TT 28: Topology: Other Topics

Time: Tuesday 9:30–12:15 Location: H 3025

TT 28.1 Tue 9:30 H 3025

Theory of local $\mathbb{Z}_2$ topological markers for finite and periodic systems — •Nicolas Baù and Antimo Marrazzo — Dipartimento di Fisica, Università degli Studi di Trieste, Strada Costiera 11, Trieste, I-34151, Italy

Topological invariants are global properties of the ground-state wave function, typically defined as winding numbers in reciprocal space. Over the years, a number of topological markers have been introduced, allowing to probe the topological order locally in real space even for disordered and inhomogeneous systems [1]. In this talk, I will address time-reversal symmetric systems in two dimensions and introduce two local $\mathbb{Z}_2$ topological markers [2]. The first formulation is based on a generalization of the spin-Chern number [3] while the second one is based solely on time-reversal symmetry [4]. Then, I will introduce a formulation of the local Chern marker for extended systems with periodic boundary conditions [5], and I extend it to the aforementioned $\mathbb{Z}_2$ markers [2]. Finally, I will show numerical simulations to validate the approach, including pristine disordered and inhomogeneous systems, such as topological/trivial heterojunctions.

[1] R. Bianco, R. Resta, Phys. Rev. B **84** (2011) 241106(R)
[2] N. Baù, A. Marrazzo, in preparation
[3] E. Prodan, Phys. Rev. B **80** (2009) 125327
[4] A. A. Soluyanov, D. Vanderbilt, Phys. Rev. B **85** (2012) 115415
[5] N. Baù, A. Marrazzo, arXiv:2310.15783 (2023)

TT 28.2 Tue 9:45 H 3025

A minimal quantum dot-based Kitaev chain with only local superconducting proximity effect — •William Samuelson, Viktor Svensson, and Martin Leijnse — Division of Solid State Physics and NanoLund, Lund University, Lund, Sweden

The possibility to engineer a Kitaev chain in quantum dots coupled via superconductors has recently emerged as a promising path toward topological superconductivity and possibly nonabelian physics. In this talk, I will discuss how some of the main experimental hurdles on this path can be avoided by using only local proximity effect on each quantum dot in a geometry resembling a two-dot version of the proposal in New J. Phys. **15** 045020 (2013), see `arXiv:2310.03536`. There is no need for narrow superconducting couplers, additional Andreev bound states, or spatially varying magnetic fields; it suffices with spin-orbit interaction and a constant magnetic field, in combination with control of the superconducting phase to tune the relative strengths of elastic cotunneling and an effective crossed-Andreev-reflection-like process generated by higher-order tunneling. We use a realistic spinful, interacting model and show that high-quality Majorana bound states can be generated already in a double quantum dot.

TT 28.3 Tue 10:00 H 3025

Signatures of topologically non-trivial band structures based on real-space simulations — •Bendegúz Nyári[1,2], Lászlóffy András[3], Levente Rózsa[3], László Szunyogh[1,2], and Balázs Újfalussy[3] — [1]Department of Theoretical Physics, Budapest University of Technology and Economics, Budapest, Hungary — [2]HUN-REN-BME Condensed Matter Research Group, Budapest University of Technology and Economics, Budapest, Hungary — [3]HUN-REN Wigner Research Centre for Physics, Budapest Hungary

The topological properties of magnetic chains placed on superconductors can be derived from momentum-space quantities related to an infinite chain. The topologically non-trivial band structure gives rise to Majorana end states at zero energy in finite chains.

However, without a translational symmetric system in hand, it is also possible to identify the signatures of the band topology in real-space calculations of finite chains based on the superconducting order parameter and the quasiparticle density of states. Also the spectrum of the chain can be approximated based on the quasiparticle spectrum obtained from the Fourier transformed density of states.

In this talk, I apply this theory to Fe chains on Au/Nb(110) [1] and Mn chains on Nb(110) and study the topology of the band structure.

