22ème conférence Claude Itzykson - Manipulation of Simple Quantum Systems

Rapport sur les contributions

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ID de Contribution: **1** Type: **Non spécifié**

Registration

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Opening

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Tomaz Prosen: Diffusive transport in Integrable lattice systems

mardi 6 juin 2017 10:15 (1 heure)

Integrable systems, having an extensive number of conserved quantities, are typically associated with ballistic transport. This picture is theoretically justified in terms of Mazur bounds [1], or the emerging field of generalized hydrodynamics [2]. However, for systems posessing parity-type symmetries (such as spin-reversal or parity-hole) there exist generic symmetric states for which ballistic contribution to transport vanishes. Extensive numerical simulations of a parity-symmetric inhomogeneous quench in the Heisenberg XXZ model clearly indicate existence of diffusive transport in the massive regime, and super-diffusive transport with a curiously looking erf-scaling profile at the isotropic point [3]. I will discuss two theoretical approaches to rigorously establishing diffusive transport in integrable lattice systems: (i) either by implementing Mazur-like bounds on the diffusion constant in terms of local conserved quantities in nearly-parity-symmetric states [4], or (ii) exact solutions of simple interacting lattice models, such as reversible, deterministic cellular automata [5].

References

[1] E. Ilievski, T. Prosen, Comm. Math. Phys. 318, 809 (2013)
[2] O. Castro-Alvaredo, B. Doyon, T. Yoshimura, Phys. Rev. X 6, 041065 (2016)
[3] M. Ljubotina, M. Žnidarič, T. Prosen, arXiv:1702.04210
[4] M. Medenjak, C. Karrasch, T. Prosen, arXiv:1702.04677
[5] M. Medenjak, K. Klobas, T. Prosen, arXiv:1705.04636

ID de Contribution: **4** Type: **Non spécifié**

Pierre Rouchon: Towards generic adiabatic elimination for bipartite open quantum systems

mardi 6 juin 2017 11:45 (1 heure)

This joint work with R. Azouit, F. Chittaro and A. Sarlette consider a composite quantum system consisting of a fast dissipative subsystem coupled to a slow one. Using the time-scale separation, we develop an adiabatic elimination technique to derive at any order the reduced model describing the slow subsystem. The method, based on an asymptotic expansion and geometric singular perturbation theory, ensures the physical interpretation of the reduced second-order model by giving the reduced dynamics in a Lindblad form and the state reduction in Kraus map form. We give explicit second-order formulas for Hamiltonian or cascade coupling between the two subsystems. These formulas can be used to engineer, via a careful choice of the fast subsystem, the Hamiltonian and Lindbald operators governing the dissipative dynamics of the slow subsystem.

ID de Contribution: **5** Type: **Non spécifié**

Clément Pellegrini: Invariant measure for quantum trajectories

mardi 6 juin 2017 14:00 (1 heure)

Quantum trajectories describe the evolution of a quantum system monitored by indirect measurement. The evolution is random and is usually described by Markov processes, either solution of stochastic differential equations or Markov chains. It is then natural to study the large time behaviour of such evolution, this is related to the notion of invariant measure. In this talk we present sufficient conditions which ensures the existence and uniqueness of such a measure and we show the convergence towards this measure.

ID de Contribution: **6** Type: **Non spécifié**

Benjamin Huard: Quantum trajectories and feedback based on the measurement of decoherence channels in a qubit

mardi 6 juin 2017 15:00 (1 heure)

Decoherence can be understood as the result of unread measurements of the system by its environment. For a superconducting qubit, the two main corresponding jump operators are the lowering operator and the Hamiltonian operator. While the former is associated with the detection of an emitted photon by fluorescence, the latter can be associated with the detection of a frequency shift of a coupled resonant mode. We will discuss a series of experiment that were designed so that a large part of the information carried by the decoherence channels is accessible and retrieved by quantum limited amplifiers. The experiments offer a textbook example of quantum trajectory monitoring in various cases including QND and destructive continuous measurements, simultaneous incompatible measurements, Zeno effect and jump dynamics, post-selection and the associated past quantum states and also measurement based feedback.

ID de Contribution: **7** Type: **Non spécifié**

Iosif Bena: Black Holes, where Quantum Mechanics and General Relativity clash

mardi 6 juin 2017 16:30 (1 heure)

Einstein's General Relativity applied to black holes appears to lead to Information loss, thus violating one of the fundamental tenets of Quantum Mechanics. Recent Quantum Information Theory based arguments imply that information loss can only be avoided if at the scale of the black hole horizon there exists a structure (commonly called fuzzball or firewall) that allows information to escape. I will discussed the highly-unusual properties that this structure must have and how this structure is realized for certain String Theory black holes.

