, (ii) measuring, for the first time, mass accretion rates onto young stars in the outer Galaxy and their mass loss rates, (iii) characterizing chemistry in the low-metallicity environments, e.g., obtaining the first identification of heavy water in the Large Magellanic Clouds. These results provide an important step forward in the understanding the impact of metallicity and environment on star formation. The project is continued in a close collaboration with the Max Planck Institute for Radio Astronomy in Bonn, Germany, where our group is involved in the spectroscopic follow-up of the "Outer Galaxy High Resolution Survey".



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 42

Title: Gene topology is stabilized by TFIIB to promote memory of transcriptional response in plants

Project leader: Lien Brzeźniak

Contact: lien.brzezniak@gmail.com

FNP programme: POWROTY / REINTEGRATION

Authors: Lien Brzeźniak, Emilia Cepowska, Katarzyna Stojek, Michał Krzysztoń, Ezgi Süheyla Karaaslan, Zofia Tojek, Michał Kadlof, Dariusz Plewczyński, Chang Liu, Szymon Świeżewski

Transcription is central to gene expression and has been shown to have a complicated interplay with chromatin marks as well as chromatin topology. Transcription orchestrates chromatin modifications and has been suggested to be key for the topological organization of genomes. On the other hand, the transcription process is itself controlled by chromatin state, as well as genome topology. To address this interplay in plants, we obtained an R58C mutation in Arabidopsis general transcription factor TFIIB, which was linked to the regulation of gene-level chromatin interactions in yeast. We show that expression of TFIIB1-R58C protein does not influence transcription or chromatin structure under standard conditions but during stress causes extensive alterations in genes' topology. Our data show that changes in genes' transcription caused by stress do not translate to genome topological changes, as those are buffered by the TFIIB. Complementary, we show that stress-induced topological changes do not lead to gene expression perturbations under primary stress. Importantly, they lead to significant transcriptome rearrangement during subsequent stress. This suggests gene topology is important for transcriptional memory response in plants. Finally, our analysis indicates that the distribution of gene-body interactions cannot be explained by gene expression levels, but does correlate with specific histone marks and is dependent on TFIIB during the stress response.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 43

Title: Promoter-pervasive transcription causes Pol II pausing to boost DOG1 expression in response to salt

Project leader: Szymon Świeżewski

Contact: sswiesz@ibb.waw.pl

FNP programme: TEAM

Authors: Miguel Montez, Maria Majchrowska, Michal Krzyszton,
Grzegorz Bokota, Dariusz Plewczynski, Szymon Świeżewski

Eukaryotic genomes are pervasively transcribed by RNA polymerase II. Yet, the molecular and biological implications of such a phenomenon are still largely puzzling. Here, we characterize new non-coding transcription upstream of the DOG1 gene, which governs salt stress response in Arabidopsis. DOG1 is a key regulator of seed dormancy. We find that expression of the DOG1 gene is induced by salt stress causing a delay in seed germination. Interestingly, we uncover extensive transcriptional activity on the promoter of the DOG1 gene. This produces a variety of lncRNAs, named PUPPIES, which are co-directionally transcribed and invasive to DOG1. We show that PUPPIES constitute an important environmental sensing element that in response to salt stress boosts DOG1 expression resulting in delayed germination. Strikingly, the positive impact of PUPPIES pervasive transcription on DOG1 gene expression is associated with augmented Pol II pausing, slower transcription, and higher transcriptional burst size. Our work highlights the positive role of upstream co-directional transcription in controlling transcriptional dynamics of the downstream gene.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 44

Title: Severe violation of the Wiedemann-Franz law in quantum oscillations of NbP

Project leader: Tomasz Dietl

Contact: matusiak@magtop.ifpan.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Pardeep Kumar Tanwar, Md Shahin Alam, Mujeeb Ahmad, Dariusz Kaczorowski, Marcin Matusiak

Topologically non-trivial materials exhibit a variety of extraordinary transport phenomena. Among them are those related to a heat flow, such as the thermal chiral anomaly, the mixed axial-gravitational anomaly, or the chiral zero sound (CZS) effect. The latter can be considered as evidence for the presence of multiple Weyl states, making CZS a new and efficient tool in studies of topologically non-trivial materials. A goal of the project was to investigate the CZS effect in the Weyl semimetal NbP and, to this end, the thermal conductivity (κ) was measured with the thermal gradient and magnetic field (B) applied parallel to the crystallographic [0 0 1] direction. At low temperatures $\kappa(B)$ exhibits large quantum oscillations with frequencies matching two of several determined from the Shubnikov – de Haas effect measured on the same sample with analogous electrical current and magnetic field orientation. Both frequencies found in $\kappa(B)$ originate from the electron pocket enclosing a pair of Weyl nodes. The amplitude of the oscillatory component of the thermal conductivity turns out to be two orders of magnitude larger than the corresponding value calculated from the electrical conductivity using the Wiedemann – Franz law. Analysis of possible sources of this discrepancy indicates the chiral zero sound effect as a potential cause of its appearance. Results of the studies were published in [P.K. Tanwar et al., Phys. Rev. B 106, L041106 (2022)].



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 45

Title: SERS combined with chemometric analysis for detection and identification of microorganisms: viruses and bacteria

Project leader: Agnieszka Kamińska

Contact: akamin@ichf.edu.pl

FNP programme: TEAM-TECH

Authors: A. Kamińska, S. Berus, K. Niciński, E. Witkowska, D. Korsak, I. Drózdź, M. Borowiec, T. Szymborski, J. Waluk

The present work demonstrates that surface-enhanced Raman scattering (SERS) coupled with chemometric analysis is a reliable and fast method for detection and identification of pathogenic bacteria and viruses. The proposed SERS-based method for bacteria identification challenges the standard biochemical methods in terms of simplicity, specificity and rapidity (maximum 60 s for single SERS measurement). The direct SERS analysis of bacteria (even single bacteria cell) is performed directly from SERS-active nanostructures incorporated into a microfluidic module. The recorded SERS data of bacteria are categorized (assigned to particular bacterial species) using data analysis software based on the SERS database created for bacteria. The long incubation time of bacteria is eliminated and the total analysis including numerical analysis of recorded SERS data not exceed 15 minutes. Additionally, the proposed FORMI device can be introduced to International Organization for Standardization (ISO) standards for bacteria identification, to avoid or skip the time-consuming methods routinely used in laboratories and as a result the time of analysis will be dramatically reduced. We have also performed a perspective investigations to: (i) study the changes in biochemical composition of saliva and nasopharyngeal swabs associated with viral infection; (ii) indicate the SERS-biomarkers for COVID-19 immunopathology controlling and detection; (iii) create the classification model (with validation stage) to develop the automated procedure of classification of patient's samples into two groups CoV(+) and CoV(-) using chemometric analysis, and (iv) calculate the sensitivity of SARS-CoV-2 detection from both, saliva and nasopharyngeal specimens. Presented approach opens a new path in microbiological diagnostics for sensitive, simple, quick, and on-site detection of pathogenic microorganisms including environmental and clinical microbiology (hospitals, health centre), food industry and environmental protection.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 46

Title: MMP-9 expression in induced pluripotent stem cells-derived models of early development of human brain

Project leader: Leszek Kaczmarek

Contact: b.badyra@nencki.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Bogna Badyra, Karolina Protokowicz, Marcin Barański, Ewa Liszewska, Jacek Jaworski, Steven Kushner, Leszek Kaczmarek

MMP-9 plays a pivotal role in physiological and pathological neuronal plasticity in adult nervous system. In particular, MMP-9 has been related to neuropsychiatric diseases, where its altered transcription and protein levels have been linked to the disease phenotypes. Taking into consideration both neurodevelopmental and synaptic aberrations in neuropsychiatric disorders the knowledge of precise spatiotemporal expression of MMP-9 at different stages of development can shed a light on the linkage between those diseases and MMP-9 expression and function. We have established different types of cultures (2D, 3D) and applied diverse protocols to obtain brain organoids. At distinct stages of differentiation cell samples were collected for comprehensive analyses. To evaluate MMP-9 enzymatic activity we performed gel zymography. Our results have shown protocol- and cell culture-specific dynamics of MMP-9 expression throughout neuronal differentiation. In particular, depending on the employed protocol, either sparse or abundant expression of MMP-9 could be observed. Additionally, the formation of MMP-9 complexes with lipocalin were demonstrated. To obtain a detailed spatiotemporal image we performed a series of immunostainings combined with in situ zymography. This data have enabled us to distinguish structural variations in different types of organoids that may influence dynamics of MMP-9 expression. The global differences between organoids were additionally confirmed by whole organoids imaging in light sheet microscopy after optical clearing. Finally, we have also confirmed proper maturation of organoids at later time points, by demonstrating expression of such synaptic-related proteins as RNA-binding proteins, glutamate receptors and postsynaptic scaffolding proteins. In aggregate, the results point to an involvement of MMP-9 in diverse stages of neuronal differentiation. Interestingly, time and level of expression of MMP-9 appear to be profoundly influenced by applied experimental protocol.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 47

Title: TETs at the crossroads of epigenomics and DNA repair

Project leader: Matthias Bochtler

Contact: mbochtler@iimcb.gov.pl

FNP programme: TEAM

Authors: Dominik Rafalski, Anton Slyvka, Honorata Czapinska, Anna Fedenko, Abhishek Pateria, Terry Karimi, Magda Klimczak, Matthias Bochtler

TET dioxygenases oxidize methylcytosine (5mC) to hydroxymethylcytosine (5hmC), formylcytosine (5fC), and carboxylcytosine (5caC). The conversion from 5mC to 5hmC interrupts maintenance methylation and leads to passive demethylation possible only in replicating cells. Further oxidation to 5fC and 5caC creates DNA bases resembling subjects of base excision repair and promotes active demethylation possible in replicating and terminally differentiated cells (Bochtler et al. Bioessays 2017). Phylogenetically, the TET enzymes are related to older and ubiquitously present ALKB enzymes involved in DNA repair. We noticed that TETs stand out in the family by binding the 2'-deoxynucleoside substrate in a strained syn conformation, which appears to be the evolutionary step that makes their epigenetic activity possible (Xu and Bochtler Nat Chem Biol 2020). We experimentally proved that the syn-anti switch is the mechanism for the activity change, by reverse-engineering a TET to recover the ancestral DNA repair activity (in prep.). To initiate active or active-passive DNA demethylation, TETs have to find their targets. We showed in collaboration with Drs. Jurkowski and Hore that TETs exhibit an unexpected specificity for the flanking sequence around the CpG dinucleotide. The effect is not only due to direct interactions, but also to TET imposed substrate distortions. The TET sequence specificity is detectable in cell culture, but also in germline and zygote of mice (Ravichandran et al. Sci Adv 2022). While it is clear that TETs co-opt DNA repair, it is also more controversially suggested that DNA repair co-opts TETs for checkpoint signaling. In collaboration with clinics in Dresden and Heidelberg, we looked at this possibility by studying samples of AML patients with highly aberrant karyotype, and indeed found an increased incidence of TET mutations, whereas other genes typically associated with normal or near-normal karyotype AML are less frequently mutated.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 48

**Title: Multifunctional composites biologically active for applications
in regenerative medicine of bone system**

Project leader: Andrzej Trochimczuk

Contact: konrad.szustakiewicz@pwr.edu.pl

FNP programme: TEAM-NET

Authors: Konrad Szustakiewicz, Małgorzata Gazińska, Sonia Zielińska,
Aleksandra Korbut, Bartłomiej Kryszak, Paweł Piszko

The aim of our research is to develop new materials for bone tissue engineering application. In the research we focus mostly on biodegradable and bioresorbable polymer – poly(glycerol sebacate) (PGS). The research involves synthesis of the PGS prepolymer (pPGS) and forming porous PGS-based scaffolds with an addition of hydroxyapatite (HAp) (synthesized by our consortium member from Institute of Ceramics and Building Materials in Warsaw) by means of thermally induced phase separation followed by thermal cross-linking and salt leaching (TIPS-TCL-SL) proces. All the obtained materials have been examined by means of pore size distribution and filler agglomeration (SEM), density, porosity (bouyancy method), thermal properties (DSC, TGA), molecular weigth distribution (GPC), hydrophobicity (water contact angle measurements) mechanical properties (compression strength). Also, chosen materials have been examined by means of biological properties (by our consortium members from University of Łódź).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 49

Title: First-principle modeling of topological systems

Project leader: Tomasz Dietl

Contact: autieri@magtop.ifpan.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Carmine Autieri, Giuseppe Cuono, Rajibul Islam, Ghulam Hussain,
Tomasz Dietl

Using first-principle modeling, we investigate the k-space topology for bulk, 2D systems, interfaces and curved systems. Additionally, we investigated interplay of topology with magnetism [1,2] but also with superconductivity [3]. The k-space topology appears in the presence of band inversion, with the wave functions of the conduction and valence having opposite parity. As a result, surface states with Dirac points and outstanding properties appear in topological compounds. Among topological insulators, we have the Z₂ insulators with the band inversion at the Γ point protected by time-reversal symmetry, the topological crystalline insulator, where the band inversion is protected by the combination of the time-reversal and crystal symmetry, and the quantum spin Hall (QSH) phase, in which the conductance is quantized to a value of $2e^2/h$. Among the topological semimetals, we have studied materials with semiDirac points protected by non-symmorphic symmetries [4,5], Weyl and Dirac semimetals[6]. When we break the time-reversal symmetry, other topological phases can take place as the quantum anomalous Hall effect and the axion insulator, where the conductance is half-quantized on both surfaces. We have proposed new topological phases, as the flat band in curved Weyl semimetal [7]. We have predicted QSH phases in new materials[8]. We have investigated how to tune other physical properties as the sign of the Anomalous Hall effect [9]. [1] C. Śliwa et al., Phys. Rev. B 104, L220404 (2021). [2] C. Autieri et al. Phys. Rev. B 103 (11), 115209 (2021) [3] Wen Lei et al., Phys. Rev. B 101, 205149 (2020). [4] G. Cuono et al., Phys. Rev. Materials 3, 095004 (2019). [5] D. J. Campbell et al., npj Quantum Materials 6, 38 (2021). [6] R Islam, et al., Physical Review Research 4 (2), 023114 (2022). [7] A. Lau et al., Phys. Rev. X 11, 031017 (2021). [8] R Islam, et al. arXiv:2207.08407. [9] T. C. van Thiel et al., Phys. Rev. Lett. 127, 127202 (2021).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 50

Title: INFECTLESS – new generation of antimicrobial wound dressings

Project leader: Izabela Sabała

Contact: isabala@imdik.pan.pl

FNP programme: TEAM-TECH

Authors: Elżbieta Jagielska, Paweł Mitkowski, Alicja Wysocka, Piotr Małecki,
Piotr Bartosz, Karolina Trochimiak, Weronika Augustyniak, Izabela Sabała

Wound infections are very common and can lead to serious local and systemic complications, especially if associated with other patient's condition, like diabetic foot, pressure ulcers or burns. The most common and at the same time the most difficult to treat are infections caused by staphylococci. Treatment of such infections is hampered by a very high level of antibiotic resistance. The lack of efficient treatment for staphylococcal infections leads to hospitalization and in many cases of diabetic foot ends with amputations. To address this issue we developed a new generation of wound dressing supplemented with bacteriolytic enzymes (enzybiotics) and based on modern nanomaterials. We have isolated, characterised and modified bacteriolytic enzyme against *Staphylococcus aureus* - AuresinePLUS. Just a few micrograms of this enzymes can eliminate millions of bacteria in minutes, also resistant strains, like MRSA, and those growing as biofilms. Unlike antibiotics or other antimicrobials, AuresinePLUS act by contact and is very selectively; it eliminates only staphylococcal cells, leaving the natural microflora unharmed. AuresinePLUS does not display any cytotoxicity and genotoxicity towards human cells. What is particularly important - the prevalence of resistance toward enzybiotics is very low. We supplemented the existing, modern wound dressings with AuresinePLUS and developed a new technology for generation of enzyme functionalized nanomaterials. They were all comprehensively tested first in vitro followed by advanced ex vivo assays and finally in animal skin infection model demonstrating a great potential of this new antimicrobial treatment. This project was carried out in collaboration with partners from academia, clinicians and pharma/biotech industry.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 51

Title: Collaboration of TEAM-TECH groups in modeling electromagnetic properties of materials

Project leader: Michał Mrozowski

Contact: piotr.kowalczyk@pg.edu.pl

FNP programme: TEAM-TECH

Authors: Piotr Kowalczyk, Małgorzata Warecka, Jerzy Krupka, Mariusz Zdrojek, Michał Mrozowski

The main goal of the project was to achieve a synergy effect for all three partners participating in the previous TEAM-TECH/2016 tasks: - The first team led by Professor Mariusz Zdrojek at Warsaw University of Technology ("Thermoplastic nanocomposites for efficient screening of microwave electromagnetic radiation" POIR.04.04.00-00-3C25/16) has been developing low-loss nanocomposites for applications in microwave circuits for 5G, which requires electromagnetic modeling and optimization. - Professor Jerzy Krupka's team at Warsaw University of Technology ("High-precision techniques of millimeter and sub-THz band characterization of materials for microelectronics" POIR.04.04.00-00-1C4B/16) has been working on techniques for characterizing various materials by means of resonant techniques, which involves processing the measurement data and fitting it to the model derived from Maxwell's equations. - The third group at Gdansk University of Technology led by Professor Michał Mrozowski ("EDISOn—Electromagnetic Design of flexible SensOrs" POIR.04.04.00-00-1DC3/16) has been developing dedicated software tools with high modeling capabilities which can be used in the tasks mentioned above. As a result of the cooperation of these three teams, optimal methods (involving software and procedures) for analyzing the aforementioned issues were developed. The modeling techniques allowed us to combine theory and practice, which was necessary for the efficient measurement of material parameters. The importance of the obtained results was confirmed by the fact that they have been presented at international conferences and published in the most renowned journals in the field. However, we hope that the end of the project will not finish the collaboration, and the resulting benefits will be revealed for many years to come.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 52

Title: Nanophotonics with low-dimensional materials

Project leader: Karolina Słowik

Contact: karolina@umk.pl

FNP programme: HOMING

Authors: Miriam Kosik, Marvin Mueller, David Dams, Julia Szczuczko,
Andres Ayuela, Carsten Rockstuhl, Garnett Bryant, Marta Pelc, Karolina Słowik

Depending on their chemical compounds and geometry, low-dimensional material structures such as 1D atomic chains or 2D nanoflakes offer a variety of electronic, optical and material properties. They can be used as elementary metal/semiconductor/insulator building blocks in heterostructures realizing nanoscaled optoelectronics. They may support topological properties or plasmonic optical response. The latter can be tuned by electronic or optical means or in presence of atomic defects (adatoms) [1]. In our investigations we develop and implement models to characterize the electrooptical properties of low-dimensional material flakes [1,2]. In particular, we have described how coupling selected flakes and neighbouring adatoms modulates their plasmonic response and emission properties. The key element that makes this system richer than other studied typically in the nanophotonic context, is the electron tunnelling, or hopping, between the flake and the adatom. Here, we include them our tight-binding-based formalism [2]. We characterize the absorption spectra in presence of adatoms and the spontaneous emission properties of hybrid adatom+nanoflake structures. [1] M. M. Müller, M. Kosik, M. Pelc, G. W. Bryant, A. Ayuela, C. Rockstuhl, K. Słowik, Phys. Rev. B 104, 235414 (2021), [2] M. Kosik, M. M. Müller, K. Słowik, G. W. Bryant, A. Ayuela, C. Rockstuhl, M. Pelc, Nanophotonics, 11 (14), 3281-3298 (2022).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 53

Title: Entanglement catalysis for quantum states and noisy channels

Project leader: Alexander Streltsov

Contact: a.streltsov@cent.uw.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Chandan Datta, Tulja Varun Kondra, Marek Miller, Alexander Streltsov

Many applications of the emerging quantum technologies, such as quantum teleportation and quantum key distribution, require singlets, maximally entangled states of two quantum bits. It is thus of utmost importance to develop optimal procedures for establishing singlets between remote parties. As has been shown very recently, singlets can be obtained from other quantum states by using a quantum catalyst, an entangled quantum system which is not changed in the procedure. Here we put this idea further, investigating properties of entanglement catalysis and its role for quantum communication. For transformations between bipartite pure states we prove the existence of a universal catalyst, which can enable all possible transformations in this setup. We demonstrate the advantage of catalysis in asymptotic settings, going beyond the typical assumption of independent and identically distributed systems. We further develop methods to estimate the number of singlets which can be established via a noisy quantum channel when assisted by entangled catalysts. For various types of quantum channels our results lead to optimal protocols, allowing to establish the maximal number of singlets with a single use of the channel.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 54

Title: Catalysis for the Twenty-First Century Chemical Industry

Project leader: Karol Grela

Contact: a.kajetanowicz@uw.edu.pl

FNP programme: TEAM-TECH

Authors: Anna Kajetanowicz, Karol Grela

Catalysis for the Twenty-First Century Chemical Industry A TEAM-TECH Project Anna Kajetanowicz and Karol Grela Biological and Chemical Research Centre, Faculty of Chemistry, University of Warsaw Żwirki i Wigury Street 101, 02-089 Warsaw, Poland “An anchor is forged and fashioned for faithfulness; give it ground that it can bite, and it will hold till the cable parts” “The Mirror of the Sea” Józef Teodor Konrad Korzeniowski (Joseph Conrad) In the TEAM-TECH project we are working on design and application of methods which may intensify chemical production mainly by immobilisation of well-defined organometallic catalysts and utilisation of various enabling technologies. We obtained a number of catalysts including supported ruthenium complexes which were screened in model reactions, in classical and green solvents, as well as in neat, with the help of various supportive techniques, like microwave irradiation, sonication, and flow chemistry. The catalysts were immobilised on selected solid supports, such as zeolites, metal-organic frameworks (MOF), and functionalised silica gel (Biotage), characterised, and tested in batch and continuous flow conditions. In addition, innovative methods of conducting chemical reactions, including sonication and microwave irradiation, have been developed. In our research, we focused on the use of green solvents and intermediates exploited in the production of active pharmaceutical ingredients, which significantly reduces the environmental impact of the developed chemical processes. Our results can be implemented in many branches of chemical industry for production of speciality chemicals, pharmaceuticals, cosmetics, fragrances, and fuel additives.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 55

**Title: Deciphering the environmental impact on star formation
in the Outer Galaxy**

Project leader: Agata Karska

Contact: miguel.figueira@ncbj.gov.pl

FNP programme: FIRST TEAM

Authors: Miguel Figueira, Ngan Le, Agata Karska, Arnaud Belloche, Marta Sewiło, Carsten König, James Urquhart, Dario Colombo, Friedrich Wyrowski, Karl Menten

While there is a significant number of studies aiming at increasing our knowledge of star formation in the inner Galaxy, the way stars are forming in the Outer Galaxy has received much less attention. The environment is of crucial importance, as it directly influences the properties of the future generation of stars. The Outer galaxy, where different physical and chemical conditions are found, is an ideal laboratory to study such impact. The benefits of such studies are twofold: 1) by studying star-formation in the Outer Galaxy where the metallicity is lower, we can better understand star formation in external galaxies with similar metallicity (for instance, the Magellanic Clouds) and 2) the level of details we can obtain from observations in the Milky Way is superior to what can be achieved in external galaxies. Our project aimed at studying a sample of star-forming regions in the Outer Galaxy at different wavelengths to constrain their physics and chemistry, and understand how these different conditions affect star formation compared to the Inner Galaxy. We proposed and got observing time on the Effelsberg and APEX telescopes to study the gas dynamics, physical conditions, chemistry, identify high-mass star-forming regions and look for trends with respect to the Galactocentric distance. Here, I will show how the far-IR line cooling from protostars changes as a function of Galactocentric radius. I will also present our forthcoming projects at APEX and Effelsberg, which are performed in a close collaboration with the "Outer Galaxy High Resolution Survey" team at the Max Planck Institute for Radio Astronomy in Bonn.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 56

Title: Comprehensive assessment of biocompatibility and bioactivity of piomelanin supporting the processes of skeletal regeneration

Project leader: Przemysław Płociński

Contact: przemyslaw.plocinski@biol.uni.lodz.pl

FNP programme: TEAM-NET

Authors: Mateusz Urbaniak, Monika Nowak, Małgorzata Gazińska, Monika Biernat, Aleksandra Szwed-Georgiou, Marcin Włodarczyk, Agnieszka Krupa, Konrad Szustakiewicz, Karolina Rudnicka, Przemysław Płociński

Globally, app. 1.5 million people each year suffer from bone fractures and require implant surgeries. Knowing that formation and accumulation of alkaptomelanin (ALK) deposits in patients with alkaptonuria is the signal for pathological ossification of their joints, our innovation is to use ALK produced by *P. aeruginosa* as bioactive substances inducing controlled bone regeneration. As part of TEAM-NET, we optimized the production of ALK by *P. aeruginosa*, achieving high yields in minimal media, reducing the level of contamination, production cost and maintaining the bioactivity of pyomelanin. Our interdisciplinary team, together with experts from TEAM-NET consortium: the Wrocław University of Science & Technology and the Institute of Ceramics and Building Materials of the Łukasiewicz Network, jointly performed detailed physicochemical analysis of the bacterial ALK. We are currently conducting advanced research to verify the biological activity of both microbial and synthetic ALK in the context of in vitro and ex vivo ossification. We have already completed a series of in vivo biocompatibility studies in a mouse model, and thanks to cooperation with material engineers, we have jointly developed polymer-ceramic composites containing pyomelanin for more advanced in vivo bioeffectiveness studies on a rat model. Based on available literature and research on the patent environment, aware of the innovative nature of the proposed solution, we intend to implement the ALK-facilitated implants to support local and strictly controlled stimulation of the ossification process as future commercial products. The result of our joint efforts in TEAM-NET, is the optimized preparation and comprehensive characterization of pyomelanin, including preclinical tests. This will lead to the patent protection (P.438865 and future patents) of the developed solution for its further commercialization. The know-how from our project will be further disseminated in certified courses led by UŁ.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 57

Title: NONA – Nonlinear Optics, Nanoparticles and Amyloids

Project leader: Joanna Olesiak-Bańska

Contact: joanna.olesiak-banska@pwr.edu.pl

FNP programme: FIRST TEAM

Authors: Patryk Obstarczyk, Manuela Grelich-Mucha, Maciej Lipok,
Anna Pniakowska, Marcin P. Grzelczak, Vladimir Torbeev, Łukasz Berlicki,
Wojciech Krężel, Marek Samoć, Joanna Olesiak-Banska

