BLiNH25

Beyond Linearity:
Frontiers in Non-Hermitian Many-Body Physics

14-18 December 2025, Erice, Italy

BOOK OF ABSTRACTS

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About BLiNH25

Scope

The workshop *Beyond Linearity: Frontiers in Non-Hermitian Many-Body Physics* (BLiNH25) aims at bringing together experts in the fields of non-Hermitian and quantum many-body physics to discuss recent advancements and future prospects at their intersection. The central goal of the workshop will be to delve into non-Hermitian physics beyond the linear regime.

The workshop will be held at Ettore Majorana Foundation and Centre for Scientific Culture, Erice, Italy. BLiNH25 will have the standard format of a conference, featuring both talks and posters. As usual for workshops and conferences hosted by the Majorana Centre, BLiNH25 will formally be a “course” within the framework of the “School of Non-equilibrium Phenomena”, directed by Alessandra Lanzara (UC Berkeley), Massimo Palma (U Palermo) and Bernardo Spagnolo (U Palermo).

Scientific organizing committee

Federico Balducci	Max Planck Institute for the Physics of Complex Systems, Germany
Pietro Brighi	University of Vienna, Austria
Francesco Ciccarello	NEST Istituto Nanoscienze-CNR & University of Palermo, Italy
Andreas Nunnenkamp	University of Vienna, Austria
Federico Roccati	University of Palermo, Italy

Erice

Erice is a charming small town in western Sicily, Italy. It is renowned for its rich history, unique character, and vibrant scientific community. Perched atop Mount Erice at around 750 metres (2,460 ft) above sea level, the town offers breathtaking panoramic views of the sea, the surrounding hills, and the nearby city of Trapani. Its historic centre is a picturesque village with winding cobblestone streets, ancient stone buildings, and a relaxed atmosphere that draws visitors from around the world.

Erice is easily accessible via the Palermo–Punta Raisi Airport (about one hour away by car) or the Trapani–Birgi Airport (about 40 minutes away). Once in Erice, visitors can immerse themselves in its cultural and architectural treasures. Among its most notable landmarks is the Castle of Venus, dating back to the Norman conquest of Sicily in the 12th century, which offers stunning views of the countryside. The town is also home to several beautiful churches, including the Chiesa Madre, a striking Gothic structure built in the 14th century.

Whether you are exploring its charming alleyways, admiring the traditional architecture, or participating in cutting-edge research at one of its renowned scientific centres, Erice offers a captivating blend of history, culture, and inspiration—making it one of Sicily's must-see destinations.

Program

BLiNH25

time	Mon 15th	time	Tue 16th	time	Wed 17th
8:45	welcome				
9:00	Verhagen *Programmable non-Hermiticity and nonlinearity in optomechanical networks*	9:00	Poddubny *Subradiance in driven-dissipative waveguide QED*	9:00	Kawabata *Symmetry and topology of monitored quantum dynamics*
9:30	del Pino *Topological classification of driven-dissipative nonlinear resonators*	9:30	Karle *Non-hermitian floquet engineering with cavity-QED tweezer arrays*	9:30	Yamamoto *Measurement-induced crossover of quantum jump statistics in postselection-free many-body dynamics*
9:50	Bergholtz *Non-Hermitian Effects in Strongly Correlated Topological Phases*	9:50	Wang Z. *Harnessing Nonreciprocity in Open Quantum Systems*	9:50	Carollo *Entanglement dynamics in monitored system: minimal model, criticality and information loss*
10:20	coffee break	10:20	photo + coffee break	10:20	coffee break
10:50	Kunst *Exceptional non-Hermitian topology*	10:50	Hanai *Photoinduced non-reciprocal magnetism*	10:50	Sala *Measurement-altered quantum criticality: from theory to an experimental proposal*
11:20	McCarthy *Diabolical sensors: a route to robust exceptional and exponentially enhanced non-Hermitian sensors*	11:20	Zhang *Non-Hermitian and Liouvillian skin effects in magnetic systems*	11:20	Lapierre *Driven Non-Unitary Dynamics of Quantum Critical Systems*
11:40	Clerk *Dissipative quantum phase transitions & non-Hermitian structures*	11:40	Brunelli *Dissipative phase transition of interacting non-reciprocal fermions*	11:40	Žnidarič *The joys and dangers of non-unitarity in many-body unitary dynamics*
12:10	lunch	12:10	lunch	12:10	lunch
14:40	Felski *Self-consistent soliton solutions in non-Hermitian chains*	14:40	Nakanishi *Lindbladian PT phase transition: Emergence of continuous time crystals and critical exceptional points*	14:40	Hamazaki *Uniqueness of steady states of time-periodic and quasiperiodic GKSL equations*
15:00	Chenu *Control of a non-Hermitian qubit with shortcuts to adiabaticity*	15:00	Garbe *Non-hermitian physics in number-conserving system: the bosonic skin effect*	15:00	Rakovszky *Slow relaxation and phases of matter in finite temperature and open quantum systems*
15:30	Martinez-Azcona *Preparing magic states with Non-Hermitian and Stochastic Hamiltonians*	15:30	Erglis *Asymmetric transport of bosons in one and two dimensions*	15:30	Ljubotina *Finite steady-state current defies non-Hermitian many-body localization*
15:50	coffee break	15:50	coffee break	15:50	Chiriacò *Exploiting memory effects and dissipative dynamics in quantum systems*
16:20	Sá *Spectral statistics in dissipative quantum chaos: from theory to experiment*	16:20	Wang T. *Non-Hermitian physics at ferromagnet-topological semimetal junctions*	16:20	coffee break
16:50	Bhattacharjee *Krylov Complexity of Open Quantum Systems: An SYK Perspective*	16:40	Weis *Nonreciprocal Phase Transitions in Multipopulation systems*	16:50	Poster session / discussion
17:10	coffee break	17:00	coffee break		
17:30	Poster session / discussion	17:20	Poster session / discussion		
		20:00	Social Dinner		

Talks Abstracts

CT Contributed Talk, IT Invited Talk.

Emil J. Bergholtz, Stockholm University IT

Non-Hermitian Effects in Strongly Correlated Topological Phases

I will discuss how non-Hermitian ingredients enrich the topology and phenomenology of strongly interacting quantum matter. Building on our earlier ideas of exceptional spin liquids and extending to ongoing work on non-Hermitian fractional Chern insulators, I will highlight the emergence of skin effects, exceptional points, and routes for dissipative state preparation. These examples illustrate how non-Hermitian physics can open new perspectives on topological many-body phases.

Budhaditya Bhattacharjee, University of Luxembourg CT

Krylov Complexity of Open Quantum Systems: An SYK Perspective

We study the operator growth in open quantum systems with dephasing dissipation terms, extending the Krylov complexity formalism. Our results are based on the study of the dissipative q-body Sachdev-Ye-Kitaev (SYKq) model, governed by the Markovian dynamics. We introduce a notion of "operator size concentration" which allows a diagrammatic and combinatorial proof of the asymptotic linear behavior of the two sets of Lanczos coefficients (ann and bnn) in the large q limit. Our results corroborate with the semi-analytics in finite q in the large N limit, and the numerical Arnoldi iteration in finite q and finite N limit. As a result, Krylov complexity exhibits exponential growth following a saturation at a time that grows logarithmically with the inverse dissipation strength. The growth of complexity is suppressed compared to the closed system results, yet it upper bounds the growth of the normalized out-of-time-ordered correlator (OTOC). We provide a plausible explanation of the results from the dual gravitational side. We connect these observations to continuous quantum measurement processes. We further investigate the pole structure of a generic auto-correlation and the high-frequency behavior of the spectral function in the presence of dissipation, thereby revealing a general principle for operator growth in dissipative quantum chaotic systems.

