TT 68: Topology: Other Topics

Time: Friday 9:30–12:15 Location: H22

TT 68.1 Fri 9:30 H22

Interaction-driven quantum Hall plateau transition between a $|C| > 1$ Chern Insulator and a $\nu = 1/3$ Laughlin state in the Hofstadter model — •Leon Schoonderwoerd[1], Frank Pollmann[2], and Gunnar Möller[1] — [1]Functional Materials Group, School of Physical Sciences, University of Kent, Canterbury CT2 7NZ, United Kingdom — [2]Department of Physics, TFK, Technische Universität München, James-Franck-Straße 1, D-85748 Garching, Germany

We present numerical evidence of an interaction-driven quantum Hall plateau transition between a $|C| > 1$ Chern Insulator and a $\nu = 1/3$ Laughlin state in the Hofstadter model. We study the model using DMRG at flux densities p/q, where the lowest Landau level (LLL) manifold is made up of p magnetic sub-bands. First, we show explicit evidence that a $\nu = 1/3$ Laughlin state can be stabilised in situations where the LLL consists of multiple bands, when the interaction strength V is sufficiently high. Matching the number of magnetic subbands to $1/\nu$, the model also realises a Chern insulator at low interaction strength. We show evidence for a direct transition between these two phases at some flux densities, and we characterise the transition in terms of its critical, topological and entanglement properties.

TT 68.2 Fri 9:45 H22

Superconducting proximity effect in a fractional quantum Hall edge state — •Andreas B. Michelsen[1], Solofo Groenendijk[1], Patrik Recher[2], Tobias Meng[3], Bernd Braunecker[4], and Thomas Schmidt[1] — [1]Physics and Materials Science Research Unit, University of Luxembourg, L-1511 Luxembourg — [2]Institut für Mathematische Physik, Technische Universität Braunschweig, D-38106 Braunschweig, Germany — [3]Department of Physics, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland — [4]SUPA, School of Physics and Astronomy, University of St Andrews, North Haugh, St Andrews KY16 9SS, UK

Parafermions have emerged as a promising platform for topological quantum computation. Current proposals for their experimental realization are usually centered around inducing them in topological edge states. This can be achieved through the application of the superconducting proximity effect to a fractional quantum Hall edge state, where Cooper pairs tunnel to form Laughlin quasiparticles, which retain the pair-correlation on a significant length scale.

While induced superconductivity is rather well understood in topological insulator or integer quantum Hall edge states, the theoretical understanding of this phenomenon in fractional quantum Hall edge states is so far rudimentary. We thus expand on the understanding of this process through a microscopic investigation of the proximity effect in such edge states.

TT 68.3 Fri 10:00 H22

Ground state splitting and robust braiding of parafermions in fractional quantum hall states — •Solofo Groenendijk[1], Alessio Calzona[1,2], Edvin Idrisov[1], Hugo Tschirhart[1], and Thomas Schmidt[1] — [1]Physics and Materials Science Research Unit, University of Luxembourg, L-1511 Luxembourg — [2]Dipartimento di Fisica, Università di Genova, Via Dodecaneso 33, 16146 Genova, Italy

Parafermion bound states generalize the exchange statistics of Majorana fermions and can appear as zero-energy bound states by inducing superconductivity in fractional quantum Hall states. It has been shown that braiding them in edge states can be achieved via a series of nucleation and fusion processes, and can be useful for topological quantum computation. We study analytically and numerically the effect of the chemical potential and a finite length on such braiding protocols.

We show using a combination of bosonization and refermionization that a nonzero chemical potential μ can lift the ground state degeneracy by a factor $\delta E \propto e^{-L/\xi} \cos(\frac{\mu L}{v})$, where L is the distance between two parafermions, ξ is a correlation length and v the Fermi velocity. This generalizes a previous result which was based on a semi-classical approach. This effect destroys the robustness of the proposed braiding protocols because it causes level crossings during the braiding process.

We investigate those avoided crossings for $\mathbb{Z}_3$ parafermions and show that multiple Landau-Zener transitions occur when using conventional braiding protocols even for slow braiding speeds. We mitigate this effect by proposing a new protocol which is robust to these diabatic transitions.

TT 68.4 Fri 10:15 H22

Error-Analysis of the Chern Number in the Haldane-Hubbard Model — •Thomas Mertz, Karim Zantout, and Roser Valentí — Institut für Theoretische Physik, Goethe Universität, 60438 Frankfurt am Main, Germany

In correlated models such as the Hubbard model, the exact form of the self-energy has proven to be elusive, even to the most state-of-the-art numerical techniques. Successors to dynamical mean field theory have been developed to treat the momentum-dependent corrections, however, there is still no general consensus among these improvements.

Here, we discuss the effects of different sources of error in the self-energy on the Chern number. Our discussion puts a particular emphasis on the non-local corrections obtained on top of the dynamical mean field self-energy. In our analysis we study the Haldane-Hubbard model, however, our results should be applicable to similar models as well.

TT 68.5 Fri 10:30 H22

Spectral analysis of the finite Kitaev chain — •Nico Leumer, Milena Grifoni, and Magdalena Marganska — Institut of Physics, Regensburg

Nearly two decades ago, Kitaev published his famous toy model about the emergence of Majorana fermions in the context of spinless electrons on a chain with p-wave superconducting pairing ([1], [2]). Due to its simplicity this model is often used to explain the concepts of topological superconductors.

