New Trends in Mathematical Physics
November 7-12, 2022, online
Steklov Mathematical Institute, Moscow

Abstracts

1. **Accardi Luigi**
University of Roma Tor Vergata, Italy
Title: A unified approach to classical and quantum Hidden Markov processes
Abstract: Hidden Markov processes (HMP) (also called Hidden Markov models (HMM)) are very popular in contemporary research in applied mathematics including a large set of disciplines, such as machine learning, speech or handwriting recognition, image reconstruction, mathematical finance, ion channels,...

Several different quantum extensions of HMP have been proposed in the literature, especially in quantum information, but they are not very satisfactory for several reasons that will be discussed during the talk. In my talk I will briefly recall the notion of quantum Markov chain (QMC) and show that, restricting to different diagonal algebras the simplest class of quantum Markov chains one obtains all the classical HMP.

This shows that, for model building in any discipline, quantum Markov chains are a much more flexible and powerful tool than classical HMP because they allow, with the same (finite) number of parameters, to deal simultaneously with infinitely many classical HMP.

Then I will give a new definition of quantum HMP and show that:
1) in the classical case, this definition covers all HMP;
2) Restricting quantum HMP to to different diagonal algebras one obtains new classes of classical processes with a nice a rich structure which opens new possibilities for model building.

This is joint work with Soueidy El Gheteb, Yun Gang Lu and Abdessatar Souissi.

2. **Ageev Dmitry**
Steklov Mathematical Institute, Russia
Title: Shadows and shapes of entanglement islands
Abstract: In our talk we discuss the unusual "shadow of entanglement" effect present in systems subject to the phenomenon of entanglement islands. The effect of the shadow of entanglement lies in the fact that within the spatial subdomain there are zones that completely do not contain the "density of entanglement" within themselves. The appearance of such shadows in the physics of black holes, the Page curve, as well as the connection of such shadows with the theory of quantum error-correcting codes will be discussed.

3. **Amosov Grigory**
Steklov Mathematical Institute, Russia
Title: On the construction of measurement channels and quantum tomography
Abstract: Measurement channels determined by positive operator-valued measures translate quantum states into probability distributions on some measurable space X. We discuss how to construct operator-valued measures in the case when X=G is a locally compact group using the Pontryagin duality. It is shown that the constructed measures are informationally complete in the sense that they allow to

restore the state according to the probability distribution obtained during the measurement.

4. **Anashin Vladimir**

Moscow State University, Russia

Title: On the causality in quantum theory with a minimal scale length

Abstract: In the talk we describe causal functions that are consistent with Volovich postulates which read: (1) only rational numbers can be observed; irrational numbers cannot; (2) distances smaller than Planck length cannot be measured; (3) fundamental physical laws should be invariant with respect to change of number field. Causal functions over discrete time are mappings of one-side infinite sequences over a finite set of `elementary causes' to one-side infinite sequences over a finite set of `elementary effects' such that each i-th term of the image depends only on the terms 0,1,..,i of the pre-image. The causal functions constitute therefore a class of all non-expansive mappings of the non-Archimedean metric spaces; or, which is equivalent, exactly the class of all mappings performed by automata which are sequential machines, namely, the letter-to-letter transducers. The automata can be judged as the least powerful computers in comparison with cellular automata, which are the most powerful ones. Causal functions therefore are also consistent with the `t Hooft's causality postulate which lies in the base of his cellular automaton interpretation of quantum mechanics and reads that 'at its most basic level there is no randomness in Nature ... Every event takes place for a reason, it was caused by the action of physical law, not just by chance'. We describe functions which are causal (thus, continuous) w.r.t. p-adic metrics for all p and which simultaneously are continuous w.r.t. real metric; we argue that namely these functions can be judged as `closed forms' of physical laws which satisfy Volovich postulates (1)—(3). By exploiting

these ideas we develop an information model of measurements of open physical systems in a theory with a minimal scale length thus relating the subject of the talk to Wheeler's `it from bit' doctrine. The talk follows the approach outlined in the author's paper «Toward the (non-cellular) automata interpretation of quantum mechanics: Volovich postulates as a roadmap», Int'l J. Modern Phys. A, 2022, DOI 10.1142/S0217751X22430035.

