Online Workshop
"Frontiers of Holographic Duality — V"

Program
Titles & Abstracts

[workshop web page]

4 – 8 December 2023,
Steklov Mathematical Institute, Moscow

НАУКА
И УНИВЕРСИТЕТЫ
НАЦИОНАЛЬНЫЕ
ПРОЕКТЫ
РОССИИ

МИАН

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Steklov International Mathematical Center

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Steklov Mathematical Institute of Russian Academy of Sciences, Moscow, Russia

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December 4 (Monday)

Opening

12:55 – 13:00 (Msc)

A simple model, extracted using holography, of a domain wall between a confining and a de-confining phases and its velocity

13:00 – 13:55 (Msc) Jacob Sonneschein (*Tel Aviv University, Tel Aviv*)

In the context of theories with a first order phase transition, we propose a general covariant description of coexisting phases separated by domain walls using an additional order parameter-like degree of freedom. In the case of a holographic dual to a confining and a de-confining phases, the resulting model extends hydrodynamics and has a simple formulation in terms of an action and a corresponding energy-momentum tensor. The proposed description leads to simple analytic profiles of domain walls, including the surface tension density, which agree nicely with holographic numerical solutions. We show that for such systems, the domain wall or bubble velocity can be expressed in a simple way in terms of a perfect fluid hydrodynamic formula, and thus in terms of the equation of state. We test the predictions for various holographic domain walls.

Binding Complexity and the Cost of Entanglement

14:00 – 14:55 (Msc) Giuseppe Policastro (*Ecole Normale Supérieure, Paris*)

I will discuss the relation of quantum complexity, especially in the geometric Nielsen's formulation, to entanglement. In particular I will show that there is a class of complexity measures, called "binding complexity" defined by a certain choice of penalty factors, which is closely related to entanglement and Renyi entropies, and characterize the minimal complexity needed to produce a certain amount of entanglement. The talk is based on the paper arXiv:2311.04277

Break

15:00 – 16:00 (Msc)

Torus shadow formalism and exact global conformal blocks

16:00 – 16:25 (Msc) Semyon Mandrygin (*Lebedev Physical Institute, Moscow*)

The talk is devoted to the investigation of the large central charge limit of conformal blocks in two-dimensional conformal field theory with torus topology. I will discuss the application of the shadow formalism of conformal field theory to the computation of global torus blocks. After reviewing the shadow formalism of two-dimensional conformal field theory, it will be shown how the known constructions generalise to conformal field theories on the torus. Using the developed formalism we find multipoint global torus conformal blocks. The found n-point blocks are expressed through previously unknown hypergeometric functions of n variables.

Renormalization group flows in $3d$ holographic model

16:30 – 16:55 (Msc) Marina Usova (*Steklov Mathematical Institute, Moscow*)

In the context of AdS/CFT correspondence, we study renormalization group flows in $3d$ supergravity with a scalar field (dilaton) and its potential. Using the dynamical systems theory, the stationary points of the corresponding equations of motion are analyzed for stability. Asymptotic solutions for the metric and the scalar field are restored in their vicinity. We show that some solutions can be interpreted as the fixed points of the dual field theory and that there are RG flows between an unstable UV fixed point and a stable IR fixed point.

December 5 (Tuesday)

Gravity from Optimized Computation

14:00 – 14:55 (Msc) Juan Pedraza (*Instituto de Fisica Teorica, Madrid*)

Inspired by the universality of computation, I advocate for a notion of spacetime complexity, where gravity arises as a consequence of spacetime optimizing the computational cost of its quantum dynamics. This principle is realized in the context of holography, where complexity is understood in terms of state preparation via Euclidean path integrals, and the linearized equations of motion, for any theory of gravity, emerge from the first law of complexity. This suggests gravity has a computational origin. When the leading $1/N$ bulk quantum corrections are included, the holographic first law is modified by an additional term which could be interpreted as "bulk complexity", leading to a derivation of semi-classical gravitational equations of motion.

Timelike Entanglement Entropy

15:00 – 15:55 (Msc) Ali Mollabashi (*Institute for Research in Fundamental Sciences, Tehran*)

Motivated by the geometrical understanding of quantum information measures in AdS/CFT, I will introduce a two-state generalization of von Neumann entropy known as pseudo-entanglement entropy as well as a novel quantity corresponding to timelike regions on the CFT side which we call "timelike entanglement entropy" (TEE). It turns out that TEE is a special case of pseudo-entanglement entropy. Concrete definitions on the CFT side together with a prescription to calculate TEE in $2d$ free quantum field theories will be introduced, which contains some clues about how to understand TEE in quantum information theory. I will also introduce our first version of a holographic prescription to calculate TEE in AdS_3/CFT_2 and address how TEE in AdS_3/CFT_2 is related to EE in dS_3/CFT_2.

