Abstracts of Posters

A time-reversal symmetric topological magnetoelectric effect in 3D topological insulators

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One of the hallmarks of time-reversal symmetric (TRS) topological insulators in 3D is the topological magnetoelectric effect (TME). So far, a time-reversal breaking variant of this effect has been discussed, in the sense that the induced electric charge changes sign when the direction of an externally applied magnetic field is reversed. Theoretically, this effect is described by the so-called axion term. Here, we discuss a time-reversal symmetric TME, where the electric charge depends only on the magnitude of the magnetic field but is independent of its sign. We obtain this non-perturbative result by a combination of analytic and numerical arguments, and suggest a mesoscopic setup to demonstrate it experimentally.
In particular, we show that threading a thin magnetic flux tube of one flux quantum through the material and applying a uniform electric field will induce a half-integer charge $\Delta Q = e/2 \operatorname{sgn} E_z$ on the surface of the topological insulator. The sign of the induced charge is independent of the direction of the magnetic field.

Variational study of U(1) and SU(2) lattice gauge theories with Gaussian states in 1+1 dimensions

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We introduce three unitary transformations and combined them with fermionic Gaussian states, to construct a family of variational ansatzs in order to study the in- and out- equilibrium properties of (1+1)-dimensional lattice gauge theories ((1+1)D LGT). The accuracy of this approach to describe U(1) and SU(2) (1+1)D LGT, relies on the use of these transformations which (1) eliminate the gauge field for Abelian and non-Abelian groups and (2) decouple the external charges from the dynamical fermions, catching the entanglement between the gauge and fermionic degrees of freedom. This allows us to accurately describe the equilibrium and out of equilibrium physics related to the phenomenon of string-breaking and compare our results with those obtained via Matrix Product States.

Multifractality at the spin quantum Hall transition revisited

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Recent analytical work predicts the multifractal spectrum of the integer quantum Hall (IQH) transition (class A) to be exactly parabolic [1, 2]. The available numerical studies of the spectrum [3, 4, 5] suggested otherwise, but they are inconclusive, since they have not taken into account finite size corrections due to irrelevant scaling variables. These corrections are known to be very important for the precise determination of the localization length exponent at the IQH transition [6, 7].
As compared to the IQH transition, the spin quantum Hall (SQH) transition (class C) appears to be under much better control, numerically, partially because the (subleading) corrections to scaling seem small. Motivated by the preceding observations, we present a detailed numerical study of wavefunction statistics for the SQH transition within the framework of network models. The spectrum

we obtain obeys the symmetry relation derived in [8]; the analytically known exponents for non-trivial wavefunction moments q = 2, 3 obtained numerically are: -0.2504 +/- 0.0008, -0.749 +/-0.002 (to be compared with -1/4, -3/4 respectively [9]). The spectrum is, however, not parabolic. Our research thus sets a consistency check for analytical theories of the SQH effect.

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Quantum Anomalous Hall Effect in Magnetic Fields – Signatures of Parity Anomaly

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Recent experimental progress in condensed matter physics gives a prospect to observe the parity anomaly in two-dimensional Dirac-like materials. Using effective field theories and analyzing the evolution of the band structure in external out-of-plane magnetic fields (orbital fields), we show that topological properties of quantum anomalous Hall (QAH) insulators are related to the parity anomaly. We demonstrate that the QAH phase survives in orbital fields, violates Onsager relations, and can be therefore distinguished from a conventional quantum Hall phase. Moreover, we predict a unique type of charge pumping from the QAH edge cone into the Landau levels, which preserves the total charge of the system, as long as the Dirac mass gap is not closed by orbital fields. As a consequence, we anticipate that the exceptionally long QAH plateau observed in HgMnTe, as well as in Bi-based QAH insulators could be related to the parity anomaly.