Matteo Brunelli, Collège de France IT

Dissipative phase transition of interacting non-reciprocal fermions

In this talk I will discuss the dynamics of an interacting fermionic chain in which nonreciprocity is induced by correlated gain and loss processes. The interplay between unitary evolution and the two dissipative processes leads to distinct non-reciprocal signatures in the transient dynamics and the steady state. These include a transition from exponential to power-law relaxation towards a finite-density steady-state, a nonzero particle current from breaking inversion symmetry, and dynamics under open boundary conditions showing directionality and charge accumulation. I will show that, while weak interactions lead to a many-body non-reciprocal phase with volume law entanglement, above a critical value of interactions, reciprocity is dynamically restored via a dissipative phase transition.

Angelo Carollo, University of Palermo IT

Entanglement dynamics in monitored system: minimal model, criticality and information loss

Measurement-induced phase transitions (MIPTs) are inherently properties of individual quantum trajectories, making their observation challenging when measurement outcomes cannot be perfectly distinguished. Using an exactly solvable Liouvillian model, we show that limited trajectory resolution effectively averages over many realizations, introducing a finite lengthscale that suppresses long-range correlations and washes out the critical features associated with MIPTs. Exact results for correlations, the Liouvillian gap, and entanglement negativity illustrate how partial averaging progressively obscures the underlying trajectory-level physics. We then examine how the detailed structure of individual trajectories shapes entanglement dynamics in a free fermionic chain monitored on a single site. Here, strongly super-Poissonian jump statistics–bunched events separated by long "dark" intervals–drive a surprising volume-law growth of entanglement, unlike both unitary quenches and fully post-selected no-click evolution. Increasing the number of monitored sites ultimately induces a Zeno-like crossover to area-law behavior. Together, these results show how the visibility of measurement-induced phases and entanglement structure hinges on the interplay between trajectory statistics and the observer's ability to resolve measurement outcomes.

Aurélia Chenu, University of Luxembourg IT

Control of a non-Hermitian qubit with shortcuts to adiabaticity

We explore the Riemann-surface topology of a non-Hermitian qubit. Using the sublattice symmetry of the system, we parametrize the eigenvectors using a complex mixing angle. Using tools from shortcut-to-adiabaticity, we design the counterdiabatic Hamiltonian that allows driving the system along an adiabatic evolution while keeping the evolution time finite. This mitigates the losses (intrinsic to non-Hermitian systems), while tracking the instantaneous eigenstates in significantly shorter timescales. We experimentally investigate the robustness of this control method using a superconducting transmon circuit with engineered dissipation. We identify the conditions and the trajectories for which the control remains Hermitian (i.e., experimentally implementable). Thanks to the developed procedure, we can explore the Riemann topology of the qubit.

Giuliano Chiriacò, University of Catania IT

Exploiting memory effects and dissipative dynamics in quantum systems

Non-Markovian dynamics, characterized by memory effects and information backflow, play a crucial role in many quantum systems, influencing properties such as coherence and entanglement. In this talk, we explore how non-Markovianity emerges in different settings, ranging from application to quantum devices to theoretical models. We analyze a monitored free-fermion system where noise in an ancilla can unexpectedly enhance entanglement, highlighting the interplay between measurement-induced dynamics and memory effects. We also characterize non-Markovianity in a simple qubit-impurity system, studying how it can be quantified via simple spectroscopic measurements.

Aashish Clerk, University of Chicago IT

Dissipative quantum phase transitions & non-Hermitian structures

Many of the most celebrated effects in non-Hermitian physics (e.g. the non-Hermitian skin effect, PT symmetry breaking) are typically studied in the setting of linear dynamics and effective single-particle Hamiltonians. It is of course interesting to ask how this phenomena might arise in truly many-body quantum systems, ideally without needing any kind of post-selection. Here, I'll discuss two examples of systems in this category. The first is a study of driven-dissipative Bose condensation transitions in the presence of non-reciprocal couplings. Directionality leads to dramatically different phase transition physics for open versus periodic boundary conditions, and the emergence of numerous exotic phases. The second example I will discuss is a quantum XXZ spin chain subject to boundary driving and loss (as described by a Lindblad master equation). I'll discuss how a recently-discovered dissipative phase transition in this non-equilibrium steady state of this model can be linked to scar states and a PT symmetry breaking phase transition in a non-Hermitian Hamiltonian.

Javier del Pino, Universidad Autónoma de Madrid CT

Topological classification of driven-dissipative nonlinear resonators

Topology provides a powerful lens to uncover global structures that remain stable despite local changes. In physics, topology has proven powerful for classifying phases and robust transport, and now plays a key role in driven-dissipative systems, revealing effects like non-Hermitian skin modes and edge-mode amplification.

In this talk, I will explore how topological tools can be pushed further, into the nonlinear regime. I will introduce a graph-based index built from the vector flow that captures the dynamics in phase space of driven-dissipative micro-mechanical systems. By tuning driving parameters like amplitude and detuning, I will reveal local and global phase transitions, such as flow chirality and connectivity flips, and present confirming experimental evidence [1].

References: [*equal contribution]

[1] Villa, G. *, del Pino, J. *, Dumont, V., Rastelli, G., Michałek, M., Eichler, A., & Zilberberg, O. (2024). Topological classification of driven-dissipative nonlinear systems. arXiv preprint arXiv:2406.16591.

Andris Erglis, University of Palermo CT

Asymmetric transport of bosons in one and two dimensions

Bosonic skin state is a nonlinear incoherent transport phenomenon in a one-dimensional lattice where bosonic populations, for sufficiently asymmetric hopping rates, exhibit a real-space zigzag pattern at the steady state near the lattice boundary. We investigate the effect of loss and hopping impurities in such a lattice and also study periodic hopping patterns like the SSH-type configuration. Moreover, we study a closed and an open bosonic Galton board for bosonic particles. Finally, we present some novel results in a two-dimensional lattice with a completely asymmetric metastable hopping configuration.

Alexander Felski, Max Planck Institute for the Science of Light CT

Self-consistent soliton solutions in non-Hermitian chains

Investigations of non-Hermitian chain models have demonstrated many intriguing phenomena, which are today well-understood within the framework of the generalised Brillouin zone and non-Hermitian Bloch band theory. These models are commonly extensions and modifications of long-standing foundational toy models, such as the Su-Schrieffer-Heeger (SSH) and Rice-Mele (RM) chains. In addition to hosting topologically insulating phases, these toy models have played an important role in the study of non-linear systems through their contribution to the development of the inverse scattering method and soliton physics.

Louis Garbe, Walther-Meißner-Institut IT

Non-hermitian physics in number-conserving system: the bosonic skin effect

I will discuss a strategy to implement non-linear transport in bosonic systems, through coupling to an engineered environment. Contrary to standard techniques relying on controlled losses, this scheme is achieved here through a number-conserving, dephasing-like process. This approach allows us to realize non-hermitian phenomena, related to the non-hermitian skin effect and exceptional point physics, directly at the steady-state level. I will discuss the role of boundary conditions in the emergence of these effects, and some of the light this model can help shed on non-hermitian many-body physics.

