Quantum Simulators

Rapport sur les contributions

https://indico.math.cnrs.fr/e/8996

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

Registration/Opening

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

Magic in many-body systems

lundi 5 février 2024 10:00 (45 minutes)

Quantum resources have entered the many body state over the last two decades. Apart from the prototypical case of entanglement, relatively little is known about how such resources relate to physical phenomena, a question that is of pivotal importance for the understanding of quantum simulators and computers as many-body systems.

In this talk, I will show how magic - a type of resource that is fundamental in determining quantum advantage - is directly related to many-body phenomena. First, I will review recent developments in quantum information theory that have demonstrated stabilizer Renyi entropies as measures of magic. Based on that, I will present method(s) to measure magic in tensor network simulations, based on the concept of Markov chains over the Clifford group, and on replicated matrix product states.

Finally, I will illustrate a series of applications, including (a) how state magic and long-range magic behave in conformal field theories - illustrating the limit of the former, and the capabilities of the latter; (b) the scaling of magic in two-dimensional systems, showing how the latter detects phase transitions in Z2 lattice gauge theories with a precisions that is considerably better than those of ordinary order parameters; and (c) how it is possible to have a distinct series of ‘complexity transitions’in monitored quantum dynamics.

I will close discussing the applicability of our methods to experiments, pointing out possibilities and challenges.

Orateur: DALMONTE, Marcello (The Abdus Salam International Centre for Theoretical Physics)

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

Passive two-photon dissipation for bit-flip error correction of a cat code

lundi 5 février 2024 11:15 (45 minutes)

Bosonic codes offer a resource-efficient method to quantum error correction [1]. Of particular interest, autonomous correction was successfully demonstrated for cat codes [2–5], where the logical |0⟩ and |1⟩ states are coherent states of opposite amplitudes |α⟩ and | − α⟩ in a superconducting resonator with single-photon loss rates κ1 as low as possible. They correct bit-flip errors by either using the non-linearity of the oscillator or parametrically pumping couplers to produce two-photon dissipation at a rate κ2.

The bit-flip time increases exponentially with |α|^2 while the phase-flip rate only increases linearly with |α|^2. In this work, we introduce and experimentally demonstrate a new superconducting circuit designed to correct for bit-flip errors of cat codes. Crucially, the two-photon dissipation does not require any pump, so that a single drive is required to stabilize the qubit manifold. This is obtained by nonlinearly coupling the cat qubit to a buffer mode that resonates at twice the frequency of the cat qubit.

We experimentally demonstrate unprecedented ratios κ2/κ1, so that bit flip times well over a ms can be reached with a few photons only. We also demonstrate quantum gates on this corrected cat qubit.

This work was partly supported by the grant ANR-19-QUAN-0006.

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Orateur: HUARD, Benjamin (ENS Lyon)

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

Strongly-interacting bosons at dimensional crossover: single-particle correlation and anomalous cooling

lundi 5 février 2024 12:00 (30 minutes)

Dimensionality plays an essential role in determining the nature and properties of quantum gases. Fruitful physics may appear at the crossover between dimensions. In the current generation of cold atom experiments, the dimensionality of the system can be controlled by optical lattices. In this talk, I will firstly present our recent study of strongly-interacting bosons at 2D-1D dimensional crossover [1].

We find, using Cesium atoms in optical lattices, that the single-particle correlation function of the system evolves from a Berezinskii-Kosterlitz-Thouless (BKT) form to a Tomonaga-Luttinger liquid (TLL) type. The behavior of the correlation with distance, reflects the fact that the particles see their dimensionality as being one or two depending on whether they are probed on short or long distances, respectively. These results are consistent with our theoretical prediction [2] obtained via ab-initio quantum Monte Carlo (QMC) calculations.

In addition, the comparison of the experimentally measured correlation function with the QMC calculation, allows us to perform thermometry on the low dimensional bosons with 1 nK sensitivity [3]. Strikingly, during the dimensional reduction process, we find that the temperature for the 1D case can be much lower than the initial temperature in 3D. Our findings show that this decrease results from the interplay of dimensional reduction and strong interactions.

[1]. Y. Guo, H. Yao, S. Ramanjanappa, S. Dhar, M. Horvath, L. Pizzino, T. Giamarchi, M. Landini and H.-C. Nägerl, arXiv: 2308.00411 (to appear in Nat. Phys.)
[2]. H. Yao, L. Pizzino, T. Giamarchi, SciPost Phys. 15, 050 (2023)
[3]. Y. Guo, H. Yao, S. Dhar, L. Pizzino, M. Horvath, T. Giamarchi, M. Landini,

H.-C. Nägerl, arXiv:2308.04144 (to appear in Sci. Adv.)

