Grete Hermann Network

Universität Würzburg

June 30 – July 2, 2025

GHN-WORKSHOP

International Network of Female Researchers in Condensed Matter Physics

ct.qmat Complexity and Topology in Quantum Matter

Julius-Maximilians-UNIVERSITÄT WÜRZBURG

TECHNISCHE UNIVERSITÄT DRESDEN

Preface

Dear participants,

welcome to the 2025 workshop of the Grete Hermann Network! We are very happy to see all of you here at Würzburg University for this event.
We look forward to three exciting days of scientific presentations, stimulating discussions and networking. In the spirit of Grete Hermann, female pioneer of quantum mechanics who anticipated Bell's inequalities as early as 1935, the Workshop aims at highlighting the work of female physicists to a physics audience of all genders. At the same time, we hope to provide to the participants a platform for exchange on scientific and career matters in a relaxed atmosphere. Moreover, there will be reports on a scientific evaluation of the career paths of female physicists and on initiatives to support them.
The Workshop is organised by the Grete Hermann Network (GHN) of female physicists that receives financial support from the Cluster of Excellence Complexity and Topology in Quantum Matter (ct.qmat). We are very happy that the Excellence Initiative of the German Federal and State Governments just extended funding of this Cluster from 2026 until 2032, under the new name of Complexity, Topology and Dynamics in Quantum Matter (ctd.qmat). This implies continued support for the Grete Hermann Network as well, and we look forward to further exciting events together with you! The Network also continues to welcome new members; please contact us if you are interested in joining. More information on the Network is given on the last page of this booklet.
A warm welcome once again to our Workshop! We invite you to join us and contribute to the GHN's mission of bringing together and raising the profile of female physicists in condensed matter physics and related areas, and look forward to your contributions!

Johanna Erdmenger and Adriana Palffy-Bus

Grete Hermann Network

Program Overview

Monday June 30, 2025	Tuesday July 1, 2025	Wednesday July 2, 2025
Session 1	**Session 5**	**Session 9**
9:00 Opening	**09:00** Andrean Sandoval	**09:00** Emma Minarelli
09:15 Olena Fedchenko	**09:45** Swarnamayee Mishra	**09:45** Deepika Gill
10:00 Nadezhda Kukharchyk	**10:00** Amina Kimouche	**10:00** Chithra Harihara Sharma
	Coffee break	
Session 2	**Session 6**	**Session 10**
11:00 Andrea Eschenlohr	**11:00** Martina Hentschel **11:45** Saskia Demulder	**11:00** Cristina Morais-Smith
11:45 Anja Wenger		**11:45** Edith Wietek
12:00 Charlotte Beneke		**12:00** Xiaochan Cai
	Lunch	
Session 3	**Session 7**	13:45 Closing
13:45 Ewelina Hankiewicz	**13:45** Bimla Danu	14:00 Wine tour & networking
	14:00 Francesca Paoletti	
	14:15 Elina Zhakina	
14:30 Laura Torchia	**14:30** Ipsita Mandal	
Coffee break		
Session 4	**Session 8**	
15:30 Setsuko Tajima	**15:30** Julia Hannukainen	
16:15 Short break/ discussion	**16:15** Coraline Bacq	
16:30 Martina Erlemann	16:30 Best poster award	
17:30 Group photo		
Dinner		
19:00 Poster session	**No scheduled events after the dinner:** Your evening, your way!	

Program

Monday, June 30, 2025

09:00 – 09:15	Opening
09:15 – 10:00	**Olena Fedchenko** A microscope for the reciprocal space
10:00 – 10:15	**Nadezhda Kukharchyk** Broadband paramagnetic resonance spectroscopy as a powerful tool for material characterization
	Coffee break
11:00 – 11:45	**Andrea Eschenlohr** Insight into electronic correlations on femtosecond timescales with ultrafast x-ray absorption spectroscopy
11:45 – 12:00	**Anja Wenger** Theory of unconventional magnetism in a Cu-based kagome metal
12:00 – 12:15	**Charlotte Beneke** Spin and charge criticality in the pseudogap two-impurity Anderson model
	Lunch
13:45 – 14:30	**Ewelina Hankiewicz** Thermal versus electric response of superconducting topological materials; are Majorana states more widespread than expected?
14:30 – 14:45	**Laura Torchia** Superconductor-Insulator transition in a two-orbital attractive Hubbard model with Hund's exchange
	Coffee break

15:30 – 16:15 **Setsuko Tajima**
Women physicists in Asia-Pacific region

Discussion break

16:30 – 17:30 **Martina Erlemann**
Gender and diversity in the cultures of physics and their impacts on careers in science

17:30 – 17:45 **Group photo**

Dinner

19:00 **Poster session**

Tuesday, July 1, 2025

09:00 – 09:45 **Andrea Sandoval**
Strain-enhanced altermagnetism in $Ca_3Ru_2O_7$

09:45 – 10:00 **Swarnamayee Mishra**
Pressure-induced structural phase transitions in the van der Waals multiferroic $CuCrP_2S_6$

10:00 – 10:15 **Amina Kimouche**
Van der Waals epitaxy of magnetic transition metal dihalides

Coffee break

11:00 – 11:45 **Martina Hentschel**
Complex dynamics in phase space

11:45 – 12:15 **Saskia Demulder**
Stringy complexity through the Heisenberg spin chain

Lunch

Program

13:45 – 14:00	**Bimla Danu** Phases and phase transitions of an S = 3/2 chain on two-dimensional solid surfaces
14:00 – 14:15	**Francesca Paoletti** Edge zeros in topological Mott insulators and topologically enabled superconductivity
14:15 – 14:30	**Elina Zhakina** Tuning superconducting properties in 3D nanoarchitectures
14:30 – 14:45	**Ipsita Mandal** Reflections of topology in magnetoconductivity of nodal-point semimetals
	Coffee break
15:30 – 16:15	**Julia Hannukainen** Local topological markers: characterising topology beyond perfect crystals
16:15 – 16:30	**Coraline Bacq** Accessing Anti-de-Sitter spacetime using optical lattices
16:30 – 16:45	**Best poster award**
	Conference **dinner**