Ryusuke Hamazaki, RIKEN CT

Uniqueness of steady states of time-periodic and quasiperiodic GKSL equations

We present a general rigorous criterion for the uniqueness of steady states of time-periodic and quasiperiodic Gorini-Kossakowski-Sudarshan-Lindblad (GKSL) equations with Hermitian jump operators. By generalizing the notion of strong symmetry to time-dependent GKSL equations, we also show that the criterion gives a sufficient and necessary condition for the uniqueness of maximally mixed steady states when the GKSL generators are analytical at every time. We demonstrate applications of the criterion using examples of two-level systems and a quantum spin chain with periodic driving.

Ryo Hanai, Institute of Science Tokyo IT

Photoinduced non-reciprocal magnetism

Out of equilibrium, the action-reaction symmetry of interactions is often broken, leading to the emergence of various collective phenomena with no equilibrium counterparts. Although ubiquitous in classical active systems, implementing such non-reciprocal interactions in solid-state systems has remained challenging, as known quantum schemes require precise single-site control. Here, we propose a dissipation-engineering protocol that induces non-reciprocal interactions in solid-state platforms with light, which we expect to be achievable with state-of-the-art experimental techniques. Focusing on magnetic metals, we show microscopically that a light injection that introduces a decay channel to a virtually excited state gives rise to non-reciprocal interactions between localized spins, resulting in chase-and-runaway dynamics. Applying our scheme to layered ferromagnets, we show that a non-reciprocal phase transition to a many-body time-dependent chiral phase occurs. Our work paves the way to bring solid-state systems to the realm of non-reciprocal science, providing yet another possibility to control quantum matter with light.

Volker Karle, Institute of Science and Technology Austria CT

Non-hermitian floquet engineering with cavity-QED tweezer arrays

We develop a theory for engineering non-Hermitian many-body states through Floquet modulation of cavity-QED tweezer arrays. In this setup, individually trapped atoms in optical tweezers couple collectively to a single cavity mode with position-dependent phases. Periodic modulation of atomic transitions via tweezer-based Stark shifts transforms the cavity-mediated all-to-all coupling into programmable interaction graphs. The intrinsic dissipation from cavity decay and spontaneous emission is captured by a time-periodic Lindblad master equation. In the fast-driving regime, we derive an effective time-independent Lindbladian, which under weak pumping conditions or post-selection reduces to a non-Hermitian effective Hamiltonian. Preliminary matrix product state simulations suggest that this driven-dissipative dynamics generates graph states with complex-valued entanglement structures and state-dependent decoherence rates. The controlled non-Hermitian evolution opens prospects for topological quantum quantum computing where engineered dissipation could actively suppress errors while preserving topological degrees of freedom. Our predictions are developed in close collaboration with ongoing experiments at ISTA where current tweezer technology already enables the necessary control for implementing Floquet-engineered protocols.

Kohei Kawabata , University of Tokyo IT

Symmetry and topology of monitored quantum dynamics

The interplay between unitary dynamics and quantum measurements induces diverse phenomena in open quantum systems with no counterparts in closed quantum systems at equilibrium. Here, we generally classify Kraus operators and their effective non-Hermitian dynamical generators, thereby establishing the tenfold classification for symmetry and topology of monitored free fermions. Our classification elucidates the role of topology in measurement-induced phase transitions and identifies potential topological terms in the corresponding nonlinear sigma models. Furthermore, we establish the bulk-boundary correspondence in monitored quantum dynamics: nontrivial topology in spacetime manifests itself as topologically nontrivial steady states and gapless boundary states in Lyapunov spectra, such as Lyapunov zero modes and chiral edge modes, leading to the topologically protected slowdown of dynamical purification.

Flore Kunst, Max Planck Institute for the Science of Light IT

Exceptional non-Hermitian topology

While topological phases of matter have predominantly been studied for isolated Hermitian systems, a recent shift has been made towards considering these phases in the context of non-Hermitian Hamiltonians. Non-Hermitian topological phenomena reveal an enrichment of the phenomenology of topological phases, and forms a rapidly growing new cross-disciplinary field. In this talk, we will see that non-Hermitian Hamiltonians, which come about due to, e.g., gain and loss, feature many exotic properties, which are radically different from their Hermitian counterparts. In particular, I will focus on our recent work on higher-order exceptional points, which are truly non-Hermitian degeneracies, the role played by symmetries and similarities, and present explicit toy models to illustrate our findings. Additionally, I will discuss the role of exceptional points in nonlinear Kerr resonators.

Bastien Lapierre, École Normale Supérieure

CT

Driven Non-Unitary Dynamics of Quantum Critical Systems

In this talk I will introduce a class of driven non-unitary quantum many-body systems described by conformal field theory (CFT). I will show analytically how non-unitarity dramatically affects the dynamics of entanglement entropy, and leads to a variety of phenomena, ranging from robust steady states to purification phase transitions for mixed states. I will compare the universal predictions from CFT to lattice models, showing remarkable agreement.

Based on [2505.01508], in collaboration with Pietro Pelliconi, Shinsei Ryu and Julian Sonner.

Marko Ljubotina, Technical University of Munich

CT

Finite steady-state current defies non-Hermitian many-body localization

Non-Hermitian many-body localization (NH MBL) has emerged as a possible scenario for stable localization in open systems, as suggested by spectral indicators identifying a putative transition for finite system sizes. In this work, we shift the focus to dynamical probes, specifically the steady-state spin current, to investigate transport properties in a disordered, non-Hermitian XXZ spin chain. Through exact diagonalization for small systems and tensor-network methods for larger chains, we demonstrate that the steady-state current remains finite and decays exponentially with disorder strength, showing no evidence of a transition up to disorder values far beyond the previously claimed critical point. Our results reveal a stark discrepancy between spectral indicators, which suggest localization, and transport behavior, which indicates delocalization. This highlights the importance of dynamical observables in characterizing NH MBL and suggests that traditional spectral measures may not fully capture the physics of non-Hermitian systems. Additionally, we observe a non-commutativity of limits in system size and time, further complicating the interpretation of finite-size studies. These findings challenge the existence of NH MBL in the studied model and underscore the need for alternative approaches to understand localization in non-Hermitian settings.

Pablo Martinez-Azcona, University of Luxembourg

CT

Preparing magic states with Non-Hermitian and Stochastic Hamiltonians

A universal quantum computer requires both entanglement and non-stabilizerness, a property commonly known as magic, to outperform a classical computer. The need for magic comes from circuits that involve Clifford gates and stabilizer states, which can be efficiently simulated on a probabilistic classical computer. In particular, Brayvi and Kitaev [1] showed that one can recover universal quantum computation if one performs Clifford operations on the magical $\langle H\rangle$ and $\langle T\rangle$ states.
In this talk, we will show how to exploit non-Hermiticity to prepare states with high magic during evolution, especially in the steady state. We will consider the case of a qubit, which has been recently realized by continuous quantum measurements and post-selection in the lab [2]. We analytically compute the values of the parameters that allow us to prepare $\langle H\rangle$ and $\langle T\rangle$ states, which are close to the Exceptional Point in the PT broken phase.
Furthermore, we analytically show that adding noise in the anti-hermitian part of the Hamiltonian, leading to antidephasing [3], can preserve and even enhance magic at the average level. We compute the distribution of the magic at single realizations of the noise, which can show exponential concentration around the maximal value, and compare the single trajectory results with the average prediction.

