New Trends in Nonequilibrium Statistical Mechanics 2nd Course

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Phaseonium-Driven Dynamics of Cascaded Systems

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We examine a pair of harmonic oscillators interacting with a thermally excited beam of phaseonium atoms in a cascaded setup. The coherence phase of phaseonium atoms influences the steady states of the subsystems and ancillas. The second subsystem undergoes non-Markovian evolution due to interactions with the "used" ancillary atoms, creating correlations with the first oscillator. The system's evolution is tracked by measuring the cavities' temperature and their correlations.

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[*] Speaker

A New Perspective on Thermally Fluctuating 2D Elastic Membranes: Introducing Odd Elastic Moduli and Non-Equilibrium Effects

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Non-equilibrium and active effects in mesoscopic scale systems have heralded a new era of scientific inquiries, whether concerning meta-materials or biological systems such as bacteria and cellular components. At mesoscopic scales, experimental and theoretical treatments of membranes, and other quasi-two-dimensional elastic surfaces cannot generically ignore Brownian motion and other thermal effects. In this paper we aim to study the behavior of thermally fluctuating 2-D elastic membranes possessing odd elastic moduli embedded in higher dimensions. We implement an isotropic generalization of the elastic tensor that includes odd elastic moduli, Kodd and Aodd, that break conservation of energy and angular momentum respectively, due to Scheibner et al. Naturally this introduces active and non-equilibrium effects. Passive equilibrium thermalized elastic membranes possess effective (renormalized) Lamé coefficients that reduce with increasing system size and a diverging effective bending rigidity. Introducing two odd elastic moduli means that deformations from a reference state can induce chiral forces that cannot be derived from a Hamiltonian. Thus, the behavior of odd elastic membranes must instead be investigated with Langevin equations. If fluctuation-dissipation relations hold, we calculate via the renormalization group that at long length scales, active effects due to Kodd can be effectively ignored whereas Aodd cannot. To validate these findings, we developed an advanced force implementation methodology, inspired by the (T)-scheme prevalent in vertex models. This contributed to a new method for the simulation of elastic membranes in higher dimensions. The novelty of the method is that microscopic/discrete and continuum in-plane elastic moduli are one-to-one and thus no coarse-graining is needed.

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*Speaker

Large Deviations Beyond the Kibble-Zurek Mechanism

Federico Balducci * [1]

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Crossing a quantum phase transition in finite time leads to the formation of excitations, such as topological defects, since the dynamics necessarily fails to be adiabatic near the critical point. The average number of excitations is well described by the celebrated Kibble-Zurek (KZ) mechanism, predicting a universal scaling law with the quench time. Recently, the scope of the KZ paradigm has been expanded, enabling the prediction of quantities beyond averages, such as the full counting statistics of defects (1). In this talk, I will present some results (2) that clarify the role of universality in beyond-KZ physics, by borrowing tools from Large Deviations Theory. Using the transverse-field Ising model as test bed, I will show how the rate function obeys a universal scaling relation with the quench time. Then, I will expand the result to classical phase transitions, using few additional assumptions on the way defects form. I will finally argue how these theoretical predictions are already testable in current quantum simulators and annealers (3).

References:
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*Speaker

Quantum many-body probes

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Quantum phase transitions manifest themselves in various forms, each with their own features. In particular, criticality is known to be a resource for quantum enhanced sensitivity. In this talk, we investigate various forms of criticality to find out what features in these phase transitions are responsible for achieving quantum enhanced sensitivity. In particular, we explore Stark localization (1), symmetry protected topological systems (2), Floquet systems for both DC (3) and AC (4) and boundary time crystals (5). While phase transition in these systems may have different origins, there is one common feature among all of them: gap closing. This suggests that gap closing is the main feature in phase transitions which is responsible for quantum enhanced sensitivity.

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[*] Speaker

Quantum correlations in neutrino mixing and oscillations

Massimo Blasone * [1]

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I will review recent work on quantum correlations and quantum coherence in neutrino oscillations. In particular, I will discuss complete complementarity relations (CCR) that fully characterize different correlations encoded in a quantum system both for pure and mixed states. CCR for neutrino oscillations unveil a complex structure of correlations, among which the non local advantage of quantum coherence is a relevant quantifier of coherence. I will also discuss chiral oscillations and their effects on spin quantum correlations in a lepton-antineutrino pair produced through weak interactions. Finally, I will discuss Leggett-Garg temporal inequalities in flavor-mixing processes.

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[*] Speaker

The transition to synchronization of networked systems

Stefano Boccaletti *[1]

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With the only help of eigenvalues and eigenvectors of the graph's Laplacian matrix, I will show that the transition to synchronization of a generic networked dynamical system can be entirely predicted and completely characterized. In particular, the transition is made of a well defined sequence of events, each of which corresponds to either the nucleation of one (or several) cluster(s) of synchronized nodes or to the merging of multiple synchronized clusters into a single one. The network's nodes involved in each of such clusters can be exactly identified, and the value of the coupling strength at which such events are taking place (and therefore, the complete events' sequence) can be rigorously ascertained. I will moreover clarify that the synchronized clusters are formed by those nodes which are indistinguishable at the eyes of any other network's vertex, and as such they receive the same dynamical input from the rest of the network.Therefore, such clusters are more general subsets of nodes than those defined by the graph's symmetry orbits, and at the same time more specific than those described by the network's equitable partitions. Finally, I will present large scale simulations which show how accurate our predictions are in describing the synchronization transition of both synthetic and real-world large size networks, and even report that the observed sequence of clusters is preserved in heterogeneous networks made of slightly non identical systems.

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*Speaker

Cooperative quantum information erasure

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We demonstrate an information erasure protocol that resets N qubits at once. The method displays exceptional performances in terms of energy cost (it operates nearly at Landauer energy cost kTln2), time duration (∼μs) and erasure success rate (∼99,9%). The method departs from the standard algorithmic cooling paradigm by exploiting cooperative effects associated to the mechanism of spontaneous symmetry breaking which are amplified by quantum tunnelling phenomena. Such cooperative quantum erasure protocol is experimentally demonstrated on a commercial quantum annealer and could be readily applied in next generation hybrid gate-based/quantum-annealing quantum computers, for fast, effective, and energy efficient initialisation of quantum processing units.

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[*] Speaker

Quantum Mpemba effect

Pasquale Calabrese * [1]

[1] SISSA, Trieste – Italy

The Mpemba effect is the counterintuitive and controversial phenomenon that hot water cools faster than cold one. Here I will introduce an analogous effect recently proposed and observed in extended quantum systems in which a symmetry is explicitly broken by the initial state, but it is restored by the time evolution. To study this phenomenon we introduce a new quantity, dubbed entanglement asymmetry, which is a measure of symmetry breaking inspired by the theory of entanglement in many-body states.