How (not) to find a topological phase: the hunt for a 2D Dirac semimetal

Jans Henke, S. V. Ramankutty, A. Schiphorst, R. Nutakki, S. Bron, G. Araizi-Kanoutas, S. K. Mishra, Lei Li, Y. K. Huang, T. K. Kim, M. Hoesch, C. Schlueter, T. -L. Lee, A. de Visser, Zhicheng Zhong, Jasper van Wezel, E. van Heumen, M. S. Golden
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SrMnSb22 is suggested to be a magnetic topological semimetal. It contains square, 2D Sb planes with non-symmorphic crystal symmetries that could protect band crossings, offering the possibility of a quasi-2D, robust Dirac semimetal in the form of a stable, bulk (3D) crystal. We report a combined and comprehensive experimental and theoretical investigation of the electronic structure of SrMnSb22, including the first ARPES data on this compound. SrMnSb22 possesses a small Fermi surface originating from highly 2D, sharp and linearly dispersing bands (the Y-states) around the (0,ππ/a)-point in kk-space. The ARPES Fermi surface agrees perfectly with that from bulk-sensitive Shubnikov de Haas data from the same crystals, proving the Y-states to be responsible for electrical conductivity in SrMnSb
22. DFT and tight binding (TB) methods are used to model the electronic states, and both show good agreement with the ARPES data. Despite the great promise of the latter, both theory approaches show the Y-states to be gapped above EFF, suggesting trivial topology. Subsequent analysis within both theory approaches shows the Berry phase to be zero, indicating the non-topological character of the transport in SrMnSb22, a conclusion backed up by the analysis of the quantum oscillation data from our crystals.

Biorthogonal Bulk-Boundary Correspondence in non-Hermitian Systems

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Non-Hermitian systems exhibit striking exceptions from the paradigmatic bulk-boundary correspondence, including the failure of bulk Bloch band invariants in predicting boundary states and the (dis)appearance of boundary states at parameter values far from those corresponding to gap closings in periodic systems without boundaries. Here, we provide a comprehensive framework to unravel this disparity based on the notion of biorthogonal quantum mechanics: While the properties of the left and right eigenstates corresponding to boundary modes are individually decoupled from the bulk physics in non-Hermitian systems, their combined biorthogonal density penetrates the bulk precisely when phase transitions occur. This leads to generalized bulk-boundary correspondence and a quantized biorthogonal polarization that is formulated directly in systems with open boundaries. We illustrate our general insights by deriving the phase diagram for several microscopic open boundary models, including exactly solvable non-Hermitian extensions of the Su-Schrieffer-Heeger model and Chern insulators.

Flore K. Kunst, Elisabet Edvardsson, Jan Carl Budich, and Emil J. Bergholtz, Phys. Rev. Lett. 121, 026808 (2018)

Charge liquids- A study of the Falicov-Kimball model on the triangular lattice

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Classical liquid phases arise due to geometrically frustrated interactions which may render the classical ground-state macroscopically degenerate. The connection between classical and quantum liquids and how the degeneracy is affected by quantum fluctuations is, however, less well understood.
In an attempt to address this problem we study a simple model of coupled quantum and classical degrees of freedom, the so-called Falicov-Kimball model, on a triangular lattice where the relevant interactions turn out to be geometrically frustrated.
Some of the results for large temperature and/or large interaction strength are in line with recent ones obtained for a square lattice. For low temperature and weaker interactions, we find a disordered phase. We explore the properties of this phase and provide compelling evidence that it constitutes a charge liquid state of the system.

Majorana-Hubbard model on the honeycomb lattice

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Phase diagram of a Hubbard model for Majorana fermions on the honeycomb lattice is explored using a combination of field theory, renormalization group and mean-field arguments, as well as exact numerical diagonalization. Unlike the previously studied versions of the model we find that even weak interactions break symmetries and lead to interesting topological phases. We establish two topologically nontrivial phases at weak coupling, one gapped with chiral edge modes, and the other gapless with anti-chiral edge modes. At strong coupling a mapping onto a novel frustrated spin-1/2 model suggests a highly entangled spin liquid ground state.