References:

[1] Brayvi, Kitaev, Phys. Rev. A 71, 022316 (2005)
[2] Naghiloo, Abbasi, Joglekar, Murch, Nature Physics 15, 1232–1236 (2019)
[3] Martinez-Azcona, Kundu, Saxena, del Campo, Chenu, arXiv:2407.07746 (Accepted in Phys. Rev. Lett.)

Maxine M. McCarthy, Max Planck Institute for the Science of Light

CT

Diabolical sensors: a route to robust exceptional and exponentially enhanced non-Hermitian sensors

Exceptional points have created great excitement as a possible route to strongly enhanced sensing [1], with a correspondence between an nth order exceptional point and an nth order pole in the Green's functions [2]. However, parametrically controlling a system to an nth order exceptional point typically requires precise control of many system parameters [3], making it experimentally difficult to explore such systems. Imperfect control and disorder can therefore have a significant impact on a particular devices sensitivity.

One way around this issue is to use disorder as a resource to increase the order of an exceptional point [4]. Through careful consideration of structural connectivity, we extend this approach. In particular, we provide a construction to engineer systems that are topologically fixed at an nth order exceptional point. That is, for randomly generated system parameters, a device is at an nth order exceptional point with probability one.

To use the scattering response for sensing, we show that it is advantageous to take the system away from an exceptional point. For a suitable structural choice, a system can be tuned to a diabolical point [5] with control of just a small number of device parameters. Any shift in parameters away from the diabolical point then immediately lifts the device to an exceptional point. The scattering response is highly sensitive to this change which can be leveraged for sensing. Using a graph-theoretic approach, we present a general recipe for designing such devices.

Under our scheme to operate such a sensor, we theoretically find an exponentially enhanced signal-to-noise ratio. This noise response is surprisingly robust to system disorder: a consequence of the devices non-Hermitian topology, and its underlying graph-theoretic construction. We discuss these results, and propose suitable experimental implementations.

[1] - Wiersig, J., “Review of exceptional point-based sensors”, Photon. Res. 8, 1457-1467 (2020).
[2] - Heiss, W.D., “Green's Functions at Exceptional Points”, Int J Theor Phys 54, 3954–3959 (2015).
[3] - Höller, J., Read, N., & Harris, J.G.E, “Non-Hermitian adiabatic transport in spaces of exceptional points”, Phys. Rev. A 102, 032216 (2020).
[4] - Zhong, Q., Kou, J., Ozdemir, S. K. , & El-Ganainy, R., “Hierarchical Construction of Higher-Order Exceptional Points”, Phys. Rev. Lett. 125, 203602 (2020).
[5] - McCarthy, M.M., & Whittaker, D.M., “Sequential topology: iterative topological phase transitions in finite chiral structures”, arXiv:2505.10773 (2025).

Yuma Nakanishi, University of Tokyo CT

Lindbladian PT phase transition: Emergence of continuous time crystals and critical exceptional points

A parity-time (PT) transition is a novel spectral transition characteristic of non-Hermitian systems. The concept of PT transition has been extended to the Gorini-Kossakowski-Sudarshan-Lindblad (GKSL) equation, which governs Markovian open quantum systems. In this talk, we describe recent advances in the study of Lindbladian PT (L-PT) phase transitions [1]. First, we perform the mean-field analysis for the L-PT phase transitions for one-collective spin systems and spatially extended bipartite bosonic systems with conserved particle number. We show that the L-PT symmetry can generally cause a continuous time-translation symmetry to break into a discrete one, leading to continuous time crystals. Furthermore, we demonstrate that the L-PT phase transition point is typically a critical exceptional point, where the critical point coincides with an exceptional point, such that multiple collective modes coalesce into a zero collective mode.

[1] YN and R. Hanai, T. Sasamoto, Continuous time crystals as a PT symmetric state and the emergence of critical exceptional points, arXiv:2406.09018.

Alexander Poddubny, Weizmann Institute IT

Subradiance in driven-dissipative waveguide QED

We theoretically study time-dependent correlations in a strongly driven array of two-level atoms, coupled to photons in a waveguide. We focus on the spectrum of the Liouvillian superoperator, governing the driven-dissipative dynamics, which allows us to find the correlation decay rates and the oscillation frequencies for the correlations between the atoms. Our main result is the absence of subradiant oscillating correlations for a strong driving amplitude. If the correlations oscillate in time, they have to decay faster than a single atom decay rate. We demonstrate the existence of the limit numerically and provide a rigorous algebraic proof based on the analytical decomposition of the Liouvillian using spectral theory of simplicial complexes and posets.

Tibor Rakovszky, Budapest University of Technology and Economics IT

Slow relaxation and phases of matter in finite temperature and open quantum systems

We prove an analogue of the “bottleneck theorem”, well-known for classical Markov chains, for Markovian quantum channels. Our theorem provides a sufficient condition for quantum channels to exhibit slow dynamics in the form of multiple approximate stationary states that are ’stuck’ in a particular subspace of Hilbert space for a long time. Specializing to the case of finite temperature Gibbs states of a quantum many-body systems, we interpret this phenomenon in terms of macroscopic free energy barriers separating different equilibrium states. This provides a new dynamical perspective on finite temperature phases of matter, connecting them to the problem of phases of matter in open quantum systems. As an application, we discuss how this approach leads to a new notion of "topological quantum spin glass" (TQSG) order, which combines features of certain classical spin glass models with those of topologically ordered systems and provide examples of long-range interacting models that realize such TQSG order at low temperatures

Lucas Sá, University of Cambridge

IT

Spectral statistics in dissipative quantum chaos: from theory to experiment

More than four decades of research on chaos in isolated quantum systems have led to the identification of universal signatures—such as level repulsion and eigenstate thermalization—that serve as cornerstones in our understanding of complex quantum dynamics. The emerging field of dissipative quantum chaos explores how these properties manifest in open quantum systems, where interactions with the environment play an essential role. I will discuss the theoretical proposal [1] and first experimental detection [2] of dissipative quantum chaos and integrability by measuring the complex spacing ratios (CSRs) of open many-body quantum systems. Experimentally, we employ gradient-based tomography to we retrieve a "donut-shaped" CSR distribution for chaotic dissipative circuits, a hallmark of level repulsion in open quantum systems. For an integrable circuit, spectral correlations vanish, evidenced by a sharp peak at the origin in the CSR distribution. As we increase the depth of the integrable dissipative circuit, the CSR distribution undergoes an integrability-to-chaos crossover, demonstrating that intrinsic noise in the quantum processor is a dissipative chaotic process. Our results reveal the universal spectral features of dissipative many-body systems and establish present-day quantum computation platforms, which are predominantly used to run unitary simulations, as testbeds to explore dissipative many-body phenomena.

[1] Sá, Ribeiro, Prosen, Phys. Rev. X 10, 021019 (2020).
[2] Wold, Zhu, Jin, Zhu, Bao, Zhong, Shen, Zhang, Li, Wang, Song, Guo, Denisov, Sá, Wang, Ribeiro, arXiv:2506.04325 (2025).