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*Speaker

Probing and Handling Quantum States

Francesco Saverio Cataliotti * [1]

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Degenerate quantum gases are considered as unique tools for quantum simulations, but their applications depend critically on the ability to prepare, read-out and ultimately control the quantum states they are used to implement. I will describe an experimental tomographic method to reconstruct with high fidelities any unknown density matrix, even with small set of data. Equipped with this state reconstruction technique and making use of the tools developed in the field of optimal control, I will demonstrate the possibility to manipulate the internal state wave function in order to prepare arbitrary superpositions. Finally, I will describe how it is possible to steer the quantum evolution of the system via measurements and strong couplings constrain the system to evolve inside a reduced Hilbert space.

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[*] Speaker

Fluctuating thermodynamics of Gaussian baths: from the Caldeira-Leggett model to autonomous engines

Vasco Cavina * [1], Massimiliano Esposito [1]

[1] University of Luxembourg – Luxembourg

We introduce a Non-Equilibrium version of the Caldeira-Leggett model (NECL) where the particle constituting the system is strongly coupled to a set of engineered reservoirs. Contrary to the classical CL model where each reservoir is composed of equilibrated quadratic modes, we consider arbitrary Gaussian modes which can be generated by squeezing and displacing the equilibrated modes. The model proves to be very versatile: we show that tracing out a reservoir with sufficient initial displacement (resp. squeezing) can be used to produce an effective system Hamiltonian with a deterministic (resp. noisy) time-dependence, which does no break (resp. breaks) the fluctuation-dissipation relation. By studying the entropy balance, we discuss whether or not the energy exchanged with a squeezed/displaced reservoir should be considered as work, obtaining an affirmative response in the weak coupling and strong displacement/squeezing limit. In the second part of the manuscript, we compute the full moment generating function (MGF) of the energy statistics in the NECL. Using a two point measurement scheme, we derive a detailed fluctuation theorem, valid at all times, for work, heat and entropy production for a particle coupled to squeezed and displaced reservoirs. We conclude our dissertation by repeating all the calculations in the classical counterpart of the NECL, i.e. a Langevin particle with several sources of squeezed and displaced colored noise, and by showing that the quantum MGF agrees with our classical results in the semiclassical limit. To compute the quantum MGF we use a modern approach based on the path integration over a modified Keldysh contour. This approach allows us to show the quantum-classical correspondence in an elegant way, by comparing the action of the quantum path integral with the action of the stochastic path integral associated to the classical MGF.

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*Speaker

Modeling chromosome organization in SARS-CoV-2 infected genomes with Polymer Physics

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Within the cell nucleus of eukaryotic organisms, chromosomes are organized in a complex, non-random three-dimensional (3D) spatial structure, which is intimately linked to vital functional purposes. Indeed, a correct folding allows an efficient communication between genes and their distal regulatory elements while, if altered, can cause severe diseases. Here I will discuss how Polymer Physics, combined with Molecular Dynamics simulations and Machine Learning based inference, represent a powerful tool to quantitatively investigate the complexity of 3D organization of real genomes, as highlighted by recent microscopy and biochemical experiments. I will show that simple physical processes, widely studied in Statistical Mechanics, such as phase-separation of molecular aggregates and coil-globule polymer transitions, allow us to make sense of recent experimental observations including the tissue-specific DNA structure and the variability of chromatin at the single cell level. Finally, polymer models can be used to study the impact of disease-linked genetic mutations or the effect of viral infections as SARS-CoV-2, opening the way to new potential tools in Biomedicine

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*Speaker

Symmetry-protected dressed states of giant atoms

Francesco Ciccarello * [1]

[1] Università degli studi di Palermo - University of Palermo – Italy

We study quantum emitters coupled non-locally (giant atom) to engineered photonic lattices, and especially in-gap atom-photon bound states mediating decoherence-free interactions in the Markovian regime (1,2). We present a theorem ruling occurrence of such bound states protected by chiral symmetry (3). We use this to predict new classes of symmetry-protected bound states (and ensuing decoherence-free Hamiltonians) unachievable with normal atoms (i.e. local coupling) in both 1D and 2D photonics lattices. The giant atom "sees" an effective non-trivial structure of the lattice despite the actual structure would be trivial when coupled to normal atoms.

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[*] Speaker

Thermal fate and many-body parametric resonances in driven sine Gordon model

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In the context of non-equilibrium physics the stability of periodically-driven many-body systems is the subject of several recent studies. According to the second law of thermodynamics, isolated equilibrium systems can only increase their energy when undergoing a cyclic process. For many-body interacting ergodic systems, it is assumed that that they will heat monotonously, approaching an infinite-temperature state. In contrast, for small systems such as a single spin, thermalization is not expected to occur and a periodic alternation of heating and cooling is predicted. In order to describe the description between these two opposite behaviors in many-body quantum systems we consider a periodically-driven sine-Gordon model. This model is well suited for analytical treatments including the renormalization group and variational methods. By performing a high-frequency expansion, we show the emergence of a sharp “parametric resonance”, separating the absorbing from the non-absorbing regimes. This transition survives in the thermodynamic limit and leads to a non-analytic behavior of the physical observables in the long-time limit. We also investigate the mode-resolved energy absorption of the slowly driven sine-Gordon model in the presence of a modulated tunnel coupling, obtained by quantizing the Hamiltonian for a chain of driven pendula. For weak driving amplitude, we find an exponentially fast energy absorption in the main resonant mode, while the heating of all remaining modes is almost perfectly suppressed on short timescales. At later times, the highly excited main resonance provides effective resonant driving terms for its higher harmonics through the nonlinearities in the Hamiltonian, and gives rise to an exponentially fast heating in these particular modes. We capture the strong correlations induced by these resonant processes by evaluating higher-order connected correlation functions. Our results can be experimentally probed in ultracold atomic settings, with parallel one-dimensional quasicondensates in the presence of a modulated tunnel coupling.