Orateur: YAO, Hepeng (University of Geneva)

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

Quantum simulation of the boundary sine-Gordon model in superconducting circuits

lundi 5 février 2024 14:30 (45 minutes)

Superconducting junction arrays constitute a versatile and tunable platform to engineer model Hamiltonians that are relevant for quantum many-body systems, dissipative quantummechanics, and non-linear quantum optics. We investigate the detailed AC spectroscopy of the boundary sine-Gordon (BSG) model for a circuit designed with a large impedance value below the resistance quantum. This regime triggers large fluctuations of the superconducting phase variable, leading to two major and related physical effects: a giant renormalization of the Josephson energy at the boundary site, and a broadband inelastic scattering of external photons induced by the dynamics at the boundary.

We also give the first direct experimental detection of three-photon down-conversion in the BSG model. We finally discuss critically the advantages and limitations of superconducting circuits for the exploration of quantum many-body phenomena.

Orateur: FLORENS, Serge (Institut Néel)

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

Magnetism and spin squeezing with arrays of Rydberg atoms

lundi 5 février 2024 15:15 (45 minutes)

This talk will present our recent work on the use of arrays of Rydberg atoms to study equilibrium and out-of-equilibrium quantum magnetism and to generate entangled states useful for quantum metrology. We rely on laser-cooled ensembles of up to one hundred individual atoms trapped in microscopic optical tweezer arrays. By exciting the atoms into Rydberg states, we make them interact by the resonant dipole interaction. The system thus implements the XY spin ½ model, which exhibits various magnetic orders depending on the ferromagnetic or antiferromagnetic nature of the interaction.

In particular, we adiabatically prepare long-range ferromagnetic order. When the system is placed out of equilibrium, the interactions generate spin squeezing. We characterize the degree of squeezing and observe that it scales with the number of atoms. Finally, the analysis of the spread of correlations across the system leads to the measurement of the dispersion relation, and we observe the predicted anomalous behavior in the ferromagnetic case, consequence of the dipolar interactions.

Orateur: BROWAEYS, Antoine (Institut d'Optique, CNRS)

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

Many-body quantum heat engines based on free-fermion systems.

lundi 5 février 2024 16:30 (45 minutes)

We study the thermodynamics of free-fermion systems coupled to quantum thermal baths within a Markovian approximation. In particular, we construct a four-stroke quantum Otto engine by alternately coupling such kind of systems to two reservoirs at different temperatures and operating adiabatic switches of some Hamiltonian parameters, followed by isochoric transformations.

We show that the engine can operate in four different modes; in particular it can act as a heat engine and as a refrigerator, with thermodynamic performances that are affected by the possible presence of quantum criticality in the model. We also discuss the effects of non perfect thermalization with the baths and of adiabatic processes which are executed in a finite width of time.

Orateur: ROSSINI, Davide (University of Pisa)

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

Exploring quantum criticality in a 4D quantum disordered system

lundi 5 février 2024 17:15 (45 minutes)

The localization-delocalization transition in disordered media is ubiquitous in quantum and classiacal systems. It is one of the rare transition for which there is no mean-field theory valid in any dimensions. We report the observation and characterization of the Anderson transition in 4D using ultracold atoms as a quantum simulator with synthetic dimensions.

We characterize the universal dynamics in the vicinity of the phase transition and measure the critical exponents describing the scale-invariant properties of the critical dynamics. The critical exponents verify Wegner's scaling relation, and we demonstrate experimentally that the Anderson transition is not mean-field in dimension four.

Orateur: RANÇON, Adam (Université de Lille)

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

Strongly-Correlated Bosons in Optical Quasicrystals: Localization, fractality, and Bose-glass physics

mardi 6 février 2024 09:15 (45 minutes)

Quasicrystals, a fascinating class of materials with long-range but nonperiodic order, exhibit fascinating properties due to their unique position at the crossroads of long-range-ordered and disordered systems. These include remarkable localization and fractal properties. While such properties are well known for single particles, the strongly-correlated regime remains largely unexplored. Quantum simulation of quasicrystals in synthetic bosonic matter now paves the way to the exploration of these intriguing systems in wide parameter ranges [1,2].

In a series of recent works [3-7], we have delved into a variety of original aspects of these systems. Our work has revealed a very rich phase diagram characterized by the emergence of a superfluid, a Mott insulator, and a Bose glass, in spite of absence of an underlying periodic lattice. We have shown that the Mott insulator exhibits a fractal structure and proposed a method for determining its Hausdorff dimension. While first evidence of a Bose glass has been reported for a weakly-interacting condensate [8], we have shown that it can be stabilized in the strongly-interacting regime. Previously, clear observation of this emblematic phase has been thwarted by thermal fluctuations, which compete with disorder. We have shown that shallow quasicrystal potentials permits to overcome this pitfall, and have demonstrated that a clear Bose glass can be stabilized in broad temperature regimes, in 1D as well as 2D. Our works pave the way to further experimental investigation of ultracold-atom quantum simulators of quasicrsytals.

