Titles and abstracts

Talks:

Denis Bernard

Statistics of Quantum Jumps and Spikes, and Applications

Quantum trajectories of systems subjected to a tight and continuous monitoring exhibit quantum jumps, observed in various experiments, but also more surprising features, quantum spikes which may be viewed as aborted jumps. We shall present a quantitative understanding of the quantum spike statistics. We conjecture the later to be universal (that is independent of the process which generate them). As an illustration, we shall discuss a scheme to control quantum flux through back-action measurement.

Édouard Boulat

Exploiting integrability out-of-equilibrium: some exact results for the Kondo model

Transport in nanoscale quantum devices can be described in some situations by quantum impurity models in which the low energy regime is often a strong coupling (SC) regime, the archetypical example maybe being the Kondo model. We have recently developed a framework for integrable models[1], in which we can exactly tackle various out-of-equilibrium situations for quantum impurities in their SC regime, using their equilibrium integrability properties. It allows to compute directly the expansion of the universal scaling functions for physical quantities (like the electrical current), in principle to arbitrarily high order in the driving out-of-equilibrium, be it voltage, frequency, In particular, we show how to apply this to the Kondo model : our approach successfully goes beyond known results for the electrical current and noise.

[1]: L.Freton and E.Boulat, PRL 112 (2014) 116802.

Jens Eisert

Many-body localisation, tensor networks, and transport

The phenomenon of many-body localisation received a lot of attention recently, both for its implications in condensed-matter physics of allowing systems to be an insulator even at non-zero temperature as well as in the context of the foundations of quantum statistical mechanics, providing examples of systems showing the absence of thermalisation following out-of-equilibrium dynamics. In this work, we establish a novel link between dynamical properties - the absence of a group velocity and transport - with entanglement properties of individual eigenvectors. Using Lieb-Robinson bounds and filter functions, we prove rigorously under simple assumptions on the spectrum that if a system shows strong dynamical localisation, all of its many-body eigenvectors have clustering correlations. In one dimension this implies directly an entanglement area law, hence the eigenvectors can be approximated by matrix-product states. We also show this statement for parts of the spectrum, allowing for the existence of a mobility edge above which transport is possible [1]. If time allows, we will also consider the question how local or approximately constants of motion imply transport [2] and briefly review other recent group work on the subject [3, 4].

[1] Many-body localisation implies that eigenvectors are matrix-product states, M. Friesdorf, A. H. Werner, W. Brown, V. B. Scholz, J. Eisert, arXiv:1409.1252 (2014).

[2] Local constants of motion imply transport, M. Friesdorf, M. Goihl, A. H. Werner, W. Brown,

J. Eisert, in preparation (2014).

[3] Quantum many-body systems out of equilibrium, J. Eisert, M. Friesdorf, C. Gogolin, Nature Physics, in press (2014).

[4] Towards experimental quantum field tomography with ultracold atoms, A. Steffens et al., arXiv:1406.3632 (2014).

Fabian Essler
Light Cone Effects after Quantum Quenches

Alexandre Faribault
Eigenvalue-based determinants for a class of integrable models derived from a Generalized Gaudin Algebra

In the traditional Algebraic Bethe Ansatz (ABA), eigenstates and eigenenergies are fully specified by a set of Bethe roots which individually characterize the excitations above a pseudo-vacuum reference state. Slavnov's determinants can then provide numerically tractable expressions for scalar products and form factors of local operators in term of these Bethe roots.

Working with spin-based Gaudin models [1] as well as a related class of spin-boson models [2] , we show how one can derive similar determinant expressions which are, this time, written explicitly in terms of the eigenvalues of the conserved charges. The eigenvalues are themselves fully symmetric in the Bethe roots and this rewriting provides major simplifications in the numerical treatment of the non-equilibirum dynamics of these models [3].

In doing so, we also demonstrate, for the spin-boson models, that one can build an alternative formulation of the ABA using a reference state which does not fulfill the usual prerequisites of a proper pseudo-vacuum [2].