Pablo Sala, UC Berkeley

IT

Measurement-altered quantum criticality: from theory to an experimental proposal

Quantum critical points are highly sensitive to perturbations, making them ideal for exploring novel measurement-induced effects. In this talk, I will discuss how weakly measuring quantum critical chains can qualitatively impact their correlations and entanglement structure in a manner dependent on the protocol. I will then present a proposal for a practical experimental realization using Rydberg atom chains tuned to Ising and tricritical Ising quantum critical points. In particular, projectively measuring a periodic subset of atoms alters quantum critical correlations in distinct ways that one can control via the choice of measured sites and the measurement outcomes. While the method relies on post-selection, we find that some of the most impactful outcomes occur with relatively high probability in systems with around 100 sites. As a direct application of these ideas, I will conclude discussing the effect of imperfections when teleporting quantum critical states between two different labs.

Ewold Verhagen, Center for Nanophotonics, AMOLF

IT

Programmable non-Hermiticity and nonlinearity in optomechanical networks

We study networks of nanomechanical resonators that are induced and controlled through radiation pressure interactions. In a multimode on-chip nano-optomechanical system, temporal modulation of the optical spring effect introduces mechanical hopping and squeezing interactions - allowing full programming of quadratic bosonic Hamiltonians describing the collective mechanical states and dynamics of the system. We use these principles to demonstrate Hermitian and non-Hermitian topological states in the network, including the quantum Hall effect and bosonic Kitaev chain. Studying thermal fluctuations, we show that nonreciprocity in the networks can enhance the efficiency of refrigeration mechanisms in the networks. Moreover, we show that the nonlinearity of the spring effect means that this platform allows programming of nonlinear mechanical interactions, that are appreciable at the level of thermal fluctuations. This enables fundamental studies of nonlinear functionalities such as computing in nonlinear networks. As a proof of concept, we demonstrate optomechanically induced nanomechanical digital logic gates.

Tong Wang, Max Planck Institute for the Science of Light

CT

Non-Hermitian physics at ferromagnet-topological semimetal junctions

Non-Hermitian systems host an abundance of unique features such as the exceptional point, topology of the complex spectra, and non-Hermitian skin effect. They extend beyond the framework of Hermitian quantum mechanics and allow for the description of open systems with loss and gain. The study of non-Hermitian physics leads to an enrichment of topological phases of matter and practical applications in photonics and sensing. Here we study the junction of a metallic ferromagnet and a Z2 Weyl semimetal [1], where a combined time-reversal symmetry and reflection symmetry leads to degenerate helical Fermi arcs on its surface. The couplings at the material interface give arise to a complex self-energy in the Green's function [2], rendering the effective Hamiltonian of the Fermi arc surface states non-Hermitian. We show that non-Hermiticity can break a degenerate Fermi arc into two pairs of exceptional point, and the resulting exceptional phase persists for a wide parameter range regarding the magnetization of the ferromagnet and topological mass term of the semimetal. We also discuss the how the exceptional points may influence the transport properties of the Z2 Weyl semimetal.

[1] T. Morimoto and A. Furusaki, Phys. Rev. B 89 235127 (2014).
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IT

Harnessing Nonreciprocity in Open Quantum Systems

TBD

Cheyne Weis, University of Chicago CT

Nonreciprocal Phase Transitions in Multipopulation systems

Non-reciprocal interactions are prevalent in various complex systems leading to phenomena that cannot be described by traditional equilibrium statistical physics. Although non-reciprocally interacting systems composed of two populations have been closely studied, the physics of non-reciprocal systems with a general number of populations is not well explored despite the potential relevance to biological systems, active matter, and dissipative quantum materials. In this work, we investigate the generic features of the phases and phase transitions that emerge in O(2) symmetric many-body systems with multiple non-reciprocally coupled populations. Using symmetry and topology of the possible orbits, we systematically show that a rich variety of time-dependent phases and phase transitions arise. Examples include multipopulation chiral phases that are distinct from their two-population counterparts that emerge via a phase transition characterized by critical exceptional points, as well as limit cycle saddle-node bifurcation and Hopf bifurcation. Interestingly, we find a phase transition that dynamically restores a discrete symmetry occurs via a homoclinic orbit bifurcation, where the two symmetry broken orbits merge at the phase transition point, providing a general route to homoclinic chaos in the order parameter dynamics for N>3 populations. The results contribute to the understanding of the novel collective behavior and provide formalism for classifying dynamic phases and their transitions in systems driven by non-reciprocal interactions.

Kazuki Yamamoto, Institute of Science Tokyo CT

Measurement-induced crossover of quantum jump statistics in postselection-free many-body dynamics

We reveal a nontrivial crossover of subsystem fluctuations of quantum jumps in continuously monitored many-body systems, which have a trivial maximally mixed state as a steady-state density matrix. While the fluctuations exhibit the standard volume law $\propto L$ following Poissonian statistics for sufficiently weak measurement strength, anomalous yet universal scaling law $\propto L^{\alpha}(\alpha \sim 2.7)$ indicating super-Poissonian statistics appears for strong measurement strength. This drastically affects the precision of estimating the rate of quantum jumps: for strong (weak) measurement, the estimation uncertainty is enhanced (suppressed) as the system size increases. We demonstrate that the anomalous scaling of the subsystem fluctuation originates from an integrated many-body autocorrelation function and that the transient dynamics contributes to the scaling law rather than the Liouvillian gap. The measurement-induced crossover is accessed only from the postselection-free information obtained from the time and the position of quantum jumps and can be tested in ultracold atom experiments.

Reference: K. Yamamoto and R. Hamazaki, arXiv:2503.02418

Shu Zhang, Okinawa Institute of Science and Technology Graduate University CT

Non-Hermitian and Liouvillian skin effects in magnetic systems

The non-Hermitian skin effect (NHSE) has emerged as a hallmark of non-Hermitian physics, with far-reaching implications for transport, topology, and sensing. While recent works have uncovered the NHSE in magnetic systems, these analyses rely on effective non-Hermitian Hamiltonians, thereby leaving open critical questions regarding their applicability and predictive power in experimentally feasible platforms. Here, we address this gap by exploring both the non-Hermitian and Liouvillian dynamics of a spin chain coupled to a shared bosonic reservoir. We identify the parameter regime in which these frameworks yield congruent predictions, while showing that the non-Hermitian approach fails to capture essential dynamical features – such as relevant timescales and conditions for experimental observability. Our analysis also reveals that the NHSE stems from the interplay between chiral spin couplings and reciprocal nonlocal dissipation–two interactions that can naturally occur in magnetic crystals and be easily engineered in magnetic heterostructures. Focusing on a concrete example of such heterostructures, we establish an explicit connection between their Landau-Lifshitz-Gilbert (LLG) dynamics and our microscopic model, providing a tangible route toward realizing the NHSE in an experimentally relevant spintronics setup.

Marko Žnidarič, University of Ljubljana IT

The joys and dangers of non-unitarity in many-body unitary dynamics

I will show how an effective non-unitary description emerges out of unitary dynamics. Non-unitarity will allow us to study the asymptotic relaxation of correlation functions, treating integrable as well as chaotic systems. Sometimes, for instance in random circuits, one though gets strongly non-normal matrices for which one should not rely on the spectral gap but rather look at the pseudospectrum.

Posters Abstracts

Pietro Borchia, University of Vienna

Relaxation Dynamics in the Non-Reciprocal Hatsugai–Kohmoto Model

Hatsugai-Kohmoto interactions have recently attracted significant attention for their exact solvability in momentum space within closed systems. Here, we extend this paradigm to open quantum systems by investigating a 1D lattice model featuring Hatsugai-Kohmoto interactions, supplemented with incoherent loss and gain. We establish the exact solvability of this system and we show that introducing non-reciprocity qualitatively reshapes both the propagation and decay dynamics. We provide compact analytic expressions and real-space diagnostics that quantify directional attenuation and interaction-tuned relaxation under periodic boundary conditions, establishing a minimal, exactly solvable platform for interaction-driven, non-reciprocal many-body dynamics.