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[*] Speaker

Phase transitions in the cell nucleus control chromosome folding and functions

Mattia Conte * [1], Andrea Chiariello [1], Simona Bianco [1], Andrea Esposito [1], Mario Nicodemi [1]

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Human chromosomes have a complex 3D organization in the cell nucleus that serves vital functional purposes as, for instance, genes have to establish specific physical contacts with distal DNA regulators to control transcriptional activities. However, it is largely unknown how the system self-organizes to shape its folding and function. In this talk, I discuss our recent results from polymer physics, confirmed by molecular biology experiments, showing that chromosome spatio-temporal organization is controlled by thermodynamic mechanisms of phase transitions, such as micro-phase separations or coil-globule transitions (1-3). Those findings trace back the comprehension of the very functioning of our genome to simple principles of physics and can be successfully employed, for example, to predict *in-silico* the structural effects of disease-associated mutations linked to congenital disorders or cancer (4,5).

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*Speaker

Detection of sine-Gordon breathers in thermally biased long Josephson junctions

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We consider sine-Gordon breathers from the perspective of thermal transport. By showing that a single breather can enhance the heat transfer in a thermally biased long Josephson junction, we provide an experimentally viable fingerprint of such an elusive nonlinear mode. More specifically, we observe that the local temperature within the system can be tailored via breathers, an intriguing fact of both fundamental and technological interest. This phenomenon implies a clear thermal signature for the breather, thus setting the stage for a long-sought breather detection protocol, which, remarkably, is non-destructive, i.e., it does not involve the mode's breakup. We show that different breathing frequencies lead to morphologically distinct local temperature peaks, which can be identified in an experiment. Furthermore, we demonstrate the protocol's robustness, by harnessing noise and ac driving as a tool for breather excitation and stabilization. In other words, we provide an experimental blueprint for the generation and the detection of breathers in noisy and ac-driven long Josephson junctions within reach of current technology.

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[*] Speaker

Optical responses of photoexcited materials: from parametric amplification to photoinduced superconductivity

Eugene Demler * [1]

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Optical drives at terahertz and mid-infrared frequencies in quantum materials are commonly used to explore the nonlinear dynamics of interacting many-body systems. Recent experiments demonstrated several surprising optical properties of transient states induced by driving, including the appearance of photo-induced edges in the reflectivity, enhancement of reflectivity, and even light amplification. I will show that many of these unusual properties can be understood from the general perspective of reflectivity from Floquet materials, in which pump-induced oscillations of a collective mode lead to parametric generation of excitation pairs. This analysis predicts a universal phase diagram of drive induced features in reflectivity, which evidence a competition between driving and dissipation. This mechanism explains several recent experimental observations, including photoinduced superconductivity in the pseudogap phase of high Tc cuprates.

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*Speaker

Quantum Sensing in Measurement-Induced Phase Transitions

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The interaction between deterministic quantum evolution and a sequence of measurement processes can give rise to sudden alterations in the entanglement characteristics of a system, leading to a phenomenon known as a measurement-induced phase transition (MIPT). In various contexts, Quantum Fisher Information (QFI) is employed to assess a quantum system's sensitivity to slight parameter variations and is commonly utilized to detect quantum phase transitions. It is natural to inquire whether phase transitions induced by measurement processes can also be identified through the QFI. In this work, we use two different approaches to assess whether the QFI can detect MIPT. With the first approach, we aim to observe the entanglement of the system. Indeed, one of the defining signatures of an MIPT is the abrupt changes in the entanglement properties of the system, typically discerned through entanglement entropy. However, when adopting an appropriate metrological approach, the QFI not only detects entanglement but also provides more comprehensive insights than entanglement entropy, revealing the presence of valuable metrological entanglement and multipartite entanglement. Our findings demonstrate that the QFI can discriminate between distinct phases within an MIPT scenario. In the second approach, we establish a scheme where the QFI is directly related to the fidelity susceptibility, and our analysis demonstrates that, for this specific class of phase transition, the QFI exhibits a non-analytic behavior at the transition point.

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*Speaker

Quantum non-linear dynamics of ultrastrongly coupled superconducting architectures: adiabatic dynamics for modular computing and the detection of virtual photons

Giuseppe Falci * [1]

[1] Università di Catania – Italy

Light-matter interaction, and the understanding of the fundamental physics behind it, is the scenario of emerging quantum technologies. Solid state devices may explore the new regime of ultrastrong coupling (USC) where coupling strengths are comparable to the energies of the subsystems, allowing ultafast quantum operations to be performed. However faster dynamics has a cost. Indeed USC breaks the conservation of the number of excitations, leading to new physical effects of fundamental interest but detrimental for quantum processing. In particular the highly entangled nature of the eigenstates, dressed by a potentially large number of virtual photons, leakage of excitations via the dynamical Casimir effect (DCE). In this seminar we will present several results regarding the physics and the applications of the "ultrastrong" coupling regime, as adiabatic protocols for quantum operations in a modular architecture and the design of a quantum circuit for the detection of ground-state virtual photons.

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*Speaker

Time crystals & Clock

Rosario Fazio * [1]

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Besides their intrinsic interest as a new state of matter, time crystals may be of great relevance for quantum technological applications. This is a very promising avenue to explore and initial steps in this directions have been explored. Their potential importance in quantum sensing or in quantum heat engines has been recently recognized. The intrinsic nature of this quantum state of matter makes them the natural candidates for high-precision clocks. I will discuss the properties of dissipative time crystals and of autonomous clocks integrated with continuous time crystals.

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*Speaker

Recent outcomes in active polymer translocation

Alessandro Fiasconaro * [1]

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Polymer translocation has long been a topic of interest in the field of biological physics given its relevance in both biological (protein and DNA/RNA translocation through nuclear and cell membranes) and technological processes (nanopore DNA sequencing, drug delivery). This contribution reports some recent results of the translocation of a semiflexible homopolymer through an extended pore driven by an end-pulling force applied to the polymer head. Similarly to pore-driven configurations, the end-pulled set-up presents regions of optimum mean translocation times as a function of the frequency of the driving –this latter applied either longitudinal to the pore or transversal to it– which are typical of the resonant activation effect. These minima are present for all the polymer rigidities studied, and reveal a linear relation between the optimum translocation time and the corresponding driving period independent of the parameter values.

Some preliminar results from the end-pulled translocation applied in a way to mimic the application of either optical or magnetic forces, will be shown with the goal to explore the evidence of specific features of either a nucleic- or amino- acid chains that the translocating polymer model aims to evidence, so candidating it as a possible sequencing method.

