ct.qmat Complexity and Topology in Quantum Matter

Julius-Maximilians-UNIVERSITÄT WÜRZBURG

TECHNISCHE UNIVERSITÄT DRESDEN

Third Spring School "Topological Quantum Matter"

02 APR – 04 Apr 2025

WEDNESDAY, April 02

	Arrival	
12:00–13:30	**Lunch**	
13:30–14:00	**Welcome**	***Prof. Matthias Bode***
14:00–15:30	**Non-Hermitian Topology with Photonic Crystals**	***Hai Son Nguyen*** Institut des Nanotechnologies de Lyon
15:30–16:00	**Coffee Break**	
16:00–17:30	**Topological photonics in 3D micro-printed model systems and beyond**	***Christina Jörg*** RPTU Kaiserslautern-Landau
17:30–19:00	**Electron-phonon coupling, charge density waves and quantum geometry in driven quantum materials**	***Tim Wehling*** University of Hamburg
19:00–20:30	**Dinner**	
20:30	**Poster Session**	

THURSDAY, April 03

07:00–08:30	**Breakfast**	
08:30–10:00	**Quantum transport in classical systems: Weak localization phenomenon**	***Leonid Golub*** THz-Center University of Regensburg (TerZ)
10:00–10:30	**Coffee Break**	
10:30–12:00	**Classifying and detecting gapped topological phases of quantum matter**	***Titus Neupert*** University of Zürich
12:00–13:30	**Lunch**	
13:30–15:00	**Effects of Proximity of Topological Insulators to Magnetic Insulators**	***Dhavala Suri*** Indian Institute of Science
15:00–15:30	**Coffee Break**	
15:30–17:00	**New opportunities on the studies of quantum matter under extreme conditions at the ESRF-EBS**	***Gaston Garbarino*** ESRF, Grenoble
17:00–18:00	Free time	

18:00	Walk to Planetarium (18:30), followed by Conference Dinner at Restaurant Bauersfeld (19:30)	

FRIDAY, April 04

07:00–08:30	Breakfast	
08:30–10:00	**Topological exciton-polaritons with halide perovskites**	***Wei Bao*** Rensselaer Polytechnic Institute, USA
10:00–10:30	Coffee Break	
10:30–12:00	**Solving 2D quantum matter with neural quantum states**	***Marcus Heyl*** University of Augsburg
12:00–13:30	Lunch	
13:30–14:00	Closing remarks	
14:00	Departure	

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Lectures

Non-Hermitian Topology with Photonic Crystals

Hai Son Nguyen

University Lyon, Ecole Centrale de Lyon, CNRS, and (IUF), France

Topological photonics has emerged as a powerful framework to engineer robust light-matter interactions, offering unprecedented control over optical properties. In this presentation, I will explore how radiative losses in photonic crystal platforms can be strategically harnessed to emulate non-Hermitian Hamiltonians and realize diverse types of topological singularities. Crucially, the photonic and radiative characteristics of these singularities establish a profound connection between topological protection and far-field radiation properties, such as polarization and quality factor. To illustrate these concepts, I will present experimental demonstrations of non-Hermitian band inversion, the hybridization of non-Hermitian topological interfaces, and exceptional points embedded in bulk Fermi ribbons. For applications, I will also demonstrate how radiation singularities can be engineered to enable new types of lasing emissions, such as vortex beams at arbitrary angles, and single-particle trapping.

Topological photonics in 3D micro-printed model systems and beyond

Christina Jörg

University of Kaiserslautern-Landau, Germany

Topological insulators are a new class of materials that behave as insulators in their bulk, but conduct current along their edges without back-scattering, even in the presence of disorder and defects. More recently, it was shown that such states are not unique to electronic systems, but rather can be observed in the photonic domain as well. In photonics, such protected states promise ways for robust transport of light with potential applications in optical communication and integrated photonic devices. Photonic systems—such as optical lattices and photonic waveguide arrays— also provide versatile platforms for studying topological effects in a controlled setting. Due to their mathematical equivalence to electronic systems, they serve as model systems for exploring condensed matter phenomena and extending topological concepts beyond electronic materials.

