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Program of 4th ExU Annual Meeting

Sept. 25

	Title	Speaker	Chair
10:00-11:00	Preparation/Registration		
11:00-11:20	Opening and Summary of Annual Activities	Tadashi Takayanagi (YITP, Kyoto U.)	Takayanagi
11:20-12:20	B03 group report and seminar [1]		
	B03 group report	Akihiro Ishibashi (Kindai U.)	
	Instabilities of AdS spacetime in holographic semiclassical gravity	Kengo Maeda (Shibaura Inst. Tech.)	
12:20-14:00	Lunch break		
14:00-14:45	Reports from Publicly Offered Research 1 [2]		Okunishi
	Nuclear and electron spin dynamics on quantum fluids	Yasuhiro Shimizu (Shizuoka U.)	
	t-design generation protocol in quantum many-body systems	Masaki Owari (Shizuoka U.)	
	Field dependence of Majorana excitations in a Kitaev quantum spin liquid	Yuta Mizukami (Tohoku U.)	
14:45-15:15	Coffee break		
15:15-16:00	Reports from Publicly Offered Research 2[2]		Okunishi
	Toward the Hawking radiation with self-interaction	Takahiro Tanaka (Kyoto U.)	
	Quantum Gas Microscopy of a frustrated XY model in Shaken Triangular lattice	Hideki Ozawa (RIKEN)	
	Tensor renormalization group study of entanglement entropy in quantum field theories (Video)	Yoshinobu Kuramashi (Center for Com. Sci.)	
16:00-16:30	Coffee break		
16:30-17:00	Gongshow (A) [3]		Nishioka
17:00-18:30	Poster Session (A)[3]		

[1] For details about the seminars (titles and abstracts), please refer to pages 5-8.
[2] For details about oral presentations (titles and abstracts), please refer to pages 9-19.
[3] For details about posters (poster numbers, location, titles, and abstracts), please refer to pages 20-33.

Sept. 26

	Title	Speaker	Chair
9:00-10:00	B01 group report and seminar[1]		Tezuka
	B01 group report	Norihiro Iizuka (NTHU)	
	String entanglement entropy	Masaki Shigemori (Nagoya U.)	
10:00-11:00	C01 group report and seminar[1]		
	C01 group report	Tadashi Takayanagi (YITP, Kyoto U.)	
	Deriving a gauge-gravity correspondence	Yasuaki Hikida (YITP, Kyoto U.)	
11:00-11:30	Coffee break		
11:30-12:30	A01 group report and seminar[1]		Nakajima
	A01 group report	Tomoyuki Morimae (YITP, Kyoto U.)	
	Quantum cryptography without one-way functions	Tomoyuki Morimae (YITP, Kyoto U.)	
12:30-14:00	Lunch break		
14:00-14:45	Reports from Publicly Offered Research 3[2]		Kobayashi
	Black Hole Singularity and Timelike Entanglement	Kotaro Tamaoka (Nihon U.)	
	What can we learn about quantum magnets from experimentally accessible entanglement measures?	Tokuro Shimokawa (OIST)	
	Physics of quantum entanglement in curved spacetimes: application of partner formula	Yasusada Nambu (Naogya U.)	
14:45-15:15	Coffee break		
15:15-16:00	Reports from Publicly Offered Research 4[2]		M.Hotta
	Emergent spin-gapped magnetization plateaus in a spin-1/2 perfect kagome antiferromagnet	Shota Suetsugu (Kyoto U.)	
	Fun with exclusion processes and the double-scaled SYK	Masataka Watanabe (Nagoya U.)	
	Measurement-induced entanglement between quantum spin chains	Masaki Oshikawa (U. of Tokyo)	
16:00-16:30	Coffee break		
16:30-17:15	Reports from Publicly Offered Research 5[2]		Izumi
	Emergent physics from quantum entanglement	Tokiro Numasawa (U. of Tokyo)	
	Detecting nonclassical primordial gravitational waves with Hanbury Brown - Twiss interferometry	Sugumi Kanno (Kyushu U.)	
	Black Strings in Standard Model and Beyond	Yuta Hamada (KEK)	
18:00-20:30	Banquet @ Cafeteria, La Foret, Osaka U.		

Sept. 27

	Title	Speaker	Chair
9:00-10:00	B02 group report and seminar[1]		Morimae
	B02 group report	Masaki Tezuka (Kyoto U.)	
	Measuring entanglement entropy in quantum many-body systems via spiral quantum state tomography	Daisuke Yamamoto (Nihon U.)	
10:00-11:00	C02 group report and seminar[1]		
	C02 group report	Go Yusa (Tohoku U.)	
	Anomalies in quantum field theory and string theory (Online)	Kazuya Yonekura (Tohoku U.)	
11:00-11:30	Coffee break		
11:30-12:30	C03 group report and seminar[1]		Ishibashi
	C03 group report	Tetsuya Shiromizu (Nagoya U.)	
	Areal inequality in weak gravity region with Maxwell field	Keisuke Izumi (Nagoya U.)	
12:30-14:00	Lunch break		
14:00-14:45	Reports from Publicly Offered Research 6[2]		Ueda
	Bridging magic and non-Gaussian resources via Gottesman-Kitaev-Preskill encoding	Ryuji Takagi (U. of Tokyo)	
	Investigation of topological phases and transitions via quantum control, quantum entanglement, and duality	Shunsuke Furukawa (Keio U.)	
	Entanglement Properties of (2+1)-dimensional SU(3) Yang-Mills Theory in Hamiltonian Formalism	Yoshimasa Hidaka (YITP, Kyoto U.)	
14:45-15:15	Coffee break		
15:15-16:00	Reports from Publicly Offered Research 7[2]		Nakata
	Symmetry classification of non-Hermitian random matrices and open quantum systems (Video)	Kohei Kawabata (U. of Tokyo)	
	Toward Measuring Entanglement Spectrum in Quantum Spin Models Using a Programmable Cold-Atom Quantum Simulator	Seiji Sugawa (U. of Tokyo)	
	High acceleration field generation by short focused laser wake field acceleration to investigate the Unruh effect	Kotaro Kondo (QST)	
16:00-16:30	Coffee break		
16:30-17:00	Gongshow (B)[3]		Shiromizu
17:00-18:30	Poster Session (B)[3]		

Sept. 28

	Title	Speaker	Chair
9:00-10:00	D02 group report and seminar[1]		Yusa
	D02 group report	Kouichi Okunishi (Niigata U.)	
	Holographic analysis of boundary correlation functions for the hyperbolic-lattice Ising model	Kouichi Okunishi (Niigata U.)	
10:00-11:00	D01 group report and seminar[1]		
	D01 group report	Tatsuma Nishioka (Osaka U.)	
	Resurgence in Lorentzian quantum cosmology: no-boundary saddles and resummation of quantum gravity corrections around tunneling saddles	Masazumi Honda (RIKEN)	
11:00-11:15	Reports from Publicly Offered Research 8[2]		
	Tensor-network study of the SU(4) Heisenberg model	Ryui Kaneko (Sophia U.)	
11:15-11:45	Coffee break		
11:45-12:45	Forum		Takayanagi
	Panel Discussion on interdisciplinary Research in ExU Collaborations	Tomonori Ugajin (Rikkyo U.)	
		Norihiro Tanahashi (Kyoto U.)	
		Hiroshi Ueda (Osaka U.)	
		Yoshifumi Nakata (YITP)	
		Shuta Nakajima (Osaka U.)	
12:45-13:05	Advisor comment	Akio Hosoya (Tokyo Inst. Tech.)	
		Nobuyuki Imoto (U. of Tokyo)	
13:05-13:15	Closing	Tadashi Takayanagi (YITP, Kyoto U.)	