Amyloids are assemblies of misfolded proteins involved in numerous diseases, e.g. Alzheimer's disease, Parkinson's disease.¹ The aim of the NONA project was to find new markers and microscopy techniques for imaging the formation and morphology of amyloids. We investigated the intrinsic nonlinear optical properties (NLO) of amyloid aggregates and showed how multiphoton microscopy can provide information on the organization of the fibrils.^{2,3} We studied in depth the mechanism of one-photon and two-photon excitation and find how they correlate with the secondary structure (β -sheet content) of amyloidogenic proteins.⁴ For chiral structures of amyloids obtained from L- and D- amyloidogenic peptides we presented the relation between autofluorescence and morphology of the fibrils.⁵ Thus, amyloid-specific autofluorescence can be a promising method of label-free detection of various polymorphs of amyloids. Furthermore, we investigated gold nanoclusters (ultra small nanoparticles, which exhibit fluorescence properties) as new markers of amyloids. Nanoclusters present favourable NLO properties and are promising for two-photon fluorescence microscopy applications.⁶ We observed low cytotoxicity in vitro, favourable biodistribution profiles in mice and efficient staining of neurons with Au18 nanoclusters.⁷ Then, we developed nanoclusters with amphiphilic properties in order to facilitate binding with various regions of amyloid fibrils. Such nanoclusters can serve as multimodal markers, for both, fluorescence and electron microscopy imaging of amyloids. 1. F. Chiti et al., *Ann. Rev. Bioch.* 2006, 75, 333-366. 2. P. Obstarczyk et al. *J. Phys. Chem. Lett.* 2021, 12, 1432-1437 3. P. Obstarczyk et al. *Biomater. Sci.*, 2022, 10, 1554-1561 4. M. Grelich-Mucha et al. *J. Phys. Chem. Lett.*, 2022 13, 21, 4673-4681 5. M. Grelich et al. *J. Phys. Chem. B*, 2021, 125, 21, 5502-5510 6. J. Olesiak-Banska et al. *Chem. Soc. Rev.*, 2019, 48, 4087-4117 7. J. Sobska et al. *Nanomaterials*, 2021, 11, 1066.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 58

Title: Quantum error correction group Kraków

Project leader: Felix Huber

Contact: felix.huber@uj.edu.pl

FNP programme: TEAM-NET

Authors: Felix Huber, Albert Rico, Gerard Munne, Moises Moran, Vinayak Jagadish

We present the recent research of the Quantum Error Correction Group at the Jagiellonian University Krakow.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 59

Title: Protein and immune signature identified by unsupervised spectral multiparameter cytometric analysis to discover novel markers, mechanisms and molecular targets

Project leader: Katarzyna Piwocka

Contact: k.piwocka@nencki.edu.pl

FNP programme: TEAM-TECH Core Facility Plus

Authors: Milena Wiech, Piotr Chroscicki, Julian Swatler, Dawid Stepnik, Michal Hampel, Anna Maliszewska, Marek Durlik, Wieslaw Wierzba, Grzegorz Basak, Sara De Biasi, Andrea Cossarizza and Katarzyna Piwocka

Advanced single-cell multiparameter flow cytometry followed by unsupervised analysis is the main direction of research in immunology, cell and cancer biology. Aim of the FlowPROSPER project was to identify specific protein and immune signature to uncover mechanisms, regulatory drivers and markers in different diseases, therapeutic strategies or biological systems. This included implementation of multicolor spectral cytometry to measure 20-30 parameters simultaneously in one cell and bioinformatics unsupervised analysis of differential clusters. This state-of-the-art methodology improved innovative research, scientific discoveries, clinical timely-relevant studies and international cooperation. We studied remodeling of immune system and immunosuppression in leukemia microenvironment. We found that extracellular vesicles (EVs) secreted by leukemic cells promote leukemia engraftment and immunosuppressive potential of Treg cells by driving specific effector signature of Tregs. We identified EVs located protein that promoted suppressive activity and effector phenotype of Tregs 1,2,3, indicating possible markers or targets. In longitudinal studies of COVID-19 convalescents we assessed dynamics of T cells immune landscape, integrated with Long Covid symptoms. T cell subsets exhibited different, severity- and time-dependent dynamics and polarization towards exhaustion/senescence. Patients from all severity groups showed Long COVID symptoms, so either the search for Long COVID predictors or any preventive treatment is mandatory in all convalescents, not only in those suffering from severe form. Altogether we believe that such direction by implementation of state-of-the-art innovative technology together with high quality expertise is a beneficial way for significant discoveries and challenging research. 1. Swatler et al. Haematologica (in revision); 2. Swatler et al. Blood Adv. 2022; 3. Swatler et al. Eur J Immunol. 2020; 4. Wiech et al. Front Immunol 2022.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 60

Title: Bunyaviral strategies to reorganize and exploit cellular translation

Project leader: Agnieszka Chacińska, Magda Konarska

Contact: p.gerlach@imol.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Author: Piotr Gerlach

RNA viruses are unconditionally dependent on the cellular protein synthesis machinery. However, in light of the innate immune response-triggered translational shut-down, they need to employ non-canonical strategies, allowing them to seize control of the ribosomes and to promote viral protein production. Bunyaviruses are a large and diverse group of previously neglected, emerging, human infectious RNA viruses. Upon reaching the cytoplasm, they transcribe their segmented negative-strand genome into viral mRNA decorated with the 5' cap structure but lacking the 3' poly(A) tail. In addition, they use an intriguing and understudied mechanism of transcription-translation coupling, potentially requiring a direct interaction between the transcribing viral polymerase and the leading ribosome. In my newly established Laboratory of Structural Virology, within the ReMedy IRAP at the recently opened IMol institute in Warsaw, I aim to perform a comprehensive investigation of the bunyaviral strategies to remodel cellular translation. Studies are focused on 1) identification of host factors critical for the bunyaviral transcription and translation; 2) providing structural insight into virus-host protein assemblies formed during pivotal bunyaviral mRNA lifetime steps; 3) gaining a detailed view of the bunyaviral impact on the host translation landscape and related innate immune response pathways. My research programme will provide a comprehensive and unprecedented insight into the bunyaviral translation, shedding light on the re-organization of the cellular translation landscape during bunyaviral infection. Output of my studies will not only open new avenues in the RNA research field but will also lead to the design of innovative therapies and host-based broad-spectrum antivirals, paving the way towards better preparedness against future pandemics.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 61

Title: Recent developments of Structural Biology Core Facility in Krakow

Project leader: Sebastian Glatt

Contact: przemyslaw.grudnik@uj.edu.pl

FNP programme: TEAM-TECH Core Facility

Authors: Piotr Wilk, Michał Rawski, Klaudia Woś, Kinga Wróbel,
Przemysław Grudnik, Sebastain Glatt

In 2018, the Structural Biology Core Facility (SBCF, www.structuralbiology.pl) for macromolecular crystallography (MX) and cryo-EM has been established at MCB (Jagiellonian University, Krakow, PL). This initiative is a logical consequence of recent developments at the neighbouring Solaris synchrotron, currently starting to construct dedicated high energy MX beamlines and acquired two cryoEM microscopes (300 keV Titan Krios and 200 keV Glacios). Our facility serves as a highly specialized national hub to assist scientists in the process of experimental design, sample preparation and data analysis. SBCF project was mainly designed to acquire sufficient local expertise by recruiting excellent young scientists, providing intense training opportunities and establishing standard operating procedures with several involved MCB research groups and other external academic users. We envisioned that the results from the SBCF project will strongly contribute to and accelerate the creation of a Structural Biology Centre of Excellence in Kraków that will attract the best Polish and international researchers for optimal open access to high-end MX and cryo-EM data collection. Our presentation summarizes three years of SBCF operation and presents opportunities for both academic users and industrial customers.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 62

**Title: Donor–Acceptor Oligopyrroles for Energy and Electron Transfer.
From Aromatic Nanohoops to Photodynamic Therapy**

Project leader: Marcin Stępień

Contact: marcin.stepien@uwr.edu.pl

FNP programme: TEAM

Author: Marcin Stępień

In this project, we have developed new oligopyrrole chromophores by means of a modular strategy based on donor-acceptor pyrrole building blocks (lead papers: *J. Am. Chem. Soc.* 2016, 138, 11390; *Angew. Chem. Int. Ed.* 2016, 55, 14658–14662). By combining different building blocks and substitution patterns, we have created new systems based on porphyrin, hexapyrrolohexaazacoronene, hexapyrrolylbenzene, and other oligopyrrole motifs. These new systems have been explored for their optical and electronic properties, such as energy and electron transfer in multichromophore assemblies, formation of electroactive ladder polymers, and triplet generation for use in antimicrobial photodynamic therapy.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 63

Title: Interfacing NbP Weyl semimetal with superconducting elements

Project leader: Tomasz Dietl, Tomasz Wojtowicz

Contact: wisni@ifpan.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: A. S. Wadge, A. Wiśniewski

Studies of materials with topologically nontrivial band structure, e.g. Weyl semimetals (WSM), became the most active field of condensed matter research. Recently, an idea of introducing superconductivity in topological materials was developed owing to the possibility of non-zero momentum Cooper pairing. A consequence of such pairing is the possibility of formation of Majorana fermions. These fermions, governed by non-Abelian statistics, show potential for practical realization of fault-tolerant topological quantum computation. There is still a long way to build such quantum computer, however one needs to find an optimal material platform for its construction. In particular, introducing nonzero superconducting order parameter into topological materials by inducing superconductivity through the proximity effect enables to employ WSMs and conventional superconductors. We have studied single crystal of NbP (WSM) with its surface covered by several hundred nm thick metallic layers of superconducting elements either Pb, or Nb, or In. The studies directly demonstrate possibility of inducing superconductivity in WSM [1]. We have also clarified what changes appear during the first stages of formation of (Nb,Pb)/NbP interfaces in their normal state [2]. On the basis of angle-resolved photoemission spectroscopy (ARPES) studies, we have determined the influence of deposited heavy metals (Pb and Nb) on NbP surfaces. We observed intriguing phenomenon of topological Lifshitz transition appearing when NbP is covered with 1 monolayer of Pb. [1] G. Grabecki, A. Dąbrowski, P. Iwanowski, A. Hruban, B.J. Kowalski, N. Olszowska, J. Kołodziej, M. Chojnacki, K. Dybko, A. Łusakowski, T. Wojtowicz, T. Wojciechowski, R. Jakiela, A. Wiśniewski, Phys. Rev. B 101, 085113 (2020) [2] A. S. Wadge, B.J. Kowalski, C. Autieri, P. Iwanowski, A. Hruban, N. Olszowska, M. Rosmus, J. Kołodziej, A. Wiśniewski, Phys. Rev. B 105, 235304 (2022).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 64

Title: The use of functionalized silica materials from fly ash to remove inorganic and organic contaminants from waters

Project leader: Wojciech Franus

Contact: bajda@agh.edu.pl

FNP programme: TEAM-NET

Authors: Tomasz Bajda, Magdalena Andrunik, Wojciech Franus, Agnieszka Grela, Agnieszka Klimek, Joanna Kuc, Jakub Matusik, Barbara Muir, Kamil Urbański, Santhana Krishna Kumar Alagarsamy, Mateusz Skalny, Maciej Sobczyk

Volatile organic compounds, pesticides, pharmaceuticals, surfactants, metal anions, metalloids, and radionuclides are released into the environment through a spill or inappropriate disposal, allowing the chemicals to get absorbed into the ground or enter the sewage system. Due to their cost-effectiveness and efficiency, mesoporous materials synthesized from coal fly ash (FA), are recognized as the most promising strategy for slowing down the impact of pollutants. VOCs (benzene, ethylbenzene, toluene, xylene), pesticides (2,4-D, MCPA, carbendazim, simazine), pharmaceuticals (erythromycin, colistin, fluoxetine), surfactants (HDTMA, TX-100), metals and metalloids (Cr(VI), V(V), As(V)), radionuclides (²³⁸U, ²³⁴U) were sorbed on zeolites (Na-X, Na-A, Na-P1), zeolite-carbon and zeolite-vermiculite composites, and mesoporous silica materials. The novelty of the work is based on the use of fly ash as a precursor to the synthesis of new materials with the structure of zeolites, mesoporous silica materials, zeolite-carbon composites, and on the utilisation of the functional materials obtained in environmental engineering. Materials synthesised from fly ash can effectively remove all tested pollutants within the range of their concentrations typically found in the environment. The sorption efficiencies found ranged from 50 to 100%, depending on the initial concentrations of sorbed compounds used, the pH of the reaction environment, and the reaction time. Sorbents modified with surfactant compounds have higher sorption efficiencies than unmodified materials. Experiments on the regeneration and reuse of sorbents indicate that they can be reused many times without significantly deteriorating their sorption capacity. Sorbents can be used in dusty or granular form, which significantly facilitates their application in flow systems. Functionalized mineral and mineral-organic materials synthesized from fly ash can be used as sorbents for water and wastewater treatment.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 65

Title: The role of ESCRT-I in crosstalk between endolysosomal trafficking, cell metabolism and cell differentiation

Project leader: Jaroslaw Cendrowski

Contact: jcendrowski@iimcb.gov.pl

FNP programme: HOMING

Authors: Jaroslaw Cendrowski, Michal Mazur, Bartosz Jary, Marta Wrobel, Surui Wang, Michal Korostynski, Maria Rohm, Anja Zeigerer, Marta Miaczynska

The endosomal sorting complexes required for transport (ESCRT) constitute a cellular protein machinery for membrane remodeling processes, acting via a coordinated recruitment of its subcomplexes (ESCRT-0, -I, II and III). Our preliminary data showed that mammalian cells depleted of ESCRT-I components, Tsg101 and Vps28, have reduced expression of genes encoding enzymes of amino acid and fatty acid oxidation. This is in line with the results of our recent report unraveling that cells lacking the ESCRT-I subcomplex (causing ESCRT inactivation) suffer from improper delivery of nutrients from lysosomal degradation – “lysosomal nutrient starvation”. Hence, we reasoned that the function of ESCRT must affect cellular metabolism. Our results obtained in cooperation with scientists from the Institute of Diabetes and Cancer at the Helmholtz Zentrum München indicated that the reduced expression of oxidative metabolism genes reflects an inhibition of signaling mediated by PPAR transcription factors, occurring likely due to altered intracellular trafficking of fatty acids. As a long-term consequence of ESCRT inactivation, cells lacking Tsg101 and Vps28 activate glycolytic metabolism reflected by increased lactic acid content. The two intracellular processes, endolysosomal trafficking and regulation of oxidative metabolism, that as we show are coordinated by ESCRT, play pivotal roles in differentiation of precursor cells during erythropoiesis. Consistently, the transcription of genes encoding ESCRT-I components is highly increased during erythropoiesis. Intriguingly, we found that Tsg101 and Vps28 are very abundant in precursor cells from a particular stage of erythroid differentiation. ESCRT-I deficiency leads to the accumulation of these precursor cells and impairs further erythroid differentiation. Ongoing experiments aim at addressing how increased ESCRT-I levels affect trafficking of fatty acids and oxidative metabolism in erythroid precursors.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 66

Title: NGS platform for comprehensive diagnostics and personalized therapy in neuro-oncology" – discovery of new targets and diagnostic tools to improve a personalized therapy of brain tumors

Project leader: Bożena Kamińska, Bartosz Wojtas

Contact: b.kaminska@nencki.edu.pl

FNP programme: TEAM-TECH Core Facility

Authors: Bożena Kaminska, Bartosz Wojtas, Bartłomiej Gielniewski, Adria-Jaume Roura, Kamil Wojnicki, Agnieszka Kaczmarczyk, Iwona A. Ciechomska, Sebastian Glatt, Mikołaj Sokolowski, Matt Guille, Paulina Szadkowska

High grade gliomas (HGGs) are aggressive, deadly primary brain tumors. Despite surgery and forceful radio- and chemotherapy, the prognosis of patients is poor with median survival 14 months and less than 10% patients surviving 2-years poor. Finding a novel diagnostic marker or target causing to tumor vulnerability could improve patient survival. We had collected a large bank of brain tumor RNA/DNA, implemented the innovative targeted next generation sequencing (NGS) of cancer-related genes, and searched for tumor pathogenic variants in hundreds of gliomas of different malignancy. Besides known genomic alterations, some of which were druggable, we identified several novel mutations in genes coding DNA helicases BLM and RECQL4 and topoisomerase 2A, some enriched in the Polish population. Computational modeling, biochemical assays with recombinant proteins and gene deletion studies verified the powerful pathogenic effects of new mutations. Moreover, the presence of mutations made tumor cells more vulnerable to chemotherapeutics, which could allow better selection of anti-tumor treatment. Thanks to the international cooperation, the access to unique patient databases and state of the art computational tools was granted and helped to define new pathogenic mechanisms driving malignant gliomas. Implementation of NGS and computational pipelines, along with the selection of the 50-gene diagnostic panel facilitated the development of liquid tumor biopsy, a new method to identify tumor circulating cell free DNA (ctDNA) in patient blood. We applied technical improvements that allowed for tumor ctDNA detection in blood of glioma patients and rapid diagnosis. While the method did not yet meet diagnostic standards, with further improvements, liquid biopsy would be available for glioma patients. Altogether, new pathogenic mechanisms, targets and tumor vulnerabilities have been identified that improve a diagnosis of those deadly tumors and new therapeutic opportunities emerged.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 67

Title: Blowing “bubbles” with DNA origami

Project leader: Jonathan Heddle

Contact: gerwilkins@gmail.com

FNP programme: TEAM

Authors: Gerrit Wilkens, Jonathan Heddle

Artificial lipid vesicles, called liposomes are valuable tools to study membrane proteins and have gained utility as drug delivery vehicles as in the case of the mRNA vaccines against COVID-19. In nature, lipid vesicles can be at the size of 10s of nanometres, however controlled production of liposomes at this size remains difficult. A novel idea is the templating of liposomes on DNA-origami structures. The DNA origami method allows bottom-up production of defined nanometric shapes build from DNA. Using this technique we here expanded the original work on templating liposomes on DNA origami scaffolds and developed a “bubble blower”, a nanometric DNA ring able to seed and constrain liposome formation, that can be combined with a solid support to produce a liposome production system. Binding the DNA origami ring on the solid support enables both purification of the DNA origami liposome complex from by-products as well as separation of the templated liposomes from the DNA origami scaffold that can be released together or combined by specific strand displacement reactions.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 68

Title: High resolution cryo-EM structures of cytochrome b6f imply a one-way traffic of quinones for efficient photosynthesis

Project leader: Artur Osyczka

Contact: artur.osyczka@uj.edu.pl

FNP programme: TEAM

Authors: Marcin Sarewicz, Mateusz Szwalec, Sebastian Pintscher, Paulina Indyka, Michał Rawski, Rafał Pietras, Bohun Mielecki, Łukasz Koziej, Marcin Jaciuk, Sebastian Glatt, Artur Osyczka

Plants use solar energy to power cellular metabolism by generating an electrochemical gradient between the positive and negative side of the thylakoid membrane. The oxidation of plastoquinol (PQH₂) and reduction of plastocyanin (PC) by cytochrome b₆f (cytb₆f) is one of the key steps of photosynthesis in higher plants. As no structural information of cytb₆f in complex with PC and plastoquinone molecules (PQ) in the oxidation site (Q_p) is available, the details of the underlying catalytic mechanism remain elusive [1]. An attractive new mechanistic perspective emerges from our recent studies that provided two high resolution cryo-EM structures of the catalytically active spinach cytb₆f homodimer (at 2.1 Å and 2.7 Å) with endogenous PQs and in complex with PC [2]. The structures revealed that three PQs line up one after another head-to-tail near Q_p in each monomer. The orientation of PQs is highly unexpected and opposite to well-defined positions of inhibitors of Q_p, so far presumed to mimic binding of substrate. This reveals the existence of a channel in each monomer that extends along the positive side of the membrane. The channel is defined by spatially distinct entry and exit points and allows PQs to continuously flow through the protein in one direction, transiently exposing the redox-active ring of quinone for catalytic reaction at Q_p. We thus propose the unprecedented one-way traffic model to explain efficient PQH₂ oxidation in photosynthesis. In addition, our structures revealed thylakoid soluble phosphoprotein (TSP9) as a novel partner binding to cytb₆f from the negative side of the membrane. We consider it as a new possible element for control the direction and/or speed of electron flow in photosynthesis. References 1. Sarewicz, M. et al. (2021) Chemical Rev., 121, 2020-2108. 2. Sarewicz, M., et al. under review Funding Supported by the Team (POIR.04.04.00-00-5B54/17-00 to AO) and Team Tech core facility (TEAM TECH CORE FACILITY/2017-4/6 to SG) grants.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 69

Title: A Zero Waste Circular Economy Approach for Sustainable Agriculture and Environment

Project leader: Kumar Pranaw

Contact: k.pranaw@uw.edu.pl

FNP programme: TEAM-NET

Authors: Kumar Pranaw, Lukasz Drewniak

The increasing world population, dwindling fossil reserves, environmental concerns, and climate change have driven research interests toward green bioprocesses for sustainable development while combating a paucity of resources. To meet global food demand, food production must be doubled by 2050; over-exploitation of arable lands using unsustainable techniques might resolve food demand issues, but they have adverse environmental effects. The plant growth-promoting bacteria is considered one of the best strategies; a better alternative for sustainable agriculture and a viable solution to meet the twin challenges of global food security and environmental stability. It provides an option to deal with different abiotic stresses like temperature, pH, and heavy metal contamination and can enhance the growth of plants under stress conditions by regulating the nutritional and hormonal balance as well as protecting them from plant pathogens. With this rationale, we are working towards developing novel biofertilizers and biopesticides as tools for restoring soil and foundations for sustainable agriculture, applying nature-based solutions for improved crop production. To date, we are in the final stage of biofertilizer formulation development and soon field trials will be started. We are also working towards the development of a zero-waste circular economy by finding a feasible way to utilize biomass as an alternative energy source. Plant biomass is a potential substitute for countering the dependence on depleting fossil-derived energy sources and chemicals. However, in particular, lignocellulosic waste materials are complex and recalcitrant structures that require effective pre-treatment and enzymatic saccharification to release the desired saccharides, which can be further fermented into a plethora of industrially important different value-added products, so far we have successfully produce enzymes, and carotenoid pigments from wheat straw and pine wood sawdust and its scale-up study is in progress.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 70

Title: Spin dynamics and spin pumping in nanostructured magnetic materials, and magnetic materials interfaced with topological and superconducting materials.

