The 15th Capri Spring School on Transport in Nanostructures 2019

	Sunday 05.05.2019	Monday 06.05.2019	Tuesday 07.05.2019	Wednesday 08.05.2019	Thursday 09.05.2019	Friday 10.05.2019	Saturday 11.05.2019
Chair		Grabert	Schönenberger	Tagliacozzo	Egger	Bercioux	
9:00-9:55		Yacoby (1)	Oreg (2)	Weiss (1)	Gueron (1)	Gueron (2)	
10:00-10:55		Neupert (1)	Neupert (3)	Morpurgo (1)	Morpurgo (2)	Weiss (2)	
11:00-11:30		Coffee Break & Poster Session					
11:30-12:25		Yacoby (2)	Altland (1)	Beenakker (1)	Beenakker (2)	Balents (2)	
13:00-16:00		Lunch Break					
Chair		Egger	De Martino		Bercioux	Grabert	
16:00-16:55		Neupert (2)	Altland (2)		Balents (1)	Morpurgo (3)	
17:00-17:30		Coffee Break & Poster Session			Coffee Break & Poster Session		
17:30-18:25	Registration Hotel Senaria	Oreg (1)	Yacoby (3)	Free Afternoon	Beenakker (3)	Balents (3)	
18:30-19:30	19:00-19:30	Participant talk	Participant talk		Participant talk	Participant talk and concluding remarks	
20:00 Dinner	Le Arcate	Il Solitario	Le Arcate		Le Arcate	Le Arcate	

School excursion to Pompeii/ Sorrento (if weather permits) Start at 9 am, Capri Harbour Return by 6 pm

Titus Neupert	Theoretical concepts for topologically ordered phases of matter
Carlo Beenakker	Weyl semimetals
Alberto Morpurgo	Interaction-driven phenomena in 2D materials
Sophie Gueron	Probing topological insulators with mesoscopic physics
Alexander Altland	Physics of the Sachdev-Ye-Kitaev model
Leon Balents	Quantum spin liquids
Yuval Oreg	Coupled wire constructions of topological phases
Dieter Weiss	Transport properties of three-dimensional topological insulators based on HgTe layers
Amir Yacoby	Recent experimental progress on Quantum Spin Hall and Fractional Quantum Hall Systems

Participant Talks

Monday Session	Reyes Calvo (25+5)	Dressed topological states in 2D topological insulators
	Alexandre Gourmelon (12+3)	Dressed topological edge states in HgTe-based 2D topological insulators
	Pietro Novelli (12+3)	Failure of Conductance Quantization in Two-Dimensional Topological Insulators due to Nonmagnetic Impurities
Tuesday Session	Apoorv Tiwari (25+5)	Higher-Order Topological Insulators: Interplay between Spatial Symmetries and Boundary Conditions in Dirac Models
	Sander Kempkes (12+3)	Cornering the zero mode - realizing an electronic higher-order topological insulator
	Max Geier (12+3)	Higher order boundary signatures of crystalline symmetry protected topological phases
Thursday Session	Maia Vergniory (25+5)	Band Theory for full classification of topological crystalline materials
	Katharina Laubscher (12+3)	Fractional second-order superconductivity in a system of coupled wires
	Alexander Bauer (12+3)	Phase-dependent heat transport with unconventional superconductors
Friday Session	Valerio Peri (12+3)	Axial gauge field in an acoustic Weyl metamaterial
	Étienne Lantagne-Hurtubise (12+3)	Traversable wormholes and the SYK model
	Sofia Ferreira Teixeira (12+3)	Variable Range Hopping dominated conduction of a Sb2Te3 ion beam sputtered topological insulator thin film
	Dario Bercioux	Information regarding the excursion to Pompeii & Sorrento

Abstract short talks: Monday Session

From 18:30 to 19:30

Reyes Calvo (CIC Nanogune) — *Dressed topological states in 2D topological insulators*

Two-dimensional topological insulators host metallic edge states with remarkable properties, such as protection against disorder, quantized conductance and spin-momentum lock-in. Yet promising, experimental observations often deviate from the theoretical predictions pointing out the need for a more thorough characterization of their properties. In this context, our results highlight the particular need for electrostatic considerations to be included in current models. In our experiments, we monitor the conductance of a HgTe topological quantum well as a function of the strength and position of a local electric field created by a movable metallic tip. The device conductance shows a remarkably different response, both in magnitude and sign, when the tip perturbs either the bulk or the edge areas of the sample. Furthermore, the edge locations where the tip has a stronger effect on the conductance, shift inwards as we increase the overall electron doping. We propose a minimal model in which | as a result of considering an inhomogeneous electrostatic profile near the edge | a set of extra massive parabolic-like states dress the topologically protected ones, accounting for our experimental observations.