5. Aref’eva Irina

Steklov Mathematical Institute, Russia

Title: Complete evaporation of black holes near extremality

Abstract: TBA

6. Barra Felipe

Universidad de Chile, Santiago, Chile

Title: Collision-induced decoherence and thermalization

Abstract: We study the state change in an N-level system induced by collisions with moving massive particles with d-internal levels. The relation between the width of the wave packet of the incident massive particle and the energy level spacing determine if populations and coherences evolve coupled or uncoupled. In the latter case, the target system decoheres as identical consecutive collisions occur [1]. If narrow (in momentum space) wave packets have average momentum distributed with the effusion distribution, the target system thermalizes. The energy exchange can be interpreted as heat. In the limit of very broad wave packets, the collision induces a change of energy but keeps the entropy unchanged. The collision performs work on the target system [2]. These results show that thermodynamic processes can be implemented in collision experiments. We use this physical description to implement a computational thermostat [3].

References [1] SL Jacob, M Esposito, JMR Parrondo, F Barra, Thermalization induced by quantum scattering, PRX Quantum

2, 020312 (2021). [2] SL Jacob, M Esposito, JMR Parrondo, F Barra, Quantum scattering as a work source, Quantum 6, 750 (2022). [3] J Tabanera, I Luque, SL Jacob, M Esposito, F Barra, JMR Parrondo, Quantum collisional thermostats, New Journal of Physics 24, 023018 (2022).

7. Basharov Askhat

National Research Center “Kurchatov Institute”, Russia

Title: Open quantum oscillators' system in terms of the algebraic perturbation theory and SDEs

Abstract: Open quantum oscillators' system in terms of the algebraic perturbation theory and SDEs. The research work deals with a system of identical independent quantum oscillators in the field of a common bosonic thermostat which is considered in terms of the algebraic perturbation theory up to the second order in the coupling constant with the thermostat. In the case of identically excited harmonic oscillators, the intensity of collective radiation can be completely suppressed for a certain number of oscillators in the ensemble. Nevertheless, a solitary superradiance pulse with a characteristic time delay is not formed in a system of harmonic oscillators. In the case of anharmonic oscillators, the algebraic perturbation theory identifies a quantum subsystem with a finite number of energy levels within each oscillator, which interacts with the surrounding bosonic thermostat. As a result, a superradiance pulse is formed in the collective decay of an ensemble of oscillators. The pulse emission can also be suppressed for a certain number of oscillators in the ensemble, which allows controlling the formation of a superradiance pulse.

8. Belokon Aleksandr

Steklov Mathematical Institute, Russia

Title: Entanglement entropy in de Sitter spacetime

Abstract: We study the dynamics of the entanglement entropy in higher-dimensional de Sitter spacetime. We find that the basic properties of the entanglement entropy of pure states are not complied in both one- and two-sided de Sitter spaces. We specify several types of Cauchy surfaces in de Sitter and discover that the entropies of pure states defined on them are either non-zero or diverge in the infrared depending on what patch we are in. We discover that the well-known complementarity property, which says that the entropies of a region and its complement that combine together into a Cauchy surface should be equal for the case of a pure state, is not obeyed.

We directly calculate the entropies for finite regions in de Sitter without explicit appealing to complementarity and find that their behaviour differs drastically from that of their complements. While for a finite region, located in the static causal diamond, the entropy is constant, the entropy for its complement grows with time. Since the entropies of the region and its complement are used interchangeably in the literature, the question of the information paradox in de Sitter space arises.

9. **Berezin Victor**
Institute for Nuclear Research of RAS, Russia
Title: Some notes on the Weyl geometry, particle production and induced gravity
Abstract: A short introduction to Weyl geometry and Weyl gravity is given. The self-consistency relation for the variation of the general form of the matter action integral to be conformal invariant is obtained. It is shown that the particle production rate per unit coordinate volume per unit coordinate time is conformal invariant. It is noticed that such a feature allows us to consider the perfect fluid action as an example of the Sakharov’s induced gravity model.