[1] B.Nyari *et al.*, Phys. Rev. B **108** (2023) 134512

TT 28.4 Tue 10:15 H 3025

Topological charge pumping in quantum many-body systems at finite temperature — •Suman Mondal[1], Eric Bertok[1], Armando Aligia[2], Robin Steinigeweg[3], and Fabian Heidrich-Meisner[1] — [1]Georg-August-Universität Göttingen — [2]Centro Atómico Bariloche and Instituto Balseiro — [3]University of Osnabrück

Adiabatic and periodic variations of the lattice parameters can make it possible to transport charge through a system even without net external electric or magnetic fields, known as Thouless charge pumping. The amount of charge pumped in a cycle is quantized and determined by the system's topology, which is robust against perturbations such as disorder and interactions. Recently, there has been a lot of interest in studying the Thouless pump at finite temperature to characterize the topology in finite temperature. We explore the finite temperature properties of a two-component fermionic Thouless pump in the presence of on-site interactions. It is theoretically studied and experimentally observed that, in the groundstate, on one hand, the system exhibits a breakdown of quantized pumping with increasing interaction. On the other hand, it is possible to define a pumping path that shows interaction-induced pumping. We will discuss these phenomena at finite temparatures. We will show a correlation between the excitation gaps in the system and the meltdown of the pump.

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TT 28.5 Tue 10:30 H 3025

Topological properties of a non-Hermitian quasi-1D chain with a flat band — •Carolina Martínez-Strasser[1,2,3], Miguel Ángel J. Herrera[1,2], Aitzol García-Etxarri[2,4], Giandomenico Palumbo[5], Flore K. Kunst[3], and Dario Bercioux[2,4] — [1]Department of Physics, University of the Basque Country UPV/EHU, Apartado 644, 48080 Bilbao, Spain — [2]Donostia International Physics Center (DIPC), 20018 Donostia–San Sebastián, Spain — [3]Max Planck Institute for the Science of Light, Staudtstraße 2, 91058 Erlangen, Germany — [4]IKERBASQUE, Basque Foundation for Science, Plaza Euskadi 5 48009 Bilbao, Spain — [5]School of Theoretical Physics, Dublin Institute for Advanced Studies, 10 Burlington Road, Dublin 4, Ireland

We explore the spectral characteristics of a non-Hermitian quasi-1D lattice in two different dimerization configurations. The lattice exhibits a zero-energy flat band, and an accumulation of bulk eigenstates at the boundaries. Despite this behavior, we identify non-trivial edge states at zero energy for the first configuration through a real-space topological invariant called the biorthogonal polarization. For the second configuration, we analyze the finite quantum metric associated with the flat band. Interestingly, this configuration exhibits the skin effect, even though the system has a spectrum that is purely real or imaginary. Both non-Hermitian diamond chains can be mapped to models of Su-Schrieffer-Heeger chains, either non-Hermitian or Hermitian, both featuring a flat band. This mapping provides valuable insights into the system's properties.

15 min. break

TT 28.6 Tue 11:00 H 3025

Time-frequency representation of Andreev-reflected charge pulses — •Benjamin Roussel[1], Pablo Burset[2], and Christian Flindt[1] — [1]Aalto University, Aalto, Finland — [2]Universidad Autonoma de Madrid, Madrid, Spain

The most fundamental AC electric current consists of a single electron and a single hole at each period of the drive. While this has been a long-held theoretician dream, the experimental progress of the past 15 years have made it come true. It is now possible to generate, manipulate and probe electric current down to a single charge in a ballistic conductor. This is the focus of electron quantum optics, in which electrons are manipulated at the most elementary level, similarly to photons in quantum optics.

The field has now reached maturity, demonstrating the experimental techniques, and is now envisioned for technological applications, in particular in metrology. However, some aspects of electronic correlations have yet to be explored. At the interface between a normal metal and a superconductor, Andreev reflections can happen, producing a quantum superposition of an electron and a hole. This generates superconducting correlations, that can be exploited for electron quantum optics.

In this talk, I will present how Andreev reflections can be understood

using the language of electron quantum optics. Introducing Wigner-like time-frequency representation for this process, I will analyze how an incoming electron is scattered by the interface.

