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

1. Stabilization of a quantum entanglement of Heisenberg spin clusters up to room temperature
2. Photometry of extrasolar planets as a tool for the study of planetary dynamics
3. Application of machine-learning methods to the inverse problem of parameters' determination of eclipsing binary stars
4. Postdoctoral study in the field of electrocatalysis
5. Cross section investigation in the deuteron-proton reaction at the intermediate energies

---

Institute of Physics

1. 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

2. 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 Hnatič, DrSc, E-mail: michal.hnatic@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.

3. 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 Hnatič, DrSc, E-mail: michal.hnatic@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: Postdoctoral study in the field of electrocatalysis

Annotation:

The sphere of use of catalysts is incredibly broad – practically all chemical reactions in industry are catalytic. Nowadays the problem of developing clean energy is particularly acute, and the hydrogen economy is one of its leading sectors. Catalysts play an important role in development of hydrogen economy, in particular, they are able to improve the efficiency of water electrolysis, photodecomposition of water, methane decomposition when obtaining hydrogen and to enhance the performance of fuel cells when converting the chemical bound energy of hydrogen and oxygen directly into electrical energy. Hydrogen and oxygen evolution reactions as well as oxygen reduction reaction are catalytic reactions, which play a key role in the efficiency of obtaining hydrogen and in generation of electrical energy. That is why the main goal of postdoctoral research will be directed to the obtaining of catalysts for the above-mentioned reactions.

Host professor: Prof. Ing. Martin Orendáč, CSc, E-mail: martin.orendac@upjs.sk

Supervisor: Dr. Vladimír Komanický, E-mail: vladimír Komanický@upjs.sk

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

5. **Topic:** Cross section investigation in the deuteron-proton reaction at the intermediate energies

Annotation:

Understanding the nature of the nuclear force is one of the most important questions in nuclear physics. The detailed knowledge of the nuclear forces provides description of the nuclear properties and their reactions. There are different theoretical models, providing good descriptions of the few nucleon phenomena by the use of the two nucleon forces below the pion production threshold. However inclusion of the three nucleon forces leads to a better description of the data in some cases. The measurements of the differential cross sections and study of the angular dependence of the vector and analyzing powers of the elastic scattering and that of deuteron pionless breakup are one of the tools to study the three nucleon forces. The spin dependency of these forces can be investigated by measuring the vector and tensor analyzing powers using polarized deuteron beams.
Experimental data have been taken within the DSS experiment LHEVB JINR, Dubna at three values of the deuteron beam kinetic energy: 300, 400 and 500 MeV. The activities involve: calibration of the scintillator detectors, selection of dp events, identification of the breakup reaction channel, determination of differential cross sections of the deuteron breakup, analyzis of experimental uncertainties, possible refinement of the angular dependence of analyzing powers in elastic channel at the polarized deuteron beam energy of 800 MeV, comparison of the obtained experimental distributions with the results of theoretical models.

Host professor: Prof. RNDr. Stanislav Vokál, DrSc, E-mail: stanislav.vokal@upjs.sk

Supervisor: Assoc. Prof. Jozef Urbán, CSc., E-mail: jozef.urban@upjs.sk
Assoc. Prof. Janka Vrláková, PhD., E-mail: janka.vrlakova@upjs.sk

Professional requirements/criteria for the candidate:
The candidate must have theoretical and practical skills in the field of the interaction of light nuclei reaction, particle detection methods, statistical methods of the data processing, simulation of physical processes, especially the kinematics of reactions. The candidate must have work experience in Unix/Linux Linux operating system. She/he must have practical skills in using the ROOT package in the analysis of experimental data.