G.IST WORKSHOP: SCIENTIFIC PROGRAM

Monday 27/10, 10:00

Speaker: Laura Foini

Title: Eigenstate Thermalization, local rotational invariance and Free probability

Abstract: The eigenstate thermalization hypothesis (ETH) was proposed to explain how isolated quantum “chaotic” systems approach thermal equilibrium from a generic initial state. ETH serves as an ansatz for the matrix elements of physical operators in the eigenbasis of the Hamiltonian. Since its formulation, extensive studies have refined and characterized these matrix elements, establishing ETH as a robust framework for understanding the (thermo)dynamics of quantum many-body systems.

ETH can be viewed as a generalization of random matrix theory, where the matrix elements are treated as random variables. In our work, we extend the ETH ansatz to incorporate correlations between matrix elements, which are crucial for describing higher-order correlation functions. Drawing an analogy with random matrix theory, and guided by a principle of ``local rotational invariance", we propose a hierarchical structure for these correlations and demonstrate how this generalized ansatz connects ETH to free probability, a mathematical field that examines non-commutative random variables. This connection reveals a distinctive structure in the time-dependent correlation functions at thermal equilibrium, offering new insights into the underlying dynamics.

Monday 27/10, 11:30

Speaker: Juan-Diego Urbina

Title: High(and 3)-dimensional hyperbolic motion as perturbative dual to JT(and Airy)-quantum gravity: Universality, Schwarzian density and scrambling (and if time permits, wormhole and cross-cap)

Abstract: I will present a progress report on the search for a quantum mechanical system whose (suitably defined) spectral correlations match order-by-order the genus expansion of the correlation functions that define quantum Jackiw-Teitelboim gravity and its low-energy (Airy) limit.

An example of such perturbative duality is the well known exact identification of JT gravity with a fine-tuned matrix ensemble, but here we will attack such correspondences from the perspective of old-fashion quantum chaos where the existence of a classical limit displaying Hamiltonian chaos automatically guarantees the emergence, for individual systems, of an universal (late-time or τ-scaling in the gravity jargon) spectral correlations given by the gaussian matrix ensembles. Since at this universal limit *any* chaotic theory is dual to any other,

the big question is whether one can also obtain the exact same non-universal features of the JT(and Airy) correlators by means of a specific, unique, quantum system.

In this talk, I will review the well known way quantized classically-chaotic systems acquire universal spectral fluctuations due to the existence of subtle correlations among the actions of their periodic orbits that, through the use of periodic-orbit theory, impact the spectrum of the corresponding quantum system. Then, I will pose the question of whether such correlations actually reach beyond the universal regime to produce system-specific contributions, to finally check them against JT(Airy) known results for the case of high(3) dimensional hyperbolic motion exactly described by the Selberg trace formula.

I will discuss three very non-trivial instances where this exact correspondence can be shown: the universal regime, the $g=0$ contribution to the one-point function (the disk) and the saturation of the Maldacena-Shenker-Stanford bound on chaos. If time permits, I will discuss the $g=0,1/2$ contributions (the wormhole and the first cross-cap) to the $n=2$ correlation function (the form factor).

Monday 27/10, 15:30

Speaker: Yi-Neng Zhou

Title: Unitary k-Design from Single-Switch Evolution

Abstract: We introduce a single-switch random chaotic Hamiltonian protocol that realizes approximate unitary k-designs with minimal control. The system evolves under one random Hamiltonian and, after a switch time chosen at or beyond the Thouless time, is abruptly switched to an independent random Hamiltonian; this single switch disrupts residual spectral structure correlations that prevent time-independent chaotic evolution from forming k-designs. We show that the resulting unitary ensemble approaches the unitary k-design, while requiring only one control action—markedly simpler than Brownian schemes that continuously randomize couplings. The protocol applies broadly to platforms capable of chaotic dynamics (e.g., trapped ions, superconducting qubits, cold atoms), offering a scalable and experimentally practical route to unitary k-design and related randomized protocols.