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List of Seminars

Kengo Maeda
Shibaura Institute of Technology

Instabilities of AdS spacetime in holographic semiclassical gravity

Sept. 25, 11:35-12:20

We show that D-dimensional AdS spacetimes (D=3,4,5) can be semiclassically unstable due to strongly interacting quantum field effects. First, we show that 3-dimensional AdS spacetime is unstable by inspecting linear perturbations of the (covering space of) static BTZ black hole with AdS4 gravity dual in the context of holographic semiclassical problems. In D=4 and D=5 cases, there are quantum corrections to the boundary Einstein–Hilbert action. In the framework of the quadratic gravity including higher derivative corrections, we show that the AdS spacetime can be unstable by inspecting linear perturbations of the hyperbolic zero mass AdS black holes with AdS5 and AdS6 gravity dual for some range of the renormalized coupling constants. Second, we study the thermodynamic stability by constructing D=3 and 5 dimensional asymptotically AdS semiclassical solutions with non-vanishing stress-energy tensor and computing free energies of the solutions. In D=3 case, the free energy of the AdS solution with non-vanishing "quantum hair" is smaller than that of the pure BTZ or the AdS3 solution. In D=5 case, we find that the free energy of the hairly AdS black hole solution is smaller than that of the hyperbolic zero mass AdS black hole when the coupling constant is small.

Masaki Shigemori
Nagoya University

String entanglement entropy

Sept. 26, 9:15-10:00

Entanglement entropy quantifies quantum entanglement between two subsystems and has become an important notion in various fields of theoretical physics. In this talk, we will discuss aspects of string entanglement entropy.

Yasuaki Hikida
YITP, Kyoto University
Deriving a gauge-gravity correspondence
Sept. 26, 10:15-11:00

Gauge-gravity correspondence can be used to define quantum gravity as it relates gravity theory to non-gravitational particle theory. A famous example is given by AdS/CFT correspondence, which states duality between gravity theory on anti-de Sitter (AdS) space and lower dimensional conformal field theory (CFT). This was proposed by Maldacena about 25 years ago but has not yet been generally proven. Recently, significant progress has been made in this direction based on the tensionless limit of string theory on 3d AdS with NSNS-flux. In this talk, I will derive an AdS/CFT correspondence involving the tensionless strings and extend it away from the tensionles limit.

Tomoyuki Morimae
YITP, Kyoto University
Quantum cryptography without one-way functions
Sept. 26, 11:45-12:30

One-way functions are the minimum assumption in classical cryptography. On the other hand, in quantum cryptography where quantum computing and quantum communications are possible, recent studies suggest that one-way functions are not necessarily the minimum assumption. In this talk, I explain recently introduced several new primitives, such as pseudorandom state generators, one-way state generators, and EFI pairs, and show relations among them. I also give many open problems in this new field. This talk is based on joint works with Takashi Yamakawa (NTT) [Morimae and Yamakawa, Crypto 2022].

Daisuke Yamamoto
Nihon University
Measuring entanglement entropy in quantum many-body systems via spiral quantum state tomography
Sept. 27, 9:15-10:00

Quantum state tomography is a crucial tool for reconstructing the density matrices of quantum states stored in quantum computers or simulators. Unlike methods that measure specific physical observables, one of the primary purposes of full density matrix reconstruction is to extract entanglement measures from the quantum state. However, this approach typically requires an exponentially increasing number of measurement setups as the size of quantum platforms grows, often necessitating local operations on individual particles or qubits to enable measurements in different bases. Here, we introduce a tomography scheme that utilizes compressed sensing based on spiral measurements, which scales far more efficiently and eliminates the need for local addressing of individual constituents. Our results demonstrate that this method can effectively measure specific entanglement properties of quantum many-body states, such as von Neumann and Rényi entanglement entropies. This technique holds promise across a wide range of quantum platforms, including those where precise individual operations are particularly challenging, such as optical lattice systems.

Kazuya Yonekura
Tohoku University
Anomalies in quantum field theory and string theory
Sept. 27, 10:15-11:00 (Online)

In the first half of the talk, I will review a nonperturbative description of anomalies in quantum field theory. It is related to "bulk-edge correspondence" or "symmetry protected topological phases" in condensed matter physics. In the second half of the talk, I talk about how that description of anomalies can be used to understand precise topological structures of spacetimes in string theory.

Keisuke Izumi
Nagoya University
Areal inequality in weak gravity region with Maxwell field
Sept. 27, 11:45-12:30

The Riemannian Penrose inequality gives the upper bound of the area of the outermost minimal surface in an asymptotically flat space with non-negative curvature. This inequality gives, roughly speaking, the upper-bound area of a black hole horizon. This inequality can be applied to a minimal surface, that is, a surface in a region with a strong gravitational field. At the ExU International Workshop in Sep. 2022, I gave a talk on a generalization of the Riemannian Penrose inequality. Our inequality can be applied to a surface (called an attractive gravity probe surface, an AGPS) in a weak gravity region. We recently analyze the effect of the Maxwell field. We show that the lower bound of the surface area also exists and that the electric charge inside the surface cannot be larger than a critical value, which becomes the extremal charge of the black hole (i.e. Q=M) if the surface is a minimal surface. We could say that this critical charge is the extremality condition for an AGPS.

Kouichi Okunishi
Niigata University
Holographic analysis of boundary correlation functions for the hyperbolic-lattice Ising model
Sept. 28, 9:15-10:00

We analyze boundary spin correlation functions of the hyperbolic-lattice Ising model from the holographic point of view. Using the corner-transfer-matrix renormalization group method, we demonstrate that the boundary correlation function exhibits power-law decay with quasi-periodic oscillation, while the bulk correlation function always decays exponentially. On the basis of the geometric relation between the bulk correlation path and distance along the outer edge boundary, we find that scaling dimensions for the boundary correlation function can be well explained by the combination of the bulk correlation length and background curvatures inherent to the hyperbolic lattice.

Masazumi Honda
RIKEN

Resurgence in Lorentzian quantum cosmology: no-boundary saddles and resummation of quantum gravity corrections around tunneling saddles

Sept. 28, 10:15-11:00

I am going to talk on our recent work revisiting the path-integral approach to the wave function of the universe by utilizing Lefschetz thimble analyses and resurgence theory. The traditional Euclidean path-integral of gravity has the notorious ambiguity of the direction of Wick rotation. In contrast, the Lorentzian method can be formulated concretely with the Picard-Lefschetz theory. Yet, a challenge remains: the physical parameter space lies on a Stokes line, meaning that the Lefschetz-thimble structure is still unclear. Through complex deformations, we resolve this issue by uniquely identifying the thimble structure. This leads to the tunneling wave function, as opposed to the no-boundary wave function, offering a more rigorous proof of the previous results. Further exploring the parameter space, we discover rich structures: the ambiguity of the Borel resummation of perturbative series around the tunneling saddle points is exactly cancelled by the ambiguity of the contributions from no-boundary saddle points. This indicates that resurgence works also in quantum cosmology, particularly in the minisuperspace model. This talk is based on a collaboration with Hiroki Matsui, Kazumasa Okabayashi and Takahiro Terada (arXiv:2402.09981).

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List of Presentations from Publicly Offered Research Projects (Group E)

Yasuhiro Shimizu
Shizuoka University

Nuclear and electron spin dynamics on quantum fluids

Sept. 25, 14:00-14:15

Quantum spin liquid hosts macroscopic quantum entanglement and emergent quasiparticles. We investigate hydrodynamics of quantum liquids in one and two dimensional systems utilizing nuclear magnetic resonance. We find the critical exponent of Tomonaga-Luttinger liquid and the fractionalized excitation of Kitaev spin liquid. The quantum time crytal behavior is observed in the nuclear spin dynamics during the long quantum coherence time of quantum spin liquid.

Masaki Owari
Shizuoka University

t-design generation protocol in quantum many-body systems

Sept. 25, 14:15-14:30

Random unitary transformations based on t-designs are essential in various quantum information processing. It has also been found to be important as a method for approximating quantum chaotic systems and as a mechanism for generating thermalization and equilibration in many-body systems. However, conventional t-design generation protocols are designed as efficient algorithms on quantum computers. Hence, it is difficult to implement them on a quantum many-body system. In this presentation, we will first introduce a method for generating efficient t-designs on quantum many-body systems and a variational quantum algorithm on quantum many-body systems based on this method. We will also introduce a recently obtained method of adapting error mitigation to variational quantum algorithms on quantum many-body systems.

