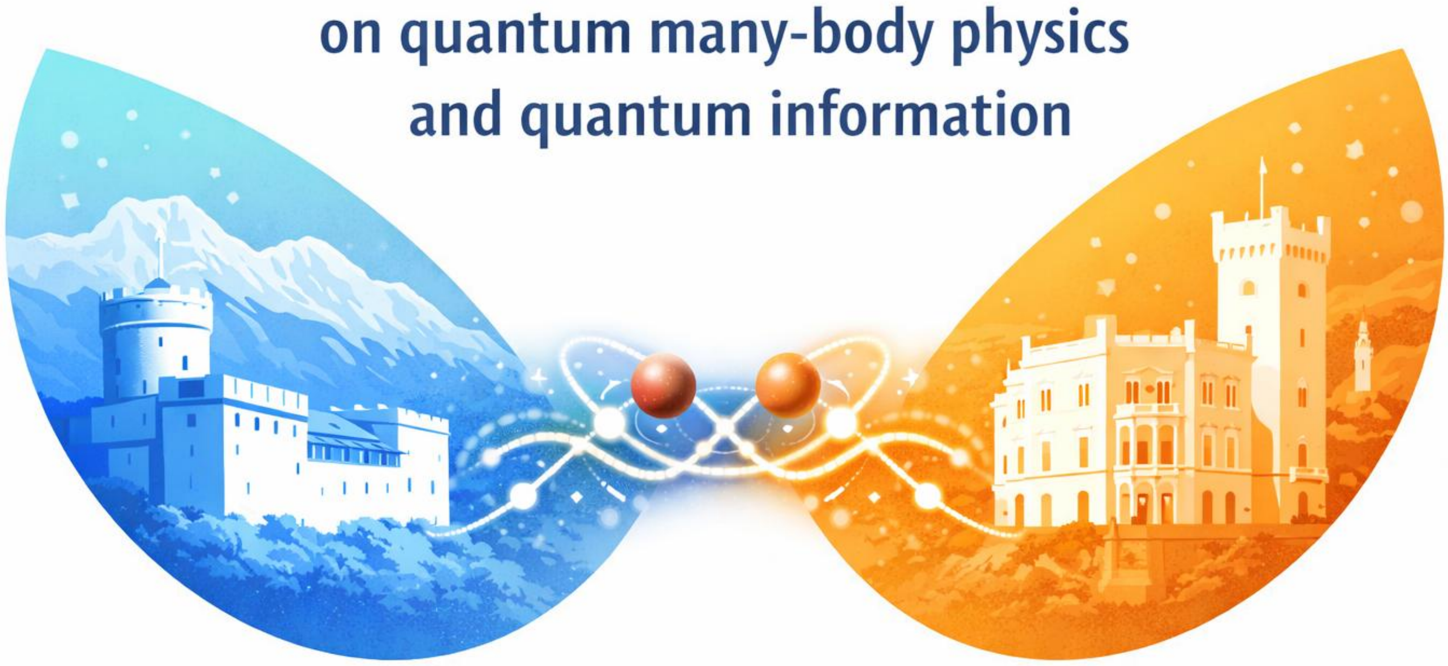
UNIVERSITÀ DI TRENTO
Dipartimento di Fisica

BEC

CNR-INO
ISTITUTO NAZIONALE DI OTTICA
CONSIGLIO NAZIONALE DELLE RICERCHE

Trento – Trieste Meeting

on quantum many-body physics and quantum information



Trento, 21-23 January 2026

Department of Sociology and Social Research
Via Verdi 26| Trento - Italy

Speakers

Oliviero Angeli, University of Trieste
Filiberto Ares, SISSA, Trieste
Devendra Singh Bhakuni, ICTP Trieste
Nicolò Defenu, CNR-INO Trieste
Giovanni Di Fresco, SISSA, Trieste
Gabriele Ferrari, Pitaevskii BEC Center, University of Trento
Stefano Giorgini, Pitaevskii BEC Center, University of Trento
Andrea Legramandi, Pitaevskii BEC Center, University of Trento
Stephanie Matern, Pitaevskii BEC Center, CNR-INO Trento
Chiara Menotti, Pitaevskii BEC Center, CNR-INO Trento
Thomas Müller, ICTP Trieste
Jacopo Niedda, ICTP Trieste
Pietro Oreglia, Pitaevskii BEC Center, University of Trento
Riccardo Panza, University of Trieste, CNR-INO Trieste
Elena Poli, Pitaevskii BEC Center, University of Trento
Alberto Tabarelli de Fatis, Pitaevskii BEC Center, University of Trento
Nikita Titov, University of Trieste
Matteo M. Wauters, Pitaevskii BEC Center, University of Trento