10. Bikchentaev Airat

Kazan Federal University, Russia

Title: Commutators in C*-algebras and traces

Abstract: Dimension functions and traces on $C^\ast$-algebras are fundamental tools in the operator theory and its applications. A C^*-algebra is a complex Banach $\ast$-algebra $\mathcal{A}$ such that $\|A^*A\|=\|A\|^2$ for all $A \in \mathcal{A}$. For a C^*-algebra $\mathcal{A}$ by $\mathcal{A}^{\mathrm{id}}$ and $\mathcal{A}^+$ we denote its subsets of idempotents ($A=A^2$) and positive elements, respectively. If $A\in {\mathcal{A}}$, then $|A|=\sqrt{A^*A} \in \mathcal{A}^+$. An element $X\in \mathcal{A}$ is a {\it commutator}, if $X=[A, B]=AB-BA$ for some $A, B\in \mathcal{A}$. A mapping $\varphi : {\mathcal{A}}^+ \to [0,+\infty]$ is called {\it a trace} on a C^*-algebra $\mathcal{A}$, if $\varphi (X+Y)=\varphi(X)+\varphi(Y), \; \; \; \varphi (\lambda X)=\lambda \varphi (X)$ for all $ X,Y \in {\mathcal{A}}^+, \; \lambda \ge 0$ (moreover, $ 0\cdot(+\infty)\equiv 0$); $\varphi (Z^*Z)=\varphi (ZZ^*)$ for all $Z \in \mathcal{A}$. The following results were obtained. Let φ be a faithful trace on a C^*-algebra $\mathcal{A}$; let $A,B \in \mathcal{A}^{\mathrm{id}}\setminus\{0\}$ be such that $ABA=\lambda A$ and $BAB=\lambda B$ for some $\lambda \in \mathbb{C}\setminus\{0, 1\}$. Then $[A, B]^n\not=0$ for all $n\in \mathbb{N}$. Corollary: Let φ be a faithful tracial state on a C^*-algebra $\mathcal{A}$, let $A,B \in \mathcal{A}^{\mathrm{id}}\setminus\{0\}$ be such that $ABA=\lambda A$ and $BAB=\lambda B$ for some $\lambda \in \mathbb{C}\setminus\{0, 1\}$. Then the element $[A, B]^{2n}$ is a non-commutator for all $n\in \mathbb{N}$. Let $\mathcal{H}$ be a separable Hilbert

space, $\dim \mathcal{H}= +\infty$. Let $X=U|X|$ be the polar decomposition of an operator $X\in \mathcal{B}(\mathcal{H})$. Then X is a non-commutator if and only if both U and $|X|$ are non-commutators. A Hermitian operator $X\in \mathcal{B}(\mathcal{H})$ is a commutator if and only if the Cayley transform $\mathcal{K}(X)$ is a commutator. Let $\mathcal{H}$ be a separable Hilbert space and $\dim \mathcal{H}\leq +\infty$, $A,B, P\in \mathcal{B}(\mathcal{H})$ and $P=P^2$. If $AB=\lambda BA$ for some $\lambda \in \mathbb{C}\setminus\{1\}$ then the operator AB is a commutator. An operator AP is a commutator if and only if PA is a commutator.

11. Buoninfante Luca

Nordic Institute for Theoretical Physics, Sweden

Title: Generalized ghost-free propagators in nonlocal field theories

Abstract: In this talk I introduce nonlocal (infinite derivative) field theories. First of all, I discuss how and which principles of quantum field theory are affected when higher-order derivative operators are taken into account in a Lagrangian. In particular, I focus on the issue of unitarity and on how to make higher-derivative theories healthy by means of non-polynomial differential operators. I present an iterative method to generate an infinite class of novel nonlocal field theories whose propagators are ghost-free. I first examine the scalar field case and show that the propagator pole structure can also contain additional pairs of complex conjugate poles which, however, do not spoil tree-level unitarity. Subsequently, I extend the same treatment to the gravity sector and consider nonlocal theories whose graviton propagators are ghost-free, and explore the possibility of regularizing singularities in these

theories. This talk is mainly based on: arXiv:2001.07830, Phys.Rev. D 101, 084019 (2020).