Yuta Mizukami
Tohoku University

Field dependence of Majorana excitations in a Kitaev quantum spin liquid

Sept. 25, 14:30-14:45

Quantum spin liquid is an exotic quantum state of matter in which interacting spins do not exhibit long-range magnetic order down to absolute zero temperature due to quantum fluctuations. Quantum spin liquid state is characterized by massive quantum entanglement, leading to realization of topological phases and fractionalized quasiparticle excitations. The Kitaev model [1] is a quantum spin model in which the bond-dependent Ising interaction JK acts on 1/2 spins on a honeycomb lattice with exactly solvable ground state of quantum spin liquid [2,3]. In this state, the spins are fractionalized and described by Majorana excitations. The low-energy excitations are characterized by gapless itinerant Majorana excitations with Dirac-type linear dispersion when the anisotropy of bond-dependent JK is small. In the presence of large JK anisotropy, on the other hand, the low-energy excitations are gapped out. In real material, the honeycomb magnet a-RuCl3 emerged as one of the promising candidates for Kitaev quantum spin liquid [2,3]. Thermal Hall conductivity measurements have reported the edge states of the Majorana fermion [4], and heat capacity measurements have revealed topological bulk state in the magnetic-field induced Kitaev quantum spin liquid state [5,6]. However, the role of magnetic field in this state is still unclear and the field dependence of the spin liquid state is not completely understood. This talk will present the detailed field dependence of the Majorana excitations for a-RuCl3 obtained by heat capacity measurements under in-plane field rotation and possible origins for the results will be discussed.

In collaboration with R. Ohno, Y. Kawai, N. Kimura, and J. Nasu in Tohoku University, O. Tanaka, R. Harasawa, K. Imamura, Y. Yoshida, K. Hashimoto, and T. Shibauchi in the University of Tokyo, Y. Suetsugu, K. Otsuka, Y. Kasahara, and Y. Matsuda in Kyoto University, K. Hwang, P. Noh, and E.-G. Moon in the Korea Advanced Institute of Science and Technology, N. Kurita and H. Tanaka in the Tokyo Institute of Technology, M. G. Yamada in Gakushuin University, S. Fujimoto in Osaka University.

[1] A. Kitaev, Ann. Phys. 321, 2-111 (2006).
[2] H. Takagi, T. Takayama, G. Jackeli, G. Khaliullin, and S. E. Nagler, Nat. Rev. Phys. 1, 264-349 (2019).
[3] Y. Motome, and J. Nasu, J. Phys. Soc. Jpn. 89, 012002 (2020).
[4] Y. Kasahara et al., Nature 559, 227-231 (2018).
[5] O. Tanaka, Y. Mizukami et al., Nat. Phys. 18, 429-435 (2022).
[6] K. Imamura, S. Suetsugu, Y. Mizukami et al., Sci. adv. 10, eadk3539 (2024).

Takahiro Tanaka
Kyoto University

Toward the Hawking radiation with self-interaction

Sept. 25, 15:15-15:30

I'd like to discuss the topin in the title. This is just a preliminary work. The semiclassical picture of Hawking radiation seems to be established. However, once the interaction of the radiating fields is turned on, the description of the process is far from well-understood. I'd like to attack the problem to unveil what kind of change is brought by introducing the interaction into account.

Hideki Ozawa
RIKEN
Quantum Gas Microscopy of a frustrated XY model in Shaken Triangular lattice
Sept. 25, 15:30-15:45

Frustrated spin systems are one of the most intriguing problems of magnetism and condensed matter physics. Even in the case of the simplest geometrical spin frustration that occurs in the triangular structure with antiferromagnetic interactions, competition between the interactions and the lattice geometry can bring about rich spin phases. There has recently been steady progress in simulating quantum magnetism using a quantum gas microscope (QGM). In our group, we have developed an experimental setup of an 87Rb Bose gas in an optical triangular lattice with QGM, which can reveal real-space properties in the frustrated spin system. To introduce the antiferromagnetic interactions, we use a lattice shaking technique, which enables independent control of the time-averaged effective tunneling by sinusoidally modulating the position of the entire lattice. Mapping the BEC phase onto spins allows the simulation of the classical XY model. We identify the interference patterns of each phase in the model by the time-of-flight method. A geometrical frustration induced by negative tunneling leads to two-fold ground states corresponding to two chiral modes. Due to spontaneous symmetry breaking, one of the chiral modes randomly appears sequence by sequence. Furthermore, in the case of non-adiabatic ramp-up of shaking amplitude, simultaneous occupation of the two chiral modes is observed, which we attribute to chiral-mode domains. In this poster, we will report on the most recent progress.

Yoshinobu Kuramashi
Center for Computational Sciences
Tensor renormalization group study of entanglement entropy in quantum field theories
Sept. 25, 15:45-16:00 (Video)

The purpose of my research project is to make a nonperturbative study of the entanglement entropy in quantum field theories with the tensor renormalization group (TRG) method. In this talk we present the TRG results of the entanglement entropy of the (1+1)-dimensional O(3) nonlinear sigma model. We calculate the von Neumann and Rényi types of entanglement entropies and examine the consistency between them. The central charge is also determined from the asymptotic scaling properties of the entropies.

Kotaro Tamaoka
Nihon University
Black Hole Singularity and Timelike Entanglement
Sept. 26, 14:00-14:15

We study timelike and conventional entanglement entropy as potential probes of black hole singularities via the AdS/CFT correspondence. Using an analytically tractable example, we find characteristic behavior of holographic timelike entanglement entropy when the geometry involves a curvature singularity. We also observe interesting phenomena that, in some particular setups, holographic timelike and conventional entanglement entropy are determined from

multiple complex saddle points, which fall outside the assumptions of the Lewkowycz-Maldacena type argument.

Tokuro Shimokawa
OIST

What can we learn about quantum magnets from experimentally accessible entanglement measures?

Sept. 26, 14:15-14:30

Quantum entanglement is currently a major research topic that is being actively discussed across various fields. In condensed matter physics, elucidating the quantum entanglement properties inherent in quantum materials and enabling their measurement and control has been a long-standing goal. Over the past decades or so, theoretical research using entanglement entropy (EE) has developed, deepening our understanding of such as the topological properties and criticality of quantum phases. However, EE is known to be difficult to apply to mixed states, and except for a few cases such as cold atom systems, it is extremely challenging to measure experimentally. Therefore, the search for new experimentally accessible entanglement measures that can replace EE continues.

In this context, several experimentally accessible quantum entanglement measures have recently garnered attention. Specifically, entanglement measures such as one-tangle, two-tangle, and quantum Fisher information [1-3] could be rewritten in terms of simple spin local magnetization, two-point correlation functions, and spin dynamics, which can be measured using existing experimental techniques. This is particularly true for spin Hamiltonians that effectively represent quantum materials, depending on their symmetries. In fact, inelastic neutron scattering experiments have already been used to measure quantum entanglement measures in several quantum magnets which could be described relatively simple spin Hamiltonians [4-6].

We have numerically investigated the usefulness of these three quantum entanglement measures, focusing on their application to the experimental identification of quantum spin liquid states and random singlet states, which manifest in low-dimensional magnetic systems [7, 8]. In our talk, we aim to summarize what we can learn and cannot learn about these two quantum states from the three quantum entanglement measures based on our numerical findings, and to discuss future prospects.

[1] L. Amico et al., Phys. Rev. A 69, 022304 (2004).
[2] W. K. Wootters et al, Phys. Rev. Lett. 78, 5022 (1997)
[3] P. Hauke et al., Nat. Phys. 12, 778 (2016).
[4] P. Laurell et al., Phys. Rev. Lett. 127, 037201 (2021).
[5] A. Scheie et al., Phys. Rev. B 103, 224434 (2021).
[6] A. O. Scheie et al., Nat. Phys. (2023).
[7] S. Sabharwal, T. S., and N. Shannon, arXiv:2407.20797.
[8] T. S., S. Sabharwal, and N. Shannon, in preparation.

