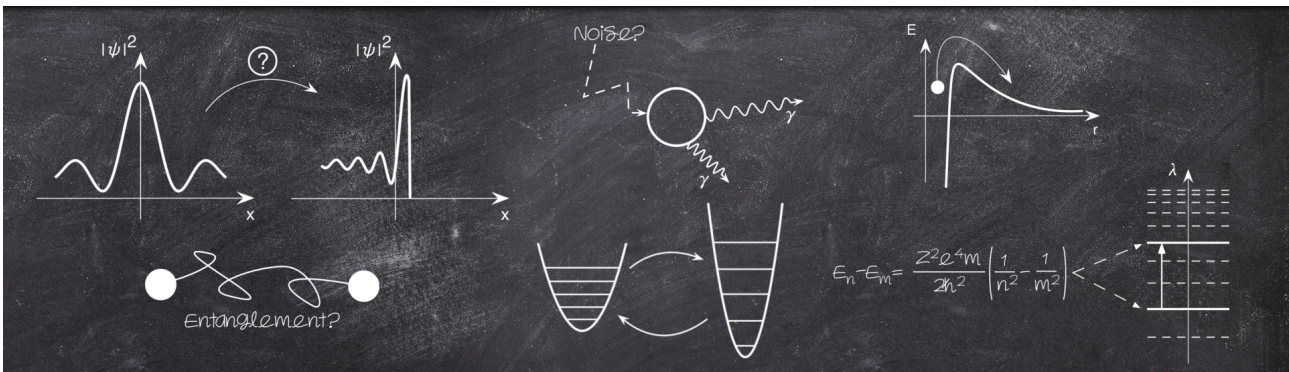


Trieste Junior Quantum Days

A glance in research: where we stand and future challenges



Program

May 11th

14:15 Welcome

14:30 **Matteo Carlesso** (University of Trieste)

Can we understand if gravity is quantum?

15:10 **Linda Anticoli** (University of Udine)

Model Checking Recursive Quantum Protocols

15:50 **Andrea Colcelli** (SISSA)

Deviations from Off-Diagonal Long-Range Order and Mesoscopic Condensation in 1D Quantum Systems

16:30 Coffee Break

17:00 **Silvia Pappalardi** (SISSA, ICTP)

Scrambling and entanglement spreading in regular chaotic long range spin chains

17:40 **Giacomo Gori** (University of Padova)

On the performance of a MatterWave based gyroscope

18:20 **Angelo Russomanno** (Scuola Normale di Pisa and ICTP)

Floquet time crystal in the Lipkin-Meshkov-Glick model

19:00 Closing

May 18th

14:15 Welcome

14:30 **Matteo Gallone** (SISSA)

The touchy business of formal computations

15:10 **Giulio Gasbarri** (University of Trieste)

General Galilei covariant Gaussian maps and macroscopicity measure

15:50 **Vincenzo Alba** (SISSA)

Entanglement and thermodynamics after a quantum quench in integrable systems

16:30 Coffee Break

17:00 **Raffaele Scandone** (SISSA)

Non-linear Schroedinger equation with point interactions

17:40 **Davide Pastorello** (University of Trento)

Geometry of Quantum Mechanics in complex projective spaces

18:20 **Stefano Marcantoni** (University of Trieste)

Quantum Model for Impulsive Stimulated Raman Scattering

19:00 Closing

20:00 Dinner

Abstracts

Vincenzo Alba (SISSA)

Entanglement and thermodynamics after a quantum quench in integrable systems

Entanglement and entropy are key concepts standing at the foundations of quantum and statistical mechanics, respectively. In the last decade, the study of quantum quenches revealed that these two concepts are intricately intertwined. Although the unitary time evolution ensuing from a pure initial state maintains the system globally at zero entropy, at long time after the quench local properties are captured by an appropriate statistical ensemble with non zero thermodynamic entropy, which can be interpreted as the entanglement accumulated during the dynamics. Therefore, understanding the post-quench entanglement evolution unveils how thermodynamics emerges in isolated quantum systems. An exact computation of the entanglement dynamics has been provided only for non-interacting systems, and it was believed to be unfeasible for genuinely interacting models. Conversely, here we show that the standard quasiparticle picture of the entanglement evolution, complemented with integrability-based knowledge of the asymptotic state, leads to a complete analytical understanding of the entanglement dynamics in the space-time scaling limit. Our framework requires only knowledge about the steady state, and the velocities of the low-lying excitations around it.

Linda Anticoli (University of Udine)

Model Checking Recursive Quantum Protocols

With the growing interest in the fields of quantum computation and information, the possibility of expressing quantum algorithms, protocols and even quantum dynamics by using an high-level specification language has become crucial. For this reason, we have witnessed the birth of different higher level formalisms allowing to define and simulate automatically formal properties of such protocols, which work by abstracting from low-level physical details. Nevertheless, with the possibility of "programming" quantum protocols comes the need to formally verify them, in order to test that both the specification and the protocols themselves are error-free. To this extent, formal methods such as temporal model checking has been investigated and extended to the quantum domain. We will show our work on Entangle, an integrated framework which provides the possibility to define and automatically verify recursive quantum protocols.

Matteo Carlesso (University of Trieste)

Can we understand if gravity is quantum?

The recent development of interferometric and optomechanical systems gave the opportunity to experimentally approach the long-standing debate whether the gravity has a classical or a quantum intrinsic nature. I will present some of the recent proposals that have been made, highlighting their strong and weak points towards a possible solution.