Organizing committee

Alberto Biella, Pitaevskii BEC Center, CNR-INO Trento
Andrea Gambassi, SISSA, Trieste
Sandro Stringari, Pitaevskii BEC Center, University of Trento

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PROGRAMME

Wednesday, 21 January

14:00	Registration and Welcome
15:00	Nicolò Defenu, CNR-INO Trieste
15:30	Elena Poli, Pitaevskii BEC Center, University of Trento
16:00	Meghadeepa Adhikary, SISSA
16:30	Coffee break
17:00	Pietro Oreglia, Pitaevskii BEC Center, University of Trento
17:30 - 18:00	Nikita Titov, University of Trieste

19:30 Social dinner at Caprizza, Via Roma 50, Trento

Thursday, 22 January

09:00	Stephanie Matern, Pitaevskii BEC Center, CNR-INO Trento
09:30	Devendra Singh Bhakuni, ICTP Trieste
10:00	Stefano Giorgini, Pitaevskii BEC Center, University of Trento
10:30	Coffee break
11:00	Riccardo Panza, University of Trieste, CNR-INO
11:30	Gabriele Ferrari, Pitaevskii BEC Center, University of Trento
12:00	Lunch
14:00	Thomas Müller, ICTP Trieste
14:30	Andrea Legramandi, Pitaevskii BEC Center, University of Trento
15:00	Giovanni Di Fresco, SISSA
15:30	Coffee break
16:00	Matteo M. Wauters, Pitaevskii BEC Center, University of Trento
16:30 - 17:00	Filiberto Ares, SISSA

Friday, 23 January

09:00	Chiara Menotti, Pitaevskii BEC Center, CNR-INO Trento
09:30	Oliviero Angeli, University of Trieste
10:00	Coffee break
10:30	Alberto Tabarelli de Fatis, Pitaevskii BEC Center, University of Trento
11:00	Jacopo Niedda, ICTP Trieste
11:30	Final discussion
12:00	

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ABSTRACTS

MEGHADEEPA ADHIKARY, SISSA, Trieste
Title:
Study of classical phase transition through quantum signalling in 1-D long range transverse field Ising model

Abstract:
Understanding the interplay between classical statistical phenomena and quantum complexity remains a central challenge in contemporary many-body physics. Classical thermal phase transitions, typically characterized by macroscopic order parameters and described through equilibrium statistical mechanics, can nevertheless display subtle quantum features when examined from the perspective of purified quantum states. In this work, we explore the behavior of several quantum informational quantities—the Schmidt gap of the entanglement spectrum, the von Neumann entanglement entropy, and quantum magic—in the vicinity of the classical phase transition of the one-dimensional long-range transverse-field Ising model (LRTFIM). Our analysis employs the time-dependent variational principle (TDVP) within the tensor-network framework. We find that these quantities, which are conventionally associated with identifying quantum phase transitions, also capture the signatures of the classical transition, revealing the underlying quantum complexity that emerges near the critical temperature.

OLIVIERO ANGELI, University of Trieste
Title:
Probing the nature of gravity via diffusion

Abstract:
Recent proposals to assess experimentally whether gravity obeys quantum mechanics or not consist in testing gravity's ability to entangle quantum systems. These tests require preparing and controlling large-mass quantum states—a formidable experimental challenge. We propose an alternative strategy: we show that if gravity is classical in the sense of being a local operation and classical communication (LOCC) channel, it must necessarily introduce a diffusive, Brownian-like motion in the dynamics of quantum systems. The presence or lack of this extra diffusion can be tested using non-interferometric experiments, thus bypassing the requirements of controlling macroscopic quantum superpositions and significantly reducing the experimental complexity.

FILIBERTO ARES, SISSA, Trieste
Title:
Probing symmetries in random quantum states

Abstract:
In this talk, I will introduce the entanglement asymmetry, a quantum information-based observable that quantifies how much a symmetry is broken within a part of an extended quantum system. As an application, I will demonstrate how entanglement asymmetry can be used to monitor the broken

symmetries of a black hole during its evaporation. Specifically, I will model the black hole and the radiation as a system of random qubits, from which we will derive the Page curve for the entanglement asymmetry. Finally, I will present experimental results for both the Page curve of the entanglement entropy and the entanglement asymmetry measured in a superconducting quantum simulator.