Break

16:00 – 17:00 (Msc)

Magnetic Catalysis in Holographic Model with Two Types of Anisotropy for Heavy Quarks

17:00 – 17:55 (Msc) Ali Hajilou (*Steklov Mathematical Institute, Moscow*)

We reconstruct a twice anisotropic five dimensional holographic model supported by Einstein-dilaton-three-Maxwell action based on the previous research, i.e. arXiv:2011.07023 [hep-th], to describe the magnetic catalysis (MC) phenomena expected from lattice results for the QGP made up from heavy quarks. This model keeps typical properties of the heavy quarks phase diagram, and meanwhile possesses the MC. The deformation of the previous model includes the modification of the "heavy quarks" warp factor and the coupling function for the Maxwell field providing the non-trivial chemical potential.

Open AdS/CFT via a Double-trace Deformation

18:00 – 18:55 (Msc) Hao Geng (*Harvard University, Cambridge, Massachusetts*)

A concrete model of extracting the physics from the bulk of a gravitational universe is important to the study of quantum gravity and its possible relationship with experiments. Such a model can be constructed in the AdS/CFT correspondence by gluing a bath on the asymptotic boundary of the bulk anti-de Sitter (AdS) spacetime. This bath models a laboratory and is described by a quantum field theory. In the dual conformal field theory (CFT) description this coupling is achieved by a double-trace deformation that couples the CFT with the bath. This suggests that the physics observed by the laboratory is fully unitary. In this talk, we present a detailed analysis of some primary quantum aspects of this model. This conveys new lessons about the AdS/CFT correspondence and provides a setup where many holographic calculations can be done.

December 6 (Wednesday)

Insights on Pentaquarks through Gauge/String Duality

13:00 – 13:55 (Msc) Oleg Andreev (*Arnold Sommerfeld Center for Theoretical Physics, Munich*)

In the framework of the gauge/string duality, I will discuss three aspects of pentaquark systems: 1. The ground state of the $Q\bar{Q}qqq$ system. 2. The possible reason for the difficulty of observing the $QQqq\bar{q}$ pentaquark. 3. Generalized baryon vertices and their implications for pentaquarks.

Weak chaos in the string S-matrix

14:00 – 14:55 (Msc) Mihailo Čubrović (*University of Belgrade, Belgrade*)

We consider the scattering of tachyons, photons and gravitons off highly excited strings and study the signs of chaos in the resulting S-matrix. We find that the S-matrix (unlike individual amplitudes) never exhibits clear chaotic behavior, i.e. it never satisfies the eigenphase repulsion statistics expected in a chaotic scattering problem. Instead, the eigenphase spectrum has both regular and chaotic contributions, and the regular component persists even when the total occupation number of the string grows to infinity. We further consider the influence of ensemble averaging over the excited string states and also try to approach the string/black hole transition point. The conclusion is that the onset of fast scrambling cannot be seen from the string S-matrix, even though we can see some other signs of the string/black hole transition.

Break

15:00 – 17:00 (Msc)

Holographic Beta-Function for Quark-Gluon Plasma with Heavy/Light Quarks

17:00 – 17:55 (Msc) Pavel Slepov (*Steklov Mathematical Institute, Moscow*)

We consider renormalization group flow and beta-function in Einstein-dilaton-Maxwell holographic models for heavy and light quarks. We obtain a significant dependence of beta function on chemical potential and temperature. Near the first-order phase transitions, the beta function undergoes junctions depending on temperature and chemical potential.

Dropping a diary into semiclassical black hole microstates

18:00 – 18:55 (Msc) Mikhail Khramtsov (*Vrije Universiteit Brussel, Brussels & University of Pennsylvania, Philadelphia*)

We study the impact of the infalling matter on the semiclassical microstate structure of black holes in general relativity with negative cosmological constant in arbitrary spacetime dimension. The matter is taken to be a sequence of thin heavy shells, which are infalling into the microstate geometry from outside the horizon. We show that the coarse-grained entropy of

the quantum black hole described by these microstates in the presence of infalling shells behaves in agreement with the expectation for the Bekenstein-Hawking entropy from classical black hole thermodynamics. Meanwhile, we also demonstrate that the finer characteristics of the overlap structure of the microstates depend on the entropies of the black hole after consuming every individual shell, thus recording the history of the black hole matter consumption during its evolution.

Universal Properties in ICFTs

19:00 – 19:55 (Msc) Yuya Kusuki (*California Institute of Technology, Pasadena & RIKEN, Wako, Saitama*)

Conformal interfaces are not well-studied except for special interfaces called topological interfaces. This lack of study is due to general interfaces breaking symmetry, where some powerful tools in CFT are not applicable. On this background, AdS/CFT can be a powerful tool. In this talk, we make use of AdS/CFT to understand universal properties of conformal interfaces in 2D. Interestingly, we show that the generalized holographic c-theorem can be interpreted as the upper bound on the entanglement between two (possibly different) systems. Moreover, we also show its CFT proof by using the results on the gravity side as a hint. Finally, we give the higher-dimensional generalization of our results. The key is that methods on the gravity side generally do not depend on dimensions, unlike QFT methods. This is another advantage of AdS/CFT to explore quantum many-body systems.

