universität innsbruck

Institut für Theoretische Physik

Quantenvielteilchenphysik

Hearings für die Besetzung einer Laufbahnstelle

am Institut für Theoretische Physik der Universität Innsbruck

Vorträge (mit Ausnahme von Dr. Sieberer): Raum SR 1, im EG im ICT-Gebäude, Campus Technik

Vortrag Dr. Sieberer: Raum 2S17, im 1. OG Süd im ICT-Gebäude, Campus Technik

Montag, 21.10.2019

08:30 Vincenzo Alba, University of Amsterdam:

SR 1 *Hydrodynamic platform for out-of-equilibrium entangled many-body systems*

Abstract:

Entanglement and entropy are key concepts standing at the foundations of quantum and statistical mechanics, respectively. In the last decade the study of quantum quenches revealed that these two concepts are intricately intertwined. For integrable models, novel hydrodynamic approaches based on a quasiparticle picture emerged as a new platform allowing for a quantitative understanding of quantum information dynamics in quantum many-body systems. Remarkably, this gives fresh insights on how thermodynamics emerges in isolated out-of-equilibrium quantum systems.

I will start by reviewing this new unifying framework. I will then discuss several applications to entanglement-related quantities, such as entanglement entropies, mutual information, logarithmic negativity. I will also show how the framework allows to study the interplay between quantum information dynamics and transport of local conserved quantities. Finally, I will derive some simple bounds on the quantum information scrambling in out-of-equilibrium systems.

09:15 Bruno Bertini, University of Ljubljana:

SR 1 *Out of equilibrium many-body dynamics: from integrability to chaos*

Abstract:

Understanding the general principles behind the dynamics of isolated quantum matter is one of the major challenges of theoretical physics. In the last fifteen years this field experienced a vigorous renaissance mainly driven by experimental breakthroughs. In this talk I will describe my main contributions to this research. The talk will be divided in two parts, representing my two main research strands.

The first part will concern the out-of-equilibrium dynamics of systems with (nearly) integrable interactions. I will summarise my key results on the analytical description of the finite-time dynamics and prethermalization in homogeneous interacting quantum systems. Then, I will present a hydrodynamic theory for inhomogeneous interacting quantum systems with a macroscopic number of conservation laws [1, 2, 3]. This theory, known as "generalized hydrodynamics" (GHD), has been recently shown to describe actual cold-atom experiments [4].

The second part of the talk concerns my works on spectral and dynamical properties of many-body quantum chaotic systems [5, 6, 7]. These works showed that — very surprisingly — exact calculations are possible even in this context. In particular, I will present an exact calculation of the entanglement spreading in the quantum-chaotic "self dual" kicked Ising model [6] and discuss the key mathematical property allowing for this exact result, identifying an entire class of such "solvable" chaotic systems [7].

[1] Bertini and Fagotti, PRL 117, 130402 (2016).

[2] Bertini, Collura, De Nardis, and Fagotti, PRL 117, 207201 (2016).

[3] Castro-Alvaredo, Doyon, Yoshimura, PRX 6, 041065 (2016).

[4] Schemmer, Bouchoule, Doyon, and Dubail, PRL 122, 090601 (2019).

[5] Bertini, Kos, and Prosen, PRL 121, 264101 (2018).

[6] Bertini, Kos, and Prosen, PRX 9, 021033 (2019).

[7] Bertini, Kos, and Prosen, arXiv:1904.02140 (PRL in print).

10:15 Lukas Sieberer, University of Innsbruck and IQOQI:

2S17 <u>Field theories for quantum many-body systems out of equilibrium: Recent progress and open challenges</u>

Abstract:

Field theory provides us with powerful analytical tools to describe phases and phase transitions of quantum matter. While the formalism is highly developed for systems in thermal equilibrium, there are fundamental open challenges in quantum many-body systems out of equilibrium. Such systems are moved into focus by the rapid experimental progress in controlling, on the one hand, open quantum systems at the interface of quantum optics and condensed matter physics, and, on the other hand, closed systems, in which the interplay of periodic Floquet drive and disorder can induce exotic nonequilibrium quantum phases. In my talk, I will first present my recent results concerning the nature of the superfluid transition in two-dimensional anisotropic quantum fluids of light. I will describe, how the celebrated theory of Kosterlitz and Thouless for the vortex-unbinding transition in superfluid films in thermal equilibrium

is modified by nonequilibrium conditions and strong spatial anisotropy. This analysis is based on nonequilibrium Keldysh field theory. Second, I will discuss my plans to advance field theories for quantum many-body systems out of equilibrium with applications to topological phases in driven-open systems, Anderson transitions in Floquet matter, and many-body systems under continuous observation.