References

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[8] J.-C. Yu, S. Bhave, L. Reeve, B. Song, and U. Schneider, Observing the two-dimensional Bose glass in an optical quasicrystal, arXiv:2303.00737.

Orateur: SANCHEZ PALENCIA, Laurent (Center for Theoretical Physics, CNRS)

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

Non-equilibrium dynamics of large bosonic quantum many-body systems under the microscope

mardi 6 février 2024 15:15 (45 minutes)

Quantum gas microscopy (QGM) provides unique access to the properties of quantum many-body system in- and out-of-equilibrium. In this talk, I will report recent work on thermalizationdynamics of hard-core bosons in quasi-1D systems. We make use of site-resolved densitysnapshots in order to monitor the full counting statistics of particle-number fluctuations inoptical ladders, contrasting systems with ballistic and chaotic dynamics.

We find excellentagreement between our results and predictions using macroscopic fluctuation theory (MFT),which allows us to accurately extract diffusion constants from fluctuation growth. Our resultssuggest that large-scale fluctuations of isolated quantum systems display emergenthydrodynamic behavior, expanding the applicability of MFT to the quantum regime. In thesecond part of my talk, I will focus on new experimental results, where we have developed atechnique to measure kinetic operators, such as kinetic energy or current operators, in QGMsby projecting the many-body wave function onto isolated double wells.

These operators canbe measured and manipulated with single-bond resolution, hence, significantly expanding thetoolbox of QGMs. Beyond simple expectation values of these observables, the singleshotmeasurements allow to access full counting statistics and complex correlation functions. Thispaves the way for the implementation of efficient quantum state tomography and hybridquantum computing protocols for itinerant particles on a lattice.

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Orateur: AIDELSBURGER, Monika (Max-Planck-Institut für Quantenoptik)

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

Kardar Parisi Zhang universal scaling in the coherence of polariton condensates

mardi 6 février 2024 11:15 (45 minutes)

The Kardar–Parisi–Zhang (KPZ) equation[1], originally derived to describe the kinetic roughening of growing interfaces is a stochastic non-linear differential equation that applies to a large class of non-equilibrium systems, ranging from the growth of nematic liquid crystal clusters, of bacterial colonies, or the propagation of a combustion front. The shape of such an interface h(r,t) is described by the following stochastic equation:
∂_t h=v∇^2 h+λ/2 (∇h)^2+η, where the first term is a smoothening diffusion, the second term is a crucial nonlinear contribution that leads to critical roughening of the interface and η is a Gaussian noise. Interestingly the spatial and temporal correlation functions of h(r,t) show universal scaling laws, with critical exponents that only depend on the dimensionality whatever the system .

Recently, it was discovered that the phase dynamics in the coherent emission of out of equilibrium condensates of light (named polariton condensates) also obeys the celebrated KPZ equation [2-4]. Interestingly, since the phase is a compact variable, periodically defined between 0 and 2□□□ the physics is enriched by the possible emergence of vortices. Actually even in 1D, where usually vortices are excluded, exotic spatio-temporel vortices have been predicted to play a role [5].

In the present talk, after a general introduction to the cavity polaritons, I will explain how we could generate extended 1D polariton condensates [6] and probe their first order coherence. We demonstrate that the spatio-temporal decay of the first order coherence presents universal scaling laws characteristic for the KPZ universality class in 1D [7]. The influence of vortices in these experiments will be discussed as well as the extension of this work in 2D [2].

Our work highlight the profound difference between driven-dissipative out of equilibrium condensates and their equilibrium counterparts. We anticipate that this physics should also be relevant in extended vertical cavity lasers.

References

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Orateur: BLOCH, Jacqueline (C2N)

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

Bogoliubov excitations driven by thermal lattice phonons in a quantum fluid of light

mardi 6 février 2024 12:00 (30 minutes)

The elementary excitations in weakly interacting quantum fluids have a non-trivial nature which is at the basis of defining quantum phenomena such as superfluidity. These excitations and the physics they lead to have been explored in closed quantum systems at thermal equilibrium both theoretically within the celebrated Bogoliubov framework, and experimentally in quantum fluids of ultracold atoms. Over the past decade, the relevance of Bogoliubov excitations has become essential to understand quantum fluids of interacting photons.

