Dresden University of Technology

Faculty of Physics

PHYSICS COLLOQUIUM



Speaker:

Dr. Toni Helm
Research group leader
Dresden High Magnetic Field Laboratory (HLD-EMFL)
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)

Topic:

Superconductors under Challenging Conditions – Exceptional Resilience of Superconductivity against External Perturbations

Time and place:

Tuesday, January 26, 2027, **2:50 pm** – hybrid event

The colloquium will be held in REC/C213.

Online participation possible:

Zoom-Meeting: Meeting-ID: 642 8554 1414 / passcode: w8$nSJjy

https://tu-dresden.zoom-x.de/j/64285541414?pwd=6UOwTkSBlWvNv16PgF2K1qZtoUC8cS.1

Host:

Prof. Jochen Wosnitza

Abstract:

Understanding mechanisms that can strengthen and enhance the robustness of superconductivity against external perturbations, such as high temperatures, strong magnetic fields, or large electrical currents is key to improved superconducting applications. This motivates investigations of the fundamental properties of superconductors under challenging conditions.

In this presentation I will focus on two extraordinary material classes, comprising conventional and unconventional superconductivity:

Superhydrides, i.e. metal-hydride systems also known as polyhydrides, synthesized at megabar pressures, exhibit signatures of phonon-mediated superconductivity close to room temperature with upper critical fields beyond 100 T. The required diamond-anvil-pressure-cell environment poses a huge challenge to the realization of complementary methods for the investigation of the fundamental properties of these materials. Our experiments combining electrical transport in pulsed magnetic fields, contactless radio-frequency transmission and nuclear magnetic resonance in steady magnetic fields have provided unambiguous evidence for their superconducting ground state. [1,2]

Ferromagnetic superconductors, more specifically Uranium-based compounds, exhibit very unusual superconducting behavior associated with a spin-triplet-type order parameter. In particular, the heavy-fermion superconductor UTe2 has excited our community very recently. Although it is a highly anisotropic paramagnet, UTe2 shows clear signs of multiple distinct superconducting phases with upper critical fields reaching beyond 70 T. We have been conducting high-precision transport measurements in high magnetic fields on multiterminal microstructure-samples. Our approach provides access to its coherent Fermi surface, the field-enhanced and reentrant superconducting phases, as well as vortex dynamics in the vicinity of the respective phase transitions.

I will discuss our current understanding and where research is headed next for those fascinating material classes.

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[1] Guo, J., et al., Nat. Sci. Rev. 11, 12: nwae149 (2024).
[2] Semenok, D. V., et al., Adv. Sci. 13, 23: e20701 (2026).
[3] Helm, T., et al., Nat. Commun. 15(1), 37 (2024).
[4] Husstedt, F., et al. Phys. Rev. B 111(23), 235131 (2025).

Bio:

Toni Helm is a Researcher at the Dresden High Magnetic Field Laboratory (HLD-EMFL). He obtained his PhD at the Technical University of Munich in 2013. He was a postdoctoral researcher, working jointly at the Lawrence Berkeley National Laboratory and the University of California, Berkeley.

In 2018, after working at the Max Planck Institute for Chemical Physics of Solids in Dresden, he joined the Helmholtz-Zentrum Dresden-Rossendorf as a Group Leader at the HLD. In 2024, he held a Visiting-Scholar position at the Tohoku University in Sendai, Japan.

His research focuses on topical quantum materials, such as unconventional superconductors and magnets, or topological semimetals under extreme conditions.