Charles University

MSCA PF/GF 2025: LIST OF TOPICS DESCRIPTIONS AND SUPERVISORS (Mathematics and Physics)

FACULTY	INSTITUTE/DEPARTMENT	RESEARCH TOPIC (PROJECT)	DESCRIPTION OF RESEARCH TOPIC (approx. 60 words)	SUPERVISOR (+ e-mail)	CONTACT PERSON (+e-mail)
Faculty of Mathematics and Physics	Institute of Theoretical Physics	**(Magneto)Hydrodynamics in Astrophysics with Discontinuous Galerkin**	The post-doc research project aims to propose a robust legal framework to address cybersecurity issues in healthcare and define solutions to emerging risks. By integrating theoretical insights with practical solutions, this project will significantly contribute to shaping the legal landscape in the critical area of health care cybersecurity.	Ondřej Pejcha (ondrej.pejcha@matfyz.cuni.cz)	Ondřej Pejcha (ondrej.pejcha@matfyz.cuni.cz)
Faculty of Mathematics and Physics	Departement of Macromolecular Physics	**Active colloids at chemically patterned surfaces**	We will combine theoretical modelling and novel multi-scale simulation methods aiming to uncover physical mechanisms controlling collective dynamics of active colloids at smart chemically patterned surfaces. Results can provide a route towards the design of autonomous microfluidic devices. Potential applications include systems for sorting and separation of micro-cargoes and generation of large-scale flows due to collective motion of active colloids.	Artem Ryabov (Artem.Ryabov@mff.cuni.cz)	Artem Ryabov (Artem.Ryabov@mff.cuni.cz)
Faculty of Mathematics and Physics	Mathematical Institute of Charles University	**Complex compressible fluids - mathematical challenges**	The project focuses on mathematical analysis of compressible fluids which do not satisfy the Newtonian rhelogical law. Possible examples are compressible viscoelastic fluids, compressible power-law fluids as well as models of multicomponent flows of compressible fluids, including also situations when the temperature is not constant. The emphasis will be put on existence analysis for large data without restriction on the length of the corresponding time interval which naturally leads to weak solutions (or, more generally, measure valued ones).	prof. Mgr. Milan Pokorny, Ph.D., DSc. (pokorny@karlin.mff.cuni.cz)	Milan Pokorny (pokorny@karlin.mff.cuni.cz)
Faculty of Mathematics and Physics	Department of Chemical Physics and Optics	**Computational methods for reliable prediction of binding properties of molecular solids**	Stability of materials is governed by their energy which can be, in principle, obtained using quantum mechanics. However, the large number of electrons requires one to approximate the theoretical treatment which results in loss of accuracy and less reliable results. Molecular solids offer a nice set of systems which can be used to test the accuracy of theoretical methods as the interaction energy can be divided into contributions of small clusters (dimers, trimers, ...) of molecules which can be treated with a high-level quantum chemistry method. Within this project we would use this approach to understand accuracy of theoretical methods and used it to obtain reference data for cohesive properties of molecular solids. The project would involve periodic calculations, finite cluster calculations, as well as development of scripts and simpler theoretical methods, allowing the researcher to strengthen their knowledge in these particular fields of theoretical materials science/quantum chemistry.	Jiří Klimeš (jiri.klimes@matfyz.cuni.cz)	Jiří Klimeš (jiri.klimes@matfyz.cuni.cz)
Faculty of Mathematics and Physics	Department of Surface and Plasma Science	**Development of trap-supported Rydberg qubit**	Join our research group and help develop an innovative quantum device that leverages a hybrid electron-ion-trap system for single-photon detection. You'll also play a key role in engineering a groundbreaking qubit platform. Whether you excel at designing advanced microwave circuitry and other critical components or delving into the theoretical nuances of light interactions, there are multiple exciting avenues for you to contribute.	Michal Hejduk (michal.hejduk@matfyz.cuni.cz)	Michal Hejduk (michal.hejduk@matfyz.cuni.cz)
Faculty of Mathematics and Physics	Institute of Physics of Charles University	**Lead-free halide perovskites - attractive and environmentally friendly materials for optoelectronic applications**	Hybrid or all-inorganic lead-based halide perovskites (LHP) have attracted global interest as highly efficient and inexpensive materials for optoelectronics applications. However, the toxicity of Pb-based perovskite materials still hinders their wider commercialization. Therefore, It is highly desirable to test alternative ions in perovskite materials to form environmentally friendly materials. The project is focused on the investigation of single crystal growth technology of lead-free perovskites and on the characterization of electrical, optical and spectroscopic properties of the grown crystals including also surface treatment and preparation of optimal electric contacts.	prof. Eduard Belas (eduard.belas@mff.cuni.cz)	Eduard Belas (eduard.belas@mff.cuni.cz)
Faculty of Mathematics and Physics	Department of Condensed Matter Physics	**Machine learning for superconducting molecular electronics**	Superconducting molecular electronics explores the interplay between superconductivity and molecular-scale quantum systems such as single-molecule junctions. Beyond uncovering novel quantum phenomena, it holds promise for applications in nanoscale superconducting circuits, quantum information processing, and ultra-low-power electronics. Join us in our effort to harvest machine learning techniques, particularly neural network quantum states, to tackle the complexity of these systems, enabling more accurate modeling, efficient simulations, and novel design strategies.	Martin Žonda (martin.zonda@matfyz.cuni.cz)	Martin Žonda (martin.zonda@matfyz.cuni.cz)
Faculty of Mathematics and Physics	Departement of Macromolecular Physics	**Rational Active Matter**	Active matter is a physics discipline exploring self-organization in natural systems like bird flocks and insect swarms. This project examines how cognition, prediction, and goal orientation influence self-organization by integrating these key aspects into active matter models—a potentially essential yet largely overlooked ingredient for understanding the self-organization of cognitive animals.	Viktor Holubec (viktor.holubec@matfyz.cuni.cz)	Viktor Holubec (viktor.holubec@matfyz.cuni.cz)