Their driven-dissipative character leads to distinct properties with respect to their equilibrium counterparts. For instance, the condensate coupling to the photonic vacuum environment leads to a non-zero generation rate of elementary excitations with many striking implications. In this work, considering that quantum fluids of light are often hosted in solid-state systems, we show within a joint theory-experiment analysis that the vibrations of the crystal constitute another environment that the condensate is fundamentally coupled to.

This coupling leads to a unique heat transfer mechanism, resulting in a large generation rate of elementary excitations in typical experimental conditions, and to a fundamental non-zero contribution at vanishing temperatures. Our theoretical framework also allows us to predict the presence of correlations in the photon field escaping the system.

Orateur: FRÉROT, Irenée (Institute Néel, CNRS)

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

Steering and Quantum Cooling

mardi 6 février 2024 14:30 (45 minutes)

Orateur: GEFEN, Yuval

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

Time-Convolutionless Master Equation Applied to Adiabatic Elimination

mardi 6 février 2024 10:00 (45 minutes)

In Open Quantum Systems (OQS) theory, where the effective dynamics of a subsystem are described by tracing out environmental degrees of freedom, model reduction techniques become crucial for both conceptual understanding and practical efficiency. In this work, we study the connection between two model reduction methods for systems described by a Lindblad equation. The first is the Time Convolutionless (TCL) master equation, a standard tool in OQS theory used to compute the projected time-evolution. The second is the geometric formulation of Adiabatic Elimination (AE), based on the timescale separation of the dynamics of those quantum systems that exhibit a rapid relaxation to an invariant subspace, followed by a slower relaxation in it.

We provide a unified perspective on the two approaches, showing that the TCL master equation offers an alternative formulation to AE. We do so by introducing a conjecture and proving it up to third order of the time-scale separation parameter in perturbative calculations. Additionally, we provide practical demonstrations of the TCL projective approach to AE.

Our findings have twofold implications: the geometric perspective of AE gives a novel understanding to the TCL master equations, while the latter provides robust solutions to challenges within AE computations.

Authors:

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Orateur: RIVA, Angela (LPENS)

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

Dynamics of multipartite entanglement: from long-range to short-range interactions

mardi 6 février 2024 16:30 (45 minutes)

Quantum simulators realize the most controlled forms of quantum matter, in which one can hope to both design and probe many-body quantum coherence and entanglement. Pursuing this program away from equilibrium offers a much richer palette of entangled states than those possible in equilibrium systems; and the possibility to reach these states in a short time, a fundamental advantage for experiments.

In this talk I will present our recent results on the dynamics of U(1) symmetric Hamiltonians, corresponding to a large family of quantum simulators from AMO physics to superconducting platforms. A generic form of many-body entanglement generated in these systems away from equilibrium is spin squeezing, whose scaling is fundamentally controlled by the ability of the system to slowly relax a spin polarization imposed on it in the initial state.

Moreover further entangled states, in the form of Schrödinger's cat states and their generalization, are also observed in the dynamics, provided that the collective spin length remains sufficiently large during the dynamics.

I will discuss in particular the role of the interactions and of dimensionality, showing that entanglement dynamics known to exist for infinite-range interactions can survive when moving to strictly short-range (i.e. nearest-neighbor) interactions in planar geometries.

Orateur: ROSCILDE, Tommaso (ENS Lyon)

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

Limit Shape Transition in Full Counting Statistics

mardi 6 février 2024 17:15 (45 minutes)

Full Counting Statistics (FCS) is a way to characterise
non-local correlations in many body systems. We calculate the generating function of FCS of the particle number on amacroscopic interval in a system of free fermions and reveal the existence of 2+\epsilon order phase transition as a function of the rescaled counting parameter. We characterise the transition as a topological change of the dominant configuration (instanton) in the coarse grained hydrodynamical fields similar to Limit Shape transitions in fluctuating statistical phenomena.

Orateur: GANGARDT, Dimitri

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

Analog of the ETH for integrable systems

mercredi 7 février 2024 09:15 (45 minutes)

The ETH addresses the structure of matrix elements of local operators in energy eigenstates of generic systems. I will discuss what replaces the ETH for integrable systems.

Orateur: ESSLER, Fabian (University of Oxford)

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

Measuring the local rapidity distribution of 1D Bose gases

mercredi 7 février 2024 10:00 (45 minutes)

I will present joint work with Léa Dubois, Guillaume Thémèze Florence Nogrette and Isabelle Bouchoule (Institut d'Optique, Palaiseau, France) on the measurement of the local rapidity distribution in 1D Bose gases.
1D bosons with point-like interaction, also known as Lieb-Liniger gas, display peculiar dynamical behavior because they are (nearly) integrable. The rapidities of a 1D Bose gas are the asymptotic momenta of the atoms, which can be measured by 1D time of flight.