Despite its popularity, not much is known about the spectrum of a *finite* Kitaev chain. We report here on a spectral analysis yielding the spectrum E(k) and the eigenvectors of the finite chain in analytic form. By mapping the Kitaev chain to a system of two coupled SSH-chains, a non trivial quantisation condition for the allowed k values is found.

[1] A. Y. Kitaev, Phys. Usp. 44, (2001)
[2] R. Aguado, Riv. Nuovo Cimento 40, 16, (2017)

TT 68.6 Fri 10:45 H22

Edge spin correlations driving topological phase transition in an 1D interacting model — •Daniel Duarte, Daniela Pfannkuche, and Marta Prada — Universität Hamburg, I. Institut für Theoretische Physik, Jungiusstrasse 9, 20355 Hamburg

We study a one-dimensional Su-Schrieffer-Heeger like dimerized chain of interacting fermions by means of density matrix renormalization group on the MPS ansatz. The different spin correlation functions are studied and a phase diagram is obtained as a function of dimerization and on site interaction parameters. We find finite spin edge correlations at the transition region of the trivial topological phase and the non-trivial one. Next we characterise the topology in terms its quantum topological phase and the existence of localized spin edge states when the phase is non-trivial. We discuss the connection between the appearance of edge-spin correlations and the phase, the calculation of the phase itself and provide an extended phase diagram, complementing existing ones [1,2]

[1] B.-T. Ye, L.-Z. Mu, and H. Fan, Phys. Rev. B 94, 165167 (2016)
[2] Da Wang, S. Xu, Yu Wang and C. Wu, Phys. Rev B 91, 115118 (2015)

15 min. break.

TT 68.7 Fri 11:15 H22

Non-Hermitian systems and topology: A transfer matrix perspective — •Vatsal Dwivedi[1] and Flore Kunst[2] — [1]Institut für theoretische Physik, Zülpicher Straße 77a, 50937 Köln — [2]Department of Physics, Stockholm University, AlbaNova University Center, 106 91 Stockholm

Non-Hermitian systems are known to exhibit features strikingly different from their Hermitian counterparts, a quintessential example being the lack of a bulk-boundary correspondence in the conventional sense. In this talk, I will describe a transfer matrix approach to these systems. The algebraic structure of the transfer matrix and a Riemann surface associated with the complex energies provide a clear and intuitive picture of various topological aspects of these systems.

TT 68.8 Fri 11:30 H22

Breakdown of the topological fracton order in the X-Cube model — •Matthias Mühlhauser and Kai Phillip Schmidt — Institut für Theoretische Physik I FAU Erlangen-Nürnberg, Erlangen, Deutschland

We investigate the robustness of type-I topological fracton order under zero-temperature quantum fluctuations. To this end the exactly solvable three-dimensional X-cube model is studied in the presence of an external homogeneous magnetic field using high-order series expansions and variational techniques. It is found that the ground-state phase diagram displays first-order phase transitions between the topologically-ordered fracton phase and the polarized phase for all studied field directions. Furthermore, the spectral properties of the low-energy excitations in the fracton phase, especially so-called lineons and planons, are determined.

TT 68.9 Fri 11:45 H22

Measuring beyond the resolution limit of a detector — •Roman-Pascal Riwar — JARA Institute for Quantum Information (PGI-11), Forschungszentrum Jülich, Germany

We recently made the unexpected prediction that the non-equilibrium transport statistics of conventional sequential electron tunneling are indistinguishable from those of fractional charges – in the sense that the statistics are effectively equivalent to fractional charges, measured with a detector that can resolve only integer charges. This effect is due to a topological transition of the system-detector dynamics. Here, we consider a potential application of this effect, when we turn it on its head: if we indeed expect to have a detector with insufficient resolution, the presence of fractional processes might not be effective, but in fact real. We propose, that this could lead to the intriguing possibility of measuring discrete stochastic processes that are smaller than the resolution limit. We provide a proof of principle at the practical example of charge detectors measuring transport through localized charge islands, where the detectors are too large to resolve individual islands. Finally, we show that the effect is indeed protected, by explicitly taking into account likely sources of perturbations or measurement errors in the setup.

TT 68.10 Fri 12:00 H22

Bulk-boundary correspondence for non-Hermitian Hamiltonians — •Heinrich-Gregor Zirnstein[1], Bernd Rosenow[1], and Gil Refael[2] — [1]Institut für Theoretische Physik, Universität Leipzig, Germany — [2]Institute of Quantum Information and Matter, California Institute of Technology, USA

For sufficiently strong gain and loss, genuinely non-Hermitian topological phases can be realized and characterized by generalized topological invariants. In such phases, the Hamiltonian cannot be deformed into a gapped Hermitian Hamiltonian without the energy bands touching each other. Since the so-called non-Hermitian skin effect causes localization of all eigenstates at a boundary of the system, we discuss topological properties by focusing on response functions, which are experimental observables. In particular, a comparison of Green functions for periodic and open boundary conditions shows that in general there is no correspondence between topological invariants computed for periodic boundary conditions, and edge states observed for open boundary conditions. We prove these statements for one-dimensional systems in several symmetry classes, and discuss generalizations to higher spatial dimensions. In particular, in more than one spatial dimension, every Hamiltonian whose bands do not touch each other is topologically equivalent to a Hermitian one, and non-Hermitian topological indices are only possible when bands touch each other.