Silvia Casulleras, University of Palermo

Long-distance entanglement via local squeezing in coupled cavity arrays

We investigate a tight-binding model of coupled photonic cavities with local single-mode squeezing. Squeezing generates localized modes below the continuum band, with detuning from the band increasing with squeezing strength. When applied to two separated cavities, squeezing induces long-distance entanglement across the array. The entanglement is maximized when the localized-mode frequencies approach the band edge and satisfy a critical condition, highlighting a nontrivial interplay between squeezing, dissipation, and band structure in engineered photonic systems.

Niladri Chakraborty, Max Planck Institute for the Science of Light

Enhanced Entanglement through Non-Hermitian Topology

Non-Hermitian topology has been connected to fascinating phenomena such as directional amplification - the selective amplification of signals in only one direction. While so far, most studies have revolved around classical effects, current experimental capabilities are reaching a level of control that will enable the exploration of quantum phenomena in non-Hermitian systems. In this work, we study entanglement in phase preserving directional amplifiers with non-Hermitian topology. In that case, two-mode squeezing interactions in the Hamiltonian lead to the creation of entangled pairs of neighbouring output modes. We reveal that while non-reciprocity slightly increases the entanglement in the end pairs of a chain, non-trivial non-Hermitian topology significantly enhances the entanglement in these end pair. This work is relevant for a range of experimental platforms including cavity optomechanics, superconducting circuits, and BEC lattices.

Nilanjana Chanda, School of Physics, Trinity College Dublin, The University of Dublin, Ireland
On the formulation of fourth- and sixth-order time-local generators in spin-phonon relaxation theory

Molecules having unpaired electrons exhibit magnetic properties by virtue of their spin magnetic moment and are known as magnetic molecules. The electron spin of the magnetic molecules placed in an external magnetic field leads to Zeeman splitting, enabling the molecular spin system to be treated as a qubit. The electron spin involves in exchanging energy with the vibrational modes of the molecule (phonons) which causes the spin system to relax to the thermal equilibrium state. Spin-phonon relaxation is a major challenge in the development of quantum technologies. A standard practice in the open quantum systems theory is to follow a weak-coupling approximation where the spin-phonon interaction is treated perturbatively. In this work, we develop a new theory of spin-phonon relaxation using fourth-order perturbation and formulate a quantum master equation that is local in time. The generator of the quantum master equation is expanded in a perturbative series. We incorporate all possible combinations of propagators that lead to the complete fourth-order generator. This fourth-order master equation can explain the two-phonon processes as observed in Raman relaxation. Furthermore, we extend the theory to the sixth order adopting the T-matrix formalism to express the superoperator more concisely. The sixth-order theory explains the three-phonon processes. We further study the temperature dependence of the spin-phonon relaxation time in the three-phonon processes. Since the phonon population increases exponentially with temperature, spin-phonon relaxation needs to be minimized in the high-temperature regime. Therefore, achieving long spin-phonon relaxation time in the high-temperature limit would allow to make use of molecular quantum devices and sensing technologies functioning at temperatures well above the cryogenic limit. Our results indicate that the three-phonon contributions to spin relaxation become relevant only at very high temperature, thus providing unprecedented evidence for the validity of the weak spin-phonon coupling assumption in molecular systems and paving the way for its study in other open quantum systems.

Enrico Di Benedetto, University of Palermo
Emergent cavity-QED dynamics along the edge of a photonic lattice

Flat bands (FBs) are dispersionless energy bands that can arise from topology or destructive interference. A notable example appears in topological semimetals such as graphene with zigzag edges, where surface modes form a partial FB defined only over a restricted region of the Brillouin zone. We investigate the coupling of qubits to the boundary of honeycomb lattices, including photonic realizations, where such flat edge modes naturally emerge. The qubit dynamics can be effectively captured by a dissipative cavity-QED model, featuring a fictitious mode that arises as a superposition of edge states localized on a single sublattice. This mode exhibits unconventional power-law localization, remaining normalizable in the thermodynamic limit while allowing its spatial range to be tuned via lattice anisotropy. Consequently, one predicts vacuum Rabi oscillations, long-range coherent state transfer, and power-law dispersive mediated interactions. These findings can be explored through implementations in superconducting circuits.

Giovanni Di Fresco, SISSA

From No-Click to Lindblad: Measurement-Induced Phase Transitions with Imperfect Detectors

Out-of-equilibrium closed systems undergo very interesting physical phenomena such as thermalization, transport, and entanglement properties. Recently, a lot of attention has been given to these systems in situations where unitary dynamics are alternated with measurements. This is particularly due to measurement-induced phase transitions (MIPT), where the interplay between measurement and unitary dynamics gives rise to different non-equilibrium phases characterized by distinct entanglement structures. In this work, we investigate whether signatures of MIPT persist under partial post-selection, i.e., averaging over a subset of trajectories as opposed to the full ensemble. Conceptually, this corresponds to retaining only partial information about the measurement outcome. Here, we introduce a Liouvillian model that interpolates between the full post-selected scenario, i.e., the so-called no-click limit, and the Lindbladian model. We examine the steady state of a continuously monitored fermionic Kitaev chain, characterizing its correlation and entanglement properties across the whole phase diagram.

Christopher Ekman, Stockholm University

Exactly solvable dissipative perturbations of Luttinger liquids

In the last few decades one-dimensional dissipative many-body systems have grown increasingly experimentally relevant, in particular in highly tunable cold atom systems. In the non-dissipative case, a great many exact solutions of such systems are available, using tools such as the Bethe ansatz and bosonization. However, in dissipative models such exact solutions remain largely unexplored. In this work, we construct and solve exactly a large class of strictly relevant Lindbladian perturbations of Luttinger liquids which arise when the environment causes particles to be lost from or introduced to the system. This allows us to study the interplay between interactions and dissipation in a widely applicable, but nonetheless exactly solvable setting.

Clement Fortin, McGill University

Rigorous correspondence between spectral winding number and localization in fully disordered Hatano-Nelson chains

For a few years, the topological origin of skin states in translation-invariant non-Hermitian systems has been established. Yet, a rigorous extension to disordered systems has remained elusive. In this work, we develop a comprehensive topological framework for fully general Hatano-Nelson chains with disordered complex-valued potentials and nearest-neighbor hopping, formulated with the Lyapunov exponent. Our approach unifies the theory of non-Hermitian Anderson localization with topologically protected directional amplification, thereby extending the bulk-boundary correspondence to a broad class of one-dimensional non-Hermitian systems. Our work opens new directions for disorder-resilient transport and sensing in photonic, optomechanical and superconducting platforms.

Alejandro Gómez, Universidad Autónoma de Madrid

Dynamical Signatures of Topological Flow Transitions in Self-Oscillatory Quantum States

Quantum non-equilibrium phases with broken time-translation symmetry are ubiquitous. In classical settings, they often display coexisting limit cycles and steady states, which undergo abrupt reorganizations of stability and connectivity in phase space. Their quantum counterparts appear only in softened form due to density matrix averaging, and the fact standard Liouvillian (evolution generator) diagnostics emphasize the steady state even though the decisive changes unfold in the transient flow. We introduce a topological invariant that captures the phase-space connectivity generated by both fixed points and limit cycles and links it directly to the open quantum dynamics. Distinct flow patterns define distinct phases, and transitions appear as sharp changes in the invariant. We demonstrate that our invariant (i) reveals flow-topological constraints that limit when Liouvillian degeneracies can occur and (ii) and exposes transitions the Liouvillian spectrum misses altogether, related to global flow-topology transitions.