It is now established that the rapidity distribution entirely characterizes these 1D gases after relaxation, and over the past few years the rapidity distribution has become the central concept in the study of their dynamics, both theoretically with the advent of Generalized Hydrodynamics in 2016 and experimentally with first measurements of the global rapidity distribution performed in 2020 by the group of David Weiss.

Here I will discuss a new experimental protocol to access the spatially resolved distribution of rapidities in the Palaiseau experiment, which should ultimately allow to experimentally map out the entire state of the gas and measure the phase-space distribution of quasi-particles. I will argue that this can be done by performing a one-dimensional expansion of a selected zone of the gas, and I will discuss new experimental results

Orateur: DUBAIL, Jerome (Université de lorraine)

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

To learn a mocking-black hole

mercredi 7 février 2024 11:15 (45 minutes)

Complex quantum systems are both hard to simulate and to learn. Generically, they require exponential resources for both. If one were able to learn and then efficiently simulate a complex quantum process, then one would be able to do wonders: for example, to decode the information scrambled by a black hole leaked through Hawking radiation, thus learning its internal structure.

Some complex quantum systems, like those modeled by Clifford circuits, can be both learned and simulated efficiently, that is, with polynomial effort. However, one wants to learn especially those quantum processes that are too hard to simulate in a classical computer. In this talk, we show some recent and surprising results: one can learn a quantum complex process that cannot be efficiently simulated on a classical computer, and once one has learned it, one can simulate it efficiently.

This is so surprising to sound contradictory. However, what one learns are its salient features, while the noisy and difficult to simulate ones can be ditched away and turn out to be irrelevant.

Orateur: HAMMA, Alioscia (Università di Napoli Federico II)

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

Dynamics of an impurity in a trapped one-dimensional Bose gas

mercredi 7 février 2024 12:00 (30 minutes)

An impurity in a Bose gas is a topical cold-atom system that allows one to investigate dynamics of quasi-particles in tunable environments. This set-up is often studied theoretically using homogeneous models, which neglect trapping potentials present in experiments. In this talk, I will consider the effect of an external confinement, and also the effect of temperature in quench dynamics using a Caldeira-Leggett (harmonic bath) model. I will argue that these effects affect the dynamics of one-dimensional systems, and must be taken into account when interpreting existing experimental data.

Orateur: VOLOSNIEV, Artem (ISTA)

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

Correlation dynamics and lattice modulation spectroscopy of interacting one dimensional systems

mercredi 7 février 2024 15:15 (45 minutes)

Quench and lattice modulation are powerful tools for probing low-energy excitations of interacting many-body systems. We present a study of correlation dynamics and absorbed energy power of one-dimensional interacting systems (fermionic and bosonic) subjected either to a quench or to a periodic drive of the optical lattice. For these Tomonaga-Luttinger liquids we find a universal scaling of the absorbed power determined by the boundaries of the system. In the case of an additional ionic staggered potential it is shown how the lattice spectroscopy approach reveals characteristics of a bond order wave phase. Our results can be readily demonstrated in ultracold atoms in optical lattices with current experimental technology.

Orateur: CITRO, Roberta (Universita'degli Studi di Salerno & Spin-CNR)

ID de Contribution: **22** Type: **Non spécifié**

Resonance Cascades as a Tool of Quantum Number Theory

jeudi 8 février 2024 09:15 (45 minutes)

In this presentation, we consider situations where the existence of a contiguous cascade of quantum resonant transitions is predicated on the validity of a particular statement in number theory. As a case study, we look at the following trivial statement: "Any power of 3 is an integer."

Consequently, we "test" this statement in a numerical experiment where we demonstrate an unimpeded upward mobility along an equidistant, log(3)-spaced subsequence of the energy levels of a potential with a log-natural spectrum, under a frequency log(3) time-periodic perturbation. With the knowledge gained in this project, we consider similar schemes aimed at two more number-theoretical statements: "Any product of two sums of two squares of integers is a sum of two squares of integers" (this one can be proven using the Diophantus-Brahmagupta-Fibonacci identity) and "Any even is a sum of two primes" (i.e. the Goldbach conjecture, still unproven).

The empirical relevance of all three projects is ensured by the current experimental progress in creating cold-atomic potentials with a tailored quantum spectrum, in the laboratory of Donatella Cassettari (U of St. Andrews).

In collaboration with Oleksandr Marchukov, Andrea Trombettoni, Giuseppe Mussardo, and Donatella Cassettari.

