ct.qmat Complexity and Topology in Quantum Matter

Julius-Maximilians-UNIVERSITÄT WÜRZBURG

TECHNISCHE UNIVERSITÄT DRESDEN

MONDAY, March 25

	Arrival	
12:00–13:00	**Lunch**	
13:00–13:20	**Welcome**	Matthias Vojta TU Dresden Ralph Claessen JMU Würzburg
13:20–15:00	**Session 1 – Magnetism & Spin Liquids**	*Chair: Dmytro Inosov*
13:20–13:40	Experimental evidence of new many-body spinaron excitations in Co atoms on Cu(111)	Artem Odobesko JMU Würzburg
14:40–14:00	Altermagnetic anomalous Hall effect emerging from electronic correlations	Toshihiro Sato IFW Dresden
14:00–14:20	Electronic reconstruction and anomalous Hall effect in $LaAlO_3/SrRuO_3$ heterostructures	Merit Spring JMU Würzburg
14:20–14:40	Fractonic spin liquids	Rafael Flores Calderon MPI PKS Dresden
14:40–15:00	A classical spin-liquid with emergent fractionalized bionic charges and chiral field excitations	Daniel Lozano-Gomez TU Dresden
15:00–15:20	**Poster Pitches I – odd numbered posters**	
15:20–16:40	**Coffee Break & Check-In**	**Poster Session I**
16:40 –18:20	Workshop – Daring to Face the Unknown: Diversity, Dignity, and Hidden Bias Part I	Inna Zeitler Wissen Haltung Wandel
18:20–19:50	**Dinner**	
19:50–21:00	Workshop – Daring to Face the Unknown: Diversity, Dignity, and Hidden Bias Part II	Inna Zeitler Wissen Haltung Wandel
21:00	**Poster Session**	

Tuesday, March 26

08:00–09:00	**Breakfast**		
09:00–10:20	**Session 2 – Superconductivity & Majoranas**		*Chair: Björn Trauzettel*
09:00–09:20	Competing phases and topological superconductivity on the triangular lattice		Stephan Rachel University of Melbourne
09:20–09:40	Evidence of superconducting Fermi arcs		Andrii Kuibarov IFW Dresden
09:40–10:00	Entanglement in interacting Majorana chains and transitions of von Neumann algebras		Pablo Basteiro JMU Würzburg
10:00–10:20	Majorana-mediated thermoelectric transport in multiterminal junctions		Daniel Gresta JMU Würzburg
10:20–10:35	**Coffee Break**		
10:35–12:40	**Guided City Tour**	**Steering Committee Meeting**	
12:40–14:00	**Lunch**		
14:00–15:00	Evidence for a broken time reversal symmetry Charge Density Wave state in RbV_3Sb_5		Vidya Madhavan University of Illinois Urbana-Champaign
15:00–15:20	**Poster Pitches II - even numbered posters & Awards**		
15:20–16:40	**Coffee Break**	**Poster Session II**	
16:40–18:20	**Session 3 – Emergent Topology**		*Chair: Ralph Claessen*
16:40–17:00	Emergent coupling of protected edge states of 2D topological insulators in a crystalline multilayer heterostructure with ion mobility		Michael Ruck TU Dresden
17:00–17:20	Edge zeros and boundary spinons in topological Mott insulators		Niklas Wagner JMU Würzburg
17:20–17:40	Continuous order-to-order quantum phase transition from fixed-point annihilation in Luttinger semimetals		David Moser TU Dresden
17:40–18:00	Kagome metals by material design		Anja Wenger JMU Würzburg
18:00–18:20	Exceptional points at x-ray wavelengths		Fabian Richter JMU Würzburg
18:20–19:50	**Dinner**		
19:50–21:00	**QMA Meeting**	**Steering Committee Meeting + SAB Meeting**	
21:00	**Poster Session**		

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WEDNESDAY, March 27

08:00–09:00	**Breakfast**	
09:00–10:40	**Session 4 – Photonics**	*Chair: Sebastian Klembt*
09:00–09:20	Topological quantum optics in atomic emitter arrays	Jonathan Sturm JMU Würzburg
09:20–09:40	Quantum emitters in SiC	Andreas Sperlich JMU Würzburg
09:40–10:00	Immortalized light-matter hybrid states via coherent perfect absorption?	Bert Hecht JMU Würzburg
10:00–10:20	Towards path-entangled photons in a topological photonic waveguide lattice	Moritz Meinecke JMU Würzburg
10:20–10:40	Room temperature exciton-polariton lasing and photonic lattices with perylene bisimides – Towards topological laser with organic emitters	Dominik Horneber JMU Würzburg
10:40–11:20	**Coffee Break & Check-Out**	
11:20–12:20	**Session 5 – Superconductivity**	*Chair: Carsten Timm*
11:20–11:40	Josephson signatures of the superconducting Higgs/amplitude mode	Aritra Lahiri JMU Würzburg
11:40–12:00	Complete zero-energy flat bands of surface states in fully gapped chiral noncentrosymmetric superconductors	Clara Johanna Lapp TU Dresden
12:00–12:20	Chiral Meissner effect in time-reversal invariant Weyl superconductors	Vira Shyta IFW Dresden
12:20–12:40	Evidence for vertical line nodes in Sr_2RuO_4 from nonlocal electrodynamics	Javier Landaeta TU Dresden
12:40–14:00	**Lunch**	
14:00–14:40	**Session 6 – Non-Hermitian Topology**	*Chair: Jan Carl Budich*
14:00–14:20	Lack of near-sightedness principle in non-Hermitian systems	Viktor Könye IFW Dresden
14:20–14:40	Observation of non-Hermitian topology in a multi-terminal quantum Hall device	Kyrylo Ochkan IFW Dresden
14:40–15:00	**Closing Remarks & Best Poster Awards**	
15:00	**Departure**	