Project leader: Vinayak Bhat

Contact: vbhat@magtop.ifpan.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Arathi Das Moosarikandy, Michał Chojnacki, Dirk Grundler, Vinayak Bhat

Magnons (quanta of spin waves) are collective excitations in magnetic material and allow information processing without transferring charge. No-charge-based devices are in great demand because of information transfer without Joule heat loss [1]. One of the crucial components of a magnonic device is detecting a magnon signal by transferring it to an electrical signal. One major way to accomplish the goal of electric detection of magnon spin current is via spin pumping using inverse spin hall effect (ISHE) phenomena. Moreover, temperature dependence capability is also needed to study the usefulness of the materials for quantum computation applications. Here, we report the spin pumping experiments on the Y3Fe5O12/Pt bilayers from 300 K - 4 K. We observed a systematic dependence in resonance field and ISHE voltage as a function of frequency, Pt thickness, and temperature. For the in-plane and out-of-plane, we observed distinct modes at temperatures below 50 K. We are now studying the magneto dynamics and spin pumping in the topological materials interfaced with magnetic materials, as well as superconducting materials interfaced with magnetic materials. We believe our ongoing study will open new avenues in quantum magnonics and quantum computations. We also investigate spin dynamics of microstates in artificial spin ice (ASI) in Ni81Fe19 nanomagnets [2,3] arranged in a kagome lattice using microfocus Brillouin light scattering, broadband ferromagnetic resonance, magnetic force microscopy, and simulations. We experimentally reconfigure microstates in ASI using a 2D vector field protocol and apply microwave-assisted switching to intentionally trigger reversal. Our work is key for the creation of avalanches inside the kagome ASI and reprogrammable magnonics based on ASIs. References: [1] Chumak et al., Nat. Phys. 11, 453 (2015) [2] V. S. Bhat et al., Phys. Rev. Lett. 125, 117208 (2020). [3] V. S. Bhat and D. Grundler, Appl. Phys. Lett. 119, 092403 (2021).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 71

Title: Unexpected spectral and redox properties of hemes b in cytochrome b6f and their potential consequences on the mechanism of plastoquinone reduction

Project leader: Artur Osyczka

Contact: marcin.sarewicz@uj.edu.pl

FNP programme: TEAM

Authors: Mateusz Szwalec, Łukasz Bujnowicz, Marcin Sarewicz, Artur Osyczka

Cytochrome b6f (cytb6f) is a structural and functional homodimer involved in photosynthetic energy conversion of cyanobacteria, algae and higher plants. It plays a role as an electronic connection between photosystems I and II by catalyzing oxidation of plastoquinol and reduction of plastocyanin. The energy released during this process is used by cytb6f to transport protons across the membrane. Spatial arrangement of the redox-active cofactors of cytb6f follows the generic pattern typical of all cytochromes bc, including cytochrome bc1 (cytbc1) – the enzyme involved in mitochondrial respiration. It features two cofactor chains and two catalytic quinone-binding sites (Qp and Qn). These sites are connected by cross-membrane electron transfer (ET) supported by hemes bp (hbp) and bn (hbn) and additionally by heme cn (hcn), which is unique for cytb6f. This heme is located close to Qn and stays spin-coupled to hbn. Therefore, it has been proposed that plastoquinone reduction at the Qn site is the one, two-electron step process. By analogy to cytbc1, it has been generally considered that redox midpoint potential (E_m) of hbp is lower than E_m of hbn. However, this issue is still a matter of debate since there is an uncertainty in determining the E_m values of these two hemes. Given this uncertainty, we performed a large-scale equilibrium redox titrations of isolated spinach cytb6f followed by the analysis of the samples by cryogenic: optical, continuous-wave and pulse EPR spectroscopy. Detailed spectral analysis of experimental data obtained for cytb6f and comparison to data obtained for cytbc1 revealed that in cytb6f the E_m of hbn is in fact lower than that of hbp. The unexpectedly low E_m of hbn introduces an uphill step in the energy landscape of the enzyme and favors spatial separation of two electrons in the low potential chain thus making concerted reaction at Qn less likely. This calls for reconsideration of sequential ET mechanism of plastoquinone reduction at Qn site.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 72

Title: Quantum computing with magnetic impurities in superconductors

Project leader: Mircea Trif

Contact: mtrif@MagTop.ifpan.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Archana Mishra, Pascal Simon, Timo Hyart, Mircea Trif

Magnetic impurities in s-wave superconductors provide a viable platform for realising a topological quantum computer based on Majorana zero modes. However, the coherent manipulation of quantum degrees of freedom in these systems remains an open challenge and novel methodology needs to be developed because electric potentials are inefficient for controlling these quantum states. For this purpose, we introduce a new type of quantum bit, a Yu-Shiba-Rusinov qubit (YSRQ), stemming from two nearby magnetic impurities on a superconductor. We demonstrate that the coherent rotation and the read out of the qubit states is possible by exploiting the dynamics of the impurity spins [1]. We establish a protocol for the generation of Rabi oscillations induced by the dynamics of the magnetic impurities, which is robust for a wide range of experimentally feasible parameters. The precession of the magnetic impurities also generates a feedback torque acting on the impurity, which in turn modifies its resonance frequency depending on the YSRQ state [2]. We show that it is possible to utilise this effect to read out the YSRQ via the well-established scanning tunneling microscopy-electron spin resonance (STM-ESR) techniques. We estimate that the difference of the resonance frequencies, corresponding to the two qubit states, is well within the STM-ESR resolution. YSRQs can be integrated naturally with topological qubits based on Majorana zero modes, allowing the possibility of transferring quantum information coherently between them. In particular, it is possible to manipulate and read out the Majorana qubits via the YSRQ, which could facilitate future implementations of a universal set of quantum gates. References: [1] A. Mishra, P. Simon, T. Hyart and M. Trif, Phys. Rev. X Quantum 2, 040347 (2021). [2] A. Mishra, S. Takei, P. Simon, and M. Trif, Phys. Rev. B 103, L121401 (2021).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 74

Title: Quantum sensors: overcoming research challenges for them to become a real technology

Project leader: Konrad Banaszek

Contact: jan.kolodynski@cent.uw.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Jan Kolodynski

Quantum sensors are expected to become the next-generation devices for sensing: magnetic fields (e.g. in magnetic resonance imaging), external forces (e.g. in precise gravimetry); and in material sciences (e.g. measuring conductivity across surfaces). Their implementations are based on very different platforms: atomic ensembles, optomechanical resonators, solid-state point defects (e.g. NV-centres in diamond) or large-scale optical interferometers such as gravitational-wave detectors. Still, all of them rely on a two-stage architecture in which a well-isolated quantum system is used as the sensing component to register the signal of interest (external field), while being interacted with the meter component (typically light) that is then directly measured to extract the information about the signal. Crucially, this opens the door for controlling continuously the quantum properties of the sensor being non-destructively measured, whose high coherence and sensitivity can then accumulate and be maintained over time. This comes, however, at the price of state-of-the-art engineering with inevitable noise sources inherent also to the meter component (light), which mask out the signal contained within the final recorded data. The grand challenge in theoretical research of such devices is currently the correct modelling of their operation and designing methods of signal inference that would allow to efficiently interpret their measurement data and attain the anticipated limits on resolution and precision. Here, I will summarise results obtained within my group, which discuss the performance limits imposed by the two-stage architecture on quantum sensors and pinpoint its key features to be explored across different quantum-sensing platforms. I will focus primarily on the results obtained in collaboration with researchers from Israel and USA on the impact of imperfect light-detection in NV-centre-based sensors, recently accepted within the Nature Communications journal.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 75

Title: The use of chemical imaging spectroscopic methods to evaluate biomaterials and hybrid polymers

Project leader: Anna Sroka-Bartnicka

Contact: anna.sroka@umlub.pl

FNP programme: POWROTY / REINTEGRATION

Authors: Barbara Gieroba, Vladyslav Vivcharenko, Grzegorz Kalisz,
Paulina Kazimierczak, Agata Przekora, Anna Sroka-Bartnicka

Polysaccharides as biodegradable polymer macromolecules have very wide biomedical potential according to their properties. It is worth to indicate wide abundance, biocompatibility, lack of toxicity and affordable and possible to modify chemically, resulting in different derivatives formed. Two of them: chitosan and 1,3- β -D-glucan are widely used in tissue engineering, as a good material to produce grafts and dressings effective clinically in regeneration. Physicochemical properties of biomaterial based on them relies on fabrication conditions, alternating cellular response in living organism. Proper evaluation of biomaterial arrangement and its surface is crucial in development of tissue engineering products. Vibrational spectroscopy: Raman, infrared (FT-IR, DRIFT), X-ray photoelectron (XPS) combined with scanning electron microscopy (SEM) and atomic force microscopy (AFM) provides information on the abovementioned aspects of biomaterial in cellular and decellularized environments. With imaging spectroscopic methodology crucial features of hybrid biomaterial can be selected and amplified. With good cytocompatibility and biodegradation polymeric materials can be applied as wound dressings, graft fillers and drug carriers in pharmacy and medicine. Our studies are focused on evaluation of molecular arrangement or polymeric thin matrices fabricated with different gelation temperatures and techniques. It was showed that the structure of matrix gelled at 70, 80 and 90 C differs distinctly in both hybrid and single-compartment matrices. We would like to acknowledgement for financial support to Foundation for Polish Science within Reintegration grant no. POIR .04.04.00-00-4398/17-00 (POWROTY/2017-4/14). Literature: 1. B. Gieroba, et all, Int. J. Mol. Sci. 23 (2022) 5953. <https://doi.org/10.3390/ijms23115953>. 2. B. Gieroba, et all , Int. J. Biol. Macromol. 159 (2020) 911–921. <https://doi.org/10.1016/j.ijbiomac.2020.05.155>.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 76

Title: How does the bone marrow vasculature regenerate? Regeneration of bone marrow endothelial cells at single cell and clonal level

Project leader: Krzysztof Szade

Contact: krzysztof.szade@uj.edu.pl

FNP programme: HOMING

Authors: Izabella Skulimowska, Jan Morys, Justyna Sosniak, Monika Gonka, Gunsagar Gulati, Joseph Noh, Sylwester Mosiolek, Agata Szade, Irving Weissman, Alicja Jozkowicz, Krzysztof Szade

The bone marrow endothelial cells (BM-ECs) are the key part of bone marrow niche critical for regulation of hematopoiesis. The rapid regeneration of endothelial network in BM after conditioning-induced injury determines the success of hematopoietic cell transplantation. However, the cellular mechanisms of BM-ECs regeneration remain unclear. Our aim was to understand how the BM-ECs regenerate at the single cell and clonal level. First, we performed single cell RNA sequencing of mouse BM-ECs and combined our data with published datasets. The analysis revealed that sinusoidal ECs express high levels of Fcgr2b, but are negative for Ly6c, while the arterial type ECs express Ly6c, but no Fcgr2b. We also identified transition cells that were double positive for Fcgr2b and Ly6c (DP-ECs). Imaging of the BM niche revealed that DP-ECs localize between the sinusoidal and arterial ECs. Next, using FACS we prospectively isolated different BM-ECs and developed single cell-derived EC organoid assay to study their clonogenic potential. Single sorted ECs from all fractions formed multicellular vessel organoids on BM stromal monolayer with similarly high efficiency ($1/4.3 \pm 2.7$ sorted cells), indicating the broad regeneration potential of BM-ECs regardless of their phenotype. Finally, we used Cdh5-CreER-Rainbow mice to study clonality of BM-ECs regeneration after irradiation. We observed highly polyclonal pattern of BM vasculature after irradiation. Modeling based on local assortativity and machine learning supports contribution of many BM-ECs, rather than rare progenitor fraction, to vascular regeneration. Concluding, our novel single-cell clonogenic assay and fate mapping indicate broad and polyclonal contribution of BM-ECs to regeneration of BM vascularization.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 77

**Title: Growth and modification of diamond nanoparticles
for biosensing purposes**

Project leader: Robert Bogdanowicz

Contact: rbogdan@eti.pg.edu.pl

FNP programme: TEAM-NET

Authors: Mateusz Ficek, Monika Janik, Srinivasu Kunuku, Mattia Pierpaoli,
Adam Filipkowski, Maciej Głowacki, Krzysztof Pyrchla, Mariusz Mrózek,
Pascal Hänzi, Alexander Heidt, Ryszard Buczyński, Wioleta Białobrzeska,
Adam Wojciechowski, Mariusz Klimczak, Robert Bogdanowicz

Recently, the interest in applying fluorescent diamond particles (FDPs) containing nitrogen-vacancy (NV) centers for enhancing the mechanical and chemical properties of some materials, biological imaging, and sensing has been expanding rapidly. The unique properties of NV centers such as intensive, time-stable fluorescence, and an electron spin, which exhibits long coherence time and may be manipulated using external stimuli, such as pH, make them a perfect candidate for a quantum-effect-based sensing platform. However, monitoring of the local changes with the use of the nonmodified diamond particles has certain limitations; therefore, to enhance their sensing properties, in this article, the growth and covalent functionalization of the FDPs' surfaces with is presented. The FDPs' surface is functionalized in an anhydrous environment, and successful attachment is confirmed by Fourier transform infrared spectroscopy (FTIR). As the surface undergoes pH-triggered changes of conformation, it also induces changes in the diamonds' surface charge, therefore modulating the fluorescence, and finally as a result enhances NV sensitivity. Further investigation of the zeta potential, particle size, and contact angle reveals remarkable colloidal stability and superior wettability of the diamond particles over a wide range of pH, which also may significantly affect their biocompatibility. Various designs of biocompatible, stable, and highly sensitive fiber-based nanosensors are also presented.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 78

**Title: ICTQT UG (MAB/IRAP FNP programme): Search of indicators
of non-classicality of light**

Project leader: Marek Żukowski

Contact: marek.zukowski@ug.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Tamoghna Das, Marcin Karczewski, Antonio Mandarino,
Marcin Marciniak, Marcin Markiewicz, Junghee Ryu, Bianka Woloncewicz,
Marcin Wieśniak, Marek Żukowski

[250 words abstract] Our Centre studies general aspects of future quantum technologies. As far as possible avenues of their implementation we concentrate on quantum optical methods. To this end one must have precisely defined indicators of non-classicality of states of light (as such a light can lead to paradoxical effects, which underpin quantum technologies). Most of non-classicality indicators, be it Bell inequalities or entanglement “witnesses”, are formulated for situations which involve fixed number of particles. However multiple quantum optical phenomena involve states of light with undefined photon numbers. The theory of non-classicality indicators is underdeveloped in this case, and as we were able to show often is littered with wrong results. We pinpoint several erroneous claims, and build our own indicators which are correct ones. This leads us to invalidating of some claims on non-classicality of some emblematic quantum optical phenomena. Still, we show that one can modify the experiments related with these in such a way that they lead to an unchallengeable non-classicality. Specifically we have shown a general method, which can be used to obtain non-classicality indicators for light of undefined photon numbers, starting from any indicator which is for a situation with one particle per observer. We also clarify how to show non-classicality of detection events at measurement stations which involve weak local oscillators (auxiliary quasi-classical optical fields). All this opens new avenues in quantum communication and related applications, and also sheds a new light on quantum complementarity.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 79

Title: The fastest thermometry in the nanoworld

Project leader: Maciej Zgirski

Contact: zgirski@ifpan.edu.pl

FNP programme: FIRST TEAM

Authors: Maciej Zgirski, Marek Foltyn, Alexander Savin, Konrad Norowski

Studies of thermal properties at the nanoscale are much less common than the corresponding electrical and magnetic investigations. This is partly due to the lack of fast thermometers capable of tracking the thermal transients that occur when an electrical circuit is driven out of equilibrium due to, say, the rapidly changing current responsible for Joule heating or photons absorbed in a bolometer. Yet, a proper understanding of thermal processes is essential for the failure-free operation of a variety of nanodevices, including nanoscale calorimeters (tools for measuring heat capacity), bolometers (detectors of radiation), qubits (basic components of quantum computers), microcoolers (cooling of circuits at the microscopic level) and single electron boxes (proposed as metrological standards of electric current). At a fundamental level, time-resolved nanothermometry opens up new possibilities for quantum thermodynamics, which deals with the creation and exchange of heat at the level of single particles, involving electrons, phonons and photons, but also resulting from the manipulation of superconducting vortices in the time domain. We proposed and experimentally demonstrated a new type of nanothermometry, which I dubbed the switching thermometry, for probing the electron temperature of nanostructures in thermal transients with unprecedented resolution approaching a single nanosecond. As a thermometer we use a superconducting Josephson junction tested with short (≥ 1 ns) current pulses to measure the temperature-dependent probability of its transition from the superconducting to the normal state, a process known as switching. We successfully implemented this idea by measuring temperature relaxation in a superconducting aluminum nanowire. We were monitoring in real time the heat pulse carried by a flux of nonequilibrium quasiparticles as it passed by the temperature detector. The developed thermometry allowed us to explore in detail the temporal dynamics of overheated electrons and phonons in superconducting nanostructures at low temperatures. Recently, we have measured the heat and subsequent thermal relaxation of the nanostructure arising from expulsion of a single magnetic field vortex with a current pulse – a result of great importance in quantum thermodynamics. Our experiments show that switching thermometry is a powerful tool for gaining new insights into the thermal physics of low temperatures on previously inaccessible time scales and offers a qualitatively new tool for exploring the emerging discipline of quantum thermodynamics.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 80

Title: Biosensors for detection of Tau protein as an Alzheimer's disease marker using Nanodiamonds nanoparticles

Project leader: Ryszard Buczyński

Contact: w.bialobrzeska@ibmm.pl

FNP programme: TEAM-NET

Authors: Wioleta Lewandowska, Anna Grela, Aleksandra Siedlar, Paweł Schweiger, Dawid Nidzworski

Tau proteins are the most frequent microtubule-associated proteins in the brain and are characterized as intrinsically disordered proteins. They are abundant in the neurons of the central nervous system (CNS) and have roles primarily in maintaining the stability of microtubules in axons. Tau dysfunction is mainly associated with neurodegenerative diseases, particularly Alzheimer's disease (AD). We report here on novel sensor architecture consisted of a ITO electrode surface modified with potato starch and nanodiamonds nanoparticles. In this study electrochemical impedance spectroscopy (EIS) was used to measure the increase in impedance when a binding occurred between the target antigen and its specific antibody. ITO electrode with Nanodiamonds is functionalized with antibodies, which then serve to identify the biomarker for the Tau protein. The great analytical performance of the immunosensor in terms of selectivity and low limit of detection (LOD) allow the direct determination of the target protein.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 81

Title: Volumetric high-resolution imaging of the human eye for assessment of age-related opacification of the vitreous and the crystalline lens

Project leader: Ireneusz Grulkowski

Contact: igrulkowski@fizyka.umk.pl

FNP programme: TEAM

Authors: Ireneusz Grulkowski, Daniel Rumiński, Spozmai Panezai, Grzegorz Gondek, Alfonso Jimenez Villar, Ashish Gupta, Bartłomiej Kałużny, Jerry Sebag, Pablo Artal

Intraocular light scattering affects the contrast of the image created on the retina thus reducing the vision quality. Although generally the ocular components are transparent, the microstructural changes associated with ageing or external factors can affect intraocular light scattering. The presence of opacifications is an indicator of vision-affecting diseases such as corneal dystrophies, crystalline lens cataracts, vitreous floaters etc. Back-scattered light can be used to map the opacities. Optical coherence tomography (OCT) is a non-invasive imaging modality enabling generation of micrometer resolution, two-dimensional (2-D) cross-sectional images and three-dimensional (3-D) volumetric data presenting internal structure of optically scattering tissues. The advantages of this interferometric imaging modality include also high sensitivity, which enables detection of ultralow scattered light levels obtained from weakly scattering tissues such as the vitreous body. The aim of this study is to perform in vivo enhanced three-dimensional visualization of vitreous and lens opacities in subjects of different ages using a swept source OCT system. We developed OCT instrument operating at the central wavelength of 1050 nm that was able to generate the cross-sectional images with axial resolution of 8 μm . We implemented tunable lens technology and image averaging to enhance the performance of the system. Different contrast enhancing approaches were applied to obtain volumetric 3-D images of the crystalline lens and the vitreous. Volumetric data sets generated en-face projection images of opacities as depth color-coded maps. to effectively map the opacities. The results revealed the changes in the transparency of the crystalline lens as well as liquefaction and scattering from well-organized opacified structures in the anterior vitreous. The age-related processes can be quantified by advanced data analysis algorithms. The proposed imaging platform can be a new-generation ophthalmic diagnostic tool in the fundamental studies as well as for objective clinical evaluation and management of eye diseases.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 82

Title: The use of novel plant resistance inducers as a sustainable approach to agriculture

Project leader: Marcin Śmiglak

Contact: marcin.smiglak@gmail.com

FNP programme: TEAM-TECH

Authors: Marcin Smiglak, Rafał Kukawka, Maciej Spsychalski, Marta Markiewicz, Stefan Stolte, Angela Pironti, Sheridan Woo, Henryk Pospieszny

Realization of the main goal of our project, which was to prove biological activity of the novel chemical substances synthesised by us, whose use enables an alternative approach to plant protection, also required demonstrating that their use is safe and meets legal requirements and environmental issues. The European Union, regarded as the world leader in the legislation on ecological development and natural environment protection, has long ago recognised the need for sustainable development in agriculture. This policy includes curbing the use of pesticides to reduce their impact on human health and the environment, as well as incentivising alternative approaches and techniques. As a result, the number of pesticides available for agricultural production has declined. The first to be eliminated were the substances most effective against pathogens but also the most toxic to the natural environment. The systemic acquired resistance (SAR) phenomenon is a very attractive option for reducing the use of pesticides. SAR is a natural mechanism triggered in plants in response to pathogen attack and resulting in systemic increased resistance to infections caused by fungi, bacteria, or viruses. It should be emphasized that SAR inducers are designed to be administered to the fields in much lower doses than conventional pesticides. Responsible research on new active substances for agricultural applications requires not only comprehensive evaluation of their biological activity but also their environmental impact. Properties of our substances satisfy both the above requirements.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 83

**Title: Designing patches with nano and microfibers delivering topically
oil and drugs for atopic skin treatment**

Project leader: Urszula Stachewicz

Contact: ustachew@agh.edu.pl

FNP programme: FIRST TEAM

Authors: Zuzanna Krysiak, Ewa Sroczyk, Krzysztof Berniak, Urszula Stachewicz

Many widespread skin problems including eczema affect people all over the world. Most of the treatment methods for atopic dermatitis (AD) are focused on increasing skin moisture and protecting from bacterial infection and external irritation. Topical and transdermal treatments have specific requirements for drug delivery. Breathability, flexibility, good mechanical properties, biocompatibility, and efficacy are important for the patches used for skin. In AD skin moisture is highly decreased due to transepidermal water loss, therefore patches, which can increase hydration in the long-term application are desired. In our studies, we used electrospun polymer membranes with a porosity above 90%, loaded with natural oils. We manufactured nano- and microfibers from various polymers (PVB, PCL, PHBV, PI, PA6, PS) and natural oils such as evening primrose, blackcurrant seeds, or hemp oil to verify experimentally and via numerical simulations their delivery to the skin. We show that oil spreading and transport in patches depends on the geometry of the fibers, their surface properties porosity, and pore sizes. These results give an enormous possibility of controlling the oil and drugs delivery to the skin, not only with AD problems. Furthermore, we performed in vivo skin hydration test with natural oil applied on the electrospun membranes on the skin to investigate hydration increase according to the design of the patches. In conclusion, we have shown the novel and easy method to apply, for controlled transdermal delivery and moisturization through electrospun patches to improve the comfort and lifestyle of people with eczema.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 84

Title: Second generations of biopolymers by modifications

Project leader: Alexander Steinbüchel

Contact: alexander.steinbuchel@p.lodz.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Franciela Arenhart Soares, Fady Abd El-Malek, Marian Rofael,
Natalia Kwiatos, Alexander Steinbüchel

Nature and Chemical Industry produce a vast number of different polymers. Polymers are not only essential for any living organisms, they are also indispensable in daily life. They are produced in large amounts in either way and represent the most abundant organic compounds on earth. Modifications of polymers after their synthesis can increase the number of available polymer structures and their applications even further. Postsynthetic modifications of polymers are achieved by enzymatic or chemical methods. One important well-known example is methylcellulose, which is obtained in large amounts by a chemical process from natural cellulose and which is used in many applications. This historical example illustrates the importance of postsynthetic modifications. The poster provides an overview on the activities of the Molecular Biotechnology group of ICRI-BioM to conduct postsynthetic modifications of biopolymers as well of synthetic polymers. The polymers are targets for modifications by enzymes or chemical catalysts using click chemistry approaches or general chemical approaches. One group of polymers are the bacterial cyanophycins, which are polymers consisting of a backbone of polyaspartic acid with the second carboxylic group of aspartic acid covalently linked to arginine or other amino acids. Another group of polymers are natural (from the *Hevea brasiliensis* tree) and synthetic rubbers comprising diene rubbers with double bonds in the macromolecular backbone after the polymerization process. A third group are polysaccharides produced by microorganisms or isolated from eukaryotic organisms. The fourth group of polymers are polyhydroxyalkanoates normally giving thermoplastic and/or elastomeric materials. The perspectives of these modifications are the provision of additional valuable polymers for a wide range for applications.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 85

Title: Quantum Measurements in Service of Practical Quantum Computing

Project leader: Michał Oszmaniec

Contact: oszmaniec@cft.edu.pl

FNP programme: TEAM-NET

Authors: Michał Oszmaniec, Filip Maciejewski, Tanmay Singal, Oskar Słowik,
Zoltan Zimborasm, Flavio Baccari

In my research group we use tools and language of quantum measurement theory to boost the performance of present-day quantum computers, without the need for significant hardware modifications. Currently available prototypes of quantum computers are inherently noisy and imperfect. Because of this it is of utmost importance to understand and mitigate imperfections affecting such machines and to propose protocols maximizing their usefulness. In my presentation I will report three aspects in which my group managed to contribute to this broad research program. First, we devised a suite of methods for diagnostics and modelling the noise and cross-talk effects in readout suitable for large-scale systems of superconducting qubits. We tested it on Rigetti's 80 qubit and IBM's 127 qubit devices. In both cases our methods effectively learned and quantified crosstalk in readout, which proved to be beneficial for error mitigation carried out on random instances of optimisation problems. Second, we introduced a new protocol for the task of estimation expectations of non-commuting observables in multi qubit systems. Our method is based on the observation that after a sufficient amount of noise is added, complementary quantum observables can be measured by a single measurement. Our scheme can outperform state-of-the art methods for this task and we expect that it will be of relevance for quantum chemistry problems implemented on a quantum computer. Third, we proposed a resource-efficient method for implementing general quantum measurements on n qubit system. Standard implementation scheme for this task requires doubling the number of qubits while ours utilizes only a single auxiliary qubit. This not only reduces the size of the required quantum system, but also makes the scheme it less prone to noise and imperfections. The above findings show that mathematical framework of quantum measurement theory can be useful for practical problems relevant for near term quantum computers.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 86

Title: Culture based growth of diatoms modified with metals - the biosynthesis of 3D structured biosilica, its properties and potential use

Project leader: Bogusław Buszewski

Contact: andrzej.witkowski@usz.edu.pl

FNP programme: TEAM-NET

Authors: Weronika Brzozowska, Przemysław Dąbek, Alexandra Golubeva, Ewa Górecka, Marta Krzywda, Piya Roychoudhury, Andrzej Witkowski

Diatoms (Bacillariophyta) unicellular, photoautotrophic eukaryotes represent the principal component of the modern World Ocean primary producers both in plankton and benthos. With, the number of species estimated to ca. 100,000 diatoms play an important role in the silica, carbon and oxygen global geochemical cycles. In recent Oceans diatoms are the major biosilica producer. Each diatom cell can be considered a bioreactor encased in a siliceous (opaline) exoskeleton producing numerous valuable organic compounds including oil and omega acids, but few species synthesize also neurotoxins (domoic acid). The great advantage of diatoms is the fact that numerous species, primarily from marine waters, are possible to isolate from the natural environment into clonal cultures and serve as a reproducible source of biosilica in laboratory conditions. The siliceous diatomaceous exoskeleton possesses species specific ornamentation in a form of nano to micro size pores and is characterized with photoluminescence properties and high volume to surface area. The nanostructured biosilica is a target of applicable research in many fields including e.g., drug delivery carrier, biosensors, nanotools, air/water purifiers, eco-friendly nanoparticles production. As a partner of the TEAM-NET consortium University of Szczecin diatomology team has established 10 strains of the best growing diatom species and is able to modify the properties of biosilica by enriching the growth medium with selected metals. The best growing strains have been characterized with growth kinetics, salinity, temperature and nutrients uptake. Experiments on those strains included metabolically controlled doping with following elements: Ti, Ge, V, Zr, Te, Pt and the biogenesis of Gold (Au) and Silver (Ag) nanoparticles made with diatomaceous biosilica including their deposition on siliceous surfaces of diatom. In case of metabolically doped biosilica pH of the culture growth medium and the proportion of a given metal to silica are crucial factors. The dry mass content of metals studied in modified biosilica ranged from ca. 0,5 to 8,5 %. Experiments with Au and Ag nanoparticles revealed that selected diatom strains are suitable for rapid reduction of metal ions and subsequent production of metal conjugated 3D nanostructure. Instrumental measurements of the resulting metabolically doped biosilica point out modification of its physical properties with positive zeta potential values at the extreme end of lowest pH values. Likewise, it has been shown that diatomaceous biosilica can be effective surface for a doping of valuable metal nanoparticles avoiding hazardous and dangerous for the environment chemical processes. We confirm that diatom strains grown in Szczecin Diatom Culture Collection can be reproducible source and cost-effective natural resource of biosilica in metal accumulation and modification of biocomposites. Results of the experiments include also approaches in scaling up the production of the biosilica in laboratory conditions.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 87

Title: Deciphering the role of epigenetic changes in DNA methylation in the pathogenesis of periodontal disease

Project leader: Aleksander M. Grabiec

Contact: aleksander.grabiec@uj.edu.pl

FNP programme: FIRST TEAM

Authors: Katarzyna B Lagosz-Cwik, Mariia Melnykova, Weronika Lipska, Malgorzata Kantorowicz, Michal Tyrakowski, Dagmara Darczuk, Tomasz Kaczmarzyk, Marjolijn Gilijamse, Teun J de Vries, Jan Potempa, Aleksander M. Grabiec