Orateur: OLCHANYI, Maxime (University of Massachusetts Boston)

ID de Contribution: **23** Type: **Non spécifié**

Holographic Realization of the Prime Number Quantum Potential

jeudi 8 février 2024 10:00 (45 minutes)

I plan to start the seminar by presenting a discussion of the experimental realization with holographic techniques of the prime number quantum potential, defined as the potential entering the single-particle Schrödinger Hamiltonian with eigenvalues given by the first N prime numbers. We also implemented the potential having as eigenvalues the first lucky numbers, a sequence of integers generated by a different sieve than the familiar Eratosthenes's sieve used for the primes. Further possible implementations are also considered. In the final part I will discuss how to possibly apply these potentials to factorization algorithms.

Orateur: TROMBETTONI, Andrea (University of Trieste)

ID de Contribution: **24** Type: **Non spécifié**

Quasi-one dimensional dipolar bosonic systems: from gas to droplet formation

jeudi 8 février 2024 11:15 (45 minutes)

We study a tightly trapped one-dimensional dipolar gas of bosonic atoms for which we derive the equation of state using a variational approximation based on the Lieb-Liniger gas Bethe ansatz wave function. We test our results by computing the breathing mode after solving the stationary generalized Gross-Pitaevskii equation, finding very good agreement with experiments.

When the strength of the dipolar interaction becomes sufficiently attractive compared to the contact one, the incipient formation of droplets is signalled by a steep increase of the breathing mode and a change in sign of the chemical potential. Eventually, on increasing the number of particles in the cloud, the density profile shows the typical droplet flat-top shape.

Upon a sudden release of the trap, varying the number of trapped atoms and the scattering length, the numerical solution of a time-dependent generalized Gross-Pitaevskii equation shows either an evaporation of the cloud, the formation of a single self-bound droplet, or a fragmentation in multiple droplets. Finally we extend the analysis of the breathing modein the region of stability of the droplets.

Orateur: DE PALO, Stefania

ID de Contribution: **25** Type: **Non spécifié**

Strongly interacting mixtures in 1D box traps: nonequilibrium dynamics and symmetry breaking

jeudi 8 février 2024 12:00 (30 minutes)

My talk focuses on strongly repulsive one-dimensional gases consisting of two-equally balanced spin components under a box confinement. We describe these systems using a generalized Tonks-Girardeau ansatz for the many-body wave function [1, 2].

In particular, we are interested in the nonequilibrium dynamics induced by the initial separation of the spin components and the subsequent evolution of the system at strong interactions. First, we extend the results of Ref.[3] to a time-dependent system and show how rigid borders of the trapping potential lead to the appearance of finite-size oscillations in the tails of the momentum distribution, the amplitude of which depends on time-dependent spin coherence.

Second, we highlight the role of the symmetry by comparing SU(2) fermions with SU(2)-breaking bosons with an interaction imbalance.

[1] F. Deuretzbacher et al., PRL, 100, 160405 (2008);
[2] A.G. Volosniev et al., Nat. Comm., 5, 5300 (2014);
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Orateur: MUSOLINO, Silvia (Institut de Physique de Nice)

ID de Contribution: **26** Type: **Non spécifié**

Quantum simulation in the age of color

jeudi 8 février 2024 14:30 (45 minutes)

Alkaline-earth and ytterbium cold atomic gases make it possible to simulate SU(N)-symmetric fermionic systems in a very controlled fashion. Such a high symmetry is expected to give rise to a variety of novel phenomena ranging from molecular Luttinger liquids to (symmetry-protected) topological phases.

I will discuss some of the phases that can be stabilized in a one dimensional lattice, including e.g. gapped valence-bond solids in frustrated chains, non-Landau quantum phase transitions in modulated SU(N) Heisenberg spin chains, as well as chiral spin liquids found numerically on various two-dimensional lattices.

Orateur: CAPPONI, Sylvain (Université Paul Sabatier)

ID de Contribution: **27** Type: **Non spécifié**

Asymptotic quantum many-body scars

jeudi 8 février 2024 15:15 (45 minutes)

We consider a quantum lattice spin model featuring exact quasiparticle towers of eigenstates with low entanglement at finite size, known as quantum many-body scars (QMBS). We show that the states in the neighboring part of the energy spectrum can be superposed to construct entire families of low-entanglement states whose energy variance decreases asymptotically to zero as the lattice size is increased. As a consequence, they have a relaxation time that diverges in the thermodynamic limit, and therefore exhibit the typical behavior of exact QMBS although they are not exact eigenstates of the Hamiltonian for any finite size.

We refer to such states as asymptotic QMBS. These states are orthogonal to any exact QMBS at any finite size, and their existence shows that the presence of an exact QMBS leaves important signatures of non-thermalness in the rest of the spectrum; therefore, QMBS-like phenomena can hide in what is typically considered the thermal part of the spectrum. We support our study using numerical simulations in the spin-1 XY model, a paradigmatic model for QMBS, and we conclude by presenting a weak perturbation of the model that destroys the exact QMBS while keeping the asymptotic QMBS.