Yasusada Nambu
Naogya University

Physics of quantum entanglement in curved spacetimes: application of partner formula

Sept. 26, 14:30-14:45

The partner formula provides "shape" of the modes that purifies specified modes of quantum fields. In this research we focus on profiles of partner modes of quantum fields in spacetimes with horizons. As an application of the partner formula, we investigate entanglement harvesting from quantum field using two local detector modes. The introduced detector modes show disentanglement behavior when the separation between local modes becomes larger. We discuss the relation between possibility of entanglement harvesting, shapes of detector modes and partner modes, and monogamy property of entanglement.

Shota Suetsugu
Kyoto University

Emergent spin-gapped magnetization plateaus in a spin-1/2 perfect kagome antiferromagnet

Sept. 26, 15:15-15:30

Quantum spin liquids (QSLs) represent an exotic states of matter characterized by the suppression of long-range magnetic order due to strong quantum fluctuations. The two-dimensional (2D) spin-1/2 kagome Heisenberg antiferromagnet (AFM) serves as a prime example for the QSL. However, understanding its ground state has been one of the most vexing issues in quantum magnetism. Indeed, whether the ground state in zero field is gapped or gapless has been highly controversial. The ground state in external magnetic field has also been largely elusive. Here we examine the ground state of YCOB in intense magnetic fields up to 60 T. Clear magnetization plateaus at 1/9 and 1/3 of the the saturation moment of Cu2+ ions have been observed [1], supporting YCOB as an ideal platform for the kagome Heisenberg AFM. Magnetocaloric measurements evince an entropy anomaly [2], constituting thermodynamic evidence that magnetic fields instigate the opening of a spin gap, driving a quantum phase transition into a 1/9 magnetization plateau state. These results provide crucial insights into the ground state of the magnetization plateau phases of the kagome AFM.

[1] S. Suetsugu et al. Phys. Rev. Lett. 132, 226701 (2024).
[2] S. Suetsugu et al., arXiv:2407.16208 (2024).

Masataka Watanabe
Nagoya University

Fun with exclusion processes and the double-scaled SYK

Sept. 26, 15:30-15:45

I will report on the stationary and the dynamical phase transitions of one-dimensional lattice gas models with infinitesimal deformation describing attachment and detachment. I will relate such deformation to that of the double-scales SYK model.

Masaki Oshikawa
University of Tokyo
Measurement-induced entanglement between quantum spin chains
Sept. 26, 15:45-16:00

We discuss the entanglement between two critical spin chains induced by the Bell-state measurements, when each chain was independently in the ground state before the measurement. This corresponds to a many-body version of "entanglement swapping". We employ a boundary conformal field theory (CFT) approach and describe the measurements as conformal boundary conditions in the replicated field theory. We show that the swapped entanglement exhibits a logarithmic scaling, whose coefficient takes a universal value determined by the scaling dimension of the boundary condition changing operator. We apply our framework to the critical spin-1/2 XXZ chain and determine the universal coefficient by the boundary CFT analysis, which is verified by a numerical calculation. This talk is based on M. Hoshino, M. O., and Y. Ashida, arXiv:2406.12377

Tokiro Numasawa
University of Tokyo
Emergent physics from quantum entanglement
Sept. 26, 16:30-16:45

Quantum entanglement plays a crucial role in both quantum gravity and condensed matter physics. In particular, the structure of entanglement is fundamentally important for understanding emergent spacetime and topological phases. In this presentation, I will discuss the relationship between entangled states, emergent spacetime, topological phases, and effective field theory, using the Fermi surface as an example.

Sugumi Kanno
Kyushu University
Detecting nonclassical primordial gravitational waves with Hanbury Brown - Twiss interferometry
Sept. 26, 16:45-17:00

I will talk about possible detection of nonclassicality of primordial gravitational waves (PGWs) by applying Hanbury Brown - Twiss (HBT) interferometry to cosmology. I will characterize the nonclassicality of PGWs in terms of sub-Poissonian statistics that can be measured by the HBT interferometry. We found that the presence of matter fields during inflation makes us possible to detect nonclassical PGWs with the HBT interferometry. It turns out that PGWs with frequencies higher than 10 kHz enable us to detect their nonclassicality.

Yuta Hamada
KEK
Black Strings in Standard Model and Beyond
Sept. 26, 17:00-17:15

The Swampland cobordism conjecture predicts various new objects in a theory with dynamical gravity. Applying this idea to the Standard Model of particle physics, a string object is predicted. We numerically constructed such an object as a black string solution.

Ryuji Takagi
University of Tokyo
Bridging magic and non-Gaussian resources via Gottesman-Kitaev-Preskill encoding
Sept. 27, 14:00-14:15

Although the similarity between non-stabilizer states—also known as magic states—in discrete-variable systems and non-Gaussian states in continuous-variable systems has widely been recognized, the precise connections between these two notions have still been unclear. We establish a fundamental link between these two quantum resources via the Gottesman-Kitaev-Preskill (GKP) encoding. We show that the negativity of the continuous-variable Wigner function for an encoded GKP state coincides with a magic measure we introduce, which matches the negativity of the discrete Wigner function for odd dimensions. We also provide a continuous-variable representation of the stabilizer Rényi entropy—a recent proposal for a magic measure for multi-qubit states. With this in hand, we give a classical simulation algorithm with runtime scaling with the resource contents, quantified by our magic measures. We also employ our results to prove that implementing a multi-qubit logical non-Clifford operation in the GKP code subspace requires a non-Gaussian operation even at the limit of perfect encoding, despite the fact that the ideal GKP states already come with a large amount of non-Gaussianity.

Shunsuke Furukawa
Keio University

Investigation of topological phases and transitions via quantum control, quantum entanglement, and duality

Sept. 27, 14:15-14:30

The concept of symmetry-protected topological (SPT) phases has been proposed and fruitfully developed over the last 15 years. While SPT phases of bosons in one spatial dimension is fully classified by projective representations of the symmetry group, it is interesting to examine when nontrivial SPT phases emerge and how they compete with ordered phases in concrete systems. Here we investigate this question in a spin-1/2 XXZ ladder with a chirality-chirality interaction (CCI). The spin-chirality duality relates the regimes of weak and strong CCIs, and helps to explore a rich phase diagram. We find that weak XXZ anisotropy crucially affects the phase structure, inducing two distinct SPT phases in the easy-plane regime and Neel and vector chiral ordered phases in the easy-axis regime. The two phases in each regime are dual to each other, and a transition between them occurs on the self-dual line. While the two SPT phases can both be viewed as twisted variants of the Haldane phase, they can be distinguished by a topological index associated with the time-reversal symmetry. We also discuss our ongoing work on error-mitigated quantum computation of string order parameters across a topological phase transition.

Yoshimasa Hidaka
YITP, Kyoto University

Entanglement Properties of (2+1)-dimensional SU(3) Yang-Mills Theory in Hamiltonian Formalism

Sept. 27, 14:30-14:45

We study the entanglement properties of (2+1)-dimensional SU(3) Yang-Mills theory using the Hamiltonian formulation. To calculate the entanglement entropy of a given region in a gauge-invariant manner, we employ the techniques of von Neumann algebra. We evaluate the entanglement entropy using an ansatz for the wave function that exactly reproduces the wave functions in both the weak and strong coupling limits.

Kohei Kawabata
University of Tokyo

Symmetry classification of non-Hermitian random matrices and open quantum systems

Sept. 27, 15:15-15:30

Non-Hermitian random matrices have been employed across diverse areas of science. However, the influence of symmetry and the corresponding classification of their universality classes have been largely unclear. Here, we present a series of our works on the classification of non-Hermitian random matrices based on the 38-fold fundamental symmetry. Furthermore, we demonstrate that non- Hermitian random matrices lay the foundation for quantum chaos in various open systems.