12. Burskii Vladimir

Moscow Institute of Physics and Technology, Russia

Title: Some new research methods of boundary value problems for general PDEs

Abstract: My communication is devoted to some questions of a general theory of boundary value problems for partial differential equations and contains results of the author. The available methods for studying such problems are closely related to the type of equation and are not suitable for a more or less general or non-classical formulation. In particular, new methods for investigating such problems are proposed and it is shown what results of their application in specific cases.

13. Boukas Andreas

Hellenic Open University, Greece

Title: On the Diagonalizability and Factorizability of Quadratic Boson Fields

Abstract: We provide a necessary and sufficient condition on the coefficient matrices A, C for the diagonalizability of quadratic fields of the form, \[X=\sum_{i,j=1}^n \left(A_{ij}a^{\dagger}_i a^{\dagger}_j +\bar{A}_{ij}a_ia_j+C_{ij}a^{\dagger}_ia_j\right)\ , \] where the a's and $a^\dagger$'s are the generators of the multi-dimensional Schr\"odinger Lie algebra. We also consider the Fock vacuum characteristic function \[\left\langle \Phi , e^{i\,s\,X}\,\Phi\right\rangle \ , \] of X and study its factorizability/decomposability and how it relates to the commutativity of the simple quadratic components of X.

14. Calcagni Gianluca

Instituto de Estructura de la Materia, Spain

Title: Fractional quantum gravity

Abstract: We propose a class of UV-complete quantum field theories motivated by fractal geometry and based on the fractional d'Alembertian. A consistent theory of quantum gravity and its possible applications to cosmology are discussed.

15. Cao Jianshu

Massachusetts Institute of Technology, USA

Title: Symmetry in non-equilibrium quantum processes

Abstract: The talk explores the role of symmetry in quantum transport and in driven systems. Symmetry in molecular systems such as benzene rings, LH2 complexes, carbon nanotubes, and C60 can result in multiple steady state solutions in non-equilibrium transport measurements. [1] However, dynamic or static disorder in open systems will break the symmetry and thus the degeneracy of multiple steady-states, leading to a unique current. To reveal the symmetry hidden under disorder, we demonstrate the slow relaxation of dynamical currents and uncover hidden signatures of multiple steady states. [1,2] Another type of symmetry is the commutativity of coupling operators, exemplified by noncommutative quantum transport [3]. Further, to study the symmetry in driven systems, we have systematically developed Floquet response theory for open quantum systems driven by a strong but periodic driving field and perturbed by a weak but arbitrary probe field.[4,5] Dynamical symmetries of the Floquet states lead to spectroscopic signatures including symmetry-protected dark states and Floquet-band selection rules. [4] (1) Dynamical signatures of molecular symmetries in nonequilibrium quantum transport. J. Thingna, D. Manzano, and J. Cao, Sci. Rep. 6, 28027

(2016) (2) Magnetic field induced symmetry breaking in nonequilibrium quantum networks. J. Thingna, D. Manzano, and J. Cao, New J. Phys. 22, 083026 (2020). (3) Unusual Transport Properties with Noncommutative System−Bath Coupling Operators. C. Duan, C.-Y. Hsieh, J. Liu, J. Wu, and Jianshu Cao, J. Phys. Chem. Lett. 11, 4080 (2020) (4) Dynamical Symmetries and Symmetry-Protected Selection Rules in Periodically Driven Quantum Systems. G. Engelhardt and J. Cao, Phys. Rev. Lett. 126, 090601 (2021) (5) Discontinuities in driven spin-boson systems due to coherent destruction of tunneling: breakdown of the Floquet-Gibbs distribution. G. Engelhardt, G. Platero and J. Cao, Phys. Rev. Lett. 123(12), 120602/1-7 (2019)