Wednesday, July 2, 2025

09:00 – 09:45	**Emma Minarelli** Optical Hopfions quantizes inverse Faraday effect
09:45 – 10:00	**Deepika Gill** Creation and control of valley currents in graphene by few cycle light pulses
10:00 – 10:15	**Chithra Harihara Sharma** Resistively detected electron spin resonance and g factor in few-layer exfoliated MoS_2 devices
	Coffee break
11:00 – 11:45	**Cristina Morais-Smith** Topology and interactions at 1.58 dimensions
11:45 – 12:00	**Edith Wietek** THz-induced conversion of exciton spin states in $MoSe_2/WSe_2$ heterostructures
12:00 – 12:15	**Xiaochan Cai** Continuum theory for topological phase transition in exciton systems
	Lunch
13:45 – 14:00	Closing
14:00	**Wine tour & networking**

Abstracts

Monday, June 30, 2025

A microscope for the reciprocal space

Olena Fedchenko
Johann Wolfgang Goethe-Universität Frankfurt am Main, Germany

The development of new materials is one of the key challenges in information technology. Electronic many-body effects, which give rise to fascinating phenomena such as superconductivity and spontaneous magnetic ordering, have inspired modern research to search for even more exotic effects to exploit for applications. Thus, understanding the correlation between unconventional superconductivity and spatial electronic modulations, such as magnetic, chiral, or charge density wave (CDW) orders, is one of the key challenges in current condensed matter research.
On the other hand, the understanding of magnetic, thermal, optical and electrical properties cannot be achieved without understanding the behaviour of the electrons within these materials and how they control the observable effects. The distribution of electronic states, the band structure, of a given material is unique, like a fingerprint. By tuning the band structure of materials, it is possible to dramatically change or even create new 'exotic' physical properties of advanced materials. Modulating band structures for the needs of modern electronics and materials science in general is therefore one of the main tasks of solid-state physics.
Angle-resolved photoelectron spectroscopy (ARPES) is one of the most powerful experimental techniques for probing the electronic states that determine most physical properties of materials. The technique is based on the photoelectric effect. By analysing the kinetic energy and angular distribution of photoelectrons emitted by light with photon energy above the work function, one gains direct access to the electronic band structure of a material. The latest and most efficient electron spectrometer for ARPES is based on the time-of-flight (ToF) recording scheme. The

time-of-flight momentum microscope (ToF-MM, is a new way of performing ARPES) allows the parallel detection of the 3D photoelectron distribution, i.e. the photo-emitted electron intensity as a function of the parallel momenta kx and ky and the final kinetic energy I(Ekin, kx, ky).
In my talk I will discuss recent developments and implementations of the ToF-MM technique for the study of electronically correlated materials. In particular, I will highlight its capabilities as a tool for structural analysis, electronic band structure studies and obtaining additional information with examples based on experimental studies of various modern materials.

Broadband paramagnetic resonance spectroscopy as a powerful tool for material characterization

Nadezhda Kukharchyk
Walther-Meißner-Institut der Bayerischen Akademie der Wissenschaften, Germany

Electron paramagnetic resonance (EPR) is a wide-developed and well-established experimental techniques with many practical applications. Typical EPR approach requires a microwave cavity, which couples to a magnetic moment of an electron. This approach is, however, spectrally limited by the cavity frequency. Further developments of this approach, mainly in studies of ferromagnetic materials, deploy coplanar waveguides allowing to cover a broad rage of applied magnetic fields and measured frequencies.
In our work, we aim to combine the broadband approach of coupling the magnetic moments to a coplanar transmission line and superconducting technologies developed withing quantum information research.
Combining both, we develop the broadband EPR spectroscopy to probe spin transitions of rare earth ions in $CaWO_4$ and $LiYF_4$ crystals at temperatures below 10 mK, enabling a detailed characterization of the energy level structure of the respective ions

in the vicinity of zero magnetic fields. Due to the hyperfine coupling being often accompanied by the quadrupolar interaction arising from the nuclear spins, these systems exhibit a rich microwave spectrum in the frequency range from 0 GHz to 4 GHz, which we are able to locate at high precision with our technique. Our approach in broadband microwave spectroscopy enables the reconstruction of the full Hamiltonian and is a crucial step toward achieving coherent control of the spin excitations in these systems.

Insight into electronic correlations on femtosecond timescales with ultrafast x-ray absorption spectroscopy

Andrea Eschenlohr
Universität Duisburg-Essen, Germany

Electronic correlations are crucial in determining the equilibrium properties of many materials. Under non-equilibrium conditions, specifically the excitation with ultrashort optical pulses, their influence is less well understood, although laser-driven states become increasingly interesting not just from the perspective of understanding fundamental dynamics processes involving the charge, spin and lattice degrees of freedom on femto- to picosecond timescales but also inducing new material properties or metastable states. I will introduce how femtosecond time-resolved, nearly shot-noise limited x-ray absorption spectroscopy at the European X-ray Free Electron Laser [1] gives insight into the role of electronic correlations in non-equilibrium. Two different material systems will be discussed: In transition metal ferromagnets, the interplay of local electronic correlations of the 3d states with ultrafast spin dynamics involves band structure modifications on few 100 fs timescales [2]. In a correlated transition metal oxide, namely the prototypical charge transfer insulator NiO, resonant photoexcitation of charge carriers, so-called photodoping, results in transient energy shifts induced by Coulomb interaction, which are distinguished from non-thermal local multiplet occupations via characteristic spectral signatures [3].

