Quantum Chaos @ Bernoulli

Report of Contributions

https://indico.psi.ch/e/Bernoulli-Quantum-Chaos-2024

Contribution ID: **1** Type: **not specified**

Welcome

Monday 30 September 2024 09:50 (10 minutes)

Contribution ID: **2** Type: **not specified**

Talk Anatoly Dymarsky: ETH and Random Matrix Universality

Thursday 3 October 2024 11:30 (1 hour)

ETH and Random Matrix Universality

ETH seems to suggest that in simple observables can be modeled by random matrices. We will discuss to what extent this is actually true.

Contribution ID: **3** Type: **not specified**

Talk Felix Haehl: Random matrix universality and modular invariance

Monday 30 September 2024 11:30 (1 hour)

Random matrix universality and modular invariance

I will discuss universal level repulsion in the context of coarse-graining the spectrum of chaotic 2d conformal field theories. Modular invariance strongly constrains the spectral correlations and the subleading corrections to the linear growth of the spectral form factor (SFF). The latter are determined by a trace formula, which highlights an interplay of universal physical properties of chaotic CFTs and analytic number theory. Remarkably, the simplest possible modular invariant SFF consistent with quantum chaos is identical to that described by a dual Euclidean wormhole geometry in AdS3 gravity. I will also discuss the universal late-time behavior of the SFF, i.e., the approach to the 'plateau', and how it is realized in modular invariant CFTs.

Contribution ID: **4** Type: **not specified**

Talk Jean-Philippe Brantut: All-to-all interacting quantum gases for quantum simulation

Monday 30 September 2024 14:30 (1 hour)

All-to-all interacting quantum gases for quantum simulation

I will present the progresses of my group in the engineering of long-range, all-to-all interacting quantum gases realized by placing cold Fermi gases in high-finesse cavities. I will then describe our experimental progresses towards the realization of random interactions, allowing in principle for the experimental realization the Sachdev-Ye-Kitaev model, a paradigmatic example of holographic quantum matter.

Contribution ID: **5** Type: **not specified**

Discussion Session

Monday 30 September 2024 16:00 (1 hour)

Contribution ID: **6** Type: **not specified**

Talk Aurelia Chenu: Two transitions in complex eigenvalue statistics of the XXZ Hamiltonian with imaginary disorder: Hermiticity and integrability breaking

Tuesday 1 October 2024 10:00 (1 hour)

Two transitions in complex eigenvalue statistics of the XXZ Hamiltonian
with imaginary disorder: Hermiticity and integrability breaking

With Aurelia Chenu, Gernot Akemann, Federico Balducci, Patricia Pässler, Federico Roccati, Ruth Shir

Open quantum systems have complex energy eigenvalues which are expected to follow non-Hermitian random matrix statistics when chaotic, or 2-dimensional (2d) Poisson statistics when integrable. We investigate the spectral properties of a many-body quantum spin chain, the Hermitian XXZ Heisenberg model with imaginary disorder. Its rich complex eigenvalue statistics is found to separately break both Hermiticity and integrability at different scales of the disorder strength. With no disorder, the system is integrable and Hermitian, with spectral statistics corresponding to 1d Poisson. At very small disorder, we find a transition from 1d Poisson statistics to an effective D-dimensional Poisson point process, showing Hermiticity breaking. At intermediate disorder we find integrability breaking, and the statistics agrees with that of non-Hermitian complex symmetric random matrices in class AI^{dag}. For large disorder, we recover the expected 2d Poisson statistics.

Our analysis uses numerically generated nearest and next-to-nearest neighbour spacing distributions of an effective 2d Coulomb gas description at inverse temperature β, fitting them to the spin chain data. We confirm such an effective description of random matrices in class AI^{dag} and AII^{dag} up to next-to-nearest neighbour spacings.

Contribution ID: **7** Type: **not specified**

Talk Fabien Alet: Many-body localisation and thermalization: introduction and new results for weak interactions

Tuesday 1 October 2024 11:30 (1 hour)

Many-body localisation and thermalization: introduction and new results for weak interactions

Many-body localization is the paradigm for how interacting quantum systems can resist thermalization in the presence of strong disorder.
In the first part of the talk, I will give a quick recap on the main ideas of many-body localization, highlighting the challenges and open questions in the field.
I will then present new results in the limit of weakly interacting systems, where our numerical simulations indicate that below a certain disorder threshold, weak interactions necessarily lead to ergodic instabilities.
Work done in collaboration with Jeanne Colbois and Nicolas Laflorencie, arXiv:2403.09608, Phys. Rev. Lett (2024, in press)

Contribution ID: **8** Type: **not specified**

Talk Fabrizio Minganti: Chaos in open quantum systems

Tuesday 1 October 2024 14:30 (1 hour)

Chaos in open quantum systems

Quantum technologies represent a frontier of both fundamental and applied research. Far from being ideal closed systems, quantum devices are open, interact with their environment experiencing dissipation, and require error correction strategies to reliably perform quantum algorithms [1]. In these systems, the interplay between dissipative and Hamiltonian evolution leads to states and phenomena distinct from those observed in equilibrium condensed matter physics, including chaos [2,3,4]. During this talk, I will briefly discuss open and monitored quantum systems, chaos, and its relation to quantum devices. I will highlight some peculiar features, from the effect of measurement backaction [3] to thermalization phenomena [4]. I will showcase some of the recent experimental demonstrations of our theoretical predictions [5,6].