14:00 Sergej Moroz, Technical University Munich:

SR 1 *Confined phases of one-dimensional spinless fermions coupled to Z_2 gauge theory*

Abstract:

I will present our recent study of a quantum many-body lattice system of one-dimensional spinless fermions interacting with a dynamical Z2 gauge field. The gauge field mediates long-range attraction between fermions resulting in their confinement into bosonic dimers. At strong coupling we developed an exactly solvable effective theory of such dimers with emergent constraints. I will show that even at generic coupling and fermion density, the model can be rewritten as a local spin 1/2 chain and forms a Luttinger liquid. In a finite chain we observed the doubling of the period of Friedel oscillations which paves the way towards experimental detection of confinement in this system. Finally, I will also discuss the possibility of a Mott phase at the commensurate filling 2/3.

14:45 Michael Scherer, University of Cologne:

SR 1 *Correlated moiré heterostructures, quantum criticality and the renormalization group*

Abstract:

The recent discovery of correlated insulators and superconductivity in moiré heterostructures has opened a novel and exciting route for controlled studies of correlated electrons. In my talk, I will present different modern renormalization group approaches directed towards the description of various aspects of such quantum many-electron systems and beyond:

(1) The electron functional renormalization group serves as a weak-coupling approach for an unbiased determination of the leading ordering tendencies in moiré heterostructures. Near a van-Hove singularity it predicts interaction-induced topological quantum anomalous Hall state and topological superconductivity.

(2) The pseudo-fermion functional renormalization group aims at studying the strong-coupling regime of an effective spin-valley model for moiré heterostructures and exhibits an extended spin-valley entangled quantum liquid and ferromagnetic correlations.

(3) Dirac electrons of twisted bilayer graphene may feature quantum critical behavior in the Gross-Neveu universality class. I will present our recent four-loop perturbative renormalization group studies aiming at a quantitative determination of critical exponents and point out the state of the art by comparison to quantum Monte Carlo and the conformal bootstrap.

(4) Then, I will discuss our recent results on the loss of conformality and Miransky scaling in the Abelian-Higgs model which has become pivotal in the description of deconfined quantum criticality. We predict a hierarchy of correlation length scales between different SU(N) models, which may be detected in future numerical simulations.

Dienstag, 22.10.2019

09:00 Michael Buchhold, Institute for Quantum Information and Matter (IQIM), Caltech:

SR 1 *Criticality, self-organization and scale invariant avalanches in spin dynamics away from thermal equilibrium*

Abstract:

The appearance of scale invariance and diverging response functions in many-body systems is inseparably linked to the presence of a critical point and spontaneous symmetry breaking. In thermal equilibrium critical points mostly correspond to isolated spots in parameter space, which require rather strong fine tuning of e.g., the temperature of magnetic fields, in order to be reached. Pushing systems away from thermal equilibrium, e.g., by exposing them to external drive fields or dissipation, can give rise to more unconventional forms of criticality. External driving and dissipation may even turn critical points robust and attractive, imposing scale invariance for a large variety of external parameters, a phenomenon known as self-organized criticality (SOC).

I will discuss the manifestation of SOC in driven dissipative cold atom ensembles, for which a direct mapping of their microscopic parameters to an SOC field theory exists. This yields an opportunity to study SOC, typically associated with hard-to-control, large scale non-equilibrium setups, such as earthquakes, solar flares, or neural networks, under very controlled conditions. I will briefly introduce the theoretical challenges for a quantum theory of self-organized criticality and point out current steps towards their realization.

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09:45 Mathias Scheurer, Harvard University:

SR 1 *<u>Gauge theories for the strongly coupled Hubbard model</u>*

Despite its simple appearance, the two-dimensional Hubbard model gives rise to very rich physics. It is widely believed to be a minimal model for the high-temperature superconductors, capable of capturing the multitude of complex phases of these materials. However, a complete understanding of its phase diagram is still missing despite extensive experimental, computational, and analytical studies. In this talk, I will discuss gauge theories we have proposed to understand various aspects of the strongly coupled Hubbard model at zero and finite doping. The first and main part of the talk is motivated by the recent thermal Hall measurements [1] that have challenged our understanding even of the undoped system, which was previously thought to be just a conventional Néel state. I will introduce our proposal [2] that the strong magnetic field applied in experiment drives the Néel state close to a state where Néel order coexists with a chiral spin liquid; as demonstrated explicitly in a spinon lattice model, this leads to the enhanced thermal Hall response seen in experiment. We will discuss the low-energy continuum field theory for the transition which is found to have interesting properties. In the second part, I will review our recent work [3-6] on effective field theories for the pseudogap phase of the doped Hubbard model, in particular, the direct comparison of predictions of these theories with both numerics [3] and experiment [4].

[1] Nature 571, 376 (2019).

[2] arXiv:1903.01992 (2019) [to appear in Nature Physics].

[3] PNAS 115, E3665 (2018).

[4] PNAS 116, 3449 (2019).

[5] Phys. Rev. Lett. 119, 227002 (2017).

[6] Phys. Rev. B 99, 054516 (2019).