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March 25

- Arrival
- Lunch
- Welcome
- Session 1 - Magnetism & Spin Liquids [5 talks]
- Poster Pitches I
- Poster Session I | Coffee & Check in
- Workshop – Daring to Face the Unknown: Diversity, Dignity, and Hidden Bias Part I
- Dinner
- Workshop – Daring to Face the Unknown: Diversity, Dignity, and Hidden Bias Part II
- Poster Session

March 26

- Breakfast
- Session 2 - Superconductivity & Majoranas [4 talks]
- Social Activity - Guided City Tour Weimar | Coffee, then Steering Committee Meeting
- Lunch
- Talk - Vidya Madhavan
- Awards & Poster Pitches II
- Poster Session II | Coffee
- Session 3 - Emergent Topology [5 talks]
- Dinner
- QMA Meeting | Steering Committee + SAB Meeting
- Poster Session

March 27

- Breakfast
- Session 4 - Photonics [5 talks]
- Coffee & Checkout
- Session 5 - Superconductivity [4 talks]
- Lunch
- Session 6 - Non-Hermitian Topology [2 talks]
- Closing Remarks & Best Poster Award
- Departure

Experimental evidence of new many-body spinaron excitations in Co atoms on Cu(111)

Artem Odobesko
JMU Würzburg

The collective screening of an impurity spin by conduction electrons in the Kondo effect is one of the most fundamental manifestations of many-body phenomena in physics. The experimental identification of the Kondo effect in individual atoms is linked to the rise of a local electronic state at the Fermi level with a characteristic temperature and field dependence. Corresponding spectroscopic signature with a zero- bias anomaly (ZBA) in the differential conductance signal was for the first time observed in scanning tunneling spectroscopy (STS) experiments on Co atoms on Cu(111) surface [1] and is explained by a Fano resonance caused by interfering tunneling paths into the Kondo state and atomic orbitals. Recent first-principle calculations [2] suggest, however, that the experimentally observed spectroscopic ZBA should be interpreted in terms of excitations of the Co atom's spin and the formation of a novel quasiparticle, the spinaron, a magnetic polaron resulting from the interaction of spin excitations with conduction electrons, rather than in terms of a Kondo resonance. Here we present state-of-the-art spin-averaged and spin-polarized scanning tunneling spectroscopy measurements on Co atoms on the Cu(111) surface in magnetic fields of up to 12T. We observe a field-induced energy shift and experimentally determined spin character of the spectral features, showing a completely opposite behavior, as expected for he Kondo, but predicted for the spinaron. Our careful study of the responses of the ZBA on Co atoms on Cu(111) to an external magnetic field in combination with spin-polarized STS allowed us to discriminate between the different theoretical models and to invalidate the prevailing Kondobased interpretation of the ZBA in favor of spinaron and for the first time experimentally detect this novel many-body excitation [3].

[1] V. Madhavan et al., Science **280**, 567 (1998)
[2] J. Bouaziz et al., Nat. Comm. **11**, 6112 (2020)
[3] F. Friedrich et al., Nat. Phys. (2023)

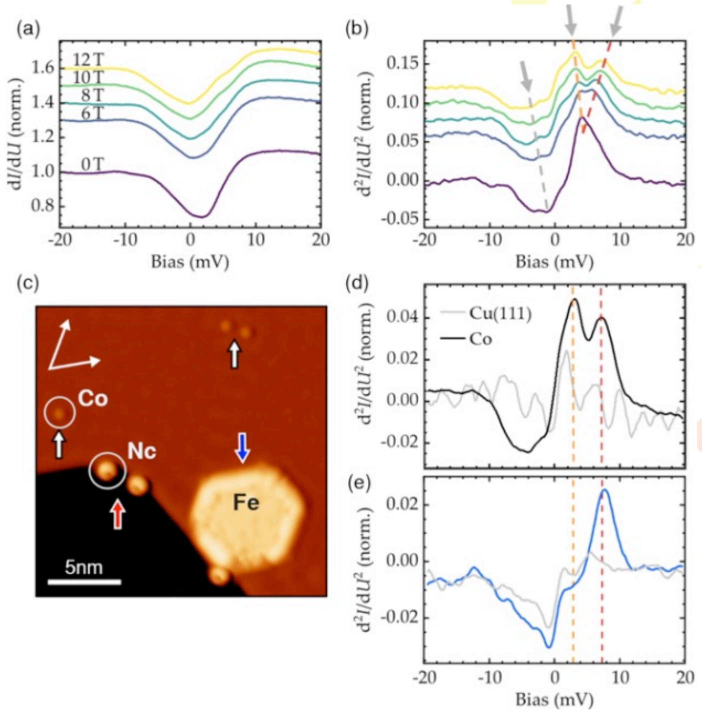

Figure 1. (a) Magnetic field-dependent splitting of the zero-bias anomaly on Co atoms on Cu(111) and (b) numerically calculated derivative. (c) Topography image of the Cu(111) surface decorated with Fe islands, Nc molecules and Co atoms. After picking up a small magnetic Fe cluster, the tip polarization is determined by measuring the SE signal on top of a Nc molecule. (d) d^2I/dU^2 signal measured at B = 12T with spin-averaged tip atop a Co atom (black) and the bare Cu(111) surface. Dashed orange and red lines indicate the position of the low-and high-energy spectral features shifting to low- and high-energies with increasing magnetic field respectively. (e) Same Co atom as in (d) measured with a majority spinpolarised tip. The data attribute high-energy spectral feature to a majority spin channel, and lowenergy spectral feature to a minority spin channel with a magnetic field dependence opposite to a Kondo picture but consistent with a spinaron.