DEVENDRA SINGH BHAKUNI, ICTP Trieste
Title:
Local vs Nonlocal dynamics in a cavity coupled Rydberg atom array

Abstract:
Locality is a transversal principle that governs quantum dynamics of many-body systems. However, for cavity embedded systems, such fundamental notion is hindered by the presence of non-local cavity modes, leaving space for new possible dynamical behaviors. In this talk, I will present results on the real-time dynamics of low-energy excitations in one-dimensional Rydberg atom arrays coupled to a global cavity mode. In particular, I will show how the non-local nature of the cavity field modifies the behavior of emergent mesons and strings.

NICOLÒ DEFENU, CNR-INO Trieste
Title:
Tuneable universality for quantum technology

Abstract:
The concept of universality has profoundly influenced our understanding of many-body physics, primarily within homogeneous systems, where the scaling of lattice systems can be described by continuous theories in integer Euclidean dimension. In this talk, we explore universality on long-range systems and graphs. Our analysis reveals that the scaling theory of such systems is governed by a single parameter, the spectral dimension, which acts as the control parameter in complex geometries. The spectral dimension can assume both integer and non-integer values, allowing us to obtain universal exponents as continuous functions. The importance of having tuneable universal scaling in quantum technology will be also discussed.

GIOVANNI DI FRESCO, SISSA, Trieste
Title:
Crossover Phenomena in Quantum First-Detection Processes

Abstract:
The quantum first-detection problem concerns the statistics of the time at which a system, subjected to repeated measurements, is detected in a prescribed target state for the first time. In contrast to the classical case, where an agent is assumed to be under continuous observation, the quantum scenario involves additional ingredients such as quantum noise, interference, and measurement back-action, all of which affect the first-detection process. We show that, for continuous systems under a potential V(x), the long-time behavior of the first-detection time is linked to the nature of the Hamiltonian spectrum. We further show that, for certain potential shapes, this scaling can be modified by the feedback introduced through the measurements. We also investigate the first-detection problem in a Wannier–Stark model, revealing characteristic features in both single- and many-body settings, including measurement-induced delocalizing effects.

GABRIELE FERRARI, Pitaevskii BEC Center, University of Trento
Title:
Heating Up the Vacuum: Observing Temperature-Dependent Metastable Decay in a Quantum Fluid

Abstract:
Understanding the decay pathways and timescales of metastable states is crucial in many areas of physics. In quantum field theories, a prominent mechanism is false vacuum decay via bubble nucleation. Here, we provide the first experimental realization of this phenomenon in a well-controlled setting: coherently-coupled ferromagnetic superfluid mixtures. We present detailed measurements of the metastable state lifetime as a function of temperature, showing clear scaling consistent with the finite-temperature extension of instanton theory. Our results establish atomic superfluids as a compelling experimental platform for quantitative studies of out-of-equilibrium quantum field dynamics, opening new avenues for testing theoretical predictions.

STEFANO GIORGINI, Pitaevskii BEC Center, University of Trento
Title:
New trends in polaron physics using quantum Monte-Carlo methods

Abstract:
Impurities coupled to a quantum bath, known as polarons, have become a topic of intensive research in the field of ultracold atoms.
Compared to its solid-state physics counterpart, the polaron problem on ultracold atom platforms is particularly clean and versatile. In particular, tunable interactions within the bath and between the bath and the impurity are experimentally accessible. Furthermore, polarons come in different flavors, Bose and Fermi polarons depending on the statistics of the bath, different geometric configurations and dimensionalities and have been investigated both in the bath ground state and in the presence of thermal excitations. We present preliminary results on two specific settings involving impurities in a 1D bath obtained using exact quantum Monte-Carlo methods at zero temperature. The first is a two-level impurity with Rabi coupling, where one of the two internal states is coupled to a 1D Bose gas. This problem is interesting to understand decoherence effects arising from the coupling to the bath. The second is the bipolaron formation, i.e. the bound state of two impurities, in a 1D Fermi gas focusing on its binding energy and transport properties.