I will introduce 3D micro-printing as a tool to research topological photonics in waveguide arrays and photonic crystals. 3D micro-printing uses multi-photon polymerization to create three-dimensional structures on the micrometer scale. Due to its high flexibility, this fabrication method allows for the potential integration of additional components, such as nonlinear materials and quantum emitters. As a result, these systems not only function as quantum simulators for fundamental research but also offer opportunities to translate topological effects into photonic applications.

I will provide an overview of our recent work, which includes the use of structured light for quantum simulations to investigate e.g. the role of spin-orbit coupling in the spin-Hall effect. Additionally, we study implementing interactions in photonic systems by employing Kerr nonlinearity to mimic mean-field interactions. I will also talk about exploring higher-dimensional systems through synthetic dimensions, such as Weyl points in photonic crystals.

Electron-phonon coupling, charge density waves and quantum geometry in driven quantum materials

Tim Wehling

Hamburg University, Germany

The intricate coupling between electronic and nuclear degrees of freedom underpins many emergent phenomena in condensed matter systems. In this talk, we discuss the dynamics of nuclear motion and quantum geometric effects in electron-nuclear coupling, illustrated through examples from charge density waves (CDWs) and driven quantum materials. First, we demonstrate how nuclear quantum and thermal fluctuations influence CDW physics in two-dimensional materials. Second, we explore how the driving of circular phonons can generate giant pseudomagnetic fields. We describe a coupling mechanism between electronic and nuclear angular momenta rooted in electron-nuclear quantum geometry. Using SrTiO3 as a prototype, we show how this coupling induces transient orbital splittings through circularly driven phonon modes, paving the way for novel approaches to dynamically controlled magnetism. These insights are enabled by an ab initio electron-lattice downfolding scheme, which enhances the efficiency of simulations of electronic properties, nuclear motion, and their interplay by several orders of magnitude

Quantum transport in classical systems: Weak localization phenomenon

Leonid Golub

University of Regensburg, Germany

Weak localization (WL) is a quantum transport phenomenon that occurs due to the interference of electronic de Broglie waves. WL is observed in metals and semiconductors as a correction to the conductivity, which anomalously depends on temperature and magnetic field. This interference can be partially disrupted by various factors such as inter-electron scattering, spin relaxation, or inter-valley scattering and valley-dependent splittings in multi-valley systems. I will review the calculation of the WL conductivity correction and apply the formalism to the problem of WL in spin-orbit coupled graphene.

Classifying and detecting gapped topological phases of quantum matter

Titus Mangham-Neupert
Zürich University, Switzerland

In this lecture, we will discuss the different definitions and schemes for classification of topological phases of matter. The purpose is to back up the widely used diverse terminology and lingo surrounding topology with clear physical concepts based on entanglement characteristics. This will cover both interacting and noninteracting topological phases. We will further dive into the meanings of topological response function and topological invariants.

Effects of Proximity of Topological Insulators to Magnetic Insulators

Dhavala Suri
Centre for Nano Science And Engineering (CENSE),
Indian Institute Of Science (IISC), india

Topological insulators are those materials with time reversal symmetry protected surface states that are conducting and insulating bulk states. The field has evolved past a couple of decades where synthesis of these materials using molecular beam epitaxy technique has unveiled a few milestones such as the observation of quantum spin Hall insulators, two dimensional electron gas, quantum Hall states in 3D topological insulators and quantum anomalous Hall effect. Another crucial experiment was the observation of proximity coupling with topological insulators. This talk will discuss the details of the experiments where topological insulators are subjected to magnetic fields along directions perpendicular and parallel to the plane and emphasize on the interface of magnetic insulators and topological insulators. Emergent states which are not accessible to conventional measurements techniques and challenges in this field will be discussed in detail.

