Driven Quantum Systems

Rapport sur les contributions

https://indico.math.cnrs.fr/e/8997

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

Defining quantum and classical chaos through adiabatic complexity

lundi 18 mars 2024 09:30 (30 minutes)

In this talk I will show that the notion of chaos both in quantum and classical Hamiltonian systems can be rigorously formulated through complexity of adiabatic transformations. This complexity is encoded in the fidelity susceptibility or more broadly in the geometric tensor. In classical systems this measure reflects complexity of trajectory-preserving canonical transformations under infinitesimal deformations of the Hamiltonian, while in quantum systems it reflects complexity of eigenstate transformations.

I will argue that generically integrable and ergodic regimes are separated by a buffer KAM glassy region with a sharp maximum of this susceptibility inside. The KAM regime can be either transient but very long lived in the thermodynamic limit or be stable in finite size systems. In gases or fluids this KAM regime is familiar to us through emergence of highly unstable turbulent flows at small interaction strengths.

I will also argue that the transition from integrable to ergodic/mixing regimes is generally described by a two-parameter finite time scaling theory with integrable points playing a similar role to critical points for continuous phase transitions.

Orateur: POLKOVNIKOV, Anatoli (Boston University)

ID de Contribution: **2** Type: **Non spécifié**

Physical Neural Networks: Harnessing Quantum Dynamics for Learning Weak Signals

lundi 18 mars 2024 10:00 (30 minutes)

Orateur: TURECI, Hakan (Princeton University)

ID de Contribution: **3** Type: **Non spécifié**

A renormalization group analysis of the Anderson transition in infinite dimensions

lundi 18 mars 2024 11:00 (30 minutes)

I will present a renormalization group analysis of the problem of the Anderson localization on a Regular Random Graph which is the limit of the RG flow of Abrahams, Anderson, Licciardello, and Ramakrishnan to infinite-dimensional graphs.

I will show how the one-parameter scaling hypothesis is recovered for sufficiently large system sizes for both eigenstates and spectrum observables and explain the non-monotonic behavior of dynamical and spectral quantities as a function of the system size for values of disorder close to the transition. I will show the implications of our work for Many-Body Localization.

Orateur: SCARDICCHIO, Antonello (The Abdus Salam ICTP)

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

Measurement-induced phase transition and KPZ physics in classical and quantum single-body systems

lundi 18 mars 2024 11:30 (30 minutes)

The tension created by the interplay of the contrary forces of chaos and measurements can lead to fascinating emerging phenomena, as exemplified by the recently discovered Measurement-induced Phase Transitions (MiPT) in quantum chaotic many-body systems undergoing continuous or projective measurements.

In this talk, I will demonstrate that this tension still remains when the problem is reduced to a single-body for both classical and quantum systems and that salient features of this problem can be understood by exploiting a connection with KPZ physics in the weak monitoring/short time/smooth interface regime.

Orateur: JIN, Zizhuo Tony (Université de Nice)

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

Topological entanglement transitions in free fermions: From projective to weak monitoring

lundi 18 mars 2024 14:00 (30 minutes)

Orateur: MEIDAN, Dganit (Ben Gurion University of the Negev, Israel)

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

Active quantum flocks

lundi 18 mars 2024 14:30 (30 minutes)

Flocks of animals represent a fascinating archetype of collective behavior in the macroscopic classical world, where the constituents, such as birds, concertedly perform motions and actions as if being one single entity. Here, we address the outstanding question of whether flocks can also form in the microscopic world at the quantum level. For that purpose, we introduce the concept of active quantum matter by formulating a class of models of active quantum particles on a one-dimensional lattice.

We provide both analytical and large-scale numerical evidence that these systems can give rise to quantum flocks. A key finding is that these flocks, unlike classical ones, exhibit distinct quantum properties by developing strong quantum coherence over long distances. We propose that quantum flocks could be experimentally observed in Rydberg atom arrays.

Our work paves the way towards realizing the intriguing collective behaviors of biological active particles in quantum matter systems. We expect that this opens up a path towards a yet totally unexplored class of nonequilibrium quantum many-body systems with unique properties.

Orateur: HEYL, Markus (University of Augsburg)

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

Adiabatic Lindbladian Evolution with Small Dissipators

lundi 18 mars 2024 15:30 (30 minutes)

We consider a time-dependent small quantum system weakly coupled to an environment, whose effective dynamics we address by means of a Lindblad equation. We assume the Hamiltonian part of the Lindbladian is slowly varying in time and the dissipator part has small amplitude. We study the properties of the evolved state of the small system as the adiabatic parameter and coupling constant both go to zero, in various asymptotic regimes.