TT 28.7 Tue 11:15 H 3025

Non-Hermitian Physics in multi-terminal devices: topological ohmmeter — Viktor Könye[1,2], •Kyrylo Ochkan[1,2], Anastasiia Chyzhykova[1,3], Jan Carl Budich[2,4], Jeroen van den Brink[1,2,4], Ion Cosma Fulga[1,2], and Joseph Dufouleur[1,2] — [1]IFW Dresden, Deutschland — [2]Würzburg-Dresden Cluster of Excellence ct.qmat — [3]Taras Shevchenko National University of Kyiv — [4]TU Dresden

We exploit the topological properties of non-Hermitian matrices to build a very sensitive ohmmeter. The ohmmeter is realized in a multi-terminal, linear electric circuit with a non-Hermitian conductance matrix, where the target resistance plays the role of the perturbation. We show that its relative accuracy increases exponentially with the number of terminals, and for large resistances outperforms a standard measurement by over an order of magnitude. This paves the way towards leveraging non-Hermitian conductance matrices in high-precision electronic sensing

TT 28.8 Tue 11:30 H 3025

Extended Hatano-Nelson model, exceptional points and spectral symmetry — •Julius T. Gohsrich[1,2], Jacob Fauman[1,2], and Flore K. Kunst[1] — [1]Max Planck Institute for the Science of Light, Staudtstraße 2, 91058 Erlangen, Germany — [2]Department of Physics, Friedrich-Alexander Universität Erlangen-Nürnberg, Staudtstraße 7, 91058 Erlangen, Germany

Non-Hermitian systems attract a lot of attention in recent years as effective description of open quantum systems. A prominent example in this context is the Hatano-Nelson model. While historically the model has short-range non-reciprocal hoppings, long-range hopping has not been systematically studied. In this talk, I will present our results on the extended Hatano-Nelson model. Using analytical techniques, we demonstrate how the underlying physics of the original Hatano-Nelson model is enriched when longer-range hoppings are also included. I will discuss how the crucial elements of the Hatano-Nelson model, namely, the non-Hermitian skin effect and the exceptional points, are modified for the generalized model.

TT 28.9 Tue 11:45 H 3025

Analytic approches to non-hermitan systems: Hatano-Nelson model with onsite impurity — •Nico Leumer and Dario Bercioux — DIPC, San Sebastian, Spain

The topology of non-hermitian (nh) systems is undoubtedly a new and interesting field of research. The change from hermitian to non-hermitian Hamiltonian's demanded the adaptation of former well-established concepts [1]. A striking feature is that nh single band models as the Hatano-Nelson (HN) inherit non-trivial topology.

Since spectra and eigenvectors of nh systems may show numerical instabilities close to so called exceptional points, analytic validation is important. In this perspective, we show that our exact approach using Fibonacci polynomials is also capable of treating generic boundary conditions and arbitrary systems length in the nh case [2, 3]. For the sake of a showcase, we present results for Hatano-Nelson model with periodic and open boundary conditions. For the latter, we include also an impurity at (of) arbitrary position (strength) in order to better illustrate the potential of our technique.

Importantly, the impurity strength influences wavefunction profiles and leads to the formation of linearly decaying modes already for the hermitian case. Interestingly, these specific modes mark a crossover in the energy spectrum where a single mode leaves the band and becomes energetically separated from all remaining ones.

[1] E. J. Bergholtz et al., Rev. Mod. Phys. 93 (2021) 015005
[2] N. Leumer et al., J. Phys.: Condens. Matter 32 (2020) 445502
[3] N. G Leumer, J. Phys. A: Math. Theor. 56 (2023) 435202

TT 28.10 Tue 12:00 H 3025

Symmetry-induced higher-order exceptional points in two dimensions — •Anton Montag[1,2] and Flore Kunst[1] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Departement of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany

Exceptional points (EPs) appear in non-Hermitian systems as points where the eigenvalues and eigenvectors coalesce. Even without any symmetries they are an abundant feature of non-Hermitian systems. In general, an EP of order n (EPn), where n eigenvectors coalesce, emerges if $2(n-1)$ real constraints are imposed. Symmetries that are local have been shown to reduce this number of constraints. In this work, we analyze higher-order EPs in two-dimensional parameter space induced by symmetries. We show that EP3s appear pairwise in the presence of any symmetry local in parameter space, and we illuminate the spectral structure around the EP3 pair. For each symmetry we show different general features that accompany the EP3s. Further we find EP4s and closely related EP5s induced by multiple symmetries. These EPs occur pairwise and have a complex spectral structure, which can be analyzed by analytically calculating the eigenvalues around those EP pairs.