Sixth Mandelstam Theoretical Physics School and Workshop 2024

January 9 - 17, 2024
University of the Witwatersrand
Johannesburg, South Africa

Schedule of Talks

	Jan 10	**Jan 11**	**Jan 12**	**Jan 15**	**Jan 16**
	Wednesday	**Thursday**	**Friday**	**Monday**	**Tuesday**
9:30 - 10:00	Seok Kim	Seok Kim	Sumit Das	Denjoe O'Connor	Denjoe O'Connor
10:00 - 10:30					
10:30 - 11:00	**Coffee Break**	**Coffee Break**	**Coffee Break**	**Coffee Break**	**Coffee Break**
11:00 - 11:30	Manus Visser	Manus Visser	Manus Visser	Keun-Young Kim	Jaco van Zyl
11:30 - 12:00				Pallab Basu	Pratik Roy
12:00 - 12:30	Byoungjoon Ahn	Kyungsun Lee	Imtak Jeon	Costas Zoubos	Arpith Kumar
12:30 - 14:00	**Lunch Break**	**Lunch Break**	**Lunch Break**	**Lunch Break**	**Lunch Break**
14:00 - 14:30	Robert de Mello Koch	Bumhoon Lee	Seok Kim	Denjoe O'Connor	Free Afternoon
14:30 - 15:00		Bana Singh			
15:00 - 15:30	**Coffee Break**	**Coffee Break**	**Coffee Break**	**Coffee Break**	
15:30 - 16:00	Joao Rodrigues	Masanori Hanada	Antal Jevicki	Sumit Das	
16:00 - 16:30					
18:00 - 21:00					**Dinner**

Titles and Abstracts

Sumit Das (University of Kentucky, USA)	
Pedagogical Talk	Title: Introduction to Periodically Driven Quantum Field Theory
	Abstract: TBA
Sumit Das (University of Kentucky, USA)	
Research Talk	Title: Floquet Dynamics in Conformal Field Theory in Dimensions Greater than Two
	Abstract: TBA
Seok Kim (Seoul National University, South Korea)	
Pedagogical Talks 1, 2	Title: Black Holes in AdS/CFT

	Abstract: In the first talk I will explain the thermal/quantum physics of black holes in AdS/CFT, emphasizing how they are supposed to tell us the novel aspects of quantum gravity at high energy/temperature. Then in the second talk I will explain how some of these phenomena can be quantitatively understood from the CFT dual. I will often consider (rather sharp) analogues in the supersymmetric sector, in which the studies often boil down to exact results in certain large N matrix models.
Seok Kim (Seoul National University, South Korea)	
Research Talk	Title: Finite *N* black hole cohomologies
	Abstract: I will explain a cohomology problem of 4d SU(*N*) maximal super-Yang-Mills theory which we expect to capture some information on the BPS black hole microstates in AdS/CFT. I will also present recent progress during the past 2 years.
Denjoe O' Connor (Dublin Institute for Advanced Studies, Ireland)	
Pedagogical Talk 1	Title: From Membranes to Matrix Models
	Abstract: I will describe to quantization of relativistic membranes in the lightcone gauge. This will lead to bosonic BFSS type models when the membranes propagate in flat spacetime and to BMN models when the membranes propagate in a PP-wave background. For the supersymmetric version of these models we will get a family of supersymmetric quantum mechanical matrix models. I will further describe the predicted strong coupling behaviour of the models from the dual supergravity backgrounds. The inclusion of a black hole background will correspond to the matrix model in a thermal background.
Denjoe O' Connor (Dublin Institute for Advanced Studies, Ireland)	
Pedagogical Talk 2	Title: Testing the Dual Geometry
	Abstract: In a second lecture I will discuss introducing probes that do not disturb the dual geometry. One natural probe will be to have a Born-Infeld D4-brane propagating on the dual gravitational background. I will describe how this is dual to the Berkooz-Douglas matrix model when the number of adjoint multiplets is small. I will further describe some details of the numerical code used to simulate these models. If time permits I will discuss the dual geometry beyond the dual approximation.
Denjoe O' Connor (Dublin Institute for Advanced Studies, Ireland)	
Research Talk	Title: Large but Finite *N* gauged matrix models and Discrete Gauge Groups
	Abstract: Traces of products of matrices and products of such traces are the natural gauge invariants of membrane matrix models. I will review the counting of matrix invariants, show how the path integral easily reproduces the Molien-Weyl formula for counting invariants and how it extends to discrete groups. For membranes in more than 2 dimensions relations between the invariants can be ignored for matrix strings of length up to N/4. For longer strings the trace relations are essential. I will show that the features of the Bosonic BFSS model are reproduced when the finite *N* counting from this microcanonical analysis is accounted for.