References

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Seiji Sugawa
University of Tokyo

Toward Measuring Entanglement Spectrum in Quantum Spin Models Using a Programmable Cold-Atom Quantum Simulator

Sept. 27, 15:30-15:45

Understanding quantum entanglement of quantum many-body states is essential for characterizing quantum many-body systems, such as topologically ordered phases and many-body localization. Despite its significance and theoretical interest, experimentally measuring entanglement in quantum many-body systems remains challenging. In our project, we aim to experimentally elucidate the entanglement structure of ground states in quantum spin models using programmable cold-atom quantum simulators. The key idea is to implement the entanglement Hamiltonian as a physical many-body Hamiltonian by deforming the original many-body Hamiltonian. By experimentally simulating this Hamiltonian, the entanglement spectrum can be measured spectroscopically. In my talk, I will review recent experimental work on measuring quantum entanglement in synthetic quantum many-body systems using cold-atoms and introduce our research plan.

Kotaro Kondo
National Institutes for Quantum Science and Technology

High acceleration field generation by short focused laser wake field acceleration to investigate the Unruh effect

Sept. 27, 15:45-16:00

Quantum field theory predicts the Unruh effect[1, 2], which states that the quantum vacuum state is a thermal radiation state for a uniformly accelerated observer and that the radiation temperature is proportional to the acceleration. The Unruh effect is intrinsically related to the Hawking radiation by the equivalence principle, which can link general relativity, quantum information, and statistical mechanics. However, the Hawking radiation is difficult to detect because the Hawking temperature from a black hole of more than one solar mass is much lower than the cosmic microwave background radiation of about 3 K. Thus, experimental verification of the Unruh effect is desired. Since extremely high acceleration is required to study the Unruh effect, laser wakefield acceleration (LWFA)[3], which can realize a higher acceleration field than that of a conven- tional radio-frequency accelerator, is an attractive method. Recently, the maximum energy of electron beams from LWFA has been achieved to 10 GeV with a scale length of 10 cm[4]. However, the acceleration field is about 100 GV/m, and the temperature expected from the Unruh effect is below the temperature of liquid nitrogen. While long-focus optics with LWFA are practically applied for high energy gain, a high laser intensity is essential for a localized high acceleration field. In this study, we propose a new method to induce the higher acceler- ation field with higher laser intensity by using short-focus optics. Particle-in-cell simulations of short focused LWFA show a high acceleration field beyond TV/m with realistic PW-class laser parameters such as the high-intensity laser J-KAREN-P at KPSI, QST.

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Ryui Kaneko
Sophia University

Tensor-network study of the SU(4) Heisenberg model

Sept. 28, 11:00-11:15

This research project aims to explore quantum spin liquids that emerge in non-equilibrium systems using tensor network methods. Quantum spin liquids are insulators without spontaneous symmetry breaking, even at zero temperature, making their characterization challenging. Quantum entanglement has recently become a good indicator for characterizing quantum spin liquids in equilibrium systems. On the other hand, research on quantum spin liquids in non-equilibrium systems remains largely unexplored, and understanding their properties could deepen our understanding of thermalization mechanisms and non-equilibrium quantum phase transitions. Tensor network methods are highly accurate numerical techniques that also provide information on entanglement, making them promising for exploring novel quantum states in non-equilibrium systems. In this talk, I will present the ground states of the SU(4) Heisenberg model in equilibrium systems using the two-dimensional tensor network method as a step toward exploring novel quantum states in non-equilibrium systems. This model can be realized in systems such as ultracold-atomic gases in optical lattices and antiferromagnets where spin and orbital degrees of freedom are intertwined. The model can realize unconventional quantum states that do not appear in the simple SU(2) Heisenberg model. I will report on the novel quantum states and phase transitions obtained through tensor network calculations and propose methods for observing these phenomena experimentally in ultracold-atomic gases in optical lattices.

Updated: September 25, 2024

List of poster presentations

Gongshow & Poster Session (A): Sept. 25, 16:30-18:30

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A-02	Ryu Hayakawa (Kyoto University)
A-03	Hirotaka Yoshino (Osaka Metropolitan University)
A-04	Hideki Ozawa (Riken)
A-05	Yoshinori Matsuo (Kindai University)
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B-06	Yuichi Sata (Tohoku university)
B-07	Yusuke Taki (YITP, Kyoto University)
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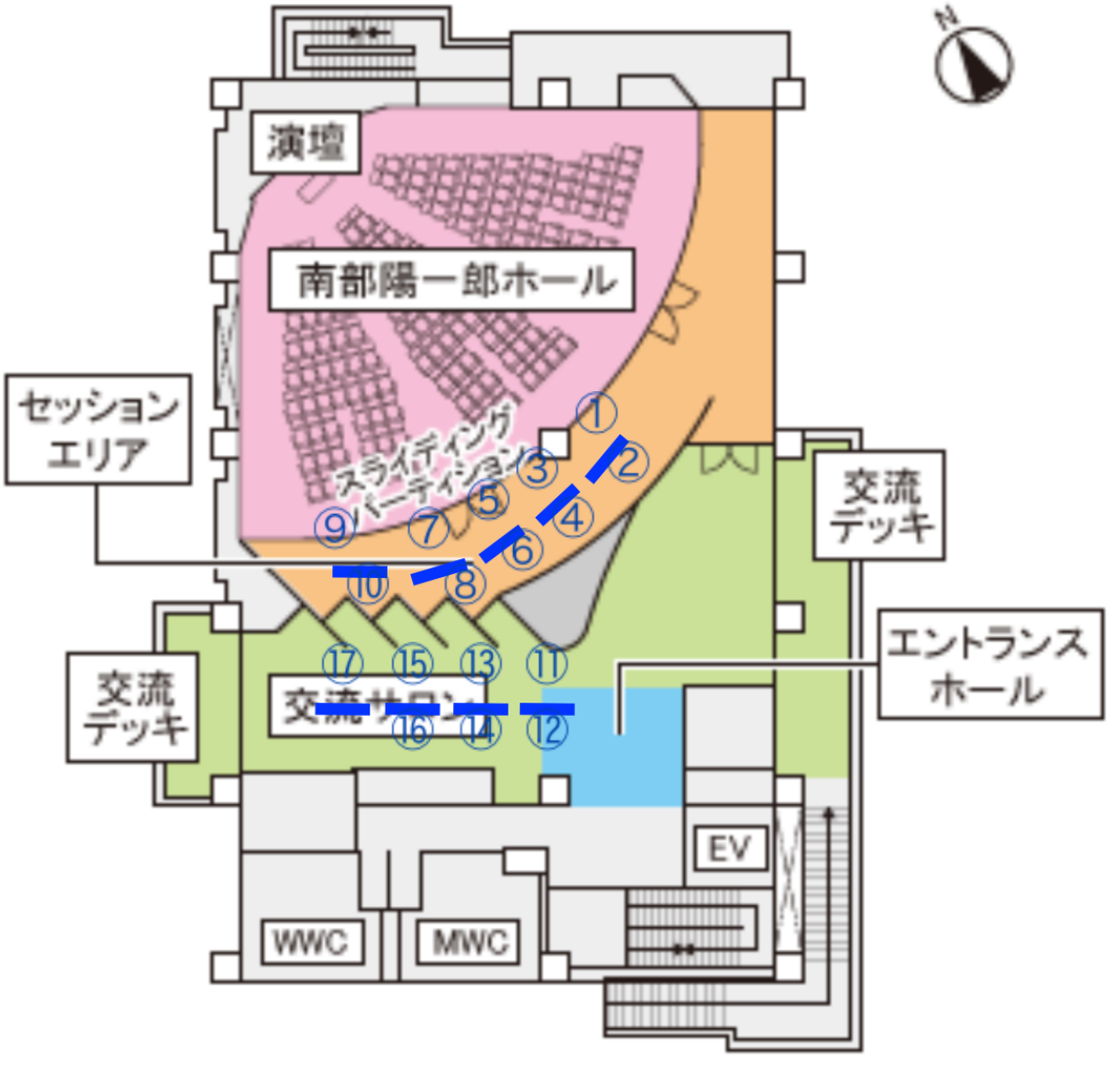
B-18	Ken-ichi Sasaki (NTT BRL)

Locations of Poster Boards in Nambu Yoichiro Hall



Notes:

- The locations of the posters are indicated by blue segments.
- Poster boards will be set up at the beginning of the coffee break from 14:45-15:15 for the first and third days.
- Poster presenters are requested to put up their posters to the corresponding poster boards during the coffee break after 15:00 on each day and remove them as soon as possible after each poster session ends.