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Faculty of Mathematics and Physics	Institute of Physics of Charles University	**Scalable Synthesis of ABC-Stacked Trilayer Epitaxial Graphene for Advanced Electronic and Optoelectronic Applications**	This project focuses on scalable synthesis of ABC-stacked trilayer epitaxial graphene on silicon carbide substrates for diverse electronic and optoelectronic applications. Graphene in the ABC stacking order exhibits tunable energy bandgap, superconductivity, and ferroelectricity phenomena. However, the major techniques used to prepare ABC graphene struggle with a maximal size of around 100 nm, hindering future applications. We aim to refine growth techniques and explore emergent electronic properties of ABC graphene. These observations, alongside scalable growth processes, promise significant advancements in graphene-based electronic and optoelectronic nanodevices.	Martin Rejhon (martin.rejhon@matfyz.cuni.cz)	Martin Rejhon (martin.rejhon@matfyz.cuni.cz)
Faculty of Mathematics and Physics	Departement of Macromolecular Physics	**Solitary cluster waves in driven Brownian motion through crowded environments**	The project will focus on overdamped solitons formed by periodic cluster waves in Brownian dynamics through crowded periodic environments. The existence of these collective modes of motion was recently predicted theoretically and verified in pioneering experiments, yet their properties and behavior are still not well understood. The research will be carried out in a close collaboration with international theoretical (Germany) and experimental (Spain) teams.	Artem Ryabov (Artem.Ryabov@mff.cuni.cz)	Artem Ryabov (Artem.Ryabov@mff.cuni.cz)
Faculty of Mathematics and Physics	Departement of Macromolecular Physics	**Sputter-driven synthesis of high-entropy alloy nanoparticles**	Alloys consisting of several elements in approximately equiatomic concentrations possess unique properties that are unattainable by individual components. These alloys are mostly known in the form of thin films; in contrast, this project will build on expertise in the sputter-driven synthesis of single- and bimetal nanoparticles using gas aggregation cluster sources. Simultaneous sputtering of several metals in an inert atmosphere potentially mixed with reactive gases is envisioned to provide an ultraclean, low-waste approach toward multi-principal-element alloy nanoparticles with unprecedented properties.	Andrey Shukurov (choukourov@kmf.troja.mff.cuni.cz)	Andrey Shukurov (choukourov@kmf.troja.mff.cuni.cz)
Faculty of Mathematics and Physics	Department of Atmospheric Physics	**Street-scale modeling of urban micrometeorology and air quality**	Our team is seeking new colleagues to advance street-scale urban meteorological and air quality modeling using computational fluid dynamics. The position offers opportunities to develop, evaluate and apply cutting-edge CFD models capturing complex urban flows, pollution dispersion, and microclimate patterns. The topic invites research at the intersection of atmospheric science, urban planning, and environmental health. The research will be conducted in cooperation with colleagues from the Czech Academy of Sciences and expects participation in the development of the LES model PALM.	Michal Belda (michal.belda@matfyz.cuni.cz)	Michal Belda (michal.belda@matfyz.cuni.cz)
Faculty of Mathematics and Physics	Department of Condensed Matter Physics	**Superconducting Nanodevices**	We invite applications for a postdoctoral position in **theoretical quantum systems**. Our research explores **composite quantum materials**, where quantum dots and spinful molecules interact with superconductors. These hybrid structures provide a platform for fundamental studies and future applications in superconducting electronics and quantum computing. Join our established team in advancing the theoretical understanding of complex systems and proposing novel device architectures.	Tomáš Novotný (tomas.novotny@matfyz.cuni.cz)	Tomáš Novotný (tomas.novotny@matfyz.cuni.cz)