Altermagnetic anomalous Hall effect emerging from electronic correlations

Toshihiro Sato
IFW Dresden

Magnetism has been so far known to host basically two classes of materials: ferromagnets and antiferromagnets. The former is characterized by finite magnetization and a spin polarized electronic band structure, while the latter consists of systems with zero net magnetization and a spin degenerate band structure. Recently a new class of magnetic materials has been uncovered, altermagnets, which have a spin-split electronic band structure (like ferromagnets) but still have zero net magnetization (like antiferromagnets). Interestingly, symmetry analysis suggests that altermagnets may also exhibit an anomalous Hall effect, despite their vanishing total magnetization. In this talk, we introduce a model with altermagnetism in which the emergence of an anomalous Hall effect is driven by interactions [1]. This model is grounded in a modified Kane-Mele framework with antiferromagnetic spin-spin correlations. Employing approximation-free auxiliary-field quantum Monte Carlo simulations, we demonstrate a finite-temperature phase transition leading to a primary antiferromagnetic order and a secondary one of Haldane type. The primary order results from spontaneously time-reversal symmetry breaking, without a net magnetic moment. The emerging secondary order is the key to inducing a significant anomalous Hall effect, as evidenced by our calculations of substantial anomalous Hall conductivity. Furthermore, we introduce a low-energy effective continuum description and discuss our findings within the context of the recently developed Landau theory of altermagnetism.

[1] Toshihiro Sato et al., arXiv:2312.16290 (2023)

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Electronic reconstruction and anomalous Hall effect in $LaAlO_3/SrRuO_3$ heterostructures

Merit Spring

JMU Würzburg

4d and 5d transition metal oxides are a promising class of materials for topological phases in the context of electron correlations. Recently, the ferromagnetic metal $SrRuO_3$ (SRO) grown on a $SrTiO_3$ (STO) (001) substrate has been reported to exhibit electronic reconstruction induced interfacial charge pinning accompanied by a topological transition of its electronic bands when capped with a $LaAlO_3$ (LAO) layer [1]. LAO is a polar oxide and the electronic reconstruction in a heterosystem of LAO/STO caused by the polar discontinuity at the interface is well known. For the LAO/SRO system a similar behavior is expected, and charge is thought to be accumulated at the very interface giving rise to strong inversion-symmetry breaking and hence change in the momentum-space topology [1]. By means of transport and photoemission experiments we find strong evidence for these statements. On one hand we show that the LAO capping drives the SRO, which turns insulating below 8 uc without capping, (deeper) into the metallic regime. Furthermore, we show not only the observation of signatures of an anomalous Hall effect (AHE) in 6uc SRO films capped with LAO, but also an inversion of the sign of the AHE, when the 6uc SRO is replaced by metallic 10uc of SRO indicating a topological phase transition. Moreover, we correlate these findings with hard and soft x-ray photoemission spectroscopy data, that show changes in the ruthenium electronic states, that can be explained in terms of correlated electrons.

[1] T. C. van Thiel et al., Phys. Rev. Lett. **127**, 127202 (2021)

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Fractonic spin liquids

Rafael Flores Calderon
MPI PKS Dresden

Classical spin liquids (CSLs) have proved to be a fruitful setting for the emergence of exotic gauge theories. Vacancy clusters in CSLs can introduce gauge charges into the system, and the resulting behavior in turn reveals the nature of the underlying theory. We study these effects for a series of CSLs on the honeycomb lattice. We find that dilution leads to the emergence of effective free spins with tuneable, and generally irrational, size. For a specific higher-rank CSL, described by a symmetric tensor gauge field, dilution produces non-decaying spin textures with a characteristic quadrupolar angular structure, and infinite-ranged interactions between dilution clusters.

A classical spin-liquid with emergent fractionalized bionic charges and chiral field excitations

Daniel Lozano-Gomez
TU Dresden

Classical spin-liquid phases are often described by emergent low-temperature gauge symmetries with fractionalized excitations and a system-size-dependent degeneracy of the ground-state manifold. In this work, we present a Hamiltonian composed of a chiral three-body spin term that realizes a novel chiral classical spin liquid phase in the pyrochlore lattice. We show that the ground state manifold of this novel spin liquid is described by a subspace of the so-called color-ice-state manifold using both a set of analytical and numerical techniques. We then demonstrate that the ground state manifold is associated with an emergent gauge field theory which possesses a divergence-free constraint on the gauge fields and an additional chiral term that constrains the total flux of the fields through a single tetrahedron. The divergence-free constraint on these gauge fields results in the observation of twofold pinch points in the reciprocal space spin correlation and the identification of bionic charges as the elementary excitations of the system. We then discuss how the mobility of these elementary charges is restricted by the additional chiral term, which in turn suggests that these charges are fractons.

Daring to Face the Unknown: Diversity, Dignity, and Hidden Bias

Inna Zeitler
Wissen Haltung Wandel

In this interactive talk we will take some courage and deep dive down the rabbit hole of unconscious bias, diverse social identities, and intersectionality. We will deal with mixed stereotypes, fearful penguins, biased seagulls, and the fabulous functionality of our brains. After a few thought experiments and some fun with Chat GPT we will explore the unconscious processes that shape our perceptions. On the basis of the concept of intersectionality, we will discuss different social identities and the ways in which we experience power, privilege and oppression in society in intersecting ways. After dinner we will pick some power flowers and face bias in physics. You will leave this talk with an idea of how to be an ally and contribute to a more inclusive and affirming environment where people can feel valued, supported, and empowered to thrive despite their social identities.

