MP 2: Mathematical Materials Science and AdS/CFT

Time: Tuesday 13:45–15:45 Location: ZHG001

Invited Talk MP 2.1 Tue 13:45 ZHG001
Mathematics of moire materials — •Simon Becker — ETH Zurich, CH

We review recent developments in the field of moire materials from a mathematics perspective. Starting from effective one-particle models for magic angle twisted bilayer graphene, we continue to interacting theory and models for twisted semiconductors (TMDs).

Invited Talk MP 2.2 Tue 14:15 ZHG001
Approaches to Discrete Holography — •René Meyer[1], Pablo Basteiro[1], Giuseppe Di Giulio[1,2], Johanna Erdmenger[1], Zhuoyu Xian[1,3], Jonathan Karl[1], and et. al.[1] — [1]Institute for Theoretical Physics and Astrophysics, Julius-Maximilians-Universität Würzburg, 97074 Würzburg — [2]Stockholm University, AlbaNova, 10691 Stockholm — [3]Freie Universität Berlin, Arnimallee 14, 14195 Berlin

I will review recent progress towards a discrete version of the AdS/CFT duality based on hyperbolic lattices. After an introduction to these lattices, I will show that the Breitenlohner-Freedman stability bound for a scalar field on such hyperbolic tilings is unaffected by the type of lattice, and present a realization of this bound in a hyperbolic electric circuit [1]. I will then present simulations [2] of a scalar field on a hyperbolic lattice with a black hole horizon, which successfully recover not only the conformal scaling of two- and three-point functions, but also determine a discretely quantized black hole temperature. In the second part of the talk, I will discuss XXZ type spin chains on the aperiodic space obtained by cutting off a hyperbolic tiling at a large radial distance. I will discuss the emergence of a non-trivial disordered fixed point [3], the logarithmic scaling of the entanglement entropy, and the effective central charge of that fixed point. I will end with an outlook on recent work on aperiodic chains of coupled SYK quantum dots [4]. [1] Phys. Rev. Lett. 130 (9), 2023; [2] Phys. Rev. Lett. 133 (6), 2024; [3] SciPost Physics 13 (5), 2022; [4] 2410.23397.

MP 2.3 Tue 14:45 ZHG001
Random Matrix Universality as a tool in 2d Quantum Gravity: Beyond the orientable case — •Torsten Weber[1], Jarod Tall[2], Fabian Haneder[1], Marco Lents[1], Juan Diego Urbina[1], and Klaus Richter[1] — [1]Universität Regensburg, Regensburg, Deutschland — [2]Washington State University, Pullman, USA

In recent years the discovery of an AdS/CFT-like correspondence of quantum JT gravity and a distinct matrix model has led to an intense cross-fertilisation of the a priori distinct fields of quantum gravity and quantum chaos. In this spirit we use random matrix universality, ubiquitous in quantum chaos, and study its implications on JT gravity. Specifically we focus on the spectral form factor (SFF), a prime example of universality on the matrix model side and thus a key characteristic of quantum chaos. While in the orientable setting the study reveals the perturbative expansion of the SFF in JT gravity to show behaviour non-perturbative from the point of view of random matrices and cancellations within key geometric quantities to match the universal prediction, this becomes even more interesting when including unorientable contributions. This is due to perturbative contributions in this setting, requiring regularisation and being more complicated to compute already, even at the regularisation-independent level showing apparent deviations from the universal prediction. We show how these deviations can be made sense of for the regularisation independent part by employing a bootstrapping-like argument and how this leads to agreement, and thus a strong sign for the presence of chaos, in full unorientable JT gravity.

MP 2.4 Tue 15:05 ZHG001
The chiral SYK model in holography — •Konstantin Weisenberger[1], Alexander Altland[1], Nele Callebaut[1], and Dmitry Bagrets[2] — [1]Universität zu Köln — [2]Forschungszentrum Jülich

We propose a (1+1)-dimensional chiral extension of the SYK model which in the infrared limit is described by the (1+1)-dimensional generalization of the Schwarzian action, namely the Alekseev-Shatashvilli (AS)-action. This action has been proposed to govern boundary gravitons in pure AdS3 gravity, giving our model the interpretation of capturing fluctuations around the BTZ saddle point. From the AS-action, correlation functions of Majorana operators can be calculated by means of Liouville field theory on the hyperbolic disk, where we solve two-point functions and out-of-time-order correlation functions using semi-classical methods. In accordance with general expectations, this theory encodes the vacuum block of a 2d CFT, leading to the expected maximal Lyapunov exponent.

MP 2.5 Tue 15:25 ZHG001
Towards identifying a genus expansion in the Selberg trace formula — •Fabian Haneder, Juan Diego Urbina, Torsten Weber, and Klaus Richter — Universität Regensburg, Regensburg, Deutschland

Jackiw-Teitelboim (JT) gravity has been a useful tool for advancing our understanding of several features believed to be generic in quantum gravity, such as the density of states (exponentially growing for black hole systems), wormholes and topological expansions of the gravitational path integral.

Key progress in doing so has been made using random matrix universality, both for orientable [Saad et al., arXiv:2210.11565, Weber et al., Weber et al., 2023 J. Phys. A: Math. Theor. 56 205206] and unorientable [Weber et al., J. High Energ. Phys. 2024, 267 (2024), Tall et al., arXiv:2411.08129] JT gravity, establishing the quantum chaoticity of the theory. In an effort to go beyond the universal regime, we use periodic orbit theory, which has been used precisely to derive universality, and study non-universal features, for quantum chaotic systems.

After reviewing recent success [Haneder et al., arXiv:2410.02270] in capturing the exact (leading genus) density of states and wormhole amplitude of JT gravity with a single quantum chaotic system, we report on our progress in identifying a topological expansion, reminiscent of the one in JT gravity, in the same system, a particle moving on a high-dimensional hyperbolic manifold. To describe the system, we make use of the Selberg trace formula, which renders periodic orbit theory exact.