[1] L. Le Guyader, A. Eschenlohr et al., J. Synchrotron Rad. 30, 284 (2023)
[2] T. Lojewski, M. F. Elhanoty et al., Mat. Res. Lett. 11, 655 (2023)
[3] T. Lojewski, D. Golez et al., Phys. Rev. B 110, 245120 (2024)

Theory of unconventional magnetism in a Cu-based kagome metal

Anja Wenger
Julius-Maximilians-Universität Würzburg, Germany

Kagome metals have established a new arena for correlated electron physics. To date, the pre- dominant experimental evidence centers around unconventional charge order, nematicity, and superconductivity, while magnetic fluctuations due to electronic interactions, i.e., beyond local atomic magnetism, have largely been elusive. From ab initio design and many-body analysis, we develop a model framework of Cu-based kagome materials the simulations of which reveal unconventional magnetic order in a kagome metal. We find the challenge of locating the appropriate parameter regime for such exotic order to center around two aspects. First, the correlations implied by lowenergy orbitals have to be sufficiently large to yield a dominance of magnetic fluctuations and weak to retain an itinerant parent state. Second, the kinematic kagome profile at the Fermi level demands an efficient mitigation of sublattice interference causing the suppression of magnetic fluctuations descending from electronic onsite repulsion. We elucidate our methodology by analyzing the proposed compound $CsCu_3Cl_5$, assessing its feasibility for future material synthesis.

Abstracts

Spin and charge criticality in the pseudogap two-impurity Anderson model

Charlotte Beneke
Technische Universität Dresden, Germany

Kondo screening of a magnetic impurity in a Fermi gas can be suppressed if the fermion-bath density of states follows a pseudogap power law. This leads to a Kondo-breakdown quantum phase transition showing non-Fermi liquid behavior due to critical local-moment fluctuations in both spin and charge sectors. Here we study a two-impurity Anderson model with a pseudogap where the interactions between the two impurities can drive additional transitions into phases with inter-moment order. We utilize perturbative renormalization-group techniques to map out the phase diagram and to study the various quantum phase transitions. For the critical fixed points, we obtain analytical results for correlation-length exponents and anomalous dimensions of physical observables. We discuss possible connections to heavy-fermion systems.

Thermal versus electric response of superconducting topological materials; are Majorana states more widespread than expected?

Ewelina Hankiewicz
Julius-Maximilians-Universität Würzburg, Germany

In this talk, we will discuss different Josephson junctions based on semimetals, metals and topological insulators proximitized with s-wave superconductors. We show that thermal response can be more sensitive to Majorana bound states than an electrical response [1,2,3]. Moreover, due to the 4pi periodicity of topological Josephson junctions, the thermal engines built on them are more efficient as the ones on the classical Josephson junctions [4]. Furthermore, we predict that the s-wave superconductivity proximitized j=3/2 particles in 2D Luttinger materials are able to host Majorana bound states even in the absence of BIA and Rashba spin-orbit couplings [5]. This originates from the hybridization of the light and heavy hole bands of the j=3/2 states in combination with the superconducting pairing. We predict that Majorana bound states should be seen in many classes of materials like p-doped GaAs, bulk HgTe, as well as many half-Heusler compounds [5].

[1] B. Sothmann, E. M. Hankiewicz Phys. Rev. B 94, 081407 (2016)
[2] A. G. Bauer, B. Scharf, L. W. Molenkamp, E. M. Hankiewicz, and B. Sothmann Phys. Rev. B 104, L201410 (2021)
[3] R. L. Klees, D. Gresta, J. Sturm, L. W. Molenkamp, and E. M. Hankiewicz Phys. Rev. B 110, 064517 (2024)
[4] B. Scharf, A. Braggio, E. Strambini, F. Giazotto, E. M. Hankiewicz,Communications Physics 3, 198 (2020)
[5] J.-B. Mayer, M. A. Sierra, and E. M. Hankiewicz, Phys. Rev. B 105, 224513 (2022)

Abstracts

Superconductor-Insulator transition in a two-orbital attractive Hubbard model with Hund's exchange

Laura Torchia
Scuola Internazionale Superiore di Studi Avanzati(SISSA), Italy

We study a two-orbital attractive Hubbard model with a repulsive Hund's exchange coupling J as an idealized model for a two-band superconductor. This framework is motivated by a system where a large isotropic electron-phonon coupling drives the on-site Hubbard repulsion U negative, while leaving the exchange term unaffected. We focus on the intra-orbital (intra-band) singlet superconducting phase and we solve the model at zero temperature and half-filling using Dynamical Mean-Field Theory. Already at $J = 0$, the two-orbital model features a superconductor-insulator transition as $|U|$ grows, as opposed to the single-orbital case which remains superconducting for any $U < 0$. We find that a finite J strengthens the effect of the attractive U, both in the normal state and, even more significantly, in the superconducting state. However, this pushes the system towards an effectively stronger coupling, hence to a faster transition to the insulating state. Remarkably, the transition from a superconductor to an insulator occurs with a vanishing quasi-particle weight Z and in a scenario that recalls strongly correlated superconductivity close to a Mott transition, even though the present model is dominated by attractive interactions.

Women physicists in Asia-Pacific region

Setsuko Tajima
Osaka University, Japan

It is well known that the rank of Japan for the Global Gender Gap Index is the 118 among 146 countries. The gender gap problem in Physics field is also serious. In the first half of my talk, I will introduce the present status of women Physicists in Japan and discuss the sources of the gender gap in Physics in Japan. There are various causes before entering and after graduating from universities. Some possible actions to solve the problems are proposed. In the latter half of my talk, I will introduce the activities of "Women in Physics" working group of AAPPS (Association of Asia Pacific Physics Societies). This is a networking activity in Asia similar to GHN.