Orateur: JOYE, Alain (Université Grenoble Alpes)

ID de Contribution: **8** Type: **Non spécifié**

Noise-induced phase transitions in encoding-decoding systems

lundi 18 mars 2024 16:00 (30 minutes)

Orateur: TURKESHI, Xhek (College de France)

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

Linear and nonlinear quantum dynamics of fractional quantum Hall fluids

mardi 19 mars 2024 09:30 (30 minutes)

In this talk I will review recent theoretical results on the linear, nonlinear and quantum dynamics of the edge modes of a trapped fractional quantum Hall fluid. A generalized nonlinear chiral Luttinger liquid theory will be presented, together with its validation against numerical results obtained with a combination of Monte Carlo and exact diagonalization methods. A first application of this theory to quantum nonlinear optics of edge waves will be discussed and schemes to generate quantum states of the edge modes will be proposed. Perspectives in the direction of using quantum point contacts as nonlinear beam splitters will be finally highlighted.

Orateur: CARISOTTO, Iacopo (CNR-INO, Pitaevskii BEC Center, Trento Italy)

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

Machine learning for and from complex quantum dynamics

mardi 19 mars 2024 10:00 (30 minutes)

This talk is a tale of two halves. In the first part, we will discuss recent progress on the use of variational neural quantum states to describe the non-unitary and/or non-equilibrium dynamics of quantum many-body systems [1,2].

In the second part, we will show how the complex dynamics of quantum systems can be harnessed as a resource for machine learning and neuromorphic devices. In particular, we will discuss photonic kernel machines [3], noisy quantum kernel machines [4], reservoir computing based on relativity-inspired quantum dynamics [5] and an efficient scheme to estimate the trainability of large-size variational quantum circuits [6].

References:
[1] F. Vicentini, A. Biella, N. Regnault, and C. Ciuti, Variational Neural-Network Ansatz for Steady States in Open Quantum Systems, Phys. Rev. Lett. 122, 250503 (2019)

[2] K. Donatella, Z. Denis, A. Le Boité, and C. Ciuti, Dynamics with autoregressive neural quantum states: Application to critical quench dynamics, Phys. Rev. A 108, 022210 (2023)

[3] Z. Denis, I. Favero, C. Ciuti, Photonic kernel machine learning for ultrafast spectral analysis, Physical Review Applied 17, 034077 (2022).

[4] V. Heyraud, Z. Li, Z. Denis, A. Le Boité, and C. Ciuti, Noisy quantum kernel machines, Phys. Rev. A 106, 052421 (2022)

[5] Z. Li, V. Heyraud, K. Donatella, Z. Denis, and C. Ciuti, Machine learning via relativity-inspired quantum dynamics, Phys. Rev. A 106, 032413 (2022)

[6] V. Heyraud, Z. Li, K. Donatella, A. Le Boité, and C. Ciuti, Efficient Estimation of Trainability for Variational Quantum Circuits, PRX Quantum 4, 040335 (2023)

Orateur: CIUTI, Cristiano (Université Paris Cité)

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

Fully Quantum Scalable Approaches to Driven-Dissipative Lattice Models

mardi 19 mars 2024 11:00 (30 minutes)

Orateur: SZYMANSKA, Marzena (UCL)

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

Time-tronics: from temporal printed circuit board to quantum computer

mardi 19 mars 2024 11:30 (30 minutes)

Time crystalline structures can be created in periodically driven systems. They are temporal lattices which can reveal different condensed matter behaviours ranging from Anderson localization in time to temporal analogues of many-body localization or topological insulators. However, the potential practical applications of time crystalline structures have not yet been demonstrated.

We pave the way for time-tronics where temporal lattices are like printed circuit boards for realization of a broad range of quantum devices. The elements of these devices can correspond to structures of dimensions higher than three and can be arbitrarily connected and reconfigured at any moment.

Moreover, our approach allows for the construction of a quantum computer, enabling quantum gate operations for all possible pairs of qubits. Our findings indicate that the limitations faced in building devices using conventional spatial crystals can be overcome by adopting crystalline structures in time.

Orateur: SACHA, Krzysztof (Jagiellonian University)

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

Multipartite entanglement and measurement induced phase transitions

mardi 19 mars 2024 14:00 (30 minutes)

Orateur: SILVA, Alessandro (SISSA)

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

Universality of time crystalline order

mardi 19 mars 2024 14:30 (30 minutes)

Orateur: DIEHL, Sébastien (Univ of cologne)

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

The Poincaré disk underlying many distinct non-equilibrium quantum dynamics

mardi 19 mars 2024 15:30 (30 minutes)

Orateur: ZHU, Qi (Purdue University)

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

Transport and Entanglement in Monitored Quantum Systems

mardi 19 mars 2024 16:00 (30 minutes)

Orateur: SHIRO, Marco (College de France)

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

Yang-Lee zeros, semicircle theorem and nonunitary criticality in open quantum dynamics

mardi 19 mars 2024 16:30 (30 minutes)

The Yang-Lee edge singularity is a quintessential nonunitary critical phenomenon characterized by anomalous scaling. However, an imaginary magnetic field involved in this phenomenon makes its physical implementation highly nontrivial. We invoke the quantum-classical correspondence and quantum measurement to physically realize the nonunitary quantum criticality in an open quantum system [1].