Tuesday 28/10, 10:00

Speaker: Daniel Jafferis

Title: Tensor Models, 3d Gravity and Simplicial Decomposition

Abstract: I will review the tensor/matrix model for 2d CFT data subject to crossing constraints, whose topological expansion is proposed to match that of pure 3d gravity. I will discuss various sources of divergences and what remains to prove the correspondence. Then I will turn to a BCFT extension of the model, particularly as associated to a purely open version of the bootstrap. I will explain how the resulting topological expansion is related to gluing tetrahedra, and show how the matrix model captures certain off-shell 3d gravity amplitudes.

Tuesday 28/10, 11:30

Speaker: Tom Hartman

Title: Triangulating Quantum Gravity in AdS_3

Abstract: I will discuss the path integral of pure 3D gravity on a finite region of spacetime, with boundary conditions that fix dihedral angles or geodesic lengths. This amplitude calculates corrections to the Gaussian statistics of OPE coefficients in the dual CFT. The fixed-length path integral is related to Virasoro TQFT; the fixed-angle path integral is the partition function of Conformal Turaev-Viro theory, a novel topological theory based on triangulations; and the two are related by a modular S-transform. This leads to a general procedure to calculate the exact path integral on hyperbolic 3-manifolds by gluing together generalized tetrahedra.

Tuesday 28/10, 14:30

Speaker: Romain Vasseur

Title: Holographic random tensor networks and complexity transitions

Abstract: Projected entangled pair states (PEPS) offer memory-efficient representations of some quantum many-body states that obey an entanglement area law, and are the basis for classical simulations of ground states in two-dimensional (2d) condensed matter systems. However, rigorous results show that exactly computing observables from a 2d PEPS state is generically a computationally hard problem. Yet approximation schemes for computing properties of 2d PEPS are regularly used, and empirically seen to succeed, for a large subclass of (‘not too entangled’) condensed matter ground states. Adopting the philosophy of random matrix theory, in this talk I will discuss the complexity of approximately contracting a 2d random PEPS by exploiting an analytic mapping to an effective replicated statistical mechanics model. I will discuss the relation to holographic random tensor networks, and argue that: i) although approximately sampling wave-function amplitudes of random PEPS faces a computational-complexity phase transition above a critical bond dimension, ii) one can generically efficiently estimate the norm and correlation functions for any finite bond dimension.

Wednesday 29/10, 10:00

Speaker: Eric Perlmutter

Title: Choose Your Own Adventure

Abstract: You are lost in the cold, dark space of two-dimensional conformal field theories. In the distance beckons a shimmering light, fluctuating chaotically and randomly. You move toward the light, but a blinding fog rolls in. Feeling around on the ground, you stumble upon an L-function. Then another. Then another. Picking one up, it feels heavy, and a little slippery, but seems to make the fog dissipate. You carry on, L-function in hand, uncertain but resolute... What happens next? It all depends on the choices you make. How does it end? Only you can find out!

Wednesday 29/10, 11:30

Speaker: Adrian Sanchez-Garrido

Title: Black hole formation from the operator product expansion

Abstract: In this talk I will present work in progress with P. Chowdhury, F. Haehl and Y. Zhao, where we are studying the conformal field theory dual of the process of black hole formation in AdS3 out of the collision of two localized shockwaves. Our starting point is a boundary state prepared by the insertion of two boosted precursor operators on the CFT vacuum. Using conformal bootstrap techniques, we are able to decompose this two-shock state over a basis of the CFT Hilbert space: We find that this decomposition is dominated by a primary dimension whose value grows initially exponentially as a function of Rindler time, with an exponent such that it crosses the black hole threshold at a time scale equal to twice the scrambling time, signalling black hole formation. I will discuss the relation of these results to operator growth and to the corresponding black hole formation condition in three-dimensional gravity.

