LDQCM-15 Workshop

ABSTRACTS

Speaker: Alexandre Abanov
Title: Geometric responses of Quantum Hall systems
Abstract: The fractional quantum Hall effect (FQHE) is a fascinating physical phenomenon of quantization of the Hall conductance of two-dimensional electron gas in terms of fundamental constants. The phenomenon is observed at low temperatures and in strong magnetic fields. It is characterized by a formation of a collective state of electrons — an incompressible electron liquid. The responses of this rather exotic fluid to external electromagnetic and elastic perturbations are rather geometric in nature. These responses can be compactly described by the effective action of FQHE. In this talk I will consider the geometric part of the effective action for FQHE. It consists of three terms: Chern-Simons, Wen-Zee and gravitational Chern-Simons terms. I will show how to derive the geometric part of the effective action and will discuss the physical meaning of the corresponding linear responses of FQHE. In particular, I will consider the role of framing anomaly in the theory of linear responses for FQHE.

Speaker: Fakher Assaad
Title: Correlated topological insulators and Dirac metals
Abstract: TBC

Speaker: Eddy Ardonne
Title: TBC
Abstract: TBC

Speaker: Andrea Cappelli
Title: TBC
Abstract: TBC

Speaker: Erez Berg
Title: Topological phenomena in periodically driven systems: the role of disorder and interactions
Abstract: Periodically driven quantum systems, such as semiconductors subject to light and cold atoms in optical lattices, provide a novel and versatile platform for realizing topological phenomena. Some of these are analogs of topological insulators and superconductors, attainable also in static systems.

Speaker: Emil Bergholtz
Title: Tuning between Weyl semimetals and fractional Chern insulators in frustrated materials
Abstract: Using the example of [111]-grown slabs of spin-orbit coupled pyrochlore materials, I will show that geometrical frustration adds exciting flavor and insight to seemingly disparate topological phenomena such as fractional Chern insulators and Weyl semimetals. While experiments with suitably grown pyrochlore iridates are presently underway, we point out that such slabs generically

exhibit surface states whose constant energy curves take the shape of Fermi arcs, localized to different surfaces depending on their quasi-momentum. Remarkably, these persist independently of the existence of Weyl points in the bulk revealing that the bulk-boundary correspondence is in fact not unique for topological semimetals. Moreover, we find that the surface bands generically carry a Chern number proportional to the thickness of the slab, and that for suitable parameter values, these bands are virtually dispersionless. Adding local interactions, these bands host a plethora of fractional Chern insulating phases qualitatively beyond conventional fractional quantum Hall states. If time permits, I will also briefly discuss quantum transport and the effect of disorder in three-dimensional semimetals which exhibit a novel quantum phase transition between a semimetallic phase at weak disorder and a diffusive metallic phase at strong disorder.

Speaker: Denis Bernard

Title: Statistical Aspects of Quantum State Monitoring and Applications

Abstract: Quantum trajectories of systems subjected to continuous monitoring exhibit particular stochastic behaviors such as ''progressive collapses'' and/or ''quantum jumps'', observed in various experiments, but also more peculiar features, ''quantum spikes'' which may be viewed as aborted jumps. This lecture will aim at describing some statistical properties of quantum trajectories. We shall discuss statistical aspects of progressive non-demolition weak measurements, as implemented in cavity QED for instance. We shall present a quantitative understanding of the statistics of quantum spikes and of their potential universality (in the sense that they are independent of the dynamical processes which generate them). As an illustration, we shall discuss a scheme to control quantum flux through back-action measurement providing a potential example of a mesoscopic Maxwell demon.

Speaker: B Andrei Bernevig

Title: Prediction of Weyl Semimental in TaAs

Abstract: Weyl Semimetals are a new phase of matter whereby the metallic behavior is protected by the Fermi Surface topology. I will discuss our recent prediction of a Weyl semimetal phase in TaAs - which was subsequently discovered experimentally - and then present two new materials where we predict Weyl physics will occur. One of these materials hosts a completely new, previously unknown type of Weyl semimetal. This new Weyl type exhibits a different type of chiral anomaly, and appears in high-symmetry planes in materials with Mirror and C_2 symmetries. We then present a general route towards searching for Weyl semimetals based on the material symmetries, and classify all the possible types of Weyls based on the theory of quadric surfaces.