[1] A. Faribault and D. Schuricht,J. Phys. A: Math. Theor. 45, 485202 (2012)

[2] H. Tschirhart and A. Faribault,J. Phys. A: Math. Theor. 47 405204 (2014)

[3]A. Faribault and D. Schuricht,Phys. Rev. Lett. 110, 040405 (2013)

Andrew Green
Field Theories over Tensor Network States

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 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.

Gianni Jona-Lasinio

Macroscopic fluctuation theory: an introduction and some applications

The macroscopic fluctuation theory, proposed in collaboration with L. Bertini, A. De Sole, D. Gabrielli and C. Landim to study diffusive systems out of equilibrium, has become over the last decade a powerful tool to analyse concrete problems. After discussing the basic ideas I will illustrate some applications among which the existence of phase transitions in the behaviour of fluctuations. Of special interest are the fluctuations of the current in stationary states. New variational principles appear in the thermodynamics of non-equilibrium stationary states.

Corinna Kollath

Critical and aging dynamics in dissipative ultracold atomic gases

Atomic gases cooled to Nanokelvin temperatures are a new exciting tool to study a broad range of quantum phenomena. The outstanding tunability of cold gases allows to rapidly change the system parameters and to observe the subsequent quantum evolution. This ability is unmatched in conventional solid state samples and poses new challenges for the understanding of quantum dynamics in correlated many-body systems. I will report on recent progress on the understanding of the dynamics of quantum gases under the influence of controlled dissipative coupling. One focus will be the occurence of critical dynamics and aging behaviour in bosonic gases coupled to a dissipative environment.

Karyn Le Hur

Stochastic Quantum Spin Dynamics and Quenches

In this Talk, we introduce a stochastic Schrodinger equation approach to discuss various aspects of the quantum spin dynamics. For example, we discuss the effect of a macroscopic environment such as a bosonic bath (leading to non-Markovian effects) on Rabi oscillations and Landau-Zener type transitions [1]. We also address recent generalizations of the method to treat driven light-matter systems beyond the weak-coupling limit [2]. We also compare our findings with others from existing methods in "known" limits. Finally, we discuss a stochastic mean-field extension to treat quantum quenches and dissipation effects in quantum Ising spin chains with long-range forces [3]. Thanks to my collaborators: Loic Henriet (CPHT Ecole Polytechnique), Peter P. Orth (Karlsruhe), Zoran Ristivojevic (now LPT Toulouse). This work has been initiated in collaboration with Adilet Imambekov.

[1] P. P. Orth, A. Imambekov, K. Le Hur, Phys. Rev. B 87, 014305 (2013) and Phys. Rev. A 82, 032118 (2010).

[2] L. Henriet, Z. Ristivojevic, P. P. Orth and K. Le Hur, Phys. Rev. A 90, 023820 (2014).

[3] L. Henriet and K. Le Hur, in progress.

Vivien Lecomte

Exclusion processes and quantum phase transitions in XXZ spin chains.

The study of rare or anomalous fluctuations in classical, stochastic systems has lead in recent years to the understanding of dynamical phase transitions occuring in phenomena where different classes of trajectories are in competition. Example systems include 'exclusion processes' (a lattice gas in which particles interact only through an exclusion rule: particles cannot occupy the same site). In such system, jammed and non-jammed histories can compete, and the dynamical phase transition reflects at the mathematical level in singularities of large deviation functions.

Although being classical, the dynamics of such systems can be mapped to the thermodynamics of an isolated quantum spin chain. Classical 'rare events' are mapped to quantum typical configurations. This mapping is known at the formal level for many years, but it has not been fully exploited. We discuss how the understanding of finite-size effects of the classical dynamical phase transition brings a new light on an example quantum phase transition.

