NICENESP

26-29th May 2026

Classical and quantum non-equilibrium statistical physics in Nice.

Programme Day 1

Tuesday, 26th May

09:00-09:30 Registration and opening

09:30-10:20 **Andrea Gambassi** (SISSA, Trieste)

Title: *Transport of bosons and fermions in 1D: a unified picture*

Abstract: In this talk, I discuss the dissipative transport of bosons and fermions on a one-dimensional lattice, where particle hopping is mediated by coupling to a Markovian reservoir. In the bosonic case, the resulting dynamics is described by the classical asymmetric inclusion process (ASIP), in contrast to the asymmetric exclusion process (ASEP) which describes fermionic transport. Despite this fundamental difference, current fluctuations in the two cases exhibit strikingly similar behavior at large scales, although their full counting statistics remain distinct. By mapping both dynamics onto fluctuating interface models, we show that they actually fall within the Kardar–Parisi–Zhang universality class, with bosonic transport corresponding to surface growth and fermionic transport to erosion. This unified framework clarifies both similarities and differences between the two cases, with potential relevance for cold atoms and nanophotonic platforms.

10:20-11:00 Coffee break

11:00-11:30 **Julien Brémont** (Collège de France, Paris)

Title: *Beyond Poisson: First-passage asymptotics of renewal shot noise*

Abstract: The first-passage time (FPT) of a stochastic signal to a threshold is a fundamental observable across physics, biology, and finance. While renewal shot noise is a canonical model for such signals, analytical results for its FPT have remained confined to the Poisson (Markovian) case, even though non-Poisson arrival statistics are common in out-of-equilibrium systems from neuronal spiking to gene expression. Here, we overcome this long-standing limitation by deriving a universal asymptotic formula for the mean FPT $\langle T_b \rangle$ to reach level b for renewal shot noise with arbitrary arrival statistics and exponential marks. Our central result is a simple, closed-form expression that exposes the physical mechanism by which temporal correlations in arrivals modulate the baseline Arrhenius law. We show that bursty arrivals introduce universal scaling corrections that markedly accelerate threshold crossings. In turn, non-bursty arrivals remain Arrhenius-like, directly linking temporal burstiness to Arrhenius scaling. Furthermore, we show and confirm numerically that the full FPT distribution becomes exponential at large thresholds, implying that $\langle T_b \rangle$ provides a complete asymptotic characterization. Our work, enabled by a novel exact expression for the moments of the noise, establishes a general framework for analyzing extreme events in non-Markovian systems with relaxation.

Ref : https://doi.org/10.1103/bbh8-n8dt.

11:30-12:00 **François Damanet** (University of Liège)

Title: *Dissipation engineering of correlations and criticality in 1D systems with structured reservoirs*

Abstract: I will present two recent results on dissipative engineering of correlations in 1D systems. First, I will present in which conditions local dephasing coming from structured environments can lead to the stabilization of long-range order in the Hubbard model in 1D [1], extending the results of [2] to structured reservoirs. Second, I will show how temporal correlations associated with the memory of local environments acting on each site of a simple classical Ising model can be transformed very generically into spatial correlations in the chain but also be used to generate criticality [3], highlighting the interest of dissipation to turn a trivial Hamiltonian into a more complex system.

References:
[1] S. Neri, F. Damanet, A. J. Daley, M. L. Chiofalo, and J. Yago Malo, "Dissipation engineering of fermionic long-range order beyond Lindblad", Accepted in Physical Review B (2026). doi:10.48550/arXiv.2507.00553;
[2] J. Tindall, B. Buca, J. R. Coulthard, and D. Jaksch, "Heating-Induced Long-Range η-Pairing in the Hubbard Model", Physical Review Letters 123, 030603 (2019). doi:10.1103/PhysRevLett.123.030603;
[3] B. Debecker, P. Westhoff, S. Paeckel, J. Martin, M. Moroder, and F. Damanet, "Dissipation engineering in structured reservoirs: transforming bath memory into spatial correlations", in preparation.

12:00-12:30 **Iman Abdoli** (Heinrich Heine University, Düsseldorf)

Title: *Brownian gyrators: from mono-to-quadrupolar gyration*

Abstract: Thermally anisotropic Brownian systems-where different spatial directions are coupled to different effective temperatures-break detailed balance and generate circulating probability currents, exemplified by the Brownian gyrator. Such systems provide a minimal framework for studying nonequilibrium energy conversion and the emergence of directed motion and torques driven purely by fluctuations. We demonstrate how these anisotropic fluctuations can be harnessed as a microscopic heat engine, whose efficiency can approach Carnot performance at maximum power when appropriately loaded with external mechanical forces [1]. Furthermore, we show that confining a thermally anisotropic particle to a narrow ring produces quadrupolar steady-state gyration, a symmetry-protected circulation pattern arising solely from anisotropic noise [2]. These results highlight the rich flux structures and energetic functionalities enabled by thermal anisotropy.

