TT 49: Topolectric Circuits and Quantum Hall Systems

Time: Wednesday 17:15–19:00 Location: HSZ 103

TT 49.1 Wed 17:15 HSZ 103

Re-entrant Topological Defect Mode in a PT-Symmetric Circuit — •Alexander Stegmaier[1], Tobias Helbig[1], Tobias Hofmann[1], Stefan Imhof[1], Lee Ching Hua[2], and Ronny Thomale[1] — [1]Institute of Theoretical Physics I, University of Würzburg, Germany — [2]National University of Singapore, Singapore

Systems obeying PT-symmetry are a special case in non-Hermitian physics where real eigenvalue spectra can still emerge. They usually exhibit a phase diagram with different regimes of symmetry conservation or spontaneous symmetry breaking in their eigenstates. We examine a localized zero-energy defect mode within a PT-symmetric SSH chain that disappears and re-emerges at different PT phase transitions and present an exhaustive explanation for this phenomenon. Our theoretical findings are confirmed by eigenstate measurements for different gain/loss profiles in an electrical circuit implementation.

TT 49.2 Wed 17:30 HSZ 103

Reciprocal skin effect and its realization in a topolectrical circuit — •Tobias Helbig[1], Tobias Hofmann[1], Ching Hua Lee[2,3], Frank Schindler[4], Titus Neupert[4], Martin Greiter[1], and Ronny Thomale[1] — [1]Institut für Theoretische Physik und Astrophysik, Universität Würzburg, 97074 Würzburg — [2]Department of Physics, National University of Singapore, Singapore 117542 — [3]Institute of High Performance Computing, A*STAR, Singapore 138632 — [4]Department of Physics, University of Zurich, 8057 Zurich, Switzerland

The non-Hermitian Skin effect heralds the start of a new paradigm in synthetic metamaterial research. The newly established notion of the Skin effect requires specifically tailored gain and loss in combination with a necessary breaking of reciprocity. In this talk we extend this viewpoint and present a model which shows extensive eigenmode localization for open boundaries despite preserving reciprocity. In contrast to non-reciprocal implementations of the Skin effect, which require an external supply of energy, this model can be realized by using exclusively passive components. We experimentally demonstrate this novel phenomenon in a passive RLC circuit network. The reciprocal Skin effect suggests itself for realization in a plethora of metamaterial platforms with limited availability of active components.

[1] T. Hofmann et al. , arXiv: 1908.02759 (2019)

TT 49.3 Wed 17:45 HSZ 103

The Chern state in electric circuits — •Hendrik Hohmann[1], Tobias Helbig[1], Tobias Hofmann[1], Alexander Stegmaier[1], Ching Hua Lee[2,3], Martin Greiter[1], and Ronny Thomale[1] — [1]Institut für Theoretische Physik und Astrophysik, Universität Würzburg, 97074 Würzburg — [2]Department of Physics, National University of Singapore, Singapore 117542 — [3]Institute of High Performance Computing, A*STAR, Singapore 138632

Topolectrical circuits present themselves as a versatile platform to investigate topological states of matter realized in a classical environment. Among them, the Chern insulator is commonly viewed as the most fundamental one, because it solely relies upon its non-trivial band topology and does not require additional symmetries. The combined breaking of reciprocity and time-reversal symmetry (TRS) as well as minimizing dissipation effects signify the central challenges of a Chern state realization in classical setups. In a passive realization, the breaking of TRS can be circumvented by creating a doubled copy of Chern bands [V. Albert et al., Phys. Rev. Lett. 114, 173902]. In contrast, the inclusion of active components allows for a nontrivial topological band structure in direct analogy to the Haldane model [T. Hofmann, T. Helbig et al., Phys. Rev. Lett. 122, 247702]. The hallmark of the active Chern state realization is its support of unidirectionally propagating voltage modes at its boundary.