Tomaz Prosen
Exact solutions of boundary-driven quantum master equations and new conservation laws

Anisotropic Heisenberg chain of spins 1/2 is one of the key paradigms of strongly correlated electrons in one dimension. While equilibrium properties of the model are relatively well understood, even very basic questions about its non-equilibrium properties were still open until very recently. A prominent example is the question [1] whether the model exhibits ballistic spin transport at finite temperatures or not? I will outline the progress on this topic which has been triggered by the discovery of exact solution of quantum master equation of the boundary driven Heisenberg chain [2,3,4]. The steady-state solution of non-equilibrium master equation leads to novel quasi-local conservation laws [2,6,9], which in turn lead to a derivation of rigorous strict lower bounds on ballistic transport coefficients [5]. I will also explain how such an approach of non-equilibrium integrability works for some other strongly interacting quantum chains, for instance, for the Hubbard model [7] or Lai- Sutherland model of spins 1 [8].

[1] J. Sirker, R. G. Pereira and I. Affleck, Phys. Rev. Lett. 103, 216602 (2009); Phys. Rev. B 83, 035115 (2011)

[2] T. Prosen, Phys. Rev. Lett. 106, 217206 (2011)

[3] T. Prosen, Phys. Rev. Lett. 107, 137201 (2011) [4] D. Karevski, V. Popkov and G. M. Schütz, Phys. Rev. Lett. 110, 047201 (2013)

[5] E. Ilievski and T. Prosen, Commun. Math. Phys. 318, 809 (2013)

[6] T. Prosen and E. Ilievski, Phys. Rev. Lett. 111, 057203 (2013)

[7] T. Prosen, Phys. Rev. Lett. 112, 030603 (2014)

[8] E. Ilievski and T. Prosen, Nucl. Phys. B 882, 485 (2014)

[9] T. Prosen, Nucl. Phys. B 886, 1177 (2014)

Dirk Schuricht
Integrability-based analysis of the hyperfine interaction induced decoherence in quantum dots

We study the decoherence of a spin in a quantum dot due to its hyperfine coupling to a fluctuating bath of nuclear spins. We calculate the spectrum and time evolution of the coherence factor using a Monte Carlo sampling of the exact eigenstates obtained via the algebraic Bethe Ansatz. The exactness of the obtained eigenstates allows us to study the full crossover from strong to weak external magnetic field in a full quantum mechanical treatment. We find a large non-decaying fraction in the zero-field limit which is explained by Bose-Einstein-condensate-like physics. We compare our results to a simple semiclassical picture and find surprisingly good agreement. Finally, we discuss the effect of weakly coupled spins and show that they will eventually lead to complete decoherence.

A Faribault and D Schuricht, Phys. Rev. Lett. 110, 040405 (2013); Phys. Rev. B 88, 085323

(2013).

Gabor Takacs
Correlations after quantum quenches in the XXZ spin chain: Failure of the Generalized Gibbs Ensemble

We study local correlations in the steady state of the XXZ chain after quenches starting from the Majumdar–Ghosh dimer product and Nel states. The correlations are computed using a quench action approach (QA) variant of the thermodynamic Bethe ansatz (TBA) and independently using an infinite time-evolving block decimation (iTEBD) algorithm which simulated the real time evolution of correlations. While the steady-state correlations obtained through the QA and the iTEBD methods agree consistently, predictions of the GGE fail to reproduce these values. Therefore the GGE, in its present form, is not a generally valid statistical description of post-quench steady states of integrable closed quantum systems. We also comment on some further recent developments related to the validity of the generalized eigenstate thermalization hypothesis, and the role of bound states.

Rogier Vlijm
Applications of algebraic Bethe ansatz matrix elements to spin chains

Algebraic Bethe ansatz based techniques at finite size afford a way into computing observables for integrable models. Dynamical correlations of the Babujan-Tahktajan spin-1 chain are obtained by a higher spin generalisation of this method. The obtained real-space spin-spin correlation displays asymptotics fitting predictions from conformal field theory. Dealing with Bethe roots explicitly as deviated string-solutions is a decisive constituent of the method. Moreover, the explicit time evolution of out-of-equilibrium initial states for the anisotropic Heisenberg spin chain can be addressed as well.