Epigenetic mechanisms, namely DNA and histone modifications, are critical regulators of inflammation which have emerged as potential targets for immunomodulating therapies. Periodontitis is a chronic inflammatory disease of the periodontium caused by microbial imbalance and recent studies identified epigenetic regulation as an important factor in disease pathogenesis. Here, in collaboration with clinicians from the Institute of Dentistry in Kraków and the Academic Centre for Dentistry Amsterdam, we established a biobank of primary human gingival and periodontal ligament fibroblasts (GF and PDLF) that were used to characterize the role of DNA methylation in fibroblast biology and assess therapeutic potential of the DNA methyltransferase (DNMT) inhibitor decitabine (DAC) in periodontitis. Our approach allowed us to identify several key cellular processes that are regulated by DNA methylation, including proliferation, inflammatory responses and interactions with pathogenic bacteria. However, we observed several potentially detrimental effects of DAC on GF and PDLF biological functions. First, DAC reduced GF proliferation and was cytotoxic after extended treatment. Second, DAC amplified production of key chemokines and matrix-degrading enzymes that are involved in periodontitis pathogenesis. Third, DAC increased adherence of oral bacteria to GFs which may contribute to bacterial dissemination. Finally, analysis of DAC-induced genes identified by RNA sequencing showed that the most affected processes were related to immune and inflammatory responses, identifying an unexpectedly broad proinflammatory effect of DNMT inhibition in GFs. These results show that hypomethylating agents, such as DAC, are an excellent tool to study the role of DNA methylation in cells relevant to the pathogenesis of a human disease. However, therapeutic potential of DNMT inhibitors in periodontitis may be limited due to their effects on GF viability and stimulation of pro-inflammatory pathways.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 88

Title: Fluorescent nanodiamond functionalizations of various optical fiber platforms for magnetic field and biological analytes sensing

Project leader: Ryszard Buczyński

Contact: mariusz.klimczak@fuw.edu.pl

FNP programme: TEAM-NET

Authors: Mariusz Klimczak, Wioleta Białobrzeska, Adam Wojciechowski,
Robert Bogdanowicz

The nitrogen-vacancy spin state dynamics in diamond enable optical readout of nanoscale magnetic field but require radical enhancement of the NV fluorescence collection efficiency. Optical fibers have the potential to satisfy this, but different geometries of fibers with various nano-sized diamond particle functionalization schemes are investigated for maximization of the coupling efficiency between the NV– fluorescence and fiber guided modes. In addition to that, nanodiamonds allow for extensive surface modification, which facilitates selectivity for dedicated optical sensors of biological analytes like peptides – some of which in turn are known early disease markers. We have reported successful implementation of step-index, suspended core and hollow core fibers with the diamond particles localized inside and along the core length. With the step index fiber we demonstrated a new approach for incorporation of NV nanodiamonds into an optical fiber using core nanostructuring, which opens the possibility controlled, uniform longitudinal and transverse plane diamond distributions. The suspended core fiber combined tight confinement and spatial overlap of the particles with of the guided mode returning 500 nT/sqrt(Hz) sensitivity, which exceeded the previous fiberized magnetic field sensing demonstrations by typically two orders of magnitude. Nanodiamond functionalization of hollow core fibers allowed for magnetic field gradiometry without the orientation of the NV color centers. The functionalization procedure is essentially room-temperature, meaning that application of surface modified nanodiamonds is feasible for integration with microfluidics sensing systems. The work involved also adaptation of in-house developed D-shape fibers to specific functionalization requirements involving: etching for control of core to D-surface distance, deposition of auxiliary layers for leaky mode resonance operation and preparation of measurement protocols for avidin-biotin interaction.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 89

**Title: High-Efficient thermoelectric materials for direct conversion
of heat into electricity**

Project leader: Krzysztof Wojciechowski

Contact: wojciech@agh.edu.pl

FNP programme: TEAM-TECH

Authors: Krzysztof Wojciechowski, Taras Parashchuk, Ashutosh Kumar,
Luu Dac Son, Artur Kosonowski, Rafal Knura, Oleksandr Cherniushok,
Adrianna Lis, Katarzyna Ungehauer, Alan Wilmanski

Waste heat harvesting is one of the most promising ways to improve the energy efficiency of numerous technological processes and energetic devices and can lead to a significant global reduction in fuel consumption and CO₂ emission. Thermoelectric devices are currently at the top of the most advanced waste heat recovery technologies. Because thermoelectric generators TEGs are made in solid-state technology they are much simpler in construction than analogous mechanical systems. They have no moving parts, so they are silent, robust, and highly reliable. The team from the Thermoelectric Research Laboratory of AGH University of Science and Technology developed innovative functional materials to produce a new class of thermoelectric converters with significantly enhanced efficiency in energy conversion, cheaper in production and more environmentally friendly than commercial modules. For this aim, the original strategies for achieving a high average thermoelectric figure of merit, based on advanced electronic structure and phonon engineering, were applied. The best materials were selected for the construction of prototypical thermoelectric power modules designed for the conversion of low-parametrical heat into electrical energy. The developed and produced TE converters exhibit very high power densities exceeding 2.4 kW/m². The new technology has the potential to be applied in large-scale industrial devices for the recovery of waste heat and reduction of CO₂ emission.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 90

Title: Breaking the diffraction limit in fluorescence microscopy by measuring photon correlations

Project leader: Radek Lapkiewicz

Contact: radek.lapkiewicz@fuw.edu.pl

FNP programme: FIRST TEAM

Author: Radek Lapkiewicz

Single fluorescent emitters in biological samples are probably the most common sources of quantum light. Nevertheless, their quantum optical properties are rarely exploited. I will discuss how fluorescence microscopy can benefit from measurements of quantum correlations. Such measurements allowed counting emitters within a diffraction-limited spot [1] and enhancing the resolution of classical super-resolution methods further beyond the diffraction limit, as in the case of recently introduced Quantum Image Scanning Microscopy (QISM) [2]. We found that the classical analog of QISM relying on classical light correlations offers a higher signal to noise ratio at short measurement times and is less demanding experimentally. This method, termed Super-resolution optical fluctuation image scanning microscopy (SOFISM) [3], exploits fluorescent emitter blinking as its image contrast. SOFISM offers a robust path to achieve high-resolution images with a slightly modified confocal microscope, using standard fluorescent labels and reasonable acquisition times. [1] Y. Israel, et al. Quantum correlation enhanced super-resolution localization microscopy enabled by a fibre bundle camera. Nat Commun 8, 14786 (2017). [2] R. Tenne, et al., Super-resolution enhancement by quantum image scanning microscopy, Nat. Phot., 13, 116–122 (2019). [3] A. Sroda, et al., SOFISM: Super-resolution optical fluctuation image scanning microscopy, SOFISM: Super-resolution optical fluctuation image scanning microscopy, Optica 7, 1308-1316 (2020).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 91

Title: New technologies for unraveling the mystery of dark matter

Project leader: Leszek Roszkowski

Contact: mkuzniak@camk.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Author: Marcin Kuźniak

Most of the matter in the universe is called dark matter, which accounts for 23% of energy density (while ordinary matter is only 4.6%, and the rest is attributed to dark energy). However, the nature of dark matter is still unknown, and its origin is one of the most important questions in physics. According to the currently favored hypothesis, dark matter consists of WIMPs, weakly interacting massive particles that have not yet been detected. The search for WIMP interactions with ordinary matter is carried out by large international collaborations with large detectors located in underground laboratories (such as SNOLAB in Canada or Gran Sasso in Italy), in order to suppress the background from cosmic rays. The currently most promising detection technology is based on the use of a large mass of liquid argon or xenon as the target in the detector, in which interactions with hypothetical dark matter particles would manifest as faint flashes of light. AstroCeNT researchers are part of the Global Argon Dark Matter Collaboration and leaders in R&D on novel light collection and detection schemes. Status of dark matter search results, with particular emphasis on those aspects of liquid argon detection technology, where Astrocent researchers play important roles, will be presented: the currently operating DEAP-3600 experiment, the DarkSide-20k detector, which is being built, and the planned ARGO detector, which will contain 400 tons of liquid argon and will allow to reach the ultimate sensitivity to dark matter. Close collaboration on these experiments with APC Paris, INFN, GSSI, Technical University Munich and McDonald Institute, based on an active personnel exchange and mobility programme and joint R&D activities, was enabled by the FNP IRAP and Horizon 2020 Twinning project DarkWave.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 92

Title: Controlled light manipulation using nanomaterials

Project leader: Wiktor Lewandowski

Contact: wlewandowski@chem.uw.edu.pl

FNP programme: FIRST TEAM

Authors: Wiktor Lewandowski, Mateusz Pawlak

The key objective of the REINFORCE project was providing ground-breaking concepts for the fabrication of responsive nanomaterials for the photonic industry. Namely, we wanted to enhance, tune, and actively regulate thin films of nanoparticles. Simple antigen biosensors, innovative displays and futuristic optical computers are just few examples of billion dollars worth markets that could benefit from the strong light-matter interactions of nanoparticles. Unfortunately, controlled, dynamic manipulation of light with nanomaterials is not trivial, particularly for the thin films used in solid state devices. Within REINFORCE we decided to face this challenge, by combining rigid particles with soft, organic liquid crystals. Over the last years we successfully developed ordered, responsive nanomaterials. Among other achievements, we have unlocked the access to materials showing complex structure (Chem. Mater., 2018, 30, 8201; ACS Nano 2021, 15, 4916; J. Am. Chem. Soc. 2020, 142), broken mirror symmetry (Adv. Mater. 2020, 32, 1904581) and polarized interactions with light (Chem. Mater. 2019, 31, 7855; ACS Nano 2020, 14, 12918). We can conclude that the field of plasmonics and photonics can greatly benefit from the use of tailored liquid crystals. Besides providing a scalable, low-energy and rapid methodology of producing materials for photonics REINFORCE translated also to establishing a well functioning group of young researchers and international collaborators able to combat interdisciplinary challenges.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 93

Title: Commercialization of self-testing quantum hardware

Project leader: Marcin Pawłowski

Contact: marcin.pawlowski@ug.edu.pl

FNP programme: FIRST TEAM

Author: Marcin Pawłowski

Self-testing is the property of a device to automatically confirm if it is functioning correctly. A problem arises when we do not trust the testing mechanism, for example if we expect a backdoor placed in the testing software or a hacking attack aimed at it. Quantum technology provides answer to this problem in the form of device independent protocols, in which two or more elements of the hardware are testing not only the main function but also the other testers. It is akin to police cross-examining witnesses in separate rooms to check if they tell the same story. These technologies find use whenever security is an important concern, especially in telecommunications. Unfortunately, the complexity of self-testing quantum machines has been too high for practical use. The aim of my First-TEAM project was to change that. We have looked for the ways of simplifying their construction without compromising the security. In this presentation I show how we went from ideas, to patent, to a start-up.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 94

**Title: Towards chiroptoelectronics: development of functional electro
- and photoactive chiral materials**

Project leader: Alexander Steinbüchel

Contact: piotr.sleczkowski@p.lodz.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Piotr Ślęczkowski, Guillermo Martinez-Denegri Sanchez

Since many decades, scientists are trying to reach Nature's proficiency in creating new materials. One common feature of materials created by Nature is their intrinsic chirality i.e. their structure do not possess elements of mirror symmetry. Chirality is a fundamental property which determines many biological functions by stereoselectivity of non-covalent interactions [1]. Importantly, just as molecules can exist in left-handed (LH) and right-handed (RH) mirror image pairs (enantiomers), light can feature either LH or RH circular polarization. Bioinspired materials comprising chiral structures, like helices, reveal particularly interesting properties when interacting with light, e.g. selective reflection of circularly polarized light (CPL) of the handedness similar to the screw sense of the helix [2] or the CPL emission [3]. The strategy of development of materials for bio-inspired optoelectronics will be presented. In addition results of studies related to control of the morphology of supramolecular polymers based on triphenylene-2,6,10-tricarboxylicamide (TTA) derivatives will be presented. After deposition on surface, the TTA polymers possess a helical topology, with preferred handedness. As a result, their implementation in the optoelectronic devices will convey added value in form of stereo-selectivity in light-matter interactions. The development of functional materials exploiting molecular and supramolecular chirality will push forward the realization of three-valued logic: CPL(LH), CPL(RH) and 0 (no light). References: [1] Karabancheva, T.; Christov, C., Adv. Prot. Chem. Struct. Biol., 80, 2010, 85-115. [2] Wang, L.; Urbas, A. M.; Li, Q. Adv. Mater., 32, 2018, 1801335. [3] Han, J.; Guo, S.; Lu, H.; Liu, S.; Zhao, Q., Adv. Optical Mater., 6, 2018, 1800538.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 95

**Title: Varied manifestations of protein conformational dynamics revealed
by hydrogen deuterium exchange**

Project leader: Michał Dadlez

Contact: michald@ibb.waw.pl

FNP programme: TEAM-TECH Core Facility

Author: Michał Dadlez

To be considered as oral: Discoveries of the last years showed that a large portion of the proteome consists of proteins which are not able to form a rigid, well-defined three dimensional structure, constituting the realm of intrinsically disordered proteins/regions (IDP/IDR), the presence of which is widely accepted now. The initial skepticism on their functional role in biology has also diminished due to flow of data on IDRs and their biological activity. Multiple cases of biologically important proteins have been found to contain large IDR's and studied, leading to the inventory of new functional classes that in some cases require disorder. Multiple functional advantages of the dynamics are also mentioned allowing for multivalency, moonlighting, mimicry, plasticity, dynamic allostery, fuzzy molecular recognition, entropic chains/bristles, liquid-liquid-demixing phase separations, etc. New techniques have enriched the portfolio of protein structural studies that enable to tackle the dynamic character of these subjects. The old approach to monitor the kinetics of exchange of backbone amide hydrogens to deuteria (HDX), and therefore to map the entanglement of these hydrogens in secondary or tertiary structure, gained new momentum as an ideal tool to get unique insight into protein regions characterised by different levels of dynamics, the timeframes of which in proteins may span several orders of magnitude. Selected cases from more than 40 protein systems studied by HDX in our lab will be presented and the dynamics-function relationships emerging from these studies will be discussed. These cases include intermediate filament proteins, centriole proteins and translation elongation protein complexes to illustrate the progress in understanding the dynamic aspects of protein function, still not appreciated due to domination of crystallographic paradigm, as we witness the change in this paradigm and fall of the dogma that function requires structure.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 96

Title: Loss of Y in leukocytes as a risk factor for critical COVID-19 in men

Project leader: Jan Dumanski

Contact: jan.dumanski@igp.uu.se

FNP programme: International Research Agendas Programme (IRAP)

Authors: Jan P. Dumanski, Bożena Bruhn-Olszewska, Hanna Davies, Daniil Sarkisyan, Ulana Juhas, Edyta Rychlicka-Buniowska, Magdalena Wójcik, Monika Horbacz, Marcin Jąkałski, Paweł Olszewski, Jakub O. Westholm, Agata Smialowska, Karol Wierzba, Åsa Torinsson Naluai, Niklas Jern, Lars-Magnus Andersson, Josef D. Järhult, Natalia Filipowicz, Eva Tiensuu Janson, Sten Rubertsson, Miklós Lipcsey, Magnus Gisslén, Michael Hultström, Robert Frithiof

COVID-19 shows a largely unexplained male bias for severity and mortality. Loss of chromosome Y (LOY) is a risk factor candidate in COVID-19 because of previous associations with many chronic age-related diseases and its effect on transcription of immune genes. We studied LOY in blood for 211 COVID-19 patients treated at intensive care units (ICU), 139 of which were subject to cell sorting for LOY analysis in granulocytes, low-density neutrophils (LDNs), monocytes and PBMCs. Over 46% and 32% of critically ill patients showed LOY above 5% cut-off in LDNs and granulocytes, respectively. Therefore, myeloid lineage that is crucial for the development of severe COVID-19 phenotype is affected by LOY. Moreover, LOY correlated with increasing WHO-grade ($p=0.0061$), death during ICU treatment ($p=0.0016$) and history of vessel disease (p .



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 97

Title: Postnatal immune activation with Poly(I:C) alters adult mouse behavior

Project leader: Leszek Kaczmarek

Contact: i.sirocka@nencki.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Iwona Sirocka, Karolina Protokowicz, Leszek Kaczmarek

Neurodivergent people, for example those with autism spectrum disorder (ASD), ADHD or learning disabilities, often suffer from social skills deficits, cognitive impairments, and sensorimotor processing difficulties. The causes of those variations are complex, ranging from genetic predispositions to environmental circumstances, including early-life immune activation. In this experiment 7-day old mice were injected with either Poly(I:C), an agent mimicking viral infection, or saline serving as control. Male mice subjected to Poly(I:C) exhibited decreased neophobia, and risk taking behaviour in comparison with their saline treated counterparts. Interestingly, locomotor activity of the Poly(I:C) group was significantly higher but only in a new, potentially threatening environment, contrasting with their diminished home-cage activity, as compared to the control male mice. Moreover, Poly(I:C) male mice were less likely to approach the new social stimulus, even though they tended to have more social interactions with their littermates. Our results indicate that postnatal immune activation might be involved in symptoms associated with neurodiversity.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 98

Title: Novel (bio-)mineral mixtures for civil engineering

Project leader: Wojciech Franus

Contact: j.fronczyk@pollub.pl

FNP programme: TEAM-NET

Authors: Joanna Fronczyk, Adam Pyzik, Martyna Janek, Nadella Marchelina, Maciej Szelać, Małgorzata Wdowska, Agnieszka Woszek, Wojciech Franus

The environmental degradation implies the need to search for innovative methods used in the construction industry. The outcome of the ongoing research is expected to be the formulas development for mineral - asphalt mixtures, self-healing concrete and biocements. The concept adopted is based on technology using bacterial strains capable of stimulating carbonate production. The study hypothesized that the addition of functionalized materials in biomaterials would have a positive effect on maintaining bacterial metabolic activity and increasing the number of nucleation centres. In addition, zeolite containing composites are supposed to support asphalt foaming process in Warm Mix Asphalt technology. Current work has focused, among other things, on selecting ureolytic and non-ureolytic bacterial strains, optimizing the precipitation of carbonates in cement composites and soil, and developing technology to impregnate zeolites with bacterial spores to increase bacterial survival rates. Research is also being carried out to evaluate the effectiveness of zeolites as a material that increases the intensity and uniformity of soil biocement and reduces ammonium ion emissions. The results of the research will be the basis for the development of technological instructions for obtaining biocement (Milestone 1) and self-healing concrete (Milestone 2). In addition, studies to obtain mineral-asphalt mixtures (Milestone 3) are at the stage of selecting composites and evaluating their parameters for their application suitability in asphalt foaming processes. The conducted investigations indicate moderate effectiveness of cementitious composites self-healing and soil biocementation using ureolytic bacterial strains selected so far. The main factor inhibiting the development of technologies of biocements and self-healing concretes production is the problem of selecting strains resistant to high pH and involved in non-uretholytic precipitation of carbonates.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 99

Title: Synthesis and application of porous materials obtained from fly ash

Project leader: Wojciech Franus

Contact: w.franus@pollub.pl

FNP programme: TEAM-NET

Authors: Wojciech Franus, Ewelina Grabias-Blicharz, Rafał Panek, Jarosław Madej

An increasing amount of fly ash produced as a result of the combustion of hard coal and lignite is still observed in the world. In Poland, the energy industry is producing about 4Mt of fly ash annually. This waste is often stored in heaps, causing a burden on the natural environment. To reduce its emission, new legal regulations are constantly being introduced. They affect both the amount and the chemical composition of the generated waste. This, combined with the still large amounts of residual fly ashes, requires research on their use. Currently, this type of waste is used in construction, for example in cements production, as an additive to concrete, ceramics and lightweight aggregates. Unfortunately, the introduced legal restrictions also cause changes in the technological processes of combustion, which often make their use in the construction industry impossible. It means that the search for new ways of using this type of waste is crucial in the context of sustainable development and the circular economy. The aim of this study is to present the possibility of obtaining materials from fly ash with a well-defined pore structure and surface area that allows for wide application in many fields of science and industry. As a result, various types of materials were obtained: (i) zeolites like Na-X, Na-P1, Na-A, ZSM-5 (milestone 1-3), (ii) mesoporous silica materials (MCM-41, SBA-15) (milestone 4-6) and (iii) Al-MOF organometallic joints (milestone 7). Research showed that materials of high purity and mono-mineral character were obtained. They represented both microporous (Na-X and Na-A zeolites) and mesoporous (Na-P1 zeolite, MCM-41, SBA-15 and Al-MOF) materials. The obtained porous structures can be used in environmental engineering (sorbents to remove pollutants from water, sewage and gases), construction (mineral-asphalt mixes, concrete, aggregates, mortars, renovation renders) and agriculture (fertilizer additives and specimens for the degraded soils remediation).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 100

Title: Salient signatures of entanglement in the surrounding environment

Project leader: Łukasz Rudnicki

Contact: lukasz.rudnicki@ug.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Łukasz Rudnicki, Waldemar Kłobus, Otavio A. D. Molitor,
Wiesław Laskowski

We develop a model in which presence of entanglement in a quantum system can be confirmed through coarse observations of the environment surrounding the system. This counter-intuitive effect becomes possible when interaction between the system and its environment is proportional to an observable being an entanglement witness. While presenting three intuitive examples we show that: i) a cloud of an ideal gas, when subject to a linear potential coupled with the entanglement witness, accelerates in the direction dictated by the sign of the witness; ii) quadratures of electromagnetic field in a cavity coupled with two qubits (or a four-level atom) are displaced in the same manner; iii) for a quantum environment given by a single qubit, its state occupies only one hemisphere of the Bloch sphere, again in full agreement with the sign of the witness.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 101

Title: Computational Support Group

Project leader: Piotr Paneth

Contact: piotr.paneth@p.lodz.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Agnieszka Krzemińska, Mateusz Pokora, Piotr Paneth

During Part 1 of the ICRI-BioM project funded within MAB PLUS program two main research areas were explored: 1. Theoretical prediction of the mechanism beyond the RNA-inspired polymerization that aimed at suggesting new structures of the linker which will facilitate degradation of polymers in seawaters. Theoretical calculations were calibrated against experimental data obtained by Prof. Wurm (Univ. of Twente, formerly MPIP Mainz) for phosphorus-based linkers. Subsequently, new linkers have been suggested and are now being tested experimentally. These studies have been communicated thus far in three publications: • “RNA-Inspired and Accelerated Degradation of Polylactide in Seawater” Rheinberger, Timo; Wolfs, Jonas; Paneth, Agata; Gojzewski, Hubert; Paneth, Piotr; Wurm, Frederik JACS 143, 16673-16681 (2021) • “RNA-inspired intramolecular transesterification accelerates the hydrolysis of polyethylene-like polyphosphoesters” Tobias P. Haider, Oksana Suraeva, Ingo Lieberwirth, Piotr Paneth, Frederik R. Wurm Chem. Sci. 12, 16054-16064 (2021) • “Environment friendly transesterification to seawater-degradable polymers expanded: Computational construction guide to breaking points” Mateusz Pokora, Timo Rheinberger, Frederik R. Wurm, Agata Paneth, Piotr Paneth Chemosphere 380, 136381 (2022) 2. Influence of the association of disaccharides on their binding properties. These studies required the development of a new protocol for binding which has been carried out in collaboration with the group of Prof. Maréchal from UA Barcelona. The results have been published: • “Influence of association on binding of disaccharides to YKL-39 and hHyal-1enzymes” Agnieszka Krzemińska, José-Emilio Sánchez-Aparicio, Jean-Didier Maréchal, Agata Paneth, Piotr Paneth Int. J. Mol. Sci. 23, 7705 (2022) In Part 2 the Computational Support group provides modeling help to groups of Prof. Steinbüchel, Dr. Plummer, and Dr. Ślęczkowski. Examples of these studies will be presented.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 102

Title: Superintegrability in matrix models

Project leader: Piotr Sułkowski

Contact: aditya.bawane@fuw.edu.pl

FNP programme: TEAM

Authors: Aditya Bawane, Pedram Karimi, Piotr Sułkowski

Matrix models, although initially inspired by and used to solve problems in physics, have proven to be useful tools to solve combinatorial problems. The calculation of moments in Gaussian Hermitian matrix model, for example, is known to be closely related to the problems of counting coloured graphs on two-dimensional surfaces, and counting of oriented ribbon graphs. These combinatorial problems have potential application in problems of enumeration of configurations of large biomolecules. Finding general expressions for moments of Gaussian matrix models (and their generalizations) is therefore crucial. It turns out that expectation values of some particular family of symmetric functions take a very simple, fully factorized form. These symmetric functions form a complete basis in the space of all observables, allowing one to compute any desired moment. For example, the expectation value of the Schur polynomial of the eigenvalues in a Gaussian Hermitian matrix model is once again a Schur polynomial. This property has come to be known as superintegrability. In a recent work, we prove the superintegrability property for a generalization of the Gaussian matrix models, called the beta-deformed Gaussian matrix model. It turns out that the expectation value of the Jack polynomial of the eigenvalues in a beta-deformed Gaussian matrix model is once again a Jack polynomial.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 103

Title: Towards on-chip plasmonics amplifiers of THz radiation

– ERC – advanced project

Project leader: Wojciech Knap

Contact: knap.wojciech@gmail.com

FNP programme: International Research Agendas Programme (IRAP)

Author: Wojciech Knap

One of the major nowadays scientific challenges lying at the border between physics and electronics, is to find solid state systems that can amplify and generate terahertz frequencies. Around 30 years ago, a new direction in solid state physics and electronics opened with the arrival of plasma-wave electronics. M. Dyakonov and M. Shur theoretically predicted that THz radiation can be rectified/detected by plasma nonlinearities and the current in the nanometer field-effect transistors could lead to the excitation of plasma oscillations. The detection part of the “plasmonics promise” was proven and nowadays THz plasmonic detectors arrays are widely used. In the case of emitters, the task appeared much more complicated. Only very recently, room temperature, current driven amplification of the incoming THz radiation in graphene grating gate structures with an innovative double grating gate geometry has been shown [1]. These results indicate that, existing model of plasmonic systems should be reconsidered and that use of the new 2D materials or their heterojunctions with semiconductors, once processed with innovative geometries may lead “Towards on-chip plasmonics amplifiers of THz radiation”. Therefore the ground-breaking objectives of the recently awarded ERC ADVANCED TERAPLASM that will be realized in CENTERA LABS (IHHP PAN 2023-2028) are : i) to understand the physics of the observed THz plasmonic amplification in graphene devices ii) investigate properties of new plasmonic 2D systems like GaN/AlGaN, Hg/HgCdTe and ii) reexamine all existing THz plasmonic amplification mechanisms/theories considering new/ innovative geometries. By extensive technological, spectroscopic and theoretical research TERAPLASM project will tend to answer 30 years old basic physics and electronics question, about the possibility of realization of on-chip plasmonics amplifiers of THz radiation, important also for society through potential applications of THz radiation in biosensing, security screening as well as for fast wireless telecommunication. [1] Room Temperature Amplification of Terahertz Radiation by Grating-Gate Graphene Structures Stephane Boubanga-Tombet, Wojciech Knap, Deepika Yadav, Akira Satou, Dmytro B. But, Vyacheslav V. Popov, Ilya V. Gorbenko, Valentin Kachorovskii, and Taiichi Otsuji Phys. Rev. X 10, 031004 (2020).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 104