In particular, we show that the essential singularity in the superconducting gap is directly related to the number of Yang-Lee zeros which are distributed on a semicircle in the complex plane of the interaction strength due to the Fermi-surface instability. We also present photonic experiments to directly measure the partition function and the Yang-Lee zeros, where unconventional scaling laws for finite-temperature quantum dynamics are observed and agree with our theory predictions [3].

[1] N. Matsumoto, M. Nakagawa, and M. Ueda, Phys. Rev. Res. 4, 033250 (2022).

[2] H. Li, X.-H. Yu, M. Nakawaga, and M. Ueda, Phys. Rev. Lett. 131, 216001 (2023).

[3] H. Gao, K. Wang, L. Xiao, M. Nakagawa, N. Matsumoto, D. Qu, H. Lin, M. Ueda, and P. Xue, arXiv:2312.01706.

Orateur: UEDA, Masahito (The University of Tokyo)

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

Minimizing resources for quantum devices with control theory

mercredi 20 mars 2024 09:30 (30 minutes)

Quantum technologies are all about controlling quantum systems. Control is the prerequisite to exploit the two essential elements of quantum physics, non-locality and coherence, for practical applications. This currently faces two major challenges — to preserve the relevant non-classical features at the level of device operation and to scale the devices up in size.

Control theory provides tools for tackling both challenges. On the one hand, controllability analysis aims at answering the question which control targets, states or operations, are accessible. On the other hand, control theory provides methods to derive the actual control fields that implement the desired dynamics. I will discuss how to leverage control theory to minimize resources for quantum devices and thus ease requirements towards scaling up their size.

In particular, I will show how controllability analysis allows us to identify the minimum number of local controls required to implement universal quantum computing in an array of coupled qubits. Moreover, I will provide examples for the control of open quantum systems where the environment leads to decoherence but also opens new prospects for control. I will discuss examples for both strategies, with practical applications in Rydberg atoms, trapped ions, and superconducting circuits.

Orateur: KOCH, Christiane (Freie Universität Berlin)

ID de Contribution: **19** Type: **Non spécifié**

Topological amplification in driven-dissipative systems

mercredi 20 mars 2024 10:00 (30 minutes)

Orateur: PORRAS, Diego (CSIC Madrid)

ID de Contribution: **20** Type: **Non spécifié**

Interplay between the phase dynamics and edge states in Josephson junctions of time-reversal invariant topological superconductors

mercredi 20 mars 2024 11:00 (30 minutes)

Two-dimensional time-reversal invariant topological superconductors (TRITOPS) host a Kramers pair of propagating edge states. Their coupling in a Josephson junction can be described by a Dirac Hamiltonian with a mass term that depends on the phase bias of the junction. Notably, this mass term exhibits different characteristics in junctions between TRITOPS compared with those between a TRITOPS and a non-topological superconductor (S). In the latter case there is an instability towards a state with broken time-reversal symmetry.

In this talk, I will briefly outline how these properties lead to a markedly different behavior of the current-phase relation in each type of junction.
Additionally, I will discuss the stability of the broken-symmetry state of the TRITOPS-S junction against the phase fluctuations.

I will also discuss the effect of fluxons in the junction giving rise to the formation solitons in the phase field. These solitons induce a spatially varying mass for the edge modes, akin to the Jackiw-Rebbi model. Consequently, topological fermionic modes emerge localized at the fluxons.
The nature of these modes also depends on the type of junction, being single Majorana fermions in the TRITOPS-S case. Lastly, I will analyze the impact of these localized modes on the dynamics of soliton-antisoliton collisions.

Orateur: ARRACHEA, Liliana (Universidad Nacional de San Martín, Buenos Aires, Argentina)

ID de Contribution: **21** Type: **Non spécifié**

Informational steady-states and conditional entropy production in continuously monitored systems

mercredi 20 mars 2024 11:30 (30 minutes)

I will put forth a unifying formalism for the description of the thermodynamics of continuously monitored systems, where measurements are only performed on the environment connected to a system. I will show, in particular, that the conditional and unconditional entropy production, which quantify the degree of irreversibility of the open system's dynamics, are related to each other by the Holevo quantity and discuss the existence of informational steady-states, i.e. stationary states of a conditional dynamics that are maintained owing to the unbroken acquisition of information.
I will illustrate the applicability of such framework through several examples, including the modelling of a recent experiment in the field of cavity optomechanics.

Orateur: PATERNOSTRO, Mauro (Queen's University Belfast)