Posters:

Bruno Bertini
Quantum Quench in the sine-Gordon Model

We consider the time evolution in the repulsive sine-Gordon quantum field theory after the system is prepared in a particular class of initial states. We focus on the time dependence of the one-point function of the semi-local operator $\exp(i\beta\Phi(x)/2)$. By using two different methods based on form-factor expansions, we show that this expectation value decays to zero exponentially, and we determine the decay rate by analytical means. Our methods generalize to other correlation functions and integrable models.

Matthew Edmonds
Kinetic Model of Trapped Finite Temperature Binary Condensates, Matthew Edmonds, Kean Loon Lee and Nick Proukakis.

In order to gain critical insight into the physical processes occurring within both classical and quantum condensed matter systems, one must consider the full equilibrium and non-equilibrium behavior. Such systems are intrinsically complicated due to the coupled nature of their many particle interactions.

One avenue to address this problem in the quantum realm is to use cold atom setups, which benefit from being highly controllable. In particular, it is now feasible to create mixtures formed from either Bosons and/or Fermions, and study the resulting coupled non-equilibrium dynamics. Here, we develop a novel Quantum Kinetic theory describing a binary mixture of partially-condensed atomic Bose-Einstein condensates [1].

Our model comprises coupled dissipative nonlinear Schrodinger equations for the two condensates, which in turn are mutually coupled to Boltzmann equations describing the dynamics of the two thermal clouds. By considering all physically relevant kinetic scattering events, a novel exchange process is identified. To understand the relevance of this term, we probe numerically the scattering rates for realistic atomic condensate mixtures, and find that this exchange term dominates close to equilibrium.

[1] M. J. Edmonds, K. L. Lee, and N. P. Proukakis, arXiv:1409.1725

Oleksandr Gamayun
Exact results on mobile impurity in one-dimensional Fermi gas

We investigate the model of an impurity interacting with free Fermi gas in one spatial dimension through a delta function potential both at zero and finite temperature. Using Bethe Ansatz technique we represent time dependent correlation function and the average momentum of an impurity as a Fredholm determinant. Our results are applicable both for finite repulsive and attractive interactions as well as in a Tonks-Girardeau limit.

Merlijn van Horssen *Open quantum reaction-diffusion dynamics: absorbing states and relaxation*

Abstract: We consider an extension of classical stochastic reaction-diffusion (RD) dynamics to open quantum systems. We study a class of models of hard core particles on a one-dimensional lattice whose dynamics is generated by a quantum master operator and where particle hopping is coherent while reactions, such as pair annihilation or pair coalescence, are dissipative. These are quantum open generalisations of the $A + A?\emptyset$ and $A + A?A$ classical RD models. We characterise the relaxation of the state towards the stationary regime via a decomposition of the system Hilbert space into transient and recurrent subspaces. We provide a complete classification of the structure of the recurrent subspace (and the non-equilibrium steady states) in terms of the dark states associated to the quantum master operator and its general spectral properties. We also show that, in one dimension, relaxation towards these absorbing dark states is slower than that predicted by a mean-field analysis due to fluctuation effects, in analogy with what occurs in classical RD systems. Numerical simulations of small systems suggest that the decay of the density in one dimension, in both the open quantum $A + A?\emptyset$ and $A + A?A$ cases, may go asymptotically as $t?b$ with $1/2 < b < 1$.