Competing phases and topological superconductivity on the triangular lattice

Stephan Rachel
University of Melbourne

Tin and lead adatoms on semiconductor substrates with a one-third monolayer coverage form a two-dimensional triangular lattice with an unpaired electron per site. Some of these materials are known to exhibit charge or magnetic order, and upon doping, even superconductivity was reported recently. Motivated by these experiments, we investigate the triangular-lattice Rashba Hubbard model as a test case. We find both magnetic and superconducting instabilities. The latter features singlet-triplet mixing and an unexpected variety of topological superconductivity.

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Evidence of Superconducting Fermi Arcs

Andrii Kuibarov
IFW Dresden

Numerous clever ideas have been proposed to generate Majorana fermions. As bulk topological superconductors remain elusive, the most promising approaches exploit proximity-induced superconductivity making systems fragile and difficult to realize. Materials with inherent topological properties, such as Weyl semimetals are also a potential candidates. Historically, the pursuit of Majorana fermions has focused on bulk superconductivity, overlooking the possibility of intrinsic superconductivity within Fermi surface arcs.

Here, by utilizing angle-resolved photoemission spectroscopy and ab initio calculations, we have identified topological Fermi arcs on two opposing surfaces of the non-centrosymmetric Weyl material, trigonal $PtBi_2$. We demonstrate that Fermi arc states on both surfaces become superconducting at temperatures around 10 K. Remarkably, the corresponding coherence peaks manifest as the strongest and sharpest excitations ever detected by photoemission from solids, underscoring their potential technological relevance. Our findings indicate that superconductivity in $PtBi_2$ can occur exclusively at the surface, rendering it a possible platform to host Majorana modes.

Entanglement in interacting Majorana chains and transitions of von Neumann algebras

Pablo Basteiro
JMUWürzburg

Analytical insights into interacting quantum many-body systems are hard to come by. A particularly difficult aspect to study is the precise characterization of the phase diagram of a system based on its entanglement properties. Recently, a version of this problem has been tackled in the context of holography via a novel take on an old paradigm, namely the theory of von Neumann algebras. Different types of algebras are known to encode distinct entanglement properties, and identifying their occurrence provides new perspectives into the different phases of a system. In this talk, I introduce a model of Majorana fermions with two-site interactions consisting of a general function of the fermion bilinear. The models are exactly solvable in the limit of a large number of on-site fermions. In particular, I study a four-site chain, which exhibits a quantum phase transition controlled by the hopping parameters and manifests itself in a discontinuous entanglement entropy. Based on these results, I identify transitions between types of von Neumann operator algebras throughout the phase diagram. In the strongly interacting limit, this transition occurs in correspondence with the quantum phase transition. This study provides a novel application of the theory of von Neumann algebras in the context of quantum many-body systems.

Majorana-mediated thermoelectric transport in multiterminal junctions

Daniel Gresta
JMU Würzburg

The unambiguous identification of Majorana zero modes (MZMs) is one of the most outstanding problems of condensed matter physics. Thermal transport provides a detection tool that is sensitive to these chargeless quasiparticles. We study thermoelectric transport between metallic leads transverse to a Josephson junction. The central double quantum dot hosts conventional or topological Andreev states that depend on the phase difference ϕ. We show that the presence of MZMs can be identified by a significant amplification of both the electrical and thermal conductance at $\phi \simeq \pi$ as well as the Seebeck coefficient at $\phi \simeq 0$. We further investigate the robustness of our results against Cooper pair splitting processes.

Evidence for a broken time reversal symmetry Charge Density Wave state in RbV_3Sb_5

Vidya Madhavan
University of Illinois Urbana-Champaign

In this talk I will first give a broad overview of my experimental program and then focus on a recent pulsed laser STM study of the Kagome superconductors. The recently discovered family of kagome superconductors AV_3Sb_5 (A = K, Rb, or Cs), host an exotic charge-density wave (CDW) state which is a strong candidate for orbital magnetism or loop current phase which spontaneously breaks time reversal symmetry. This idea however is being intensely debated due to conflicting experimental data. In this talk I will describe our laser-coupled scanning tunneling microscopy (STM) studies of RbV_3Sb_5. In the absence of any external stimulation, we find that the intensities of the three CDW Fourier peaks are different, indicating that the CDW breaks rotational and mirror symmetries. By applying linearly polarized light along the CDW direction, we can switch the relative intensities of the CDW peaks. This implies a substantial electro-striction response, indicative of strong non-linear electron-phonon coupling. We observe a similar CDW intensity switching with perpendicular magnetic fields, which implies an unusual piezo-magnetic response that, in turn, requires time-reversal symmetry-breaking. We show that the simplest CDW that satisfies these constraints is an out-of-phase combination of bond charge order and loop currents that we dub congruent CDW flux phase. I will discuss how this order parameter reconciles previous seemingly contradictory experimental data. The newly set up laser-STM opens the door to the possibility of dynamic optical control of complex quantum phenomenon in correlated materials.

Emergent Coupling of Protected Edge States of 2D Topological Insulators in a Crystalline Multilayer Heterostructure with Ion Mobility

Michael Ruck
TU Dresden

Crystals of weak 3D topological insulators (TIs) of the $Bi_{14}Rh_3I_9$-type can be seen as nano-periodic multilayer heterostructures of 2D TIs spaced by topologically trivial insulators. The newest member, $Bi_{12}Rh_3Ag_6I_9$, contains silver iodide spacers that exhibit 2D cationic conductivity, which allows to electrochemically adjust the Fermi level. The gap of 286 meV, determined by angle-resolved photoemission spectroscopy, is the widest observed so far in a weak 3D TI. The experimental electronic structure shows good agreement with bulk band-structure calculations. The calculated invariants indicate the topological nature of the bandgap. Magnetoresistance measurements in macroscopic crystals reveal Landau quantization at low magnetic fields, which coincides with a drastic drop in resistivity across the layers. The observation of such an effect in a crystalline multilayer structure suggest, as theoretically predicted, the formation of a collective [1+1]-dimensional surface state arising from tunneling between the protected edge states of the numerous closely spaced 2D TI layers. The odd-symmetric characteristic of the magnetoresistance, which is reversible with the magnetic field, points to a chiral surface state. A chiral macroscopic system of some 10^5 coupled spin channels with only one protected spin orientation in a magnetic field appears promising for applications in spintronics and quantum computing.

