TT 17: Topology: Quantum Hall Systems

Time: Monday 16:45–18:45 Location: HSZ 304

TT 17.1 Mon 16:45 HSZ 304

Quantum Hall effect in the 2d topological insulator HgTe in pulsed magnetic fields of up to 65 T — •Christopher Fuchs[1,2], Tobias Kiessling[1,2], Saquib Shamim[1,2], Lena Fürst[1,2], Hartmut Buhmann[1,2], and Laurens W. Molenkamp[1,2] — [1]Physikalisches Institut, Universität Würzburg, Germany — [2]Institute for Topological Insulators, Würzburg, Germany

HgTe quantum wells are a two-dimensional topological insulator with highest electron mobilities as large as $1 \cdot 10^6\,\mathrm{cm}^2/\mathrm{Vs}$. As a result of this outstanding sample quality, the material shows a well-resolved electron-type as well as hole-type quantum Hall effect, which has been studied extensively at lowest temperatures and in fields of up to 16 T. Here, we present an extension of this parameter space all the way to 65 T using pulsed magnetic fields. The high field behavior of the electron-type quantum Hall effect is studied, revealing that it forms a smooth continuation of the low field (< 20 T) behavior. For example, a characteristic breakdown of the quantum Hall effect, which occurs at the filling factor $\nu = 1/2$, is observed at > 50 T for corresponding carrier densities. In addition, a general circuit, wiring and analysis scheme for measurements of the quantum Hall effect within a few milliseconds (a magnetic field pulse lasts only around 100 ms) is presented, along with design rules for gated samples. The presented method is universal and can be applied to any other gated semiconductor/2d sample for transport studies in pulsed magnetic fields.

TT 17.2 Mon 17:00 HSZ 304

Robustness of the topological quantization of the Hall conductivity for correlated lattice electrons at finite temperatures — Anton Markov[1], •Georg Rohringer[2], and Alexey Rubtsov[1] — [1]Moscow, Russia — [2]Institute of Theoretical Physics, University of Hamburg, 20355 Hamburg, Germany

Electrons on a two-dimensional lattice which is exposed to a strong uniform magnetic field show intriguing physical phenomena. The spectrum of such systems exhibits a complex (multi)band structure known as Hofstadter's butterfly. For fillings at which the system is a band insulator, one observes a quantized integer-valued Hall conductivity σ_{xy} corresponding to a topological invariant, the first Chern number C_1 . This is robust against many-body interactions as long as no changes in the gap structure occur. Strictly speaking, this stability holds only at zero temperatures T , while for $T > 0$ correlation effects have to be taken into account. In our paper, we address this question by presenting a dynamical mean-field theory (DMFT) study of the Hubbard model in a uniform magnetic field. The inclusion of local correlations at finite temperature leads to (i) a shrinking of the integer plateaus of σ_{xy} as a function of the chemical potential and (ii) eventually to a deviation from these integer values. We demonstrate that these effects can be related to a correlation-driven narrowing and filling of the band gap, respectively.

Invited Talk TT 17.3 Mon 17:15 HSZ 304

Noise signatures of anyon statistics and Andreev scattering in the $\nu = 1/3$ fractional quantum Hall regime — •Anne Anthore, Pierre Glidic, Olivier Maillet, Colin Piquard, Abdel Aassime, and Frédéric Pierre — U Paris Cité, U Paris-Saclay, CNRS, C2N, Palaiseau (France)

Anyons are exotic quasiparticles which can carry a fractional charge of an electron and with an exchange statistics inbetween that of fermions and bosons. These properties were revealed using quantum point contacts (QPC) in the fractional quantum Hall regime[1,2].

In this talk, I will report further noise investigation of anyon physics. Sourcing e/3 anyons at a first QPC, noise measured on a downstream "analyzer" QPC reveals different mechanisms. Setting the analyser to allow e/3 tunneling charges, we reproduce the negative cross-correlations previously observed[2], indicative of a non-trivial anyon exchange phase[3]. When 1 e charges tunnel across the analyser, the braid phase is predicted to be trivial. Our observation of negative cross-correlations points on a scattering mechanism akin to Andreev reflection at Normal/Superconductor interfaces, as suggested in[4].

Remarkably, in both cases, electrical conduction across the analyzer conserves neither the nature nor the number of quasiparticles, rending the beam-splitter analogy of a QPC lapsed.

[1] L. Saminadayar et al., PRL 79, 2526 (1997)
[2] H. Bartolomei et al., Science 368, 173 (2020)
[3] B. Rosenow et al., PRL 116, 156802 (2016)
[4] C. L. Kane and M. P. A. Fisher, PRB 67, 045307 (2003)

TT 17.4 Mon 17:45 HSZ 304

Topological properties of a two-dimensional non-symmorphic wallpaper group lattice — •Miguel Ángel Jiménez Herrera[1] and Dario Bercioux[1,2] — [1]Donostia International Physics Center, 20018 San Sebastian, Spain — [2]IKERBASQUE, Basque Foundation for Science, Euskadi Plaza, 5, 48009 Bilbao, Spain

We investigate the topological spectral properties of a two-dimensional electronic lattice belonging to a non-symmorphic wallpaper group: the herringbone lattice. We induce the topological phase either by applying an external magnetic field perpendicular to the plane of the lattice, and by enabling spin-orbit coupling of Kane-Mele type. On the one hand, when applying a magnetic field, the bands of the lattice rearrange into Landau levels. The phase diagram of the system shows a fractal disposition of the band gaps, known as the Hofstadter butterfly. Each gap is characterized by a non-zero Chern number whose distribution follows the Diophantine equation. On the other hand, we study the effects of enabling spin-orbit coupling in the lattice. We study both bulk and ribbon geometry, to reveal the helical states appearing at the edges of the ribbon, arising from the topological properties of the bulk.