New opportunities on the studies of quantum matter under extreme conditions at the ESRF-EBS

Gaston Garbarino
European Synchrotron Radiation Facility, France

In the last decades, we have witnessed an unprecedented surge in high-pressure research that has greatly improved our fundamental understanding of materials under high compression. The X-ray investigations of matter under extreme conditions has become one of the major activities at the ESRF and other 3rd generation synchrotron sources. The array of techniques includes X ray diffraction, Inelastic X-ray Scattering, Nuclear Inelastic Scattering, X ray absorption and emission spectroscopy, X ray magnetic circular dichroism, X-ray Compton scattering, X-ray magnetic scattering, among many others. As a direct consequence, many scientific breakthroughs have been achieved across fields ranging from fundamental physics to Earth and planetary sciences, chemistry and materials research, and extending into

biophysics/biochemistry including questions concerning life and biological function under extreme conditions. Since August 2020, the inauguration of new ESRF-EBS (extremely brilliant source) opened to the user community a new generation of synchrotron light sources with unprecedented characteristics. In particular, the crystallography beamlines dedicated to the studies of materials under extreme conditions (ID15B and ID27) benefit enormously of the beam focusing capabilities and the coherent fraction. Moreover, the reconstruction of these beamlines, with the strengthen of the user support on the High-pressure laboratory, allow to perform the most challenging structural studies under extreme pressure (P<2Mbar) and temperature (3K<T<6000K) conditions.
In this presentation, the status of the high pressure activity at the ESRF dedicated to the study of quantum material will be presented with a detailed overview of the possible X ray experiments available and a description of the on-site high pressure preparation dedicated laboratories.
We will also discuss the possibilities of collaborations and discussions on particular scientific problems.

Topological exciton-polaritons with halide perovskites

Wei Bao
Rensselaer Polytechnic Institute, USA

Strong coupling of the photon with semiconducting excitonic materials in the high-quality optical cavity can create new quasiparticles called exciton-polaritons and many exotic phenomena. Exciton-polariton experiments were mainly performed in quantum-well microcavities grown with molecular beam epitaxy (MBE), where liquid helium temperatures must be maintained to prevent exciton autoionization.

Recently, semiconducting lead halide perovskites with a composition of ABX3 (where A is commonly CH3NH3+ (MA+) or Cs+; B is Pb2+; X is Cl−, and Br−) have emerged as contenders to MBE-grown quantum wells like GaAs for polaritonic but at room temperature.

This talk will first highlight recent researchers' efforts on topological polariton. Then, I will introduce our approaches to obtain various large halide perovskite single crystals inside optical nanocavities. Due to the uniform confined environment, the solution growth approach shows uniformity, comparable to the MBE-grown GaAs quantum well, enabling submillimeter-large single crystals with superb excitonic quality. These crystals with Wannier-Mott excitons allowed us to demonstrate a polaritonic XY spin Hamiltonian as an example. Further, we will introduce our recent work using halide perovskite on topological valley Hall polariton condensation.

Solving 2D quantum matter with neural quantum states

Marcus Heyl
Augsburg University, Germany

Neural quantum states have emerged as a novel promising numerical method to solve the quantum many-body problem both in and out of equilibrium. In this talk I will highlight the recent progress in particular concerning correlated quantum matter in two spatial dimensions both for the equilibrium ground-state as well nonequilibrium real-time dynamics problem. For the calculations of ground states, I will introduce the minimum-step stochastic reconfiguration method that reduces the optimization complexity by orders of magnitude. I will show that with this method we can now accurately train on unprecedentedly deep neural quantum states with millions of parameters allowing us to obtain the lowest variational energies as compared to existing numerical results for frustrated quantum magnets. Further, I will highlight the recent results on solving the real-time dynamics of correlated quantum matter using neural quantum states, which has allowed us to verify for instance for the first time the quantum Kibble-Zurek mechanism for interacting quantum many-body systems in two spatial dimensions.