[1] I Abdoli, A Sharma, H Löwen, Phys. Fluids. 37 (4)-2025
[2] I Abdoli, H Löwen, npj Soft Matter 2 (1), 5-2026

12:30-14:30 Lunch break

14:30-15:20 **Juan P. Garrahan** (University of Nottingham)

Title: *Generating quantum ensembles via quantum diffusion models*

Abstract: I will describe a theoretical framework for sampling from ensembles of quantum states that generalises classical generative diffusion models. In analogy with the classical case, starting from a fully quantum noising dynamics which transforms data samples into noise, I will show how to derive a quantum trajectory-based denoising dynamics which transforms noise into new samples of the quantum ensemble of interest. I will discuss similarities and differences with classical diffusion models, and more broadly connect to ideas about rare events.

15:20-16:00 Coffee break

16:00-16:50 **Aurélien Grabsch** (LPTMC, Paris)

Title: *Dynamical correlations in diffusive interacting particle systems*

Abstract: In this talk, I will review recent results obtained on dynamical correlations in the symmetric simple exclusion process (SSEP) and other models of 1D diffusive systems. At large scales, these models can be studied within the framework of macroscopic fluctuation theory (MFT).
For a few models, like the SSEP, the MFT equations are classically integrable and can be solved to obtain exact results. However for most systems this is not the case. Nevertheless, exact results can still be obtained in this case and applied to realistic models of interacting particles.

16:50-17:20 **Jitendra Kethepalli** (Cergy-Paris University)

Title: *Ballistic macroscopic fluctuation theory via mapping to point particles*

Abstract: In this talk, we discuss the recently developed Ballistic Macroscopic Fluctuation Theory (BMFT). It is a framework for describing how initial fluctuations in

ballistic systems propagate through Euler-scale hydrodynamics and how correlations between hydrodynamic variables like conserved densities and currents evolve. We outline the main ideas of BMFT and contrast it with the Macroscopic Fluctuation Theory (MFT) used for diffusive systems. The talk focuses on applying BMFT to integrable models, whose many conserved quantities give rise to generalised hydrodynamics (GHD). Recent work shows that Euler-scale GHD can be mapped to the hydrodynamics of effectively non-interacting particles. In certain cases, such as hard rods and the Toda model, this correspondence has been proven to hold microscopically, and one expects such a mapping to hold for generic integrable models. We illustrate this mapping through classical and quantum examples and present our BMFT approach based on this effective non-interacting description. We demonstrate the method using observables such as particle currents in generic integrable models and the rank (ordering) of particle positions in the hard-rod system.

Programme Day 2

Wednesday, 27th May

09:30-10:20 **Fabian Essler** (Oxford University)

Title: *Dissipative dynamics with decoupled Bogoliubov hierarchies*

Abstract: I consider a class of spinless-fermion Lindblad equations and dissipative quantum circuits that exhibit decoupled BBGKY hierarchies. In the cases where particle number is conserved, their late time behaviour is characterized by diffusive dynamics, leading to an infinite temperature steady state. Some of these models are Yang-Baxter integrable, others are not. The simple structure of the BBGKY hierarchy makes it possible to map the dynamics of Heisenberg-picture operators on few-body imaginary-time Schrödinger equations with non-Hermitian Hamiltonians. We use this formulation to obtain exact hydrodynamic projections of operators quadratic in fermions, and to determine linear response functions in Lindbladian non-equilibrium dynamics.

10:20-11:00 Coffee break

11:00-11:30 **Florent Ferro** (LPTMS, Paris)

Title: *Kicking quantum Fisher information out of equilibrium*

Abstract: We investigate the dynamics of symmetry-breaking states under both non-interacting [1] and interacting [2] Hamiltonians following a local quench. We show that such states exhibit a breakdown of clustering properties at ballistic scales, resulting in anomalously large fluctuations of extensive order parameters. Using the Quantum Fisher Information (QFI), we show that this setting is an ideal framework for the emergence of macroscopic quantum coherence. Specifically, we show that the breaking of clustering allows the system to develop coherence at scales proportional to the time after the quench. We confirm these results both through semi-classical descriptions and numerical methods leveraging the link between QFI and Skew information, which is easily accessible in non-interacting systems. Our findings presents this scenario as one of the most natural ways to develop cat-like states from product states through simple local interactions.

