SYQM 1: Complexity and Topology in Quantum Matter

Time: Friday 9:30–12:15 Location: H1

Invited Talk SYQM 1.1 Fri 9:30 H1

The role of crystalline symmetries in topological materials: the topological materials database — •Maia Vergniory — Max Planck for Chemical Physics of Solids, Nöthnitzer Str. 40, 01187 Dresden, Germany

Quantum materials are a collection of atoms with interacting electrons and nuclei displaying emergent behaviour and topological properties. The past two decades has witnessed an explosion in the field of topological materials: from weak interacting electrons to strongly correlated ones, topological materials represent one of the most exciting application for future technologies. High performance electronics, quantum information or ultrafast spintronics are just a few of the possible technologies that can be developed based on these materials. In this talk I will discuss the route to go from pure mathematical prediction of topological properties, through high through-put materials search to device fabrication. I will discuss both topological insulators, in non magnetic and magnetic phases as well as topological (chiral) semimetals using the the modern theory of topological band structure. Topological Quantum Chemistry built upon symmetry-based considerations and complemented with chemical theories of bonding, ionization, and covalence. Consequently, it describes the universal global properties of all possible band structures and materials. Beyond the single particle picture, I will present our formalism based on Green's functions aiming to discover topological correlated phases in materials displaying electronic entanglement.

Invited Talk SYQM 1.2 Fri 10:00 H1

Microwave Bulk and Edge Transport in HgTe-Based 2D Topological Insulators — •Erwann Bocquillon[1,2], Matthieu C. Dartiailh[1], Alexandre Gourmelon[1], Hiroshi Kamata[1], Kalle Bendias[3,4], Simon Hartinger[3,4], Jean-Marc Berroir[1], Gwendal Fève[1], Bernard Plaçais[1], Lukas Lunczer[3,4], Raimund Schlereth[3,4], Hartmut Buhmann[3,4], and Laurens Molenkamp[3,4] — [1]Laboratoire de Physique de l'École Normale Supérieure, ENS, PSL Research University, CNRS, Sorbonne Université, Université Paris-Cité, 24 rue Lhomond, 75005 Paris — [2]Physikalisches Institut 2, Universität zu Köln, D-50937 Köln — [3]Physikalisches Institut (EP3), Universität Würzburg, D-97074 Würzburg — [4]Institute for Topological Insulators, Universität Würzburg, D-97074 Würzburg

Research on the helical edge states of 2D topological insulators is motivated by exotic fundamental physics, robust topological quantum computation and novel spinorbitronics. In this talk, we report on the use of microwave methods to investigate dynamical transport in HgTe-based 2D topological insulators. More specifically, capacitance spectroscopy highlights the response of the edges which host very mobile carriers, while bulk carriers are drastically slowed down in the gap. Charge relaxation timescales are shorter on the edges, which suggests that edge states can be selectively addressed on timescales over which bulk carriers are frozen. Additionally, we also propose edge resonator geometries to characterize Coulomb interaction by via high-frequency measurements.

Invited Talk SYQM 1.3 Fri 10:30 H1

Spectral Sensitivity of Non-Hermitian Topological Systems — •Jan Carl Budich — Institute of Theoretical Physics, Technische Universität Dresden and Würzburg-Dresden Cluster of Excellence ct.qmat, 01062 Dresden, Germany

In a wide variety of physical scenarios ranging from classical metamaterials to correlated quantum many-body systems, non-Hermitian (NH) Hamiltonians have proven to be a powerful and conceptually simple tool for effectively describing dissipation. Motivated by recent experimental discoveries, investigating the topological properties of such NH systems has become a broad frontier of current research. In this talk, I will focus on a remarkable spectral sensitivity unique to NH topological systems. After an introductory discussion of the general theoretical background of this algebraic phenomenon, I will present several of its salient physical manifestations, including its impact on quasi-particles in correlated solids, and its potential for devising novel high-precision sensors.

15 min. break

Invited Talk SYQM 1.4 Fri 11:15 H1

Topological photonics and topological lasers with coupled vertical resonators — •Sebastian Klembt — Chair for Applied Physics and Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany.

Topological Photonics is an emerging and novel field of research, adapting concepts from condensed matter physics to photonic systems adding new degrees of freedom. After the first demonstations of topological photonic insulators, the field has moved on to study and exploit the inherent non-hermiticity of photonic systems and the interplay with their topological nature. In my talk I will discuss novel photonic lattice devices resulting from the coupling of individual vertical III-V semiconductor microresonators. So-called exciton-polaritons (hybrid states of light and matter) can emerge in the strong coupling regime. By chosing precise lattice geometries we are able to taylor optical band structures realizing novel photonic lattice. Here, the specific geometry as well as the hybrid light-matter nature allow for ways to break time-reversal symmetry and implement topologically non-trivial systems. Thus we were able to experimentally demonstrate the first exciton-polariton topological insulator, manifesting in chiral, topologically protected edge modes. In order to study topological effects in combination with optical non-linearities, topological lasers have been envisaged and realized. They exploit topological effects to efficiently couple and phase-lock extended arrays of lasers to behave as one single coherent laser. Here, I report on the first experimental demonstration of a topological insulator vertical cavity laser array.

Invited Talk SYQM 1.5 Fri 11:45 H1

Spectroscopic Studies of the Topological Magnon Band Structure in a Skyrmion Lattice — •Markus Garst — Karlsruhe Institute of Technology

When magnons propagate across a non-collinear magnetic texture, they collect a Berry phase that can be interpreted as the flux of a synthetic orbital magnetic field. The magnon thus experiences a synthetic Lorentz force that bends the quasi-classical trajectories of the magnons. For a magnetic skyrmion lattice, the average synthetic field is finite such that the magnons are confined to cyclotron orbits of the corresponding magnon Landau levels. This is reflected in a magnon band structure with finite Chern numbers. Here, we report on a series of spectroscopic studies of this band structure using various techniques that allow to probe different regimes in energy-momentum space: magnetic resonance spectroscopy [1], spin-wave spectroscopy [2], inelastic neutron scattering [3] and Brillouin light scattering [4,5]. These techniques have been applied to various cubic chiral magnets like MnSi, FeCoSi and Cu2OSeO3, that are well described by a universal effective continuum theory parametrized by a few parameters only. The combined data from all techniques are found to be in quantitative agreement with theory.

[1] R. Takagi et al. Phys. Rev. B 104, 144410 (2021). [2] S. Seki et al. Nat. Commun. 11, 256 (2020). [3] T. Weber et al. Science 375, 1025 (2022). [4] N. Ogawa et al. PNAS 118, e2022927118 (2021). [5] P. Che et al. unpublished.