Gender and diversity in the cultures of physics and their impacts on careers in science

Martina Erlemann
Freie Universität Berlin, Germany

In recent years, there has been growing recognition that a scientist's gender–as well as other social characteristics, among them ethnicity, national origin, or social background –can impede a career in physics, even though such factors should ideally be irrelevant. This talk presents current research on gender and diversity in physics, with a particular focus on workplace cultures and their impact on early-career researchers. It explores how these environments shape young scientists' sense of belonging within the physics community and affect their visibility both inside and outside the scientific sphere.

Abstracts

Tuesday, July 1, 2025

Strain-enhanced altermagnetism in $Ca_3Ru_2O_7$

Andrea Sandoval
University of Chile, Chile

$Ca_3Ru_2O_7$ is an antiferromagnetic (AFM) polar metal considered a fascinating material due to its wide range of remarkable electronic phenomena, including colossal magnetoresistance, spin waves, and multiple phase transitions. Exploring these properties under external manipulation, such as electrical current, pressure, or strain, opens new pathways for understanding its electronic behavior and controlling its quantum states. In this talk, we address the theoretical challenges of describing the electronic properties of $Ca_3Ru_2O_7$ [1,2], and we explore the feasibility of manipulating its magnetic states through lattice deformation using ab-initio methods. Our study identifies potential altermagnetic (AM) states, a recently discovered elemental magnetic phase, and demonstrates that these states can be stabilized under strain. Furthermore, we discuss the underlying mechanisms behind the stability of the AM phase and propose a novel approach for tuning quantum states via AFM-to-AM transitions [3] in $Ca_3Ru_2O_7$ through lattice deformation.

Pressure-induced structural phase transitions in the van der Waals multiferroic $CuCrP_2S_6$

Swarnamayee Mishra
Technische Universität Dresden, Germany

Two-dimensional (2D) crystals with strong in-plane covalent bonds and weak van der Waals (vdW) interlayer interactions have garnered significant attention following the discovery of graphene and its remarkable properties. $CuCrP_2S_6$ (CCPS) is a promising 2D material exhibiting antiferromagnetic behavior due to the collective ordering of

Cr^{3+} spins and antiferroelectric properties driven by Cu^{+} ion ordering. As a type-I multiferroic, CCPS is particularly notable for its coexistence of antiferroelectricity and antiferromagnetism, coupled with strong polarization-magnetization interactions. These ferroic properties arise from spin-orbit coupling associated with crystal symmetry breaking. Despite its potential, a detailed pressure-dependent crystallographic study of CCPS remains unexplored. In this work, we address this gap using high-pressure single-crystal X-ray diffraction (XRD) to investigate the interplay between structural changes and the material's ferroic behaviors. Our study reveals a phase transition from the low-pressure monoclinic Pc phase to the high-pressure monoclinic C2/c phase at low temperatures, providing new insights into the structure-property relationships of this promising 2D vdW material.

Van der Waals epitaxy of magnetic transition metal dihalides

Amina Kimouche
University of Potsdam, Germany

There has been a growing interest in exploring two-dimensional (2D) materials beyond graphene. Starting from 2017, new platforms have been discovered with which magnetism at low dimensions is explored. The introduction of a variety of atomically thin magnetic crystals like transition metal dihalides (TMHs) has inspired efforts to not only understand the nature of magnetism but also to investigate the growth mechanism in these magnetic crystals. In this regard, nickel bromide monolayer islands were grown on metallic substrates. I will show how Low Temperature Multimodal Scanning Probe Microscopy (SPM) imaging combined with Kelvin Probe Force Microscopy (KPFM) and Magnetic Force Microscopy (MFM) can reveal a ferromagnetic ground state persisting even in the monolayer regime. Occasionally, various phases have been formed giving rise to a reach variety of electronic structures as revealed by KPFM. These van der Waals materials are expected to open a wide range of possibilities for quantum applications.

Abstracts

Complex dynamics in phase space

Martina Hentschel
Technische Universität Chemnitz, Germany

Nonlinear dynamics and chaos are paradigm examples for complex dynamical behaviour. Quantum chaos, the quantum or wave mechanical treatment of classically chaotic systems, has attracted a lot of interest since the 1990s when mesoscopic electronic and photonic systems provided an experimental platform. In this talk we will illustrate the complex dynamics of various systems in phase space. To this end, and using the principle of ray-wave correspondence, we will use the Poincaré surface of section to visualize the classical dynamics in phase space, and Husimi functions for the wave mechanical counterpart.

We will start with the so-called Limacon cavity where chaotic dynamics was shown to be the basis for lasing from microdisk resonators: the unstable manifold, an inherent property of nonlinear dynamics, determines their far-field characteristics, yielding an universal and robust unidirectional emission. Next, we consider anisotropic systems where the loss of angular momentum conservation induces complex dynamics with chaotic features even for circular cavity shapes. We will investigate Dirac fermion billiards realized in graphene systems, especially in bilayer graphene where trigonal warping gives rise to preferred propagation directions. For birefringent optical cavities we use transformation optics to reveal their dynamical behaviour and the differences to the usually considered isotropic counterparts.

The intrinsic openness of optical systems makes their eigenenergies complex numbers, and non-Hermitian effects can occur. We will lift their mystery and briefly illustrate how exceptional points structure the complex properties of the resonance morphology especially in realistic three dimensional systems.

