Gran Sasso Quantum Meetings @GSSI

From Equilibrium Phenomena Towards Open Quantum System

March, 22-26 2021

GSSI

Contributed Talks

Monday, March 22 - Session 1

Schedule

16:00 - 16:20	Amirali Hannani *Univ. Paris Dauphine-PSL*	Hydrodynamic limit for a disordered quantum harmonic chain
16:20 - 16:40	Severin Schraven *University of Zurich*	Bose-Einstein condensation with optimal rate for trapped bosons in the Gross-Pitaevskii Regime
16:40 - 17:00	Dario Feliciangeli *IST Austria*	The strongly coupled polaron on a torus: quantum corrections to the Pekar asymptotics

Abstracts

Hydrodynamic limit for a disordered quantum harmonic chain

Amirali Hannani
CEREMADE, Université Paris Dauphine-PSL

Obtaining the macroscopic evolution of conserved quantities and their corresponding currents for a "physical" system from its microscopic dynamics also known as hydrodynamic limits is a matter of interest both in Physics and Mathematics communities. In this talk, I present a hydrodynamic limit, in the hyperbolic space-time scaling, for a one-dimensional unpinned chain of quantum harmonic oscillators with random masses. This model is among the famous toy-models for studying heat transfer in solid. To the best of my knowledge, this is among the first examples, where one can prove the hydrodynamic limit for a quantum system rigorously. In fact, I show that the distribution of the elongation, momentum, and energy averaged under the proper Gibbs state converges to the solution of the Euler equation.

There are two main phenomena in this chain that let us deduce this result. First is the Anderson localization which decouples the mechanical and thermal energy, providing the closure of the equation for energy and indicating that the temperature profile does not evolve in time. The second phenomena is similar to some sort of decay of correlation phenomena which let us circumvent the difficulties arising from the fact that our Gibbs state is not a product state due to the quantum nature of the system.

Bose-Einstein Condensation with optimal rate for trapped bosons in the Gross-Pitaevskii Regime

Severin Schraven
Universität Zürich

We consider a Bose gas consisting of N particles in $\mathbb{R}^3$, trapped by an external field and interacting through a two-body potential with scattering length of order N^{-1}. We prove that low energy states exhibit complete Bose-Einstein condensation with optimal rate, generalizing previous works of Boccata, Brennecke, Cenatiempo and Schlein, restricted to translation invariant systems. This extends recent results of Nam, Napiórkowski, Ricaud and Triay, removing the smallness assumption on the size of the scattering length.

The strongly coupled polaron on a torus: quantum corrections to the Pekar asymptotics

Dario Feliciangeli
IST Austria

In this talk we present recent progress on the Fröhlich Polaron model in the strong coupling regime. In particular, we focus on quantum corrections to the Pekar asymptotics for its ground state energy. Compared to previous works, the main novelty is that we are able to treat the problem in a translational invariant setting, namely a (sufficiently large) torus in $\mathbb{R}^3$. This substantially complicates the discussion and calls for a precise study of the set of minimizers of the classical functional(s) corresponding to the Fröhlich Hamiltonian. We carry out this study by introducing an (almost) infinite dimensional diffeomorphism and formalizing some heuristic arguments contained in the physics literature.

Wednesday, March 24 - Session 2

Schedule

11:00 - 11:20	Oliver Siebert *FSU Jena*	Thermal ionization for short-range potentials
11:20 - 11:40	Marco Caporaletti *University of Zurich*	Excitation spectrum of Bose Gases beyond the Gross-Pitaevskii regime
11:50 - 12:10	Peter Mühlbacher *University of Warwick*	Dimerization in quantum spin chains with $O(n)$ symmetry
12:10 - 12:30	Giovanni Gramegna *University of Trieste*	Generic aspects of the resource theory of quantum coherence

Abstracts

Thermal ionization for short-range potentials

Oliver Siebert
FSU Jena

We consider an open quantum system consisting of a Schrödinger operator with a compactly supported smooth potential coupled to a bosonic field at positive temperature. It is expected that the model exhibits the behavior of thermal ionization. This can be expressed as the absence of time-invariant normal states in a suitable von Neumann algebra, which correspond to zero eigenstates of the Liouvillian. After an introduction to the model we will briefly sketch the idea of the proof, which is based on positive commutators. Joint work with David Hasler.

Excitation spectrum of Bose gases beyond the Gross-Pitaevskii regime

Marco Caporaletti
University of Zurich

We consider Bose gases of N particles in a box of volume one, interacting through a repulsive potential with scattering length of order $N^{-1+\kappa}$. For $0 < \kappa < 2/3$, such scalings are less dilute than the Gross-Pitaevskii one, and they interpolate between the latter and the thermodynamic limit. Assuming that κ is sufficiently small, we determine the ground-state energy and the low-energy excitation spectrum of the system, up to errors vanishing in the limit of large N. This is a joint work with C. Brennecke and B. Schlein.