Speaker: Sebastian Diehl

Title: Topology by Dissipation in Atomic Fermion Systems

Abstract: Controlled dissipation can be used as a resource to drive a many-body system into quantum mechanically ordered states from an arbitrary initial one. We discuss this concept in the context of atomic fermions, highlighting a dissipatively induced pairing mechanism, which is operative in the absence of attractive forces. We show how this targeted cooling can be utilized to cool atomic fermions into topologically non-trivial states in one dimension by quasi-local dissipative operations, and point out a possible physical implementation. This realizes a dissipative analog of the ground state of Kitaev's quantum wire. In higher dimensions, the analogy to Hamiltonian ground states breaks down due to a fundamental incompatibility of topology and locality. We present a new quasi-local dissipative mechanism for the preparation of Chern insulators, which bypasses these obstacles by making use of the intrinsic open system character of the preparation process, with no Hamiltonian counterpart. This greatly extends the scope of efficiently attainable topological symmetry classes via tailored dissipation.

Speaker: Benjamin Doyon
Title: Non-equilibrium steady states in many-body quantum systems
Abstract: Let an infinite, homogeneous, many-body quantum system be unitarily evolved for a long time from a state where two halves are independently thermalized. If there are nonzero steady currents in the central region then we say that a non-equilibrium steady state emerges.

Speaker: Fabian Essler
Title: Threshold singularities in 1D interaction fermion models
Abstract: TBC

Speaker: Paul Fendley
Title: A parafermionic avatar of the MBL transition
Abstract: TBC

Speaker: Andrew Green
Title: Field Theories over MPS states
Abstract: Tensor networks embody deep insights about the entanglement structure of many-body quantum systems. In one dimension, they have led to algorithms that can determine groundstates and follow time evolution with remarkable precision. Entanglement is treated in a very different way in field theories of quantum systems. These are constructed in such a way that the saddle points do not support entanglement â which is introduced by instanton or fluctuation corrections. We lift some of the insights about entanglement structure from tensor networks to field theory. Our approach is to explicitly construct a field integral for the partition function over matrix product states, rather than coherent states. The saddle points of such a theory support entanglement in a way that bears interesting comparison with fluctuation and instanton corrections to the usual field theory. In contrast to numerical applications of tensor networks, where the bond order is increased until a certain degree of accuracy is attained, in this field theoretical application, qualitatively new features appear even at low bond order. We demonstrate this by discussing the field theory of certain deconfined quantum critical points.

Speaker: Mohammad Hafezi
Title: Topological states in driven photonic systems
Abstract:

Speaker: F. Duncan. M. Haldane
Title: Geometrodynamics of the fractional quantum Hall effect
Abstract: The fractional quantum Hall effect in a partially-filled Landau level I can be described as a condensation of "composite bosons" formed by "flux-attachment" of q flux quanta to a cluster of p particles. This flux attachment gives rise to a intrisinc geometry characterized by a dynamical

spatial metric tensor field. This leads to an effective theory of the incompressible fluid and the origin of the gap.

Speaker: Lisa Huijse
Title: TBC
Abstract: TBC

Speaker: Robert Konik
Title: Quantum stutter: arrested expansion without a lattice and impurity snaking
Abstract: We consider the real time dynamics of an initially localized distinguishable impurity injected into the ground state of the Lieb-Liniger model. Focusing on the case where integrability is preserved, we numerically compute the time evolution of the impurity density operator in regimes far from analytically tractable limits. We find that the injected impurity undergoes a stuttering motion as it moves and expands. For an initially stationary impurity, the interaction-driven formation of a quasibound state with a hole in the background gas leads to arrested expansion -- a period of quasistationary behavior. When the impurity is injected with a finite center of mass momentum, the impurity moves through the background gas in a snaking manner, arising from a quantum Newton's cradle-like scenario where momentum is exchanged back-and-forth between the impurity and the background gas.

Speaker: Austen Lamacraft
Title: The fine structure of quantum hall edge states
Abstract: The edge states of Fractional Quantum Hall (FQH) fluids in harmonic traps are described exactly by Wen's Chiral Luttinger Liquid (CLL) theory. Motivated by the possibility of realising FQH states in atomic gases, we study how the degeneracies of the CLL theory are lifted by anharmonicity in the trapping potential. We interpret our results for the spectral function in the light of the nonlinear Luttinger Liquid. This is joint work with Tom Price.

