TT 12: Topological Insulators 2 (joint session TT/HL)

Time: Monday 15:00–16:45 Location: HSZ 103

TT 12.1 Mon 15:00 HSZ 103

Simulating Floquet topological phases in static systems — •Selma Franca[1], Fabian Hassler[2], and Ion Cosma Fulga[1] — [1]IFW Dresden and Würzburg-Dresden Cluster of Excellence ct.qmat, Helmholtzstr. 20, 01069 Dresden, Germany — [2]JARA-Institute for Quantum Information, RWTH Aachen University, 52056 Aachen, Germany

We show that the transport properties of static, higher-order topological insulators (HOTIs) can be used to simulate the behavior of time-periodic (Floquet) topological insulators, without the need for external driving. We consider D-dimensional HOTIs with gapless corner states, which are weakly probed by means of a transport measurement. The unitary reflection matrix describing back-scattering from the HOTI boundary is topologically equivalent to a $(D-1)$-dimensional nontrivial Floquet operator. To characterize the topology of the resulting unitary, we introduce the concept of "nested" scattering matrices, showing that they correctly determine its topological invariants. Our results provide a route to engineer topological unitaries in the lab, using HOTIs and measurement techniques that have already been demonstrated in experiment. Unlike previous methods used to simulate Floquet systems, the resulting phase is expected to be robust against decoherence, since it occurs in the absence of any external driving field.

TT 12.2 Mon 15:15 HSZ 103

Boundary State Engineering and Topological Charge Pumps in non-Hermitian Floquet systems — •Bastian Höckendorf, Andreas Alvermann, and Holger Fehske — Institut für Physik, Universität Greifswald, Greifswald, Germany

In Hermitian topological systems, the bulk-boundary correspondence strictly constraints boundary transport to values determined by the topological properties of the bulk. We demonstrate that this constraint can be lifted in non-Hermitian Floquet insulators. Provided that the insulator supports an anomalous topological phase, non-Hermiticity allows us to modify the boundary states independently of the bulk, without sacrificing their topological nature. Non-Hermitian boundary state engineering specifically enables the enhancement of boundary transport relative to bulk motion, helical transport with a preferred direction, and chiral transport in the same direction on opposite boundaries [1]. Through dimensional reduction, the Floquet insulator reduces to a one-dimensional Floquet chain which possesses a topological phase with unidirectional transport. The topological signature of this phase are non-contractible loops in the spectrum of the Floquet propagator that are separated by an imaginary gap. We define the corresponding topological invariant as the winding number of the Floquet propagator relative to the imaginary gap and then establish that the charge transferred over one period equals the winding number. In fundamental difference to the situation for static or Hermitian chains, the chain acts as a topological charge pump [2].

[1] Phys. Rev. Lett. **123**, 190403 (2019)
[2] arXiv:1911.11413

TT 12.3 Mon 15:30 HSZ 103

Experimental evidence for spin-momentum locking in topological insulator nanoribbons — •Jonas Kölzer[1], Abdur Rehman Jalil[1], Daniel Rosenbach[1], Kristof Moors[1,2], Dennis Heffels[1], Peter Schüffelgen[1], Tobias W. Schmitt[1,3], Gregor Mussler[1], Thomas L. Schmidt[2], Detlev Grützmacher[1], Hans Lüth[1], and Thomas Schäpers[1] — [1]Peter Grünberg Institut, Forschungszentrum Jülich and JARA Jülich-Aachen Research Alliance, 52425 Jülich, Germany — [2]University of Luxembourg, Physics and Materials Science Research Unit,Avenue de la Faïencerie 162a, 1511 Luxembourg, Luxembourg — [3]JARA-FIT Institute Green IT, RWTH Aachen University, 52056 Aachen, Germany

Crosses and triple junctions of nanoribbons are at the center of most of the Majorana braiding schemes proposed, since a minimum of three leads is geometrically required for braiding. Topological insulators are a promising class of materials for realizing Majorana states when combined with a superconductor. Making use of these states in a braiding scheme would allow fault tolerant quantum computing. An experimental realization of a Bi_2Te_3 nanoribbon triple junction which is grown selectively using molecular beam epitaxy is presented. The magneto-transport characteristics of the topological insulator triple junctions at low temperatures are analyzed and compared to the theoretical prediction derived from tight binding transport simulations. The experimental data not only suggests the contribution of surface state transport, but it also provides evidence for spin-momentum locking in topological insulators.