16. Capozziello Salvatore

University of Naples, Italy

Title: Non-local gravity cosmology

Abstract: Recently the so-called Non-Local Gravity acquired a lot of interest as an effective field theory towards the full Quantum Gravity. In this talk, we sketch its main features, discussing, in particular, possible infrared effects at astrophysical and cosmological scales. In particular, we focus on general non-local actions including curvature invariants like the Ricci scalar and the Gauss-Bonnet topological invariant, in metric formalism, or the torsion scalar, in teleparallel formalism. In both cases, characteristic lengths emerge at cosmological and astrophysical scales. Furthermore, it is possible to fix the form of the Lagrangian and to study the cosmological evolution considering the existence of Noether symmetries.

17. **Cattaneo Marco**

University of Helsinki, Finland

Title: Symmetries in physical dilations of open quantum systems

Abstract: Symmetry plays a fundamental role in Physics and quantum mechanics. More specifically, it is a key concept in the theory of open quantum systems, as the symmetries of a master equation set some constraints on the open system dynamics and on the structure of the steady states. However, a well-known and remarkable result states that Noether's theorem is not valid for open quantum systems. That is, a symmetry does not always correspond to a conserved quantity, and vice versa. Then, a natural question arises: given a symmetry in the dynamics of an open quantum system, can we always find an analogous symmetry and a conserved quantity in the physical dilations of this open dynamics? In other words, is there always an observable living in the extended Hilbert space that is conserved under the time evolution driven by the unitary operator given by the Stinespring-like dilation? In this talk, we address this question and show some results and conjectures about it.

18. **Cavina Vasco**

University of Luxembourg, Luxembourg

Title: Energy counting statistics in open quantum systems: a microscopic approach to thermodynamic consistency

Abstract: Starting from a microscopic system-baths description of the energy counting statistics, we study how the problem of thermodynamic consistency translates from the unitary level to the reduced open system dynamics. In the first part of the talk, we focus on quantum master equations (QMEs) and derive a general condition for a time-local QME to satisfy the first and second law of thermodynamics at the fluctuating level. In this context, we show that the fluctuating second law can be rephrased as a Generalized Quantum Detailed Balance condition (GQDB) i.e. a symmetry of the time-local generators which ensures the validity of the fluctuation theorem. When requiring in addition a strict system-bath energy conservation, the GQDB reduces to the usual notion of detailed balance. In the second part of the talk, we approach the problem of thermodynamic consistency from a different point of view, showing that the validity of the fluctuation theorem can be seen as a symmetry of a modified version of the Keldysh contour. Building on these premises we study the work and heat statistics in the Caldeira - Leggett model with time dependent strong coupling, and we use it as a starting point to approach the problem of thermodynamic consistency in the Zwanzig model both in general and in the markovian limit.

19. Chuprikov Nikolay
Tomsk State Pedagogical University, Russia
Title: Restrictions Imposed by the Wave Function on the Results of Particle Momentum Measurements
Abstract: Using the example of a particle in a one-dimensional configuration space (OCS), it is shown that knowledge of the wave function implies not only statistical restrictions on the results of measurements. In particular, in addition to the probability (density) field in the OCS, the wave function also assumes the existence of two fields that predict two (equiprobable) values of the particle momentum for each point of the OCS: the average value of these two momentum fields at each point is related only to the phase of the wave function, and their difference (coinciding with Bohm's "quantum-mechanical potential") is related only to the amplitude of the wave function. For both fields, an analogue of the Heisenberg uncertainty relation

is obtained. For any unit wave function, streamlines in the OCS cannot be interpreted as particle trajectories.

20. Digernes Trond

Norwegian University of Science and Technology, Norway

Title: In search of a non-Archimedean Schwartz space

Abstract: We point out the problems of finding a good substitute for Schwartz space in a non-Archimedean setting and present a "No-go" theorem. Given these problems, we explore the possibilities of using the multiplicative structure of a local field (instead of the additive structure) and present some results in that direction. Our space of test functions is constructed from a family of weighted modulation spaces (Feichtinger algebras).