[1]: F Ferro and M Fagotti, arxiv.org/abs/2503.21905
[2]: F Ferro, arxiv.org/abs/2602.15969

11:30-12:00 **Rustem Sharipov** (University of Ljubljana)

Title: *New integrability structures of classical and quantum cellular automata Rule 54*

Abstract: The reversible cellular automaton Rule 54 (RCA 54) exhibits striking signatures of integrability, including stable solitons and elastic scattering. Nevertheless, a systematic structural formulation of its integrability has remained elusive. In this talk, I propose a new perspective on integrability in RCA 54. From the classical viewpoint, I introduce a mechanism that I call integrability by projection: interacting solitonic dynamics with nontrivial phase shifts emerge from a projection of SWAP dynamics. This provides a structural explanation for the observed factorized scattering. From the quantum perspective, I present a new duality linking Rule 54 to the integrable quantum Heisenberg spin chain, suggesting a deeper algebraic connection between classical reversible automata and quantum integrable systems.

12:00-12:30 **Alberto Brollo** (TU Munich)

Title: *Universal efficiency boost in prethermal quantum heat engines at negative temperature*

Abstract: Quantum heat engines lie at the intersection of quantum thermodynamics and non-equilibrium many-body physics. Technological advances in quantum platforms have motivated studies beyond canonical equlibrium. In this talk, I will discuss whether prethermalization enhances or reduces engine efficiency by investigating Otto cycles in quantum systems with varying numbers of conserved quantities. Additional conservation laws reduce efficiency at positive temperatures, but enhance it in regimes of negative temperatures. Our findings stem from general thermodynamic inequalities for infinitesimal cycles, and we provide evidence for integrable models undergoing finite cycles using Generalized Hydrodynamics. The relevance of our results for quantum simulators is also discussed, bridging theoretical advances in non-equilibrium physics of 1d systems with novel quantum devices. The talk is based on Nat. Commun. 16, 10593 (2025), joint work with Alvise Bastianello and Adolfo del Campo.

12:30-14:30 Lunch break

14:30-15:20 **Denis Bernard** (LPENS, Paris)

Title: *Toward a Quantum Mesoscopic Fluctuation Theory: Progress and Open Questions*

Abstract: Over the past two decades, the Macroscopic Fluctuation Theory (MFT) has provided a universal framework to deal with classical diffusive non-equilibrium systems. A natural question is whether this framework can be extended to quantum mechanics to capture the statistics of inherently quantum phenomena—such as interference and entanglement—in diffusive, out-of-equilibrium systems. In this talk, we first review key insights from model systems, including the Quantum Simple Symmetric Exclusion Process. We then present recent progress toward formulating a Quantum Mesoscopic Fluctuation Theory (QMFT) and conclude by outlining the open challenges and steps required to achieve a comprehensive theory.

15:20-16:00 Coffee break

16:00-16:50 **Michele Filippone** (CEA Grenoble)

Title: *Exact Description of Transport in Quantum Stochastic Resistors and Monitored Devices*

Abstract: Understanding the emergence of diffusion in quantum systems remains a challenging problem in theoretical physics. An extended class of models expected to exhibit diffusive behavior is given by Quantum Stochastic Hamiltonians (QSHs) [1], which describe lattice models affected by time- and space-dependent noise. However, the averaged dynamics of such models are governed by non-linear Lindblad equations, whose theoretical study usually relies on numerical methods or case-by-case solutions, with strong constraints on geometries and driving protocols. In this talk, I will present a systematic method to derive exact and analytical solutions for the stationary quantum transport of QSHs in arbitrary configurations [1,2]. For this workshop, I will put a particular emphasis on the importance of tools coming from the mesoscopic/quantum-transport community to tackle this problem [2,3]. Our solution is also based on an exact self-consistent Born scheme for diagrammatics in the Keldysh representation [4]. We show that most QSHs behave as diffusive "quantum stochastic resistors," whose properties are encoded in the Keldysh component of the single-particle Green's function. I will provide a semi-classical interpretation of such systems [5], and in particular, I will discuss how our exact solution demonstrates the validity of a new perturbation scheme in the inverse system size, named the 1/N expansion, to study out-of-equilibrium diffusive/ohmic

systems. I will conclude by discussing how our approach can be extended to describe quantum transport in continuously monitored settings. I will show that measurements trigger non-reciprocal currents in quantum devices, thus acting as a resource for power generation and quantum measurement cooling [6].

