Adriatic Conference on Strongly Correlated Systems

Schedule & Abstract book v2

Dates: March 22th-24th

Online conference at ICTP organized by:
-Adriano Angelone
-Pierre Fromholz

Scientific board:
-Adriano Angelone
-Pierre Fromholz

Local organizer:
-Rozario Fazio

Sponsor:
ICTP

1. Schedule

	Monday 22th	Tuesday 23th	Wednesday 24th
8.40 - 9	**Welcome + remarks**		
9 - 10	Stefano Scopa	Shraddha Sharma	
10 - 11	Karen Hovhannisyan	Emanuele Tirrito	Giuseppe Magnifico
11 - 12	Aritra Kundu	Andrea Richaud	Kevin Falls
12 - 13.30	Break		
13.30 - 14.30	Andrei Pavlov	Spyros Sotiriadis	Ana Laura Gramajo
14.30 - 15.30	Giuliano Chiriacò	Simone Notarnicola	Piotr Sierant
15.30 - 16			**Closing remarks**

Up to two additional guest talks from ICTP associates may also be included in the schedule.

Chairs:

	Chair	Title of the session
Session 1	Piotr Siearant	Gapless or long-time correlations
Session 2	Aritra Kundu	Non-equilibrium transport
Session 3	Giuseppe Magnifico	Fermionic and bosonic models
Session 4	Shraddha Sharma	Numerics for Quantum simulators
Session 5	Spyros Sotiriadis	Non-perturbative approaches
Session 6	Andrei Pavlov	Non-equilibrium: localization and entanglement

2. Abstract book

Session 1: Gapless or longtime correlations

Speaker: Stephano Scopa

Affiliation: SISSA

Title: Correlation functions of interacting 1d anyonic gases

Abstract: In this seminar, I will investigate the correlation functions of a 1d gas of particles with generalized statistics, aka of the so-called anyonic particles. In particular, I will provide a thorough characterization of the one-particle density matrix at zero temperature and at finite interactions, extending the known results for the limit of infinite repulsion. To do this aim, I will briefly revisit the Bethe-Ansatz solution and the Luttinger-liquid description of 1d anyonic gases with point-wise interactions. Finally, I will focus on trapped gases with non-trivial density profiles. By exploiting recent analytic and numerical techniques for inhomogeneous Luttinger liquids, I will present the results for the one-particle density matrix in different confining potentials, highlighting the main differences with respect to bosonic gases.

Speaker: Karen Hovhannisyan

Affiliation: ICTP

Title: Analog of many-body Berry–Esseen theorem for critical systems

Abstract: Energetic spectra of many-body systems are impenetrably complex, and very little can be said about them in general. Nonetheless, certain general statements can be made about probability distributions of many-body systems' energies. Most notably, the many-body Berry–Esseen theorem establishes that the energy distribution of a locally interacting quantum lattice Hamiltonian becomes Gaussian in the thermodynamic limit as long as the correlation length is finite. In this talk, I will present a result similar to the Berry–Esseen theorem that extends to lattices with diverging correlation lengths. More specifically, I will show that the energy distribution of a translation-invariant lattice at a finite-temperature phase transition point tends to a Gaussian as long as its specific heat diverges logarithmically in the thermodynamic limit. For systems with polynomially diverging specific heats, the energy distribution is still unimodal, with exponentially decaying tails, but Gaussianity is no longer guaranteed.

Speaker: Aritra Kundu

Affiliation: SISSA

Title: Revisiting Mazur-Suzuki bound for finite systems

Abstract: The Mazur/Suzuki inequality gives a lower bound on the long-time saturation value of time-dependent auto-correlation function of observables in terms of equilibrium correlation functions involving conserved quantities. We discuss the bounds for small systems and find that inclusion of products of conserved quantities improves the bound.

Session 2: Non-equilibrium transport

Speaker: Andrei Pavlov

Affiliation: ICTP

Title: Quantum thermal transport in the Sachdev-Ye-Kitaev quantum dot

Abstract: A microscopic theory for quantum thermoelectric and heat transport in the conformal and Schwarzian regime of the Sachdev-Ye-Kitaev (SYK) model is presented. As a charged fermion realization of the SYK model in nanostructures we assume a setup based on Quantum Dot connected to the charge reservoirs through weak tunnel barriers. We analyze particle-hole symmetry breaking effects crucial for both Seebeck and Peltier coefficients. We show that the quantum charge and heat transport at low temperatures is defined by the interplay between elastic and inelastic processes such that the inelastic processes provide a leading contribution to the transport coefficients at the temperatures smaller compared to charging energy. We demonstrate that both electric and thermal conductance obey power law in temperature behavior while thermoelectric, Seebeck and Peltier coefficients are exponentially suppressed. This selective suppression of only non-diagonal transport coefficients have not been previously reported. We discuss validity of Kelvin formula in the presence of strong Coulomb blockade.

