Program and abstracts

Program

Thursday, january 26, 2023

- 14:30-15:15 D. Bernard
  The Quantum SSEP and the emergence of free probability in noisy mesoscopic systems
- 15:20-16:05 P. Calabrese
  The quantum Mpemba effect and entanglement asymmetry
- 16:10-16:40 COFFEE BREAK
- 16:40-17:25 J. Moore
  Dynamics in integrable and non-integrable low-dimensional quantum systems
- 17:30-18:15 M. Znidaric
  Relaxation in local many-body Floquet systems

Friday, january 27, 2023

- 9:30-10:15 D. Abanin
  Influence functionals, temporal entanglement, and quantum many-body dynamics
- 10:20-11:05 W. De Roeck
  Rigorous results on the many-body-localization avalanche model
- 11:10-11:40 COFFEE BREAK
- 11:40-12:25 A. Scardicchio
  Localization and melting of interfaces in the two-dimensional quantum Ising model
- 12:30-14:30 LUNCH BREAK
- 14:30-15:15 C. Di Castro
  New quantum criticality for the strange metal and Planckian behavior in high temperature superconductors
- 15:20-16:05 V. Mastropietro
  Quantum transport and small divisors
- 16:10-16:55
  Round table and concluding remarks

Abstracts

D. Abanin: *Influence functionals, temporal entanglement, and quantum many-body dynamics*

We will describe dynamics of a many-body system by its Feynman-Vernon influence functional (IF), which encodes the properties of the system as a quantum bath. In addition to exact solutions in certain integrable and non-integrable models, in many relevant cases IF can be efficiently computed using tensor-networks methods, thanks to favourable scaling of its temporal entanglement. This approach also leads to an intriguing reformulations of the many-body localization problem in terms of disorder-averaged quantities. Influence-functional approach offers a new lens on non-equilibrium many-body phenomena, both in ergodic and non-ergodic regimes, connecting theory of open quantum systems to quantum statistical physics.

D. Bernard: *The Quantum SSEP and the emergence of free probability in noisy mesoscopic systems*

An alternative title could have been "How to characterise fluctuations in diffusive out-of-equilibrium many-body quantum systems?" In general, the difficulty to characterise non-equilibrium systems lies in the fact that there is no analog of the Boltzmann distribution to describe thermodynamic variables and their fluctuations. Over the last 20 years, however, it was observed that fluctuations of diffusive transport show universal properties that do not depend on the microscopic details. The general framework to characterise these systems from a macroscopic point of view is now called the "Macroscopic Fluctuation Theory". A natural question is whether this framework can be extended to quantum mechanics to describe the statistics of purely quantum mechanical effects such as interference or entanglement in diffusive out-of-equilibrium systems. With this aim in mind, I will introduce the Quantum Symmetric Simple Exclusion Process (Q-SSEP), a microscopic model system of fluctuating quantum diffusion. I will in particular present the recent observation that fluctuations of coherences in Q-SSEP have a natural interpretation as free cumulants, a concept from free probability theory, and heuristic arguments why we expect free probability theory to be an appropriate framework to describe coherent fluctuations in generic mesoscopic systems.

P. Calabrese: *The quantum Mpemba effect and entanglement asymmetry*

Symmetry and symmetry breaking are two pillars of modern quantum physics. However, quantifying how much a symmetry is broken is an issue that has received little attention. In extended quantum systems, this problem is intrinsically bound to the subsystem of interest. In this talk, we borrow methods from the theory of entanglement in many-body quantum systems to introduce a subsystem measure of symmetry breaking that we dub entanglement asymmetry. As a prototypical illustration, we study the entanglement asymmetry in a quantum quench of a spin chain in which an initially broken global U(1) symmetry is restored dynamically. We find the counterintuitive result that more the symmetry is initially broken, faster it is restored, a quantum Mpemba effect.

W. De Roeck: *Rigorous results on the many-body-localization avalanche model*

A few years ago, we proposed a toy model featuring the instability of many body localization in dimension higher than 1 and for large localization lengths. I refer to this model as the avalanche model. In this talk I will present some recent rigorous results on this model and I try to put this into a broader context.