Speaker: Andreas Lauchli
Title: TBC
Abstract: TBC

Speaker: Miguel A. Martin Delgado
Title: Symmetry-Protected Topological Orders at Finite Temperature
Abstract: We construct a topological invariant that classifies density matrices of symmetry-protected topological orders in two-dimensional fermionic systems. As it is constructed out of the previously introduced Uhlmann phase, we refer to it as the topological Uhlmann number nU. With it, we study thermal topological phases in several two-dimensional models of topological insulators and superconductors, computing phase diagrams where the temperature T is on an equal footing with the coupling constants in the Hamiltonian. Moreover, we find novel thermal-topological transitions between two non-trivial phases in a model with high Chern numbers. At small temperature we recover the standard topological phases as the Uhlmann number approaches to the Chern number.

Speaker: Dragan Mihailovic
Title: Ultrafast Switching to a Stable Hidden Quantum State in an Electronic Crystal

Abstract: Hidden states are distinct from thermodynamic phases of matter, and cannot be reached under ergodic conditions. We present an example where a hidden many body quantum state is reached under non-equilibrium conditions by laser excitation of an electronic crystal (TaS2). The mechanism relies on the separation of the fundamental degrees of freedom under nonequilibrium conditions: a transient particle-hole asymmetry creates conditions under which a long-range ordered state is formed, which is topologically distinct from the ground state. The long range order and topology ensures long-term stability of the quantum state. I will show different ways to manipulate the hidden state transition experimentally discuss the conditions for treating the transition to the hidden state in terms of macroscopic quantum tunneling between many-body states.

Speaker: Frederic Mila
Title: Exact diagonalizations of SU(N) Heisenberg models taking full advantage of SU(N) symmetry
Abstract: The SU(N) Heisenberg model, which describes some special cases of quantum magnetism, is attracting increasing attention these days because it is the generic model of the Mott insulating phase of ultracold fermionic atoms with internal degrees of freedom. For alkaline earths, N can be as large as 10 since it is related to the nuclear spin by N=2I+1. For such large values of N, working in the subpace of fixed number of colors - the equivalent of fixed total Sz for SU(2) - is not sufficient because the Hilbert space of the smallest relevant clusters is already much too large. In this talk, I will describe a simple way to take full advantage of the SU(N) symmetry, i.e. to work directly in the irreducible representations of SU(N). This allows one to perform exact diagonalizations for cluster sizes in the range 20-30 sites regardless of the value of N. I will present some results obtained in this way on the square and other lattices for the fundamental representation at each site, and I will briefly discuss our current efforts to extend the method to more complicated representations, as well as to other types of numerical simulations.

Speaker: Joel Moore
Title: Non-equilibrium transport and optical probes of topological phases
Abstract: TBC

Speaker: Giuseppe Mussardo
Title: Off-equilibrium QFT
Abstract: I will discuss off-equilibrium features of QFT.

Speaker: Philip Phillips
Title: Optical conductivity in the cuprates from holography and unparticles
Abstract: In the undoped state, the cuprates exhibit an optical conductivity that is featureless at frequencies less than 1eV. By contrast the doped state exhibits low-energy and mid-infrared features whose integrated intensity exceeds the number of dopant carriers as would be anticipated for doping a semiconductor. This excess intensity can only be understood if one invokes an effective high-low-energy mixing and hence the number of low-energy degrees of freedom is dictated by the high-energy scale. I will review how such mixing is expected from doping the Hubbard model and the modern attempts to understand the mid-infrared power law based on holography and a scale-invariant sector termed unparticles. I will show that within holography, no power-law scaling of the optical conductivity obtains in the mid-infrared regime. Within an unparticle construction, I show

how such power laws can be produced. The key feature here is a large anomalous dimension. I will discuss how such large anomalous dimensions arise from UV-IR mixing.

Speaker: Thilo Plucker
Title: TBC
Abstract: TBC

Speaker: Tomaz Prosen
Title: New quasi-local concerved operators in XXX spin 1/2 chain
Abstract: I will outline a simple procedure which yields new familes of quasi-local conserved operators of Heisenberg spin 1/2 chains that are linearly independent from all well known local conserved operators (charges).

Speaker: Enrico Randellini
Title: TBC
Abstract: TBC

Speaker: Hubert Saleur
Title: Conformal loop ensembles and Liouville at c<1
Abstract: I will discuss preliminary observations about the relationship between Liouville theory at central charge c<1 and geometrical loop models.

