Open Postdoctoral Positions - Faculty of Science
P. J. Šafárik University in Košice

1. Revealing morphological and molecular diversity of terrestrial subterranean arthropods (Arthropoda) of Iran.
2. Stabilization of a quantum entanglement of Heisenberg spin clusters up to room temperature.
3. Photometry of extrasolar planets as a tool for the study of planetary dynamics.
4. Application of machine-learning methods to the inverse problem of parameters' determination of eclipsing binary stars.
5. To establish functional 3D model of Parkinson disease as organoids from SH SY5Y differentiated cells.
6. Completeness in (topological) semigroups.

Institute of Biology and Ecology

1. Topic: Revealing morphological and molecular diversity of terrestrial subterranean arthropods (Arthropoda) of Iran

Annotation:
By its territory, Iran belongs to the largest countries in Asia. The country is characteristic with high ecosystem diversity that is the result of complex geological history and evolution of natural communities. In spite of relatively intensive research of Iranian biodiversity during the last 50 years, several regions remain unexplored in their most parts. This is also the case of caves and other subterranean habitats that are very numerous across the country in karst areas. Recent knowledge from Iran indicates potentially high biodiversity of the cave organisms and presence of animal forms extremely adapted to this hidden environment. The goal of the postdoctoral stay will be focused on a detailed study of Collembola (Hexapoda), the arthro-pods that are characteristic with high ecological plasticity and adaptations to subterranean environment. This study will be based on the modern integrative approach in delimitation of individual species, that is the combination of morphological characters and molecular data to reveal diversity of this group of hexapods in selected Iranian caves. We expect discovery of numerous unique species highly adapted to subterranean environment.

Host professor and responsible person:
prof. RNDr. Ľubomír Kováč, CSc., E-mail: lubomir.kovac@upjs.sk

Professional requirements/criteria for the candidate: PhD. in Biology or related disciplines, such as Ecology, Zoology and Entomology. Advanced knowledge in ecology of soil and subterranean animals. Practical skills in taxonomical identification of Collembola (Arthropoda) based on morpholo-gical criteria. Scientific publications dealing with the ecology of the soil or cave fauna. Strong personal motivation in development of scientific career. Assistance in laboratory work and research activities during the field work.

Institute of Physics

2. Topic: Stabilization of a quantum entanglement of Heisenberg spin clusters up to room temperature

Annotation:
Molecular magnetic materials, which are composed from discrete magnetic molecules, belong to the most perspective electron spin systems for quantum computation and quantum information processing. The main goal of the postdoctoral fellow will be examination of temperature resistance of a quantum entanglement of selected Heisenberg spin clusters depending on a magnetic structure and spin size. The quantum entanglement of Heisenberg spin clusters will be quantified through the measures such as „negativity“ or „concurrence“, whereas the project also aims at the proposal of protocol for their experimental testing through measurements of basic magnetic (magnetization, susceptibility), thermodynamic (specific heat) and resonance (ESR spectrum) quantities. The main outcome of the postdoctoral project will be characterization of a few paradigmatic examples of molecular magnetic materials, which will persist quantum-mechanically entangled at high enough (room) temperatures.

Host professor:
Prof. RNDr. Michal Jaščur, CSc, E-mail: michal.jascur@upjs.sk

Supervisor:
Assoc. Prof. RNDr. Jozef Strečka, PhD., E-mail: jozef.strecka@upjs.sk

Professional requirements/criteria for the candidate: experiences with solving quantum spin models, programming skills, knowledge of analytical and numerical computational methods: exact analytical and numerical diagonalization, Lanczos algorithm, DMRG method

3. Topic: Photometry of extrasolar planets as a tool for the study of planetary dynamics

Annotation:
Transits of extrasolar planets are an extensive source of information not only about the planets themselves but also about the individual planetary systems. Long-term observations of the transits and determination of their exact times could show the presence of an unknown planet in the system (TTV method) which gravitationally interacts with the transiting one. Precise photometric observations of the transits could be, at the present time, easily performed also with smaller telescopes. Another important aspect of planetary systems is their long-term dynamical stability. The current computer technique allows performing different extensive numerical simulations within the planetary dynamics which moves the studying of the exoplanets to a higher level. At least the basic analysis of the planetary dynamics becomes the necessary part of any other research of multiplanetary systems. The main goals of the post-doctoral fellowship would be:

- precise photometry of newly discovered exoplanets for which additional follow-up observations are highly important. Observations will be performed with faculty instruments at Kolonica Observatory;
- observed data reduction and analysis together with data from space missions (Kepler, TESS, etc.) for searching of new potential planets using the TTV method;

- analysis of systems' dynamics for a possible restriction of the parameters of hypothetical planets in the studied systems.