The Anomalous Hall Effect in Magnetic Topological Insulators

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We have studied the anomalous Hall effect (AHE) on the surface of a 3D magnetic topological insulator, which provides a deep insight into the interplay between magnetism and the transverse transport of massive Dirac Fermions due to an external applied electric field. In this work, the AHE in a 3D TI is investigated using the semi-classical Boltzmann approach along with a modified relaxation time scheme, in terms of the chemical potential of the system, the spatial orientation of the surface magnetization and the concentration of magnetic and non-magnetic impurities. All three different contributions to the AHE -the intrinsic berry-phase curvature effect, the extrinsic side-jump and the skew scattering effects- are systematically treated. By applying a fully analytical method we show how the relative importance of these contributions can be tuned, and can even turn-off the AHE. For example it is shown that the anomalous Hall conductivity can even change sign by altering the orientation of the surface magnetization, in agreement with recent experimental observations.

Quantum Hall edge plasmonics for quantum computation

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Quantum Hall edge magnetoplasmons (EMPs) are low energy and long wavelength excitations confined at the edge of 2D materials in the quantum Hall regime. These EMPs are driven by applying a time-dependent voltage to external electrodes capacitively coupled to the material and they have some characteristic features that can be useful to measure and control solid state qubits. For example, it was recently demonstrated that their chirality can be exploited to implement passive non-reciprocal devices, such as gyrators and circulators, that exhibit good scalability performance. Moreover, one can also take advantage of the high off-diagonal resistance to manufacture nearly dissipationless transmission lines and resonators with characteristic impedance of the order of the quantum of resistance.
We develop a theory that describes the response of these devices based on linear response theory in the random phase approximation. The theory captures the main physics of the problem: the renormalization of the capacitance due to a finite density of states (quantum capacitance) and the multiplicity of the EMP modes. It also applies to several cases of interest, in particular, we focus on confinement potentials that are either smooth or sharp on the scale of the magnetic length in 2D electron gas, and monolayer graphene.

Topological Phases in Superconductors with Intrinsic Textured Magnetic Order

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Systems that inherently exhibit topological superconductivity are rare in nature and the highly coveted Majorana fermions are mainly pursued in engineered hybrid devices. Here we propose to harness the possible microscopic coexistence of superconductivity and magnetism as an alternative pathway to craft intrinsic topological superconductors [1]. We focus on materials with spontaneous textured magnetic order driven by Fermi surface nesting. Our work is motivated by the iron pnic-tides, in which such a coexistence has been shown experimentally, and a recent theoretical analysis [2] has revealed that textured magnetism is also accessible. We explore the arising topological superconducting phases in layered multiband materials with magnetic spiral, whirl or skyrmion order, coexisting with various types of spin-singlet superconductivity. The diverse magnetic phases lead to a variety of flat, unidirectional, helical and chiral Majorana edge modes. We show that this multifaceted manifestation of Majorana fermion modes stems from the interplay of topological phases with both gapped and nodal bulk energy spectra.

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DFT calculations of surface states of topological insulators and Weyl semimetal using slab method

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The surface states of materials are very interesting from band structure point of view. The surface provide new bands which can have nontrivial meaning, eg. they can close the energy gap of material such that it becomes metallic at the surface (and remains as insulator in bulk). This type of material is so-called topological insulator.
The other example of nontrivial surface state is Weyl semimetal, where Dirac-like cone is formed in the band structure without relativistic effects (so-called Weyl cone) and spin-orbit effect leads to splitting this cone to two cones, which are connected by piece of Fermi curve (two-dimensional Fermi surface) so-called Fermi arc.
In this work the calculations of surface band structure of topological insulators and topological semimetals were computed with slab method using density-functional theory (DFT). Two methods of treating DFT were used: pseudopotential with plane wave method as implemented in Quantum Espresso [1] and fullpotential with linerized augmented plane waves (LAPW) as implemented in Wien2k [2].
The goal is to show an ability of DFT method to calculate band structure of surface and to compare the results obtained with these to methods.
Particularly the influence of relativistic effects is considered, as both methods allow to computing without as well as with relativistic effects taken into account.
At the end, some issues of these methods will be shown such as the influence of number of stacked unit cell in slab method or the choosing of exchange potential.