Speaker: Jörg Schmiedmayer
Title: Solving a Quantum Many Body Problem by Experiment
Abstract: The knowledge of all correlation functions of a system is equivalent to solving the corresponding quantum many-body problem. If one can identify the relevant degrees of freedom, the knowledge of a finite set of correlation functions is in many cases sufficient to determine a sufficiently accurate solution of the corresponding field theory. Complete factorization is equivalent to identifying the relevant degrees of freedom where the Hamiltonian becomes diagonal. I will give examples how one can apply this powerful theoretical concept in experiment. A detailed study of non-translation invariant correlation functions reveals that the pre-thermalized state a system of two 1-dimensional quantum gas relaxes to after a splitting quench [1], is described by a generalized Gibbs ensemble [2]. This is verified through phase correlations up to 10th order. Interference in a pair of tunnel-coupled one-dimensional atomic super-fluids, which realize the quantum Sine-Gordon / massive Thirring models, allows us to study if, and under which conditions the higher correlation functions factorize [3]. This allowed us to characterize the essential features of the model solely from our experimental measurements: detecting the relevant quasi-particles, their interactions and the different topologically distinct vacuum-states the quasi-particles live in. The experiment thus provides a comprehensive insights into the components needed to solve a non-trivial quantum field theory. Our examples establish a general method to analyse quantum systems through experiments. It thus represents a crucial ingredient towards the implementation and verification of quantum simulators. Work performed in collaboration with E.Demler (Harvard), Th. Gasenzer und J. Berges (Heidelberg). Supported by the Wittgenstein Prize, the Austrian Science Foundation (FWF): SFB FoQuS: F40-P10 and the EU: ERC-AdG QuantumRelax [1] M. Gring et al., Science, 337, 1318 (2012).

Speaker: Steven Simon
Title: Status Report on Superconductivity in Strontium Ruthenate
Abstract: TBC

Speaker: Maarten Wegewijs
Title: Gauge freedom in transport through quantum dots: interaction-induced geometric pumping
Abstract: Authors: M. R. Wegewijs, T. Pluecker, J. Splettstoesser, H. Calvo Quantum dots are electrically controlled structures in which electrons confined to a single orbital are responsible for quantum transport, ranging from fabricated heterostructures down to single atoms. Adiabatic driving of bias and gate voltages applied to a quantum dot was found to result in a pumping of charge [1] and in a static magnetic field one can pump spin [2] without pumping charge. Strikingly, both of these nonequilibrium pumped quantities were shown to be entirely due to Coulomb interaction. Additionally, they also turn out to be geometric quantities, providing elementary examples of open-system geometric phases generated by interaction. In this talk I will discuss the gauge freedom in such open quantum systems which underlies this geometric structure from two different angles: (A) Landsberg's adiabatic-response approach to general dissipative systems with symmetry [3] and (B) the strictly adiabatic counting-statistics approach to pumping of Sinitsyn-Nemenman [4]. The apparent discrepancy between these approaches regarding adiabaticity is clarified by physically accounting for the "counter" device (charge detector) and applying the standard Lidar-Sarandy adiabatic approximation for open systems – generalizing Berry's closed system geometric phase. Moreover, we identify the precise relation between the apparently different gauge freedom in approaches (A) and (B) and physically relate both to the literal "gauging" of the "counter" which detects the pumping. These relations allow one to exploit geometric insights within the encompassing real-time diagrammatic density-operator framework which is able to access pumped physical observables beyond the Born-Markov approximation. It allows the required time-evolution kernel superoperators to be calculated systematically, combining real-time diagrammatics, superoperator fermion-fields [5], and field-theoretical techniques such as renormalized perturbation theory and renormalization-group flow for open quantum systems [6]. [1] F. Reckermann, J. Splettstoesser, and M. R. Wegewijs Interaction-induced adiabatic nonlinear transport Phys. Rev. Lett. 104, 226803 (2010) [2] H. L. Calvo, L. Classen, J. Splettstoesser, and M. R. Wegewijs Interaction-induced charge and spin pumping through a quantum dot at finite bias. Phys. Rev. B 86, 245308 (2012) [3] See for a review A. S. Landsberg, Mod. Phys. Lett. B 7, 71,1993 [4] See for a review N. A. Sinitsyn, J. Phys. A: Math. Theor. 42,193001 (2009) [5] O. Kashuba, H. Schoeller and J. Splettstoesser, Nonlinear adiabatic response of interacting quantum dots Eur. Phys. Let.. 98, 57003 (2012) [6] R. B. Saptsov and M. R. Wegewijs Fermionic superoperators for zero-temperature nonlinear transport: Real-time perturbation theory and renormalization group for anderson quantum dots Phys. Rev. B 86, 235432 (2012).