Dimerization in quantum spin chains with $O(n)$ symmetry

Peter Mühlbacher
University of Warwick

We consider quantum spins with $S \geq 1$, and two-body interactions with $O(2S+1)$ symmetry. We discuss the ground state phase diagram of the one-dimensional system. We give a rigorous proof of dimerization for an open region of the phase diagram, for S sufficiently large.

Generic aspects of the resource theory of quantum coherence

Giovanni Gramegna
University of Trieste

The class of incoherent operations induces a pre-order on the set of quantum pure states, defined by the possibility of converting one state into the other by transformations within the class. We prove that if two n-dimensional pure states are chosen independently according to the natural uniform distribution, then the probability that they are comparable vanishes as $n \to \infty$. We also study the maximal success probability of incoherent conversions and find an explicit formula for its large-n asymptotic distribution. Our analysis is based on the observation that the extreme values (largest and smallest components) of a random point uniformly sampled from the unit simplex are distributed asymptotically as certain explicit homogeneous Markov chains. This is a joint work with Fabio Deelan Cunden, Paolo Facchi and Giuseppe Florio.

Wednesday, March 24 - Session 3

Schedule

16:00 - 16:20	Laurent Lafleche *University of Texas at Austin*	From N-body Schrödinger to Vlasov equation with singular potentials
16:20 - 16:40	Stefano Marcantoni *University of Nottingham*	Irreversibility mitigation in unital non-Markovian dynamical maps
16:50 - 17:10	Christiaan van de Ven *University of Trento*	Strict deformation quantization: a C*-algebraic approach to the classical limit of quantum systems
17:10 - 17:30	Cristina Caraci *University of Zurich*	Bose-Einstein condensation for two-dimensional bosons in the Gross-Pitaevskii regime

Abstracts

From N-body Schrödinger to Vlasov equation with singular potentials

Laurent Lafleche
University of Texas at Austin

In this talk I will present several techniques and concepts used in the context of the mean-field and the semiclassical limit allowing to go from the quantum models to the classical mean-field equations of kinetic theory. The N-body Schrödinger equation describes the motion of N interacting particles at the quantum scale. In the case of Fermions, when making N go to infinity, one obtains a mean-field equation called the Hartree-Fock equation. In parallel, one can also make the Planck constant h go to 0, leading to the Vlasov equation.

To link these equations, one possibility is to understand the similarity of the models to obtain weak-strong uniqueness principles and propagation of a semiclassical notion of regularity independent of N and h.

Irreversibility mitigation in unital non-Markovian dynamical maps

Stefano Marcantoni
University of Nottingham

We study the behavior of the stochastic entropy production in open two-level quantum systems undergoing unital non-Markovian dynamics. In particular, for the family of Pauli channels, we show that in some specific time intervals both the average entropy production and the

variance can decrease, provided that the quantum dynamics fails to be P-divisible, i.e. it belongs to the class of the so-called "essentially non-Markovian dynamics". For a simple model, we provide analytical bounds on the parameters of the dynamics that ensure the mentioned phenomenology. From a physical point of view, although the dynamics of the system is overall irreversible, our result may be interpreted as a transient tendency towards reversibility, described as a delta-peaked distribution of entropy production around zero.
Joint work with S. Gherardini and F. Caruso, based on *Phys. Rev. Research* **2**, *033250 (2020)*.

Strict deformation quantization: a C^*-algebraic approach to the classical limit of quantum systems.

Christiaan van de Ven
University of Trento

The concept of a strict deformation quantization provides a mathematical formalism that describes the transition from a classical theory to a quantum theory in terms of deformations of (commutative) Poisson algebras (representing the classical theory) into non-commutative C^*-algebras (characterizing the quantum theory). In the first part of this talk we introduce the definitions, give several examples and show how quantization of the closed unit 3-ball $B^3 \subset \mathbb{R}^3$ is related to quantization of its smooth boundary (i.e. the two-sphere $S^2 \subset \mathbb{R}^3$). In the second part we apply this formalism to prove the existence of the 'classical limit' of quantum (spin) systems and discuss the concept of spontaneous symmetry breaking (SSB).

Bose-Einstein condensation for two-dimensional bosons in the Gross-Pitaevskii regime

Cristina Caraci
University of Zurich

We discuss the problem of establishing Bose-Einstein condensation for N bosons trapped in a two dimensional box with area one, interacting through a repulsive potential with scattering length exponentially small in the number of particles, i.e. the Gross-Pitaevskii regime. In a recent paper we have shown that low-energy states exhibit complete Bose-Einstein condensation, with almost optimal bounds on the number of orthogonal excitations.

This is a joint work with S. Cenatiempo and B. Schlein.