Speaker: Giuliano Chiriacò

Affiliation: ICTP

Title: Understanding the non equilibrium phase transition in strongly correlated ruthenates: heating and Peltier effects

Abstract: Current-driven insulator-metal transitions are in many cases driven by Joule heating proportional to the square of the applied current. Recent experiments in Ca2RuO4 reveal that the non equilibrium transition can be induced by a small current and that the metal-insulator phase boundary depends on the direction of the applied current, suggesting an important non-heating effect. We investigate the effects of an electric current in a system containing interfaces between metallic and insulating phases using a general model. We derive a heat balance equation from the Onsager transport theory and in addition to the usual Joule heating effect, we find a heating term proportional to the product of the current across the interface and the discontinuity in the Seebeck coefficient, so that heat can either be generated or removed at an interface, depending on the direction of the current relative to the change in material properties. For parameters appropriate to Ca2RuO4, this heating can be comparable to or larger than Joule heating. A simplified model of the relevant experimental geometry is shown to provide results consistent with the experiments

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<u>Session 3:</u> Fermionic and bosonic models

Speaker: Shraddha Sharma

Affiliation: ICTP

Title: Entanglement and criticality in the Long-range Bose-Hubbard model.

Abstract: We investigate the stationary phases of two-dimensional extended Bose-Hubbard model with infinite long-range interactions. This model describes ultracold bosonic atoms confined by a two-dimensional optical lattice and coupled to a cavity mode with the same wavelength as the lattice. The competition between tunneling, onsite interactions, and the long-range interactions mediated by the cavity photons gives rise to a rich ground-state phase diagram, which exhibits Mott-insulator, superfluid, lattice super solid, and charge-density wave phases. We perform a mean-field analysis with slave-boson approach and probe the behavior of entanglement-entropy in different phases and at the transition between these phases. These results can be explained by careful investigation of the physical spectrum and corresponding entanglement spectrum. Using this approach we also probe the scaling of entanglement entropy in different phases.

Speaker: Emanuele Tirrito

Affiliation: SISSA

Title: Investigations of topological phases for quasi-1D systems

Abstract: TBA

Speaker: Andrea Richaud

Affiliation: SISSA

Title: Interaction-resistant metals in multicomponent Fermi systems

Abstract: We analyze two different classes of fermionic systems that defy Mott localization showing a metallic ground state at integer filling and very large Coulomb repulsion. The first is a multiorbital Hubbard model with a Hund's coupling, where this physics has been widely studied and the new metallic state is called a Hund's metal, and the second is a SU(3) Hubbard model with a patterned single-particle potential designed to retain important features of the multiorbital Hubbard model in a set-up which can be implemented with SU(N) ultracold atoms. With simple analytical arguments, and by means of the exact numerical diagonalization of the Hamiltonians for a minimal three-site system, we point out the conditions which support the existence of strongly correlated metals, and we highlight how the metal emerges at the boundary between competing correlated insulators.

<u>Session 4:</u> Numerics for Quantum simulators

Speaker: Spyros Sotiriadis

Affiliation: Dahlem Center for Complex Quantum Systems

Title: Hamiltonian truncation methods for the study of continuous quantum field dynamics

Abstract: One of the greatest recent achievements of theoretical physics is the classical simulation of quantum many-body systems and of their dynamics. However, this task remains highly challenging for continuous models of quantum fields which are of strong significance for a wide range of applications from particle and black hole physics to condensed matter and ultra-cold atoms. I will present recent numerical results on Quantum Field Theory dynamics based on the Hamiltonian truncation method and applications to experiments that can play the role of analog quantum field simulators.