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Poster Contributions

#	Title	Presenter
1	A Single Crystal Study of the Kagome Magnets RMn6Sn6 (R = Er and Tm)	Ana Kurtanidze HZDR
2	Non-Hermitian Skin Effect in Quantum Emitter Chains	Pia Kress JMU Würzburg
3	Growth of altermagnetic MnTe thin films	Lena Hirnet JMU Würzburg
4	Moire Phases of an Epitaxial Honeycomb Monolayer AgTe/Ag(111)	Romana Ganser JMU Würzburg
5	From Condensed Matter to Holography: Complexity Dynamics of Rotating Strings via the XXX Spin Chain	Rathindra Nath Das JMU Würzburg
6	Encapsulated Macroscopic WS2 in open-cavity photonic lattices	Sander Scheel JMU Würzburg
7	Spectroscopic Study of the Interface between Organic Molecules and Platinum Tellurides	Lorenz Klein JMU Würzburg
8	Phase diagram of the J–Jd Heisenberg model on the maple leaf lattice: Neural networks and density matrix renormalization group	Jonas Beck JMU Würzburg
9	Meissner-Effect in Non-Hermitian Superconductors	Linus Aliani JMU Würzburg
10	Proposed STM Study on FeSe: Investigating the Superconducting Nature and Surface Properties	Soumya Datta JMU Würzburg
11	CDW transition in AV_3Sb_5 kagome metals	Stefan Enzner JMU Würzburg
12	Engineering Topological Laser in Organic Microcavities	Harman Jot Singh JMU Würzburg
13	Band geometry induced electro-optic effect and polarization rotation	Maneesh Kumar M IIT Kanpur
14	Suppression of Generation Recombination Noise in Topological Insulators	Kanav Sharma IISER Kolkata
15	Fabrication and Low-Temperature Transport investigation of 2D TI HgTe microstructures in disc and ring geometry	Torsten Umlauf JMU Würzburg
16	Exponential sensitivity of an open-link SSH chain for optical sensing	Jakob Lindenthal TU Dresden

A Single Crystal Study of the Kagome Magnets RMn_6Sn_6 (R = Er and Tm)

Ana Kurtanidze
HZDR

The kagome magnets RMn_6Sn_6 (R = Sc, Y, Gd-Lu) with a hexagonal structure (P6/mmm) attract attention due to a possible correlation between the observed topological electronic properties and various magnetic phases. We synthesized high-quality single crystals of RMn_6Sn_6 (R = Er and Tm) by a tin-flux method. We performed scanning electron microscopy, energy-dispersive x-ray spectroscopy, and wavelength-dispersive x-ray fluorescence measurements to characterize the phase purity of the samples, which showed a composition close to the nominal stoichiometric ratio. We observed approximately 0.25 at.% aluminum impurity, which originated from the alumina crucibles used. In addition to the chemical characterization, we will discuss the magnetic properties from our preliminary magnetization and ultrasound results under magnetic fields applied along the principal crystallographic axes.

Non-Hermitian Skin Effect in Quantum Emitter Chains

Pia Kress
JMU Würzburg

We theoretically investigate the emergence of the non-Hermitian skin effect (NHSE) in a one-dimensional chain of quantum emitters coupled to a waveguide. Mediated by the waveguide, the emitters interact via non-reciprocal long-range couplings, rendering the system a generalized Hatano-Nelson model. We explore the topology of this non-Hermitian system by analyzing the winding number as a topological invariant in the complex energy spectrum. Beyond a critical asymmetry, multiple spectral loops are formed, yielding a nonzero winding number. Furthermore, we study the relation of the spectral winding number to the emergence of the NHSE in presence of long-range couplings.

Growth of altermagnetic MnTe thin films

Lena Hirnet
JMU Würzburg

Recently, altermagnets have attracted great attention combining antiferromagnetic spin alignment in real space with a momentum-dependent spin polarization of the electronic states in the band structure. One of the proposed altermagnet workhorse materials is MnTe [1,2]. Here, we investigate the epitaxial growth of MnTe on different substrates ranging from trivial band insulators to topological van der Waals metals with spin-momentum-locked surface states. The atomic and electronic structure of these films is studied employing low-energy electron and x-ray diffraction as well as soft x-ray angle-resolved photoemission spectroscopy, respectively.

References:

1. L. Šmejkal et al., Phys. Rev. X 12, 031042 (2022)

2. J. Krempaský et al., Nature 626, 517-522 (2024)

Moire Phases of an Epitaxial Honeycomb Monolayer AgTe/Ag(111)

Romana Ganser
JMU Würzburg

We present angle-resolved photoemission spectroscopy (ARPES) measurements on tunable one-dimensional moiré phases of an epitaxial honeycomb monolayer AgTe/Ag(111) [1]. In this model system, the moiré structure can be tuned almost continuously, in contrast to the hardly controllable twist angles in bilayer van-der-Waals heterostructures [2]. We experimentally observe moiré minibands and band gaps of up to 170 meV, suggesting sizable superlattice potentials. By comparing the experimental data to simple model calculations, we analyze the local character of the potential. This provides important information on interface hybridization effects on the band structure, which may not be limited to the system at hand but rather a broad range of moiré interfaces.