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*Speaker

Analysis of thermal and quantum escape times of Josephson junctions for signal detection

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Josephson junctions are interesting as detectors, for they can reach the quantum sensitive limit (1,2). Moreover, as they are superconducting elements, the temperature can be lowered as much as cryogenics allow to minimize thermal noise. On this basis, it is maintained that Josephson junctions hold promises for the detection of very weak electromagnetic signals, possibly close to the single photon limit(3), and of potential interest for direct axion detection(4). However, one encounters a number of difficulties connected to the quantum nature of the superconducting phase and the nonlinear confining potential. In fact, the quantum phase of the Josephson junction cannot be directly measured, and therefore the experimentally accessible information is only connected to the appearance of a voltage when a special threshold is reached. While thermal escapes can be kept at bay lowering the operating temperature, the contribution to the escapes through tunnel remains at any temperature and eventually becomes statistically dominant. In this work we show how the limits to detection can be embedded in the frame of signal detection (5). As a consequence, the optimization of the detection probability (and the minimization of the false alarm probability) gives a guide to select the Josephson junction parameters that best suit to reveal weak microwave signals fields.

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[*] Speaker

Stochastic dynamics of particles in fluctuating correlated fields

Andra Gambassi * [1]

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The effective dynamics of a colloidal particle immersed in a complex medium is usually described in terms of an overdamped generalized Langevin equation — which is linear — possibly with memory. However, recent numerical simulations and experiments have shown that this linear model fails, suggesting that the intrinsic dynamics of the probe is actually non-linear. Focussing on the case in which the medium can be described as a fluctuating and correlated Gaussian field linearly coupled to the colloid, we derive such a dynamics and discuss its various consequences. In particular, we consider those on the statistics and the relaxation of the position of a single trapped particle, in and out of equilibrium, on the dynamics of the effective interaction between two particles, and on the stochastic thermodynamics in the presence of driving.

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*Speaker

Implementation of Quantum Heat Engines with Josephson Circuits

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Thermoelectric effects in metals are typically small due to the nearly perfect particle–hole symmetry around their Fermi surface. Furthermore, thermo-phase effects and linear thermoelectricity in superconducting systems have been identified only when particle–hole symmetry is explicitly broken, since thermoelectric effects were considered impossible in pristine superconductors.Here, we experimentally demonstrate that superconducting tunnel junctions develop a very large bipolar thermoelectricity in the presence of a sizable thermal gradient thanks to spontaneous particle–hole symmetry breaking. Our junctions show Seebeck coefficients of up to $\pm 300\mu$VK–1, which is comparable with quantum dots and roughly 105 times larger than the value expected for normal metals at subkelvin temperatures. Moreover, by integrating our junctions into a Josephson interferometer, we realize a bipolar thermoelectric Josephson engine generating phase-tunable electric powers of up to _˜140nWmm–2. Notably, our device implements also the prototype for a persistent thermoelectric memory cell, written or erased by current injection.We expect that our findings will lead to applications in the field of superconducting quantum technologies.

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*Speaker

Unveiling order-parameter symmetry in iron-based superconductors through linear thermoelectricity in tunnel junctions

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Over the fifteen years since their discovery, iron-based superconductors (FeSCs) have been investigated with many experimental tools and different theoretical models. Despite the amount of efforts, the precise symmetry of the superconducting order parameter still remains under dispute. The mostly accepted pairing state falls within the standard weak-coupling $s+-$ paradigm, however the multiband character of FeSCs offers chances for more exotic pairing states. Here we demonstrate that an opportunity to address the unanswered question above is potentially provided by *thermoelectric* (TE) *effect*, offering a venture into unexplored directions (1).
Intriguingly, we show that linear TE effects in tunnel junctions with FeSCs, at low temperatures provide information about the superconducting order parameter symmetry. In particular, nodal order parameters present a maximal TE effect at temperatures one order of magnitude lower than nodeless cases. TE measurements may be very effective to investigate the gap symmetry in Fe-based systems, overcoming the difficulties of conventional phase-sensitive Josephson experiments with unconventional pairing symmetries. Furthermore, we demonstrate that superconducting tunnel junctions between a Fe-based and a conventional BCS superconductors could provide astounding TE figures of merit, which may be relevant for energy harvesting applications and quantum technologies.

References:
(1) C. Guarcello, A. Braggio, F. Giazotto, R. Citro, *Thermoelectric signatures of order-parameter symmetries in iron-based superconducting tunnel junction*s, Phys. Rev. B Letters **108**, L100511 (Editors' Suggestion) (2023)

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*Speaker
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New Trends for Non-Stable Interactions in Statistical Mechanics

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Non-equilibrium statistical mechanics is understood as the statistical and thermal behaviour of many-body systems that do not fall within the domain of applicability of equilibrium statistical mechanics. A primary and fundamental example are non-stable systems. Non-stable systems are many-body systems for which the ground state energy does not scale linearly with N, the number of particles resp. the number of degrees of freedom. Non-stable systems show metastability, transient dynamics, non-equivalence of ensembles and non-existence of the thermodynamic limit. In recent years these systems have found increasing interest. The presentation will give a paradigmatic example for recent progress in the field.

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[*] Speaker

Quantum state estimation via quantum extreme learning machines

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Quantum reservoir computing and quantum extreme learning machines (QELMs) are computational paradigms that have recently attracted considerable interest thanks to their ease of implementation in many practical scenarios, and their potential for processing data encoded into input quantum states. We present an in-depth analysis of the potential of QELMs to estimate the properties of input states. In particular, we show that a full characterisation of the target properties achievable in this way is possible, and provide explicit conditions telling us when an observable is achievable in terms of the effective measurement corresponding to the dynamic of a given reservoir. We also prove a close analogy between the training process of QELMs and the reconstruction of the effective measurement characterising the given device. Finally, we show that the estimation framework of quantum shadow tomography fits naturally to analyse the performances of QELMs in the general case. Our analysis provides the theoretical foundations to understand better the potential and limitations of QELMs and reservoir computing, as well as providing explicit methods to apply these methods for practical experimental applications.

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*Speaker

Interactions Enhance Self-Diffusion in Odd-Diffusive Systems

Erik Kalz *† [1], Hidde Vuijk [2], Iman Abdoli [3], Jens-Uwe Sommer [4,5,6],
Hartmut Löwen [3], Abhinav Sharma‡ [2,5], Ralf Metzler§ [1,7]

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Odd systems exhibit unusual and novel behavior with no counterpart in normal systems. They are characterized by transverse responses to perturbations. Classical examples would be the Hall effect in conductors and the Magnus effect in fluids. Therefore, in recent years, the physics community has developed an interest in odd physics which arises in the continuous descriptions of matter, such as odd viscosity, odd elasticity, or odd diffusion. Specifically odd-diffusive systems, which, for example, are realized in Brownian systems under Lorentz force, active chiral particles, or diffusing skyrmions are of special interest to us. Particle interactions in these systems result in novel diffusive behavior, the most surprising of which is that particle-collisions enhance the self-diffusion rather than decreasing it. The origin of such a counterintuitive behavior can be traced back to the unusual dynamics in odd systems, which are encoded in correlation tensors with non-zero off-diagonal elements, even though the systems are isotropic.