Title: Nanostructured microoptical components - towards new functionalities and applications

Project leader: Ryszard Buczyński

Contact: ryszard.buczynski@fuw.edu.pl

FNP programme: TEAM-TECH

Authors: Ryszard Buczyński, Alicja Anuszkiewicz, Dariusz Pysz, Rafał Kasztelanic, Tomasz Stefaniuk, Marcin Franczyk, Hue Thi Nguyen, Van Thuy Hoang, Damian Michalik, Przemysław Gołębiewski, Krzysztof Haraśny, Ryszard Stępień

Free-form gradient index optics is a new class of flat surface passive microoptical components where internal nanostructure determines their optical properties. The structure is composed of a few thousand subwavelength rods made of two types of glass, ordered into hexagonal lattice according to the computed distribution pattern. According to Maxwell-Garnett's effective medium model, the binary patterns mimic continuous gradient index distribution for wavelengths much larger than the diameter of individual nanorods. Nanostructured optical elements can be developed using a modified stack-and-draw fibre drawing technology commonly used to develop optical fibers. We demonstrate the capabilities of this method for developing several types of microoptical components, such as parabolic GRIN microlenses, axicons, diffractive optical elements, vortex phase masks, and artificially birefringent bulk glass. In particular, we focus on selected applications of the components: Shack-Hartmann wavefront detector with record resolution, achromatic microlenses for miniaturized imaging systems, and excitation of orbital angular modes in fibres with vortex beam converters. The optical properties of the components are measured and analysed. Limits and the ability of the method for mass manufacture are discussed.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 105

Title: Uridylation of lncRNA controls alternative polyadenylation

Project leader: Szymon Świeżewski

Contact: sebastian.sacharowski@gmail.com

FNP programme: TEAM

Authors: Sebastian Sacharowski, Michał Krzysztoń, Katarzyna Muter,
Miguel Coelho, Szymon Świeżewski

Uridylation is a pervasive post-transcriptional RNA 3'end modification detected for most RNA molecules, catalyzed by terminal uridylyltransferases (TUTases). Uridylation is implicated in RNA degradation in a variety of eukaryotes, including fission yeast, plants, and animals. We suggest that additionally in plants, uridylation of lncRNAs is required for their biological function. We focused our work on lncRNA involved in Arabidopsis seed dormancy, named MUSHER. We found that MUSHER regulates multiple genes implicated in dormancy and in addition to being polyadenylated is extensively uridylated. Unexpectedly, the inactivation of URT1 - main Arabidopsis TUTase results in loss of MUSHER uridylation and alters its adenylation, without affecting its expression. MUSHER is localized downstream of DOG1 – a key regulator of dormancy in many plant species. DOG1 is subjected to alternative polyadenylation resulting in the production of two mRNA isoforms, shDOG1 and lgDOG1, produced as a consequence of proximal and distal polyA site selection respectively. MUSHER controls proximal polyA site selection of DOG1 with a minor effect on distal polyA site selection. This notion is further supported by the effects of MUSHER on RNA polymerase II kinetics and CPSF complex binding to the DOG1 proximal polyA region. Interestingly uridylation is required for MUSHER's ability to induce DOG1 proximal polyA site selection. The putative mechanism explaining this phenomenon will be discussed during the conference. Our results uncover an unexpected role of uridylation in lncRNA functioning. We show that in the case of MUSHER this results in altered polyA site selection on a key seed dormancy regulator.

Key-words: uridylation; lncRNA; polyA site selection; seed dormancy.



Number: 106

Title: Changes in structural stability of FeS cluster scaffold protein upon interactions with molecular chaperones

Project leader: Jarosław Marszałek

Contact: aneta.grabinska@phdstud.ug.edu.pl

FNP programme: TEAM

Authors: Igor Grochowina, Aneta Grabińska-Rogala, Brenda Schilke, Szymon Ciesielski, Michał Dadlez, Elizabeth Craig, Rafał Dutkiewicz, Jarosław Marszałek

During function of the bacterial and mitochondrial ISC iron-sulfur-cluster biogenesis pathway, Fe-S clusters are first assembled on a dedicated 14-kDa scaffold protein, and then transferred to recipient apo-proteins. Cluster transfer requires a J-domain protein (JDP)/Hsp70 molecular chaperone pair. The JDP binds the scaffold on its own, and then delivers it for interaction with Hsp70. Evidence indicates that formation of the scaffold-Hsp70 complex is critical for cluster transfer. However, how the Hsp70 binding mechanistically facilitates the cluster transfer is a long-standing question. Here we used *Escherichia coli* proteins (scaffold - IscU, JDP - HscB and Hsp70 - HscA) to test how the interaction with chaperones affects the structural stability of the scaffold. Using hydrogen exchange coupled with mass spectrometry (HX-MS) we have demonstrated that HscA binding increases IscU's HX rate, indicating its structural destabilization and consistent with Hsp70's role in the FeS transfer. Conversely, HscB binding reduces IscU's HX rate, indicating that the scaffold structure is stabilized by HscB. Consistent with this stabilizing effect, HscB binding protects IscU against Lon dependent proteolysis. Taken together the opposite effects on the scaffold stability suggest that the chaperones might play different roles in the ISC pathway; Hsp70 via destabilization of the scaffold structure facilitates the cluster transfer, while JDP, by protection against proteolysis, controls physiological levels of cluster loaded scaffold.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 107

Title: Silicon-based all-electronic quasi-optical pairs for THz frequency range

Project leader: Wojciech Knap

Contact: alisauskas@mail.unipress.waw.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Dmytro B. But, Kestutis Ikamas, Alexander Chernyadiev,
Cezary Kolacinski, Alvydas Lisauskas

We overview the state-of-the-art on CMOS-based electronic sources and detectors developed for the THz frequency range. In particular, we report on a system operating at 250 GHz and exhibiting input power-related signal-to-noise ratio (SNR) above 70 dB in the direct detection regime for one Hz equivalent noise bandwidth. It combines the state-of-the-art detector based on CMOS field-effect-transistors (FET) and a voltage-controlled oscillator (VCO) employing SiGe bipolar transistors provided by the BiCMOS process. The poster presents different modalities of emitter–detector pair operation such as data transmission, spectroscopy, and imaging.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 108

Title: Lenticular morphology and transparency changes with age using swept-source OCT imaging system

Project leader: Ireneusz Grulkowski

Contact: ashish_gupta@doktorant.umk.pl

FNP programme: TEAM

Authors: Ashish Gupta, Daniel Ruminski, Alfonso Jimenez Villar, Raúl Duarte Toledo, Grzegorz Gondek, Spozmai Panezai, Barbara Pierscioneck, Pablo Artal, Ireneusz Grulkowski

Crystalline lens morphology studies showed that the lens is made of fiber-shaped cells. The lenticular transparency is ensured by the fiber cells arranged in very highly ordered layers in the formation of concentric elliptical rings like an onion. The crystalline lens is formed starting with fiber cells making the core of the lens as a nucleus in the embryo, and then the fiber layers keep growing throughout life towards the periphery of the lens capsule, thus changing the lenticular morphology with age. Age-related alterations in the crystalline lens's optical properties lead to diseases like presbyopia and cataract. The changes in the morphology and transparency of the crystalline lens can be imaged in-vivo using a high-resolution optical coherence tomography (OCT) imaging system. OCT is a three-dimensional, non-invasive, pseudo-real-time imaging system that incorporates a highly sensitive optical interferometer. This study aims to demonstrate in-vivo visualization of the crystalline lens internal structure based on optical signal discontinuities in the images and evaluate changes in morphology and transparency with age. We also used standard clinical methods to measure the degradation of the eye's optical quality with age. OCT images of the crystalline lens were acquired from the healthy eyes of 50 volunteers aged from 9 years to 78 years old. The in-vivo optical imaging of the crystalline lens revealed the optical signal discontinuity (OSD) zones that have been used to characterize the types of cataracts and to elucidate the age-related morphological changes in the crystalline lens. Our findings conclude that the crystalline lens morphology; that is, thickness increases, and the radii of curvature of the lens surfaces decrease with age. The transparency of the lens decreases as back-scattering from the lens increases. The age-related changes are more significant in C3 zone and thus highly contribute to morphological changes in the human lens with age.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 109

Title: 3D printed electronics

Project leader: Marcin Słoma

Contact: marcin.sloma@pw.edu.pl

FNP programme: FIRST TEAM

Authors: Marcin Słoma, Bartłomiej Podsiadły, Kacper Skarżyński,
Bartłomiej Wałpuski, Andrzej Skalski

Here we present selected results from the project "Functional heterophase materials for structural electronics", First TEAM/2016-1/7, focused on preparing materials and techniques for the fabrication of 3D printed and structural electronics. At the beginning of the project realisation, most of the state-of-the-art results in the field of structural electronics were proof of concept or commercialised technologies, with numerous examples of practical applications. The missing element was detailed characteristics of materials properties, looking into the details, suggesting physical mechanisms and trends for their results, proposing hypotheses for improving properties or gaining new ones. On the other hand, there were plenty of research results on common composites, pastes or inks, with various types of functional phases, including nanomaterials, not targeted for 3D print or structural electronics. The real challenge was to go deeply into material science to develop specific composites that can serve as conductors, semiconductors, resistors, dielectrics or other functions. Interdisciplinary research within this project covers areas of electronics, materials engineering, chemistry, processing technology and nanotechnology. Results from the project, currently disseminated in 20 JCR publications are, cover the fields of Fused Deposition Modeling with composites with conductive, magnetic, dielectric and other properties, Aerosol Jet Printed structures for sensors, and electronic circuits with microwave systems on the way, Selective Laser Sintering of Direct Write pastes on various 3D printed low-temperature substrates and other elements including Ink-Jet printing materials evaluation, flexible and conformable circuits on foils and textiles, use of nanomaterials for the improvement of electrical and mechanical properties. Several prepared demonstrators include sensors, circuits, 3D printed electric motor or thermoelectric structures.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 110

**Title: Developing microfluidic techniques for biochemical
and medical applications**

Project leader: Piotr Korczyk

Contact: piotr.korczyk@ippt.pan.pl

FNP programme: FIRST TEAM

Authors: Slawomir Blonski, Barbara Kupikowska-Stobba, Tetuko Kurniawan,
Damian Zaremba, Piotr Korczyk

Our group aims to develop microfluidic techniques, improving their precision and applicability in biology and medicine. We cooperate with biological and medical groups to develop microfluidic devices customized for the particular research requirements of our collaborators. A successful example of the development of such a biological-oriented design is our microfluidic system, enabling spatial and temporal control over the formation of tension gradients arising from epithelial monolayer deformation. Another system developed in our laboratory allows for estimating the gas-handling properties of red blood cells by using single-cell oxygen saturation imaging. Recently, in collaboration with Prof. Przemysław Juszcyński's group, we have been elaborating on a system with single cell traps. That system is envisioned to manipulate three types of cells, enabling interactions between single cells within a defined sequence. This work aims to investigate the mechanism responsible for developing the immunosuppressive microenvironment in lymphomas and therapeutic approaches to reprogram its functions. A vast part of our activities is devoted to droplets in microfluidic channels. Each droplet in the microfluidic channel is equivalent to a tiny reactor that can include samples, reagents, or biological components for chemical synthesis, analytical assays, biological processes, drug discovery, and more. In these and other applications, obtaining the concentration of a given reagent in a precise, accurate, and above all, reproducible manner is paramount. We developed unique microfluidic geometries for the passive manipulation of droplets and sequential logic devices for the controlled permutations of droplets within the sequence. Then we used digital algorithms that ensure superior accuracy, repeatability, and flexibility in concentration settings through a series of operations of selective merging and splitting droplets into equal parts.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 111

Title: Diabetic Retinopathy, the quest for a new biomarker: bring together chemistry, physics and biology

Project leader: Humberto Fernandes

Contact: hfernandes@ichf.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Vineeta Kaushik, Luca Gessa, Nelam Kumar, Humberto Fernandes

Diabetic Retinopathy (DR) is a complication of diabetes, affecting a growing number of people, and is a significant cause of blindness in developed and developing countries. Current diagnostics are based on fundus photography, fluorescein angiography, and optical coherence tomography, with artificial intelligence gaining ground and promising more accurate diagnostics. But all of them are based on structural imaging and the search for other biomarkers that could potentially allow an early detection, and/or functional characterization, is important. A link has been revealed between retinal binding protein 3 (RBP3) and the severity of DR [1, 2], and can potential be an early molecular signature. The studies indicate that patients with decreased levels of RBP3 have more severe DR, and have shown that supplementation of RBP3 confers DR protection [2]. The ophthalmologic field has recently been reporting exciting new functional imaging capacities, such as two-photon excitation (TPE) fluorescence (TPEF) imaging. The technique overcomes tissue penetration and prohibitive excitation wavelength by simultaneous excitation by two photons with longer wavelengths, resulting in shorter wavelength emission light. It was validated in mouse models, proven safe in human subjects [3], and already used to detect different retinoids in retinas [4]. We are characterizing RBP3 and its ligand binding structurally and biophysically as a starting point to prepare complexes with modified ligands (or specific antibodies) -the chemistry. The modified reagents will have unique excitation signatures that will allow detection and quantification of RBP3 levels -the biology- using TPEF imaging -the physics. Thus, opening the possibility for early detection of DR. REFERENCES 1. Garcia-Ramirez M, et al. 2009 Diabetologia 52:2633 2. Yokomizo H, et al. 2019 Sci Transl Med. 11:eaau6627 3. Boguslawski J, et al. 2022 J Clin Invest. 132:e154218 4. Palczewska G, et al. 2018 JCI Insight. 3:e121555.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 112

Title: Easy-to-Assemble Stack Type (EAST): Development of solid oxide fuel cell stack for the innovation in the Polish energy sector

Project leader: Grzegorz Brus

Contact: brus@agh.edu.pl

FNP programme: FIRST TEAM

Authors: Grzegorz Brus, Marcin Moździerz, Szymon Buchaniec, Maciej Chalusiak, Karol Śreniawski

A solid oxide fuel cell (SOFC, hereafter) is an electrochemical device that directly converts the chemical energy of fuel and oxidant into electricity. A single SOFC consists of an ion-conducting solid electrolyte sandwiched between two electrodes, an anode, and a cathode. At elevated temperatures, hydrogen is fed to the anode side, and the air is fed to the cathode side. Oxygen ions from the air are transported via electrolyte and react with hydrogen; as a result, producing steam and providing electrons to the external circuit. A single cell produces a small voltage, and therefore, cells must be connected in stacks to obtain sufficient power output. The objective of the project was to design and manufacture a prototype of such a stack, with novel micro- and macro-patterned electrodes and an easy-to-assemble stack design. The construction took into account the latest advances in heat transfer management and microstructure-oriented cell design. In the project, we developed a multi-scale numerical simulation of the entire stack. The simulation is used to establish local thermal conditions for each cell. The output is then employed in a genetic algorithm to propose the optimal microstructure at every particular location. Finally, the optimal microstructure of the electrode is printed on the electrolyte using high-resolution adhesive-manufacturing technology. The stack is then assembled into the system and electrochemically tested. The prototype represents an important step in SOFC technology development.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 113

Title: Brain and More Lab

Project leader: Alessandro Crimi

Contact: a.crimi@sanoscience.org

FNP programme: International Research Agendas Programme (IRAP)

Authors: Alessandro Crimi, Joan Falco-Roget, Aleksandra Pestka, Monika Pytlarz, Rosmary Blanco, Sylwia Malec

Neuroimaging is the use of quantitative method to study the structure and function of the central nervous system. It uses quantitative tools to investigate the structure and operation of the central nervous system. This is a multidisciplinary approach heavily based on computational tools, which given the increasing advancements in machine learning is seen as very promising to extract biomarkers and to shed some lights about genesis of brain diseases. Indeed, increasingly it is also being used for quantitative studies of brain disease and psychiatric illness, neurodegeneration and brain tumors. The computer vision group, renamed "brain and more lab" given the focus on neuroimaging, is interested in research projects related to neurodegeneration (as Alzheimer, Parkinson, etc) and brain tumor. The research has been focused at different layers of medical imaging analysis. We investigated classification of brain tumor grade from the histological biopsies by using deep learning architecture, capitalizing on recent advancements on computational pathology and microscopy image analysis. We have analyzed the spreading of misfolded protein for Alzheimer on brain connectome and the changes of brain connectome after surgical resection of tumors. A connectome is a comprehensive map of neural connections or functional correlation in the brain, and may be thought of as its "wiring diagram" either functional or structural of the brain, and it is generally obtained by magnetic resonance images (MRI). Lastly, the group is investigating application of neurotech wearables to both collect novel imaging modalities (as functional near-infrared spectroscopy), to obtain real time and daily biomarkers beyond MRI modalities.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 114

Title: Superintegrability in β -deformed eigenvalue models

Project leader: Piotr Sułkowski

Contact: pedram.karimi@fuw.edu.pl

FNP programme: TEAM

Authors: Aditya Bawane, Pedram Karimi, Piotr Sułkowski

It is not surprising from a statistical point of view to observe the randomness in nature, from the spread of viruses to cosmic fluctuations of the fabric of spacetime. Also, it is common practice in modeling nature to use matrices. Random matrix theory deals with matrices with random elements. It was conjectured that multi-point correlation functions of random matrix models in various ensembles can be written in a simple factorized way, which is known as superintegrability. In this poster, we outline a proof of superintegrability in β -deformed eigenvalue models. Our work is a rigorous step toward understanding the phenomenon. The proof contains advanced mathematical techniques ranging from combinatorics to group theory. The expectation is that superintegrability does not confine in the matrix model and eventually has to be connected to problems in knot theory, molecular folding, and gauge theories. We hope our proof shed light on various aspects of modern mathematical physics and its application in natural sciences.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 115

Title: SARS-CoV-2 pseudoparticles system for testing of antiviral strategies

Project leader: Alicja Chmielewska

Contact: alicja.chmielewska@ug.edu.pl

FNP programme: POWROTY / REINTEGRATION

Authors: Alicja Chmielewska, Natalia Stachura, Krystyna Bieńkowska-Szewczyk

SARS-CoV-2 is a high containment laboratory pathogen and, as a respiratory virus, it needs special protective measurements. The main aim of presented project was to implement a safe SARS-CoV-2 research model system to study antiviral approaches against COVID-19. We implemented and optimised two approaches. First, a model coronavirus NL 63 that is milder than SARS-CoV-2, but shares cellular receptor ACE-2 and basic biology. Second, a system based on SARS-CoV-2 pseudoparticles - lentivirus vectors that express coronavirus spike protein (S) on their surface. In their genome pseudoparticles contain reporter gene that enables easy measurement of the level of entry into the cells. After optimisation and validation of the method, we used pseudoparticles system to test antiviral strategies against COVID-19. Tested strategies included several non-canonical types of interferons, anti-SARS-CoV-2 antibodies and a panel of antibodies directed against cellular protein IFITM1, which plays a major role in SARS-CoV-2 entry.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 116

Title: Identification of candidate regulatory single nucleotide variants relevant for Alzheimer's disease development

Project leader: Magdalena Machnicka

Contact: m.machnicka@mimuw.edu.pl

FNP programme: POWROTY / REINTEGRATION

Authors: Marcelina Kieroń, Bartosz Wojtaś, Bartłomiej Gielniewski, Paulina Szadkowska, Bartek Wilczyński, Bożena Kamińska, Magdalena A. Machnicka

Alzheimer's disease (AD) is a complex neurodegenerative disorder. Risk factors for AD include both genetic background and influence of environment and lifestyle. Genetic risk factors for AD have been studied very intensely, mainly by genome-wide association studies (GWAS) which uncovered more than 30 AD risk loci, many of which localize in non-coding regions of the genome, making interpretation of their relevance for disease pathology difficult. What is more, GWAS include polymorphisms with relatively high population frequency and low impact on disease risk. Associations for high-impact rare variants are difficult to identify in genome-wide studies due to large cohort sizes required to reach statistical significance. One strategy to restrict the search space is identification of active regulatory regions which should carry functional variants, prior to variants identification and analysis. We have analyzed a set of regulatory regions of the genome expected to be active in human brain and we identified a set of single nucleotide variants (SNVs) present in several samples from a cohort of Polish AD patients but very rare in global, European and Polish populations. We have computationally predicted that these SNVs can interfere with transcription factor (TF) binding and, as a result, change expression of target genes. These SNVs are located in putative enhancers of three genes involved in metabolism of key proteins in AD or associated with biomarker levels: PRKCA (amyloid precursor protein (APP) metabolism), AXIN1 (tau protein phosphorylation) and MTHFD1L (homocysteine metabolism). We have also identified a SNV in a promoter of the GPR19 gene involved in activation of Akt and ERK signaling in neuronal cells. These SNVs are promising candidates for non-coding variants relevant for AD development. However, their interference with TF binding, the enhancer-target gene interactions and SNVs impact on pathological processes relevant for AD require experimental validation.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 117

Title: Cellular consequences of ESCRT-I depletion for lysosomal degradation and metabolism

Project leader: Marta Miączyńska

Contact: mwrobel@iimcb.gov.pl

FNP programme: TEAM

Authors: Marta Wróbel, Jarosław Cendrowski, Ewelina Szymańska, Malwina Grębowicz-Maciukiewicz, Noga Budick-Harmelin, Matylda Macias, Aleksandra Szybińska, Michał Mazur, Krzysztof Kolmus, Krzysztof Goryca, Michalina Dąbrowska, Agnieszka Paziewska, Michał Mikula, Marta Miączyńska

The endolysosomal trafficking pathway in mammalian cells mediates uptake and intracellular transport of internalized cargo in membrane-bound compartments such as endosomes and lysosomes, the latter involved in degradation of cargo. The endosomal sorting complexes required for transport (ESCRT complexes) are crucial components of a machinery that targets cargo to lysosomes. Depletion of ESCRT complexes induces dysfunction of endosomes with multiple effects on cellular trafficking and signaling. We discovered that ESCRT complexes are also important for homeostasis and function of lysosomes. Specifically, we showed that mammalian ESCRT-I restricts the size of lysosomes and promotes degradation of proteins from lysosomal membranes, including MCOLN1, a Ca²⁺ channel protein. The altered lysosome morphology upon ESCRT-I depletion coincided with elevated expression of genes that are targets of TFEB/TFE3 transcription factors. Activation of these factors induces biogenesis of new lysosomes that can occur in response to multiple cues. Aiming to uncover a molecular mechanism of TFEB/TFE3 activation upon ESCRT-I dysfunction, we revealed that it occurs due to the inhibition of Rag GTPase-dependent mTORC1 pathway. Our results identify a novel homeostatic response to counteract lysosomal nutrient starvation, that is, improper supply of nutrients derived from lysosomal degradation. Moreover, our findings show that the function of ESCRT complexes in endolysosomal transport is linked to the regulation of metabolic signaling. Further studies may address whether cancer cells with increased lysosomal function via TFEB/TFE3 signaling could be particularly dependent on lysosomal membrane protein turnover that, as we show here, is mediated by ESCRT-I.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 118

Title: Achievements and Research Challenges of Computational Medicine

Project leader: Maciej Malawski

Contact: m.malawski@sanoscience.org

FNP programme: International Research Agendas Programme (IRAP)

Authors: Maciej Malawski, Marian Bubak, Alessandro Crimi, Jose Sousa, Ahmed A. Hamed, Przemysław Korzeniowski

Nowadays' medicine is increasingly entering a field similar to engineering and adopts advanced modeling methods as well as computational and data analysis technologies. Sano is a new, independent research institute dedicated to the advancement of computational medicine in five domains which comprise Sano's research core. Health Informatics – development of new diagnostic and therapeutic processes based on patient data to extract insights that can be used to improve patient care and prevention, and new generation of medical communication. Multidisciplinary research "VR-Lab" is built at the cross-section of AI, simulation, virtual and augmented reality, human-computer interaction, and robotics. Computer Vision Data Science – applies computer vision in medicine, in neuroimaging, from microscopy to magnetic resonance imaging. The research includes combination of simulation and data analysis techniques for diagnosis and prediction of neurodegenerative diseases as well as brain tumors. Clinical Data Science – development of AI clinical decision support systems based on clinical and other types of data. Using means of biomedical algorithms and computational approaches, it aims to advance our understanding of novel human diseases and provide safe treatments by investigating new purposes for already existing approved drugs. Extreme-scale Data and Computing – efficient processing of large data sets with the use of advanced computing infrastructures (HPC and Cloud) to meet the demands of medical applications. Personal Health Data Science – “citizen before patient” approach to empowering personal health decision making within actionable insights of a computational intelligence architecture of choice, aiming to deliver AI machine self-learning models for improving the health of entire populations. All these research areas are based synergy of two paradigms: modelling and simulation and data science enhanced with AI methods. Sano combines the research excellence in development and application of computational models in medicine and to turn these research results into translatable outputs with the impact on clinics and society in general. Acknowledgements. Sano Centre is financed by the European Union's Horizon 2020 Teaming grant 857533, the International Research Agendas Programme of the Foundation for Polish Science grant MAB PLUS/2019/13 co-funded by the European Union in the scope of the European Regional Development Fund, and Polish Ministry of Education and Science (after 2023).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 119

Title: Droplet Microfluidics: from Soft Granular Materials for Tissue Engineering

Project leader: Jan Guzowski

Contact: jguzowski@ichf.edu.pl

FNP programme: FIRST TEAM

Authors: Katarzyna Rojek, Jan Guzowski

Microfluidics has recently emerged as a powerful tool in generation of cell-laden microgels, so-called microtissues, capable of performing tissue-specific functions, for applications in drug testing, regenerative medicine, and cell therapies. Microgels, in particular those consisting of several independent compartments can be precisely tailored with high reproducibility and throughput at submillimeter scale by using microfluidics and used to provide “initial conditions” for cell proliferation and maturation into functional tissue-like microstructures. Within the First Team project we have developed new microfluidic tools of microgel synthesis and self-assembly towards controlled generation of microtissues of well defined topology. In particular, we have shown that (i) microfluidics can be used to generate droplet and/or microgel clusters as well as all-hydrogel core-shell structures and chains, (ii) it can be combined with 3D printing to deposit such structures at a substrate or to assemble biocompatible functional 3D porous scaffolds, and that (iii) granular microgels can be manipulated to serve as scaffolds, e.g., for long-term culture of well-controlled microvascular networks on-chip.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 120

Title: Chemical Infrared Imaging at Solaris – from micro- to nano-scale

Project leader: Tomasz P. Wróbel

Contact: tomek.wrobel@uj.edu.pl

FNP programme: HOMING

Authors: Maciej Roman, Karolina Kosowska, Paulina Kozioł, Danuta Liberda,
Tomasz P. Wróbel

Infrared (IR) microspectroscopy is a microscale, label-free, nondestructive, and information-rich technique successfully applied for years in biological and material science. In past decades, increased efforts have been made to implement IR techniques as fast and accurate diagnostic tools, with the cancer detection field being one of the most widely explored areas. On the other hand, the rapid development of nanotechnology has created a need for extensive research at the nanoscale. Several new IR techniques have been proposed, including Optical Photo-Thermal IR (O-PTIR), Atomic Force Microscopy – IR (AFM-IR), and scattering-Scanning Near-field Optical Microscopy (s-SNOM), to overcome the diffraction limit of IR light. As an example of fast hyperspectral imaging at the microscale, Multiple Tissue Micro Arrays of pancreatic cancer providing high patient statistics (250 cases, 663 tissue cores) were studied by Fourier-Transform IR (FT-IR) imaging with the support of machine learning. The aim of the study was the comparison of classification models' performance based on High and Standard Definition FT-IR data. A new avenue of FT-IR was to use polarization to deduct macromolecular orientation in tissues. Improving the spatial resolution, the molecular orientation of a model polycaprolactone spherulite was analyzed by the application of the "concurrent analysis" (4P-3D) using FT-IR and O-PTIR (at the submicron level) techniques. Finally, AFM-IR and s-SNOM techniques were applied for nanoscale imaging of biological (protein aggregates) and material (polymer, graphene) samples at the new Chemical InfraRed Imaging (CIRI) beamline at the Solaris National Synchrotron Radiation Centre. The current status of the CIRI beamline with all available microscopic techniques will be presented as well. This research was supported by the Foundation for Polish Science (Grant No. Homing/2016-2/20) and the National Science Centre, Poland (Grant No. 2018/31/D/ST4/01833).