Orateur: MAZZA, Leonardo (Université Paris Saclay)

ID de Contribution: **28** Type: **Non spécifié**

Generalised hydrodynamics for quantum fluids at low-temperature: anomalous transport and quantum ripples

jeudi 8 février 2024 16:30 (45 minutes)

I will show some applications and extensions of the theory of generalised hydrodynamics to quantum systems at low temperature. Taking the paradigmatic model of the Lieb-Liniger for interacting bosons, I will show how non-integrable fluids can display super-diffusive charge fluctuations at low temperature and low coupling, and how to correctly describe non-equilibrium quantum fluctuations beyond the Luttinger liquid paradigm.

Orateur: DE NARDIS, Jacopo (CYU)

ID de Contribution: **29** Type: **Non spécifié**

Amorphous quantum magnets in a two-dimensional Rydberg atom array

jeudi 8 février 2024 17:15 (45 minutes)

Amorphous solids, characterized by a well-defined short-range order but do not present long range order, constitute an important research topic in condensed matter. While their properties are known to differ from their crystalline counterpart, a microscopic description is still missing.

In this talk, we propose to explore amorphous quantum magnets with a Rydberg quantum simulator. To this end, we outline an algorithm to generate amorphous quantum magnets and study their ground state and dynamical properties with the help of a linear spin-wave approach. In particular, we calculate the mean-field phase diagrams, probe the energy spectra and calculate dynamical structure factors for given realisations of amorphous solids.

This work opens the road towards the study of amorphous quantum magnets in regimes difficult to simulate classically.

Orateur: VOVROSH, Joseph (PASQAL)

ID de Contribution: **30** Type: **Non spécifié**

Engineering pseudo-thermal distributions in quantum simulators

vendredi 9 février 2024 09:15 (45 minutes)

In this talk I will describe our research on QAOA-like algorithms, in which a quantum simulator is used for brief periods of time, in combination with local drives. We have shown in Ref. [1] that using a quantum simulator for an Ising mode just once, for an arbitrarily brief period of time, results in a pure state that resembles a Boltzmann distribution up to a limiting temperature, that scales favorably with problem size.

This result, which can be shown analytically for a single use of the simulator, has been extended recently for multiple layers, reaching arbitrarily low temperatures. I will discuss the connection between this and errors in adiabatic quantum computation and quantum annealing.

[1] Quantum Approximate Optimization Algorithm Pseudo-Boltzmann States, Pablo Díez-Valle, Diego Porras, and Juan José García-Ripoll, Phys. Rev. Lett. 130, 050601 (2023)

Orateur: GARCIA RIPOLI, Juan José (Institute of Fundamental Physics, CSIC)

ID de Contribution: **31** Type: **Non spécifié**

Quantum simulation of the tricritical Ising model in tunable Josephson junction ladders

vendredi 9 février 2024 10:00 (45 minutes)

L. Maffi, N. Tausendpfund, M. Rizzi, M. Burrello

Modern hybrid superconductor-semiconductor Josephson junction arrays are a promising platform for analog quantum simulations. Their controllable and non-sinusoidal energy/phase relation opens the path to implement nontrivial interactions and study the emergence of exotic quantum phase transitions. Here, we propose the analysis of an array of hybrid Josephson junctions defining a 2-leg ladder geometry for the quantum simulation of the tricritical Ising phase transition.

This transition provides the paradigmatic example of minimal conformal models beyond Ising criticality and its excitations are intimately related with Fibonacci non-Abelian anyons and topological order in two dimensions. We study this superconducting system and its thermodynamic phases based on bosonization and matrix-product-states techniques. Its effective continuous description in terms of a three-frequency sine-Gordon quantum field theory suggests the presence of the targeted tricritical point and the numerical simulations confirm this picture.

Our results indicate which experimental observables can be adopted in realistic devices to probe the physics and the phase transitions of the model. Additionally, our proposal provides a useful one-dimensional building block to design exotic topological order in two-dimensional scalable Josephson junction arrays.

arXiv:2310.18300

Orateur: RIZZI, Matteo (Universität zu Köln)

ID de Contribution: **32** Type: **Non spécifié**

Prediction and Observation of the Universal Hall Response in Strongly Interacting Fermions

vendredi 9 février 2024 11:15 (45 minutes)

The Hall effect originates from the motion of charged particles in a magnetic field and has deep consequences for the description and characterization of materials, far beyond the context of condensed matter physics. Understanding the Hall effect in interacting systems still represents a fundamental challenge.