Reference:
(1) https://doi.org/10.1103/PhysRevLett.129.090601

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[*] Speaker

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Selection by Additive Stochastic Noise in a Driven Out of Equilibrium System

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In this talk, I discuss how a driven out of equilibrium system evolves to a unique stationary state which is selected from an infinity of possible states by additive stochastic noise which is very counter intuitive. For simplicity, the system studied is the stabilized Kuramoto-Sivashinsky equation with additive stochastic noise in one space dimension. We believe that this is also true in other systems in higher dimensions such as the evolution of a biological species but there are some technical difficulties in demonstrating this.

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* Plenary speaker

The mutual information as a detector of topological and non-topological phase transitions

Luca Leonforte * [1]

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The entanglement of the ground state (GS) can be used to determine the phase and the phase transition of *symmetry-protected topological phase (SPTP)*. By investigating the behavior of the quantum conditional mutual information (QCMI), an upper bound to the squashed entanglement, we show that this quantity identifies the phase transitions and discriminates between topological order and the usual ordered phases associated with spontaneous symmetry breaking. Being the QCMI the mutual information between two subsystems given a third subsystem, one can consider different QCMIs for the same ground state. Evaluating the QCMI over all possible partitions, both considering open boundary conditions and periodic boundary conditions, for different one-dimensional systems, including the Ising model, the Kitaev chain and the SSH model, we find that the QCMI distinguishes efficiently the trivial phase from the non-trivial ones, discriminates topological transitions from symmetry-breaking ones, and assesses whether a topological phase admits Dirac or Majorana fermions at the edges. It turns out that the QCMI is quantized throughout the topologically ordered phases: therefore it identifies both a topological invariant and a non-local order parameter characterizing the ground-state physics of symmetry-protected topological systems.

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*Speaker

Thermodynamics of negative absolute temperatures

Roberto Livi * [1]

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Do negative absolute temperatures matter physics and specifically Statistical Physics? The models typically investigated by statistical mechanics exhibit positive absolute temperature, because their entropy is a nondecreasing function of energy. Nonetheless, it has been realized that this may not be the case for some physical systems as incompressible fluids, nuclear magnetic chains, lasers, cold atoms and optical waveguides. We discuss models of physical interest characterized by negative absolute temperatures, for providing evidence that negative absolute temperatures are consistent with equilibrium as well as with non-equilibrium thermodynamics. In particular, thermometry, thermodynamics of cyclic transformations, ensemble equivalence, fluctuation–dissipation relations, response theory and even transport processes can be reformulated to include them, thus dissipating any prejudice about their exceptionality, typically presumed as a manifestation of transient metastable effects.

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*Speaker

Preparing high entanglement from noisy states through indistinguishability effects

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Realistic preparations of entangled states are jeopardized by the unavoidable interaction with the surrounding environment, whose noisy action is detrimental for the quantum correlations within the system. For this reason, many different techniques to circumvent the problem have been proposed over time.

Firstly, we discuss the success probability for distilling useful entanglement from thermal Gibbs states of two identical qubits via harnessing the spatial overlap of the qubits at distinct locations. The entanglement is activated by means of spatially localized operations and classical communication (sLOCC). Interestingly, thanks to indistinguishability effects, the higher the temperature, the higher the distilled entanglement by this procedure.

Secondly, we present a general scheme, valid for both bosons and fermions, to prepare maximally entangled states of two identical qubits in a way that is robust under the effect of any type of local noise, both quantum and classical. Considering linear optics operations, the procedure utilizes an externally-activated depolarizing channel and a pseudospin-insensitive, non-absorbing, parity check detector in an iterative process with probability which converges exponentially to one with the number of repetitions. The scheme is thus asymptotically deterministic. Distributing the particles over two distinct spatial modes, we show that all the two-qubit maximally entangled states can be connected to each other via an equivalence based on passive optical transformations and parity check detector.

These methods may pave the way towards quantum repeaters in quantum networks composed of controllable identical particles.

References:
(1) M. Piccolini, V. Giovannetti, R. Lo Franco, *Phys. Rev. Research*, in press (2023) (arXiv:2303.11484)
(2) M. Piccolini, V. Giovannetti, R. Lo Franco, *Adv. Quantum Technol.* **2023**, 2300146 (2023). DOI: 10.1002/qute.202300146.
(3) F. Nosrati, B. Bellomo, G. De Chiara, G. Compagno, R. Morandotti, R. Lo Franco, arXiv:2305.11964.

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*Speaker

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Entropic Measures of Quantum Information Scrambling

Gabriele Lo Monaco * [1]

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Quantum Information Scrambling (QIS) is a phenomenon where information becomes delocalized across a system, making it impossible to retrieve locally. It is an hallmark of phenomena such as quantum chaos, thermalization, and plays a central role in some secure communication protocols. Hence, it is important having a reliable method to accurately recognize whether a given dynamics induces scrambling. The Tripartite Information (TI) is considered an efficient entropic witness of QIS. However, this talk aims to reveal its limitations in precisely charting how information delocalizes across a system. To address these shortcomings, I propose two innovative quantifiers that effectively overcome the intrinsic flaws in TI's definition. The first proposed quantifier presents a generalization of the tripartite information, utilizing accessible information to gain a more comprehensive understanding of quantum information scrambling. The second quantifier involves a generalized capacity of a quantum channel and has an operative interpretation in terms of quantum state discrimination. The advantage of this latter quantity is that it can be computed efficiently using semi-definite convex programming techniques. I wil present explicit applications of this latter definition to spin chain models.

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*Speaker

Quantum properties reconstruction via QELM

Salvatore Lorenzo * [1]

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Quantum extreme learning machines (QELMs) aim to efficiently post-process the outcome of fixed — generally uncalibrated — quantum devices to solve tasks such as the estimation of the properties of quantum states (1). The characterisation of their potential and limitations, which is currently lacking, will enable the full deployment of such approaches to problems of system identification, device performance optimization, and state or process reconstruction. We present a framework to model QELMs, showing that they can be concisely described via single effective measurements, and provide an explicit characterisation of the information exactly retrievable with such protocols. We furthermore find a close analogy between the training process of QELMs and that of reconstructing the effective measurement characterising the given device (2). We present also an experimental realization in which the input state evolution is implemented using the coined quantum walk of high-dimensional photonic orbital angular momentum, and performing projective measurements over a fixed basis. We demonstrate how the reconstruction of an unknown polarization state does not need a careful characterization of the measurement apparatus and is robust to experimental imperfections, thus representing a promising route for resource-economic state characterisation (3). Our analysis paves the way to a more thorough understanding of the capabilities and limitations of QELMs, and has the potential to become a powerful measurement paradigm for quantum state estimation that is more resilient to noise and imperfections.