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Majorana bound states from interfacial Dzyaloshinskii-Moriya interaction

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We investigate an interface of a ferromagnetic thin film on a superconducting substrate. The magnetic configuration of the system can realize different phases depending on the competing effects of Dzyaloshinskii-Moriya (DM) interaction, exchange interaction, out-of-plane axis anisotropy, and a Zeeman field. Notably, DM interaction may lead to a non-collinear ground state which exhibits either a spiral state or magnetic skyrmions.
The coexistance of such non-collinear phases with superconductivity in the substrate can render the interface topological, and thus Majorana bound states (MBS) may be expected. We discuss different possibilities to obtain and manipulate MBS from single or multiple skyrmions. In particular, we consider a chain of skyrmions as a platform for MBS.

Topological Properties of Quasiperiodic Tilings

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Topological properties of finite quasiperiodic tilings are examined. We study two specific physical quantities: (a) the structure factor related to the Fourier transform of the structure; (b) spectral properties (using scattering matrix formalism) of the corresponding quasiperiodic Hamiltonian. We show that both quantities involve a phase, whose windings describe topological numbers. We link these two phases, thus establishing a “Bloch theorem” for specific types of quasiperiodic tilings.

Topological Ordering in the Majorana Toric Code

Alexander Ziesen, Fabian Hassler and Ananda Roy
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At zero temperature, a two dimensional lattice of Majorana zero modes on mesoscopic superconducting islands has a Z2 topologically-ordered toric code phase. Recently, a Landau field theory was proposed for this system that describes its phases and the different phase-transitions separating them. The system is in the toric code phase as a Mott insulator and a charge-2e superconductor. However, the topological ordering is absent in the charge-e superconducting phase. While the field theories for the different phase-transitions were obtained in the earlier work, the signatures of topological ordering in the different phases were not investigated in detail. This is the goal of the current work. We describe a lattice gauge theory of the Majorana toric code in terms of a U(1) matter field coupled to an emergent Z2 gauge field. Subsequently, we use a generalized Wilson-loop order-parameter, namely, the equal-time Fredenhagen-Marcu order parameter, to distinguish between the different phases. This allows us to provide a loop-condensation picture of the different phases and to classify the different phase-transitions. Our findings confirm the previously-obtained field theory results. In contrast to the earlier work where the topological ordering of the different phases was inferred indirectly from the Landau field theory, our method directly detects the topological ordering in the system and is thus, an independent check for the earlier results.

Decoding of the Toric Code: A High Temperature Series Analysis

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The toric code is a promising candidate for providing topological protection to quantum information. The decoding of this information, when assuming perfect syndrome measurements, is known to be described by the statistical mechanics of the random-bond Ising model (RBIM). In this model, the nearest neighbor interaction, J_{ij}, is a quenched random variable such that interaction is ferromagnetic ($J_{ij} > 0$) with probability $1 - p$ and antiferromagnetic ($J_{ij} < 0$) with probability p. Of particular interest in the phase diagram is the Nishimori Line, defined by $p/(1-p) = e^{-\beta J}$, where β is inverse temperature. On this line, the threshold for the order-disorder transition of the RBIM coincides with the accuracy threshold for storage of quantum information in the toric code when using maximum-likelihood decoding. We analyze the entire phase diagram of the two dimensional RBIM by computing high temperature series expansion to higher orders than was previously performed. From our analysis, we calculate the accuracy threshold of the two-dimensional toric code. Our results provide an additional check of the value of the threshold obtained by the Monte-Carlo and network model analyses. Furthermore, we also investigate the 3D RBIM, which has a much richer phase-diagram, exhibiting a spin-glass phase, in addition to the ferromagnetic and paramagnetic phases.