[1] Google Quantum AI and Collaborators, Quantum error correction below the surface code threshold, arXiv:2408.13687v1 (2024).
[2] D. Dahan, G. Arwas, and E. Grosfeld, Classical and quantum chaos in chirally-driven, dissipative Bose-Hubbard systems. npj Quantum Inf 8, 14 (2022).
[3] F. Ferrari, L. Gravina, D. Eeltink, P. Scarlino, V. Savona, and FM, Transient and steady-state quantum chaos in driven-dissipative bosonic systems, arXiv 2305.15479 (2023).
[4] F. Ferrari, FM, C. Aron, V. Savona, Chaos and spatial prethermalization in driven-dissipative bosonic chains, arXiv:2409.12225 (2024).
[5] L. P. Peyruchat, F. Ferrari, FM, and P. Scarlino, Signature of dissipative quantum chaos in coupled nonlinear driven resonators, in preparation.
[6] L. Peyruchat, FM, M. Scigliuzzo, F. Ferrari, V. Jouanny, F. Nori, V. Savona, and Pasquale Scarlino, Landau-Zener without a Qubit: Unveiling Multiphoton Interference, Synthetic Floquet Dimensions, and Dissipative Quantum Chaos, arXiv:2404.10051 (2024).

Contribution ID: **9** Type: **not specified**

Talk Laura Foini: The eigenstate thermalization hypothesis and free probability

Monday 30 September 2024 10:00 (1 hour)

The eigenstate thermalization hypothesis and free probability

The eigenstate thermalization hypothesis (ETH) was developed to explain the mechanism by which "chaotic" systems reach thermal equilibrium from a generic state. ETH is an ansatz for the matrix elements of physical operators in the basis of the Hamiltonian, and since its postulation, numerous studies have characterised these quantities in increasingly fine detail, providing a solid framework for understanding the (thermo)dynamics of quantum many-body systems. ETH can be viewed as a generalisation of random matrix theory and, in fact, within this ansatz matrix elements are modelled as random variables.

Contribution ID: **10** Type: **not specified**

Talk Matt Walters: Thermalization and Chaos in QFT

Wednesday 2 October 2024 10:00 (1 hour)

Thermalization and Chaos in QFT

Despite the many successes of QFT, we still have very few tools for directly computing strongly-coupled dynamics, and even fewer means of studying QFTs at finite temperature. I will discuss a new approach for accomplishing this goal, called conformal truncation, which uses data from conformal field theories to compute observables in more general QFTs. After presenting the general approach, I will discuss its application to 1+1d scalar field theory, in particular the calculation of finite-temperature observables and the signatures of chaotic dynamics at general coupling.

Contribution ID: **11** Type: **not specified**

Talk Miguel Paulos: Bootstrapping chaos?

Wednesday 2 October 2024 16:00 (1 hour)

Bootstrapping chaos?

In this talk I will discuss the systematics of the conformal bootstrap in 1d systems and their relation to (generically chaotic) 2d QFTs.

Contribution ID: **12** Type: **not specified**

Talk Armando Angrisani: Classical simulation of quantum circuits via Pauli Propagation

Wednesday 2 October 2024 14:30 (1 hour)

Classical simulation of quantum circuits via Pauli Propagation

Contribution ID: **13** Type: **not specified**

Talk Xiangyu Cao: Objectivity and encoding in inflationary quantum dynamics

Thursday 3 October 2024 10:00 (1 hour)

Objectivity and encoding in inflationary quantum dynamics

Quantum chaotic dynamics is known to encode information, making them practically inaccessible. Meanwhile, macroscopic environments and measurement devices are able to broadcast information about quantum degrees of freedom, leading to the emergence of classical objectivity [1]. Such "classicalization"is also believed to happen during cosmological inflation [2]. I will report recent [3] and ongoing works about sharp dynamical transitions between encoding and objectivity in inflationary quantum dynamical systems.

[1] Zurek, W., Nature Phys 5, 181–188 (2009).
[2] Martin, J., Vennin V., Phys. Rev. D 93, 023505 (2016).
[3] Ferte, B, XC, Phys. Rev. Lett. 132, 110201 (2024),
Phys. Rev. A 109, 032226 (2024).

Contribution ID: **14** Type: **not specified**

Talk Masud Haque: Assigning temperatures to eigenstates of isolated quantum systems

Wednesday 2 October 2024 11:30 (1 hour)

Assigning temperatures to eigenstates of isolated quantum systems

We examine and compare different possible ways of assigning temperatures to energies, or equivalently, to eigenstates, of isolated many-body quantum systems.

Contribution ID: **15** Type: **not specified**

Talk Julian Sonner: Gravity as a mesoscopic system

Thursday 3 October 2024 14:30 (1 hour)

Gravity as a mesoscopic system

We employ a probabilistic mesoscopic description to draw conceptual and quantitative analogies between Brownian motion and late-time fluctuations of thermal correlation functions in generic chaotic systems respecting ETH. We apply this formalism to the case of semiclassical gravity in AdS3, showing that wormhole contributions can be naturally identified as moments of stochastic processes. Adopting this perspective shows that semiclassical gravity in AdS can be naturally interpreted as a mesoscopic description of quantum gravity, and a mesoscopic holographic duality can be framed as a moment-vs-probability-distribution duality.

Contribution ID: **16** Type: **not specified**

Conclusion of Workshop

Thursday 3 October 2024 15:30 (10 minutes)