Stringy complexity through the Heisenberg spin chain

Saskia Demulder
Ben-Gurion University of the Negev, Israel

Chaos in local quantum systems has recently been proposed to be characterisable via Krylov complexity, which measures the spread of states in Hilbert space under Hamiltonian evolution. While Krylov complexity is now well studied in bosonic settings, its extension to systems with fermions or supersymmetry remains underexplored. We generalise spread complexity to include fermionic and supercoherent states, enabling an analytic treatment of semiclassical quantum systems with underlying Lie superalgebra symmetries. This opens the door to computing complexity in the semiclassical regime of holography where the global symmetry group is a superalgebra. We apply these techniques to compute the complexity of coherent states arising in the semiclassical limit of the dilatation operator on the CFT side. This operator is known to coincide, remarkably, with Heisenberg spin chains at one loop. Through the holographic dictionary, our results give access to the complexity of the corresponding large-charge string states propagating in curved backgrounds.
This talk is based on [hep-th/2412.09673], in collaboration with R.N. Das, J. Erdmenger and C. Northe.

Abstracts

Phases and phase transitions of an S = 3/2 chain on two-dimensional solid surfaces

Bimla Danu

Julius-Maximilians-Universität Würzburg, Germany

Motivated by recent scanning tunnelling microscopy experiments on chains of Co adatoms on Cu surfaces, we investigate the physics of a spin-3/2 Heisenberg chain on metallic and semi-metallic surfaces. In the strong Kondo coupling limit, a perturbative analysis maps the system onto a topological Haldane spin-1 chain, ferromagnetically coupled to the metallic surface. On a two dimensional semi-metal, the Kondo coupling (JK) is irrelevant at the decoupled fixed point JK=0, resulting in a Kondo breakdown phase at weak coupling. As JK increases, the decoupled spin-3/2 chain undergos a continuous Kondo breakdown quantum phase transition into an under-screened topological Kondo phase characterized by emergent spin-1 degrees of freedom. In contrast, on a two dimensional metal, the dissipative Ohmic bath acts as a marginal perturbation at the decoupled fixed point, leading to dissipation-induced antiferromagnetic ordering along the spin chain for weak JK This antiferromagnetically ordered phase is separated from the strong coupling under screened topological Kondo phase via a Hertz-Millis-type quantum critical point. Using unbiased auxiliary-field quantum Monte-Carlo simulations, we provide numerical evidence supporting this scenario and present a concrete numerical instance where masless spin-1/2 edge modes coexist with Kondo effect. Furthermore, we explore the role of single-ion anisotropy and its influence on the emergent phases and the nature of associated quantum critical behaviour.

Edge zeros in topological Mott insulators and topologically enabled superconductivity

Francesca Paoletti
Julius-Maximilians-Universität Würzburg, Germany

We investigate the role of Green's function zeros in strongly interacting topological Mott insulators [1], focusing on their meaning and physical interpretation. Recent advancements, particularly through subsidiary rotor calculations of the Kane-Mele-Hubbard model, have established a connection between zeros and spinons and with U(1) gapped spin liquids [2,3]. We find a macroscopic spin-charge separation resulting from the non-trivial interplay with the conventional boundary modes of the topological insulator. We further employ our method to an attractive Hubbard-Haldane honeycomb model. In this context, the extensive slave-rotor mean-field calculations are used as a microscopic foundation to determine the phase diagram of the model as well as important phenomenological properties, such as the coherence length and penetration depth (Pearl length) within a topologically enabled mechanism of superconductivity.

[1] Wagner, N., Crippa, L., Amaricci, A. et al., Nat. Commun. 14, 7531 (2023)
[2] Wagner, N., Guerci, D., Millis, A. J. and Sangiovanni, G., Phys. Rev. Lett. 133, 126504 (2024)
[3] Bollmann, S., Setty, C., Seifert, U. F. P. and König, E. J., Phys. Rev. Lett. 133, 136504 (2024)

Abstracts

Tuning superconducting properties in 3D nanoarchitectures

Elina Zhakina
Max Planck Institute for Chemical Physics of Solids Dresden, Germany

Introducing 3D nanoconfinement into the superconducting system can open a path for local geometrical control and the possibility of going beyond intrinsic properties [1]. However, the fabrication of such intricate nanoarchitectures remains challenging [2, 3]. In this context, we present an extended approach to creating superconducting 3D nanoarchitectures through focused electron-beam-induced deposition of tungsten [4]. This method allows the realisation of 3D superconducting nanostructures with arbitrary geometries within a wide range of critical temperatures, providing local geometrical control of critical fields and, for example, the realisation of reconfigurable weak links. With transport measurements, we demonstrate the motion of superconducting vortices within these 3D superconducting nanostructures [5]. Therefore, three-dimensional superconducting nanostructures offer new horizons for experimental investigations of the dynamics of vortices, anisotropy and possible applications of curvilinear 3D nanoarchitectures.

[1] V. Fomin et al, Appl. Phys. Lett. 120, 090501 (2022)
[2] F. Porrati et al., ACS Nano 13, 6287 (2019)
[3] R. Cordoda et al., Beilstein J. Nanotechnol., 11, 1198–1206 (2020)
[4] L. Skoric et al., Nano Letters 20 (1), 184-191 (2020)
[5] E. Zhakina et al., arXiv:2404.12151

Reflections of topology in magnetoconductivity of nodal-point semimetals

Ipsita Mandal

Shiv Nadar University Delhi-NCR, India

We will elucidate the nature of the linear-response tensors in planar-Hall and planar-thermal-Hall set-ups, where we subject a chiral 3D semimetal to the combined influence of an electric field (and/or temperature gradient) and a weak (i.e., non-quantising) magnetic field. We will explain why it is essential to include the effects of orbital magnetic moment in conjunction with the Berry curvature, in order to obtain a holistic picture of the effects of bandstructure-topology in linear response. Going beyond the well-studied example of Weyl semimetals, we will discuss the cases of their multifold as well as anisotropic cousins, harbouring higher Chern numbers. We will highlight how we can compute internode scatterings between nodes of higher-valued Chern numbers, where the associated nodal points can carry differing pseudospin representations. Finally, we will outline how to systematically compute the contributions from the so-called Lorentz-force operator – it turns out that it furnishes in-plane components of response in addition to the out-of-plane ones, which has been overlooked so far.

