Workshop: Wonders of Broken Integrability

Events for:
Monday, October 2nd - Friday, October 6th

Monday, October 2nd

9:00am **Hubert Saleur - SCGP 102**

Title: Geometrical correlations in 2D stat. mech. modelsâ€™

9:50am **Jean-Sebastien Caux - SCGP 102**

Title: Dynamics of probed, pulsed, quenched and driven integrable quantum systems.

10:35am **Coffee - SCGP Cafe**

11:15am **Bruno Bertini - SCGP 102**

Title: Transport in Integrable Quantum Spin Chains and Beyond

Abstract: I consider a general framework for studying transport problems in closed systems. Two semi-infinite systems at different temperatures and magnetisations are suddenly joined together and then evolved unitarily. In the integrable case, at large times, the system can locally be represented by a family of space- and time- dependent stationary states, which are fully characterised by a set of continuity equations. I illustrate this procedure for the example of the XXZ spin-1/2 chain, comparing the results with TEBD numerical simulations. Depending on the initial configuration many interesting effects appear, and I focus on two of them. 1) For initial magnetisations of opposite sign, qualitative differences in the transport dynamics emerge between the gapless and the gapped regime. While in the gapless regime transport is always ballistic, in the gapped regime there is a sub-ballistic transport of spin. 2) For small temperatures, the transport of conserved charges in the gapless phase acquires some universal features which can be determined in a non-linear Luttinger liquid framework. These effects go beyond integrability and are expected in the low-temperature transport of generic observables in generic critical systems describable by Luttinger liquids.

12:00pm **Lunch - SCGP Cafe**

2:00pm **Maurizio Fagotti - SCGP 102**

Title: Intermediate-time dynamics in out-of-equilibrium systems.

Abstract: I consider two situations with peculiar dynamics in an intermediate time window. In the first part of the talk, I present a particular form of prethermalization which can emerge at low temperature both in integrable and in nonintegrable quantum many-body systems. In the second part of the talk, I address the problem of whether a higher-order (generalized) hydrodynamic theory gives access to additional information with respect to the theory at the first order.

2:50pm **Romain Vasseur - SCGP 102**

Title: Hydrodynamics of clean and disordered systems near integrability

Abstract: In this talk, I will discuss hydrodynamic approaches to many-body quantum systems near integrability (of Yang-Baxter or MBL type). I will first focus on Boltzmann-like kinetic equations for clean integrable systems with an emphasis on how to solve these hydrodynamic equations efficiently. I will then discuss possible ways to go beyond integrability, in relation with recent results on the hydrodynamics of thermalizing systems.

3:35pm **Tea**

Tuesday, October 3rd

9:00am **Frank Verstraete - SCGP 102**

Title: Symplectic matrix product state algorithms for simulating time evolution in quantum spin chains

9:50am **Marcos Rigol**

Title: Emergent eigenstate solution to quantum dynamics far from equilibrium

Abstract: The quantum dynamics of interacting many-body systems has become a unique venue for the realization of novel states of matter. In this talk, we discuss how it can lead to the generation of time-evolving states that are eigenstates of emergent local Hamiltonians, not trivially related to the ones dictating the time evolution. We study geometric quenches in fermionic and bosonic systems in one-dimensional lattices, and provide examples of experimentally relevant time-evolving states that are either ground states or highly excited eigenstates of emergent local Hamiltonians. We also discuss the expansion of Mott insulating domains at finite temperature. Surprisingly, the melting of the Mott domain is accompanied by an effective cooling of the system. We explain this phenomenon analytically using the equilibrium description provided by the emergent local Hamiltonian.

10:35am **Coffee - SCGP Cafe**

11:15am **Neil Robinson - SCGP 102**

Title: Non-thermal states in the non-integrable Ising field theory

Abstract: Truncated spectrum methods can give numerical access to the low-lying eigenstates in strongly perturbed quantum field theories. Following an introduction to these methods, I will discuss recent work with Andrew James (UCL) and Robert Konik (BNL) where we use truncated spectrum methods to study properties of the low-lying eigenstates and non equilibrium dynamics in the non-integrable Ising field theory. We find that there are rare non-thermal states, and I will discuss the nature of these states.

12:00pm **Lunch - SCGP Cafe**

2:50pm **Lorenzo Vitale - SCGP 102**

Title: Renormalization in Hamiltonian Truncation

Abstract: In this talk I will review the Hamiltonian truncation method and the renormalization program aimed at mitigating the problem of dimensionality. In particular I will introduce a new renormalization framework which has given promising results in the two-dimensional Landau-Ginzburg theory.

3:35pm **Tea**

4:10pm **Nikolay Bogoliubov - SCGP 102**

Title: Totally Asymmetric Models as Generators of Oriented Multi-Dimensional Random Walks

Abstract: The exactly solvable totally asymmetric models of the low dimensional non-equilibrium statistical mechanics described by the non-Hermitian Hamiltonians are considered. We demonstrate that the conditional probabilities of the Totally Asymmetric Zero Range Process and Totally Asymmetric Simple Exclusion Process may be considered as the generating functions of oriented multi-dimensional lattice walks bounded by a hyperplane. This type of walks we call the walks over the multi-dimensional simplicial lattices. The answers for the conditional probability and for the number of random walks over the multi-dimensional simplicial lattice are expressed through the symmetric functions.

Wednesday, October 4th

9:00am **Denis Bernard - SCGP 102**

Title: From ballistic to diffusive transport, and localization, in 1D critical systems.

9:50am **Austen Lamacraft**

Title: Noisy Spins and the Richardson-Gaudin Model.