Masato Nozawa
Osaka Institute of Technology
Supersymmetry of the Robinson-Trautman solution
Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-01

The Robinson-Trautman solution in Einstein-Maxwell-Λ system admits a shear-free and twist-free null geodesic congruence with a vanishing expansion. Restricting to the case where the Maxwell field is also aligned, i.e., the spacetime is algebraically special, we undertake a comprehensive classification of spacetimes allowing a Killing spinor in the four dimensional N = 2 gauged supergravity. The differential constraints coming from the integrability conditions of the Killing spinor equation enable us to systematically reconstruct the metric.

Ryu Hayakawa
Kyoto University
Quantum algorithms and complexity of persistent Homology
Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-02

Topological data analysis (TDA) is a modern framework for information processing based on the "topology of the data". Interestingly, recent results suggest that the "extreme" complexity of persistent homology is fundamentally quantum. I argue this through 1. quantum algorithms with potential quantum advantage, 2. quantum computational complexity, and 3. relation to quantum many-body physics.

Hirotaka Yoshino
Osaka Metropolitan University
Initial data for a Kluza-Klein bubble with a black hole
Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-03

If the extra dimension shrinks to zero size, there "appears" a Kaluza-Klein (KK) bubble of nothing, whose first solution was found by Witten. Recently, several exact solutions for a black hole spacetime with a KK bubble ("a capped black hole") have been found. While Witten's KK bubble expands rapidly, the KK bubble of a capped black hole stays static. In order to explore the interaction between the KK bubble and a black hole in more general setups, I am planning to develop the method for studying such phenomena by numerical relativity. In this presentation, I present the preliminary results for the initial data construction.

Hideki Ozawa
Riken

Quantum Gas Microscopy of a frustrated XY model in Shaken Triangular lattice

Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-04

Frustrated spin systems are one of the most intriguing problems of magnetism and condensed matter physics. Even in the case of the simplest geometrical spin frustration that occurs in the triangular structure with antiferromagnetic interactions, competition between the interactions and the lattice geometry can bring about rich spin phases. There has recently been steady progress in simulating quantum magnetism using a quantum gas microscope (QGM). In our group, we have developed an experimental setup of an 87Rb Bose gas in an optical triangular lattice with QGM, which can reveal real-space properties in the frustrated spin system. To introduce the antiferromagnetic interactions, we use a lattice shaking technique, which enables independent control of the time-averaged effective tunneling by sinusoidally modulating the position of the entire lattice. Mapping the BEC phase onto spins allows the simulation of the classical XY model. We identify the interference patterns of each phase in the model by the time-of-flight method. A geometrical frustration induced by negative tunneling leads to two-fold ground states corresponding to two chiral modes. Due to spontaneous symmetry breaking, one of the chiral modes randomly appears sequence by sequence. Furthermore, in the case of non-adiabatic ramp-up of shaking amplitude, simultaneous occupation of the two chiral modes is observed, which we attribute to chiral-mode domains. In this poster, we will report on the most recent progress.

Yoshinori Matsuo
Department of Physics, Kindai University

Universal structure of islands in evaporating black holes

Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-05

We discuss universal behaviors of islands in black hole spacetimes. The entanglement entropy of Hawking radiation contains contributions from a region inside the horizon, which is called the island. Islands extend outside the horizon in the case of eternal black hole spacetimes, while are terminated behind the horizon in the case of evaporating black holes. This structure does not depend on details of the spacetime. We use the s-wave approximation for the matter part of the entanglement entropy, and see effects of islands explicitly. The gravity part pulls the quantum extremal surface outward while the matter part pushes it inward. We found that the effect of the matter part is stronger independent of details of the spacetime, and the island in evaporating black holes is always hidden behind the horizon.

Nicoló Zenoni
YITP, Kyoto University
Multipartite information in sparse SYK models
Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-06

In quantum field theories that admit gravity dual, specific inequalities involving entanglement entropy between arbitrary disjoint spatial regions hold. An example is the monogamy of mutual information. Inspired by this, we investigate the analogous entropy inequalities in the Sachdev-Ye-Kitaev (SYK) model and its sparse version, in which some of the SYK couplings are set to zero. Since these models have been argued to admit gravity duals up to a certain sparseness, it is interesting to see whether the multipartite entanglement structure changes in a sparseness-dependent manner. Rather than spatial entanglement, these models involve the entanglement among different flavors of Majorana fermions. Surprisingly, in the parameter space explored by our numerical analysis, all entropy inequalities are satisfied for any temperature and degree of sparseness for an arbitrary choice of flavor subregions.

Atis Yosprakob
Niigata University
The armillary sphere: a tensor network formulation for non-Abelian gauge theory
Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-07

We present a tensor network formulation for non-Abelian gauge theory in the reduced form–'the armillary sphere'. Using character expansion, it can be shown that matrix indices form a closed tensor network around each lattice site and can be completely traced out. This process eliminates the degeneracy in the singular value spectrum that the original tensor network has. We apply this technique for 2+1D SU(2) and SU(3) gauge theories at zero and finite temperatures and reproduce the deconfinement transition.

Kazuya Yamashita
Center for Quantum Information and Quantum Biology, Osaka University
New construction of a cold atomic system towards experiments on quantum information dynamics
Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-08

Quantum simulators using ultracold atoms are promising platform for quantum information study of many-body systems. We have been constructing an experimental setup of ultracold atoms in an optical lattice for observing measurement-induced transitions and for measuring out-of-time-ordered correlations (OTOC), which is an indicator of delocalization of quantum information. We have already achieved quantum degeneracy of lithium and loaded them into a two-dimensional optical lattice in Kyoto University. This past February, our laboratory moved to Osaka University and we have temporarily deconstructed our experimental setup and are now upgrading them to incorporate new coils and circuits for magnetic field control towards OTOC measurements and a high-resolution optical system for the measurement of entanglement entropy. We will report the current status of the reconstruction of the setup and future improvements.

Akira Matsumoto
Yukawa Institute for Theoretical Physics, Kyoto University

Theta-dependent mass spectrum of the 2-flavor Schwinger model in the Hamiltonian formalism

Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-09

We compute the theta-dependent mass spectrum of the 2-flavor Schwingr model using the tensor network in the Hamiltonian formalism. Since the theta term causes the operator mixing, we define the meson operators by diagonalizing the correlation matrix, and then the meson mass is obtained from the one-point functions. The method of computing the dispersion relation via the energy and momentum of the excited states can also be applied at any θ. We confirmed that the meson masses obtained by these methods agree with each other and are consistent with the calculation by the bosonized model. Furthermore, the one-point functions at $\theta = \pi$ reproduce the expected CFT-like behavior.

Taishi Kawamoto
Yukawa Institute of Theoretical Physics, Kyoto University

Finite Scaling of Eigenstate Thermalization from Black Hole Horizon

Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-10

The eigenstate thermalization hypothesis (ETH) provides a sufficient condition for thermalization and equilibration from any initial states in isolated systems with a large number of degrees of freedom. One part of this statement is that for large systems, the diagonal matrix elements of typical observables in the Hamiltonian eigenstate basis, that is, the expectation values of the energy eigenstates, depend smoothly on the corresponding energy values. This statement is highly related to the fact that the variance of the energy eigenstate expectation values is small. Indeed, it is conjectured that this variance shows power-law decay with respect to the Hilbert space dimension. On the other hand, in general relativity, it is expected that heavy objects undergo gravitational collapse. Additionally, it is known that gravitational systems with black holes exhibit maximally chaotic properties. By using the holographic principle, or specifically the AdS/CFT correspondence, these facts imply that holographic theories dual to higher-dimensional Einstein gravity will show chaotic behavior and also thermalization from high-energy states. Thus, we expect that holographic theories exhibit ETH, although there is no definitive proof for this. In this talk, we discuss that the variance of the eigenstate expectation values of primary and descendant operators shows power-law decay with respect to the Hilbert space dimension. This fact is derived from the quantum mixing properties of holographic theories with black hole gravitational duals. We also discuss the consequences of this scaling on thermalization. This talk is based on work in progress.