Edge zeros and boundary spinons in topological Mott insulators

Niklas Wagner
JMU Würzburg

Recently, Green's function zeros and their relation to topology have attracted considerable interest [1-4]. Using slave-rotor calculations I will demonstrate a connection between gapless zeros and gapless spinons -- both in the bulk and at the boundary [5]. I will then apply these results to interfaces between topological insulators and topological Mott insulators, showing that the previously observed annihilation of edge zeros and egde poles can be interpreted using the spinon language. This approach reveals the occurrence of a spin-charge separation at the interface.

[1] A. Blason and M. Fabrizio, arxiv:2304.08180 (2023)
[2] J. Zhao et al., PRL **131**, 106601 (2023)
[3] C. Setty et al., arXiv:2309.14340 (2023)
[4] N. Wagner et al., Nat. Commun. **14**, 7531 (2023)
[5] N. Wagner et al., arXiv:2312.13226 (2023)

Continuous order-to-order quantum phase transition from fixed-point annihilation in Luttinger semimetals

David Moser
TU Dresden

Luttinger semimetals are three-dimensional strongly-spin-orbit-coupled systems, in which valence and conduction bands touch quadratically at the Fermi level. They provide a rich playground for unconventional physics and serve as a parent state to a number of exotic states of matter, such as Weyl semimetals, topological insulators, or spin ice. Here, we discuss various quantum critical phenomena beyond standard quantum criticality, including quasiuniversality and fixed point annihilation scenarios. Our results are relevant for the low-temperature behavior of rare-earth pyrochlore iridates, such as $Pr_2Ir_2O_7$ or $Nd_2Ir_2O_7$.

Kagome metals by material design

Anja Wenger
JMU Würzburg

In this project, we theoretically identify and investigate a promising copper-based kagome metal candidate, yet to be experimentally realized. We endeavor to engineer a kagome metallic phase exhibiting the smallest possible multi-orbital character, thereby bridging the gap between theoretical modeling and experimental realizations. The ideal candidate is found in the $CsCu_3Cl_5$ compound. Our results were obtained employing both ab-initio calculations, in the framework given by density functional theory (DFT), as well as crystal field analysis. Remarkably, we generically obtain a mixed-type van Hove singularity in close proximity to the Fermi level. Our proposed material promises to exhibit exotic electronic features, opening new possibilities for exploring unprecedented quantum phenomena in kagome metals.

Exceptional points at x-ray wavelengths

Fabian Richter
JMU Würzburg

Non-Hermitian Hamiltonians allow for an effective description of dissipative systems. They exhibit a variety of exciting phenomena that cannot be observed in the Hermitian realm. Exceptional Points (EPs) are a prime example of this. At EPs not only the complex eigenvalues, but also the eigenvectors coalesce and sensitivity to perturbations is drastically enhanced. This concept has recently found fertile ground in optics and photonics where non-Hermitian eigenstates can be created and superposed through optical gain and loss [1]. So far, these concepts have been mostly discussed in the optical regime. Similar control of x-rays is desirable due to their superior penetration power, high focusability and detection efficiency. Here, we investigate theoretically non-Hermitian x-ray photonics in a thin-film cavity setup containing Mössbauer nuclei resonant to the x-ray radiation entering under grazing incidence. These cavities present loss that can be controlled via adjustment of the cavity geometry and the incidence angle of the x-rays [2]. Application of a magnetic hyper- fine field paves the way to tune the system towards EPs and to explore their rich topological properties.

[1] L. Feng et al., Nature Photon **11**, 752–762 (2017)
[2] X. Kong, D. Chang, A. Pálffy, Phys. Rev. A **102**, 033710 (2020)

Topological quantum optics in atomic emitter arrays

Jonathan Sturm
JMU Würzburg

Quantum emitter arrays are a powerful platform enabling tailored control of quantum optical phenomena, like super- and subradiance or efficient photon storage [1]. Since state-of-the-art experimental techniques allow the realization of almost arbitrary lattice structures, a natural question is what physical effects arise if the lattice has nontrivial topology. Here, we study a one-dimensional chain of quantum emitters implementing the Su-Schrieffer-Heeger model. Going beyond previous studies [2], we show how the presence or absence of topologically protected edge states depends on the orientation of the transition dipole moment with respect to the chain axis. Moreover, we discuss how this parameter can be used to implement a novel protocol for the geometrical pumping of light. Our results demonstrate the potential of atomic emitter arrays as a platform for topological quantum optics.

[1] M. Reitz et al., PRX Quantum **3**, 010201 (2022)
[2] B. X. Wang and C. Y. Zhao, Phys. Rev. A **98**, 023808 (2018)

Quantum emitters in SiC

Andreas Sperlich
JMU Würzburg

We present the very first demonstration of a maser utilizing silicon vacancies (VSi) within 4H silicon carbide (SiC). Leveraging an innovative feedback-loop technique, we elevate the resonator's quality factor, enabling maser operation even above room temperature. The SiC maser's broad linewidth showcases its potential as an exceptional preamplifier, displaying measured gain surpassing 10dB and simulations indicating potential amplification exceeding 30dB. By exploiting the relatively small zero-field splitting (ZFS) of VSi in SiC, the amplifier can be switched into an optically-pumped microwave photon absorber, reducing the resonator's mode temperature by 35 K below operating conditions. This breakthrough holds promise for quantum computing advancements and fundamental studies in cavity quantum electrodynamics. Our findings highlight SiC's transformative potential in revolutionizing contemporary microwave technologies.

