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

1. Preparation and study of topologically nontrivial nanostructures by scanning tunneling microscopy.
2. To establish functional 3D model of Parkinson disease as organoids from SH SY5Y differentiated cells.

Institute of Physics

1. Topic: Preparation and study of topologically nontrivial nanostructures by scanning tunneling microscopy.

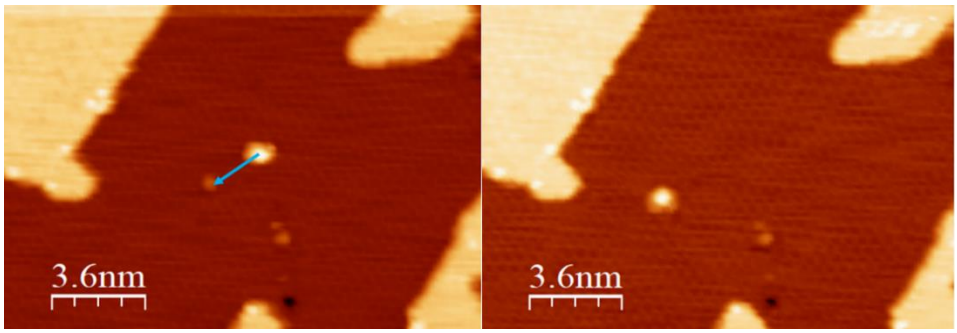
Annotation

The newly discovered topological aspect of otherwise well-known condensed matter systems opened an immense playground for exploring and designing systems which demonstrate quantum phenomena that were previously overlooked. Topologically nontrivial superconductors can host the putative Majorana quasiparticles, which can serve as the basis of topologically protected qubits immune to decoherence and unitary errors, major obstacles in constructing a useful quantum computer. However, despite the enormous efforts, the conclusive experimental evidence of Majorana quasiparticles is still missing. While intrinsic topological superconductors are very hard to find, topological superconductivity can be artificially engineered in hybrid structures. Recently, in our laboratory we have characterized an unconventional type of superconductors with strong spin – orbit coupling [1-3]. This makes them a suitable substrate for the construction of magnetically ordered nanostructures capable of hosting the Majorana quasiparticles, under specific conditions. The topic for this postdoctoral position would be to prepare and characterize various nanostructures utilizing various techniques:

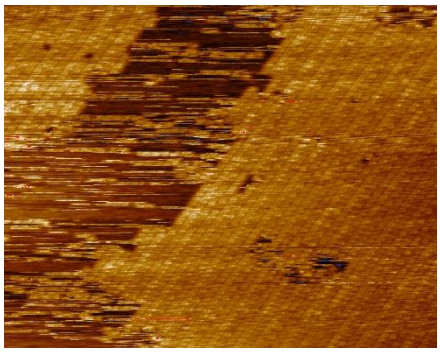
- mechanical exfoliation and layering of monolayers of superconductors and topological insulators [4]
- by self-assembly (fig. 1) or
- by nanomanipulation (fig. 2) of atoms and molecules on the superconducting substrates,

with the aim to find the required conditions for hosting the Majorana quasiparticles.

Our latest experimental apparatus for monolayer positioning and our ultra-high vacuum cryogenic scanning tunneling microscope with in-situ evaporators and spin resolution (fig. 3) is particularly suitable for such task. Markedly, this research topic is well in line with the EU scientific priorities represented by the Quantum flagship [5]. Moreover, it coincides with the international projects COST Superqumap [6] and QWorld [7] as well as the Slovak National Initiative on Quantum Technology [8], in all of which our laboratories participate.



Obr. 1: Nanomanipulation of Co atoms on Cu(111) surface carried out in our laboratory.



Obr. 2: Self-assembled molecules on the Cu(111) surface prepared in our laboratory.

Obr. 3: Our cryogenic scanning tunneling microscope in ultra-high vacuum.

[1] O. Šofranko, R. Leriche, A. P. Morales, T. Cren, S. Sasaki, L. Cario, P. Szabo, P. Samuely, and T. Samuely, Acta Phys. Pol. A 137, 785 (2020).

[2] R. T. Leriche, A. Palacio-Morales, M. Campetella, C. Tresca, S. Sasaki, C. Brun, F. Debontridder, P. David, I. Arfaoui, O. Šofranko, T. Samuely, G. Kremer, C. Monney, T. Jaouen, L. Cario, M. Calandra, and T. Cren, Adv. Funct. Mater. 2007706 (2020).

[3] Samuely, T., Wickramaratne, D., Gmitra, M., Jaouen, T., Šofranko, O., Volavka, D., Kuzmiak, M., Haniš, J., Szabó, P., Monney, C., Kremer, G., Fèvre, P. le, Bertran, F., Cren, T., Sasaki, S., Cario, L., Calandra, M., Mazin, I. I., Samuely, P. (2023). Protection of Ising spin-orbit coupling in bulk misfit superconductors. http://arxiv.org/abs/2304.03074

[4] Martinez-Castro, J., Wichmann, T., Jin, K., Samuely, T., Lyu, Z., Yan, J., Onufriienko, O., Szabó, P., Tautz, F. S., Ternes, M., Lüpke, F. (2023). One-dimensional topological superconductivity in a van der Waals heterostructure. http://arxiv.org/abs/2304.08142

[5] qt.eu
[6] https://superqumap.eu/
[7] https://qworld.lu.lv/
[8] qute.sk

Host professor:
prof. Ing. Martin Orendáč, DrSc. **E-mail:** martin.orendac@upjs.sk

Supervisor: Mgr. Tomáš Samuely, PhD. **E-mail:** tomas.samuely@upjs.sk

Professional requirements/criteria for the candidate: A third-level degree in physics or similar. Experience with scanning tunneling microscopy and spectroscopy, working with cryogenic techniques and ultra-high vacuum.

2. 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:
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Professional requirements/criteria: PhD. degree in Biophysics or a related field, proven publication activity (1-2 articles registered in WoS). Experience with cell cultures, cell physiology, and methods in confocal microscopy, molecular biology, and biochemistry.