References:

1. Ünzelmann, M. et al. PRL, 124, 176401 (2020).
2. Lisi, S. et al. Nat. Phys, 17, 189-193 (2021).

From Condensed Matter to Holography: Complexity Dynamics of Rotating Strings via the XXX Spin Chain

Rathindra Nath Das
JMU Würzburg

State complexity in the Krylov subspace, known as the spread complexity, is a quantum information-theoretic measure of operator and state growth that has emerged as a powerful tool for analyzing quantum many-body dynamics. In this work, we extend the spread complexity beyond bosonic systems to fermionic and supersymmetric settings, enabling its application in holography and the AdS/CFT correspondence. We compute the spread complexity of large-charge semiclassical string states propagating in $AdS_5 \times S^5$, utilizing the integrable XXX spin chain—a fundamental model in condensed matter physics—to construct the Krylov basis. By employing coherent states and spin chain techniques, we describe the evolution of complexity as a Krylov path in a higher-dimensional lattice, effectively capturing the geometry governing the string's propagation. This work establishes a direct connection between quantum information, condensed matter physics, and holography, demonstrating how spread complexity, applied to the XXX spin chain and coherent states, reveals new insights into semiclassical string dynamics and emergent dynamical symmetries in Krylov space.

Encapsulated Macroscopic WS_2 in open-cavity photonic lattices

Sander Scheel
JMU Würzburg

Transition metal dichalcogenide (TMDC) monolayers are promising candidates for optoelectronic applications, but so far, their high optical quality is typically limited to micrometer-sized flakes, requiring labor-intensive production methods. Large-area TMDC films, however, are often affected by surface defects and optical inhomogeneities due to the lack of effective passivation.

In this work, an alternative encapsulation technique using 1-dodecanol is investigated to passivate gold tape-aided exfoliated WS_2 monolayers, ensuring uniform high optical quality over lateral scales exceeding 0.5 x 0.5 mm^2. These samples are compared in an open optical microcavity system to the well-known hBN-encapsulated WS_2 monolayers obtained by scotch-tape exfoliation. After establishing the high optical quality of the 1-dodecanol encapsulated monolayer, we were able to conduct investigations involving extended photonic lattices that were previously restricted by the limited material size. The results indicate that 1-dodecanol encapsulation preserves excitonic properties and enables scalable integration with photonic architectures, representing an important step towards large-area experiments on (strong) light-matter coupling and next-generation optoelectronic devices.

Spectroscopic Study of the Interface between Organic Molecules and Platinum Tellurides

Lorenz Klein

JMU Würzburg

Van der Waals heterostructures of organic molecules and transitionmetal chalcogenides (TMCs) represent excellent model systems for thestudy of weak molecule-substrate interactions.Here, we use two phases of metallic platinum telluride, which bothhost spin-polarized surface states in their electronic surface band structures.Using those as substrates, we deposit copper phthalocyanine(CuPc) and study the resulting atomic and electronic interface structureby means of x-ray (XPS) and angle-resolved photoemission spectroscopy(ARPES) as well as low-energy electron diffraction (LEED).On that basis, we discuss the differences in surface ordering, workfunction, and the binding energies of the observed molecular features.

Phase diagram of the J–Jd Heisenberg model on the maple leaf lattice: Neural networks and density matrix renormalization group

Jonas Beck

JMU Würzburg

We microscopically analyze the nearest-neighbor Heisenberg model on the maple leaf lattice through neural quantum state (NQS) and infinite density matrix renormalization group (iDMRG) methods. Embarking to parameter regimes beyond the exact dimer singlet ground state with a dimer bond spin exchange coupling Jd varied against the exchange strength J of all other bonds, the iDMRG (NQS) method finds a dimer state paramagnetic phase for Jd/J>1.464 (Jd/J>1.39) and a canted 120∘ magnetic order for Jd/J<1.419 (Jd/J<1.23). Assessing training convergence inaccuracies of the NQS method and the influence of finite cylindric circumference in the iDMRG method, we discuss the possible existence of an intermediate phase between the magnet and the dimer paramagnet.

