

# From Coadjoint Orbits to Black Holes

## Alexander Altland

*Matrix theory*

Abstract

## Alexandre Belin

*Statistics of OPE coefficients from the Virasoro crossing kernel*

Understanding the statistical distribution of OPE coefficients is crucial for quantum chaos in conformal field theories. Conformal symmetry, more precisely crossing symmetry and modular invariance highly constrains this statistical distribution. I will explain how to extract moments of the distribution in two-dimensional CFTs using the Virasoro crossing kernel which has a known closed form expression. In particular, I will show that higher moments of the distribution are exponentially suppressed in the entropy, as required by the Eigenstate Thermalization Hypothesis or the OPE Randomness Hypothesis.

## Jean-Michel Bismut

*Coherent sheaves, Chern character, and RRG*

Let  $X$  be a compact complex manifold. If  $(E, \nabla^{E''})$  is a holomorphic vector bundle, and if  $g^E$  is a Hermitian metric on  $E$ , we get an associated Chern connection on  $E$ , and corresponding Chern character forms.

I will show how to extend this construction to arbitrary coherent sheaves, using the antiholomorphic superconnections of Block. An antiholomorphic superconnection is a differential operator of degree 1, with the same principal symbol as  $\bar{\partial}$ , whose square vanishes.

Using generalized metrics, we obtain a Chern character with values in Bott-Chern cohomology.

For complex varieties and arbitrary coherent sheaves, we establish a Riemann-Roch-Grothendieck theorem with values in Bott-Chern cohomology. One can interpret part of this theorem as a refined version of the Atiyah-Singer families index theorem.

This is joint work with Shu SHEN and Zhaoting WEI. <https://arxiv.org/abs/2102.08129>.

# Mirjam Cvetič (Colloquium)

## *String Theory Confronts Black Holes*

Over the past decades, String Theory has emerged as the prime candidate for the unification of quantum gravity and elementary particle physics. The existence of extra dimensions and important geometrical aspects of string theory such as the introduction of extended objects - Dirichlet branes shed light on important fundamental questions of theoretical physics, such as the geometric origin of the microscopic structure of black holes (and the geometric origin of particle physics). We review these past developments for extremal black holes and highlight some progress on studies of the internal structure for non-extremal black holes via the introduction of the so-called subtracted geometry and its connections to two-dimensional models of quantum gravity.

# Johanna Erdmenger

## *Computational complexity in AdS/CFT from coadjoint orbits*

I review recent work of our group on constructing the information theory concepts of circuits and computational complexity for conformal field theories, in view of relating them holographically to complexity proposals in AdS gravity. This requires extending complexity definitions from finite to infinite dimensional Hilbert spaces. Gates and cost functions in the CFT are introduced based on symmetry transformations, and used for a complexity definition based on geometric actions on Virasoro and Kac-Moody orbits. Alternative complexity definitions are based on the Fubini-Study metric as cost function. Moreover, we construct the gravity dual of circuits built from local conformal transformations. In this approach to holographic complexity, the gravity dual to the optimal circuit is the one that minimizes an externally chosen cost assigned to each circuit.

# Thomas Hartman

## *3d gravity and conformal blocks*

Abstract

# Kristan Jensen

## *Soft gravitons in three dimensions*

Abstract.

# Alexander Maloney

## *Wormholes and Statistics in Averaged Holographic Duality*

I consider an explicit example of a disordered holographic duality, where the average over an ensemble of free boson CFTs is dual to an exotic (but extraordinarily simple) theory of gravity in AdS. This can be regarded as an explicit example of AdS/CFT duality, where all perturbative and non-perturbative effects can be computed exactly. For example, we can sum over Euclidean wormholes to obtain an exact formula for the two-point correlation function of the

density of states. This wormhole sum reproduces precisely the late time "plateau" behaviour in the spectral form factor, which is related to discreteness of the spectrum. This leads to some interesting questions and speculations about the role of averaged holographic duality more generally.

## **Eckhard Meinrenken**

### *On Hamiltonian Virasoro spaces*

The Virasoro Lie algebra is the non-trivial central extension of the Lie algebra of vector fields on the circle. There is a well-known 1-1 correspondence between the coadjoint orbits in the affine dual of the Virasoro algebra and conjugacy classes in a certain open subset of the universal cover of  $SL(2, \mathbb{R})$ . We extend this to a geometric correspondence, taking into account the Lie-Poisson structure. As an application, one obtains a correspondence between Hamiltonian Virasoro spaces and quasi-Hamiltonian spaces for the universal cover of  $SL(2, \mathbb{R})$ .

## **Adrian Sanchez Garrido**

### *Phenomenology of Krylov complexity*

Krylov complexity is a notion of complexity that characterizes the spread of an operator over the algebra of observables by measuring its projection over a suitable orthonormal basis of this algebra built out of nested commutators of the Hamiltonian with the operator. Using this basis, operator dynamics can be mapped to a one-dimensional hopping problem. In this talk I will present recent results on the time evolution of Krylov complexity away from the thermodynamic limit for both chaotic and integrable systems. While the former display the complexity profile expected in the context of the butterfly effect in AdS/CFT, the latter feature a late-time suppression of complexity due to an enhanced localization effect in the afore-mentioned hopping problem.

## **Samson Shatashvili**

### *Coadjoint orbits, quantization and conformal welding*

Abstract

## **James Sully**

### *The Landscape of Gravitating Branes*

Abstract

## **Leon Takhtajan**

### *Supersymmetry and trace formulas*

I will discuss a new supersymmetric localization principle, with application to trace formulas for a full partition function, and will illustrate it by deriving bosonic trace formulas on compact Lie

groups, including classical Jacobi inversion formula. Based on the joint work with Changha Choi, arXiv: 2112.07942

## Erik Verlinde

*Title*

Abstract

## Donald Youmans

*Free field coordinates in the Schwarzian theory*

In this talk, we define free field (Darboux) coordinates for the Schwarzian theory on a wide class of Virasoro coadjoint orbits. In these coordinates, the theory becomes Gaussian and therefore explicit calculations are feasible. We compute time ordered and out-of-time ordered correlation functions of bilocal operators and show that the latter shows signs of quantum chaos. This talk is based on joint work with Anton Alekseev and Olga Chekeres.

## Peter Zograf

*Asymptotics of intersection numbers on moduli spaces of curves: a review*

Intersection numbers of tautological classes on moduli spaces of  $n$ -pointed genus  $g$  complex algebraic curves appear in various models of two dimensional quantum gravity. We will survey their large  $g$  and  $n$  behavior with a special emphasis on Weil-Petersson volumes.