Immortalized light-matter hybrid states via coherent perfect absorption?

Bert Hecht
JMU Würzburg

Coherent perfect absorption (CPA) is the time-reversed process of lasing at threshold [1]. In a CPA-system a coherent light field is used to pump a resonant system that exhibits losses. At the CPA condition, the light field delivers just the right amount of energy to the system to compensate the losses without any reflection. The absence of reflection means that the pumped system is effectively decoupled from the pump. Here we investigate the idea of whether it is possible to compensate the losses of a mixed light-matter quantum state and thereby keep it alive for an infinite amount of time, i.e. immortalizing it [2]. This cannot be achieved simply by pumping the state because that would cause the state vector to move on the Bloch sphere. Immortalized mixed light-matter states may also be achieved in systems with topological protection, such as SSH-like structures thereby opening the road to comparative investigations of the long-term stability of topologically protected and unprotected systems.

[1] Y.D. Chong et al., Phys. Rev. Lett. **105**, 053901 (2010)
[2] Room Temperature Quantum Coherent Perfect Absorption, Y. Lai, D. D. A. Clarke, P. Grimm, A. Devi, D. Wigger, T. Helbig, T. Hofmann, R. Thomale, J.-S. Huang, B. Hecht, and O. Hess, **in review**

Towards path-entangled photons in a topological photonic waveguide lattice

Moritz Meinecke
JMU Würzburg

The recent emergence of topological photonics has opened a wide field for exploring the robustness of topologically protected transport in optical devices and condensed matter. Until recently and in contrast to electronic systems, however, there had been no notion on how topological photonic systems would be able to 'topologically protect' photonic quantum information such as path entanglement and whether a topological protection of quantum information exists at all.

A theoretical proposal from 2016 predicted that path-entangled photonic states can be topologically protected in quantum photonic Floquet waveguide lattices despite the presence of disorder. In this talk, we propose to test this hypothesis by building tailor-made deterministic sources of true bi-photonic path-entangled input states (so-called N00N states) based on semiconductor quantum dots, which are guided through a photonic topological insulator, implemented as helical honeycomb photonic lattices. We present the recent progress on our approach and discuss the challenges along the road.

Room temperature exciton-polariton lasing and photonic lattices with perylene bisimides - Towards topological laser with organic emitters

Dominik Horneber
JMU Würzburg

Perylene bisimides (PBIs) are organic dyes with photoluminescence quantum yields (PLQY) close to unity and excellent thermal and photo-chemical stability. These features make them a promising candidate for polariton lasing at room temperature. While polariton condensation is well understood in conventional III-V semiconductor systems at cryogenic temperatures, the search for suitable emitter materials for robust and versatile room temperature applications is still ongoing. So far e.g. perovskites and several organic materials are found to show strong light-matter coupling and polariton lasing. Nevertheless, many of these materials lack long-term stability under ambient conditions and the tunability of their optical properties.

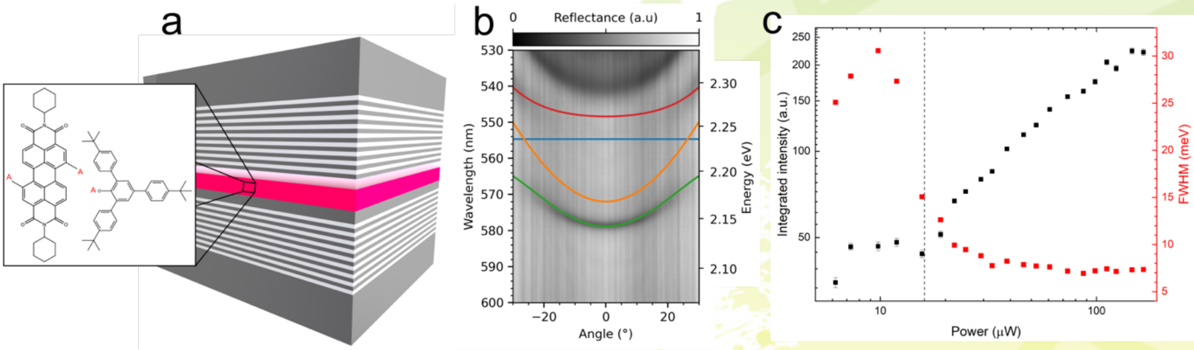

FIG. 1. a) PBI monomer based microcavity. b) Angle-resolved reflection measurement with coupled harmonic oscillator fit. c) Non-linear input-output characteristics and strong decrease of linewidth indicating lasing.

In this work, we fabricated optical microcavities with a neat emitter layer of a PBI monomer [1] that is shielded by voluminous bay-substituents o prevent aggregation induced PLQY-quenching (fig. 1a). We show strong light-matter coupling (fig. 1b) and exciton-polariton lasing (fig. 1c) at room temperature. In addition, photonic confinement in 0D resonators and linear chains is demonstrated, which leads to modes with dispersionless discretization in energy and the formation of a distinct band-structure, respectively. Due to the possibility of precisely controlling the aggregation properties of the PBI, our results pave the way for the study of polarization dependent light-matter coupling including topological effects with PBI J-aggregate resonator structures.