[1] T. Jin, J. S. Ferreira, M. Filippone, T. Giamarchi, Physical Review Research 4, 013109 (2022)
[2] T. Jin, M. Filippone, T. Giamarchi, Physical Review B 102, 205131 (2020)
[3] Y. Meir and N. S. Wingreen, Physical Review Letters 68, 2512 (1992)
[4] P. E. Dolgirev, J. Marino, D. Sels, E. Demler, Physical Review B 102, 100301 (2020)
[5] T. Jin, J. S. Ferreira, M. Filippone, T. Giamarchi, Physical Review Research 5, 013033 (2023)
[6] J. S. Ferreira, T. Jin, J. Mannhart, T. Giamarchi, M. Filippone, Physical Review Letters 132, 136301 (2024) – Editors' Suggestion.

16:50-17:20 **Ewan McCulloch** (LPENS, Paris)

Title: *Long-lived local quantum coherences from hydrodynamic large deviations*

Abstract: Generic chaotic quantum systems are often said to “act as their own bath”: initially local operators rapidly spread into complicated many-body operators, leaving only hydrodynamic conserved densities as slow degrees of freedom. I will discuss an important exception to this picture in one-dimensional diffusive systems with a conserved charge. A particle-creation operator $c^\dagger$ creates a local coherence between distinct charge sectors but has no direct hydrodynamic projection. Naively, one would therefore expect single-particle Green's functions $\langle c_x^\dagger(t)\ c_0(0)\rangle$ to decay exponentially. Instead, these coherences decay only subexponentially, by binding to rare hydrodynamic fluctuations: low-entropy charge voids.

To explain this, we develop a framework that incorporates the dynamics of local coherences into macroscopic fluctuation theory. The central result is a reduction of a formally quantum problem —computing the single-particle Green's function— to a classical problem of hydrodynamic large deviations. The dominant operator histories are those in which the coherence creates and propagates with a self-generated void, forming a collective coherence--void polaron. This framework predicts stretched-exponential decay and subdiffusive spacetime scaling of the Green's function. In the weak-noise setting, our framework predicts a spectral gap that vanishes nonperturbatively with the noise strength, ruling out conventional gapped Ruelle—Pollicott resonances even after projecting out hydrodynamic slow modes. We verify these results in $U(1)$-conserving random unitary circuits.

19:30

Social Dinner *

Hotel Le Saint Paul

** offered to all participants*

Programme Day 3

Thursday, 28th May

09:30-10:20 **Thierry Giamarchi** (University of Geneva)

Title: *Non-equilibrium physics by the way of reservoirs, Lindbladians and non-reciprocity*

Abstract: Systems coupled to reservoirs offer a rich way to create out of equilibrium situations. This can go from the possibility to transport charge [1] or entropy or energy [2] through some structure such as a quantum point contact or a quantum dot. Reservoirs are also an excellent way to model the loss of particles [3].
I will discuss such situations in this talk and compare with experimental realizations in cold atomic gases. I will also connect this physics with other ways of realizing out of equilibrium situations such as non-reciprocal (sometimes improperly called "non Hermitian") treatments [4].

[1] A.-M. Visuri, J. Mohan, S. Uchino, M.-Z. Huang, T. Esslinger, T. Giamarchi, ``DC transport in a dissipative superconducting quantum point contact'', Phys. Rev. Research 5, 033095 (2023).
[2] D. Bertolusso, C.J. Bolech, T. Giamarchi, ``Entropy transport through a superfluid quantum point contact: A Keldysh field-theory approach'', arXiv:2605.00679.
[3] T. Jin, M. Filippone, T. Giamarchi, ``Generic transport formula for a system driven by Markovian reservoirs'', Phys. Rev. B 102, 205131 (2020)
[4] C.J. Bolech, T. Giamarchi, ``Spontaneous emission as a bridge from Lindbladian to nonreciprocal reservoirs'', arXiv:2508.00689.

10:20-11:00 Coffee break

11:00-11:50 **Jacopo De Nardis** (Cergy-Paris Univ. & Collège de France, Paris)

Title: *Quantum-to-classical simulability transitions in noisy dynamics*

Abstract: Quantum advantage refers to the possibility of performing quantum operations

on a quantum computer that would be practically impossible to reproduce on a classical computer, whose memory resources scale only polynomially with the number of qubits. However, present-day quantum computers are affected by external noise, and in the absence of error correction this noise can drive transitions from genuinely quantum behavior, which is exponentially complex to simulate, to effectively classical behavior, which is only polynomially complex.
In this talk, I will present two distinct noise-induced transitions from quantum to classical simulability. First, I will show that any noisy quantum system with a noise rate above a finite threshold of order one becomes classically simulable via Monte Carlo sampling. Second, I will discuss how even a small noise rate of order 1/N is sufficient to make local operators efficiently simulable through Pauli-truncation schemes.