References:
(1) Commun Phys 6, 118 (2023);
(2) arXiv:2301.13229;
(3) arXiv:2308.04543v1.

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*Speaker

Heat transport in the quantum Rabi model: Universality and ultrastrong coupling effects

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Heat transport in the quantum Rabi model at weak interaction with the heat baths is controlled by the qubit-oscillator coupling. Universality of the linear conductance versus the temperature is found for temperatures lower than a coupling-dependent Kondo-like temperature. Coherent heat transfer via virtual processes yields a Tˆ3 behavior. As the temperature increases, incoherent emission and absorption are the dominant heat transfer mechanism. In moving from weak to ultrastrong qubit-oscillator coupling, the conductance makes a transition from a resonant to a broad, zero-bias peak regime, a behavior that parallels the one found for the spin-boson model in (K. Saito and T. Kato, Phys. Rev. Lett. 111, 214301 (2013)), with the qubit-oscillator coupling playing a similar role as the qubit-baths coupling.

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*Speaker

Field theory of strongly correlated dynamics in multi-mode cavity QED

Jamir Marino * [1]

[1] Johannes Gutenberg Universität – Germany

Cavity quantum-electrodynamics is the science of strong light-matter interactions between a quantum gas and the photonic modes of an optical cavity. Cavity QED experiments have become pivotal platforms to realize on demand phases of matter beyond conventional thermodynamics. Thanks to the cooperative enhancement of photon-mediated interactions, long-lived coherent dynamics of collective modes can be used for quantum metrological applications, and in the long-run to promote novel quantum technologies in light-matter interfaces.

In this talk, I will illustrate our progress to upgrade cavity QED systems into operational regimes working beyond the response of collective modes, where strong many-particle correlations impact both dynamics and the onset of non-equilibrium steady states, with the prospect to motivate a new generation of quantum experiments. I will present a non-equilibrium field theory approach based on effective quantum actions with a pedagogical introduction for the broad audience, and then apply our method to the dynamical formation of quantum spin glasses in multi-mode cavity QED experiments.

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*Speaker

Robust Nonequilibrium Edge Currents with and without Band Topology

Miguel Angel Martin-Delgado * [1]

[1] Universidad Complutense de Madrid – Spain

We study two-dimensional bosonic and fermionic lattice systems under nonequilibrium conditions corresponding to a sharp gradient of temperature imposed by two thermal baths. In particular, we consider a lattice model with broken time-reversal symmetry that exhibits both topologically trivial and nontrivial phases. Using a nonperturbative Green function approach, we characterize the nonequilibrium current distribution in different parameter regimes. For both bosonic and fermionic systems, we find chiral edge currents that are robust against coupling to reservoirs and to the presence of defects on the boundary or in the bulk. This robustness not only originates from topological effects at zero temperature but, remarkably, also persists as a result of dissipative symmetries in regimes where band topology plays no role. Chirality of the edge currents implies that energy locally flows against the temperature gradient without any external work input. In the fermionic case, there is also a regime with topologically protected boundary currents, which nonetheless do not circulate around all system edges.

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*Speaker

Long range dependent stochastic motion: heterogeneity and non-stationarity

Ralf Metzler * [1]

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Stochastic processes driven by Gaussian yet power-law correlated noise, such as Mandelbrot's fractional Brownian motion (FBM) represent a quite ubiquitous effective description of the dynamics in a range of complex systems, e.g., for the motion of tracers in viscoelastic environments, in "rough" financial data, or for the persistent motion of animals. FBM is an ergodic yet strongly non-Markovian process, with often surprising behavior. In this talk I will briefly introduce these processes and demonstrate that in strong confinement their probability density may assume non-Boltzmannian, multimodal stationary shapes, while in soft external potentials no steady state exists. An application of this effect to brain fibre growth is discussed. In heterogeneous environments the memory correlations of a diffusing test particle may become a (random or deterministic) function of time or space. For these cases I will introduce "doubly-stochastic" extensions such as FBM with random scaling exponent, memory-multimodal FBM, and FBM with a "diffusing diffusivity". In explicitly time-dependent environments new formulations of long range dependent processes are needed. I will introduce minimal models and discuss their specific dynamic behaviour. I will also address questions of data assimilation for anomalous diffusion trajectories from single particle tracking data.

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*Speaker

Generation of autonomous quantum resources by dissipative quantum systems

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I will first review our recent work (1,2) on the autonomous quantum coherences which constitute a novel possible resource for quantum information procedures. In particular, I will identify their microscopic origin and a range of operations which can be performed with them. Furthermore, I will also discuss technical aspects of their description and evaluation including the issue of detrimental bath backaction as well as the question of statistics of constituent systems.

In the second part of my talk, I will return to the evergreen question of (un)reliability of generalized master equation description of various quantum mechanical as well as thermodynamic phenomena occurring in dissipative quantum systems in or out of equilibrium (3,4) with a particular focus on the recent issue of the (non)existence of autonomous entanglement in a generic nonequilibrium Caldeira-Leggett-like model setup (5).

References:
(1) Artur Slobodeniuk, Tomáš Novotný, and Radim Filip, *Extraction of autonomous quantum coherences*, Quantum **6**, 689 (2022)
(2) Artur Slobodeniuk, Tomáš Novotný, and Radim Filip, *Synthesizing and multiplexing autonomous quantum coherences*, arXiv:2303.07795 (submitted to Quantum)
(3) Tomáš Novotný, *Investigation of apparent violation of the second law of thermodynamics in quantum transport studies*, Europhys. Lett. **59**(5), 648 (2002)
(4) Jan Prachař and Tomáš Novotný, *Charge conservation breaking within generalized master equation description of electronic transport through dissipative double quantum dots*, Physica E **42**, 565 (2010)
(5) Bradley Longstaff, Michael G. Jabbour, and Jonatan Bohr Brask, *Bosonic autonomous entanglement engines with weak bath coupling are impossible*, arXiv:2212.13309