Host professor:
Prof. RNDr. Michal Jaščur, CSc, E-mail: michal.jascur@upjs.sk

Supervisor:
Assoc. Prof. Mgr. Štefan Parimucha, PhD., E-mail: stefan.parimucha@upjs.sk

Professional requirements/criteria for the candidate: Completed PhD study in astrophysics or related fields; advanced knowledge of Python programing language; minimum 5 publications registerd in WoS or Scopus; minimum 3 publications in Q1 and/or Q2 Scimago rank.

4. Topic: Application of machine-learning methods to the inverse problem of parameters' determination of eclipsing binary stars

Annotation:

The inverse problem in the study of eclipsing binary stars means a determination of basic parameters of the binary using available photometric and spectroscopic measurements. In the last decades, several approaches for the solution of the inverse problem were developed. However, practically all of them require substantial input from the more or less experienced users. It is timeconsuming and largely restricts the number of binaries, we can solve. Archive data from space missions (KEPLER, TESS, GAIA) as well as ground-based surveys (SuperWASP, ASASS…) consist of several ten thousand eclipsing binaries. One can expect that planned surveys like PLATO or Vera C. Rubin Observatory (LSST) will discover several millions of eclipsing binaries. Their analysis with current methods is practically impossible. Current development in machine learning methods gives us an opportunity to significantly reduce the input from users. Such an approach would enable to vastly increase a capacity to solve the inverse problem for a large amount of eclipsing binaries even with surface inhomogeneities like spots, and/or with pulsations. Therefore, the main goals of the proposed position are:

- development of machine learning models to estimate initial parameters of the eclipsing binaries that could be used as starting values for more conventional methods;
- development of automatized solution of the inverse problem with emphasis on the eclipsing binaries with only photometric observations available;
- testing the developed algorithm on large datasets available from ground-based and spacebased instruments.

Host professor:
Prof. RNDr. Michal Jaščur, CSc, E-mail: michal.jascur@upjs.sk

Supervisor:
Assoc. Prof. Mgr. Štefan Parimucha, PhD., E-mail: stefan.parimucha@upjs.sk

Professional requirements/criteria for the candidate: Completed PhD study in astrophysics or related fields; advanced knowledge of Python programing language; minimum 5 publications registerd in WoS or Scopus; minimum 3 publications in Q1 and/or Q2 Scimago rank.

5. Topic: To establish functional 3D model of Parkinson disease as organoids from SH SY5Y differentiated cells

Annotation:
Models of Parkinson´s disiease (PD) can represent aspects of found on the level of behaviour, electrical activity, individual cells and molecules. The cellular models develop pathology more quickly, are less costly and do not require ethical approval as animal models. The SH-SY5Y neuroblastoma and the PC12 pheochromocytoma cell lines have been most often used as cellular PD model. Studies using both undifferentiated and differentiated SH SY5Y cells have shown distinct responses to cellular stressors. Despite the relevance for PD research, only about 6% of published papers use differentiated cells. However, the simplicity of 2D culture does not reflect the complexity and cellular diversity of the tissues in vivo. To overcome limitations of 2D and animal models with respect to special resolution and ethical issues, 3D tissue-like models, known as organoids and spheroids, have been developed. It was shown that cellular response to drugs and ionizing radiations was significantly affected by 2D and 3D conditions. The main goal of the project **is to establish the method to create reproducible the 3D organoid SH SY5Y culture construct** with differentiated SH SY5Y cells **with dopaminergic phenotype**. Further objectives are **to establish the 3D organoid PD model** by using exposure to rotenone and **to characterized established SH SY5Y organoids** with respect to viability, level of oxidative stress and a-synuclein in 3D environment.

Host professor:
Prof. RNDr. Pavol Miškovský, DrSc., pavol.miškovský@upjs.sk
Supervisor:
Assoc. Prof. RNDr. Katarína Štroffeková, Ph.D., katarina.stroffekova@upjs.sk

Professional requirements/criteria: PhD. degree in Biophysics or a related field.
Experience with cell cultures, cell physiology, and methods in confocal microscopy, molecular biology, and biochemistry are welcome.

Institute of Mathematics

6. Topic: Completeness in (topological) semigroups

Annotation:
Topological methods provide better understanding of the algebraic structure of semigroups which has applications in Computer Science, in particular in Automata Theory and Formal Languages. Moreover, topological semigroups are applicable in Dynamical Systems.

The aim of the research project will be to study the interplay between topological and algebraic structures on semigroups. In particular, to study properties related to completeness and categorical closedness of semigroups. An important aspect of this research will be the investigation of the correlation between categorical closedness and topologization of semigroups. Principal tools in this investigation are assumed to be Zariski topologies as well as different filters on semigroups.
The candidate is supposed to have in-depth knowledge in Semigroup Theory and General Topology. Experience with the set-theoretic techniques provides an advantage.

Host professor:
prof. RNDr. Tomáš Madaras, PhD., tomas.madaras@upjs.sk
Supervisor:
Assoc. Prof. RNDr. Ondrej Hutník, PhD., ondrej.hutnik@upjs.sk

Professional requirements/criteria:
PhD. in mathematics, focus on topological semigroups; high-level publications and presentations at international conferences.