11:50-12:20 **Giovanni Zirilli** (INPHYNI, Nice)

Title: *Stochastic cascade dynamics and non-equilibrium universality in turbulence*

Abstract: Turbulence remains a paradigmatic example of a strongly non-equilibrium system, where energy is injected, transferred across scales, and dissipated in a statistically stationary yet intrinsically irreversible regime. Capturing such scale-to-scale dynamics within a tractable statistical framework remains a central challenge of non-equilibrium statistical physics. We introduce a stochastic cascade model defined on a dyadic grid, in which coarse-grained energy variables evolve according to a continuous-time Markov process with self-similar transition rates. The construction is directly rooted in the Kármán–Howarth–Monin–Hill equation, which expresses the conservation of velocity-increment energy across space and scale. Its discretization yields a minimal yet dynamically consistent representation of the turbulent energy cascade, amenable to efficient simulation via the Gillespie algorithm. Despite its simplicity, the model reproduces three hallmark features of fully developed turbulence: anomalous dissipation, spatial intermittency, and spontaneous stochasticity. In contrast to classical multiplicative cascade models, intermittency emerges here from the intrinsic stochastic dynamics rather than being imposed a priori. Under steady forcing, the system reaches a non-equilibrium stationary state characterized by non-Gaussian statistics and anomalous scaling of energy moments, reflecting a constant flux of conserved quantities across scales. At the analytical level, the master equation enables explicit predictions for the statistics of energy fluxes, in good agreement with numerical simulations. The stationary measure is well described by a log-divisible process, highlighting deep connections with multiplicative cascades while extending them to a dynamical, time-resolved setting. Furthermore, the fluctuating direction of energy transfers gives rise to backward propagation of uncertainties from small to large scales, providing a minimal framework to investigate spontaneous stochasticity as an emergent non-equilibrium phenomenon. This approach opens a route toward identifying universality classes of turbulent cascades within the broader context of non-equilibrium statistical mechanics. Perspectives include extensions to incorporate additional conserved quantities, coupling with particle dynamics, and connections with large-deviation theory and stochastic thermodynamics, with the aim of characterizing irreversibility and flux fluctuations in multiscale systems.

12:30-14:30 Lunch break

14:30-15:20 **Marko Znidaric** (University of Ljubljana)

Title: *Truncated propagator as a tool for many-body dynamics*

Abstract: I will describe the truncated operator propagator as a tool to study properties of many-body quantum systems. The leading eigenvalue and the associated eigenvector, a so-called Ruelle-Pollicott resonance, can be used to find conserved operators, including finding new integrable systems, efficiently study diffusion, or calculate the long timescales present under weak conservation-law breakdown. It also provides a many-body Kolmogorov cascade as an explanation of how chaos arises in quantum many-body lattice systems.

15:20-16:00 Coffee break

16:00-16:50 **Cristian Giardinà** (Università di Modena & Reggio Emilia)

Title: *The harmonic model and its non-equilibrium steady state*

Abstract: We introduce and discuss the “harmonic model”, an integrable Markov process (arising from the integrable XXX chain with non-compact spins) which describes heat conduction in interacting particle systems [1]. The model is closely related to the celebrated Kipnis-Marchioro-Presutti (KMP) process, which instead arises from the quadratic Casimir. In particular, the two models share an $\mathfrak{sl}_2$ symmetry, which underlies their dualities, although they differ in their energy redistribution rule. Furthermore, the harmonic model is integrable in the sense of Yang-Baxter.
Exploiting this structure, we compute the non-equilibrium steady state of the boundary-driven harmonic model in closed form [2]. We show that it can be expressed as a mixture of product Gibbs distributions, with local temperatures given by the ordered Dirichlet distribution [3]. As a consequence, we prove that the empirical energy profile satisfies a large deviation principle, with a rate function in agreement with the prediction of Macroscopic Fluctuation Theory [4]. If time allows, we shall discuss ongoing work (in collaboration with T.Sasamoto) about dynamical large deviations.