Meissner-Effect in Non-Hermitian Superconductors

Linus Aliani

JMU Würzburg

The Meissner effect in non-hermitian BCS superconductors is theoretically studied. It is shown how the variation of the parameters (temperature and chemical potential and the value of the mean-field) leads to a paramagnetic or diamagnetic Meissner effect.

Proposed STM Study on FeSe: Investigating the Superconducting Nature and Surface Properties

Soumya Datta
JMU Würzburg

The study of iron selenide (FeSe), an unconventional superconductor, offers exciting opportunities to probe novel electronic states and investigate the interplay between superconductivity and topological surface phenomena. This research aims to utilize a state-of-the-art Low-Temperature Scanning Tunneling Microscope (LT-STM), which is currently being set up at the Surface Characterization Station at the Institute for Topological Insulators (ITI). FeSeâ€™s intriguing superconducting properties, including the possible presence of nematic order and the potential for topological superconductivity, provide an excellent platform for atomic-scale investigations. The primary goal of this work is to characterize the superconducting gap structure, quasiparticle interference (QPI), and any signatures of Majorana bound states at the surfaces and interfaces of FeSe. The investigation will be conducted on thin layers of FeSe on $SrTiO_3$, a system known for its enhanced superconductivity and potential for Majorana fermions. Using LT-STM, atomic-resolution imaging will allow for the direct observation of the gap anisotropy and topological surface states that may emerge in this material. This study will contribute to a deeper understanding of the electronic and topological properties of FeSe, with the ultimate aim of linking these findings to potential applications in quantum computing and topological quantum materials. Initial progress will focus on sample preparation and system installation, followed by data collection once the STM system is operational.

CDW transition in AV_3Sb_5 kagome metals

Stefan Enzner
JMU Würzburg

The origin of charge density wave (CDW) formation and the nature of structural transitions in $\mathbf{AV_3Sb_5}$ kagome metals remain highly debated. While van Hove singularity (VHS) nesting scenarios have been widely proposed as key drivers, our **ab-initio** calculations challenge this conventional view. We find that the electronic instabilities leading to the CDW originate deep within the Brillouin zone, away from high-symmetry points, suggesting a more intricate electron-phonon-driven mechanism. Furthermore, our Raman spectroscopy data, supported by density functional perturbation theory (DFPT) calculations, reveal a splitting of the $\mathbf{E_{2}g}$ phonon mode. This indicates a rotational symmetry breaking ($\mathbf{D_6h \rightarrow D_2h}$) accompanying the CDW transition, providing new insight into the structural evolution of these systems.

Engineering Topological Laser in Organic Microcavities

Harman Jot Singh
JMU Würzburg

In this work, we study the physics of exciton-polaritons in highly controllable and versa- tile potential landscapes. Exciton-polaritons are quasi-particles that emerge from the strong coupling of bound electron-hole pairs to light. This is achieved by modifying the electric field distribution in z-direction via distributed bragg reflectors (DBRs). Additional confinement in the x-y plane can be achieved by milling hemielliptical shaped potentials in the glass substrate of the upper DBR, this results in Laguerre-Gaussian eigenmodes. When potentials are arranged in a lattice structure analogous to atomic lattices, the resulting modes can overlap, forming polaritonic band structures. This phenomenon is similar to how bound, quantized electronic states in atoms overlap in solids to create electronic band structures, which are often described using the tight binding model.

A deformed honeycomb lattice, with stretched and compressed hexagonal unit cells is a realization of the topological crystalline insulator model and shows topologically protected edge states at their boundary [1]. These edge states have nonzero group velocity and are robust against small differences between resonators [2]. Topological insulator lasers are arrays of semi- conductor lasers that exploit fundamental features of topology to force all emitters to act as a single coherent laser [2]. The use of topological platforms enables mode locking of several emitters and lase as a single coherent laser due to the topological properties of the device [3], in the topological protected state. These protected states increases the output efficiency as well as provides platform for other applications requiring coherence,interference, imaging with coupled laser array systems. In this project we aim to show this topological laser array in organic (m- Cherry) based microcavities in topologically crystalline structure of honeycomb lattice. The technological control over the hoppings and eigenmode energies is important with respect to topological gap, which is governed by hemielliptical shape and overlap distance of confinement. In this project, we systematically study the variation of shape, size and depth of potentials in regard to the parameters of milling device (Focused ion beam parameters such as dwell time, passes) which affects the quantised energy levels of polaritonic states. The impact of over- lapping of potentials on the energy splitting of the fundamental mode and therefore coupling of adjacent lattice sites, is studied through series photoluminescence measurements. These measurements allow for precise tuning of the potential landscape, facilitating the formation of topological crystalline structures in organic materials.