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[*] Speaker

Supercurrent noise in short ballistic graphene Josephson junctions

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Short ballistic graphene Josephson junctions sustain superconducting current with a non-sinusoidal current-phase relation up to a critical current threshold. The current-phase relation, arising from proximitized superconductivity, is gate-voltage tunable and exhibits peculiar skewness observed in high quality graphene super-conductors heterostructures with clean interfaces. These properties make graphene Josephson junctions promising sensitive quantum probes of microscopic fluctuations underlying transport in two-dimensions. Understanding material-inherent microscopic noise sources possibly limiting the phase-coherent behavior of GJJ-based quantum circuits represents an essential, still unexplored, prerequisite. In this presentation we present the investigation of the effect of a dilute homogeneous spatial distribution of non-magnetic impurities on the equilibrium supercurrent within the Dirac-Bogoliubov-de Gennes approach and modeling impurities by the Anderson model. The potentialities of the supercurrent power spectrum for accurate spectroscopy of the hybridized Andreev bound states-impurities spectrum are highlighted. In the low temperature limit, the supercurrent zero frequency thermal noise directly probes the spectral function at the Fermi energy. Our results suggest a roadmap for the analysis of decoherence sources in the implementation of coherent devices by hybrid nanostructures.

References:
(1) F. M. D. Pellegrino, G. Falci, E. Paladino, Comm. Phys. (2022) 5:265
https://doi.org/10.1038/s42005-022-01042-7

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*Speaker

Quantum neuromorphic approach for efficient sensing of gravity-induced entanglement

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The detection of entanglement provides a definitive proof of quantumness. Its ascertainment might be challenging for hot or macroscopic objects, where entanglement is typically weak, but nevertheless present. I will discuss a platform for measuring entanglement by connecting the objects of interest to an uncontrolled quantum network, whose emission (readout) is trained to learn and sense the entanglement of the former. First, I will demonstrate the platform and its features with generic quantum systems. As the network effectively learns to recognise quantum states, it is possible to sense the amount of entanglement after training with only non-entangled states. Furthermore, by taking into account measurement errors, I demonstrate entanglement sensing with precision that scales beyond the standard quantum limit and outperforms measurements performed directly on the objects. Finally, I will utilise such platform for sensing gravity-induced entanglement between two masses and predict an improvement of two orders of magnitude in the precision of entanglement estimation compared to existing techniques.

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*Speaker

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Indistinguishability-based direct measurement of the exchange phase of identical quantum particles

Matteo Piccolini * [1,2], Yan Wang [3,4,5], Ze-Yan Hao [3,4,5], Zheng-Hao Liu [6,7,8], Kai Sun [4,6,8], Jin-Shi Xu [4,6,8], Chuan-Feng Li [4,6,8], Guang-Can Guo [4,6,8], Roberto Morandotti [2], Giuseppe Compagno [9], Rosario Lo Franco [10]

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The symmetrization postulate in quantum mechanics leads to the appearance of an exchange phase dictating the symmetry of identical particle global states under particle swapping. Many indirect measurements of such a fundamental phase have been reported so far, while a direct observation has been only recently carried out for photons. We introduce a general scheme capable to directly measure the exchange phase of any type of particles (bosons, fermions, anyons), exploiting spatial indistinguishability within the operational framework of spatially localized operations and classical communication. An experimental implementation has been performed in an all-optical platform, providing a direct measurement of the real bosonic exchange phase of photons and a proof-of-principle measurement of different simulated exchange phases. Our results confirm the symmetrization tenet and provide a tool to explore it in various scenarios, with particular attention to achieve the first direct measurement of the fermionic exchange phase.

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*Speaker

Quantum Coherence and Thermodynamics

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Finite-time thermodynamic transformations typically lead to the generation of energetic coherence in the out-of-equilibrium state of a quantum system. In fact, it is possible to identify a contribution to the irreversible entropy production that is due to coherence generation.
On the other hand, coherence is tightly connected to the non-adiabaticity of a processes, for which it gives the dominant contribution for slow-enough transformations. With the help of fluctuation theorems, we will provide a full characterization of the irreversible entropy being generated because of both deviation from adiabaticity, and coherence production.

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[*] Speaker

Non-Hermitian Hamiltonian deformations in quantum mechanics

Federico Roccati * [1]

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The construction of exactly-solvable models has recently been advanced by considering integrable TT}-deformations and Hamiltonian deformations in quantum mechanics. We introduce a broader class of non-Hermitian Hamiltonian deformations to account for the description of a large class of open quantum systems, including Markovian evolutions conditioned to the absence of quantum jumps. We relate the time evolution operator and the time-evolving density matrix in the undeformed and deformed theories in terms of integral transforms. Non-Hermitian Hamiltonian deformations naturally arise in the description of energy diffusion that emerges in quantum systems from time-keeping errors in a real clock used to track time evolution. We show that the latter can be related to an inverse TT}-deformation with a purely imaginary deformation parameter. In this case, the integral transforms take a particularly simple form when the initial state is a coherent Gibbs or a thermofield double state, as we illustrate by characterizing the spectral form factor. As the dissipative evolution of a quantum system can be conveniently described in Liouville space, we further study the spectral properties of the Liouvillians. As an application, I will discuss the interplay between decoherence and quantum chaos in non-Hermitian deformations of random matrix Hamiltonians and the Sachdev-Ye-Kitaev model.

References:
(1)Matsoukas-Roubeas, A.S., Roccati, F., Cornelius, J. *et al.* Non-Hermitian Hamiltonian deformations in quantum mechanics. *J. High Energ. Phys.* **2023**, 60 (2023).

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*Speaker

Resonances in end-pulled polymer translocation

Alejandro Sainz-Agost * [1,2], Alessandro Fiasconaro† [1,2,3], Fernando Falo‡ [1,2]

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In this work, we simulate the translocation of a semiflexible homopolymer through an extended pore, driven by both a constant and a time-dependent end-pulled forces. The time dependence is simplistically modeled as a cosine function, and we distinguish between two scenarios for the driving depending on the relative orientation of the force with respect to the pore axis, i.e. longitudinal (parallel) or transversal (perpendicular). Besides some key differences between the two pulling regimes, the mean translocation times present a large minimum region as a function of the frequency of the force that is a typical feature of the Resonant Activation effect. The presence of the minimum is independent of the characteristics of the polymer chains and reveals a strong linear relation between the optimum mean translocation time and the corresponding period of the driving. We studied the translocation processes of chains with different lengths and flexibilities, establishing a scaling law for the recorded mean translocation times. Lastly, we derive an analytical expression of the mean translocation time for low driving frequency, verified by the numerical simulations. Work published as: *Polymer translocation driven by longitudinal and transversal time-dependent end-pulling forces* A. Sainz-Agost, F. Falo, A. Fiasconaro. Physical Review E 108, 034501 (2023).