21. Dimitrijevic Ivan

University of Belgrade, Serbia

Title: Anisotropic cosmological solutions in nonlocal de Sitter gravity

Abstract: Nonlocal de Sitter gravity is defined by the action \begin{equation*} S = \frac 1{16\pi G} \int (R-2\Lambda + \sqrt{R-2\Lambda} \mathcal{F}(\Box) \sqrt{R-2\Lambda}) \sqrt{-g} \mathrm d^4 x. \end{equation*} Recently, several cosmological solutions for the homogeneous and isotropic Universe have been found. In this talk we discuss cosmological solutions of the Nonlocal de Sitter gravity with homogenous and anisotropic metric. In particular we discuss Bianchi type I metric. This talk is based on joint work with Branko Dragovich, Zoran Raki\'c and Jelena Stankovic.

22. Dobrokhotov Sergey

Ishlinsky Institute for Problems in Mechanics, Russia

Title: Keplerian trajectories and effective asymptotics of some solutions of the Schrodinger equation with a repulsive Coulomb potential.

Abstract: We consider the stationary Schrodinger equation with a repulsive Coulomb potential. We construct explicit global asymptotic formulas in the form of the Airy function of a complex argument based on Lagrangian manifolds woven from Keplerian trajectories for the following problems: 1) for the scattering problem and 2) for the inhomogeneous problem with a spatially localized right-hand side. In the second case the considered problem is close to the well-known problem of the asymptotics of the Green function. The results of the work were obtained jointly with S.B.Levin, A.A.Tolchennikov and are based on approaches recently developed jointly with A.Yu.Anikin, V.E.Nazaikinsky and A.V.Tsvetkova. The work is supported by the Russian Science Foundation, project 21-11-00341.

23. Dolgopolov Mikhail

Samara University, Russia

Title: Holographic interface of heterostructures with 2D Fermi gas and activation

Abstract: Mathematical description of criteria for the formation of semiconductor heterostructures on silicon with sharp barrier transitions with accumulation of 2DEG during activation of splitting of quasi-Fermi levels by radiation sources is considered. By means of inversion, a large density of electron and/or hole 2D gas is created. The possibilities of optimization by doped modulation of graded heterojunction and quasi-electric built-in field in the technological process of endotaxy of thin films into silicon are determined. Optimization is carried out according to the

parameters of the band gap width and concentrations of alloying impurities for I(V). The conditions of physical separation of 2D Fermi gas from impurity in the depletion mode with low scattering of interface roughness, which leads to high carrier mobility, are considered.

24. Dragovich Branko

University of Belgrade, Serbia

Title: Nonlocal de Sitter Gravity and Cosmology

Abstract: This talk is devoted to a simple nonlocal de Sitter gravity model and its exact vacuum cosmological solutions. I plan to present construction of this model, equations of motion, several cosmological solutions for FLRW universe and their discussion. One of these solutions mimics effects that are usually assigned to dark matter and dark energy. Some other solutions are examples of the nonsingular bounce ones in flat, closed and open universe. There are also singular and cyclic solutions. All these cosmological solutions are a result of nonlocality and do not exist in the local de Sitter case. See arXiv:2206.13515 [gr-qc].

25. Efremova Lyudmila

Lobachevsky State University, Russia

Title: Ramified chaotic attractors of smooth geometrically integrable self-maps of a cylinder

Abstract: We give the definition of a geometrically integrable self-map of a cylinder and formulate criteria for the geometric integrability. Then we prove the geometric integrability of C^1 - smooth self-maps of a cylinder, close to C^1 - smooth skew products and satisfying some additional conditions. Finishing these considerations, we give the example of the family of geometrically integrable cylinder maps so that each map from this family admits the global chaotic attractor, which is a one-dimensional

ramified continuum with a complicated topological structure. The global attractor of every map from the family under consideration consists of arcs of two types. On the unique arc of the first type the map is mixing; on arcs of the second type (the family of such arcs is countable) the map is not mixing (for details see [1]). REFERENCES [1] L.S. Efremova, Ramified continua as chaotic attractors of C 1 -smooth self-maps of a cylinder close to skew products, J. Difference Equ. Appl., Special issue "Lozi, He´non and other chaotic attractors. Theory and applications", 28 (2022) (to appear).