C. Di Castro: *New quantum criticality for the strange metal and Planckian behavior in high temperature superconductors*

The recent high-resolution RIXS (resonant inelastic X-ray scattering) experiments have given a new impulse to the physics of cuprates [1]. In particular, the newly discovered short-range dynamical charge density fluctuations [2], precursors of the three-dimensional charge density waves, account for the long-standing problem of the strange metal behaviour of the cuprates [3]. Due to their broadness, charge density fluctuations mediate an almost isotropic scattering among the Fermi quasiparticles. For temperatures greater than their characteristic energy (proportional to the inverse correlation length squared and to the inverse dissipation parameter), their scattering provides the famous linear-in-T resistivity [3]. The linearity and a seemingly divergent specific heat [4] are then extended to the lowest temperatures by an increase of the damping of the fluctuations while the correlation length stays finite [5], thus providing the so called Planckian behavior. Namely, in [5] we are proposing a new paradigm in contrast with the standard hot-spot model. Usually, the diverging correlation length is invoked to produce quantum criticality, here the strange-metal behaviour with linear resistivity and a diverging specific heat occurring near an anomalous QCP can be attributed to and accounted for by the increase of the damping parameter only. When the damping increases by lowering the temperature, the CDFs relax at longer and longer times giving rise to a glass of islands (finite correlation length) of CDFs. We are now developing a theory for enhanced dissipation which would lead to this “anomalous” quantum criticality [6].

References:
[1] R. Arpaia, G. Ghiringhelli: Charge order at high temperature in cuprate superconductors, J. Phys. Soc. Jpn. 90, 111005 (2021)
[2] R. Arpaia et al: Dynamical charge density fluctuations pervading the phase diagram of a copper-based high-Tc superconductor, Science 365, 906 (2019)
[3] G. Seibold et al: Strange metal behaviour from charge density fluctuations in cuprates, Commun. Phys. 4, 7 (2021)
[4] B. Michon et al: Thermodynamic signatures of quantum criticality in cuprate superconductors, Nature 567, 218222 (2019)
[5] S. Caprara, C. Di Castro, G. Mirarchi, G. Seibold, M. Grilli: Dissipation-

driven strange metal behavior, Commun. Phys. 5, 10 (2022)
[6] M. Grilli, C. Di Castro, G.Seibold, S.Caprara: Disorder-driven dissipative quantum criticality as a source of strange metal behavior, arXiv:2205.10876

V. Mastropietro: *Quantum transport and small divisors*

We present two rigorous results on the effect of quasi-periodic disorder and interaction in 3d fermionic systems at zero temperature. In the first we prove the stability of Weyl semimetals with Hubbard interaction under the presence of a weak quasi-periodic potential; in the second we prove the vanishing of the Drude weight in lattice fermions with strong quasi periodic potential and Hubbard interaction. The proof combines exact RG methods with number theoretical properties and KAM theory. Due to the presence of small divisors, physical informations cannot be be extracted by lower order analysis but are typically encoded in the convergence or divergence of the whole series.

J. Moore: *Dynamics in integrable and non-integrable low-dimensional quantum systems*

This talk starts with a quick review of a decade of rapid progress in the dynamics of integrable one-dimensional systems, culminating in the prediction and experimental observation of Kardar-Parisi-Zhang dynamics in Heisenberg spin chains. The key idea is a kind of hydrodynamics, previously introduced in the context of classical dense integrable systems, based on a modified Boltzmann-like integrodifferential equation that describes the long-time behavior and can be checked against numerics. The observation of integrable dynamics, at least approximately, in real systems raises the question of how integrability-breaking perturbations affect the dynamics, and we discuss this question in several problems including the non-equilibrium behavior of generic one-dimensional metals. The end of the talk discusses how some of these ideas apply in higher dimensions, for example at the boundaries of topological states, and how a better understanding of far-from-equilibrium dynamics is necessary for current quantum calculations.

A. Scardicchio: *Localization and melting of interfaces in the two-dimensional quantum Ising model*

I will show how the melting of a smooth interface in the 2D Ising model in transverse and longitudinal fields shows signs of localization. This is done by means of a holographic mapping to a 1D integrable model of fermions in the large ferromagnetic coupling J limit and after the systematic introduction of $1/J$ corrections.

M. Znidaric: *Relaxation in local many-body Floquet systems*

We would like to understand relaxation towards a long-time steady state under unitary pure state evolution. Focusing on a bipartite entanglement, or on out-of-time-ordered correlations, one finds that the relaxation rate typically exhibits a jump at an extensive time. Furthermore, building on some solvable cases of random circuits one finds that this non-uniform relaxation can be traced back to interesting non-Hermitian physics. Relaxation is not given by the 2nd largest eigenvalue of the Markovian matrix, as one would expect, but rather by a phantom eigenvalue – an eigenvalue that is not in the spectrum of any finite matrix. Resolution of this puzzle will lead to a pseudospectrum and a realization that when dealing with finite non-Hermitian matrices it can happen that being exact is actually wrong, while being slightly wrong is correct.