Abstracts

Local topological markers: characterising topology beyond perfect crystals

Julia Hannukainen
University of Cambridge, United Kingdom

Topological phases of matter have traditionally been studied in crystalline systems using momentumspace methods. Recent experiments have demonstrated topological edge states in amorphous materials, motivating the development of new tools for systems that lack translation invariance.
In this work, we introduce real-space, local topological markers for odd-dimensional quantum systems.
Local topological markers are real-space expressions of topological invariants, useful for characterising topological phases in materials without translation invariance. The Chern marker–the Chern number expressed in terms of the Fourier-transformed Chern character–s an easily applicable local marker in even dimensions, but until now has lacked an analogue in odd dimensions.
I will explain why we cannot Fourier transform the corresponding odd-dimensional invariants to obtain local markers, and how we can use dimensional reduction to overcome this problem. This requires the reformulation of the Chern character in erms of a single-particle density matrix, which is a projector onto the filled bands, and the introduction of a parameter #, which interpolates between a trivial state and the topological state of interest in odd dimensions.
By interpreting the parameter # as an additional dimension, we express the Chern character in terms of a family of projectors P#. Integrating over # gives a closed-form expression for local markers in odd dimensions. These new markers include the chiral marker, a Z invariant equivalent to the chiral winding number, and the Chern–Simons marker, a Z2 invariant characterising all non-chiral phases in odd dimensions, including topological insulators in three dimensions. The single-particle density matrix

formalism has the advantage that the markers can be used to characterise the topology of a given quantum state, without requiring knowledge of the parent Hamiltonian. This formalism extends to interacting systems through the one-particle density matrix. While the one-particle density matrix of an interacting state is no longer a projector, as long as its spectrum remains gapped, it can be adiabatically flattened to a topologically equivalent free-fermion-like form. The local markers provide a practical approach to identifying topological phases in both disordered and interacting quantum systems.

Phys. Rev. Lett. 129, 277601 (2022)
Phys. Rev. Research. 6, L032045 (2024)
EPL 142 16001 (2023)

Accessing Anti-de-Sitter spacetime using optical lattices

Coraline Bacq
Julius-Maximilians-Universität Würzburg, Germany

Reconciling quantum mechanics with gravity remains a fundamental challenge in high-energy physics. Directly probing quantum gravity in experiments is infeasible due to the small length scales involved, but analog quantum simulations offer alternative approaches. In this work, we investigate the propagation of light in one-dimensional coupled waveguide arrays and demonstrate that, when appropriately engineered, these systems can emulate the evolution of Dirac fermions in a two-dimensional Anti-de-Sitter (AdS) hyperbolic spacetime. We show that the center-of-mass motion of the light beam indeed simulates the expected trajectory of a Dirac fermion in AdS. Our results suggest that optical platforms provide a viable route for simulating quantum dynamics in curved backgrounds, with potential implications for both condensed matter and high-energy physics.

Abstracts

Wednesday, July 2, 2025

Optical Hopfions quantizes inverse Faraday effect

Emma Minarelli
Chalmers University of Technology, Sweden

Recent advancing in fine-tuning of degrees of freedom and dimensions of light, the so-called structured light [1], enabled the experimental observation of non-trivial spin textures of light. This uncovered the realm of optical topological quasiparticles [2]. Their distinctive properties such as topological stability, resolution on ultrafast timescale and localization on nanometer-scale, present both fundamental and technological relevance. Among different instances, optical Hopfion shows robust topological protection in 3D and established experimental records [3]. Yet, topological light application is mostly unexplored.

In this talk, I will start with a general motivation to optical skyrmionic textures and our proposition of topological light-matter coupling in the context of standard light-matter one. This latter interaction has recently gained traction because both optical counterpart and emergent phenomena can be currently investigated, leading to further control and manipulation of quantum materials.

After a brief introduction to electromagnetic knots [4] as model to describe optical Hopfion and to optical helicity [5] to define the Hopf number, I will present our first example of optical Hopfion-matter coupling: the topological quantized [6] version of the classical inverse Faraday effect [7]. By relating the Hopf number to the effective magnetization, I will discuss the possibility of inducing a topological magnetization in a non-magnetic material by applying a topological light source. This result is an additional contribution to the standard induced magnetization, and I will consider further its implication.

[1] Forbes, A., et al. Structured light. Nat. Photonics 15, 253–262 (2021).
[2] Shen, Y., et al. Optical skyrmions and other topological quasiparticles of light. Nat. Photon. 18, 15–25 (2024).
[3] Sugic, D., et al. Particle-like topologies in light. Nat Commun 12, 6785 (2021).
[4] Rañada, A.F. J. Phys. A: Math. Gen.23 L815 (1990). Rañada, A.F. Eur. J. Phys.13 70 (1992).
[5] Arrayás, M., et al. Knots in electromagnetism. Physics Reports, 667, pp.1-61 (2017).
[6] Rañada, A.F., et al. Electromagnetic knots, Physics Letter A (1995).
[7] Minarelli, E. and Geilhufe, R.M., Optical Hopfions quantizes inverse Faraday effect, in preparation.