Charge Transport in a Graphene Flake Realization of the Sachdev-Ye-Kitaev Model

Oguzhan Can, Emilian M. Nica and Marcel Franz
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We address the transport properties of a mesoscopic realization of the Sachdev-Ye-Kitaev (SYK) model which is an exactly solvable system of interacting spinless fermions connected to the black hole physics through the holographic principle. Starting with a recent proposal for simulating the SYK model in a graphene flake in an external magnetic field and extending it by considering leads attached to it, we model a realistic transport experiment and calculate directly measurable quantities featuring non-Fermi liquid signatures of the SYK physics. We show that the graphene flake realization is robust in the presence of leads and that measuring the tunneling current across the leads one can experimentally observe a non-Fermi liquid - Fermi liquid transition by tuning the external magnetic field threading the flake. After establishing the transport signatures of the SYK model near equilibrium using linear response framework, we then derive a formula to extend our results for tunneling current using Keldysh formalism to explore the effects of finite bias voltage across the leads, going beyond equilibrium.

Bulk-Boundary Correspondence in the Quantum Hall Effect

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We present a detailed microscopic study of the edge excitations for quantum Hall states living on a spatial disk. For what concerns integer filling fractions, we show that the higher-level wavefunctions close to the boundary possess a non-trivial radial dependence. That is due to the extrinsic curvature of the disk geometry. Therefore, in presence of a confining potential the states of higher levels acquire higher energies. In the edge theory, this leads to a Casimir effect parametrized by the electron orbital spin s_i for each level, i = 1, …n. These results are in agreement with the effective field theory approach of [1] and let us clarify, from a microscopic point of view, the role of the electron orbital spin in the edge theory. Thus, we provide a further instance of the bulk-boundary correspondence. We also generalize the previous findings to fractional fillings and discuss the Coulomb blockade experiment where the ground-state charge could be measured.

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Spinon hopping model for Calciumchromide

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One primary component of quantum spin liquids is the emergence of fractional spin-1/2 excitations called spinons. We propose a simple hopping model of spinons in order to explain recently measured neutron scattering data of $Ca_{10}Cr_7O_{28}$. This material does not develop any magnetic order down to experimentally accessible temperatures. Contrary to other spin liquid candidates Calciumchromide has a complicated crystal structure including ferro- and antiferromagnetica exchange interactions. Our model reduces the complexity yet capturing key features of the data.

Topological Properties of Quantum Magnets: Zak-Phase in BiCu_2PO_6 and Chern numbers in RE_5-Si_4

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There is an increasing interest in finding topological one-particle excitations in quantum magnets. The combination of geometrical frustration and Dzyaloshinskii–Moriya interactions is prone to make topological properties emerge in magnetic systems. Thus, we present the compounds $BiCu_2PO_6$ and RE_5Si_4 as promising topological materials. $BiCu_2PO_6$ is a quasi-one-dimensional dimerized quantum antiferromagnet displaying a non-trivial quantized Zak phase, but no edge states occur. In contrast, RE_5Si_4 is a layered three-dimensional material realizing a ferromagnetic Shastry-Sutherland model in each layer. The magnon bands show non-trivial Chern numbers.

Universal quantum noise in adiabatic pumping

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[1] Leiden University, [2] Weizmann Institute of Science

We consider quantum pumping in a system of parafermionic zero-modes.
Our pumping protocol, which employs the topologically protected degeneracy of parafermions, leads to an unconventional noisy behavior of the pumped current. Namely, as the adiabatic limit is approached, the noisy behavior persists, and the counting statistics of the pumped current becomes robust and universal. In particular, the resulting Fano factor is given in terms of the system's topological degeneracy and the pumped quasiparticle charge. Our results are also applicable to the more conventional Majorana fermions.