10:35am **Coffee - SCGP Cafe**

11:15am **Shivaji Sondhi - SCGP 102**

Title: Operator hydrodynamics, OTOCs, and entanglement growth in systems without conservation laws

Abstract: Thermalization and scrambling are the subject of much recent study from the perspective of many-body quantum systems with locally bounded Hilbert spaces (`spin chains'), quantum field theory and holography. We tackle this problem in 1D spin-chains evolving under random local unitary circuits and prove a number of exact results on the behavior of out-of-time-ordered commutators (OTOCs), and entanglement growth in this setting. These results follow from the observation that the spreading of operators in random circuits is described by a `hydrodynamical' equation of motion, despite the fact that random unitary circuits do not have locally conserved quantities (e.g., no conserved energy).

12:00pm **Lunch - SCGP Cafe**

2:00pm **Philippe Lecheminant - SCGP 102**

Title: Fate of spinons in two-leg SU(N) spin ladder

Abstract: Two-leg SU(2) spin ladder is an elegant paradigm for confinement of fractional quantum numbers since the spinons (spin-1/2) of individual chains are confined into triplons (spin-1) excitations as soon as an interchain spin-exchange J_{\perp} is introduced. We have applied field theory techniques and large-scale numerical calculations to tackle the problem of confinement for a two-leg SU(N) spin ladder which can be be manufactured in the context of ultracold alkaline-earth atoms. In a stark contrast to the N=2 case, we find that for odd N a small antiferromagnetic interchain coupling the SU(N) spinons acquire a gap, but remain deconfined and become gapless again for a sufficiently strong J_{\perp}. For even N>2, the spinons get confined in gapful excitations which are domain walls of a fully gapped phase with N/2 ground state degeneracy.

2:50pm **Frank Goehmann - SCGP 102**

Title: Thermal form factors and form factor series for correlation functions of the XXZ chain

Abstract: Correlation functions of Yang-Baxter integrable lattice models can be expanded into form-factor series involving matrix elements of the quantum transfer matrix rather than the usual transfer matrix. This is called the thermal form-factor approach to correlation functions. We have calculated the thermal form factors of local operators for the XXZ chain and have analyzed the corresponding form factor series in the low-temperature limit. In this talk I review the method, show results for static correlation functions in the massive antiferromagnetic regime of the phase diagram and give an outlook to the dynamical case.

3:35pm **Tea**

4:10pm **Barry McCoy - SCGP 102**

Title: Understanding versus Ignorance; Integrability, differential equations, zeros, universality.

Abstract: I will discuss four problems concerning the Ising model; The row versus diagonal meaning of integrability The extension of differential equations for correlations beyond Painleve VI Partition function zeros and the tyranny of the Lee-Yang pinch Universality for the long range Ising model

Thursday, October 5th

9:00am **Andreas Kluemper - SCGP 102**

Title: The Anderson Impurity Model as a Derivative of the Hubbard Model

Abstract: We derive the integrable Anderson Impurity Model (AIM) as a continuum limit of the Hubbard model with an integrable `transparent impurity'. This construction allows for an alternative derivation of the Bethe ansatz equations for the Hamiltonian, but also provides i) an alternative treatment of the thermodynamics of the AIM on the basis of finitely many non-linear integral equations, ii) the host of the AIM can be manipulated such that a vanishing density of states is realized and integrability is kept.

9:50am **Vladimir Korepin - SCGP 102**

Title: Models solvable in a weak sense.

Abstract: For some models, we know only analytical expression for the ground-state [and some excited states]. Can we deform these models and restore integrability? Is Fredkin model exactly solvable?

10:35am **Coffee - SCGP Cafe**

11:15am **Lea Santos - SCGP 102**

Title: Analytical results for the evolution of chaotic many-body quantum systems

Abstract: Possible strategies to describe analytically the dynamics of many-body quantum systems out of equilibrium include the use of integrable models and of full random matrices. They provide bounds and serve as references for the studies of systems investigated experimentally. We take the path of random matrices and obtain analytical expressions for the survival probability, density imbalance, and out-of-time-ordered correlator. Using these findings, we propose an expression that matches very well numerical results for the evolution of realistic disordered spin-1/2 models that are strongly chaotic and quenched far from equilibrium. By comparing the outcomes from the random matrix and spin models, a late power-law behavior followed by the so-called correlation hole are identified as generic features of chaotic many-body quantum systems. The power-law exponent and depth of the hole are then employed in the analysis of the transition from chaos to localization, which occurs as the disorder strength of the spin model increases.

12:00pm **Lunch - SCGP Cafe**

2:00pm **Robert Konik - SCGP 102**

Title: Studies of the Loschmidt Echo and Entanglement Spreading in Two Dimensional Anisotropic Spin Systems

Abstract: We describe a method for simulating the real time evolution of extended quantum systems in two dimensions. The method combines the benefits of integrability and matrix product states in one dimension. In particular it can be extended to systems whose geometry is that of an infinitely long cylinder. As a specific example application, we present results for quantum quenches in arrays of coupled quantum Ising chains. In quenches that cross a phase boundary we find that the return probability shows non-analyticities in time. We also consider how entanglement spreads post-quench in the array of chains. We see notable differences in the spreading on whether the chains are in their ordered or disordered phase. This difference arises because of the presence of linearly confined bound states in the ordered phase.

2:50pm **Vincenzo Alba - SCGP 102**

3:35pm **Tea**

Friday, October 6th

9:00am **GÃ¡bor Takacs - SCGP 102**

9:50am **German Rodero Sierra**

10:35am **Coffee - SCGP Cafe**

11:15am **Balazs Pozsgai - SCGP 102**

Title: Integrable quenches of integrable spin chains

12:00pm **Lunch - SCGP Cafe**

3:35pm **Tea**