Number: 121

Title: POLR1D, a common subunit of RNA polymerases I and III, interferes with TOR signalling

Project leader: Damian Graczyk

Contact: n.gorjao@ibb.waw.pl

FNP programme: FIRST TEAM

Authors: Neuton Gorjão, Damian Graczyk

mTOR (mammalian target of rapamycin) is a major regulator of cell growth, proliferation and survival by coordinating upstream signals from growth factors and amino acid availability. mTOR is implicated in different physiological and pathological conditions such as cancer, neurodegenerative diseases and diabetes. POLR1D is a small subunit that is common to RNA polymerase I and III, which synthesize rRNA and tRNA, respectively. The products of these polymerases are crucial for protein synthesis. POLR1D is frequently amplified in colorectal cancer (CRC) and POLR1D high expression is positively correlated with tumour size and poor survival of CRC patients. In contrast, POLR1D knock-down inhibits CRC cells proliferation in vitro and tumour-growth in mouse xenograft model. Here we show that the ectopic overexpression of POLR1D in mammalian cells stimulates the mTOR signalling. On the other hand, we demonstrate that the downregulation of POLR1D expression results in the repression of mTOR pathway activity. Concomitantly, and with agreement with TOR activity downregulation, we observe that POLR1D knock-down induces autophagy. We also see that, when overexpressed, POLR1D localizes to subcellular organelles present in the cytoplasm, interacts with RAGULATOR complex and alters the cellular localisation of RagC and Raptor, components of RAGULATOR and mTORC1 (mTOR complex 1) complexes, respectively. Our data therefore shows an unexpected novel role of Pol I/III subunit in the regulation of mTOR signalling. This phenomenon may constitute a feedback mechanism that coordinates Pol I/III activity with protein translation. Moreover, given that POLR1D is frequently overexpressed in colorectal cancer, one may speculate that this stimulates TOR signalling, which in turn drives growth and proliferation of these cells .



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 122

Title: dCas9-directed transcriptional activation modulates meiotic recombination frequency in Arabidopsis

Project leader: Piotr A. Ziółkowski

Contact: pzio@amu.edu.pl

FNP programme: TEAM

Authors: Wojciech Dziegielewski, Maja Szymanska-Lejman, Karolina Hus, Piotr A. Ziolkowski

During meiosis, homologous chromosomes reciprocally exchange their fragments in a specific type of recombination called crossover (CO). This process is a foundation of genetic diversity of offspring in sexually reproducing organisms. Localization of COs is controlled by various factors, however across the genome some regions exhibit higher recombination rates than others. These regions are known as recombination hotspots. In this project we aim to investigate how modifying gene expression ectopically affects crossover formation at the hotspot scale. To this end, we increased levels of gene expression in one of the natural recombination hotspots in a model plant *Arabidopsis thaliana*. To locally increase gene expression, we adopted a CRISPR-dCas9 system. The dCas9 (catalytically inactive endonuclease Cas9) has been fused with a transcriptional activator VP64 and guided to a promoter of a long non-coding RNA gene within the recombination hotspot. The hotspot is flanked with dsRED and eGFP coding sequences expressed in seeds; these reporters allow measurement of recombination frequency in the interval, by counting the single-fluorescent seeds produced by the studied individual. Initial measurements indicate that our genetic construct efficiently increases expression of the targeted gene. Using ChIP-qPCR, we confirmed that dCas9-VP64 fusion proteins specifically occupies the targeted locus. Plants harbouring the genetic construct show a mild increase in recombination frequency within the hotspot containing the targeted gene. These results indicate that ectopically increased transcriptional activity might contribute to elevated recombination frequency. Further studies will include determining the mechanism of this phenomenon, as well testing loci in distinct genome regions. In a broader perspectives, this research may help to develop new strategies for targeting crossovers to specific loci within the genome, providing a new powerful tool for plant breeding.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 123

Title: Fiber laser source for Stimulated Raman Scattering imaging of leukemia cells

Project leader: Czesław Radzewicz

Contact: kkrupa@ichf.edu.pl

FNP programme: TEAM-NET

Authors: Cássia Corso Silva, Łukasz Zinkiewicz, Mateusz Pielach, Agnieszka Jamrozik, Milena Krolikowska, Joanna Purzycka, Piotr Wasylczyk, Katarzyna Krupa, Yuriy Stepanenko

The goal of our TEAM-NET project “Label-free and rapid optical imaging, detection and sorting of leukemia cells” (RAPID) is to develop a novel instrument with a detection based on Stimulated Raman Scattering (SRS) for application to leukemic diagnostics. The proposed approach based on non-invasive and faster imaging of live leukemia cells will help to objectify and accelerate initial diagnostics and follow up of leukemia patients. Our objective within this project is to build a tunable SRS laser source that will allow for measurements with 15cm⁻¹ resolution and in the spectral range below 1700cm⁻¹. Access to the fingerprint region is supposed to provide information about the cells important from their chemical viewpoint. Achieving these conditions has typically required state-of-the-art, free-space cavity, solid-state lasers that are bulky, costly and environmentally sensitive, thus not suitable for use in a clinical environment. The latest advances in fiber laser technology has allowed to develop, over the past years, a tunable two-color SRS light source based on ultrafast fiber laser allowing for Raman shift in the limited CH spectral region (i.e. 2800-3200cm⁻¹). Very recently, all-fiber laser system covering a wide range of 570-3300cm⁻¹ was demonstrated. We have built the light source based on all-polarization maintaining Ytterbium-doped fiber oscillator mode-locked via nonlinear-optical-loop-mirror instead, which assures an environmentally stable and long-term reliable operation. It consists of two 100mW 1nm-wide beams that can be tuned in the range of 910-930 nm and 1023-1037 nm, respectively, with 1 nm spectral width, resulting in the accessible SRS signals between 970 and 1350 cm⁻¹ with 15 cm⁻¹ spectral resolution. The beam at 920-nm central wavelength has been generated through self-phase-modulation in photonic crystal fibers. After integration with a microscope we obtained the first high-resolution image of live leukemic cells performed over few seconds.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 124

**Title: Transcriptional and immunoregulatory consequences of PIM inhibition
in diffuse large B-cell lymphoma**

Project leader: Przemysław Juszczynski

Contact: pjuszczynski@ihit.waw.pl

FNP programme: TEAM

Authors: Sonia Dębek, Dorota Komar, Maciej Szydlowski, Michał Pawlak,
Aleksandra Matrejek

The PIM kinase family consists of 3 proto-oncogenic proteins: PIM1, PIM2 and PIM3, expressed in multiple human malignancies. PIM kinases regulate crucial processes, such as proliferation, apoptosis, metabolism, and migration, therefore their inhibition is of great interest as a potential therapeutic strategy. However, the detailed mechanisms of PIM's oncogenic effects and the consequences of their inhibition remain insufficiently understood. Since PIM kinase inhibitors are in clinical development, thorough characterization of PIM functions is critical to design novel rational therapeutic strategies and extend the therapeutic indications. The TEAM project "Non-canonical PIM kinase functions in lymphomas" aims to broadly characterize the role of PIM kinases and the consequences of their inhibition in the most common adult lymphoma, DLBCL (diffuse large B-cell lymphoma). In our studies, we have characterized the immunomodulatory functions of PIM kinases in lymphoid malignancies, and demonstrated that their inhibition increases the efficacy of immunotherapy with anti-CD20 antibodies. In addition, we characterized the role of PIMs in regulation of gene expression. PIM inhibition markedly downregulated the expression of transcripts controlled by super-enhancers (SE), i.e. extensive regulatory regions responsible for high levels of expression of key oncogenes. PIM Inhibition markedly reduced the H3S10ph, H3K9Ac, H3K14Ac and H4 panacetylation, which was associated with reduced BRD4 binding to the SE regions and reduced RNAPII serine 5 (S5) phosphorylation, but not S3 or S7 phosphorylations. Together, these observations suggest the participation of PIM in the elongation phase of SE-dependent gene transcription via H3S10 dependent epigenetic mechanism. The results document new, epigenetic function of PIM kinases and present a novel cytotoxicity mechanism of their inhibition in DLBCL. They also indicate that PIM inhibition can be a therapeutic option in DLBCL.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 125

Title: Seismic Characterisation for Astronomical Observatories

Project leader: Leszek Roszkowski

Contact: jensing@camk.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Author: Josiah Ensing

Seismic site characterisation is crucial component of site selection for astronomical observatories, sometimes in unexpected ways. Ground-based astronomical observatories are located on the surface of Earth and are subject to seismic wave that propagate through it. Site selection for astronomical observatories differs with the type of observatory. Of course seismic observatories must be built to withstand the effects of the earthquake on the observatory itself, but sometimes the observed data itself is also affected by seismic waves, even very weak ones. Here I outline examples of seismic site characterisations I have worked on, such as for the future Southern Wide-field Gamma-ray Observatory (SWGO) and Einstein Telescope (ET).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 126

**Title: Ladder-like Polymer Brushes Containing Conjugated
Poly(Propylenedioxythiophene) Chains**

Project leader: Szczepan Zapotoczny

Contact: uchacz@chemia.uj.edu.pl

FNP programme: TEAM

Authors: Gabriela Grześ, Karol Wolski, Tomasz Uchacz, Justyna Bała,
Szczepan Zapotoczny

Conductive polymer brushes composed of densely packed conductive polymer chains are very promising materials that can be used in many applications, e.g. nanoelectronics, due to the enhanced directional transport of electrons. In this context, we would like to present our results on conductive polymer brushes based on proDOT monomer (3,4-(2-dimethylpropylenedioxy)thiophene methacrylate). The brushes were prepared via a self-templating surface-initiated technique (ST-SIP) that combines the surface-initiated atom transfer radical polymerization (SI-ATRP) of bifunctional ProDOT-based monomers and subsequent oxidative polymerization (with FeCl₃) of the pendant ProDOT groups in the parent brushes. The final Poly(ProDOT)-Poly(MM) brushes with conjugated Poly(ProDOT) chains exhibit a ladder-like architecture. The dry thickness of the parent polymer brushes is in the range of 15–40 nm and substantially increases after oxidative polymerization. Our photophysical analysis (UV-VIS absorption, photoluminescence, and lifetimes) provided information about the population of macromolecular segments having various effective conjugation lengths within the brushes. The FT-IR measurements revealed that conjugated poly(ProDOT)-poly(MM) brushes were very stable in ambient conditions. The high stability was further confirmed by photodegradation measurements performed using standardized solar light (AM 1.5 G) of 100 mW/cm². Iodine-doped poly(ProDOT)-poly(MM) brushes exhibits exceptionally high vertical conductivity (0,2 S/m - two orders of magnitude higher than PEDOT: PSS). These findings indicate that the ladder-like architecture of conjugated Poly(ProDOT)-Poly(MM) brushes might be advantageous in the case of fabricating highly ordered and stable molecular wires based on hardly processable conjugated polymers for potential applications in, e.g., sensors and nanoelectronics.



Number: 127

Title: Investigation on scintillating materials and optic fibers for measuring the spatial distribution of radiation dose with Dose-3D detector

Project leader: Tomasz Szumlak

Contact: rucinski@agh.edu.pl

FNP programme: TEAM-NET

Authors: A. Ruciński, S. Beddar, T. Fiutowski, J. Hajduga, P. Jurgielewicz, D. Kabat, K. Kalecińska, Ł. Kapłon, M. Kopeć, S. Koperny, D. Kulig, B. Mindur, J. Moroń, G. Moskal, S. Niedźwiecki, M. Silarski, F. Sobczuk, T. Szumlak

In the frame of Dose-3D project, cutting-edge scintillator and optic fiber technology is investigated to design and develop a novel detector for measuring in real time the spatial distribution of radiation dose in radiotherapy. The Dose-3D detector concept assumes granulated matrix of scintillator cubes fixed in the 3D printed mechanics. Each scintillator cube excited by ionizing radiation produces visible light transmitted via an individual optic fiber to the multi-channel readout electronics and signal processing unit. For the purpose of the Dose-3D detector development, in collaboration with researchers from Hanyang University, South Korea, digital light processing (DLP) 3D printing technique was applied to print customized scintillators. We have recently characterized and compared 3D printed and the commercially available scintillating cubes and we are currently testing the detector system, particularly considering various scintillator surface finishing methods and wrapping configurations. Although the light output of the 3D-printed scintillators is about 50% lower than that of the commercial plastic scintillator, due to fast, low-cost production, and easy customization of the printed shape the 3D-printed scintillators are promising as an active part of dosimeters for use in high intensity gamma radiation fields produced by medical linear accelerators with acceptable signal-to-noise ratio level.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 128

Title: Dark Matter Axions in the Early Universe with a Period of Increasing Temperature

Project leader: Leszek Roszkowski

Contact: josin@camk.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Paola Arias, Nicolás Bernal, Jacek K. Osiński, Leszek Roszkowski

We consider the production of axion dark matter through the misalignment mechanism in the context of a nonstandard cosmological history involving early matter domination by a scalar field with a time-dependent decay rate. In cases where the temperature of the Universe experiences a temporary period of increase, Hubble friction can be restored in the evolution of the axion field, resulting in the possibility of up to three "crossings" of the axion mass and the Hubble expansion rate. This has the effect of dynamically resetting the misalignment mechanism to a new initial state for a second distinct phase of oscillation. The resultant axion mass required for the present dark matter relic density is never bigger than the standard-history window and can be smaller by more than three orders of magnitude, which can be probed by upcoming experiments such as ABRACADABRA, KLASH, ADMX, MADMAX, and ORGAN, targeting the axion-photon coupling. This highlights the possibility of exploring the cosmological history prior to Big Bang Nucleosynthesis through searches for axion dark matter beyond the standard window.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 129

Title: TDP-43-metabolism interplay in neurodegenerative disorders

Project leader: Ali Jawaïd

Contact: a.jawaid@nencki.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Ismail Gbadamosi, Izabela Lepiarz-Raba, Ali Jawaïd

Background: Amyotrophic lateral sclerosis (ALS) and frontotemporal lobar degeneration (FTLD) are two fatal neurodegenerative disorders with considerable molecular overlap. Cytoplasmic aggregation of transactive response DNA binding protein of 43 kDa (TDP-43) in neurons and glia is a consistent feature of a majority of ALS and FTLD cases. Certain metabolic conditions that are conventionally considered risk factor for cardiovascular and cerebrovascular diseases; such as type 2 diabetes mellitus, high body mass index, and dyslipidemia are intriguingly associated with delayed onset, slower disease progression, and/or longer survival in both ALS and FTLD. **Aims:** This study aims to investigate the molecular mechanisms underlying the disease-modifying effects of metabolic disorders in ALS and FTLD with a particular focus on the role of TDP-43 in regulation of neuronal metabolism. **Results:** Our investigations performed in NSC-34 mouse motor neuron-like cells reveals a regulatory role of TDP-43 in neuronal glucose metabolism. Notably, TDP-43 knock-down alters the expression of key rate-limiting enzymes involved in glycolysis and citric acid cycle. At the functional level, these changes correlate with an increased utilization of glucose and increase in both glycolysis and oxidative phosphorylation. **Conclusion:** Our current findings underscore an interplay between TDP-43 and neuronal glucose metabolism that may have important implications for neuronal survival under conditions of metabolic stress. Our current focus is on validation of the findings via modeling TDP-43 aggregation in NSC-34 cells as well as identifying the underlying molecular cascade that could be targeted to modify TDP-43 aggregation or its down-stream toxicity in brain organoids derived from induced pluripotent stem cells (iPSCs) harboring TDP-43 disease-linked mutations. **Keywords:** TDP-43, metabolism, neurodegeneration, ALS, FTLD.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 130

Title: Consistent metabolic and miRNA signatures of childhood trauma across different body fluids in humans

Project leader: Ali Jawaid

Contact: a.jawaid@nencki.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Magdalena Gomolka, Weronika Tomaszewska, Ali Jawaid

Aims: The main goal of this project is to systematically examine miRNA changes in different human body fluids, i.e., serum, sperm and milk that are relevant to long-term sequelae of childhood trauma including its intergenerational transmission. **Methods:** Small RNA sequencing followed by quantitative reverse transcriptase polymerase chain reaction assays were performed to identify and validate differentially regulated miRNAs in the serum of children with recent trauma in the form of paternal loss and maternal separation (PLMS), sperm of adult men with history of complex trauma up to the age of 17 years, and milk from lactating mothers with prior history of childhood trauma. Pathway analysis for altered miRNAs was performed based on the Tarbase database. **Results:** Small RNA sequencing analysis revealed 48 miRNAs to be differentially expressed in the serum of PLMS children vs. control; whereas 29 miRNAs were differentially expressed in the sperm of adult men with a history of complex childhood trauma. Several differentially regulated miRNAs overlapped between analyses. Furthermore, the pathway analysis and functional relevance of the altered miRNAs suggest potential implication of lipids-associated miRNA carriers in the observed changes. Notably, miR-145-5p and miR-223-3p that were confirmed to be upregulated in the sperm of adult men with complex childhood trauma via qPCR analysis are known to interact with SR-B1: the receptor for high-density lipoproteins. miR-223-3p was also found to be increased in the milk of lactating mothers with a history of childhood trauma. **Conclusions:** This study found overlapping miRNA changes in a range of human body fluids after childhood trauma that seem to be conserved across diverse cohorts and age-groups. The close relevance of these miRNAs to lipid-derived carriers is the premise of our current investigations.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 131

Title: Audio Processing using Distributed Acoustic Sensors

Project leader: Kowalczyk Konrad

Contact: konrad.kowalczyk@agh.edu.pl

FNP programme: FIRST TEAM

Authors: Konrad Kowalczyk, Stanisław Kacprzak, Marcin Witkowski,
Julitta Bartolewska, Magdalena Rybicka, Mieszko Fraś

Recent developments of Internet Technologies (IT) have caused a rapid increase in numbers of smart devices in our surroundings, many of which are equipped with microphones. Connecting several smart devices, known as the Internet of Things (IoT), has a great potential in overcoming the challenges of hands-free voice communication from distance such as a weak signal of a desired speaker, room reverberation, and high levels of background noise and interfering sounds. The challenges and opportunities related to distributed processing are addressed in this project using a handful of audio signal processing and machine learning techniques. The algorithms developed during the project include self-localization and synchronization of distributed devices, distributed multi-array noise reduction scheme based on exchanging a limited number of audio signals, multichannel source separation based on non-negative tensor factorization, optimum filters for joint extraction and enhancement of signals of the desired speakers, as well as deep learning based solutions for speaker verification and diarization. The ultimate goal is to improve speech intelligibility in hands-free communication and provide robust voice-based human-computer interfaces from distance, which is achieved in co-operation with international project partners from John Hopkins University, University of Valencia and Tampere University.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 132

Title: Development of a technology for the production of mineral-organic fertilizers with the addition of functionalized fly ash and lignite for the biofortification of plants

Project leader: Monika Mierzwa-Hersztek

Contact: mierzwa@agh.edu.pl

FNP programme: TEAM-NET

Authors: Monika Mierzwa-Hersztek, Renata Jarosz, Adam Kowalski, Katarzyna Wolny-Koładka, Justyna Szerement, Jakub Mokrzycki, Lidia Marcińska-Mazur, Karolina Biel, Piotr Rusiniak, Tomasz Bajda, Wojciech Franus

The use of mineral-organic fertilizers with the addition of functionalized materials is a fully innovative method of rational management of soil resources is to , as it may protect the productive value of soils in the light of the principles of sustainable development and the global direction of economic development, i.e. the bio-economy. The aim of this study is to develop a technology for the production of mineral-organic fertilizers based on functionalized materials derived from fly ash, strains of microorganisms and lignite or leonardite for biofortification of crop plants (wheat, rapeseed, corn) with selected micro- and macronutrients. The effect of the fertilizer formulations on selected plant growth parameters as well as on soil biological and chemical properties was verified in laboratory and pot experiments. The fertilizers prototypes obtained from this task have sequential release of nutrients during periods of real demand by plants. Our study shows that use of these fertilizers reduced the problem of soil acidification, reduced nutrient losses by leaching, improved soil biological activity, and, thanks to the use of strains of microorganisms, increase the efficiency of using fertilizer ingredients, and perhaps activate their inaccessible forms in soil reserves. However, to be able to unequivocally determine the most favorable fertilization variant, it is necessary to conduct further tests and analyze the results obtained. This will allow checking the relationship between individual soil parameters and the type of fertilization used, and consequently, the final assessment of the impact of fertilizer mixtures on soil properties as well as qualitative and quantitative parameters of plant biomass. Acknowledgments The POIR.04.04.00-00-14E6/18-00 project is carried out within the TEAM-NET programme of the Foundation for Polish Science co-financed by the European Union under the European Regional Development Fund.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 133

**Title: ATML1 regulates ER bodies - a chemical defence system
in *Arabidopsis thaliana***

Project leader: Kenj Yamada

Contact: alwine.wilkins@gmx.de

FNP programme: TEAM

Authors: Alwine Wilkens, Kenji Yamada

Plants cannot run away from dangers or fight off aggressors, yet they are by no means at the mercy of their environment. Using the model plant *Arabidopsis thaliana*, we are examining a chemical defence system, the so-called endoplasmic reticulum body (ER body) system. ER bodies contain large amounts of enzymes, which are called β -glucosidases. If herbivores attack *Arabidopsis*, β -glucosidases are set free and come into contact with glucosinolates that are stored in the vacuole. This triggers the formation of a toxic chemical called isothiocyanate which is responsible for the pungent smell and taste of cabbage plants like mustard. Three types of ER bodies have been identified that have different components, regulatory mechanisms, and localizations and thus optimize the cost-benefit balance. Leaf ER bodies that are situated in large epidermal cells, are the most recently described type. Here, we show that ATML1, a transcription factor known for its involvement in epidermis formation, is also responsible for the induction of leaf ER bodies.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 134

Title: Characterization of the Seismic Field in Virgo CEB

Project leader: Leszek Roszkowski

Contact: alamsh@camk.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Sk Shariful Alam, Tomek Bulik, Mariusz Suchenek, Marek Cieřlar

The general theory of relativity predicts that all moving objects with asymmetric mass distributions generate gravitational waves (GWs). LIGO, Virgo, and KAGRA are the interferometric detectors searching for GWs and by investigating GWs the astrophysical sources can be identified. Fluctuations of the Newtonian noise (NN) resulting from environmental seismic and anthropogenic disturbances set a limit to the sensitivity of ground-based GW detectors at the low-frequencies ranging from 1 Hz to 10 Hz. Seismic disturbances are predicted to be the strongest contribution to NN. It is significant to characterize the seismic environment near the gravitational wave detector and comprehend how the neighboring environments play a vital role in the performance of the interferometric GW detectors. We want to introduce the impact of seismic gravity perturbations that put a limit on the detection of low-frequency GW signals in future underground GW detectors. The mitigation of the NN depends strongly on the number of seismometers, the sensitivity of the seismometers, and the position of these seismometers around the test masses. All these parameters can be controlled with proper modeling of the seismic field. There are several seismic sensors have been set near the GW detectors and these sensor data have been analyzed in terms of wave-vector space at different frequencies to identify the presence of potential local seismic sources. We find the spatial spectrum from the cross-spectral densities originated from each pair of sensors. It is noticed two similar wave fields are present continuously in the spatial spectrum while the mode of propagation (i.e., velocity) of the wave fields are different. For proper characterization of the seismic field, we investigate the amplitude, velocity, and direction (angle) of the seismic wave field for the frequency range 5Hz ~ 20Hz.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 135

Title: A novel concept of sustainable capacitor based on the carbon-ion technology - CARBionCAP