ID de Contribution: **9** Type: **Non spécifié**

Guillaume Aubrun: Convex geometry and high-dimensional entanglement

mercredi 7 juin 2017 10:30 (1 heure)

We will consider the phenomenon of quantum entanglement from the point of view of high-dimensional convex geometry. We estimate several geometric invariants (volume, mean width, approximability by polytopes) associated with the convex set consisting of all unentangled quantum states, and with the dual set. This information can be translated into results about the complexity of entanglement, or about the entanglement of random quantum states.

ID de Contribution: **10** Type: **Non spécifié**

Mazyar Mirrahimi: Dissipation as a resource for stabilizing quantum states with superconducting qubits

mercredi 7 juin 2017 12:00 (1 heure)

Recent advances in quantum-limited amplification have opened doors to high-fidelity non-demolition measurement of superconducting qubits and have already led to successful experiments on closed-loop control of such systems. However, the finite bandwidth of the amplification procedure, together with the time-consuming data acquisition and post-treatment of the output signal, lead to important latency in the feedback procedure. Alternatively, the reservoir (dissipation) engineering circumvent the necessity of a real-time data acquisition, signal processing and feedback calculation. Coupling the quantum system to be stabilized to a strongly dissipative ancillary quantum system allows us to evacuate the entropy of the main system through the dissipation of the ancillary one. I will overview some theoretical proposals as well as the related experiments through the past few years illustrating the power of such autonomous feedback schemes for stabilizing highly non-classical states as well as for quantum error correction.

ID de Contribution: **11** Type: **Non spécifié**

Julia Kempe: Battling Decoherence, from quantum error correction to the three-electron qubit

mercredi 7 juin 2017 14:15 (1 heure)

In this talk we give a brief survey on ways to encode quantum information in order to protect it against decoherence and noise. We will give a quick overview of quantum error correction with it's challenges and applicability, and then describe an alternative way to avoid decoherence: decoherence-free subspaces. We will focus on the 3-qubit exchange qubit and also give a surprising connection to encoded universality. This talk is mostly a survey of results obtained in the last decades, yet we will broach recent applications of the "three-electron qubit" in quantum dots.

ID de Contribution: **12** Type: **Non spécifié**

Antoine Tilloy: Non-Markovian linear quantum feedback of continuous measurements

mercredi 7 juin 2017 15:15 (1 heure)

Continuous measurement schemes have an interest beyond the simple unraveling of an open system evolution as they allow for control. Indeed, a certain function of the past measurement signal can be fed back into the system through an external drive to provide e.g. a controllable dissipation source, stabilize a state or purify it faster. However, very few situations yield a manageable master equation (after averaging) once the control scheme is taken into account. One such example is the so called Markovian feedback setup in which an external potential proportional to the instantaneous signal is applied on the state. Beyond that, if the signal is convoluted with a linear filter (e.g. to include some integration window, a delay, or a low pass component), it seems that nothing is known. I will show that the general case of a non-Markovian linear feedback can be solved formally to yield a master equation identical to that of a system coupled to a specific non-Markovian bosonic bath. From this structural correspondence, it will be clear that can import the standard techniques known in open-system theory (projection operator techniques, time convolutionless master equations, Dyson expansions…) to obtain numerical results from the analytical but formal solution.

ID de Contribution: **13** Type: **Non spécifié**

Yves Couder: Wave-particle duality as it emerges in the dynamics of a classical particle driven by its memory-endowed wave-field

mercredi 7 juin 2017 16:45 (1 heure)

We have introduced, some time ago, an experimental system in which a droplet bouncing on a vertically vibrated liquid interface can become self-propelled by its interaction with the waves it generates. It thus becomes a self-propelled “walker”, a symbiotic object formed by the droplet and its associated wave. A specificity of this system is that owing to the parametric forcing due to the substrate vibration the generated waves are standing Faraday waves that can be sustained in time. In these conditions there is information interplay between the drop and its wave-field so that the latter contains a memory of the recent trajectory of the droplet. Since this wave-field drives the drop a very specific self-organized dynamics emerges. Usually self-organization is a characteristic of the interaction of multiple entities. Here it is observed for a single structure interacting with its own past. I will specifically discuss recent experiments in which a walker, confined in a potential well, has an orbiting motion. Surprisingly, in spite of the classical nature of this system, several quantum-like characteristics emerge with a form of double quantization(1) of the orbits as well as probabilistic behaviors(2).

(1) S. Perrard, M. Labousse, M. Miskin, E. Fort, & Y. Couder, Nature Com. 5, 3219, (2014)
(2) S. Perrard, M. Labousse, E. Fort, Y. Couder, Phys Rev Lett, 113, 104101, (2014).