ANDREA LEGRAMANDI, Pitaevskii BEC Center, University of Trento
Title:
Complexity and Chaos in Quantum Many-Body Systems

Abstract:
Complexity and chaos in quantum many-body systems underlie both fundamental physics and emerging quantum technologies. In this talk, I first analyze how different notions of complexity behave across localization transitions in random matrix models, showing that distinct diagnostics capture complementary facets of quantum complexity. This highlights the necessity of combining multiple markers to achieve a reliable and comprehensive characterization of phase transitions.
I then turn to the Sachdev–Ye–Kitaev (SYK) family of models, which provide a genuinely many-body setting. I introduce spectral probes of quantum chaos and discuss the Yukawa-SYK model, which interpolates between localized and many-body chaotic regimes while offering a promising route toward experimental realization in cavity QED platforms.

STEPHANIE MATERN, Pitaevskii BEC Center, CNR-INO Trento
Title:
A Light Touch: Quantum Dots Sensing Microwave Photons

Abstract:

In this talk, I will present a theoretical framework for detecting a single propagating microwave photon in a circuit quantum electrodynamics architecture. We consider a resonant microwave cavity that interacts dispersively with a double quantum dot tunnel-coupled to a lead, and show that under suitable conditions a single intracavity photon can produce a measurable change in the electronic occupation of the charge states. To capture the full time dynamics, we develop a quantum cascade approach that describes the evolution of an incoming single-photon wave packet as it impinges on the cavity. Using a simplified model of a charge detector, we evaluate the detection efficiency as a function of key physical parameters, including coupling strength, tunneling rate, temperature, and photon linewidth. Since temperature poses a major bottleneck for experimental realization, I will also discuss potential strategies to mitigate its impact. Finally, I will highlight the subtle measurement-induced backaction on the cavity mode that arises from the inherently dispersive, non-absorptive nature of the detection process.

CHIARA MENOTTI, Pitaevskii BEC Center, CNR-INO Trento
Title:
Quanto, an engaging card game as a tool for quantum physics education

Abstract:
Quanto is a shedding card game designed to introduce quantum physics and the concepts of quantum state, uncertainty, superposition, and entanglement, using a game-based learning approach. The mechanics of the game are implemented based on quantum operations and measurement processes on two qubits, with special action cards included to mimic quantum noise and error correction. Clear and exhaustive graphics, combined with short-term strategy and scalable complexity, make Quanto accessible to players of a broad age range and background. To complement the positive feedback received, Quanto will be integrated into high school teaching modules and validated as an educational tool.

THOMAS MÜLLER, ICTP Trieste
Title:
Quantum Mpemba effect, eigenstate thermalization hypothesis and hydrodynamics

Abstract:
According to the eigenstate thermalization hypothesis, closed chaotic quantum systems relax after a quench into a Gibbs ensemble. At late times, the relaxation speed is determined by their local conservation laws and hydrodynamics. I show that there exist pairs of initial states which thermalize to the same ensemble, yet exhibit drastically different hydrodynamic relaxation. This enables a simple and robust realization of the quantum Mpemba effect: a system initially closer to equilibrium relaxes slower than one that starts farther away, despite both approaching the same final state.

JACOPO NIEDDA, ICTP Trieste
Title:
Quantum spin glass phase in the two-dimensional disordered Heisenberg model

Abstract:
Quantum spin glasses represent a long-standing challenge in many-body physics, where the interplay of quenched disorder and quantum fluctuations gives rise to complex low-temperature behavior that remains difficult to characterize theoretically. While mean-field models offer analytical insights into the emergence of quantum spin-glass order, determining whether such phases persist in finite spatial dimensions is far more demanding, as disorder averaging introduces substantial analytical and

numerical difficulties. Evidence of a spin glass phase has been found in the ground state of the two dimensional Heisenberg model with random couplings using the recently introduced Foundation Neural-Network Quantum States framework, which enables accurate and efficient computation of disorder-averaged observables with a single variational optimization. The numerical prediction of the spin glass order is supported by a semiclassical analysis of non-interacting spin waves.

PIETRO OREGLIA, Pitaevskii BEC Center, University of Trento
Title:
Magnetic feedback cooling of a Meissner-levitated micromagnet

Abstract: I theoretically study the dynamics of fluctuations under feedback in a Meissner-levitated system, consisting of a spherical micromagnet suspended in a superconducting trap. I analyzed a theoretical model corresponding to a dedicated arrangement of magnetic coils, used both to generate the required feedback force and to detect the Brownian motion of the micromagnet. This model was then applied to describe an experiment conducted here in Trento. I will present results showing that the system is cooled by up to three orders of magnitude.