Takato Mori
YITP, Kyoto University/Perimeter Institute
Krylov complexity of purification
Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-11

Krylov complexities are known to quantify the spread of operators and states in time evolution and thus closely related to scrambling. However, it is usually very complicated to compute them as they are defined through recursion relations. In this poster, we define the Krylov complexities of purification (CoP) and consider how it is related to the original definition of complexities for states. We find that they can be computed in some cases from a few qubit to infinite dimensional systems. We show evidence that one definition of CoP behaves very similarly to the original complexity for mixed states before purification. Thus, it is anticipated that CoP provides an alternative measure for complexity of mixed states.

Akane Tanaka
Kindai university
Quantum focusing conjecture and string transition in evaporating black hole
Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-12

In general relativity, the focusing theorem is key to understanding the basic properties of gravitation. By combining the Raychaudhuri equation and certain energy conditions, the focusing theorem plays a central role in establishing various important results in general relativity, such as the singularity theorems[1]. But the focusing theorem is violated with quantum effects taken into account. The quantum focusing conjecture(QFC) was devised to solve this problem[2]. In the context of the black hole evaporation, the entanglement entropy of the Hawking radiation is decreasing after the Page time[3], and therefore it is not obvious whether the QFC holds in the black hole evaporation process especially after the Page time. The previous study[4] showed that the QFC is indeed satisfied in this context. However the background considered in [4] was approximated by the Vaidya metric, and quantum effects of matters in the semiclassical regime were not fully taken into consideration. In this presentation, I address this problem in a two-dimensional dynamical black hole of the Russo-Susskind-Thorlacius (RST) model[5], which allows us to solve the semiclassical equations of motion exactly. I will first give a suitable definition of the quantum expansion in two-dimensions and then prove that the QFC is satisfied for evaporating black holes in the RST model with the island formation taken into account[6]. As an extension of the results of [6], I will discuss a possible endpoint for the black hole evaporation. Specifically, I will explore the possibility of the black hole/string transition.
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Yunhyeon Jeong
Tohoku University

Analog Universe Expansion using Quantum Hall Edges

Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-13

Quantum Hall edges can be regarded as 1+1 dimensional spacetime from their properties of chiral Luttinger liquids. This spacetime is known as one of the conformal fields. We experimentally explore the properties of expanding spacetime of quantum Hall edges and reveal its condition of conformal symmetry. In this presentation, works for determining scale factors on created spacetimes, evaluating if the conformal symmetry survives and future experiments using this system will be shown.

Yu-ki Suzuki
Yukawa Institute for Theoretical Physics, Kyoto University

An alternative derivation of entanglement entropy

Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-14

We find an alternative derivation of entanglement entropy via double cone regularization. We demonstrate the calculation in free boson theory and 2-dim CFT. This is based on a collaboration with Taishi Kawamoto (C01).

Akihito Takeuchi
Tohoku University

The Ground State in Frustrated Ising Spin Ladder Systems

Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-16

In the Ising anisotropic quantum ANNNI models, the geometrical frustration and quantum effects are known to induce the KT transition and a liquid-like phase called the floating phase. However, the detailed role of frustration in these phase transitions remains elusive. In this presentation, we report on the phase diagram of the ground state obtained by the DMRG method.

Satoshi Matsumoto
Kindai University

No-hair properties of static black holes with cosmological constant in higher dimension

Sept. 25, (Gongshow & Poster Session (A) 16:30-18:30); Poster number: #A-17

We study no-hair properties of static black holes in four and higher dimensional spacetimes with a cosmological constant, and establish several theorems, which correspond to generalizations of Pena-Sudarsky's no-hair theorem, Nunez-Quevedo-Sudarsky's no-short-hair theorem and Sudarsky-Gonzalez's no-hair theorem to heigher dimension. For the vanishing cosmological constant case, we show a no-hair theorem and also a no-short-hair theorem under certain conditions for the energy-momentum of matter fields. For the positive cosmological constant case, we discuss conditions for hairy static black holes to exist in terms of the energy density of matter fields evaluated at the black hole horizon and the cosmological horizon. For the negative cosmological constant case, we study conditions for hairy black holes by presenting a no-hair

theorem in which the asymptotic structure is assumed to be determined by the true cosmological constant. This talk is based on the paper of A. Ishibashi, S. Matsumoto, Y. Yoneo, arXiv number 2210.03966 [gr-qc].

Kazunori Akiyama
Tohoku University

Conductive properties of edge channels in $\nu = 1/3$ fractional quantum Hall states

Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-01

It is known that nontrivial ordered states appear at certain filling factor in two-dimensional electron systems in a high magnetic field. In these systems there are conduction channels with unidirectional non-dissipative current at the sample edge. In this study, we use the DMRG and TDVP methods to numerically calculate the time evolution of the edge region of a $\nu = 1/3$ fractional quantum Hall state with the simplest edge structure. We will present the propagation of charge excitations along the edge when a potential breaking translational symmetry is added to an edge region.

Kotaro Shinmyo
YITP, Kyoto University

Probing de Sitter Space Using CFT States

Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-03

In this study we construct CFT states dual to local excitations in the three-dimensional de Sitter space (dS), called the bulk local states. We find that the conjugation operation in dS3/CFT2 is notably different from that in AdS3/CFT2. This requires us to combine two bulk local states constructed out of different primary states in a CPT-invariant way. This analysis explains why Green's functions in the dS Euclidean vacuum cannot simply be obtained from the Wick rotation of those in AdS. We also argue that this characteristic feature explains the emergence of time coordinate from the dual Euclidean CFT. We show that the information metric for the quantum estimation of bulk coordinate values replicates the de Sitter space metric.

Tomotoshi Nishino
Kobe University

Ising Model on the Stacked Pentagon Lattice

Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-04

We analyze the phase transition of the ferromagnetic Ising model on the stacked pentagon lattice, which has recursive structure like the Cayley tree. We observed the surface phase transition, which may occur by the loop structure of the lattice. A variant of the CTMRG method is employed for the numerical analyses.

Soichiro Mori
Nagoya University
Firewall in JT gravity
Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-05

This research builds upon Stanford and Yang's "Firewalls from Wormholes," which suggests that wormholes may create firewalls. Previous studies demonstrated that in the high-energy limit of JT gravity, a two-dimensional theory of quantum gravity, quantum effects cause the universe to emit baby universes, leading to the formation of firewalls in the process. In our study, we more clearly formulate the conditions under which firewalls emerge and show that, contrary to earlier discussions that focused only on high-energy contributions, low-energy contributions are in fact leading. Additionally, we introduce discussions related to the recently debated double-scaled SYK model.

Yuichi Sata
Tohoku university
Potential dependence of the edge state in fractional quantum Hall systems
Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-06

Fractional quantum Hall states are realized as incompressible quantum liquids with dissipationless topological transport properties. Since the bulk state is incompressible, the transport properties are characterized by the edge state of the incompressible quantum liquid. In this study, we numerically investigate the microscopic structural changes when a local potential is applied to the edge state. We report results obtained for $\nu = 1/3$ and $2/3$ Landau level fillings.