[1] R. Frassek, C. Giardinà, J. Kurchan, "Non-compact quantum spin chains as integrable stochastic particle processes", J. Stat. Phys. 180, 135-171 (2020)
[2] R. Frassek, C. Giardinà, "Exact solution of an integrable non-equilibrium particle system", J. Math. Phys. 63, 103301 (2022)
[3] G. Carinci, C. Franceschini, D. Gabrielli, C. Giardinà, D. Tsagkarogiannis, "Solvable stationary non-equilibrium states", J. Stat. Phys. 191, 10 (2024)
[4] G. Carinci, C. Franceschini, R. Frassek, C. Giardinà, F. Redig, "Large deviations and additivity principle for the open harmonic process” Comm. Math. Phys. 406, 103 (2025)

16:50-17:30

FLASH TALK SESSION

1) **Urban Duh** (University of Ljubljana)

Title: *Ruelle-Pollicott resonances and the many-body Kolmogorov cascade: An exactly solvable toy model*

Abstract: In recent years, the Ruelle-Pollicott spectrum of the truncated propagator has emerged as a powerful framework for studying non-equilibrium dynamics of many-body systems. It has proven successful in identifying (unconventional) symmetries and extracting thermalization timescales or phenomenological transport coefficients, e.g., the diffusion constant. The method centers on the spectrum of the Heisenberg propagator truncated to a finite number of sites (the Ruelle-Pollicott spectrum), i.e., it approximates the unitary dynamics in the thermodynamic limit with effective non-unitary local dynamics. In this talk, I will discuss an exactly solvable toy model inspired by dual-unitary circuits and use it to justifying this approach. I will show that the effective non-unitarity is not merely a convenient numerical approximation but is related to a fundamental feature of global unitary dynamics. While global dynamics is dissipationless, effective dissipation in the space of local observables emerges as observables spread to an ever-increasing number of sites with time. We dub this the many-body Kolmogorov cascade, drawing a parallel to the energy flow to higher-wave-vector modes in classical turbulence. The many-body Kolmogorov cascade is encoded in eigenvectors corresponding to Ruelle-Pollicott resonances, which are not elements of the appropriate Hilbert space, but are rather Gamow vectors lying in the space of generalized functions. In addition to the rigorous construction using the language of rigged Hilbert spaces in the toy model, I will also provide numerical evidence in generic many-body systems.

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2) **Ali Zahra** (LPCT, Nancy)

Title: *Emergent Hydrodynamics in an Exclusion Process with Long-Range Interactions*

Abstract: We study the symmetric Dyson exclusion process (SDEP)— a lattice gas with exclusion and long-range, Coulomb–type interactions that emerge both as the maximal-activity limit of the symmetric exclusion process and as a discrete version of Dyson's Brownian motion on the unitary group. Exploiting an exact ground-state (Doob) transform, we map the stochastic generator of the SDEP onto the spin-1/2 XX quantum chain, which in turn admits a free-fermion representation. At macroscopic scales we conjecture that the SDEP displays ballistic (Eulerian) scaling with a conservation law featuring a current that is a genuinely non-local functional of the density. This non-local one-component description is equivalent to a local two-components "complex Hopf" system for finite particle density. Closed evolution formulas allow us to solve the melting of single- and double-block initial states, producing limit shapes and arctic curves that agree with large-scale Monte-Carlo simulations. The model thus offers a tractable example of emergent non-local hydrodynamics driven by long-range interactions.
Joint work with Jerome Dubail and Gunter Schutz [SciPost Phys. 20, 141 (2026)].

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3) **Shiyi Wei** (INPHYNI, Nice)

Title: *Quantum corrections to current large deviations in noisy quantum systems: beyond classical typicality*

Abstract: The leading-order current cumulants of the classical symmetric simple exclusion process (SSEP) coincide exactly with those of quasi-1D disordered fermionic wires in the metallic regime (Lee–Levitov–Yakovets 1995; Derrida–Douçot–Roche 2004). This is puzzling because the two systems share no microscopic details—yet their current fluctuations are indistinguishable at the dominant scale. It naturally raises the question: do genuine quantum signatures emerge at subleading orders, and can they be computed exactly? We address this question in the Quantum Symmetric Simple Exclusion and Inclusion Processes (QSSEP for fermions, QSSIP for bosons)—boundary-driven chains with stochastic nearest-neighbor hoppings driven by Brownian noise. Their exact solvability allows us to isolate subleading corrections in a controlled setting. To leading order, and for each noise realization, the large deviation function converges to its classical counterpart, establishing classical typicality of current fluctuations.

We then isolate the leading $\mathcal{O}(1/N)$ quantum correction to the cumulant generating function—a contribution of purely quantum origin, encoded in residual two-point coherences, that is entirely absent in the classical SSEP/SSIP. We provide explicit closed-form expressions for the corresponding corrections to the current variance and skewness. These predictions are testable in current quantum simulation platforms where noise realizations can be engineered. The results demonstrate that subleading transport statistics require a quantum extension of Macroscopic Fluctuation Theory, and raise the question of a deeper connection to universal conductance fluctuations in mesoscopic systems.