Spin-Orbit Coupling effects in a multi-band tight-binding model of graphene

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The description of Dirac electrons in the band structure of graphene is commonly performed using effective tight binding models [1]. These effective models use singleorbital Hamiltonians with modified hopping parameters in order to account for the influence of the higher energy orbitals in graphene. We go beyond such effective models by including d-orbitals in an atomistic tight-binding model. We characterize the resulting bands by computing their quantum numbers and discuss the localization of the edge states [2] of a graphene plaquette and their spin polarization. The influence of the intrinsic spin-orbit coupling on the dispersion relation is shown as well as that of the Bychkov-Rashba spin-orbit coupling [3] that arises due to e.g. an external electric field. The effect of a magnetic field on the edge states is discussed on the grounds of the Peierls phase and the Zeeman shift.
With closed boundary conditions on both ends of the graphene plaquette, the Bychkov-Rashba spin-orbit coupling splits each of the two Dirac cones into four distinct ones [4] due to the trigonal wrapping of the d-orbitals. In the future this will be the key to understand the crossing of the edge states via chirality and helicity arguments under the influence of spin-orbit coupling.

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Short Talks

To have (Kondo effect) and have not: Renormalization and scaling

Eugene Kogan
Bar-Ilan University, Israel

We discuss Kondo effect in the framework of a general model, describing a quantum impurity with degenerate energy levels interacting with a gas of itinerant electrons and derive scaling equation for the interaction parameters to the second order for such a model.
The approach is applied to the spin-anisotropic Kondo model generalized for the case of the power law DOS for itinerant electrons. The scaling equation is specified and solved analytically in terms of elliptic functions.
We also introduce spin-anisotropic Coqblin--Schrieffer model, apply the general method to derive scaling equation for that model and integrate the derived equation analytically.

Transport signatures of symmetry protection in one-dimensional topological insulators

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The edge states in 1D time-independent (Floquet) topological insulators are protected by symmetries meaning that they cannot split in energy (quasienergy) under local symmetry-preserving perturbations. In this talk I will propose a scheme for probing this intriguing feature by attaching an array of dimers to external leads and calculating the transport characteristics. Numerical results obtained from non-equilibrium Green's function theory will be presented. It will be discussed that the transport system experiences a rapid conductance drop under a local symmetry-breaking perturbation while it remains conducting if the symmetries are maintained. The numerical data will be supported with a short analytic analysis. Both types of 1D topological insulators, conventional time-independent and periodically-driven (Floquet), will be considered. The talk will be based on my very recent work done in collaboration with Henrik Johannesson (to be submitted).

Charge Transport in a Graphene Flake Realization of the Sachdev-Ye-Kitaev Model

Oguzhan Can, Emilian M. Nica and Marcel Franz
Department of Physics and Astronomy and Stewart Blusson Quantum Matter Institute, University of British Columbia, Vancouver, Canada

We address the transport properties of a mesoscopic realization of the Sachdev-Ye-Kitaev (SYK) model which is an exactly solvable system of interacting spinless fermions connected to the black hole physics through the holographic principle. Starting with a recent proposal for simulating the SYK model in a graphene flake in an external magnetic field and extending it by considering leads attached to it, we model a realistic transport experiment and calculate directly measurable quantities featuring non-Fermi liquid signatures of the SYK physics. We show that the graphene flake realization is robust in the presence of leads and that measuring the tunneling current across the leads one can experimentally observe a non-Fermi liquid - Fermi liquid transition by tuning the external magnetic field threading the flake. After establishing the transport signatures of the SYK model near equilibrium using linear response framework, we then derive a formula to extend our results for tunneling current using Keldysh formalism to explore the effects of finite bias voltage across the leads, going beyond equilibrium.

Simulating topological tensor networks with Majorana qubits

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The realization of topological quantum phases of matter remains a key challenge to condensed matter physics and quantum information science. In this talk, we demonstrate that progress in this direction can be made by combining concepts of tensor network theory with Majorana device technology. Considering the topological double semion string-net phase as an example, we exploit the fact that the representation of topological phases by tensor networks can be significantly simpler than their description by lattice Hamiltonians.
The building blocks defining the tensor network are tailored to realization via simple units of capacitively coupled Majorana bound states. Our results indicate that the implementation of tensor network structures via mesoscopic quantum devices may define a powerful novel avenue to the realization of synthetic topological quantum matter.

