IMPRS for Science and Technology of Nano-Systems
INTERNATIONAL MAX PLANCK RESEARCH SCHOOL

CRC / TRR 227
Ultrafast Spin Dynamics

Joint Winter School on Ultrafast Spin Systems and Correlated Matter (November 12-14, 2025)

Venue

Max Planck Institute of Microstructure Physics, Weinberg 2, 06120 Halle (Saale)
Leopoldina, Jägerberg 1, 06108 Halle (Saale)
Löwengebäude Martin Luther University Halle-Wittenberg, Universitätsplatz 11, 06108 Halle (Saale)
Hallesches Brauhaus, Große Nikolaistraße 2, 06108 Halle (Saale)

Wednesday, November 12

Time	Topic	Room
10.00	**Stuart Parkin** (IMPRS) & **Wolf Widdra** (TRR227) Welcome note	Lecture hall (B.1.11)
10.15	**Kin Fai Mak** (MPI for the Structure and Dynamics of Matter, Hamburg) *Simulating Hubbard model physics in moiré semiconductors* Chair: Johanna Richter	
11.45	Lunch	Lounge
13.00	**Matias Bargeehr** (University of Potsdam) *Picosecond ultrasonics with x-rays - applications to energy transport and magnetisation dynamics* Chair: Johanna Richter	Lecture hall (B.1.11)
14.30	Coffee break	
15.00	Poster session	Lounge + lobby
18.00	Guided tour Leopoldina (German National Academy of Sciences) / Löwengebäude (Martin Luther University Halle-Wittenberg)	
19.00	Dinner at Hallesches Brauhaus	

Thursday, November 13

Time	Topic	Room
9.00	Walk-in & Coffee	Lounge
9.30	**Maxim Mostovoy** (University of Groningen) *Field and current driven motion of topological magnetic defects* Chair: Mihir Date	Lecture hall (B.1.11)
11.00	Coffee break	
11.30	**Annika Johansson** (MPI Halle) *Orbital magnetism in solids* Chair: Alexandra Schrader	
12.30	Lunch	Lounge
13.30	**Tobias Kampfrath** (FU Berlin) *Ultrafast control of magnetic order by terahertz spin-orbit torques* Chair: Alexandra Schrader	Lecture hall (B.1.11)
14.45	Career talk Chair: Jenny Davern & Johanna Richter	
15.45	Poster session	Lobby & lounge
17.45	Dinner	Lounge
18.45	Discussions	
20.00	Social evening featuring karaoke	

Friday, November 14

Time	Topic	Room
9.00	Walk-in & Coffee	Lounge
9.30	**Dmytro Afanasiev** (Radboud University) *Light-driven antiferromagnetic magnonics* chair: Mihir Date	Lecture hall (B.1.11)
10.30	Lab tours	Labs at MPI and MLU Halle
12.30	Lunch	
13.30	**Melanie Müller** (Fritz Haber Institute Berlin) *Ultrafast scanning tunneling microscopy: Principles and prospects for quantum materials* chair: Jenny Davern	Lecture hall (B.1.11)
14.30	Closing remarks & farewell	

Poster session Wednesday, November 12

A1 Alexandra Schrader: All-magnonic frequency multiplication in ferromagnetic microstructures

A2 Oliver Franke: Finite-frequency admittance and noise of a helical edge coupled to a magnet

A3 Eddie Harris-Lee: Femtosecond spin dynamics

A4 Theresa Albrecht: Influence of defects on the ultrafast orbital Hall effect in metallic nanoribbons

A5 Ayan Halder: Dynamic screening of excitons by interfacial water-layer

A6 Puloma Singh: Element-specific magnetization dynamics of epitaxial ultrathin Co/Pt heterostructures

A7 Michael Saur: Atomistic spin simulation of Mn_3Sn considering multiple shells

A8 Anagha Mathew: Superstructural ordering in Mn_3Pt thin films

A9 Johanna Richter: Resolving orientation-dependent ultrafast magnetization dynamics in the extreme ultraviolet spectral range

A10 Chris Körner: Frequency multiplication by collective nanoscale spin wave dynamics

A11 Kathrin Plass: Orbital-resolved correlation energies for C60 via photoelectron coincidence spectroscopy

A12 Chehao Hsu: Gate Control Superconductivity (GCS) for cryogenic logic and memory

A13 Niklas Landos: Selective probe of 4f multiplet states in rare-earth metals with Resonant inelastic X-ray scattering

A14 Jenny Davern: Scanning tunnelling microscopy of superconducting magnetic heterostructures

A15 Friederike Wührl: Electron dynamics in antiferromagnetic perovskite oxides $LaFeO_3$ and $BiFeO_3$

A16 Natalie Lehmann: Microspectroscopy of 2D materials

A17 Tiange Dong: Novel 3-dimensional nanomagnetism + spintronic devices

A18 Prajwal Rigvedi: Quaternary probabilistic switching in kagome antiferromagnets

A19 Naye Kwon: Effect of heavy metal thickness and structure on chiral domain wall motion

A20 Selcuk Sözeri: Ab-inito exploration of complex magnetism of frustrated Mn and Cr films on hexagonal metallic surfaces