RICCARDO PANZA, University of Trieste, CNR-INO Trieste
Title:
Assembling many-body fermionic systems with ytterbium atoms

Abstract:
A full understanding of strongly correlated many-body fermionic systems is still a major challenge in various fields of physics. The high degree of control in neutral atom fermionic simulators is an essential feature for investigating such systems. I will present our experimental setup of ytterbium tweezers, designed to study out-of-equilibrium dynamics of fermionic system exploiting rich internal structure of ytterbium atom combined with the high controllability of tweezers setups: in particular, I will focus on our recent results on single-atom resolved detection scheme [1]. Ytterbium features make it a promising platform for metrology, quantum computing and analog quantum simulation.

References:
[1] Muzi Falconi et al., Phys. Rev. Lett. 90, 203402 (2025)

ELENA POLI, Pitaevskii BEC Center, University of Trento
Title:
Supersolidity in dipolar quantum gases
Abstract:
Since the first dipolar Bose-Einstein condensate (BEC) made of strongly magnetic atoms, novel fascinating phenomena genuinely arising from the long-range and anisotropic dipole-dipole interaction have been observed. This includes the discovery of the long-sought after supersolid phase—a state that
simultaneously manifests a crystalline order and superfluid properties. Moreover, the recent achievement of two-dimensional supersolidity has opened a new avenue for exploring the system's rotational response, which is connected to the contrasting yet coexisting nature of superfluidity and solidity. Here, I will present the most recent theoretical and experimental results on vortex nucleation in two-dimensional supersolids and the subsequent rich and intriguing vortex-crystal dynamics. Finally, I will show an application of rotating dipolar supersolids, i.e. the possibility to simulate "glitches", instantaneous jumps of the rotation frequency occurring due to the internal vortex dynamics, akin to observations in neutron stars.

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ALBERTO TABARELLI DE FATIS, Pitaevskii BEC Center, University of Trento
Title:
Adiabatic preparation of many-body states in atomic and photonic systems

Abstract:
Preparing many-body correlated states is generally an extremely challenging task. One possible strategy is to adiabatically vary the Hamiltonian parameters, allowing to convert an initial, easily prepared ground state into the desired target state. In this talk I will present two different adiabatic schemes: the first enables the preparation of a gas of fermionized photons in the thermodynamic limit starting from coherent radiation, whereas the second allows the preparation of a Laughlin state of about ten particles with neutral ultracold atoms.

NIKITA TITOV, University of Trieste
Title:
From Laplacian-to-Adjacency Matrix for Continuous Spins on Graphs

Abstract:
The study of spins and particles on graphs has applications across many areas, from time dynamics on networks to combinatorial optimization. In this talk, I will discuss the large n limit of the O(n) model on general graphs, a problem that is substantially more challenging than on regular lattices. The loss of translational invariance leads to an infinite set of saddle point constraints in the thermodynamic limit. I will show that the free energy at low and high temperature T is controlled by two central graph-theoretic objects: the Laplacian matrix at low T and the Adjacency matrix at high T. Their interplay will be illustrated across several classes of graphs. On trees, we obtain an exact solution in which the Lagrange multipliers depend only on the local coordination numbers. For decorated lattices, the singular part of the free energy is governed by the Laplacian spectrum, while the full free energy matches it only in the zero-temperature limit. I will also discuss a bipartite fully connected graph, which highlights the importance of a finite coordination number, and conclude with brief remarks on analogous results for quantum spin models on a loopless graph.

MATTEO M. WAUTERS, Pitaevskii BEC Center, University of Trento
Title: Discrete Non-Abelian lattice gauge theories: a quantum simulation playground

Abstract:
Lattice gauge theories (LGTs) are one of the main targets for quantum simulators, with the long-term goal of making accurate predictions for QCD that elude classical approaches. Moreover, their rich phenomenology and intricate physics make such models interesting also for the quantum many-body community. In this perspective, discrete non-Abelian LGTs represent the perfect playground: their simpler structure, in contrast to Lie groups, and finite local degrees of freedom allow for an exact encoding on quantum platforms, while simultaneously maintaining the essential ingredients of QCD; additionally, they also display a rich physics of their own, such as topologically ordered phases and deconfinement phase transitions. In this talk, I will discuss some of the peculiar features of pure-gauge LGT on a ladder with the smallest discrete non-Abelian symmetry group, the dihedral group D_3, where exotic color-screening mechanisms and thermalization properties emerge that are distinctly different from their abelian counterparts.