Manus Visser (University of Cambridge, UK)	
Pedagogical Talk 1	Title: Thermodynamics of Black Holes in a Box
	Abstract: TBA
Manus Visser (University of Cambridge, UK)	
Pedagogical Talk 2	Title: De Sitter Thermodynamics
	Abstract: TBA
Manus Visser (University of Cambridge, UK)	
Research Talk	Title: Partition Function for a Volume of Space
	Abstract: TBA
Byoungjoon Ahn (Gwangju Institute of Science and Technology, South Korea)	
Research Talk	Title: Deep learning bulk spacetime from boundary optical conductivity
	Abstract: We employ a deep learning method to deduce the bulk spacetime from boundary optical conductivity. We apply the neural ordinary differential equation technique, tailored for continuous functions such as the metric, to the typical class of holographic condensed matter models featuring broken translations: linear-axion models. We successfully extract the bulk metric from the boundary holographic optical conductivity. Furthermore, as an example for real material, we use experimental optical conductivity of UPd2Al3, a representative of heavy fermion metals in strongly correlated electron systems, and construct the corresponding bulk metric.
Robert de Mello Koch (Huzhou University, China)	
Research Talk	Title: Some comments on bilocal holography
	Abstract: Bilocal holography provides a constructive approach to the AdS/CFT duality. It entails two steps: (1) a change to invariant bilocal variables and (2) an identification of the CFT coordinates with those of the dual AdS spacetime. In this talk I will review some ongoing work which aims to clarify the second step.
Kyungsun Lee (Korea Institute for Advanced Study, South Korea)	
Research Talk	Title: Gravitational edge mode in N=1 super Jackiw-Teitelboim gravity
	Abstract: We demonstrate the edge mode of the 2D supersymmetric Jackiw-Teitelboim (SUSY JT) gravity. First, we present the superspace formalism of the SUSY JT gravity. We provide that the wiggling boundary of the superspace can lead to the edge mode of the SUSY JT gravity which can be described by super-Schwarzian theory. In addition, we deal with the alternative derivation of the edge mode by the standard analysis for would-be gauge mode in gravity.
Joao Rodrigues (University of the Witwatersrand, South Africa)	
Research Talk	Title: Large *N* Master Field Optimization for Multi-Matrix Systems