A21 Moritz Winterott: Hamiltonian reverse engineering from magnetic skyrmion images via deep learning surrogates

Poster session Thursday, November 13

B1 Maksim Degoev: Electric-field tuning of dynamics in 2D materials

B2 Jasmin Jarecki: Energy-dispersive soft-x-ray reflectometer to follow complex electronic, structural, and magnetic phenomena in space and time

B3 Awsaf Chowdhury Shadman: Resonant X-ray reflectivity dynamics in FM/AFM heterostructure

B4 Tulio Henrique Lopes Gomes de Castro: ARPES on FGT thin layers

B5 Ricardo Manuel De Sousa Barbosa: Longitudinal magnetoconductance in systems with spin-orbit coupling

B6 Mihir Date: Charge density wave instability beyond the Liftshitz transition in 2H-$Ta_{1+\delta}S_2$

B7 Jiaju Wang: Deviation from parallel spin momentum locking in a chiral topological semimetal

B8 Yung-Cheng Li: Magnetic dynamics in MTJ

B9 Wolfgang Hoppe: On-chip THz current sources

B10 Bruno Rosinus Serrano: Spin-orbit fields in NiMnSb

B11 Florian Faaber: Influence of atomic-scale defects on coherent phonon excitations by THz near fields in an STM

B12 Pierre Gautier: Spectroscopic insights into ultrafast magnetization: A reflectometry-based investigation in the extreme ultraviolet spectral range

B13 Duc Pham: Topological properties of archimedean lattices

B14 Constantin Walz: Coherent 600GHz phonons in metal-only Au/Pt superlattices probed by UXRD

B15 Liu Wei: Probing ultrafast antiferromagnetic dynamics by optical second-harmonic generation

B16 David Huber: On-chip THz generation and THz streaking in PEEM

B17 Yicheng Guan: Highly efficient current induced domain wall motion in a room temperature van der Waals magnet

B18 Corvin Krohn: Interfacial magnon generation drives ultrafast spin dynamics in Gd

B19 Melvin Grumser: Investigation of chiral helicene derivatives on the superconducting substrate Pb(111) via STM

B20 Hayato Nakayama: Spin-current generation using electric-current vorticity in Ti-W system

B21 Ilias Klepetsanis: Ab-initio investigation of YSR States of Fe adatoms interacting with Rashba-split surface states on $BiAg_2$

Kin Fai Mak - Simulating Hubbard model physics in moiré semiconductors

The Hubbard model is a simple theoretical model of interacting quantum particles in a lattice. It is thought to capture the essential physics of high-temperature superconductors and other complex quantum many-body phenomena, but has proved difficult to solve accurately. Physical realizations of the Hubbard model therefore have a vital role to play in solving the strong-correlation puzzle. Moiré materials, metamaterials built on artificial "moiré atoms", have emerged as a promising Hubbard model simulator. The ability to continuously control the Hubbard Hamiltonian in these materials has provided a unique opportunity to address some of the long-standing questions in condensed matter physics. For instance, can unconventional superconductivity and quantum spin liquids emerge from the Hubbard model? In this talk, I will discuss recent efforts to simulate Hubbard model physics in moiré semiconductors. Specific topics include the realization of Wigner-Mott insulating states, the Mott-Hubbard transition and the complex phase diagram of high-temperature superconductors.

Matias Bargheer - Picosecond ultrasonics with x-rays - applications to energy transport and magnetisation dynamics

Picosecond ultrasonics with x-ray probe pulses (PUX) [1] provide unique access to coherent longitudinal acoustic phonons (coherent strain wave packets) and heat transport at the nanoscale (flow of incoherent excitations). Bragg-peak shifts are especially useful experimental observables in nano-layered systems, where all layers can be simultaneously probed and identified by their Bragg angle.

We will highlight fascinating phenomena such as the counterintuitive localization of heat via dissipation [2], dominant phonon heat transport in metals [3], stress on the lattice induced by demagnetization [4] and transduction of THz strain waves by electronic pressure in metallic heterostructures [5] that can be analyzed by PUX.

Additionally, we shall focus on the analysis of magnetoelastic excitations, and how tailoring strain waves can help to actuate spin precession [6-8].