Orateur: FILIPPONE, Michele (CEA)

ID de Contribution: **33** Type: **Non spécifié**

From Středa's formula to Luttinger's theorem: Topological signatures unveiled through density probes

vendredi 9 février 2024 12:00 (30 minutes)

Identifying experimentally accessible probes that are able to reveal truly distinctive properties of topological phases of matter has remained as an ever-relevant mission. In this talk, I will start reviewing recent advances that were made possible thanks to a remarkable thermodynamic relation known as the Widom-Středa formula, which relates the quantized Hall conductivity of an insulator to its density response under an external probe magnetic field.

I will discuss how this response can be interpreted as a genuine local topological marker and briefly show how we adapted this well-known formula to explore the emergence of quantized valley Hall signals in strained honeycomb lattices [1]. Then, I will explain how this non-perturbative relation allowed us to derive a fundamental connection between the failure of Luttinger's theorem and the classification of correlated quantum Hall phases with winding numbers built from single-particle Green's functions [2].

[1] Maxime Jamotte, Lucila Peralta Gavensky, Cristiane Morais Smith, Marco Di Liberto, and Nathan Goldman, "Quantized valley Hall response from local bulk density variations,"Communications Physics 6, 264 (2023).

[2] Lucila Peralta Gavensky, Subir Sachdev, and Nathan Goldman, "Connecting the Many-Body Chern Number to Luttinger's Theorem through Středa's Formula,"Phys. Rev. Lett. 131, 236601 (2023)Phys. Rev. Lett. 131, 236601Phys. Rev. Lett. 131, 236601

Orateur: PERALTA, Lucila (Université libre de bruxelles)

ID de Contribution: **34** Type: **Non spécifié**

Fermionization of 2D anyons in a tight wave-guide

vendredi 9 février 2024 14:30 (45 minutes)

Since free quantum particles with general statistics parameter $\alpha \in]0, 2[$ are formally equivalent to free bosons (or fermions) strongly coupled to an appropriate gauge field, it is tempting to simulate exotic statistics e.g. using cold atoms coupled to density-dependent synthetic gauge fields.

This has raised interest both in the context of 2D and 1D anyons, reviving the question of the connection between the two concepts. We ask the question of what 1D anyon model (amongst the several proposed ones), if any, is the limit of the main 2D anyon model.

We consider a many-body system of 2D anyons, described in the magnetic gauge picture as bosons attached to Aharonov-Bohm fluxes of intensity $2\pi\alpha$. A dimensional reduction to 1D is obtained by imposing a strongly anisotropic trapping potential. This freezes the motion in the direction of strong trapping, leading to 1D physics along the weak direction. We find (via a rigorous mathematical theorem) that the latter is governed to leading order by the Tonks-Girardeau model of impenetrable bosons (exactly soluble via Girardeau's Bose-Fermi mapping) independently of α.

Joint work with Qiyun Yang

Orateur: ROUGERIE, Nicolas (ENS)

ID de Contribution: **35** Type: **Non spécifié**

A definir by Eugene Demler

vendredi 9 février 2024 15:15 (45 minutes)

ID de Contribution: **36** Type: **Non spécifié**

Molecular Bose-Einstein Condensates

mercredi 7 février 2024 14:30 (45 minutes)

I shall discuss the two newly discovered molecular BEC: those of ground state dipolar molecules of NaCs achieved in January 2024, and those of G-wave Feshbach molecules realized in 2023. I shall discuss their phase coherence different from those of the atomic BECs.

Orateur: HO, Tin-Lun (Jason) (The Ohio State University)

ID de Contribution: **37** Type: **Non spécifié**

Theory of free fermions dynamics under partial post-selected monitoring

mercredi 7 février 2024 16:30 (45 minutes)

Monitored quantum systems undergo Measurement-induced Phase Transitions (MiPTs) stemming from the interplay between measurements and unitary dynamics. When the detector readout is post-selected to match a given value, the dynamics is generated by a Non-Hermitian Hamiltonian with MiPTs characterized by different universal features.

Here, we present a partial post-selected stochastic Schrödinger equation based on a microscopic description of continuous weak measurement. This formalism connects the monitored and post-selected dynamics to a broader family of stochastic evolution. We apply the formalism to a chain of free fermions subject to partial post-selected monitoring of local fermion parities. Within a 2-replica approach, we obtained an effective bosonized Hamiltonian in the strong post-selected limit. Using a renormalization group analysis, we find that the universality of the non-Hermitian MiPT is stable against a finite (weak) amount of stochasticity.

We further show that the passage to the monitored universality occurs abruptly at finite partial post-selection, which we confirm from the numerical finite size scaling of the MiPT. Our approach establishes a way to study MiPTs for arbitrary subsets of quantum trajectories and provides a potential route to tackle the experimental post-selected problem.

Orateur: ROMITO, Alessandro (Lancaster Unviersity)