Creation and control of valley currents in graphene by few cycle light pulses

Deepika Gill
Max Born Institute, Germany

Well established for the visible spectrum gaps of the transition metal dichalcogenide family, valleytronics - the control of valley charge and current by light - is comparatively unexplored for the THz gaps that characterize graphene and topological insulators. Here we show that few cycle pulses of THz light can create and control a 100% valley polarized current in graphene, with light wave control over the current magnitude and direction. The latter is equal to an emergent pulse property of few cycle circularly polarized pulses, the "global" carrier envelope phase. Our findings both highlight the richness of few cycle light pulses in control over quantum matter, and provide a route towards a "THz valleytronics" in meV gapped systems.
[1]D Gill, S Sharma, S Shallcross - arXiv preprint arXiv:2411.02379, 2024
[2] S Sharma, D Gill, J Krishna, JK Dewhurst, S Shallcross- Nature Communications, 15, 7579 (2024)

Abstracts

Resistively detected electron spin resonance and g factor in few-layer exfoliated MoS_2 devices

Chithra Harihara Sharma
Christian-Albrechts-Universität zu Kiel & Universität Hamburg, Germany

MoS_2 has recently emerged as a promising material for enabling quantum devices and spintronic applications. In this context, the demonstration of resistively detected electron spin resonance (RD-ESR) and the determination and improved physical understanding of the g factor are of great importance. However, its application and RD-ESR studies have been limited so far by Schottky or high-resistance contacts to MoS_2. Here, we exploit naturally n-doped few-layer MoS_2 devices with ohmic tin (Sn) contacts that allow the electrical study of spin phenomena. Resonant excitation of electron spins and resistive detection is a possible path to exploit the spin effects in MoS_2 devices. Using RD-ESR, we determine the g factor of few-layer MoS_2 to be ≈1.92 and observe that the g factor value is independent of the charge carrier density within the limits of our measurements.

Topology and interactions at 1.58 dimensions

Cristiana Morais-Smith
Utrecht University, Netherlands

We know how topological insulators behave in 1,2,3 dimensions, but what happens in between? In this talk, I will first present theoretical and experimental results on the behavior of ultranarrow germanene nanoribbons and show the transition from 1D topological edge states into 0D end states as the width of the nanoribbons is reduced below 2 nm [1]. Then, I will discuss the topological properties of electrons in self-formed single-layer bismuth fractals with dimension d = 1.58 on InSb [2].

Finally, I will present theoretical results on the Hubbard model in a fractal geometry [3] and discuss ongoing studies on a fractal made of Rydberg atoms with long-range interactions, trapped by optical tweezers (in preparation).

[1] D. J. Klaassen, L. Eek, A. N. Rudenko, E. D. van't Westende, C. Castenmiller, Z. Zhang, P. L. de Boeij, A. van Houselt, M. Ezawa, H. J. W. Zandvliet, C. Morais Smith, P. Bampoulis "Realization of a one-dimensional topological insulator in ultrathin germanene nanoribbons", Nature Communications 16, 2059 (2025).
[2] R. Canyellas , Chen Liu, R. Arouca, L. Eek, G. Wang, Yin Yin, D. Guan, Yaoyi Li, S. Wang, Hao Zheng, Canhua Liu, J. Jia, C. Morais Smith "Topological edge and corner states in Bi fractals on InSb," Nature Physics 20, 1421 (2024).
[3] M. Conte, V. Zampronio, M. Rontgen, and C. Morais Smith, "The fractal-lattice Hubbard model", Quantum 8, 1469 (2024).

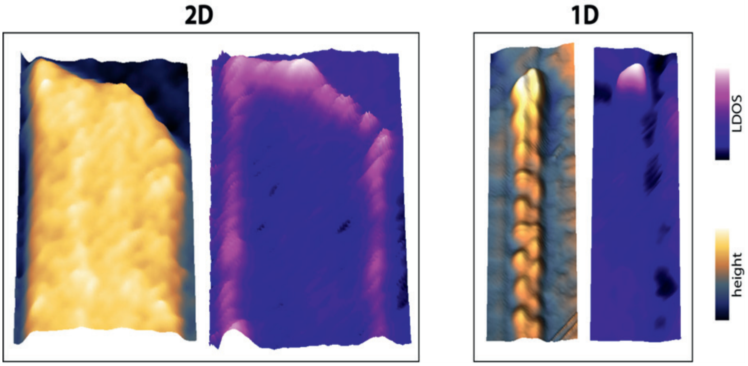

Figure 1: Topographic view (left) and local density of states (LDOS, right) for broad (2D) and ultranarrow (1D) germanene nanoribbons. The topological states are visible in pink (high LDOS).

Abstracts

THz-induced conversion of exciton spin states in $MoSe_2/WSe_2$ heterostructures

Edith Wietek
Technische Universität Dresden, Germany

Vertically stacked heterostructures of transition metal dichalcogenides (TMDCs) are a versatile platform to study electronic many-body phenomena. In these systems, the commonly encountered type-II band alignment and the presence of strong Coulomb interactions result in the formation of tightly-bound interlayer excitons (IXs). In view of their dipolar nature and rich interaction physics TMDC heterostructures offer an excellent platform for manipulation and engineering of optically active states. While forbidden for its monolayer constituents, the symmetry arguments in TMDC heterobilayers allow for the unique transition between spin triplet and singlet excitonic states. This motivates the investigation of transitions between different excitonic species in heterostructures and even consider potential conversion pathways from inter- to intralayer excitons.

Here, we address this topic by studying spectrally narrow IXs in the moiré-free limit of atomically reconstructed domains in hBN-encapsulated $MoSe_2/WSe_2$ heterobilayers, with well-defined dipolar selection rules and in absence of localization. We demonstrate the conversion of IX spin triplet to spin singlet excitonic states on ultrafast timescales of a few picoseconds induced by short pulses of THz radiation arriving after initial optical excitation. Monitoring the time-resolved photoluminescence dynamics, a strong quenching of the triplet population induced by the THz pulses is observed, accompanied by a simultaneous increase of the singlet state emission. Interestingly, upon THz arrival we also observe the reemergence of intralayer exciton signatures of $MoSe_2$ even several 100s of picoseconds after their initial decay. These results are intriguing from the perspective of many-body states coupled to low-frequency radiation and offer interesting possibilities towards ultrafast external control of spin states in van der Waals heterostructures. Furthermore, these finding open a pathway to engineer the optical selection rules by designing the symmetry of the system.