December 7 (Thursday)

Fluctuations in the entropy of Hawking radiation and interior information recovery

13:00 – 13:55 (Msc) Masamichi Miyaji (*Institute for Advanced Research, Nagoya University, Nagoya*)

Recent study revealed that the inclusion of Euclidean wormhole into the gravitational path integral renders the entropy of Hawking radiation consistent with unitarity, deriving the Page curve of the Hawking radiation. On the other hand, since the gravitational path integral with Euclidean wormhole computes quantities of ensemble average of theories, it is possible that the entropy of Hawking radiation of each gravity theory fluctuate wildly around the ensemble average. In this talk we show that such fluctuation is as small as the dimension of the system, ensuring the answer from the ensemble average is typical. We also study information recovery from the black hole interior which is also known to be possible after the Page time. We again find that the recovery is also typical, by studying information theoretic quantities of the encoding map as well as directly examining the entanglement fidelity of the Petz recovery map.

Black Holes, Cavities and Blinking Islands

14:00 – 14:55 (Msc) Timofei Rusalev (*Steklov Mathematical Institute, Moscow*)

We consider the evolution of the entanglement entropy and entanglement islands in the two-sided generalization of the Schwarzschild black hole in a cavity. Introducing a reflecting boundary in the eternal black exteriors we regulate infrared modes of Hawking radiation and find that entanglement entropy saturates at some constant value. This value could be lower than black hole thermodynamic entropy, thus not leading to Page formulation of information paradox. We find a universal effect induced by the presence of a boundary, which we call "blinking island" — for some time the entanglement island inevitably disappears, thus leading to a non-unitary evolution. The talk is based on the paper arXiv:2311.16244.

Break

15:00 – 16:00 (Msc)

Wilson networks in AdS and global conformal blocks

16:00 – 16:25 (Msc) Vladimir Khiteev (*Lebedev Physical Institute, Moscow*)

I will tell about Wilson networks in AdS_2 constructed from Wilson lines and cap states. Cap states regulate the boundary behaviour of Wilson line operators and by imposing right restrictions on cap states one can obtain the global conformal block at the boundary of the AdS_2. I will show how to find cap states and obtain dictionary relation between Wilson networks and global conformal blocks. Then I will tell about calculation of the n-point global conformal block in the comb channel.

Classical Liouville Action and Uniformization of Orbifold Riemann Surfaces

16:30 – 16:55 (Msc) Behrad Taghavi (*Institute for Research in Fundamental Sciences, Tehran*)

In this talk, based on arXiv:2310.17536, we will study the classical Liouville field theory on Riemann surfaces of genus $g > 1$ in the presence of vertex operators associated with branch points of orders $m_i > 1$. In particular, classical correlation functions of branch point vertex operators on a closed Riemann surface are related to the on-shell value of Liouville action functional on the same Riemann surface but with the insertion of conical points (of angles $2\pi/m_i$) at the location of these operators. With this motivation, and using the results of arXiv:1508.02102 and arXiv:1701.00771, we will study the appropriate classical Liouville action on a Riemann orbisurface using the Schottky global coordinates. We will also study the first and second variations of this action on the Schottky deformation space of Riemann orbisurfaces and show that the classical Liouville action is a Kähler potential for a special combination of Weil-Petersson and Takhtajan-Zograf metrics which appear in the local index theorem for Riemann orbisurfaces (see arXiv:1701.00771).

On the role of the z^4 and z^5 terms in the metric strain coefficient for the holographic description of QGP in magnetic field

17:00 – 17:55 (Msc) Kristina Rannu (*Steklov Mathematical Institute, Moscow*)

TBA

QG-seminar

18:00 – 18:55 (Msc)

December 8 (Friday)

Krylov Complexity in Free and Interacting Scalar Field Theories with Bounded Power Spectrum

13:00 – 13:55 (Msc) Viktor Jahnke (*Gwangju Institute of Science and Technology, Gwangju*)

This talk will be based on arXiv:2212.14702v2, in which we studied a notion of operator growth known as Krylov complexity in free and interacting quantum field theories. We will discuss in detail the effects of mass, perturbative interactions and ultraviolet cutoffs on the Lanczos coefficients and Krylov complexity.

How chaos reigns in free field theories

14:00 – 14:55 (Msc) Dmitry Ageev (*Steklov Mathematical Institute, Moscow*)

In this talk, I will discuss a work in progress with V. Pushkarev which devoted to out-of-equilibrium dynamics and chaotic behaviour in the simplest quantum field theories — free ones. Recently, in the paper by Bianchi, Firrotta, Sonnenschein and Weissman, it was shown how one can quantitatively estimate the chaotic behaviour of certain string amplitudes. We show that similar behaviour could be observed in massive Gaussian free scalar field theories confined in finite volume after different types of quenches.

Closing remarks

15:00 – 16:00 (Msc) Irina Aref'eva (*Steklov Mathematical Institute, Moscow*)