TT 17.5 Mon 18:00 HSZ 304

Hofstadter butterflies in hyperbolic space — •Alexander Stegmaier[1], Lavi Upreti[4], Ronny Thomale[1], and Igor Boettcher[2,3] — [1]Institut für Theoretische Physik und Astrophysik, Universität Würzburg, 97074 Würzburg, Germany — [2]Department of Physics, University of Alberta, Edmonton, Alberta T6G 2E1, Canada — [3]Theoretical Physics Institute, University of Alberta, Edmonton, Alberta T6G 2E1, Canada — [4]Department of Physics, University of Konstanz, 78464 Konstanz, Germany

Hofstadter's Butterfly is the spectrum of a charged particle moving in a tight binding lattice under a constant magnetic field. Beyond its well-known fractal-shaped spectrum, this model is also relevant as a prototypical topological Chern insulator.

In light of recent interest in the physics of lattices in hyperbolic space, we re-consider the problem of Hofstadter's butterfly in {p,q} lattices. They tile the hyperbolic plane, a 2D space with constant negative curvature, with regular p-gons, q of which meet at each vertex. We develop methods to calculate the bulk spectra of a hyperbolic tight-binding system and apply them to uncover the features of Hofstadter's Butterflies in hyperbolic space. We find that the move to negatively curved space destroys the spectra's fractality, but preserves features of the spectral gaps, depending on the type of tiling {p,q}.

TT 17.6 Mon 18:15 HSZ 304

Observation and applications of non-Hermitian topology in a multi-terminal quantum Hall device — •Kyrylo Ochkan[1], Viktor Könye[1], Anastasiia Chyzhykova[1,2], Jan Budich[3], Jeroen van den Brink[1], Cosma Fulga[1], and Joseph Kyrylo[1] — [1]IFW Dresden, Deutschland — [2]Taras Shevchenko National University of Kyiv, Ukraine — [3]TU Dresden, Deutschland

One of the simplest examples of non-Hermitian topology is encountered in the Hatano-Nelson (HN) model, a one-dimensional chain where the hopping in one direction is larger than in the opposite direction. We present here the first experimental observation of non-Hermitian topology in a quantum condensed-matter system. The measurements are done in a multi-terminal quantum Hall device etched in a high mobility GaAs/AlGaAs two-dimensional electron gas ring. The conductance matrix that connects the currents flowing from the active contacts to the ground with the voltage of the active contacts is topologically equivalent to the HN Hamiltonian.

In our device, we directly measure and evidence the non-Hermitian skin effect. We also compute for our experimental device two topological invariants that are found to be more robust than the Chern number. We finally use the unique properties of our system and continuously tune the system configuration between open and periodic boundary conditions.

In this talk, we present the latest developments with regard to the application of the devices with these topological properties.

TT 17.7 Mon 18:30 HSZ 304

Dirac Landau levels on a pseudosphere — •Maximilian Fürst[1], Denis Kochan[1,2], Cosimo Gorini[3], and Klaus Richter[1] — [1]Universität Regensburg, 93053 Regensburg, Deutschland — [2]Slovak Academy of Sciences, 84511 Bratislava, Slovakia — [3]Université Paris-Saclay, 91191 Gif-sur-Yvette, France

Topological insulator nanowires host Dirac-like surface states with strongly suppressed backscattering [1]. As suggested in Ref. [2], surfaces with conical singularity could host Quantum Hall states which lead to an intrinsic angular momentum quantization of an electronic fluid which is put on the tip of the singularity. Topological insulators might be a good platform to examine this experimentally. However, they host surface states with Dirac-like dispersion instead of Schrödinger-like which is assumed in Ref. [2]. This raises the question if such effect may also be observed in those systems. A first step towards the answer is to choose an appropriate surface and calculate the Dirac Landau levels on it. We choose the pseudosphere which has a conical singularity and allows for analytical solution of the emerging eigenvalue equations. The spectrum and the eigenstates are computed for a constant magnetic field which is aligned perpendicularly to the surface. We further use the tight-binding package *Kwant* [3] to verify our analytically gained results numerically (see Ref. [4]).

[1] X.-L. Qi and S.-C. Zhang, Rev. Mod. Phys. **83**, 1057 (2011)
[2] T. Can *et al.*, Phys. Rev. Lett. **117**, 266803 (2016)
[3] C. W. Groth *et al.*, New J. Phys. **16**, 063065 (2014)
[4] R. Kozlovsky *et al.*, Phys. Rev. Lett. **124**, 126804 (2020)