Speaker: Simone Notarnicola

Affiliation: Quantum Theory Group at Padova University

Title: Tensor networks for quantum simulation benchmarking

Abstract: I would talk about current experimental advances in quantum simulation especially with Rydberg atoms and would talk about recent numerical works in which we exploit tensor networks to simulate large systems. (basically based on https://arxiv.org/abs/2011.08200)

<u>Session 5:</u> Non-perturbative approaches

Speaker: Giuseppe Magnifico

Affiliation: Quantum Theory Group at Padova University

Title: Tensor Networks approach for Lattice Gauge Theories

Abstract: I would talk about the last advances in the tensor networks (TNs) approach for simulating challenging lattice gauge theories. In particular, I would present the discretisation of these continuous theories in terms of quantum simulation models, that we analyse with TN algorithms, and that could be relevant for current and future experiments on quantum hardware.

Speaker: Kevin Falls

Affiliation: SISSA

Title: Essential Non-perturbative renormalisation group

Abstract: I will give an introduction to non-perturbative renormalisation group techniques which can be applied to a variety of different physical (strongly correlated) systems from the Ising model to quantum gravity. I'll then discuss essential formalism which takes advantage of the freedom to perform general field redefinitions. Using the 3D Ising model as an example, I will explain how this new approach simplifies the renormalisation group equations since only the essential coupling constants need to be renormalised.

<u>Session 6:</u> Non-equilibrium: localization and entanglement

Speaker: Ana Laura Gramajo

Affiliation: ICTP

Title: Non-equilibrium dynamics and entanglement in strongly driven coupled-qubits

Abstract: We investigate the dynamics of superconducting (SC) qubits driven by strong harmonic external fields, focussing on the effects of noise, the generation of entanglement, and their application as quantum simulators. The effects of environmental noise are addressed using the Floquet-Markov master equation applied to the Landau- Zener-Stückelberg interferometry. We present a new mechanism for the generation of steady-state entanglement, which can be tuned as a function of the driving amplitude. We have also experimentally implemented a quantum simulator to study mesoscopic effects (weak localization) using coherent scattering at an avoided crossing in a system of two coupled SC-qubits. The scattering events are controllably implemented as Landau-Zener transitions by driving the two-qubit system multiple times through an avoided crossing. These results demonstrate how a well-controlled driven qubit system can be used to study complex effects in mesoscopic physics.

Speaker: Piotr Sierant

Affiliation: ICTP ; Institute of Theoretical Physics, Jagiellonian University in Krakow

Title: POLFED - a new diagonalization approach to study non-equilibrium phenomena: application to many-body localization

Abstract: I will introduce polynomially filtered exact diagonalization method (POLFED) of computing eigenvectors of large sparse matrices at arbitrary energies - a task that often arises when studying non-equilibrium phenomena in quantum many-body systems. The algorithm finds an optimal basis of a subspace spanned by eigenvectors with eigenvalues close to a specified energy target using a high order polynomial of the matrix. The memory requirements scale much better with system size than in the state-of-the-art shift-invert approach, while the total CPU time used by the two methods is similar. Also, the performance of POLFED is not severely impeded when the the number of nonzero elements in the matrix is increased allowing to efficiently study models with long-range interactions.

I will demonstrate the potential of POLFED examining many-body localization (MBL) transition in 1D interacting quantum spin-1/2 chains. Spectral statistics encode Thouless and Heisenberg time scales whose ratio determines whether the system is chaotic or localized. Similarities in the scaling of the Thouless time with the system size and disorder strength in one-body Anderson models and in disordered quantum many-body systems suggest a slowing-down of dynamics at large disorder strengths in many-body systems but access to small system sizes only prevents one from reaching unambiguous conclusions about MBL transition. This is further supported by system size dependence of bipartite entanglement entropy and of the gap ratio which highlights the importance of finite-size effects in the system. Possible scenarios regarding the MBL transition along with estimates for the critical disorder strength will be discussed. Finally, I will present results regarding MBL in highly constrained one-dimensional quantum spin chains. The increase of Hilbert space dimension with system size is slower than in the usually considered spin-1/2 chains which allows to investigate considerably larger system sizes.

[1] P. Sierant, M. Lewenstein, J. Zakrzewski, Phys. Rev. Lett. 125, 156601 (2020)
[2] P. Sierant, D. Delande, J. Zakrzewski, Phys. Rev. Lett. 124, 186601 (2020)
[3] P. Sierant, J. Zakrzewski, Phys. Rev. B 101, 104201 (2020)
[3] P. Sierant, G. Giudici, E. Gonzalez Lazo, M. Dalmonte, A. Scardicchio, J. Zakrzewski, in preparation

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