TT 49.4 Wed 18:00 HSZ 103

Observation of the non-Hermitian skin effect in topolectric circuits — •Tobias Hofmann[1], Tobias Helbig[1], Stefan Imhof[2], Tobias Kiessling[2], Ching Hua Lee[3,4], Martin Greiter[1], and Ronny Thomale[1] — [1]Institut für Theoretische Physik und Astrophysik, Universität Würzburg, 97074 Würzburg — [2]Physikalisches Institut und Röntgen Research Center for Complex Material Systems, Universität Würzburg, 97074 Würzburg — [3]Department of Physics, National University of Singapore, Singapore, 117542 — [4]Institute of High Performance Computing, A*STAR, Singapore, 138632

A contemporary frontier of metamaterial research is the challenge non-Hermitian systems pose to the established characterization of topological matter. There, one of the most relied upon principles is the bulk-boundary correspondence (BBC). In Hermitian systems energy eigenvalues and eigenstates exhibit a perturbatively small change as the boundary conditions are modified from periodic to open. The framework of BBC captures the emergence of protected surface states at the boundary of a system with nontrivial bulk topology. In this talk, we present a periodic circuit network, where gain and loss conspire with the violation of reciprocity to affect this principle dramatically and result in the non-Hermitian Skin effect: upon switching from periodic to open boundary conditions, the spectrum changes drastically and all eigenstates localize at one boundary. We experimentally observe this phenomenon for the first time.

[1] T. Helbig et al., arXiv:1907.11562 (2019)

TT 49.5 Wed 18:15 HSZ 103

"Energy stacks" of Quantum Hall transitions in dirty surfaces of topological superconductors — Björn Sbierski[1], •Jonas Karcher[2,3,4], and Matthew Foster[4,5] — [1]Department of Physics, University of California, Berkeley, CA 94720, USA — [2]Institut für Nanotechnologie, Karlsruhe Institute of Technology, 76021 Karlsruhe, Germany — [3]Institut für Theorie der Kondensierten Materie Karlsruhe Institute of Technology, 76128 Karlsruhe, Germany — [4]Department of Physics and Astronomy, Rice University, Houston, Texas 77005, USA — [5]Rice Center for Quantum Materials, Rice University, Houston, Texas 77005, USA

Normally QHPT states occur only at isolated energies; accessing them therefore requires fine-tuning of the electron density or magnetic field. In this work we show that QHPT states can be realized throughout an energy continuum, i.e. as an "energy stack" of critical states wherein each state in the stack exhibits QHPT phenomenology. The stacking occurs without fine-tuning at the surface of a class AIII topological phase, where it is protected by U(1) and time-reversal symmetries. Criticality is diagnosed by comparing numerics to universal results for the longitudinal Landauer conductance and multifractality at the QHPT. Results are obtained from an effective 2D surface field theory and from a bulk 3D lattice model. We demonstrate that the stacking of QHPT states is a robust phenomenon that occurs for AIII topological phases with both odd and even winding numbers. The latter conclusion may have important implications for the still poorly-understood logarithmic conformal field theory believed to describe the QHPT.

TT 49.6 Wed 18:30 HSZ 103

Microscopic theory of fractional excitations in gapless bilayer quantum Hall states: semi-quantized quantum Hall states — •Tobias Meng — Institut für Theoretische Physik and Würzburg-Dresden Cluster of Excellence ct.qmat, Technische Universität Dresden, 01062 Dresden, Germany

Recent experiments in quantum Hall bilayer systems have revealed a new strongly correlated state: the semi-quantized quantum Hall state. This state arises in a bilayer quantum Hall system with strong interlayer-interactions, has a quantized Hall resistance and vanishing longitudinal resistance, while at the same time featuring a gapless sector that allows this state to exist for a continuum of filling factors. In this talk, I will explain what a semi-quantized quantum Hall state is, and use a coupled-wire construction to predict possible future experiments in the already existing experimental platforms.

TT 49.7 Wed 18:45 HSZ 103

Thermal Hall effect in a Bulk Quantum Hall System $EuMnBi_2$ — •Mohammad Pakdaman[1], Jan Bruin[1], Claus Muehle[1], Xinglu Que[1], Yosuke Matsumoto[1], and Hidenori Takagi[1,2,3] — [1]Max Planck Institute for Solid State Research, Stuttgart, Germany — [2]Department of Physics, University of Tokyo, Japan — [3]c Institute for Functional Matter and Quantum Technologies, University of Stuttgart, Germany

The recent observation of a quantum Hall effect in $EuMnBi_2$ is attracting a lot of attention since it is a rare example of quantum Hall physics in a bulk material. Here, the largely suppressed coupling between 2D

electron layers is a key. Moreover, the 2D electrons are understood to have a Dirac dispersion, which may help explain their low carrier density and high mobility. In this study, diagonal and nondiagonal thermal conductivity of $EuMnBi_2$ were measured down to 90 mK up to the field range of 14 T. We report a strong thermal Hall effect and a field dependent thermal conductivity that carries signatures of both electronic and magnetic origins. Possible origin and signatures of quantization will be discussed in the talk.