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4) **Yilin Ye** (Ecole Polytechniqu, Palaiseau)

Title: *The geometric control of boundary-catalytic branching processes*

Abstract: Boundary-catalytic branching processes describe a broad class of natural phenomena where the population of diffusing particles grows due to their spontaneous binary branching (e.g., division, fission, or splitting) on a catalytic boundary located in a complex environment. We investigate the possibility of the geometric control of the population growth by compensating for the proliferation of particles due to catalytic branching events by their absorptions in the bulk or on absorbing regions of the boundary. We identify an appropriate Steklov spectral problem to obtain the phase diagram of this out-of-equilibrium stochastic process. The principal eigenvalue determines the critical line that separates an exponential growth of the population from its extinction in a bounded domain. In other words, we establish a powerful tool for calculating the optimal absorption rate that equilibrates the opposite effects of branching and absorption events and, thus, results in steady- state behavior of this diffusion–reaction system. Moreover, we show the existence of a critical catalytic rate above which no compensation is possible, so that the population cannot be controlled and keeps growing exponentially. The proposed framework opens promising perspectives for better understanding, modeling, and control of various boundary-catalytic branching processes, with applications in physics, chemistry, and life sciences.

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5) **Frederick Del Pozo** (LKB, Paris)

Title: *Quench dynamics of entanglement in O(N) bosons at infinite N*

Abstract: We investigate the non-equilibrium dynamics of the entanglement spectrum of the $N = \infty$ limit of an interacting *O(N)* field theory, following a sudden quench starting from the disordered phase. Depending on the quench depth, a dynamical phase transition is observed, with universal dynamical exponents characterizing the shape of the correlation functions. We characterize the three distinct quench regimes — above, at or below the critical point — based on their entanglement spectra, and observe universal spatio-temporal scaling in the largest entanglement eigenvalue. By considering subregions which are periodic in two spatial directions, we formulate a ``band theory" for the entanglement modes, and demonstrate that the gap relaxes algebraically to zero for quenches to and below the critical point. Finally, we also take a closer look at the lowest lying bands. We reveal the ballistic propagation of entanglement directly by analyzing the amplitudes of the eigenvectors, shedding new light on the dynamics of the entanglement modes following the quench.

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6) **Friedrich Hübner** (LPENS, Paris)

Title: *Systematic approach to solvability in brickwork circuits*

Abstract: Solvable circuits, such as dual unitary circuits and their extensions, have arisen as paradigmatic examples of tractable chaotic non-equilibrium dynamics, both in classical and quantum systems. These correspond to local algebraic relations which allow for calculation of observables due to a simplification of the corresponding tensor network. However, so far these relations are not exhaustive, and it is not clear what their limitations are. We fill this gap by providing a sufficient and necessary local condition under which a circuit is solvable (by this we mean that its influence matrix can be written as a uniform MPS). The result is based on a version of the fundamental theorem of MPS with open boundary conditions. We then apply these conditions to study the simplest case: factorized initial state and Markovian bath. For this case we classify all solvable classical circuits (with local dimension 2 and 3) and all solvable quantum circuits with local dimension 2.

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7) **Hugo Lóio** (Cergy-Paris University)

Title: *Quantum-to-Classical Computability Transition via Negative Markov Chains*

Abstract: We develop a recently introduced representation of quantum dynamics based on sampling negative Markov chain processes. By introducing particles and antiparticles, this formalism maps generic quantum dynamics onto a Markov process defined over an exponentially large configuration space. Within this framework, quantum complexity arises from the proliferation of stochastic particles, which ultimately renders classical simulation and sampling intractable beyond a certain timescale. In the presence of noise, we demonstrate that for any unitary evolution generated by a linear combination of local

or pairwise interactions, there exists at least one noise channel that effectively classicalizes the system by suppressing particle growth and making Monte Carlo sampling efficient. As a corollary, we show that for this class of unitaries, the dynamics of an open quantum spin chain subject to depolarizing noise undergoes an exact transition to classical simulability once the noise strength exceeds a critical threshold which can be efficiently determined for any model.

17:45 - 19:00

Poster session + apéro

Programme Day 4

Friday, 29th May

09:30-10:20 **Benjamin Doyon** (King's College, London)

Title: *Generalised hydrodynamics and the quasi-particle problem of the KdV soliton gas*

Abstract: Generalised hydrodynamics is the hydrodynamic theory for many-body integrable systems. The basic equations of generalised hydrodynamics arise in the Euler scaling limit, but also take the form of kinetic equations for a phase-space density of ``quasi-particles". The notion of quasi-particles is fundamental in integrable systems, quantum and classical. In the context of soliton gases, identifying quasi-particles is the problem of locating solitons in a many-soliton field at finite densities. I will explain what this problem entails, and express some recent results where I propose a solution. The results are based on a new, physically natural expression of the tau function from which the multi-soliton field is constructed, whose structure resembles that of the Bethe ansatz. In find that, as predicted some time ago, and also proven recently in the Toda model, solitons satisfy what we refer to as the semi-classical Bethe equations, from which we believe the full all-order hydrodynamic theory of integrable systems can be obtained.