Project leader: Paula Ratajczak

Contact: paula.ratajczak@put.poznan.pl

FNP programme: POWROTY / REINTEGRATION

Authors: Andres Parejo-Tovar, Francois Beguin, Paula Ratajczak

Abstract content: At present, lithium-ion batteries (LIBs) are the dominant energy storage system (ESSs) applied e.g., in cell phones and laptops. On the other hand, electrical double-layer capacitors (EDLCs) (also known as supercapacitors), owing to the electrostatic charge storage mechanism, display high power density of ca. 15 kW kg⁻¹ when compared to ca. 2 kW kg⁻¹ offered by, e.g., LIBs. Moreover, EDLCs typically exhibit two orders of magnitude greater cycle life span than secondary batteries. Therefore, they are adapted for applications requiring repeated charging/discharging at high power, e.g., in automotive industry, security systems in aircrafts, etc. However, EDLCs store lower amount of energy (5–8 Wh kg⁻¹) than, e.g., Li-ion batteries (up to 180 Wh kg⁻¹). Therefore, considering the industrial applications, such as electric vehicles and portable tools which require high amounts of energy delivered in a short period of time, new approaches should be oriented to introduce a novel concept of system that overcomes the weak points of LiBs and EDLCs, while being environmentally friendly. In this context, the objective of the CARBionCAP project is to propose a novel concept of sustainable capacitor, introduced as carbon-ion capacitor (CIC), for designing ESSs utilizing safe, cheap and available materials, free of political constraints ('lithium-free'). This presentation will be focused on the outcomes of the project in: i) studying the mechanisms of intercalation of organic cations into a carbon electrode; ii) analyzing physicochemical and electrochemical properties of electrolytes to provide the cations for the intercalation into the negative electrode and the anions to be electrostatically attracted at the positive one, while avoiding the electrolyte decomposition. The results will provide a validation of the carbon-ion concept as well as allow new directions for replying to its weak points to be defined.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 136

Title: Novel optical sensors based on glass and nitrogen-vacancy color centers in diamond

**Project leader: Adam Wojciechowski (Team leader),
Ryszard Buczyński (Project leader)**

Contact: a.wojciechowski@uj.edu.pl

FNP programme: TEAM-NET

Authors: Mariusz Mrózek, Mona Jani, Armin Ebrahimi, Tomasz Kołodziej, Saravanan Sengottuvel, Paulina Czarnecka, Zuzanna Orzechowska, Mikołaj Kałdan, Wojciech Gawlik, Adam Wojciechowski, Maciej Głowacki, Mateusz Ficek, Robert Bogdanowicz, Adam Filipkowski, Grzegorz Stępniewski, Ryszard Buczyński, Mariusz Klimczak

The negatively charged Nitrogen-Vacancy (NV) color center in diamond lattice is a prominent quantum system commonly used as a sensor for the detection and imaging of magnetic and electric fields, temperature, strain, and pressure in micro- and nano-scale. We propose a novel approach to sensing and mapping, based on the use of nanodiamonds (NDs) that can be directly deposited on a given material surface [1,2]. We investigate, so called, optically detected magnetic resonance (ODMR) signals with arbitrarily spatially oriented NDs and aim to use the wide-field microscopy for fast magnetic imaging and sensing. Moreover, we study the NDs deposited on or covalently attached to the facet of an imaging fiber bundle that may find applications in a high resolution endoscopic magnetic imaging [3]. Our approach can also be extended to the deposition on irregular surfaces, which shows a promising path to nanodiamond-based photonic sensors. Furthermore, we demonstrate optical fibers with NDs embedded inside glass structures [4-6]. By recording strong ODMR signals, we show that such sensors can be very effective for sensing applications. Finally, we discuss applications of NDs for biochemical and biophysical studies. We demonstrate the influence of surface termination and local environment on the spin properties [7,8] of NV centers inside NDs. Combining fluorescence microscopy and ODMR techniques, we demonstrate local probing with live biological cells. References: [1] A. M. Wojciechowski et al., *Materials* 12, 2951 (2019) [2] S. Sengottuvel et al., arXiv:2206.06337, submitted to *Sci. Rep.* [3] P. Czarnecka et al., *Opt. Mater. Express* 12, 444 (2022) [4] Z. Orzechowska et al., *Adv. Quantum Technol.* 5, 2100128 (2022) [5] A. Filipkowski et al., *Carbon* 196, 10 (2022) [6] A. Filipkowski et al., *Opt. Express* 30, 19573 (2022) [7] M. Mrózek et al., *Materials* 14, 833 (2021) [8] M. Mrozek et al., *Diam. Relat. Mater.* 120, 108689 (2021).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 137

Title: Label-free and rapid optical imaging, detection and sorting of leukemia cells - How to teach RApID device to recognize leukemia cells

Project leader: Czesław Radzewicz

Contact: pmrowka@ihit.waw.pl

FNP programme: TEAM-NET

Authors: Piotr Mrówka, Paulina Laskowska, Maciej Szydlowski,
Małgorzata Zasowska, Aleksandra Szlachetka, Aleksandra Matrejek,
Przemysław Juszczynski

Neoplastic diseases, including leukemia, are one of the greatest challenges of modern medicine. Quick diagnostic methods that do not require complicated preparatory procedures would significantly reduce the time-to-treatment, and thus increase the chances for successful therapy. The aim of the Team-Net project is to create a stimulated Raman spectroscopy (SRS) imaging device that will recognize neoplastic cells and their specific features determining the choice of the most appropriate therapy. Within the consortium, our team's task is to provide the reference material for teaching the device to correctly identify leukemic cells and their characteristic features. Specifically, we focus on mutations in driver oncogenes that control key cellular processes such as proliferation, differentiation, and apoptosis. To achieve this goal, we have implemented a two-stage approach. Firstly, we selected 5 most commonly mutated genes in acute myeloblastic leukemia (AML), i.e. FLT-3, IDH1/2, DNMT3, MLL, and RUNX1. By introducing single mutations into myeloid cells we created cell models that subsequently undergo Raman imaging by the cooperating groups in Krakow and Warsaw. The comparison of the Raman spectrometry images of the model to the wild type cells will allow to find the characteristic features of the spectra ("fingerprints") of mutated oncogenes in tumor cells. In the second stage, we analyse Raman images of AML cell lines (n = 20) and primary cells obtained from AML patients (n = 30) with well characterized genotype and phenotype (including NGS genotyping, immunophenotyping, kinome analyses). The spectra and Raman images are then interpreted in the context of biological data and information obtained from the models. These data and the developed algorithms for their analysis will become an integral part of the device developed by our consortium.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 138

Title: Spherically-shaped WGM resonators for cancer detection

Project leader: Dorota Anna Pawlak

Contact: piotr.paszke@ensemble3.eu

FNP programme: TEAM

Authors: Piotr Paszke, Jarosław Mazuryk, Rafał Nowaczyński, Piotr Piotrowski, Katarzyna Klepacka, Maria Michalska, Andrea Csaki, Dorota Anna Pawlak

Whispering gallery mode (WGM) resonators [1] are a type of optical resonator trapped the light using a series of total internal reflections thanks to the spherical surface of the resonator. Inside the such structure, photons can circulate several thousand times. Additionally, light after a round trip around WGM resonator can constructively interfere. Then, a high amount of light can effectively interact with the molecules deposited on its surface. Therefore, one of the most popular applications of such resonators is the detection of biomaterials. Our work aimed to prepare WGM resonators for the detection of exosomes [2]. Exosomes are small vesicles (about 100 nm in diameter) excreted by every cell in our body into body fluids. Based on our experiments with exosomes from healthy donors, we estimate that our method can detect 100,000 exosomes in several dozen microliters of an aqueous solution. Further research will focus on finding tumor exosomes and a specific monoclonal antibody that will enable us to perform fast, early, and non-invasive cancer diagnostics. References: [1] J. Ward, O. Benson, Laser & Photonics Reviews 5.4, 553-570, 2011. [2] H. Valadi, et al., Nature cell biology, 9.6, 654-659, 2007.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 139

**Title: Design, synthesis and preclinical evaluation of radiopharmaceuticals
at NOMATEN**

Project leader: Mikko Alava

Contact: marek.pruszyński@ncbj.gov.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Marek Pruszyński, Anna Krzyczmonik, Ihab Shokair, Renata Mikołajczak,
Paweł Sobkowicz, Mikko Alava

The Radiopharmaceuticals Group at NOMATEN Centre of Excellence focuses on design and synthesis of diagnostic and therapeutic molecular radiopharmaceuticals for targeted, personalized medicine. The research is carried out in various areas: i) reactor- and cyclotron-produced medical radionuclides; ii) target's material preparation, radiochemical separation and target recovery; iii) development of novel and simple (optionally automated) methods for radiolabelling of various biomolecules and carriers; iv) translation research – preclinical studies in the state-of-art programmes. The results of these studies will improve portfolio of nuclear medicine in terms of imaging, prognostic and therapeutic novel strategies to defeat cancer. Commercial and potentially applicable novel radioisotopes are produced recently at research Reactor Maria at the National Centre for Nuclear Research (NCBJ) and in the near future also at currently installed IBA Cyclone 30 XP cyclotron at CERAD centre. The Radiopharmaceuticals Group is also interested in modelling studies on docking radiolabelled biomolecules to receptors overexpressed on cancerous cells, especially to check if modifications done to a biomolecule during labelling procedures may decrease or improve their binding. Research is performed in collaboration with Commissariat à l'énergie atomique et aux énergies alternatives (CEA, France) and Teknologian Tutkimuskeskus VTT Oy (VTT, Finland). Close collaboration with Radioisotope Centre POLATOM at National Centre for Nuclear Research, the worldwide known manufacturer of radiopharmaceuticals enables translation of developed radiopharmaceuticals into clinical studies and their further commercialization. In the future, the Radiopharmaceuticals Group at NOMATEN CoE intends to further strengthen joint work and synergistic effects. NOMATEN is also actively looking for external collaborations at industrial, national and international level, including Horizon Europe and Euratom instruments.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 140

Title: Materials science for extreme conditions at NOMATEN

Project leader: Mikko Alava

Contact: iwona.jozwik@ncbj.gov.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Mikko Alava, Iwona Jozwik, Lukas Kurpaska, Stefanos Papanikolaou

The NOMATEN CoE has developed comprehensive capabilities in materials research, from materials theory and machine learning to sample preparation, characterization and manufacturing of advanced materials for applications at extreme conditions of mechanochemical environments, irradiation or/and temperature. We have now four operational groups (Materials' Complexity, M.Alava; Materials Structure, Informatics and Function, S. Papanikolaou; Functional Properties, L. Kurpaska; and Materials Characterization, I. Jozwik). The CoE focuses on advanced metal alloys to ceramics to glasses, and develops excellence-oriented research that combines topics of major societal interest. This is a base for research and development of materials for challenging applications – for the space, nuclear and (renewable) energy, industry sectors. Multiscale approaches are developed for the understanding of mechanical properties of High-Entropy Alloys and Metallic Glasses, towards composition optimization and experimental predictions. Machine learning workflows tackle simulation and experimental data alike. The CoE material simulations, especially for nanomechanical applications, range from the nanoscale to the macroscale, using quantum simulations, molecular dynamics and finite element methods. This is combined with advanced techniques (SEM, TEM, Raman, XRD) to characterize material samples. Experiments are carried out in-situ at high temperature, under external load and on ion-irradiated samples. The CoE works together as a team including foreign collaborators. In the future, we strengthen our joint work. NOMATEN is actively looking for external collaborations (industry, national and Horizon Europe projects). The emerging big pan-European INNUMAT project, coordinated by Karlsruhe Institute of Technology and assisted by the CoE Teaming partners VTT (Finland) and CEA (France), shows the CoE's international role and its key capabilities for the development of novel alloys.



Number: 141

Title: Design and characterization of integrated photonics components specific to the silica-titanium platform

Project leader: Alicja Bachmatiuk

Contact: jacek.olszewski@pwr.edu.pl

FNP programme: TEAM-NET

Authors: Jacek Olszewski, Edyta Środa, Piotr Pala, Andrzej Gawlik, Paweł Mrowiński, Krzysztof Rola, Muhammad Ali Butt, Paweł Karasiński, Katarzyna Komorowska, Tadeusz Martynkien, Alicja Bachmatiuk

SiO₂:TiO₂ layers produced on a glass substrate constitute an attractive material platform for integrated photonics, mainly due to the possibility of using the sol-gel method, which results in low production costs of both high-quality layers and complex components of integrated optics. The choice of material platform determines the refractive index contrast, i.e., the difference between the refractive index of the waveguide core and the refractive indexes of the media surrounding the core; through the available deposition techniques and etching or imprinting processes, it also dictates the geometry of the waveguides based on which the PICs are designed. Currently, SiO₂:TiO₂ waveguides of the rib, ridge and strip-loaded type are manufactured. The refractive index difference for this type of waveguides, amounting to 0.31-0.35 in the spectral range of 0.6 μm - 1.6 μm, imposes minimum SiO₂: TiO₂ layer heights of 0.2 μm, 0.40 μm and 0.6 μm, respectively for visible light (approx. 0.635 μm), the second one (1.31 μm) and the third (1.55 μm) telecommunications window, assuming single-mode operation. In this contribution we present exemplary simulation results for various integrated photonics components (straight/bent waveguides, micro-ring resonators, couplers etc.), as well as the results for the produced and characterized SiO₂:TiO₂ waveguides samples. The results were obtained from consortial collaboration in the TEAM-NET project “Hybrid sensor platforms of integrated photonic systems based on ceramic and polymer materials.”



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 142

Title: Quantum-enhanced Optical Communications

Project leader: Konrad Banaszek

Contact: k.lukanowski@cent.uw.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Karol Łukanowski, Marcin Jarzyna, Jan Kołodyński, Konrad Banaszek

I discuss scenarios in which quantum technologies provide an advantage over conventional classical communication methods, based on three projects carried out within the “Quantum Optical Technologies” unit. The first project concerns the capacity of a lossy photon channel—i.e., the achievable rate of information flow through an optical channel experiencing attenuation (modelling optical fibres as well as free-space propagation)—when one utilises fully quantum states of light instead of contemporary schemes incorporating classical light and detection techniques. We show that quantum strategies vastly outperform the currently achievable rates in the limit of low light attenuation, paving the way for a development of more efficient short haul information links. In the second project we study the performance of quantum-enhanced communication in long haul links when phase-sensitive amplifiers are used to strengthen the signal attenuated in the optical channel. Our research proves that a conversion to novel phase-sensitive amplification from the typical phase-insensitive operation of modern amplifiers will offer an advantage in information transmission rates on longer distances. At the same time, we show that quantum states of light and sophisticated detection techniques become irrelevant in this distance regime due to the large amounts of accumulated noise degrading their fidelity. Still, they greatly outperform classical limits in short haul links, where, however, no amplification is needed. Finally, in the third discussed project we consider a wide family of quantum cryptographic protocols that allow to construct fully secure and practical secret communication channels, impenetrable by any adversary. Adopting the paradigm of device independence, in which one is able to relinquish the unrealistic trust in communication devices typically required for secret communication, we provide tight requirements on the quality of experimental realisation of such protocols.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 143

Title: An innovative approach to protecting plants against pathogens, combining the action of biostimulating plant growth and development

Project leader: Marcin Smiglak

Contact: kukawka.rafal@gmail.com

FNP programme: TEAM-TECH

Authors: Rafał Kukawka, Maciej Szychalski, Anna Jarecka-Boncela, Magdalena Ptaszek, Artur Mikiciński, Joanna Puławska, Agnieszka Rutkowska, Tomasz Kleiber, Renata Gaj, Agnieszka Kiniec, Jacek Piszczek, Henryk Pospieszny, Marcin Śmiglak

The main goal of our project was to develop an alternative approach to plant protection and to prove its effectiveness. The innovation was that instead of focusing on individual pathogens, we concentrated on helping the plants to become healthier. The active substances obtained by us supplements or substitutes of standard protection products developed for various crops. The significance of such an alternative approach is consistent with the overall strategy of the European Union, according to which the number of plant protection products authorized to trade will decrease, which has stimulated the search for new effective methods of plant protection, based on the use of new active ingredients that satisfy legal requirements, environmental issues, and societal expectations. SAR inducers, due to their mode of action, directed toward the stimulation of a plant's natural defence mechanisms and not toward pathogens, require adaptation of technology that may differ among crops. The main barrier to the widespread use of SAR inducers is their inappropriate use, understood as their application in improper concentration or at wrong development stages of plants, which may result in a significant reduction in the yield. As a result of the project, we developed application technologies for several crops such as: rapeseed, wheat, tomato, cucumber and sugar beet. Notably, the results demonstrated that the plant's response was much broader than just an induction of defence mechanisms and also concern biostimulation. Positive effects were observed on plant growth and development, resulting in an increase in quantitative and qualitative parameters of yield.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 144

**Title: Process optimisation and valorisation of combustion by-products
in transition to circular economy**

Project leader: Sylwester Kalisz

Contact: sylwester.kalisz@polsl.pl

FNP programme: TEAM-TECH Core Facility

Authors: Sylwester Kalisz, Joanna Wnorowska, Piotr Sakiewicz,
Krzysztof Piotrowski

The main objective of the UPS-Plus project is to obtain combustion by-products prone to be valorised and usable in industry so as the principle of Circular Economy is implemented. The research ideas behind comprise optimising the combustion process, improvement of combustion by-products quality, finding specific material applications and finally, after new product lifetime ended, incineration and looping the obtained by-products back to economy. The optimisation of low-quality solid fuel combustion is realised (e.g., biomass, cow dung, automotive shredder residue - ASR) and based mostly on upgrading fuel properties with additives, resulting in materials or products that are useful in the industry. For example, aluminosilicate additive – halloysite is recommended for heavy metals immobilisation in ASR thermal conversion processes for the best performance of combustion and potential leaching with respect to heavy metals strong retention in the ash. Additionally, functionalization-based approach to the combustion of substrate mixtures with nano-structural additives was introduced to improve the performance of straw biomass combustion and bottom ash formation in power boilers, clearly increasing the CO₂ adsorption capacity of the modified ashes. During various practical tests it was noticed that with the increase in the amount of ash in the polymer matrix composites, the tensile strength of the produced specimens increases, with a simultaneous decrease in the total elongation. Compression testing was also carried out for foam glass specimens, which were produced with the addition of combustion by-products. Finally, the proof of concept consisting in predicting the properties of regranulates based on polyethylene and polypropylene produced from a non-homogeneous stream of post-consumer raw materials modified with by-products of combustion based on research on a technical scale is done (research in progress).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 145

Title: Dose-3D Project

Project leader: Tomasz Szumlak

Contact: szumlak@agh.edu.pl

FNP programme: TEAM-NET

Project Dose-3D, dedicated to creating a next-generation active medical phantom, passed its third-year mark. Significant progress has been made regarding its data acquisition system, software infrastructure and scintillating materials studies. The final year will be dedicated mainly to integrating various systems and performing test beam experiments using medical accelerators. The poster reports on the most significant accomplishments of all respective groups that established the Dose-3D Collaboration.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 146

Title: Development of multi-material photo-curable resins for 3D printing

Project leader: Joanna Ortyl

Contact: monika.topa@doktorant.pk.edu.pl

FNP programme: TEAM-TECH

Authors: Monika Topa-Skwarczyńska, Magdalena Jankowska, Andrzej Świeży, Bartosz Oksiuta, Dawid Oksiuta, Małgorzata Noworyta, Paweł Jamróz, Paweł Niezgoda, Weronika Wańczyk, Karolina Gałuszka, Katarzyna Starzak, Joanna Ortyl

Nowadays, 3D printing plays an extremely important role in creating three-dimensional objects for various applications. More and more frequently, 3D printing techniques can be found where photo-cured resins are used as input material, so it is very important to constantly improve photoinitiating systems, as well as the monomer composition of resins. 3D-VAT printing is an additive manufacturing method that is considered one of the most advanced methods of manufacturing materials. This is mainly due to the lack of need for molds and mechanical processing of the resulting objects. 3D printing techniques based on photopolymerization, such as stereolithography (SLA) or digital light processing (DLP), are currently attracting a lot of attention due to their versatility and ability to be customized. They are characterized by a number of advantages, which include: producing materials with well-defined geometries and high optical resolution. Composite materials are a class of multifunctional materials that are very popular due to their favorable properties. Particularly worthy of attention are nanocomposite materials, in which the addition of nanofiller changes the final properties of the product, for example: improves its thermomechanical properties, increases its heat resistance, provides conductive properties. The final properties depend on the selection of a suitable nanofiller, among which carbon nanotubes, silica, aluminum oxides, natural and polymer fibers are widely used additives. In the present study, the suitability of 9 compounds from the anthracene group, as well as 9 compounds from the phenanthrene group, varied in terms of the type of attached substituent to act as photosensitizers of iodonium salts, was investigated. Optimum printing parameters such as critical energy and curing light penetration depth were then determined for the prepared photo-cured resins. The effects of different nanoparticles (e.g.: ZnO or TiO₂) on the kinetics of the photopolymerization process, as well as on the 3D printing parameters, were investigated.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 147

Title: Introduction to ENSEMBLE3 (E3) Centre of Excellence for nanophotonics, advanced materials and novel crystal growth based technologies

Project leader: Dorota Anna Pawlak

Contact: dorota.anna.pawlak@ensemble3.eu

FNP programme: International Research Agendas Programme (IRAP)

Authors: Kingshuk Bandopadhyay, Katarzyna Sadecka, Aleksandra Kossowska, Dorota A. Pawlak

The scientific and economic challenge of ENSEMBLE3 is to utilize crystal-growth techniques, as well as developing new methodologies for manufacturing novel advanced materials with special optical/electromagnetic properties, which can find applications in such fields as photonics, optoelectronics, telecommunication, solar energy conversion, medicine and/or aerospace. E3 builds on the strengths of Polish science and technology - where historically crystal growth is a very important field, famously developed by prof. Jan Czochralski whose crystal growth method remains the most widely-used technique for manufacturing single crystals of semiconductors. Crystals are used in every day life – every person having a computer, mobile phone or other optoelectronic device has a small piece of crystal. Our Centre is a place fostering innovation and international collaboration by providing infrastructure and know-how for both young and advanced researchers with pioneering ideas. ENSEMBLE3 gathers the expertise, know-how, and facilities in the field of crystal growth of novel photonic composite materials, single crystals of oxides, fluorides, III-V semiconducting compounds, SiC, and organic materials. The available growth methods include Czochralski, Liquid Encapsulated Czochralski, floating zone, micro-pulling down and others. Based on unique expertise, materials, and apparatus we offer: joint research and development in the field of novel materials for photonics; crystalline materials technology development; on-demand designed materials including crystal boules, wafers, fibres, and elements; material characterization. Visit us at www.ensemble3.eu If You look for career opportunities visit us at our website, or send e-mail to contact@ensemble3.eu. Acknowledgement We thank the ENSEMBLE3 Project (MAB/2020/14) which is carried out within the International Research Agendas Programme (IRAP) of the Foundation for Polish Science co-financed by the European Union under the European Regional Development Fund and the Teaming Horizon 2020 programme (GA. No. 857543) of the European Commission for supporting the ENSEMBLE3 Centre.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 148

Title: Deposition of neuro-supportive self-assembling peptides by zone casting for bioelectronic applications

Project leader: Tomasz Marszalek

Contact: tomasz.marszalek@p.lodz.pl

FNP programme: FIRST TEAM

Authors: Hanna Zajackowska, Michal Borkowski, Piotr Sleczkowski, Azadeh Jafari, Agnieszka Michalska, Julia Fidyk, Mateusz Brzezinski, Wojciech Grodzicki, Jakub Lewandowski, Wojciech Pisula, Beata Luszczynska, Paul Blom, Xinliang Feng, Tomasz Marszalek

Biosensing is one possible application of flexible, organic/inorganic transistors, however, it is still highly limited by the interaction between organic semiconductor and biomolecules. As it was pointed out in the current literature, the controlled molecular deposition at the air/liquid/solid interface could be implemented for biomolecules for a specific future applications. For example, the ability to create electronic devices that enable the monitoring of cell-cell communication has important implications for many disciplines such as cellular biology, material science, and molecular electronics. Current systems typically use thin coatings of polycations like poly(L-lysine) (PLL) to facilitate the attachment and growth of neuronal cells on the final device. While this polymer is widely available, it does not allow for easy chemical modifications and consequently it is difficult to introduce bioactive signals into these systems. On the other hand, supramolecular polymers from self-assembling peptides have gained significant interest in recent years, as they mimic the fibrous structure natural extracellular matrix proteins, while using much smaller building blocks. They provide ideal substrates for different types of cells both in 2D and 3D environments. Due to the assembly of small peptide building blocks, different functionalities such as bioactive epitopes can be easily incorporated into the nanofibers, thus enabling to study cellular responses to different types of signals that cannot be achieved with simple PLL coatings. However, the homogeneity and controlled surface morphology is the main disadvantage in their application as cell-cell communication device. To address this challenge Marszalek's group knowledge obtained on deposition of organic semiconductors is applied to the coating of biomolecules. Preliminary results show that zone-casting can provide superior, homogenous coatings of biomolecules.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 149

**Title: INTRODUCTION OF CARBON DOTS INTO CATIONIC
PHOTOPOLYMERIZATION IN A NANO-PHOTOINITIATING SYSTEM**

Project leader: Joanna Ortyl

Contact: pawelniezgodaa@gmail.com

FNP programme: TEAM-TECH

Authors: Paweł Niezgoda, Wiktoria Tomal, Andrzej Świeży, Bartosz Oksiuta,
Dawid Oksiuta, Małgorzata Noworyta, Paweł Jamróz, Weronika Wańczyk,
Karolina Gałuszka, Katarzyna Starzak, Joanna Ortyl

Light-initiated polymerization technologies are one of the most rapidly increasing segments of the chemical industry. They are commonly utilized in coatings, paints, and varnishes, but especially in 3D printing. These procedures offer various benefits, including high kinetics, the absence of high-temperature processing, minimal energy consumption, and the absence of solvents. By allowing the use of human-safe light sources of the Vis-LED kind, the latter dramatically broadens the scope of potential applications in sectors such as medicine, dentistry, and tissue engineering. The issue with commercially available photopolymerization initiators is their low absorption maxima, which oscillate in the UV range, preventing them from being used in conjunction with very safe Vis-LEDs. Photosensitizers are used to alter the absorption maximum. Citric acid-based carbon dots were utilized as effective iodonium salt sensitizers in this study. Citric acid dots (CA-CDs) and those doped with amines (N-doped-CA-CDs) and sulfur (N, S-doped-CA-CDs) were used to explore the kinetics of cationic photopolymerization of vinyl and epoxy monomers, as well as free radical photopolymerization of acrylates and hydrogels. The entire study procedure included synthesizing appropriate carbon dots, the purification process, the production of appropriate formulations, and thorough examinations ranging from spectrophotometry to the kinetics mentioned above of photopolymerization processes. Finally, 3D printing studies for an initiator system to print hydrogel materials were carried out.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 150