[1] M. Stolte et al., Chem. Mater. **32**, 62226236 (2020)

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Complexity and Topology in Quantum Matter

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Josephson Signatures of the Superconducting Higgs/Amplitude Mode

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The Higgs/amplitude collective mode in superconductors corresponds to oscillations of the amplitude of the order parameter. While its detection typically relies on optical techniques with an external electromagnetic field resonant with the Higgs mode, we present a purely transport-based setup wherein it is excited in a voltage biased Josephson junction. Demonstrating the importance of the order parameter dynamics, we find that in highly transparent junctions featuring single-band s-wave superconductors, the interplay of the Higgs resonance and the Josephson physics enhances the second harmonic Josephson current oscillating at twice the Josephson frequency. If the leads have unequal equilibrium superconducting gaps, this second harmonic component may even eclipse its usual first harmonic counterpart, thus furnishing a unique hallmark of the Higgs oscillations.

Complete zero-energy flat bands of surface states in fully gapped chiral noncentrosymmetric superconductors

Clara Johanna Lapp
TU Dresden

Noncentrosymmetric superconductors can support flat bands of zero-energy surface states in part of their surface Brillouin zone. This requires that they obey time-reversal symmetry and have a sufficiently strong triplet-to-singlet-pairing ratio to exhibit nodal lines in the bulk. These bands are protected by a winding number that relies on chiral symmetry, which is realized as the product of time-reversal and particle-hole symmetry. We reveal a way to stabilize a flat band in the entire surface Brillouin zone, while the bulk dispersion is fully gapped. The necessary ingredient is an additional spin-rotation symmetry that forces the direction of the spin-orbit-coupling vector not to depend on the momentum component normal to the surface. We define a winding number which leads to flat zero-energy surface bands. In addition, we consider how a weak breaking of the additional symmetry affects the surface band, employing first-order perturbation theory and a quasiclassical approximation.

Chiral Meissner effect in time-reversal invariant Weyl superconductors

Vira Shyta
IFW Dresden

Weyl semimetals have nodes in their electronic structure at which electrons attain a definite chirality. Due to the chiral anomaly, the non-conservation of charges with given chirality, the axion term appears in their effective electromagnetic action. We determine how this affects the properties of time-reversal invariant Weyl superconductors (SCs) in the London regime. For type II SCs the axion coupling generates magnetic B-fields transverse to vortices, which become unstable at a critical coupling so that a transition into type I SC ensues. In this regime an applied B-field not only decays inside the SC within the London penetration depth, but the axion coupling generates an additional perpendicular field. Consequently, when penetrating into the bulk the B-field starts to steadily rotate away from the applied field. At a critical coupling the screening of the magnetic field breaks down. The novel chiral superconducting state that emerges has a periodically divergent susceptibility that separates onsets of chiral Meissner regimes. The chiral anomaly thus leaves very crisp experimental signatures in structurally chiral Weyl SCs with an axion response.

Evidence for vertical line nodes in Sr_2RuO_4 from nonlocal electrodynamics

Javier Landaeta
TU Dresden

By determining the superconducting lower and upper critical fields $H_{c1}(T)$ and $H_{c2}(T)$, respectively, in a high-purity spherical Sr_2RuO_4 sample via ac-susceptibility measurements, we obtain the temperature dependence of the coherence length ξ and the penetration depth λ down to 0.04 T_c. Given the high sample quality, the observed T^2 dependence of λ at low temperatures cannot be explained in terms of impurity effects. Instead, we argue that the weak type-II superconductor Sr_2RuO_4 has to be treated in the non-local limit. In that limit, the penetration depth data agree with a gap structure having vertical line nodes, while horizontal line nodes cannot account for the observation.

Lack of near-sightedness principle in non-Hermitian systems

Viktor Könye
IFW Dresden

The non-Hermitian skin effect is a phenomenon in which an extensive number of states accumulates at the boundaries of a system. It has been associated with nontrivial topology, with nonzero bulk invariants predicting its appearance and its position in real space. Here we demonstrate that the non-Hermitian skin effect is not a topological phenomenon in general: when translation symmetry is broken by a single non-Hermitian impurity, skin modes are depleted at the boundary and accumulate at the impurity site, without changing any bulk invariant. This may occur even for a fully Hermitian bulk.

Observation of non-Hermitian topology in a multi-terminal quantum Hall device

Kyrylo Ochkan
IFW Dresden

One of the simplest examples of non-Hermitian topology is encountered in the Hatano-Nelson (HN) model, a one-dimensional chain where the hopping in one direction is larger than in the opposite direction. We present here the first experimental observation of non-Hermitian topology in a quantum condensed-matter system. The measurements are done in a multi-terminal quantum Hall device etched in a high mobility GaAs/AlGaAs two-dimensional electron gas ring. The conductance matrix that connects the currents flowing from the active contacts to the ground with the voltage of the active contacts is topologically equivalent to the HN Hamiltonian. In our device, we directly measure and evidence the non-Hermitian skin effect. We also compute for our experimental device two topological invariants that are found to be more robust than the Chern number. We finally use the unique properties of our system and continuously tune the system configuration between open and periodic boundary conditions.