Yusuke Taki
YITP, Kyoto University
Semi-classical saddles of three-dimensional gravity via holography
Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-07

We find out the complex geometries corresponding to the semi-classical saddles of threedimensional quantum gravity by making use of the known results of dual conformal field theory (CFT), which is effectively given by Liouville field theory. We examine both the cases with positive and negative cosmological constants. We determine the set of semi-classical saddles to choose from the homotopy argument in the Chern-Simons formulation combined with CFT results and provide strong supports from the mini-superspace approach to the quantum gravity. For the case of positive cosmological constant, partial results were already obtained in our previous works, and they are consistent with the current ones. For the case of negative cosmological constant, we identify the geometry corresponding a semi-classical saddle with three-dimensional Euclidean anti-de Sitter space dressed with imaginary radius three-dimensional spheres. The geometry is generically unphysical, but we argue that the fact itself does not lead to any problems.

Kazuyoshi Yano
Nagoya University

Late Time Saturation of Bulk Complexity Probes : Operator Wormholes

Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-08

Recently, complexity has been studied intensively as a holographic dual of bulk quantities which grows for long time, far beyond the thermalization of entanglement entropy. Originally, the volume of wormhole was proposed as a complexity dual in bulk, but it has been pointed out that wide classes of bulk observables are candidate for gravitational dual of complexity. In previous study, the length of wormhole was evaluated using gravitational path integral including non-trivial geometry, and the transition from linear growth to saturation was observed. In this study, we focus on the codimension-0 observables in JT gravity, and evaluate the late time behavior. We compare these behaviors to the complexity and discuss the difference between the volume case.

Kosuke Makino
Kindai University

Probing energy conditions around hairy black holes by gravitational waves.

Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-09

Recently, hairy black holes have attracted much attention, as they can be regarded as an effective model of a black hole surrounded with dark matter and/or a quantum black hole. It is known that certain energy conditions are violated in some hair black hole solutions. It is of great interest to consider how to probe such hairy black holes, if exist in our universe, and the violation of the energy conditions via gravitational waves. In this talk, I will first review some examples of hairy black holes, e.g., Bardeen black holes and Hayward black holes, and show which type of energy conditions are violated in those hairy black hole solutions. Then, I will discuss how to probe the violation of energy conditions via quasi-normal modes (QNMs) by using WKB approximation.

Hiroki Kanda
YITP, Kyoto University

The g-theorem from Strong Subadditivity

Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-10

We show that strong subadditivity provides a simple derivation of the g-theorem for the boundary renormalization group flow in two-dimensional conformal field theories. We work out its holographic interpretation and also give a derivation of the g-theorem for the case of an interface in two-dimensional conformal field theories. We also geometrically confirm strong subadditivity for holographic duals of conformal field theories on manifolds with boundaries.

Kensuke Sueto
Osaka Metropolitan University
Spacetime structure of non-singular black holes with infinite evaporation time
Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-11

We study spacetime structures of non-singular black holes that evaporate spending an infinite period of time due to Hawking radiation. Such evaporating black holes can be classified into two types according to whether the radius of the inner apparent horizon increases or decreases, which we call Case 1 and Case 2 respectively. All known models, such as the Bardeen and Hayward black holes are classified as Case 1. In this presentation, we present the spacetime structures of Case 1 and Case 2 without assuming any specific model. Moreover, the Hayward black hole is examined as an example to investigate whether the spacetime can be extended beyond the Cauchy horizon and a fully extended spacetime structure is presented.

Daisuke Yoshida
Nagoya University
First law and the weak cosmic censorship for de Sitter black holes
Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-12

We investigate the covariant phase space approach to de Sitter black hole. Evaluating the first order identity for the Noether charge associated with the static Killing vector of the background static black hole over the asymptotically de Sitter hypersurface, we obtain the first law of the black hole thermodynamics with respect to the Abbott-Deser mass and the Wald entropy for black hole. We extend the discussion by Sorce-Wald about the gedanken experiment to destroy an asymptotically flat black hole to an asymptotically de Sitter one. Then, we find that the weak cosmic censorship holds for any energy sources falling into the blackhole if the null energy condition is satisfied.

Hiroki Hasegawa
Tohoku University
Simulation of quench dynamics in the ANNNI model using iTEBD
Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-13

Unlike the transverse field Ising model, which can discuss its eigenstates with quasiparticle excitations, the ANNNI model cannot be reduced to a Nanbu representation, and it is difficult to evaluate the excitation probability after a quench by hand calculations as a problem in the dynamics of two-level systems based on the Landau-Zener formula. In this study, we performed long-time numerical simulations without bias using iTEBD and obtained results that significantly modify the mean-field approximation solutions by a previous study, finding power law between kink density and quantum critical points. We also performed the same calculation for a complex magnetic ordered phase ($\uparrow\uparrow\downarrow$) and phenomenologically discussed the adaptability of existing theories such as the Landau-Zener formula and the Kibble-Zurek mechanism.

Sunil Kumar Sake
YITP, Kyoto University
York slicing in JT gravity
Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-14

In this talk, I will explore In AdS_2, states corresponding to slices of constant extrinsic curvature. We give an explicit construction of such states in JT gravity by studying the problem of non-smooth boundary conditions. The states are obtained by carrying out the appropriate Euclidean path integrals. We will discuss various checks on these states such as the classical limit, how the states constructed this way satisfy the WDW constraint etc.

Dongsheng Ge
Osaka University
Localized RG flows on composite defects and C-theorem
Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-15

We consider a composite defect system where a lower-dimensional defect (sub-defect) is embedded to a higher-dimensional one, and examine renormalization group (RG) flows localized on the defect. A composite defect is constructed in the (3-ϵ)-dimensional free O(N) vector model with line and surface interactions by triggering localized RG flows to non-trivial IR fixed points. Focusing on the case where the symmetry group O(N) is broken to a subgroup O(m) $\times$ O(N-m) on the line defect, there is an O(N) symmetric fixed point for all N, while two additional O(N) symmetry breaking ones appear for N $\geq$ 23. We also examine a C-theorem for localized RG flows along the sub-defect and show that the C-theorem holds in our model by perturbative calculations.

Giacomo Marmorini
Nihon University
Further aspects of spiral quantum state tomography
Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-16

Spiral quantum state tomography (sQST) is an efficient protocol of reconstruction of the density matrix, particularly tailored for cold-atom quantum simulators since it does not require single-atom addressing. In addition, the possibility of measuring certain entanglement properties of interesting many-body quantum states in realistic experimental setups has been established in principle [see D. Yamamoto's talk in this workshop]. In this poster, besides presenting more details of the numerical treatment of sQST, we illustrate some additional aspects starting from the analysis of relevant quantum states. For example, we show that the compressed sensing protocol employed in sQST introduces a systematic underestimation of entanglement entropy, which is however state-dependent and relatively important only for low-entanglement states.

Pratik Nandy
YITP, Kyoto University& iTHEMS, RIKEN
Effective Tridiagonalization of Double-Scaled SYK model
Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-17

By analyzing the global density of states in the Double-Scaled Sachdev-Ye-Kitaev (DSSYK) model, we numerically construct an integrable, "effective", and finite-dimensional toy Hamiltonian that replicates this density of states. We then tridiagonalize the Hamiltonian to determine the statistical distribution of its tridiagonal elements, namely the Lanczos coefficients within the parameter range. The Lanczos coefficients in the bulk of the spectra can be analytically expressed as a q-deformation of the logarithm. Numerical results are corroborated by semi-analytical findings and edge computations using the method of moments.

Ken-ichi Sasaki
NTT BRL
Stationary two-state system in graphene optics
Sept. 27, (Gongshow & Poster Session (B) 16:30-18:30); Poster number: #B-18

In scenarios where electrons are confined to a flat surface, such as graphene, quantizing electrodynamics reveals intriguing insights.We find that one of Maxwell's equations manifests as part of the Hamiltonian, leading to novel constraints on physical states due to residual gauge invariance. We identify two quantum states with zero energy expectation values: one replicates the scattering and absorption of light, a phenomenon familiar in classical optics, while the other is more fundamentally associated with photon creation. These states form an inseparable two-state system, giving a new formula for reflection and transmission coefficients with photon emission effects. We explain measured results using the formula and discuss the effects of phonons and plasmons on the system.