[1] M. Mattern, A. von Reppert, S.P. Zeuschner, M. Herzog, J.-E. Pudell, and M. Bargheer, Concepts and use cases for picosecond ultrasonics with x-rays, Photoacoustics 31, 100503 (2023).
[2] F. Stete, S. Kesarwani, C. Ruhmlieb, F. Schulz, M. Bargheer, H. Lange, Inverted Temperature Gradients in Gold-Palladium Antenna-Reactor Nanoparticles, https://doi.org/10.48550/arXiv.2501.02566
[3] Herzog M., von Reppert A., Pudell J.-E., Henkel C., Kronseder M., Back C. H., Maznev A., and Bargheer M., Phonon-dominated energy transport in purely metallic heterostructures, Advanced Functional Materials 32, 2206179 (2022).
[4] M. Mattern, J.-E. Pudell, K. Dumesnil, A. von Reppert, and M. Bargheer, Towards shaping picosecond strain pulses via magnetostrictive transducers, Photoacoustics 30, 100463 (2023).
[5] M. Bargheer, et al., Electron pressure drives THz phonons in metal-metal superlattices, Research Square 2025, https://doi.org/10.21203/rs.3.rs-6597328/v1
[6] J. Jarecki, M. Mattern, F.-C. Weber, J.-E. Pudell, X.-G. Wang, J.-C. Rojas-Sánchez, M. Hehn, A. von Reppert, and M. Bargheer, Controlling effective field contributions to laser-induced magnetization precession by heterostructure design, Communications Physics 7, 12 (2024).
[7] Mattern M., Weber F.-C., Engel D., von Korff Schmising C., and Bargheer M. Coherent control of magnetization precession by double-pulse activation of effective fields from magnetoacoustics and demagnetization, Applied Physics Letters 124, 102402 (2024).
[8] C. Walz, F.-C. Weber, S.-P. Zeuschner, K. Dumesnil, A. von Reppert, M. Bargheer, Large strain contribution to the laser-driven magnetization response of magnetostrictive TbFe2, Appl. Phys. Lett. 127, 052406 (2025).

Maxim Mostovoy - Field and current driven motion of topological magnetic defects

I will discuss dynamics of topological magnetic defects, such as domain walls, merons and skyrmions. I will give a pedagogical introduction into topology of magnetic textures and an effective description of their collective degrees of freedom. I will also discuss possible manipulation of the topological defects by light based on the coupling between the magnetic modes localized at the defects, large-amplitude helicity dynamics and translational motion.

Annika Johansson - Orbital magnetism in solids

In addition to their spin, electrons in a crystal carry an orbital angular momentum. In recent years, the field of „orbitronics" emerged, focusing on the transport and dynamics of orbital magnetization in solids. This field aims to exploit the orbital degree of freedom, alongside with spin and charge, in electronic devices. Although equilibrium orbital magnetization is often quenched by crystal symmetries, nonequilibrium orbital transport phenomena usually exceed their spin counterparts [1-4]. Unlike spintronic phenomena, orbital transport effects do not rely on spin-orbit coupling and can even occur in materials composed of light elements [1]. However, despite some analogies between spin and orbital magnetization, the definition of orbital angular momentum in solids is highly non-trivial, and some established spin transport concepts do not directly apply to orbital transport. In particular the definition and interpretation of „orbital currents" is under debate, since orbital angular momentum in a crystal is not conserved [5].

In this lecture, I will give an introduction into the definition, calculation, and interpretation of orbital magnetism in solids. This will include small exercises employing the „atom-centered approximation" as well as the „modern theory of orbital magnetization" [6]. I will present materials hosting unique orbital textures, such as chiral topological semimetals and orbital Rashba systems. Finally, I will introduce orbital transport phenomena, including the orbital Hall effect and the orbital Edelstein effect, and showcase examples from our recent research projects on orbital magnetization in solids [2,7].

1] Y.-G. Choi, D. Jo, K.-H. Ko, D. Go, K.-H. Kim, H. G. Park, C. Kim, B.-C. Min, G.-M. Choi, and H.-W. Lee. Nature 619, 52 (2023).
[2] A. Johansson, B. Göbel, J. Henk, M. Bibes, and I. Mertig, Phys. Rev. Res. 3, 013275 (2021).
[3] O. Busch, F. Ziolkowski, I. Mertig, and J. Henk, Phys. Rev. B 108, 104408 (2023).
[4] A. Johansson, T J. Phys.: Condens. Matter 36 423002 (2024).
[5] N. H. Aase, E. W. Hodt, J. Linder, and A. Sudbø. Phys. Rev. B 110, 104423 (2024).
[6] T. Thonhauser. International Journal of Modern Physics B 25, 1429 (2011).
[7] S. Leiva-Montecinos, L. Vojáček, J. Li, M.Chshiev, L. Vila, I. Mertig, and A. Johansson, ArXiv:2505.21340 (2025).

Melanie Müller - Ultrafast scanning tunneling microscopy: Principles and prospects for quantum materials

Ultrafast scanning tunneling microscopy (USTM) combines the atomic spatial resolution of conventional STM with femtosecond time resolution. Thanks to recent advances in coupling single-cycle THz and ultrafast laser pulses to low-temperature STM, it has become within reach to directly visualize dynamical processes in quantum materials at their natural length and time scales. These powerful but still young approaches bridge the long-standing gap between ultrafast spectroscopy and static STM, with new opportunities for future quantum materials research.

In this lecture, I will introduce the basic principles of USTM, explain how femtosecond time resolution can be reliably implemented in tunneling measurements, and discuss the associated challenges and capabilities. I will then present recent experimental results, including our studies on charge order dynamics in 1T-TaS_2 and selected pioneering results from the community. Finally, I will outline potential applications of USTM to light-driven phenomena in topological materials, serving as a starting point for discussing its potential application to other classes of quantum materials.

The goal of this lecture is to provide graduate students and researchers in ultrafast spectroscopy with both a conceptual understanding of ultrafast STM and a forward-looking perspective on its potential impact in quantum materials research.