Jan Korbel
On new hybrid information measure for classical and quantum systems, Jan Korbel and Petr Jizba

We combine an axiomatics of Rnyi with the non-extensive axioms of Tsallis-Havrda-Charvt entropy to obtain a measure of information which accounts both for systems with embedded self-similarity and non-extensivity. We show that the entropy thus obtained is uniquely solved in terms of a one-parameter family of information measures. The ensuing maximal-entropy distribution is expressible via Lambert W-function. Analysis of both high- and low-temperature expansion reveals a non-trivial structure of the parameter space and presence of a critical "condensation" energy. These findings offer an interesting potential for applications in a currently relevant field of few-body quantum thermodynamics.

Oleg Lychkovskiy
Perpetual motion of a mobile impurity in a quantum uid.

Abstract: What happens to an impurity particle injected with some initial velocity v_0 into a quantum fluid at zero temperature? It is known that if the fluid has nontrivial dispersion, the impurity will end up in a steady state with some non-vanishing velocity v_∞. We prove an upper bound on $|v_0 - v_\infty|$. In the limit of vanishing impurity-fluid coupling this bound vanishes which amounts to $v_\infty = v_0$. This can be regarded as a rigorous proof of the Landau criterion of superfluidity.

Herve Ness
Some non-equilibrium properties of open quantum electronic systems in the steady state regime

Quantum systems can be driven far from equilibrium by time-dependent perturbation or by coupling to reservoirs at different chemical potentials or temperatures. In the latter case, the system is open and particle- or energy-currents flow throughout the system. Such processes take place in different contexts, ranging from nanoscale quantum transport to chemical reactions.

In this presentation, we consider the non-equilibrium (NE) steady state properties of open quantum system connected to reservoirs. In such a regime, we show that the NE density matrix takes the form of a generalised Gibbs ensemble [1]. This permits us to define rigorously a NE distribution function from the NE Green's functions [2]. The NE distribution is a very useful concept for studying of NE properties of open quantum systems such as NE fluctuation-dissipation relations [3] or NE generalised susceptibilities [4].

[1] H. Ness, arXiv:1409.4982 and Phys Rev. E. 88, 022121 (2013).

[2] H. Ness, Phys. Rev. B 89, 045409 (2014).

[3] H. Ness and L. K. Dash, J. Chem. Phys. 140, 144106 (2014).

[4] H. Ness and L. K. Dash, Phys. Rev. Lett. 108, 126401 (2012).

Thierry Platini
The repeated interactions applied to Free fermionic spin systems

We study the evolution offermionic systems interacting with a quantum environment via the repeated interaction process. In particular we focus our attention on the steady state of afinite XX spinchain coupled at its boundaries to quantum reservoirs. The two-point correlations are calculated exactly, and it is shown that the steady state is completely characterized by the magnetization profile and the associated current. The steady-state current, proportional to the difference in the reservoirs magnetizations, shows a nonmonotonic behavior with respect to the system-reservoir coupling strength, with an optimal current state for a finite value of the coupling. Moreover, we show that the steady state can be described by a generalized Gibbs state.

Zoltan Zimboras
Mutual Information and Entanglement Negativity in Nonequilibrium Steady States

In the poster we present our studies on nonequilibrium steady states of fermion and boson chains, resulting from an initial state where the two sides of the system were prepared at different temperatures. For the case of the fermionic chain, the mutual information between two adjacent subsystems is calculated. We find that it scales logarithmically in the subsystem size, providing he first example of the violation of the area law in a quantum many-body system outside a zero temperature regime. However, it is observed that in the low temperature (conformal) limit the logarithmic divergence tends to zero, and the mutual information behaves as a sum of contributions pertaining to left- and right-moving excitations emitted from the two reservoirs. Similar averaging behavior is found for the logarithmic negativity for the case of nonequilibrium steady states of harmonic oscillators. We investigate also how these correlations build up in time, before the system relaxes locally to the steady state. As a particular case, we also discuss a local quench where both sides of the chain are initialized in their respective ground states.

[1] V. Eisler and Z. Zimbors, Phys. Rev. A 89, 032321 (2014).

[2] V. Eisler and Z. Zimbors, New J. Phys. 16, 123020 (2014).