	Abstract: I revisit the problem of solving multi-matrix systems through numerical large N methods. The framework is the constrained optimization of a loop truncated, collective loop space representation of these systems. The loop space constraints are handled by the use of master variables. For the large N dynamics of two Yang-Mills coupled matrix quantum mechanics, the method is successfully applied directly in the massless limit for a range of values of the Yang- Mills coupling constant, and the scaling behaviour of different physical quantities derived from their dimensions are obtained with a high level of precision, for both the large N planar properties of the theory and the spectrum of the theory. For the spectrum, we establish that the U (N) traced fundamental constituents remain massless and decoupled from other states, and that bound states develop well defined mass gaps, with the mass of the two degenerate lowest lying bound states being determined with a particularly high degree of accuracy.
Imtak Jeon (APCTP, South Korea)	
Research Talk	Title: Supersymmetry and Complexfied Spectrum on Euclidean AdS2
	Abstract: I will address a problem concerning supersymmetric boundary conditions. If we use the standard normalizable functional basis on Euclidean AdS for well-defined functional integration, it is incompatible with supersymmetry. We propose a resolution to this problem by demonstrating that the supersymmetric boundary condition on Euclidean AdS2 requires a complexified spectrum of the Dirac operator.
Antal Jevicki (Brown University, USA)	
Research Talk (Online)	Title: Spin Model of AdS Holography
	Abstract: TBA
Bana Singh (IISER Mohali, India)	
Research Talk	Title: Two-dimensional Maximally Supersymmetric Yang-Mills Theory on the Lattice
	Abstract: Our interest lies in two-dimensional maximally supersymmetric Yang–Mills (SYM) theory. This theory is derived from the dimensional reduction of the four-dimensional N = 4 theory. The continuum action of the two-dimensional SYM theory is then transformed into a lattice action through a lattice discretization scheme. With the lattice formulation of two-dimensional N = (8,8) SYM, we aim to compute operator expectation values using the Rational Hybrid Monte Carlo (RHMC) algorithm, which involves importance sampling of gauge field configurations. Additionally, we introduce a few crucial measurements, particularly the phase of the complex Pfaffian of the fermion operator. We employ the existing parallel software SUSY LATTICE for lattice studies of two-dimensional N = (8,8) supersymmetric Yang–Mills theory. This involves utilizing existing routines from the four-dimensional N = 4 theory and creating new routines for the dimensionally reduced terms.
Masanori Hanada (QMUL, UK)	
Research Talk (Online)	Title: Toward QCD on Quantum Computer: Orbifold Lattice Approach

	Abstract: Although Kogut-Susskind Hamiltonian is a popular choice for quantum simulations, there are some technical complications when it is applied to QCD, and more generally, to SU(N) gauge theory. In this talk, we try to convince you that the orbifold lattice can be a simpler alternative. The orbifold lattice was proposed in 2003 by Kaplan, Katz and Unsal, to construct a supersymmetric lattice gauge theory. Now we forget about supersymmetry and apply the same technique to build a simple lattice Hamiltonian suitable for quantum simulations. This talk is based on arXiv:2011.06576 [hep-th] (published in JHEP) and a paper in preparation. We will try to convey the main messages avoiding too much technical details.
Bumhoon Lee (Sogang University, South Korea)	
Research Talk	Title: The dilaton-Einstein-Gauss-Bonnet Gravity and Cosmology
	Abstract: The dilaton-Einstein-Gauss-Bonnet(dEGB) Gravity is one of the simplest extensions of Einstein's gravity with the higher curvature term. After some motivation to beyond Einstein Gravity models, we briefly describe the dEGB model through the black holes. The most prominent property may be that there exists a minimum mass below which the black hole cannot be formed, unlike Einstein's gravity. Moreover, there exists a parameter range in which the black hole may be unstable under fragmentation. Then, we move on to the implication of this theory on the cosmological evolution. The major message is that in addition to the effects of the Gauss-Bonnet term at each stage of the cosmology, it opens new possible phases: “Slow-roll”, “fast-roll”, and “kination” at the higher temperatures, in addition to the well-accepted radiation dominant, matter dominant, and cosmological constant dominant phases of the standard cosmological model. We also present the WIMP physics and gravitational waves to put the bounds on the parameters of dEGB gravity theory.
Keun-Young Kim (Gwangju Institute of Science and Technology, South Korea)	
Research Talk	Title: Comments on quantum chaos and complexity
	Abstract: Quantum physics has been successful for more than 100 years and is believed to be well understood. However, the concept of chaos in quantum physics is still incomplete. It may be essential for the fundamental understanding of thermalization and the microscopic nature of quantum physics. Quantum complexity is a novel quantum informational concept that is under development. Its basic idea is to quantify a "distance" between two states or operators, where "distance" may be measured by the "cost" along the path between two states (operators). Chaos and complexity are two different concepts, but they may be related to each other in certain aspects. Therefore, studying both concepts together is useful. It is also beneficial to think about the gravity dual of these concepts from a holographic perspective. For example, complexity may have physical implications for the black hole interior. In this presentation, I will explore the subjects of quantum chaos and complexity, placing particular emphasis on Krylov complexity.
Pallab Basu (University of the Witwatersrand, South Africa)	
Research Talk	Title: Chaos from higher spin