Alex Hanrath, AMOLF

Optomechanical platform for programmable non-Hermitian and nonlinear resonator networks

Non-Hermitian and nonlinear Hamiltonians give rise to rich phenomena that differ fundamentally from Hermitian and linear counterparts. A broad range of physical systems exist that allow engineering of such Hamiltonians. We develop multimode optomechanical resonators in which networks of nanomechanical resonators can be programmed using laser drives. Engineered silicon nanostructures host a spectrum of mechanical modes coupled strongly to a high-quality optical nanocavity. Various types of linear, nonlinear, and non-Hermitian (parametric) couplings between the modes can be achieved by time modulation of the drive laser. We show that this enables experimental programming of Hamiltonians, and strong control over the network dynamics. This allows for example the realization and characterization of novel topological phases. Moreover, we can leverage and control the intrinsic optomechanical nonlinearity – important for many functionalities. We explore how such networks can be optimized for specific functionalities, such as sensing and (mode-locked) acoustic lasing. We seek to identify how the performance of optimized networks relates to their structure and physical resources, including symmetries, topology, gain, and nonlinearity.

Niklas Hörnedal, University of Luxembourg

Exploring the topology of a non-Hermitian superconducting qubit using shortcuts to adiabaticity

Open quantum systems described by a non-Hermitian Hamiltonian exhibit rich dynamics due to the topology of their complex energy spectrum. By encircling an exceptional point degeneracy, this topology allows for topological state transport, chiral geometric phases, and eigenvalue braiding. To access these topological features, it is desirable to drive the system adiabatically. However, adiabatic transport in a system with complex spectrum is conventionally only possible for the eigenstate whose eigenenergy has the lowest loss. Previous experiments have demonstrated such adiabatic evolution for the quantum state with relative gain, yet observed a breakdown in adiabaticity for quantum states with relative loss. In this work, we harness a shortcut to adiabaticity – counterdiabatic driving – to avoid the effects of loss while maintaining trajectories that follow the instantaneous eigenstates in significantly shorter timescales. We experimentally investigate the robustness of this control method using a superconducting transmon circuit with engineered dissipation. We observe that counterdiabatic driving stabilizes quasistatic transport and preserves the complex energy spectrum's topology.

Yumin Hu, Max Planck Institute for the Physics of Complex Systems

Asymptotic Exceptional Steady States in Dissipative Dynamics

Spectral degeneracies in Liouvillian generators of dissipative dynamics generically occur as exceptional points, where the corresponding non-Hermitian operator becomes non-diagonalizable. Steady states, i.e. zero-modes of Liouvillians, are considered a fundamental exception to this rule since a no-go theorem excludes non-diagonalizable degeneracies there. Here, we demonstrate that the crucial issue of diverging timescales in dissipative state preparation is largely tantamount to an asymptotic approach towards the forbidden scenario of an exceptional steady state in the thermodynamic limit. With case studies ranging from NP-complete satisfiability problems encoded in a quantum master equation to the dissipative preparation of a symmetry protected topological phase, we reveal the close relation between the computational complexity of the problem at hand, and the finite size scaling towards the exceptional steady state, exemplifying both exponential and polynomial scaling. Formally treating the weight W of quantum jumps in the Lindblad master equation as a parameter, we show that exceptional steady states at the physical value W=1 may be understood as a critical point hallmarking the onset of dynamical instability.

Jimin Li , University of Cambridge

Scattering States in One-Dimensional Non-Hermitian Baths

A single quantum emitter coupled to a structured non-Hermitian environment shows anomalous bound states and real-time dynamics without Hermitian counterparts, as shown in [Gong et al., Phys. Rev. Lett. 129, 223601 (2022)]. In this work, we establish a general approach for studying the scattering states of a single quantum emitter coupled to one-dimensional non-Hermitian single-band baths. We formally solve the exact eigenvalue equation for all the scattering states defined on finite periodic lattices. In the thermodynamic limit, the formal solution reduces to the celebrated Lippmann-Schwinger equation for generic baths. In this case, we find that the scattering states are no longer linear superpositions of plane waves in general, unlike those in Hermitian systems; Instead, the wave functions exhibit a large, yet finite localization length proportional to the lattice size. Furthermore, we show and discuss the cases where the Lippmann-Schwinger equation breaks down. We find the analytical solutions for the Hatano-Nelson and unidirectional next-to-nearest-neighbor baths in the thermodynamic limit.

ZhiXing Lin, Princeton University

Chiral instabilities in driven-dissipative quantum liquids

We investigate the nonequilibrium dynamics of periodically driven Tomonaga-Luttinger liquids (TLLs) coupled to a thermal bath using a Floquet-Lindblad approach. When the coupling to the bath satisfies detailed balance, we obtain a condition for parametric instabilities to be suppressed, symmetrically for both chiralities. Remarkably, by designing a purely chiral coupling to the bath, instead of instability suppression, we uncover a driven-dissipative phase transition between the former symmetric parametric instability and a new chiral parametric instability. In the latter, a single chirality of bosonic quasiparticles gets exponentially amplified, leading to a dynamical chiral imbalance within the TLL, reminiscent of the non-Hermitian skin effect.

Maika Matogawa, Waseda University

Numerical Investigation of Transitions in Nonlinear Dynamical Behaviors for a Non-Orthogonal Mode Pair in an Asymmetric Two-Dimensional Microcavity Laser Near an Exceptional Point

Proximity to an exceptional point can strongly influence nonlinear interactions between nearly degenerate modes in two-dimensional microcavity lasers. In this work, we numerically examine how variations of cavity parameters modify the competitive dynamics between a non-orthogonal mode pair in an asymmetric two-dimensional microcavity. Instead of varying the external pumping power [1], we focus on how changes in cavity parameters and the resulting properties of eigenfrequencies and eigenmodes of a passive microcavity near an exceptional point influence the nonlinear dynamical behavior. The numerical simulations are performed by solving the full Maxwell-Bloch (MB) equations for two-dimensional microcavities. We present fixed points and trajectories in the MB-variable space corresponding to locked states and limit-cycle oscillations [2]. A bistable region between these two regimes is identified in the cavity parameter space including the Exceptional Point. A methodology for analytically investigating lasing dynamics using only quantities of the passive microcavity is presented [3,4]. Joint work with Jung-Wan Ryu and Takahisa Harayama.

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Apollonas S. Matsoukas-Roubeas, University of Cambridge

Disorder-induced transitions in analog quantum processors

We investigate how the distribution of programmable local Hamiltonian parameters influences the collective behavior of commercially available neutral atom arrays. When interatomic interactions are sufficiently strong and disorder is low, energy eigenvalues display spectral signatures of random-matrix correlations, the entanglement entropy of initial states grows ballistically with time, and the subsystem entropy of excited states obeys volume-law scaling. In contrast, at high disorder, eigenstates become effectively uncorrelated, the entanglement entropy of initial states grows logarithmically, and the entanglement entropy of excited states follows an area law. To observe this transition experimentally, we introduce a pulse-sequence protocol that implements randomized measurements without local control, enabling direct estimation of the survival probability of accessible initial states and the second Rényi entropy of subsystems.