References

1. Long-Hua Wu and Xiao Hu. “Scheme for Achieving a Topological Photonic Crystal by Using Dielectric Material”. In: Phys. Rev. Lett. 114 (22 2015).

2. Alex Dikopoltsev et al. “Topological insulator vertical-cavity laser array”. In: Science 373.6562 (2021).

3. Gal Harari et al. “Topological insulator laser: Theory”. In: Science 359.6381 (2018), eaar4003.

Band geometry induced electro-optic effect and polarization rotation

Maneesh Kumar M

IIT Kanpur

Electric field-induced modulation of the optical properties is crucial for amplitude and phase modulators used in photonic devices. Here, we present a comprehensive study of the band geometry induced electro-optic effect, specifically focusing on the Fermi surface and disorder-induced contributions. These contributions are crucial for metallic and semimetallic systems and for optical frequencies comparable to or smaller than the scattering rates. We highlight the importance of the quantum metric and metric connection in generating the phenomenon in parity-time reversal symmetric systems such as CuMnAs. Our findings establish the electro-optic effect as a tool to probe band geometric effects and open different avenues to design electrically controlled efficient amplitude and phase modulators for photonic applications.

Suppression of Generation Recombination Noise in Topological Insulators.

Kanav Sharma

IISER Kolkata

In this work we carry out low-frequency noise spectroscopy (1/f) of highly bulk insulating and disordered thin films of $(Bi_{0.3}Sb_{0.7})_2Te_3$(BST) topological insulator and compare these experimental results on these thin films with the In-doped $In_{0.14}(Bi_{0.3}Sb_{0.7})_{1.86}Te_3$(IBST) which has enhanced bulk insulating character. The thickness of these thin films are kept around 20nm and temperature-dependent resistance measurements show a highly bulk insulating character where the fermi level is located in the bulk band gap intersecting the Dirac cone only. The analysis of temperature-dependent power spectral density of the two thin films reveals a significant role of Indium (In) substitution in reducing the noise spectra caused by the generation-recombination mechanism in these ternary topological insulator thin films which is attributed to reduction of impurity defect density.

Fabrication and Low-Temperature Transport investigation of 2D TI HgTe microstructures in disc and ring geometry

Torsten Umlauf

JMU Würzburg

We investigate disc- and ring-shaped microstructures of HgTe-based quantum well heterostructures in electrical magneto transport experiments. To achieve this, advanced lithography techniques are employed to pattern the heterostructure layer stack using an isotropic wet chemical etching process. We plan to separately contact inner and outer edge channels of the ring structure using side contacts and an air bridge technology. Subsequently, low temperature transport measurements will be conducted to investigate the guantum spin Hall edge channels in our 4-terminal devices. On our poster we will present the initial findings of this research.

Exponential sensitivity of an open-link SSH chain for optical sensing

Jakob Lindenthal

TU Dresden

The advancement and miniaturization of sensing devices is an ongoing quest of applied research. The contribution showcases an optical fiber array that implements a non-Hermitian SSH model exhibiting exponential sensitivity to the strength of a weak coupling link in an open chain[1]. The model has been experimentally implemented in an electronic circuit for measuring high electrical resistances [2]. By harnessing the model for an optical platform, a pathway is opened for ultra-sensitive photonic measurements. The poster summarizes the current state of the theoretical concept, simulation and preliminary experimental results.

References:

1. Non-Hermitian Topological Sensors, J Budich, E Bergholtz, Phys. Rev. Lea. 125, 180403 (2020)

2. Non-Hermitian topological ohmmeter, V Könye, K Ochkan, A Chyzhykova, J C Budich, J van den Brink, I C Fulga, J Dufouleur, Phys. Rev. Applied 22, L031001, 2024.