Continuum theory for topological phase transition in exciton systems

Xiaochan Cai
Julius-Maximilians-Universität Würzburg, Germany

Excitons are bound states of electrons excited into conduction bands and holes left behind in valence bands, which are known to dominate the optoelectronic properties of a wide range of materials. Recently, topological excitons in quasi-two-dimensional systems have attained particular interest, owing to both reduced screening (i.e., larger binding energies in 2D systems) and the enhanced transport characteristics inherent to topological excitons, which are crucial for optimizing optoelectronic devices.

In this talk, we present a continuum theory to study the exciton topology near a topological phase transition, marked by a band-gap closure in the exciton bands. The central idea is that, the changes in exciton Chern numbers across the transition depend exclusively on the topological charges of gap-closing points, which can be captured within the continuum theory description. Although this approach is well studied in single-particle systems, exemplified by the seminal work of the Bernevig, Hughes, and Zhang (BHZ) on HgTe quantum wells, it has not yet been extended to excitons, i.e., interacting two-particle excitations.

We focus on exciton systems with time-reversal symmetry (TRS) and showed that, although the system is topologically trivial in this case, breaking the TRS can drive the system into a topologically nontrivial phase, where the exciton Chern number is determined by the Berry phases associated with the gap-closing points. Our framework predicts optically active topological excitons and is applicable to a variety of concrete systems such as transition metal dichalcogenide (TMD) monolayers, their Moiré superlattices and BHZ-type materials, such as magnetically doped HgTe and InAs/GaSb quantum wells. Especially, for systems with a single gap-closing point at Q=0 (e.g., TMD Moiré superlattice, where the gap-closing point manifests as an exciton qubit), the exciton topological nature can be indirectly probed through polarization-resolved optical experiments.

List of posters

Posters will be presented on Monday, June 30.

No.	Name	Title
1	**Chyzhykova, Anastasiia**	The Feynman paradox in axion insulators
2	**Ganser, Romana**	Line-Moiré phases of an epitaxial honeycomb monolayer AgTe/Ag(111)
3	**Hirnet, Lena**	Growth of altermagnetic MnTe thin films
4	**Hollstein, Helena**	Structural dynamics of excimer formation in single crystalline α-perylene
5	**Huang, Shiyu**	Light-matter coupling of macroscopic WS_2 monolayer in an open cavity
6	**Kreß, Pia**	Non-Hermitian skin effect in quantum emitter chains
7	**Kukharchyk, Nadezhda**	Broadband paramagnetic resonance spectroscopy as a powerful tool for material characterization
8	**Spring, Merit**	Oxide membranes: a new platform for emergent quantum effects like charge transfer and Mott transitions

Venue

The workshop will be held at the Graduate School of Life Sciences, located on the Hubland North Campus at **Beatrice-Edgell-Weg 21, 97074 Würzburg**. The nearest bus stop is "Am Hubland," which can be reached directly from the central station via bus lines 114 and 14.

Graduate School of Life Sciences
Campus Hubland Nord
Beatrice-Edgell-Weg 21
97074 Würzburg

Further information

Accommodation

All workshop participants who do not reside in Würzburg will be accommodated at the Melchior Park Hotel. We have reserved rooms for you based on your travel dates. Your stay at the hotel is free of charge.
The hotel is located at:
Am Galgenberg 49, 97074 Würzburg
It is only 750 meters from the workshop venue.

Conference dinner

The conference dinner will be held on Tuesday, July 1, at 18:00 at Wirtshaus am Dom, located in the city center of Würzburg at Paradeplatz 4. If the weather is pleasant, we will walk together to the restaurant. The walk takes approximately 40 minutes and offers a great opportunity for informal exchange and conversation. There are no scheduled program activities after the dinner, so you are free to spend the evening exploring the city or returning to the hotel or home at your leisure.

Wine tour

To conclude the workshop on a relaxed and social note, we invite all participants to join us for a wine hike on Wednesday, starting at 14:00. We will take a scenic walk together through the vineyards, heading to the Ludwig Schmitt Winery, a traditional Franconian estate known for its excellent regional wines.

Once there, you'll be treated to a guided wine tasting featuring a selection of high-quality Franconian wines, accompanied by a light snack. This final program point offers the perfect opportunity to unwind, continue conversations, and deepen connections with fellow participants in a warm and informal atmosphere.

After the tasting, we will walk back to the university campus together. The entire excursion is designed to be easygoing and enjoyable, providing space for both reflection and new inspiration as the workshop comes to a close.

About GHN

The Grete Hermann Network (GHN) is an international network of female researchers in condensed matter physics and related areas. It involves both experienced and early-career researchers. The Network is associated with the Cluster of Excellence ct.qmat – Complexity and Topology in Quantum Matter, which is funded by the German federal government and the federal states. At the heart of the network's mission is the goal to promote excellent female-led research and to support the recruitment and careers of female scientists within the field. To achieve this, the GHN provides networking and mentoring opportunities, increases visibility of female senior scientists as role models, and creates a comprehensive pool of female researchers in view of future hirings.
The network is named after the pioneering physicist and philosopher Grete Hermann (1901 – 1984), whose interdisciplinary approach and contributions to quantum mechanics continue to inspire new generations of scientists. By bringing together talented women from different academic levels and cultural backgrounds, the GHN fosters a dynamic and inclusive environment where collaboration, innovation, and mutual support are central. Regular events such as workshops and seminars allow members to share their research, to exchange experiences, and to build long-lasting professional connections. These activities not only strengthen the scientific output of the network but also empower its members to take on leadership roles in academia and beyond.

Grete
Hermann
Network