Wednesday 29/10, 15:30

Speaker: Marco Ambrosini

Title: Holography of K-complexity: the bulk of the story

Abstract: Recent work has revealed that Krylov complexity (or K-complexity) plays a central role in holography. In this talk, we review some new developments in the two-dimensional holographic duality between JT gravity and double-scaled SYK, where K-complexity describes a notion of emergent length. We explore how this emergent geometric character manifests in both single and multi-operator settings, and we complement the bulk–boundary correspondence by incorporating details of the matter sector. Additionally, we define a class of two-sided perturbations on top of the Lanczos evolution, which allows us to establish that, in the appropriate limit, K-complexity exhibits the switchback effect, consistently with its geometric interpretation in the bulk.

Thursday 30/10, 10:00

Speaker: Scott Colier

Title: Summing over topologies in 3d gravity

Abstract: I will discuss the sum over topologies in three-dimensional quantum gravity and its relationship with the statistical interpretation of the boundary theory. I will begin by articulating properties that a statistical CFT ensemble should possess. I will then identify a series of surgery moves on the gravity side that correspond to statistical contractions of OPE data in the boundary theory. The resulting analysis demonstrates that, despite generating a large number of non-trivial manifolds, these moves do not produce off-shell (non-hyperbolic) manifolds or even all on-shell (hyperbolic) manifolds. The proofs rely on structure theorems of 3-manifolds, which nicely interact with the requirements of the statistical boundary ensemble. I will illustrate the application of this procedure with many examples. Our findings reveal a large space of possible choices of which manifolds can consistently be included in the gravitational path integral, reflecting a wide range of possible statistical ensembles consistent with crossing symmetry. Based on work with Alexandre Belin, Lorenz Eberhardt, Diego Liska, and Boris Post.

Thursday 30/10, 11:30

Speaker: Diego Liska

Title: Microstate counting from shells in de Sitter

Abstract: In this talk, I will examine the microscopic origin of the de Sitter entropy using the Lorentzian path integral. I will construct a Hilbert space whose states are configurations of thin shells or end-of-the-world branes. By analysing these geometries, I will show that the variance of microstate overlaps is dominated by Lorentzian wormholes with conical singularities. From the on-shell action of these wormholes, I will recover the Gibbons-Hawking entropy law, relating the size of the de Sitter Hilbert space to the area of the cosmological horizon. Finally, I will extend the analysis to Schwarzschild-de Sitter spacetime and show that both the cosmological and black hole horizons contribute to the total entropy.

Thursday 30/10, 14:30

Speaker: Victor Gorbenko

Title: Bra-ket wormholes in cosmology

Abstract: I will discuss cosmological spacetimes that have a geometry connecting bra and ket of the wavefunction of the universe.

Friday 31/10, 10:00

Speaker: Marcos Marino

Title: Non-perturbative effects in matrix models and in topological recursion

Abstract: The 1/N expansion is generically accompanied by exponentially small, non-perturbative effects due to large N instantons. In this talk I focus on these effects in matrix models and, more generically, in models whose 1/N expansion is described by the topological recursion. In simple cases, e.g. in models relevant to 2d gravity, these effects are due to eigenvalue tunneling and can be described in detail. In more general cases one needs a more abstrac approach, based on the holomorphic anomaly equations. This approach leads to universal formulae which describe large N instantons in a wide class of models.

Friday 31/10, 11:30

Speaker: Thomas Mertens

Title: Quantum groups in lower-dimensional gravity models

Abstract: In this talk I will discuss recent progress in uncovering the presence of quantum group symmetries in both 2d and 3d gravity models. This structure is then utilized to better understand various aspects of gravitational models, such as edge states or the structure of boundary correlation functions.

Friday 31/10, 14:30

Speaker: Tomas Reis

Title: Resurgence in CFT2 - From degenerate operators to forbidden singularities

Abstract: I will talk the resurgence of the large charge expansion of the identity block in CFT2. Specifically, inspecting the resurgence analysis of four-point functions with degenerate operators at finite cross-ratio z, both for 4 heavy operators and two heavy two light “HHLL". We see how resurgence sheds light on semi-classical approximations and their regimes of validity. We expand on how Stokes phenomena in the asymptotic series in large c are controlled by the cross-ratio z, that they reveal the other block in the OPE, and that this solves the “forbidden singularities” of Kaplan et al., which might be related to information loss and suggest future directions for resurgence in CFT2.