Andrea Colcelli (SISSA)

Deviations from Off-Diagonal Long-Range Order and Mesoscopic Condensation in One-Dimensional Quantum Systems

A quantum system exhibits off-diagonal long-range order (ODLRO) when the largest eigenvalue λ_0 of the one-body-density matrix scales as $\lambda_0 \sim N$, where N is the total number of particles. Putting $\lambda_0 \sim N^C$ to define the scaling exponent C then $C=1$ corresponds to ODLRO and $C=0$ to the single-particle occupation of the density matrix orbitals. When $0 < C < 1$, C can be used to quantify deviations from ODLRO. In this talk I will present the study of the exponent C in a variety of one-dimensional bosonic and anyonic systems.

Matteo Gallone (SISSA)

The touchy business of formal computations

Quantum mechanics requires to deal with unbounded self-adjoint operators on Hilbert spaces which means, in practice, to consider both their action and their domains. Despite that, domain issues are often regarded as "a minor problem". In this talk I will recall the main definitions, I will present with basic examples what can go wrong when one neglects this "minor issue" and I will discuss some more challenging problems including physical Hamiltonians that are central in my research activity: relativistic hydrogen atom, singular potentials and positronium.

Giulio Gasbarri (University of Trieste)

General Galilei covariant Gaussian maps and macroscopicity measure.

Space-time symmetries in open quantum systems have been fully analyzed only in the special, but very important, case of a Markovian, completely positive (CP) and trace preserving (TP) dynamics and the structure of the dynamics fully characterized by Holevo.

This characterization play a major role in the description of several important physical phenomena such as environmental decoherence and relaxation phenomena. Furthermore, it is also relevant for the foundations of quantum mechanics, where an intrinsic non-unitary dynamics is postulated to solve the measurement problem, the black hole information paradox, or to combine principles of general relativity with quantum mechanics.

Although the assumption of Markovianity is often well justified, recent technological advances have led to investigating several phenomena exhibiting memory effects, e.g. ultra fast chemical reactions, side band cooling and light harvesting in photosynthesis. In this talk we present a complete characterisation for effective non-Markovian Gaussian maps that are Galilei covariant.

We further show how this result can be used to discuss measures of macroscopicity based on classicalization maps, specifically addressing dissipation, Galilean covariance and non-Markovianity.

Giacomo Gori (University of Padova)

On the performance of a MatterWave based gyroscope

We discuss the sensitivity of a guided matter wave interferometer built to measure rotation. We consider the effect of the interaction and temperature on the instrument with different interferometric schemes.

Stefano Marcantoni (University of Trieste)

Quantum Model for Impulsive Stimulated Raman Scattering

Impulsive Stimulated Raman Scattering (ISRS) is a process in which a light pulse is inelastically scattered by a solid sample, exciting vibrations in the latter. This kind of light-matter interaction is usually investigated using time-resolved spectroscopic techniques, in particular pump-probe experiments in which a first intense light pulse, the pump, excites vibrational modes in the crystal and a second less intense light pulse, the probe, is used to test the sample dynamics.

We present a fully-quantum theoretical model that we have recently developed for the description of ISRS in the context of pump-probe experiments. Some preliminary results of this model are validated with measurements performed on quartz.

Silvia Pappalardi (SISSA, ICTP)

Scrambling and entanglement spreading in regular chaotic long range spin chains

We study scrambling, bipartite and multipartite entanglement dynamics in regular and chaotic long range spin chains, with a well defined semi-classical limit. We show that scrambling is a full quantum phenomenon, different from entanglement dynamics. It is characterized by a first semiclassical growth (up to the Ehrenfest time), followed by a fully quantum non-perturbative regime, symmetric around the recurrence time. While entanglement is a state dependent property, we associate scrambling with the growth of the operator's support.

Davide Pastorello (University of Trento)

Geometry of Quantum Mechanics in complex projective spaces

The talk will be focused on the geometric Hamiltonian formulation of quantum mechanics where the projective Hilbert space (as a Kähler manifold) plays the role of phase space. Within such a framework quantum observables are represented by phase space functions, quantum states are described by Liouville densities (phase space probability densities), and Schrödinger dynamics is induced by the flow of a Hamiltonian vector field w.r.t. a natural symplectic structure. Then I will discuss how this viewpoint leads to a new approach to quantum control theory based on the Riemannian structure of the projective space.

Angelo Russomanno (Scuola Normale di Pisa and ICTP)

Floquet time crystal in the Lipkin-Meshkov-Glick model

In this talk I will discuss the existence of time-translation symmetry breaking in a kicked infinite-range-interacting clean spin system described by the Lipkin-Meshkov-Glick model. This Floquet time crystal is robust under perturbations of the kicking protocol, its existence being intimately linked to the underlying Z_2 symmetry breaking of the time-independent model. I show that the model being infinite range and having an extensive amount of symmetry-breaking eigenstates is essential for having the time-crystal behavior. In particular, I discuss the properties of the Floquet spectrum, and show the existence of doublets of Floquet states which are, respectively, even and odd superposition of symmetry-broken states and have quasienergies differing of half the driving frequencies, a key essence of Floquet time crystals. Remarkably, the stability of the time-crystal phase can be directly analyzed in the limit of infinite size, discussing the properties of the corresponding classical phase space.

Raffaele Scandone (SISSA)

Non-linear Schroedinger equation with point interactions

A central topic in mathematical physics is the rigorous investigation of many body quantum systems subject to very short range interactions. The dynamics of such systems can be efficiently described by non-linear Schroedinger equations with singular potentials. In this talk, I will discuss a recent result on the well-posedness of the Hartree equation with a point interaction in R^3 , in a suitable class of singular Sobolev spaces. I will also discuss various open problems.