Title: Phase-only shaping of light pulses for applications in quantum technologies

Project leader: Michał Karpiński

Contact: mkarp@fuw.edu.pl

FNP programme: FIRST TEAM

Authors: Filip Sośnicki, Michał Mikołajczyk, Arifah Nurul Amaliah, Jerzy Szuniewicz,
Michał Karpiński

Optical pulses form the backbone of photonic technologies. Their key characteristics are their temporal profile and their frequency spectrum. Experimentally, only one of these two parameters can be easily accessed, due to the incompatibility of time and frequency resolutions of detection and manipulation devices. The power of quantum mechanics manifests itself chiefly through the superposition principle: if two states of a system are valid quantum states, then their superposition is also a valid quantum state. The emerging quantum technologies are based on the ability to create, manipulate and detect quantum superpositions, which relies on the ability to access conjugate variables, such as the time and frequency for single-photon pulses. Here we will use novel tools to experimentally access temporal and spectral characteristics of quantum light pulses. We will manipulate and detect their quantum superpositions, and demonstrate their applications in quantum networks and metrology. We present key experimental and theoretical developments towards arbitrary electro-optic and nonlinear optical shaping of single-photon pulses developed within the First Team Project. They include in particular: (1) experimental results on large-scale spectral bandwidth modification using complex high-power electro-optic phase modulation; (2) results on determining arbitrary spectral and temporal phases required to perform arbitrary spectral-temporal manipulations; and (3) progress towards nonlinear spectral-temporal shaping using three wave mixing. Finally, we will present a new measurement method to determine the envelope of a short classical and non-classical optical pulse: the Fourier transform chronometry.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 151

Title: Implementation of LC-MS technology for identification of new cancer PD1 interacting partners. Towards better understanding of cancer PD1 intrinsic signalling and its significance for immunotherapy

Project leader: Natalia Marek-Trzonkowska

Contact: katarzyna.pietrzak@phdstud.ug.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Katarzyna Dziubek, Jakub Faktor, Sachin Kote

Cancer treatment approach has been recently revolutionized by immunotherapies, which majorly target PD1/PDL1 axis. PD1 is an immune checkpoint receptor, which acts as a break to the immune system and is known to be expressed by activated immune cells. Thus, PD1 blockade results in immune-mediated tumour killing. Despite remarkable success of immune checkpoint blockade in certain types of cancer, there is still a group of patients who do not respond to the therapy. In fact, some of them rapidly deteriorate after immunotherapy implementation but the reason for that is still unknown. Only recently, it was reported that PD1 is not only expressed on immune cells but also on cancer cells. While some groups observed that cancer PD1 promotes tumour growth, others described it as a tumour suppressor. Contradictory evidence is available regarding the role of cancer PD1 intrinsic signalling, thus further studies are required to clarify its importance for the therapy and its safety in patients with tumours expressing PD1 receptor. Our group showed that human osteosarcoma cancer cells spontaneously express PD1 receptor and we are currently investigating its effects on U2OS cell line. We implement LC-MS technology to characterise cancer PD1 intrinsic signalling and its significance in cancer cell growth, proliferation, and ability to metastasize. LC-MS is a cutting-edge technique allowing to identify thousands of proteins and their changes in a sample with highest confidence and accuracy. First, we evaluated global changes in cellular proteome upon either PD1 silencing or protein overexpression. Then, by performing pull-down experiments followed by LC-MS analysis, we are currently identifying new cancer PD1 interacting partners. Strikingly, many of the identified hits were reported in the literature as cancer – associated proteins. This work will surely contribute to better understanding of PD1 pathway in cancer cells and its ultimate role in immunotherapy implementation.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 152

Title: Perspectives of developing low-cost optical sensor structures with SiO₂:TiO₂ waveguide films

Project leader: Alicja Bachmatiuk

Contact: andrzej.kazmierczak@pw.edu.pl

FNP programme: TEAM-NET

Authors: Andrzej Kaźmierczak, Muhammad Ali Butt, Cuma Tyszkiewicz, Magdalena Zięba, Łukasz Kozłowski, Muhammad Shahbaz, Ryszard Pyramidowicz, Paweł Karasiński

For more than two decades integrated photonics has developed tremendously allowing the fabrication of numerous successful devices and finding its use in a wide range of applications. Unfortunately, most of the mainstream technologies are based on expensive and fabrication effort-demanding techniques like chemical vapor deposition, electron-beam lithography, or plasma etching. This limits the user base of integrated photonics to the well-established research institutes and universities. The quest for an affordable and efficient fabrication technology for integrated photonics is the foundation of our project. One of the possible solutions identified by our project is the use of SiO₂:TiO₂ sol-gel derived waveguide films deposited with dip-coating technique on low-cost glass substrates. This technique allows for the fabrication of waveguide films having a propagation loss as small as 0.3 dB/cm, precise adjustment of a refractive index of a waveguiding film (between 1.45 and 1.9) and a waveguide film thickness (between 120 nm and 210 nm in a single deposition process). To complete a fabrication cycle our project consortium investigates various patterning techniques including low-cost processes like direct nanoimprinting of deposited waveguide film and optical lithography combined with dry and wet chemical etching. The availability of our technology (still under development) with respect to its use for sensor application has been investigated by numerical simulation of some sensor devices including ring resonators, subwavelength gratings, and 1D photonic crystal cavities. The proposed designs offered high sensitivity for ambient refractive index change (as high as 175 nm/RIU in the case of photonic crystals cavity) with a simple and versatile device layout. In the concluding phase of our project, we are looking forward to fabrication and experimental evaluation of proposed designs pursuing a commercially-viable technology and configuration of photonics sensor devices.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 153

Title: Cwc15 stabilizes the spliceosomal catalytic interactions for the second step

Project leader: Magda Konarska

Contact: m.magnus@imol.institute

FNP programme: International Research Agendas Programme (IRAP)

Authors: Marcin Magnus, Katarzyna Eysmont, Magda Konarska

To better understand structural rearrangements between the catalytic steps of splicing, we performed a structural search of the cryo-EM spliceosomal structures to identify proteins in the close proximity to the catalytic center, likely to affect splicing catalysis. We focused on a poorly characterized protein, Cwc15, which through its disordered N-terminal domain interacts directly with U6 snRNA at the catalytic center. In the *cwc15Δ* strain, splicing of introns with mutations limiting the second step (BS-c, gAG, A3c) is inhibited, whereas splicing of introns limiting for the 1st step (BS-g, G5A, A3u, BS-U257c) is not affected, suggesting that interactions of Cwc15 stabilize the second step catalytic conformation. The deletion of *cwc15* is synthetically lethal with U6-A59c and -C61a alleles, suggesting that Cwc15 interacts with the catalytic triplex. Furthermore, *cwc15Δ* strain with U2-U23a/g/c and U6-A53u (residues from the triplex) showed a decreased growth at high temperatures. Additionally, we discovered genetic interactions between Cwc15, and U2-A27 and U6-U57 which form a base pair in helix Ia (destabilization of which is required for the transition to the second step). Whereas *cwc15* deletion or *cwc15*-R6a mutation inhibit the second step of splicing, *cwc15*-H5a mutation suppresses cold-sensitivity of the U2-A27c allele. Thus, mutations at two adjacent positions in Cwc15, H5a and R6a, exhibit opposite effects. Similarly, *cwc15* deletion or *cwc15*-R6a mutation strongly inhibit the second step of splicing in the context of *prp8* first-step allele (e.g., *prp8*-R1753K) (Liu, 2007), supporting the conclusion that *cwc15*-R6 position is critical for the second step. By contrast, *cwc15*-H5a phenotype is not affected by *prp8* alleles. We conclude that wt Cwc15 improves the transition from the first to the second step, improving the second step of splicing. This is consistent with the observed inhibition of splicing for intron mutants limiting for the second step by deletions and point mutants in Cwc15. A detailed analysis of Cwc15 with point mutations is being performed and the mechanism of action is being explored, including the use of computational approaches such as molecular dynamics with support of rna-tools (a toolbox to analyze structures and simulations of RNA, <http://rna-tools.online>).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 154

Title: Modelling ELANE-related congenital neutropenia using genetically engineered laboratory mouse

Project leader: Wojciech Młynarski

Contact: jakub1.kwiecinski@uj.edu.pl

FNP programme: TEAM-NET

Authors: Michal Kanoza, Izabela Ciaston, Jan Potempa, Joanna Koziel,
Jakub Kwiecinski

Congenital neutropenia is a hematological condition characterized by a greatly reduced number of blood neutrophils. As neutrophils are the first line of defense against pathogenic microorganisms, patients with neutropenia suffer from recurrent and life-threatening bacterial infections. The commonest form of congenital neutropenia arises from mutations in ELANE gene, encoding neutrophil elastase. However, the mechanism through which these mutations lead to decreased neutrophil numbers remain unclear. There are also no animal models of congenital neutropenia available, hindering further mechanistical studies or quest for efficient treatments. Using CRISPR/Cas9 we have introduced point mutations homologous to the ones observed in human neutropenia patients into a mouse Elane gene. Even though we have not observed any of the resulting mouse strains to develop a full-blown neutropenia, some of the mutations resulted in moderately decreased neutrophil levels and affected neutrophil functionality. This opens avenue for further mechanistical studies connecting these mutations with the observed phenotypes, and for understanding how neutropenia develops in human patients.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 155

Title: The discovery of the intrinsic oscillator with a mutually opposite common core gene network regulated by BMP-Id2 axis controls stem cells regeneration and stemness maintenance during the hair cycle

Project leader: Krzysztof Kobiela

Contact: k.kobiela@cent.uw.edu.pl

FNP programme: TEAM

Authors: Łukasz Boryń, Patrycja Daszczuk, Xiaoyang Wang, Paula Mazurek, Alicja Olczak, Tomasz Pieczonka, Guangfang Wang, Raul Ramos, Xiaojie Wang, Konrad Łukaszyk, Maksim Plikus, Mark Israel, Kyuson Yun, Krzysztof Kobiela

Previously, we revealed how regenerative hair cycle behavior in vivo is orchestrated by hair follicle stem cells (hfSCs) homeostasis as the result of the competitive balance between BMP and WNT pathways. Inhibition of BMP pathway (Bmpr1a-KO) leads to Id2 downregulation in hfSCs, identifying this transcription regulator (TR) as an effector of this signaling. Here, we generated Id2 gain of function (ID2-GoF) transgenic mouse line that allowed investigation of Id2 role in hfSCs. We showed that Id2 overexpression in hfSCs is sufficient to promote telogen and sequentially postpone anagen activation leading to prolonged stem cells quiescence. Performing RNA-seq on FACS isolated ID2-GoF hfSCs at 1st postnatal hair cycle allowed an intersection with common bulge signature genes in the quiescent hair follicles. With Id2 dependent gene set, we were able to recapitulate more than half of common bulge signature genes (51%), extending this pool with Bmpr1a-KO targets (from 29% up to 63%). Interestingly, genes affected by Id2 overexpression are also BMP dependent (almost 37%), emphasizing this TR's role in supporting the BMP-centered hfSCs transcriptional program. Surprisingly, we discovered that 80% of common genes (370 out of 460) are discordantly regulated in Id2GoF and Bmpr1aKO, indicating the intrinsic oscillation of a mutually opposite common core gene network regulated by BMP-Id2 axis interplay. Moreover, to mark all possible pSmad binding sites in quiescent hfSCs we took advantage of our previously generated transgenic mouse model expressing the constitutively active form of Bmpr1a (Bmpr1A-CA) and performed ChIP-seq analysis. Indeed, we observed that up to almost 60% of Id2-dependent genes have pSmad peaks assigned which were similar to Bmpr1aKO-affected genes. These results clearly show that Id2 is specifically targeted by BMP signaling pathway to expand the pool of affected genes to impose hfSCs quiescence transcriptional program maintaining stemness genes expression.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 156

Title: Novel technologies for selection microorganisms useful in bioremediation and development of biopreparations for pollutant removal.

Project leader: Wojciech Franus

Contact: ts.kaminski2@uw.edu.pl

FNP programme: TEAM-NET

Authors: Tomasz S. Kaminski, Maria Dąbrowska, Luca Potenza, Ewa Poniecka, Marco Gunthel, Mikołaj Iwan, Klaudia Stankiewicz, Joanna Rosinska, Wiktoria Pietrowicz, Łukasz Drewniak

The poster presents the most important results from three main research activities in my research team:

- a) Characterization of toxicity and bioleaching of fly ashes and zeolites. In order to develop methods for immobilization of microorganisms on the surface of fly ashes and zeolites derived from fly ashes, the impact of these materials on the physiology of bacteria had to be assessed in the first place. And vice versa, we needed to know how the structure and materials can be modified in the presence of the growth of bacteria. We have performed comprehensive geochemical characterization of zeolites and fly ash materials, followed by characterization of chemicals released from zeolites and fly ash (including hydrocarbons and metals).
- b) Development of selected bioremediation processes. The first step of the development of bioremediation processes usually comprises the biological and chemical characterization of the wastewaters and selection of the efficient bacteria for the bioaugmentation process. During first phase of the project we successfully isolated and characterized following strains of microorganisms: i) urea degrading bacteria, ii) siderophore producing bacteria, and iii) sulphur oxidizing bacteria.
- c) Development of novel microfluidic technologies for screening, selection and characterization of microorganisms for bioremediation applications. In order to more efficiently select and better characterize bacteria for bioremediation processes we decided to develop a series of droplet microfluidics technologies. These ultra-high throughput methods offer unprecedented increase in the number of reactions that can be measured and sorted within a single day. The readout can rely on the bacterial growth and/or presence of detectable products of bioconversions e.g. degradation of cellulose. Additionally, we developed passive microfluidic methods for selection of bacteria producing biosurfactants and microorganisms degrading biopolymers.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 157

Title: High-quality ZnO nanostructures of desired functionality

Project leader: Janusz Lewiński

Contact: lewin@ch.pw.edu.pl

FNP programme: TEAM

Authors: Małgorzata Wolska-Pietkiewicz, Michał Terlecki, Janusz Lewiński

Zinc oxide (ZnO) is a versatile material of long-standing interest due to its unique catalytic and electro-optical characteristics, and a systematic approach to in-depth understanding of the structure-property-function relationship of ZnO nanostructures is indispensable for the development of ZnO-based devices. The classical wet-inorganic sol-gel methodology has played a crucial role in advancing ZnO science by providing access to a multitude of tailored nanostructures. While this process is versatile, it showcased some significant drawbacks. Here, we present the power and the uniqueness of our one-pot self-supporting organometallic (OSSOM) approach to creating ZnO nanoplatelets (NPLs) with the atomically precise thickness[1] and high-quality ZnO quantum dots (QDs) with desired functionality. [2] The superiority of our rational-by-design organometallic approach over the traditional sol-gel process for the preparation of high-quality ZnO QDs has been well-documented using atomic-scale characterization through dynamic nuclear polarization (DNP)-enhanced solid-state NMR (ssNMR) spectroscopy. More recently, we have also developed an easily scalable technology that affords an unprecedented ZnO QD prospective for photocatalytic applications and fabricating high-quality electron transport layers (ETLs) for the vast array of electronic devices.[3] For example, we will demonstrate a novel approach toward low-temperature processed pure ZnO ETLs for highly stable planar heterojunction perovskite solar cells (PSCs). The champion PSC achieved a power conversion efficiency of 20.05% which is the state-of-the-art performance among reported non-passivated pure-ZnO ETL-based PSCs.[3] [1] Adv. Funct. Mater. 2021, 31, 2105318. [2] Angew. Chem. Int. Ed. 2019, 25, 17163 [3] Adv. Funct. Mater. 2022, accepted



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 158

Title: How to measure temperature with light? transition metal ions based luminescence thermometry

Project leader: Lukasz Marciniak

Contact: l.marciniak@intibs.pl

FNP programme: First Team

Authors: L. Marciniak, K. Kniec, K. Trejgis, J. Stefanska, K. Elzbieciak-Piecka

Temperature measurement and imaging often provide key information about the course and rate of physical and biological processes and chemical reactions. The ability of remote temperature readout enables to obtain this information in a noninvasive manner. Such a possibility is offered by luminescence thermometry. The application of transition metal ion doped phosphors for this purpose allows temperature imaging with unprecedentedly high spatial and thermal resolution. Within the framework of this project, we have developed nanoscale super-sensitive luminescent thermometers and developed a number of strategies to modulate the thermometric parameters of luminescent thermometers according to the requirements of a specific type of application. As we have proven, the use of the luminescence intensity ratio of transition metal ions and lanthanide ions (acting as an internal luminescent reference) in co-doped materials allows not only local in-real time temperature readout but also thermal imaging in, among other applications, microelectronics and biological systems.



Number: 159

Title: Thickness-dependent Elastic Softening of Few-layer

Free-standing MoSe₂

Project leader: Bartłomiej Graczykowski

Contact: bgraczykowski@gmail.com

FNP programme: First Team

Authors: Visnja Babacic, David Saleta Reig, Sebin Varghese, Thomas Vasileiadis, Emerson Coy, Klaas Jan Tielrooij, Bartłomiej Graczykowski

Few-layer van der Waals materials have been extensively investigated in terms of their exceptional electronic, optoelectronic, optical, and thermal properties. Simultaneously, a complete evaluation of their mechanical properties remains an undeniable challenge due to the small lateral sizes of samples and the limitations of experimental tools. In particular, there is no systematic experimental study providing unambiguous evidence on whether the reduction of vdW thickness down to a few layers results in elastic softening or stiffening with respect to the bulk. In this work, micro-Brillouin light scattering is employed to investigate the anisotropic elastic properties of single-crystal free-standing 2H-MoSe₂ as a function of thickness, down to three molecular layers. The so-called elastic size effect, that is, significant and systematic elastic softening of the material with decreasing numbers of layers, is reported. In addition, this approach allows for a complete mechanical examination of few-layer membranes, that is, their elasticity, residual stress, and thickness, which can be easily extended to other vdW materials. The presented results shed new light on the ongoing debate on the elastic size effect and are relevant for the performance and durability of the implementation of vdW materials as resonators, optoelectronic, and thermoelectric devices. [1]

[1] Babacic, V. et al. Thickness-Dependent Elastic Softening of Few-Layer Free-Standing MoSe₂. *Advanced Materials* 33, 2008614 (2021).



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 160

**Title: Infrasound microphones for studies of 1 - 30 Hz acoustic range
in the VIRGO Gravitational Wave detector's environment**

Project leader: Mariusz Suchenek, Tomasz Bulik

Contact: msuchenek@camk.edu.pl

FNP programme: International Research Agendas Programme (IRAP)

Authors: Mariusz Suchenek, Tomasz Bulik, Marek Cieřlar

Gravitational wave detectors measure minuscule signals against a rich background of noises and interferences. The environment dominates the detector's frequency range from 1 Hz to 30 Hz (e.g., seismic waves, Newtonian noise, weather, anthropogenic). To suppress unwanted signals, a diverse set of sensors and probes is employed alongside modelling the static (hours-/days-long) components of environmental signals. In the case of infrasound studies, the scope of measurements was limited due to the expensive nature of commercially available sensors. To mitigate this problem, we developed and manufactured in AstroCeNT our inexpensive infrasound microphones compatible with VIRGO standards. In total, we deployed almost 100 microphones in the "end-buildings" housing end-mirrors as well as the "central-building" housing the interferometer - the gravitational wave detection apparatus. The analysis shows that due to the number of microphones, it is now possible to determine the distribution of infrasound intensity in the whole building, the intensity of each measured frequency and their distribution in the building, including the coherence of particular frequencies. The results show a high impact on the infrasound field noise and interference signals from ventilation systems, mechanical pumps and fans.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 161

**Title: Quantum-enhanced interferometry with large heralded
photon-number states**

Project leader: Magdalena Stobińska

FNP programme: First Team

Authors: Guillaume S. Thekkadath, Monika E. Mycroft, Bryn A. Bell, Chris G. Wade, Andreas Eckstein, David S. Phillips, Raj B. Patel, Adam Buraczewski, Adriana E. Lita, Thomas Gerrits, Sae W. Nam, Magdalena Stobińska, Alexander I. Lvovsky, Ian A. Walmsley

Quantum metrology is a technology which uses quantum states to overcome the classical limit of precision to measurements. It is particularly relevant in optics where it can be applied to enhance the sensitivity of optical interferometers. Interferometry allows us to measure small changes in the phase of light and in theory, the best quantum states for such measurements are the so-called NOON states. In practice, however, they are found to be very delicate in the presence of noise, especially photon loss. It is thus necessary to find alternative quantum states which are more robust to losses. In our work, we propose novel quantum probes which can be created with resources readily available in the laboratory and which offer quantum-enhanced sensitivity even at large photonic losses. We confirm our idea with both numerical simulations and an experimental realisation. Moreover, the probes we used to beat the classical limit are also the largest, in terms of photon number, experimentally achieved states which have been used in quantum metrology to date. Thus, our work paves the way towards using multi-photon quantum states as a resource in creating new technologies with real-life applications.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 162

Title: Role of neutrophil serine proteases in neutropenia

Project leader: Paulina Kasperkiewicz

FNP programme: Team-Net

Authors: Paulina Kasperkiewicz, Lauren Eyssen, Marcin Wojniłowicz, Marcin Poręba, Marcin Drąg, and Wojciech Młynarski

Abnormally low neutrophil count in circulating blood is called neutropenia that may be caused by many factors such as mutations in the ELANE gene, encoding NE. Neutropenia patients are more susceptible to infections and/or premature death. NE is stored in the active form in azurophil granules and its leakage to the cytoplasm causes neutrophil damage and decrease in the count of circulating cells/neutrophils. Most of the neutrophils die via apoptosis, however during inflammation they can switch the death type to netosis, pyroptosis or necrosis that may be a cause of neutropenia. To date little is known about the mechanisms involving NSPs in neutrophil death and neutropenia. We speculate that one of them depends on the formation of N-GSDMD after cleavage by one of the neutrophil enzymes. In this project we test the involvement of NSPs and its potential role in neutropenia with our chemical molecules and commercial inhibitors. Determination of key factors and understanding the mechanisms of this disease may lead to development of new drug target for neutropenia. We think that these results will show for the first time a proof of concept for alternative treatment method and will provide a new strategy for detection of some mutations in neutropenia.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 163

Title: Passive and active THz components based on carbon based nanomaterials

Project leader: Wojtek Knap

Contact: dlyubchenko@mail.unipress.waw.pl, dml@kth.se

FNP programme: IRAP

Authors: Aleksandra Krajewska, Aleksandra Przewłoka, Piotr Drózdź,
Serguei Smirnov, Nikolaos Xenidis, Dmitry Lyubchenko

Research and development in the frequency region of 0.1-1.0 THz is extremely significant for the wide range of applications, such as telecommunication and imaging systems, material spectroscopy, medical imaging and treatments, etc. Despite the problems in technology and high prices for basic components (phase shifters, directional couplers, etc.), the THz systems offer higher data rates for telecommunication, high spatial resolution in the visualization of objects, small size of antennas and other elements. The state-of-the-art of the THz devices reveals serious problems with radiation sources with continuous wave semiconductor-based source, electronically tunable phase shifters, etc. Carbon nanotubes (CNT) offer unique properties due to their natural small dimensions and outstanding electrical properties. Their tunability properties makes them very attractive in application to the THz system. Integration of CNTs with the dielectric rod waveguide (DRW) technology transferred from cellulose membranes onto other substrates (sapphire DRW, optical glass, polished silicon) by direct dry transfer enables a novel technology platform for tunable THz systems. Phase shifter can be developed by introducing the optically controlled varactor to the DRW. The phase change of 10-20 deg with almost negligible change in attenuation less than 0.1 dB can be achieved in the frequency range of 75-500 GHz. Besides, DRWs have no cut-off frequency enabling broad band operation. The effect of the dielectric constant tuning of single-walled carbon nanotubes under light illumination is observed in the very wide frequency range of 0.1–1 THz. The optical absorption spectrum is not uniform and it consists of several absorption peaks related to electron transitions. Therefore, the change of capacity and resistance under different light wavelength illumination is different at different wavelengths. The losses are attributed to the electromagnetic absorption by the CNT layers with differences stemming from variations in nanotube densities and total lengths of the transferred samples on the DRWs. The increased absorbance at lower frequencies has also been previously observed for CNTs. Carbon based nanomaterials are perspective materials for very wide applications in millimeter wave and THz frequency range. Phase shifter based on DRW loaded with CNT layer is a perspective candidate for ultra-wide band device application. The ultra-wide band optically controlled CNT-based phase shifter can enable THz beam steering.



4th INTERDISCIPLINARY FNP CONFERENCE

6-7 OCTOBER 2022

Number: 164

Title: Quantum steering from a post-quantum perspective: extremality and robustness against super-quantum attacks

Project leader: Michał Banacki

Contact: michal.banacki@ug.edu.pl

FNP programme: IRAP

Authors: Michał Banacki, Ravishankar Ramanathan, Piotr Mironowicz, Ricard Ravell Rodriguez, Paweł Horodecki

The idea of extremality considered within the convex analysis is a useful tool providing security of various protocols typical for quantum information theory. However, in the usual multiparty Bell scenario, described by the notion of local, quantum, and no-signaling correlations, it is impossible to provide quantum realization of non-local and yet extreme points within the set of all no-signaling correlations. Motivated by this, we show that a similar no-go result remains true even in the case of correlations obtained in experiments with sequential measurements. On the other hand, for steering scenarios (with no-signaling constraints) described mathematically by the notion of assemblages, we surprisingly provide a path for the quantum realization of non-local extremality, giving a foundation for post-quantum security of quantum cryptographic protocols. Moreover, we extend our results to the realm of sequential assemblages and assemblages describing the steering of quantum channels. We also discuss and characterize the related concept of edge assemblages. Finally, in the context of multiparty Bell experiments, we introduce and analyze an intermediate set of hybrid correlations for which typical no-go result regarding the quantum realization of non-local extremality is no longer applicable.



www.fnp.org.pl



The 4th Interdisciplinary FNP Conference is co-financed by the European Union under the European Regional Development Fund within the Smart Growth Operational Programme.