	Abstract: Inspired by chaos in string scattering amplitude, we will discuss a simple model of higher spin theory which shows chaotic scattering. The talk would start with a quick introduction of chaos and it's implications for scattering esp of string amplitude. Then we would go into the details of our higher spin construction.
Costas Zubos (University of Pretoria, South Africa)	
Research Talk	Title: Quantum Symmetries in N=2 SCFT's
	Abstract: A large class of N=2 4d superconformal field theories can be obtained by orbifolding the N=4 SYM theory and marginally deforming. Naively, this breaks the SU(4) R-symmetry of N=4 SYM to the SU(2) R-symmetry of a generic N=2 theory. I will argue that if one is willing to consider quantum groups, the naively broken SU(4) generators can be promoted to those of a quantum groupoid version of SU(4). Some implications of this hidden symmetry in organising the spectrum of these theories will be discussed.
Jaco van Zyl (University of Cape Town, South Africa)	
Research Talk	Title: Spread Complexity and PT symmetry
	Abstract: Krylov complexity is a measure of operator growth in quantum systems based on the number of orthogonal basis vectors needed to approximate the time evolution of an operator. It has been demonstrated that chaotic dynamics and topological phase transitions can be diagnosed from simple features associated with this measure. In this talk it will be shown that the measure can also distinguish between PT-symmetric and PT symmetry-broken phases - the specific focus will be on a system of two coupled harmonic oscillators of which the famed Bateman oscillator is a special case.
Pratik Roy (University of the Witwatersrand, South Africa)	
Research Talk	Title: Quantum thermodynamics from holographic quenches
	Abstract: Quantum entanglement has been the focus of a lot of research over the past couple of decades. In particular, a new bound on the second derivative of relative entropy in QFTs has emerged from the study of holographic theories. This bound, called the Quantum Null Energy Condition (QNEC), has been proven rigorously in a very general setting. In the context of a two-dimensional quantum conformal field theory that undergoes a sudden injection of energy (i.e., a global quench), we will show that QNEC can be used to place bounds on, e.g., the amount of increase of entropy in terms of the increase in temperature. The bound obtained is stronger than the Clausius inequality of classical thermodynamics, which is necessary but not sufficient to ensure that QNEC is not violated. Based on arXiv:2109.09914 and work in progress.
Arpith Kumar (Central China Normal University, China)	
Research Talk	Title: Complex Langevin Study of Spontaneous SO(10) Symmetry Breaking in Euclidean IKKT Matrix Model

	Abstract: Superstrings are the most promising theories for unifying all interactions, including gravity. However, these theories are consistently defined in ten dimensions. The connection to the real world, where only four dimensions are macroscopic, is realized in the non-perturbative definition of superstrings via the compactification of the six extra dimensions. In this talk, we will discuss a constructive formulation of the type IIB superstring, the IKKT (type IIB) matrix model. A smooth spacetime manifold is expected to emerge from the eigenvalues of the ten bosonic matrices in this model. When this happens, the SO(10) symmetry in the Euclidean signature must be spontaneously broken. The Euclidean version has a severe sign problem due to the inherently complex nature of the Pfaffian. In recent years, the complex Langevin method (CLM) has successfully tackled the sign problem. We apply the CLM method to study the Euclidean version of the IKKT matrix model and investigate the possibility of spontaneous SO(10) symmetry breaking. In doing so, we encounter a singular-drift problem. To counter this, we introduce supersymmetry-preserving deformations with a Myers term. The original IKKT model can be recovered at the vanishing deformation parameter limit. Our preliminary analysis suggests that the Pfaffian phase does indeed trigger the spontaneous breaking of SO(10) symmetry in the Euclidean IKKT model.