10:20-11:00 Coffee break

11:00-11:30 **Joël Mabillard** (MSC, Paris-Cité)

Title: *Transport in crystals: from microscopic dynamics to spectral functions*

Abstract: Crystals are systems with broken continuous symmetries whose hydrodynamics differs qualitatively from that of fluids, due to the presence of elastic modes and additional slow variables. Deriving this hydrodynamic description directly from microscopic dynamics, and identifying the associated transport coefficients, remains a nontrivial problem in non-equilibrium statistical mechanics. In this talk, I present a statistical-mechanical framework that derives the hydrodynamic equations of a crystal from its microscopic dynamics. Applicable to both classical and quantum regimes, it yields a closed set of equations for the coupled evolution of density, momentum, energy, and vacancies, together with explicit microscopic expressions for all transport coefficients. This framework allows for the analytical computation of dynamical correlation functions and their spectral functions, whose resonances are determined by the hydrodynamic modes. This establishes a direct link between microscopic transport and experimentally accessible quantities such as inelastic scattering spectra. Finally, these theoretical predictions are challenged using molecular dynamics simulations of a monatomic hard-sphere crystal. We compute the full set of transport coefficients, including viscosities, thermal conductivities, and vacancy thermodiffusion, using both the Helfand moment method and the analysis of spectral function poles. These results confirm the quantitative link between microscopic dynamics and the emergent hydrodynamic modes, providing a unified description of transport in the solid state.

11:30-12:00 **Vanja Maric** (University of Ljubljana)

Title: *Slow dynamics from a nested hierarchy of frozen states*

Abstract: We identify the mechanism of slow heterogeneous relaxation in quantum kinetically constrained models (KCMs) in which the potential energy strength is controlled by a coupling parameter. The regime of slow relaxation includes the large-coupling limit. By expanding around that limit, we reveal a nested hierarchy of states that remain frozen on time scales determined by powers of the coupling. The classification of such states, together with the evolution of their Krylov complexity, reveals that these time scales are related to the distance between the sites where facilitated dynamics is allowed by the kinetic constraint. While correlations within frozen states relax slowly and exhibit metastable plateaus that persist on time scales set by powers of the coupling parameter, the correlations in the rest of the states decay rapidly. We compute the plateau heights of correlations across all frozen states up to second-order corrections in the inverse coupling. Our results explain slow relaxation in quantum KCMs and elucidate dynamical heterogeneity by relating the relaxation times to the spatial separations between the active regions. joint work with Luka Paljk and Lenart Zadnik reference: Phys. Rev. B 113, 024313 (2026).

12:00-12:30 **Mathias Albert** (INPHYNI, Nice)

Title: *Interaction induced Anderson transition in a kicked one dimensional Bose gas*

Abstract: Understanding how interactions affect localization and transport in isolated quantum systems is a central question in non-equilibrium statistical physics. While Anderson localization is well established for non-interacting particles, its fate in the presence of interactions remains a subtle issue. In this talk, I will present recent results [1,2] on dynamical localization in an interacting one-dimensional Bose gas subjected to periodic driving. In the absence of interaction, the system exhibits dynamical localization, characterized by energy saturation at long times. Remarkably, we show that finite interactions can induce a transition from a localized (insulating) regime to a delocalized (metallic) one above a critical driving strength, provided the particle number is sufficiently large. This transition can be understood through an exact mapping onto an effective Anderson model in a synthetic dimension set by the number of particles, and displays critical properties consistent with the orthogonal Anderson universality class. I will then discuss how interactions and quasiperiodic driving can be combined to engineer synthetic dimensions in a controlled way, enabling the realization of effective Anderson models in arbitrary dimensions. This framework provides a versatile route to explore localization phenomena, critical behavior, and the interplay between integrability and chaos in driven quantum systems. These results highlight how concepts from Anderson localization, integrable models, and non-equilibrium quantum dynamics can be brought together to shed light on the emergence of transport and its breakdown in interacting many-body systems.

[1] H. Olsen, P. Devillard, G. Aupetit-Diallo, P. Vignolo and M. Albert, Phys. Rev. Lett. 135, 173403 (2025).
[2] H. Olsen, P. Vignolo and M. Albert, arXiv:2511.05344

12:30-14:30 Lunch break

14:30

End of the conference