Walther-Meißner-Institut
Bayerische Akademie der Wissenschaften

SS 2024

Walther-Meißner-Seminar

Walther-Meißner-Institute, Seminar Room 143

Date: **Friday, 21 June 2024, 11:15 h**

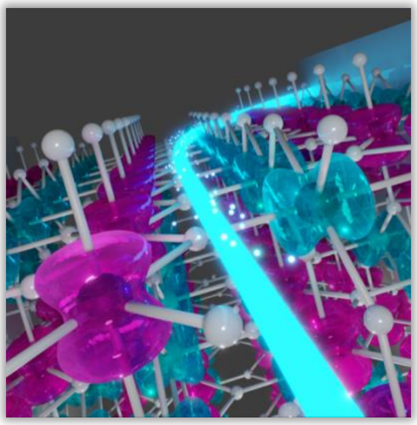
Speaker: **Libor Šmejkal**

Institute of Physics, Johannes Gutenberg University Mainz, Germany
Institute of Physics, Czech Academy of Sciences, Czech Republic

Title: **Altermagnetism: from spintronics to unconventional magnetic phases**

Abstract:

The search for unconventional quantum phases that break the symmetries of the crystal lattice has been a focus in physics since the early days of quantum theory, driven by both fundamental interest and potential applications. Prominent examples include cuprate superconductors, which are known for their unconventional d-wave Cooper pairing, and dissipationless transport.



In this presentation, we will discuss our recent discovery[1] of an unconventional magnetic phase motivated by our earlier predictions and observations of unconventional spintronics effects [2,3,4]. This unconventional altermagnetic phase (see Figure), unlike common ferromagnetism and antiferromagnetism, breaks the symmetries of the crystal lattice, and features d, g, or i-partial wave characteristics simultaneously in its spin and electronic structure[1]. D-wave altermagnetism thus represents magnetic analogue of d-wave superconductivity.

We identified altermagnetism by employing and developing a symmetry framework that considers paired transformations involving electron spin and the crystal lattice. This framework is emerging as a new paradigm in the study of magnetic crystals. We will demonstrate its usefulness by discussing (i) the altermagnetic band structure of the semiconductor MnTe, which we recently experimentally observed through collaborative work using photoemission spectroscopy[5], and (ii) our identification of more than 240 realistic altermagnetic candidates.

Additionally, we will explore the rapid expansion of altermagnetic concepts to many fields with focus on ultrafast spintronics memories[6], dissipationless transport [2-4] and two-dimensional band topology [7]. Finally, we will outline the latest developments in the field, including our theoretical identification of p-wave magnetism, an analog of superfluid helium-3, and we will propose transport experiments which can be used for its detection[8].

[1] L. Šmejkal, J. Sinova, and T. Jungwirth, Phys. Rev. X 12, 031042 (2022)
[2] L. Šmejkal, et al., Sci. Adv. 6, eaaz8809 (2020)
[3] I. Mazin, et al., PNAS 118, e2108924118 (2021)
[4] H. Reichlová, et al., Nature Communications 15, 4961 (2024)
[5] J. Krempasky*, L. Šmejkal*, S. Souza*, et al., Nature, 626, 517 (2024)
[6] L. Šmejkal et al., Phys. Rev. X 12, 011028 (2022)
[7] I. Mazin, R. Gonzalez-Hernandez, and L. Šmejkal, arXiv:2309.02355 (2023)
[8] Birk Hellenes, et al., arXiv:2309.01607v2 (2024)