MP 1: Many-body Theory I

Time: Monday 9:30–13:00 Location: HL 001

Invited Talk MP 1.1 Mon 9:30 HL 001

Fractional Anderson model and long range self-avoiding random walk. — •Margherita Disertori[1], Constanza Rojas-Molina[2], and Roberto Maturana[1] — [1]University of Bonn, Bonn, Germany — [2]CY Cergy Paris University, Paris, France

The Anderson model with long-range interactions has been subject to increasing interest in recent years. I will review some properties and recent results connecting the corresponding Green's function with the two point function of a self-avoiding random walk with long range jumps. These results adapt a strategy proposed by Schenker in 2015 and are joint work with C. Rojas-Molina and R. Maturana.

MP 1.2 Mon 10:00 HL 001

Renormalization group analysis of a D-dimensional PT-symmetric non-Hermitian superfluid — •Eduard Naichuk[1,2], Jeroen van den Brink[1,3], and Flavio Nogueira[1] — [1]Institute for Theoretical Solid State Physics, IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany — [2]Bogolyubov Institute for Theoretical Physics, 03143 Kyiv, Ukraine — [3]Institute for Theoretical Physics and Würzburg-Dresden Cluster of Excellence ct.qmat, TU Dresden, 01069 Dresden, Germany

We analyze the phase structure of a two-component non-Hermitian PT-symmetric superfluid system in 1+1 and 2+1 dimensions. The non-Hermitian character emerges from complex off-diagonal chemical potentials in field space, which in addition cause the internal symmetry of the system to be U(1) rather than U(1)*U(1). We show that this system is effectively described by an XY model with a four-state clock interaction. The quantum critical behavior 1+1 dimension is shown to lead to three line of fixed points and a continuously varying correlation length exponent ν. When the PT symmetry is broken, on the other hand, a Berezinskii-Kosterlitz-Thouless phase transition occurs. In 2+1 dimensions the critical behavior is governed by the three dimensional XY universality class in the PT-symmetric regime when the clock interaction small. The behavior in 2+1 dimensions is radically changed when the PT symmetry is broken. Despite featuring an additional fixed point, the phase transition is a weakly first-order one.

MP 1.3 Mon 10:20 HL 001

Wrestling with the finite temperature two dimensional Fermi-Hubbard Model: A Tensor Network Attempt — •Aritra Sinha[1,2], Marek M. Rams[2], Piotr Czarnik[2], and Jacek Dziarmaga[2] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Jagiellonian University, Kraków, Poland

The Fermi Hubbard Model is a simple model of interacting electrons on a lattice. However, solving it in two dimensions has been a longstanding challenge. Recently, progress has been made with tensor network methods like infinite projected entangled pair states (PEPS), especially in understanding its ground states in the infinite-size limit. Despite this, finding finite temperature solutions remains challenging, particularly for larger lattices. Our research uses the Neighborhood Tensor Update (NTU) and infinite PEPS for imaginary time evolution, achieving temperatures as low as 0.17 times the hopping rate. We've observed disruptions in the antiferromagnetic order in lattices with slight doping at strong coupling regimes. To reach even lower temperatures, we developed a new algorithm that applies minimally entangled typical thermal states (METTS) to finite PEPS. In my upcoming presentation, I'll explore the numerical challenges we faced and the innovative tensor network strategies we developed, shedding light on the physics of the under-doped Hubbard model and offering insights applicable to other models. These findings serve as valuable benchmarks for theoretical studies and experiments with ultracold atoms.

MP 1.4 Mon 10:40 HL 001

A Topological Classification of Time Reversal Symmetric Frustrated Systems and Metamaterials — •Shayan Zahedi — Institute for Theoretical Physics, University of Cologne, Zülpicher Straße 77, D-50937 Köln

Inspired by a paper by Roychowdhury and Lawler, we classify time reversal symmetric frustrated systems and metamaterials, guided by the Bott-Kitaev classification of topological insulators and superconductors, homotopically. This is done by investigating the topology of the space of rigidity matrices which mediate between linearised degrees of freedom and ground state constraints of frustrated systems and metamaterials.

We impose canonical time reversal symmetry on rigidity matrices and obtain Z_2-equivariant iterated loop spaces of complex Stiefel manifolds whose sets of path components are our sought for topological invariants. In the presence of canonical time reversal symmetry, our computations reveal novel topological invariants beyond those in the Bott-Kitaev periodic table. The symmetry impositions on our rigidity matrices lead to Z_2-equivariance conditions introducing the three symmetry classes AIII, AIII/BDI and AIII/CII depending on the existence and type of canonical time reversal symmetry.

We achieve such a classification by extending some of the methods used to construct the Bott-Kitaev periodic table for topological insulators and superconductors from Hermitian matrices to non-Hermitian matrices, such as the flattening of singular values of rigidity matrices.