Alexandre Gourmelon (ENS Paris) — *Dressed topological edge states in HgTe-based 2D topological insulators*

The research on helical edges states in 2D topological insulators is motivated by exotic fundamental physics, robust topological quantum computation and novel spinorbitronics. Progress is however impeded by the fragility of the edge states, visible only on short distances. By microwave transport measurements on HgTe topological insulators, we have isolated the edges response from that of the bulk, and found a much denser than expected density of states. We propose a scenario of topological edge states dressed with bulk states confined at the edges, contributing to the large density of states and possibly enhancing the fragility of topological edge states.

Pietro Novelli (Scuola Normale Superiore) — *Failure of Conductance Quantization in Two-Dimensional Topological Insulators due to Nonmagnetic Impurities*

Despite topological protection and the absence of magnetic impurities, two-dimensional topological insulators display quantized conductance only in surprisingly short channels, which can be as short as 100 nm for atomically thin materials. We show that the combined action of short-range nonmagnetic impurities located near the edges and on site electron-electron interactions effectively creates noncollinear magnetic scatterers, and, hence, results in strong backscattering. The mechanism causes deviations from quantization even at zero temperature and for a modest strength of electron-electron interactions. Our theory provides a straightforward conceptual framework to explain experimental results, especially those in atomically thin crystals, plagued with short-range edge disorder.

Abstract short talks: Tuesday Session

From 18:30 to 19:30

Apoorv Tiwari (University of Zurich) — *Higher-Order Topological Insulators: Interplay between Spatial Symmetries and Boundary Conditions in Dirac Models*

We examine several Dirac models in 2 + 1 and 3 + 1-dimensions with different combinations of C_n-rotation, mirror and chiral symmetries on manifolds with corners. In particular we pay attention to the kinds of (symmetric) boundary conditions that can be imposed on such models. By studying constraints that the interplay of spatial symmetries and boundary conditions impose on the possible mass textures around codimension-2 or codimension-3 corners, we realize that topologically protected zero modes on codimension-p corners may be diagnosed by studying the degree of a map from a sphere that links with the codimension-p corner to the space of symmetric masses.

Sander Kempkes (Utrecht University) — *Cornering the zero mode — realizing an electronic higher-order topological insulator*

Quantum simulators are an essential tool for understanding complex quantum materials. Platforms based on ultracold atoms in optical lattices and photonic devices led the field so far, but electronic quantum simulators are proving to be equally relevant. Simulating topological states of matter is one of the holy grails in the field. Here, we experimentally realize a higher-order electronic topological insulator (HOTI): the dimerized Kagome lattice. We engineer alternating weak and strong bonds to show that a topological state emerges at the corner of the non-trivial configuration. The corner mode is protected by a generalized chiral symmetry, which leads to a particular robustness against perturbations.

Max Geier (Freie University Berlin) — *Higher order boundary signatures of crystalline symmetry protected topological phases*

In contrast to symmetry protected topological phases (SPTs) protected by local symmetries for which bulk boundary correspondence requires the system to support gapless excitations at every boundary, crystalline SPTs may have ingap or gapless excitations on corners or hinges of the crystal. Those boundary excitations are termed intrinsic higher order boundary signatures of a higher order crystalline SPT. Conversely, extrinsic higher order boundary signatures can be induced and removed by a change of crystal termination. The presentation will emphasize the difference of those boundary signatures and exemplify how they can be realized in insulators and superconductors.
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Abstract short talks: Thursday Session

From 18:30 to 19:30

Maia Vergniory (Donostia International Physics Center) — *Band Theory for full classification of topological crystalline materials*

In this talk a new field that classifies all topological crystalline phases of all known materials will be introduced: Topological Quantum Chemistry (TQC). It links the chemical and symmetry structure of a given material with its topological properties. This field tabulates the data of the 10398 real-space atomic limits of materials, and solves the compatibility relations of electronic bands in momentum space. A material that is not an atomic limit or whose bands do not satisfy the compatibility relations, is a topological insulator/semimetal. We use TQC to find the topological stoichiometric non-magnetic, ``high- quality'' materials in the world. We develop several code which can compute all characters of all symmetries at all high-symmetry points in the Brillouin Zone (BZ). Using TQC we then develop codes to check which materials are topological. Out of 26938 stoichiometric materials in our filtered ICSD database, we find around 7300 topological materials. For the majority of the ``high-quality'' topological materials, we compute: the topological class, the symmetry(ies) that protects the topological class, the representations at high symmetry points and the direct gap (for insulators), and the topological index. For topological semimetals we then compute whether the system becomes a topological insulator (whose index/class we compute) upon breaking symmetries - useful for experiments. Our exhaustive results show that a large proportion of all materials in nature are topological.

Katharina Laubscher (University of Basel) — *Fractional second-order superconductivity in a system of coupled wires*

We consider a system of weakly coupled Rashba nanowires in the strong spin-orbit interaction regime. We show that the system can be driven into a helical topological superconducting phase hosting Kramers partners of Majorana edge modes in the non-interacting case and Kramers partners of Z_{2m} parafermion edge modes in the presence of strong electron-electron interactions. Furthermore, upon turning on a small time-reversal breaking perturbation, the system is driven into a second-order topological superconducting phase hosting exotic Majorana/parafermion bound states localized at two opposite corners of a rectangular sample.