Juan Diego Mazo Vasquez, Max Planck Institute for the Science of Light

Bifurcations and Exceptional Features in Kerr Ring and Fabry–Pérot Resonators

This work presents an approach for studying the bifurcations of the stationary state solutions in Kerr ring resonators, where nonlinear effects give rise to complex behavior. By establishing a mapping between the nonlinear system and a corresponding linear non-Hermitian system, we characterize the bifurcations as exceptional points. Our approach, based in nonlinear algebra, provides a powerful tool for analyzing the behavior of these systems and elucidates the role of exceptional points in nonlinear optical phenomena. The results of this study contribute to a deeper understanding of the interplay between nonlinearity and symmetry in optical systems, with potential implications for the design and operation of nonlinear optical devices.

Konstantinos Panagiotis Rompotis, AMOLF

Testing sensitivity enhancement in multimode nanomechanical resonator networks through optomechanical implementation of the bosonic Kitaev chain

We investigate the sensing performance of a laser-driven nanomechanical resonator network, comprised of sliced nanobeams which are coupled through radiation pressure. Our non-Hermitian system features multiple mechanical modes, each exhibiting large phonon-photon coupling rates. By dynamically modulating the optical spring effect at the mechanical frequency differences (sums) we implement beam-splitter (two-mode squeezing) interactions, which are necessary properties to experimentally realize the Bosonic Kitaev Chain. Implementing the latter mechanism enables us to achieve parametric directional amplification of the input signal and breaking of reciprocity for a specific quadrature while the orthogonal quadrature experiences amplification in the opposite direction. By converting quadrature, a small perturbation on the last resonator produces a large response that scales exponentially with the chain length. We seek to test whether the signal to noise ratio gets exponentially enhanced with the number of resonators, as predicted from theory, for either thermal or quantum noise sources in the driven chain. We report our experimental progress on these efforts in room-temperature and cryogenic environments. The simultaneous parametric signal gain and the suppression of noise in the system makes it a promising platform for quantum metrology.

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Dissipative spectral form factor for elliptic Ginibre unitary ensemble and applications

The dissipative spectral form factor (DSFF) has recently emerged as a diagnostic for quantum chaos in non-Hermitian systems. We investigate the elliptic Ginibre unitary ensemble (eGinUE), which interpolates between the non-Hermitian Ginibre unitary ensemble (GinUE) and the Hermitian Gaussian unitary ensemble (GUE) via a symmetry breaking parameter. We derive exact finite-dimensional expressions and large-dimension approximations for the DSFF of eGinUE. We uncover a compelling scaling relationship that links the DSFF of eGinUE to the DSFF of GinUE and the spectral form factor (SFF) of GUE. The DSFF of eGinUE exhibits a dip-ramp-plateau structure across the GinUE, GUE, and crossover regimes, with time scale differences well-explained by the scaling relation. Additionally, we refine estimates of dip-ramp and ramp-plateau transition times for different symmetry regimes. Our analytical results are validated through Monte Carlo simulations of the eGinUE random matrix model. We further demonstrate application of our finding to the crossover Sachdev-Ye-Kitaev model and crossover Power-Law Banded random matrices. Finally, we discuss an analogy between the eigenvalue correlations of eGinUE and the positions of a rotating fermionic gas in a two-dimensional anisotropic trap. (arxiv: 2407.17148)

Waranon Sroyngoen, University of Kaiserslautern-Landau
Breathing soliton as a non-Markovian open system

We study the collective modes of an atomic bright soliton realised in a quasi-one-dimensional Bose-Einstein condensate, using Bogoliubov-de Gennes theory. In particular we focus on the breathing mode of the soliton, which is not a single linearized normal mode but a common component of many modes, and therefore decays within a $t^{-1/2}$ envelope due to dispersion. If the soliton is held in the center of a harmonic trap, we show that the breathing amplitude revives periodically, as atoms shed from the vibrating soliton oscillate in the trap, and return. After each revival the breathing amplitude again decays, and this cycle repeats every trap half-period. The evolution, however, is non-trivial; instead of producing a similar copy of its past evolution, like other linear oscillator systems, it exhibits a distinct pattern. The evolution of the soliton is different in the next period. This implies a non-Markovian nature of the system. In each subsequence period, the evolution becomes more different. We explain the pattern by deriving a close analytical approximation to the Bogoliubov-de Gennes frequency spectrum, and offer this coherent Bogoliubov-de Gennes phenomenon as a background against which to compare possible quantum many-body effects, including decoherence over trap-period time scales.

Margherita Valenza, Max Planck Institute for the Science of Light

Interacting bosonic system

The collective behaviour of many-body systems is one of the main interests of contemporary quantum physics, particularly within the frameworks of nonlinear optics and Bose–Einstein condensate. From the perspective of open quantum system, studying the interplay between coherent and incoherent interactions can create robust quantum resources and new phases of matter can arise as a consequence of the non trivial behaviour of the steady state [1]. Additionally, it is possible to study incoherent transport in bosonic systems [2] and characterise the emergence of non-Hermitian topology in presence of non-linear interaction [3]. In this scenario, interacting bosonic systems can be analysed as non-equilibrium open systems involving active motion of particles in non linear platforms, and since the number of particle is preserved, the Louvillian exhibits a strong U(1) symmetry, which simplifies the definition of steady-state phase transitions.

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Fan Yang, Stockholm University

Quantum dynamical signatures of non-Hermitian boundary modes

The non-Hermitian bulk-boundary correspondence features an interplay between the non-Hermitian skin effect and anomalous boundary-mode behavior. Whereas the skin effect is known to manifest itself in quantum dynamics in the form of chiral damping, it has remained less clear what impact the boundary modes may have. Here we derive experimentally accessible signatures of the boundary modes. We also establish clear criteria, based on the effective generalized Brillouin zone, that determine when bulk and boundary effects can be dynamically discerned using the Liouvillian separation gap. This leads to telltale signatures in both stable regimes – where particle number remains finite – and in the unstable regimes – where a macroscopic boundary mode population occurs.

Mengjie Yang, National University of Singapore

Percolation-induced $\mathcal{PT}$ symmetry breaking

We propose a new avenue in which percolation, which has been much associated with critical phase transitions, can also dictate the asymptotic dynamics of non-Hermitian systems by breaking PT symmetry. Central to it is our newly-designed mechanism of topologically guided gain, where chiral edge wavepackets in a topological system experience non-Hermitian gain or loss based on how they are topologically steered. For sufficiently wide topological islands, this leads to irreversible growth due to positive feedback from interlayer tunneling. As such, a percolation transition that merges small topological islands into larger ones also drives the edge spectrum across a real to complex transition. Our discovery showcases intriguing dynamical consequences from the triple interplay of chiral topology, directed gain and interlayer tunneling, and suggests new routes for the topology to be harnessed in the control of feedback systems.

Zhao Zhang, University of Oslo

Three-local conserved charge implies quantum integrability

It is shown that the conservation of a local charge supported by three neighboring sites, or its local version, Reshetikhin's condition, suffices to guarantee the existence of all higher conserved charges and hence the integrability of a quantum spin chain. This establishes Grabowski and Mathieu's long-standing conjecture as a theorem, ending the folklore that the existence of higher conserved charges imposes additional constraints not implied by the conservation of the three-local charge.

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