20 min. break

MP 1.5 Mon 11:20 HL 001

A simple electronic ladder model harboring Z4 parafermions — Botond Osváth[1], Gergely Barcza[2], Örs Legeza[2], Balázs Dóra[3], and •László Oroszlány[1,2] — [1]Department of Physics of Complex Systems, Eötvös Loránd University, Budapest, Hungary — [2]Wigner Research Centre for Physics, H-1525, Budapest, Hungary — [3]Department of Theoretical Physics, Institute of Physics, Budapest University of Technology and Economics, H-1111 Budapest, Hungary

Parafermions are anyons with the potential for realizing non-local qubits that are resilient to local perturbations. Compared to Majorana zero modes, braiding of parafermions implements an extended set of topologically protected quantum gates. This, however, comes at the price that parafermionic zero modes can not be realized in the absence of strong interactions whose theoretical description is challenging. In the present work, we construct a simple lattice model for interacting spinful electrons with parafermionic zero energy modes. The explicit microscopic nature of the considered model highlights new realization avenues for these exotic excitations in recently fabricated quantum dot arrays. By density matrix renormalization group calculations, we identify a broad range of parameters, with well-localized zero modes, whose parafermionic nature is substantiated by their unique 8π periodic Josephson spectrum.

MP 1.6 Mon 11:40 HL 001

Role of Quantum Geometry on Spin Fluctuations and Pairing in Chiral Superconductors — •Niclas Heinsdorf and Andreas Schnyder — Max-Planck-Institut für Festkörperforschung, Heisenbergstrasse 1, 70569 Stuttgart, Germany

Recently the B20 Weyl Semimetal RhGe has been proposed to be a topological superconductor. Chiral symmetries enforce multi-fold topological band crossings in the bulk band structure of the material's normal state and strongly enhance the quantum geometry in its proximity. The imaginary part of the quantum geometry, the Berry curvature, is well-known to result in exotic transport properties such as circular photogalvanic or spin Nernst effect, whereas its real part, the Fubini-Study metric, has been shown to favor ferromagnetic spin fluctuations. Using effective modeling and random phase approximation, we separate the effective interactions into effective mass and topological contributions, analyze the effect of quantum-geometry on the pairing and gap symmetry and discuss the presence of multipole order for RhGe and chiral superconductors in general.

MP 1.7 Mon 12:00 HL 001

The Ultra quantum critical Floquet Non-Fermi Liquid — •Likun Shi[1], Inti Sodemann Villadiego[1], Oles Matsyshyn[2], and Justin Song[2] — [1]Institute for Theoretical Physics, Leipzig University, Leipzig, Germany — [2]Division of Physics and Applied Physics, Nanyang Technological University, Singapore, Republic of Singapore

We demonstrate the existence of a quantum non-equilibrium steady state of periodically driven fermions that has no analogue in equilibrium. This state is a Floquet non-Fermi liquid state that arises for periodically driven fermions coupled to a bosonic bath. It features 'higher order Floquet Fermi surfaces' where the occupation in momentum space displays cusp-like non-analyticities, but without an associated jump or quasiparticle residue.

More intriguingly, the sharpness of these higher order Floquet Fermi surfaces survives even at finite temperatures, implying that this Floquet Non-Fermi Liquid remains quantum critical at finite temperatures. This property has no analogue in equilibrium systems because finite temperature always smears out the sharpness of the Fermi surfaces, leading the fermions to behave as a classical fluid at sufficiently large distances. We discuss how monochromatic radiation in the microwave range impinging on high-quality electronic systems is a promising regime to realize these states in experiments.

MP 1.8 Mon 12:20 HL 001

Landau quantization near generalized van Hove singularities: magnetic breakdown and orbit networks — •Vladimir A. Zakharov[1], Ahmet Mert Bozkurt[2,3], Anton R. Akhmerov[2], and Dmytro O. Oriekhov[2] — [1]Instituut-Lorentz, Universiteit Leiden, P.O. Box 9506, 2300 RA Leiden, The Netherlands — [2]Kavli Institute of Nanoscience, Delft University of Technology, Delft 2600 GA, The Netherlands — [3]QuTech, Delft University of Technology, Delft 2600 GA, The Netherlands

We develop a theory of magnetic breakdown (MB) near high-order saddle points in the dispersions of two-dimensional materials, where two or more semiclassical cyclotron orbits approach each other. MB occurs due to quantum tunneling between several trajectories, which leads to non-trivial scattering amplitudes and phases. We show that for any saddle point this problem can be solved by mapping it to a scattering problem in a 1D tight-binding chain. Moreover, the occurrence of magnetic breakdown on the edges of the Brillouin zone facilitates the delocalization of the bulk Landau level states and the formation of 2D orbit networks. These extended network states compose dispersive mini-bands with finite energy broadening. This effect can be observed in transport experiments as a strong enhancement of the longitudinal bulk conductance in a quantum Hall bar. In addition, it may be probed in STM experiments by visualizing bulk current patterns.

MP 1.9 Mon 12:40 HL 001

Unified description of the Aharonov–Bohm effect in isotropic multiband electronic systems — •Róbert Németh and József Cserti — Department of Physics of Complex Systems, ELTE Eötvös Loránd University, Pázmány Péter sétány 1/A, H-1117 Budapest, Hungary

A unified treatment of the Aharonov–Bohm (AB) effect is presented for two-dimensional multiband electronic systems possessing isotropic band structures. We propose a complex contour integral representation of the AB scattering states of an electron scattered by an infinitely thin solenoid. Moreover, we derive the asymptotic forms of these scattering states and obtain the differential cross section from those. A remarkable result is found, namely, that this cross section is the same for all isotropic systems and agrees with that obtained first by Aharonov and Bohm for spinless free-particle systems [Phys. Rev. **115**, 485 (1959)]. To demonstrate the generality of our theory, it is applied to several specific multiband systems relevant to condensed matter physics. Finally, we extend our approach to the case of the non-Abelian AB effect, that is, the scattering of particles on a gauge field corresponding to a noncommutative Lie group.