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*Speaker

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Arrhenius law for interacting diffusive systems

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Finding the mean time it takes for a particle to escape from a meta-stable state due to thermal fluctuations is a fundamental problem in physics, chemistry and biology. For weak thermal noise, the mean escape time is captured by the Arrhenius law (AL). Despite its ubiquity in nature and wide applicability in practical engineering, the problem is typically limited to single particle physics. Finding a generalized form of the AL for interacting particles has eluded solution for a century. Here, we tackle this outstanding problem and generalize the AL to a class of interacting diffusive systems within the framework of the macroscopic fluctuation theory. The generalized AL is shown to conform to a non-trivial yet elegant form that depends crucially on the particle density and inter-particle interactions. We demonstrate our results for the paradigmatic exclusion and inclusion processes to underpin the key effects of repulsive and attractive interactions. Intriguingly, we show how to manipulate the mean escape time using not only temperature, but also the particle density. We further discuss how from the generalization of AL, a novel set of effects can be explored. The results are discussed in ArXiv 2306.06879

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[*] Speaker

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Multi-partite entanglement in measurement induced phase transitions

Alessandro Silva * [1]

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External monitoring of quantum many-body systems can give rise to a measurement-induced phase transition characterized by a change in behavior of the entanglement entropy from an area law to an unbounded growth. We show that this transition extends beyond bipartite correlations to multipartite entanglement. Using the quantum Fisher information, we investigate the entanglement dynamics of a continuously monitored quantum Ising chain. Multipartite entanglement exhibits the same phase boundaries observed for the entropy in the post-selected no-click trajectory. Instead, quantum jumps give rise to a more complex behavior that still features the transition, but adds the possibility of having a third phase with logarithmic entropy but bounded multipartiteness.

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[*] Speaker

Out of equilibrium topological edge state constrictions

Niccolò Traverso Ziani * [1]

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The quantum spin Hall effect is intriguing both from a fundamental and a technological point of view, thanks to its symmetry protected topological edge channels. Recently, as a way to efficiently manipulate the edge channels, long constrictions have been experimentally realized. The properties of such constrictions, in and out of equilibrium, will discussed in particular in connection to transport anomalies, Floquet bound states, and the anomalous Josephson effect.

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*Speaker

Effects of randomly fluctuating solar irradiance on the dynamics of a complex trophic web

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The analysis of experimental data of the solar irradiance, collected on the sea surface, highlights the intrinsic stochasticity of such an environmental variable. Given this result, the effects of randomly fluctuating irradiance on the population dynamics of a marine ecosystem are studied on the basis of the stochastic 0-dimensional biogeochemical flux model (BFM). The noisy fluctuations of the irradiance are formally described by a multiplicative Ornstein-Uhlenbeck process, i.e., a self-correlated Gaussian noise. Nonmonotonic behaviours of the variance of the marine populations' biomass are found with respect to the intensity and the autocorrelation time of the noise source, manifesting a noise-induced transition of the ecosystem to an out-of-equilibrium steady state. Moreover, noise-induced effects in the organic carbon cycling processes, underlying the food web dynamics, are observed. These findings clearly show the profound impact the stochastic behaviour of environmental variables can have on both biological and chemical components of a marine trophic network.

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*Speaker

Information scrambling in quantum tomography performed with quantum extreme learning

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In the era of big data and complex problem domains, machine learning has emerged as a powerful tool for extracting meaningful patterns and insights from vast amounts of data. While traditional learning algorithms have achieved remarkable success in various domains, they often face challenges in terms of scalability, computational efficiency, and adaptability to diverse problem settings. In this regard, extreme learning machines (ELMs) have emerged as a promising alternative, offering a fresh perspective on learning algorithms. ELM and reservoir computing (RC) are neural networks constructed using an untrained randomly generated hidden layer, which is called in this context "reservoir", and a single output layer which applies a linear map trained by supervised methods. This analytical computation step eliminates the need for time-consuming iterative adjustments, significantly speeding up the learning process. As a result, ELMs and RCs achieve fast learning without compromising the model's ability to generalize well to unseen data. The information processing and memorization capabilities of the random evolution given by the random hidden layer can also be observed in many different physical systems. During the last few years it has also been explored the possibility to use quantum systems as reservoirs to solve quantum problems giving rise to the era of Quantum Extreme Learning (QELM) and Quantum Reservoir Computing (QRC). In our context, we exploited a simulated N-qubits network with a mixed field Ising hamiltonian as a reservoir to make quantum tomography of a qubit with a QELM algorithm. The objective of our work is to find a correlation between information scrambling and the accuracy of the QELM algorithm and investigate how different measurement protocols affect its efficiency. The efficiency of the task is quantified by computing the trace distance between the real and the reconstructed states. Information scrambling serves to measure how rapidly the information about a perturbation spreads among the degrees of freedom of a many body system and is generally quantified via Out of Time Ordered Correlators (OTOCs). Furthermore, we will measure the classical information about the initial state of the qubit stored locally in the nodes of the reservoir re-adapting the definition of Holevo information, which is the maximal accessible information stored in a system. The results prove that information scrambling has a strong influence in the functioning of these kind of algorithms, with the efficiency saturating to a minimum value when reaching the scrambling time we perform measurements on all of the qubits at the same time. Furthermore, when making local measurements we obtain the a faster saturation to a maximal efficiency, lower than in the previous case, with many irregularities in time present due to the delocalization of the information about the initial state.

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*Speaker

Complex quantum systems for machine learning

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In the last decades, Complex Systems have been explored in physical systems also in the quantum regime, with enormous advances both in their theoretical treatment as well as in the ability to detect and manipulate individual quantum objects and couple them under control.
Their potential applications range from quantum computing, to the quantum Internet, or quantum simulations. In this talk I will present some results on the use of complex quantum systems for machine learning purposes, focusing on Reservoir Computing (RC). This is a non-conventional computing approach inspired by the brain, standing-out among other neuromorphic approaches, for easy training and reduced energy footprint.
Quantum reservoir computing has the potential to remarkably boost the processing performance in temporal tasks by exploiting quantum coherences, not requiring error correction, and it is suited for fully quantum information processing (with quantum inputs). The extension from classical reservoir computing to quantum RC opens a series of new challenging questions, related to fundamental as well as implementation aspects. Examples are the identification of the best quantum regimes of operation, the role of statistics, or of quantum coherences and entanglement as well as the problem of measurement in online processing.

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[*] Speaker

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