Alexander Bauer (University of Duisburg-Essen) — *Phase-dependent heat transport with unconventional superconductors*

I am currently interested in the theoretical description of quantum transport in topological heterostructures. In particular, I focus on phase-coherent caloritronics in such systems as an alternative way to probe fundamental topological properties.

Abstract short talks: Friday Session

From 18:30 to 19:30

Valerio Peri (ETH Zurich) — *Axial gauge field in an acoustic Weyl metamaterial*

Topological band theory, known from the description of electrons in solids, provides us with a powerful design-principle for acoustic metamaterials. Here, we present the first observation in a Weyl system of chiral Landau levels induced by an axial gauge field in a classical acoustic metamaterial. The axial gauge field couples differently to Weyl points of opposite chirality and does not break time reversal symmetry. This enables the realization of chiral channels for sound in a three-dimensional bulk system. Moreover, it provides a new platform to study phenomena that arise when Weyl particles are coupled to a gauge field.

Étienne Lantagne-Hurtubise (University of British Columbia) — *Traversable wormholes and the SYK model*

We explore the physics of two coupled SYK models, proposed by Maldacena and Qi, that realize a holographic dual to an "eternal traversable wormhole". We also discuss possible physical realizations in condensed matter settings, and protocols to measure scrambling in such systems using simple (time-ordered) operations.

Sofia Ferreira Teixeira (University of Porto) — *Variable Range Hopping dominated conduction of a Sb_2Te_3 ion beam sputtered topological insulator thin film*

3D Topological Insulators (TI) are novel materials that host a protected spin-textured metallic surface state, which allows for several applications. However, TI nanomaterials studies and experimental realisations are still lacking. In this presentation, the properties of a Sb_2Te_3 thin film fabricated by ion beam sputtering are addressed. The thin film bulk conduction being dominated by Variable Range Hopping in an Efros and Shklovskii regime will be discussed. However, the weak anti-localisation cusps on the magnetoresistance is analysed and is consistent with the TI surface state. Since the fabrication technique was scalable and inexpensive, these results herald promising future applications.

Dario Bercioux (Donostia International Physics Center) — *Information regarding the excursion to Pompeii & Sorrento*

Important information for the excursion of Saturday to Pompeii and Sorrento.

Poster session

From Monday to Friday in parallel to the coffee breaks

1. Maciej Chrobak (AGH University of Science and Technology) — *Magnetoresistance studies of Bi_2Se_3 and Bi_2Te_3 single crystals doped with metals*
2. Samuel Díaz Escribano (Universidad Autónoma de Madrid) — *Effects of the electrostatic environment on superlattice Majorana nanowires*
3. Janis Erdmanis (TU Delft) — *Soft Constrained Topological Transition*
4. Maxime Garnier *(University of Paris-Sud)* — *Many Majorana zero modes around the deformable edge of a magnetic skyrmion*
5. Lucía González Rosado (Forschungszentrum Jülich) — *Weak localization correction to the thermal conductivity in conventional superconductors*
6. Yaroslav Herasymenko (Leidein University) — *Braiding of chiral edge vortices*
7. Paritosh Karnatak (University of Basel) — *Investigating a magnetic field driven nodal superconductor*
8. Rebekka Koch (TU Dresden) — *Bulk-Boundary Correspondence in Non-Hermitian Systems*
9. Angelika Knothe (University of Manchester) — *Influence of minivalleys and Berry curvature on electrostatically induced nanostructures in gapped bilayer graphene*
10. Simon Körber (University of Würzburg) — *Interacting topological frequency converter*
11. Nico Leumer (University of Regensburg) — *Spectral Analysis of a finite Kitaev chain*
12. Yen-Ting Lin (RWTH Aachen) — *Functional RG study on SSH model*
13. Simon Mundinar (University of Duisburg-Essen) — *Resonant tunneling through interacting quantum-dot spin valves*
14. Aleksandra Nelson (University of Zurich) — *Hopf Insulators: Localized Representation and Observable Phenomena*
15. Risto Ojajärvi (University of Jyväskylä) — *Competition of electron-phonon mediated superconductivity and Stoner magnetism on a flat band*
16. Jinhong Park (Weizmann Institute of Science) — *Noise on complex quantum Hall edges*
17. Fernando Peñaranda (Universidad Autónoma de Madrid) — *Non-Hermitian topology: a unifying framework for the Andreev versus Majorana states controversy*
18. Linsey Rodenbach (Stanford University) — *Characterizing Electron Beam Damage to Topological Insulators*
19. Gal Shavit (Weizmann Institute of Science) — *Fractional Conductance in Strongly Interacting 1D Systems*
20. Even Thingstad (Norwegian University of Science and Technology) — *Chiral Phonon Transport Induced by Topological Magnons*
21. Jann Hinnerk Ungerer (University of Basel) — *Circuit quantum electrodynamics with semiconducting nanowires*
22. Kyle Wamer (University of British Columbia) — *Self Conjugate Representations of SU(3) Chains*