TT 12.4 Mon 15:45 HSZ 103

Meta-magnetism of weakly-coupled antiferromagnetic topological insulators — •Aoyu Tan[1,3], Valentin Labracherie[1,3], Narayan Kunchur[1], Anja Wolter[1], Joseph Dufouleur[1], Bernd Buechner[1,2], Anna Isaeva[1,2], and Romain Giraud[1,3] — [1]Leibniz Institute for Solid State and Materials Research, IFW Dresden, 01069 Dresden, Germany — [2]Faculty of Physics, TU Dresden, 01062 Dresden, Germany — [3]Univ. Grenoble Alpes, CEA, CNRS, Spintec, 38000 Grenoble, France

The magnetic properties of van der Waals magnetic topological insulators $MnBi_2Te_4$ and $MnBi_4Te_7$ are investigated by magneto-transport measurements. We evidence that the relative strength of the inter-layer exchange coupling J to the uniaxial anisotropy K controls a transition from an A-type antiferromagnetic order to a ferromagnetic-like metamagnetic state. A bi-layer Stoner-Wohlfarth model allows us to describe this evolution, as well as the typical angular dependence of specific signatures, such as the spin-flop transition of the uniaxial antiferromagnet and the switching field of the metamagnet. In micron-size magnets, the single-domain switching-field astroid are however partly truncated by the nucleation of domain walls along the easy-axis direction.

TT 12.5 Mon 16:00 HSZ 103

Analytic continuation of Bloch states and the significance for universal boundary physics — Mikhail Pletyukhov[1], Dante Kennes[1], Jelena Klinovaja[2], Daniel Loss[2], and •Herbert Schoeller[1] — [1]RWTH Aachen University, Germany — [2]University of Basel, Switzerland

For generic tight-binding models in one dimension with non-degenerate bands we present an analytic continuation of Bloch states to complex quasimomentum [1], useful for an understanding of boundary physics in half-infinite systems. We show that the pole positions provide the oscillation frequency and localization length of edge states and the branching points define the corresponding quantities for the total density. Each edge state is shown to have a fingerprint in the bulk density which cancels exactly the edge state density. The remaining part of the density is shown to have a pre-exponential power-law with universal exponent -1/2. Introducing a phase variable which continuously shifts the boundary, we derive topological constraints for the edge modes and show that the pole positions oscillate around the branch cuts. We find that the phase dependence of the model parameters can always be chosen such that no edge mode crosses the chemical potential when shifting the boundary by one lattice site. This provides a rigorous proof for universal properties of the boundary charge found in Ref.[2].

[1] M. Pletyukhov et al., arXiv:1911.06886.
[2] M. Pletyukhov et al., arXiv:1911.06890.

TT 12.6 Mon 16:15 HSZ 103

Strong topology and Dirac semimetal phase in cubic half-Heusler under strain — •Sanjib Kumar Das[1], Jorge Facio[1], Ion Cosma Fulga[1], and Jeroen van den Brink[1,2] — [1]IFW Dresden, Helmholtzstrasse 20, 01069 Dresden — [2]Department of Physics, Technical University Dresden, 01062 Dresden, Germany

Theoretically, many half-Heusler compounds exhibit topological phases under strain. Depending on sign of the strain, they can host either a Dirac semimetal or a topological insulating phase. Strain along a suitable direction can split the quadratic band crossing of the bulk band structure, and hence open up a topological gap in these materials. By combining density functional theory(DFT) and tight-binding model calculations, we show that one such cubic half-Heusler material hosts strong topological and Dirac semimetallic phases under compressive or tensile strain, respectively. We hope that our work will motivate further experiments in this direction.

TT 12.7 Mon 16:30 HSZ 103

Fractional corner charges in a 2D super-lattice Bose-Hubbard model — •Julian Bibo[1,4], Izabella Lovas[1,4], Yizhi You[3], Fabian

Grusdt[1,2,4,5], and Frank Pollmann[1,4] — [1]Technische Universität München — [2]Ludwig-Maximilians-Universität München — [3]Princeton Center for Theoretical Science — [4]Munich Center for Quantum Science and Technology — [5]Department of Physics and Institute for Advanced Study, Technical University of Munich

Higher order topological insulators (HOTIs) represent a novel class of topological phases protected by a combination of spatial and internal symmetries. While many non-interacting system have been introduced and studied, it is unclear to which extend the results obtained in non-interacting systems transfer to their strongly-interacting counter parts. In our work, we introduce an experimentally accessible model, a 2D super-lattice Bose-Hubbard model on a square lattice at half-filling, that realizes a robust higher order topological phase protected by charge conservation and fourfold rotation symmetry. Excitingly, our model predicts the presence of symmetry protected fractional charges e/2 to occur at the corners. The presence and robustness of the predicted fractional corner charges is confirmed using the Density Renormalisation Group Ansatz (DMRG). Finally, we propose a way to measure the characteristic fractional corner charges and also provide simulations for the measurement.