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Poster Presentations

No	Title	Presenter
1	Chern number landscape of spin-orbit coupled chiral superconductors	Matthew Bunney University of Melbourne
2	Tuning strategy for Curie-temperature enhancement in the van der Waals magnet $Mn_{1+x}Sb_{2-x}Te_4$	Manaswini Sahoo IFW Dresden
3	Emergent non-Hermitian topology in transport response of Chern insulators	Raghav Chaturvedi IFW Dresden
4	Electric Conductivity in Non-Hermitian Holography	Zhaohui Chen JMU Würzburg
5	tba	Kristian Chung MPI PKS Dresden
6	Heterogeneous Ta-dichalcogenide bilayer: heavy fermions or doped Mott physics?	Lorenzo Crippa JMU Würzburg
7	Paradigm for finding d-electron heavy fermions: the case of Cr-doped $CsFe_2As_2$	Matteo Crispino JMU Würzburg
8	Krylov Space Probes of Non-Hermitian Dynamics: Measurement-Induced Phenomena and $\mathcal{PT}$-Symmetric Systems	Rathindra Nath Das JMU Würzburg
9	Higher Order Topological Insulators in Hybrid Dielectric-Semiconductor Microcavities	Johannes Düreth JMU Würzburg
10	On the valence of chalcogen spinels	Vinícius Estevo Silva Frehse JMU Würzburg
11	Fragility of local moments against hybridization with discrete energy levels	Max Fischer JMU Würzburg
12	Topological quantum criticality from multiplicative topological phases	Rafael Alvaro Flores Calderon MPI PKS Dresden
13	Spin vestigial orders and weak ferrimagnetism in $Na_2Co_2TeO_6$	Niccolò Francini TU Dresden
14	tba	Jochen Geck TU Dresden
15	Catalogue of C-paired Spin-Valley Locking in Antiferromagnetic System	Mengli Hu IFW Dresden
16	Spin dynamics in rouaite, $Cu_2(NO)_3(OD)_3$	Dmytro Inosov TU Dresden
17	Topology of SmB_6 by means of topological quantum chemistry	Mikel Iraola IFW Dresden
18	Gap Structure Evolution of Infinite-Layer Lanthanum Nickelates from Enhanced Correlations	Fabian Jakubczyk TU Dresden
19	Discrete JT gravity as an Ising model and its holographic dual	Jonathan Karl JMU Würzburg
20	Thermodynamic properties of the checkerboard model of altermagnet	Volodymyr Kravchuk IFW Dresden
21	Superconductivity in the type-I Weyl semi-metal trigonal-$PtBi_2$	Ankit Kumar IFW Dresden
22	Probing Spin-Dependent Ballistic Charge Transport at Single-Nanometer Length Scales	Markus Leisegang JMU Würzburg
23	Non-Abelian Hyperbolic Band Theory from Supercells	Patrick Lenggenhager MPI PKS Dresden
24	Magnetic enhancement of second-order non-Hermitian skin effect	Changan Li JMU Würzburg

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No	Title	Presenter
25	Dirac gap opening in Bi_2Se_3 by Dy doping	Himanshu Lohani JMU Würzburg
26	Black hole mirages: Tilt-tronics and electron lensing in Weyl semimetals	Tobias Meng TU Dresden
27	Entanglement and Symmetries in Conformal Field Theories and Holography	René Meyer JMU Würzburg
28	Holographic Mott insulators: Duality between zeroes and poles	Amelie Mierau JMU Würzburg
29	Quasiuniversality from all-in-all-out Weyl quantum criticality in pyrochlore iridates	David Moser TU Dresden
30	Investigating skyrmionic behavior in $Mn_{1+x}Sb_{2-x}Te_4$	Louis Müller JMU Würzburg
31	Stability of Weyl node merging processes under symmetry constraints	Gabriele Naselli IFW Dresden
32	Resolving the interference of Yu-Shiba-Rusinov states a with double functionalized STM probe	Artem Odobesko JMU Würzburg
33	Linear- and circular dichroism ARPES on the charge density wave material $TiSe_2$	Hibiki Orio JMU Würzburg
34	Hydrodynamic transport of charged Dirac electrons in two dimensions: The role of dynamical screening and plasmons	Kitinan Pongsangangan TU Dresden
35	Signatures of spinon dynamics and phase structure in dipolar-octupolar quantum spin ices in two-dimensional coherent spectroscopy	Mark Potts MPI PKS Dresden
36	Entanglement and information dynamics in generalized dual-unitary circuits	Michael Rampp MPI PKS Dresden
37	Numerical analysis of electronic transport in finite-sized graphene sheets and its dependence on the boundary conditions	Adrien Reingruber JMU Würzburg
38	Symmetry-Resolved Entanglement and Boundary Conformal Field Theory	Henri Scheppach JMU Würzburg
39	HoPtSn: distorted kagome magnet	Avdhesh Kumar Sharma MPI CPfS Dresden
40	Floquet Engineering in Topolectric circuits	Riccardo Sorbello JMU Würzburg
41	Formation of Exceptional Points in Pseudo-Hermitian Systems	Grigorii Starkov JMU Würzburg
42	Conductance oscillations of antiferromagnetic layer tunnel junctions	Haipeng Sun JMU Würzburg
43	Tuning the magnetic properties of V-doped $(Bi,Sb)_2Te_3$ topological insulators	Abdul-Vakhab Tcakaev JMU Würzburg
44	THz Nonlinear effects in topological HgTe	Tatiana Aureliia Uaman Svetikova HZDR Dresden
45	Measuring information flows in neural networks	Yanick Thurn JMU Würzburg
46	Surface superconductivity on time-reversal symmetric Weyl systems: a self-consistent approach	Mattia Trama IFW Dresden
47	Advanced Photoemission Spectroscopy on Quantum Materials	Muthu Masilamani JMU Würzburg
48	Spin frustrated system constructed from adatoms on top of monolayer hBN	Maksim Ulybyshev JMU Würzburg

No	Title	Presenter
49	Advanced Photoemission Spectroscopy on Quantum Materials	Max Ünzelmann JMU Würzburg
50	Theoretical modeling of pump-probe dynamics in charge-density-wave systems	Manuel Weber TU Dresden
51	Thermalization of the SYK model and BH: entanglement and operator size	Zhuo-Yu Xian JMU Würzburg
52	**ct.**qmat Collaborative Research Data Infrastructure	Jonas Schwab JMU Würzburg
53	Keep in touch (kit)	Natalie Nikolaus JMU Würzburg