ID de Contribution: **14** Type: **Non spécifié**

Patrice Bertet: Magnetic resonance at the quantum limit and beyond

jeudi 8 juin 2017 09:30 (1 heure)

The detection and characterization of paramagnetic species by electron-spin resonance (ESR) spectroscopy has numerous applications in chemistry, biology, and materials science [1]. Most ESR spectrometers rely on the inductive detection of the small microwave signals emitted by the spins during their Larmor precession into a microwave resonator in which they are embedded. Using the tools offered by circuit Quantum Electrodynamics (QED), namely high quality factor superconducting micro-resonators and Josephson parametric amplifiers that operate at the quantum limit when cooled at 20mK [2], we investigate magnetic resonance in a new regime where the quantum nature of the microwave field plays a role and the spin sensitivity is correspondingly enhanced. We report an increase of the sensitivity of inductively detected ESR by 5 orders of magnitude over the state-of-the-art, enabling the detection of 300 Bismuth donor spins in silicon with a signal-to-noise ratio of 1 in a single echo [3,4]. We also demonstrate that the energy relaxation time of the spins is limited by spontaneous emission of microwave photons into the measurement line via the resonator [5], which opens the way to on-demand spin initialization via the Purcell effect. Finally, we show that the sensitivity can be enhanced beyond the quantum limit by using quantum squeezed states of the microwave field [6].

[1] A. Schweiger and G. Jeschke, Principles of Pulse Electron Magnetic Resonance (Oxford University Press, 2001)

[2] X. Zhou et al., Physical Review B 89, 214517 (2014).

[3] A. Bienfait et al., Nature Nanotechnology 11(3), 253-257 (2015)

[4] S. Probst et al., in preparation (2017)

[5] A. Bienfait et al., Nature 531, 74 (2016)

[6] A. Bienfait et al., arxiv :1610.03329

ID de Contribution: **15** Type: **Non spécifié**

Jürg Fröhlich: Dynamics of Quantum Systems Featuring Events

jeudi 8 juin 2017 10:30 (1 heure)

I report on results concerning the stochastic dynamics of quantum systems featuring events and of systems under repeated observation. In particular, I will mention a new type of "quantum branching process" (apparently not studied by mathematicians, yet) and outline a theory of indirect measurements and of associated quantum jump processes.

ID de Contribution: **16** Type: **Non spécifié**

Christoph Westbrook: Using phonons to simulate the behavior of other quantum fields

jeudi 8 juin 2017 12:00 (1 heure)

In a quantum fluid such as a condensed Bose gas, elementary excitations such as phonons behave as quantized fields with dispersion relations and non-linearities that bear some resemblance to those of the electromagnetic field. The very low temperatures of these gases means that in some cases quantum fluctuations are important. Several remarkable phenomena in quantum electrodynamics have found acoustic analogs, and I will discuss two of them. The first is the dynamical Casimir effect, a prediction that the vacuum can generate real particles when boundary conditions are suddenly changed. That is, photon pairs can be spontaneously generated in an empty cavity with nonuniformly accelerating boundaries. A second is Hawking radiation. Here again photon pairs are generated at the horizon of a black hole. I will discuss how certain aspects of both these effects can be mimicked in a Bose Einstein condensate, and outline the state of the experimental art in this domain.

ID de Contribution: **17** Type: **Non spécifié**

Michel Brune: Quantum trajectory of a field stored in a cavity, the past quantum state approach

mercredi 7 juin 2017 09:30 (1 heure)

We perform experiments where photons are trapped in a nearly ideal "photon box"as discussed by Einstein and Bohr in one of the gedanken experiments they introduced for emphasizing the unbelievable strangeness of quantum theory. Our photon box consists in a high Q cavity trapping microwave photons between superconducting mirrors.

In the experiments, we probe and manipulate the trapped microwave field with Rydberg atoms, which act as extremely sensitive and even non-destructive probes of the cavity field. We will show various methods for reconstructing the quantum state of the field and of is evolution. We will introduce the past quantum state method, which consists in reconstruction the field state at a given time, using knowledge obtained by measurement performed both before and after this time.

ID de Contribution: **18** Type: **Non spécifié**

Stéphane Attal: Open Quantum Walks, Unitary Quantum Walks and in Between

jeudi 8 juin 2017 13:00 (1 heure)

I shall give an introduction to Open Quantum Walks, which are a new type of quantum walks, implementing dissipation. I shall relate them to the usual (unitary) quantum walks and show that there exists a very interesting type of quantum walks interpolating in between the two. One knows very very few things about these interpolating quantum walks.