Classification of Crystalline Topological Insulators and Superconductors with Point Group Symmetries

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Tel Aviv University and Tel Hai Academic College, Israel

Crystalline topological phases have recently attracted a lot of experimental and theoretical attention as some of them were discovered to host 2nd and 3rd order edge states. Current classification schemes of these phases are either implicit or limited in scope. We present a new paradigm for the explicit classification of crystalline topological insulators and superconductors. These phases are protected by crystal point group symmetries and are characterized by bulk topological invariants. The classification paradigm generalizes the Clifford algebra extension process of each Altland-Zirnbauer symmetry class and utilizes algebras which incorporate the point group symmetry into the Altland-Zirnbauer classes. Explicit results for all 27 point group symmetries of 3 dimensional crystals are presented. Our work is also extendable for treating nonsymmorphic and magnetic crystals as well as defected and higher dimensional systems.

Hall viscosity as a diagnostic for topological phases of chiral superfluids

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The Hall viscosity is a non dissipative stress response, possible in gapped phases of matter, analogous to the more familiar Hall conductivity. Unlike the Hall conductivity, the Hall viscosity is dimensionful and unquantized, though the ratio between the Hall viscosity and the density is a rational topological invariant protected by spatial rotation symmetry, which can be interpreted as an angular momentum per particle. In p-wave superfluids this ratio is fixed by the p-wave pairing and does not indicate the topological phase diagram. Nevertheless, on a curved sample the Hall viscosity receives a correction proportional to the curvature, with a coefficient given by the bulk Chern number, or edge central charge, and is described by a gravitational Chern-Simons term. We derive this curvature correction for Galilean invariant p-wave superfluids from both a microscopic model and an effective action. We find a few additional, non universal, curvature corrections, which are due to the spontaneous breaking of U(1) symmetry, and show how these can be filtered out, leaving only the central charge. We also discuss k^2 corrections to the Hall viscosity on a nearly flat sample, where k is the wave number of the strain tensor, or metric perturbation. Our results imply that the Hall viscosity may be used as a bulk probe for topological phases of p-wave superfluids in experiments that access stress-strain responses.

Higher-Order Topological Phases

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The mathematical field of topology has become a framework to describe the low-energy electronic structure of crystalline solids. A typical feature of a bulk insulating three-dimensional topological crystal are conducting two-dimensional surface states. This constitutes the topological bulk-boundary correspondence. In my talk, I will explain how one can extend the notion of three-dimensional topological insulators to systems that host no gapless surface states, but exhibit topologically protected gapless hinge states. I furthermore present experimental evidence establishing that the electronic structure of bismuth, an element consistently described as topologically trivial, is in fact topological and follows this generalized bulk-boundary correspondence of higher-order. The type of hinge states discussed here may be used for lossless electronic transport, spintronics, or — when proximitized with superconductivity — for topological quantum computation.

Slow quenches in two-dimensional time-reversal symmetric Z2 topological insulators

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We study the topological properties and transport in the Bernevig-Hughes-Zhang model undergoing a slow quench between different topological regimes. Due to the closing of the band gap during the quench, the system ends up in an excited state. We prove that for quenches that preserve the time-reversal symmetry, the Z2 invariant remains equal to the one evaluated in the initial state. On the other hand, the bulk spin Hall conductivity does change, and its time average approaches that of the ground state of the final Hamiltonian. The deviations from the ground-state spin Hall conductivity as a function of the quench time follow the Kibble-Zurek scaling. We also consider the breaking of the time-reversal symmetry, which restores the correspondence between the bulk invariant and the transport properties after the quench.

Spontaneous mass generation due to phonons in a two-dimensional Dirac fermion system

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Fermions with one and two Dirac nodes are coupled to in-plane phonons to study a spontaneous transition into the Hall insulating phase. At sufficiently strong electron-phonon interaction a gap appears in the spectrum of fermions, signaling a transition into a phase with spontaneously broken parity symmetry.
The structure of elementary excitations above the gap in the corresponding phase reveals the presence of scale invariant parity breaking terms which resemble Chern-Simons excitations. Evaluating the Kubo formula for both models we find quantized Hall plateaux in each case, with conductance of binodal model exactly twice as large as of the mononodal model.