26. Ermakov Igor

Steklov Mathematical Institute & Skoltech, Russia

Title: Almost Complete local Revivals in quantum spin systems and delayed disclosure of a secret

Abstract: Revivals of initial nonequilibrium states is an ever-present concern for the theory of dynamic thermalization in many-body quantum systems. Here we consider a nonintegrable lattice of interacting spins 1/2 and show how to construct a quantum state such that a given spin 1/2 is maximally polarized initially and then exhibits an almost complete recovery of the initial polarization at a predetermined moment of time. An experimental observation of such revivals may be utilized to benchmark quantum simulators with a measurement of only one local observable. We further propose to utilize these revivals for a delayed disclosure of a secret.

27. Fagnola Franco

Polytechnic University of Milan, Italy

Title: On Irreducibility of Gaussian Quantum Markov Semigroups

Abstract: \titsbf{Abstract}: % The abstract The generator of a Gaussian quantum Markov semigroup on the algebra of bounded operator on a d-mode Fock space is represented in a generalized Gorini-Kossakowski-Lindblad-Sudharsan form \[x\mapsto G^*x + \sum_{\ell}L_\ell^*\, x L_\ell + x\, G \] with an operator G quadratic in creation and annihilation operators and Kraus operators $L_1,\dots,L_m$ linear in creation and annihilation operators. Kraus operators, commutators $[G,L_\ell]$ and iterated commutators $[G,[G,L_\ell]],\dots$ up to the order $2d-m$, as linear combinations of creation and annihilation operators determine a vector in $\mathbb{C}^{2d}$. We show that a Gaussian quantum Markov semigroup is irreducible if such vectors generate $\mathbb{C}^{2d}$, under the technical condition that the domains of G and the number operator coincide. Conversely, we show that this condition is also necessary if the linear space generated by Kraus operators and their iterated commutator with G is fully non-commutative. We discuss open problems and illustrate them by examples. % The abstract end's {\small \renewcommand{\section}[2]{}% \begin{thebibliography}{} \bibitem{Paper1} J. Agredo, F. Fagnola and D. Poletti, The decoherence-free subalgebra of Gaussian QMSs. {\sl Milan J. Math.} {\bf 90} (2022) 257–289 \quad {\tt doi.org/10.1007/s00032-022-00355-0} \quad {\tt arxiv.org/abs/2112.13781}. \bibitem{Paper2} F. Fagnola and D. Poletti, On Irreducibility of Gaussian Quantum Markov Semigroups. {\sl Infin. Dimens. Anal. Quantum Probab. Relat. Top.} {\bf 25} (2022) To appear. \end{thebibliography}}

28. Fedorov Alexey

Russian Quantum Center, Russia

Title: Efficient control for quantum many-body systems

Abstract: Quantum many-body control is among most challenging problems in the field of quantum technologies, yet it is absolutely essential for further developments of this vast field. In this work, we propose a novel approach for solving control problems of many-body quantum systems. The key feature of our approach is the ability to run tens of thousands of iterations of a gradient-based optimization of a control signal within reasonable time. This is achieved by a tensor-networks-based reduced-order modeling scheme allowing one to build a low-dimensional reduced-order model of a many-body system, whose numerical simulation in many orders of magnitude faster and more memory efficient than for the original model; these reduced-order models can be seen as "digital twins" of many-body systems. The control protocols developed for the "twins" can be directly applied to the quantum many-body system of interest. We validate the proposed method by demonstrating solutions of control problems for a one-dimensional XYZ model, such as controllable information spreading/transmission over the system, and for a spin chain in many-body localization phase, such as controllable dynamics inversion. Interestingly, our approach by design uses environmental effects (such as non-Markovianity) to make control protocols more efficient: instead of fighting against a potential loss caused by the interaction with the environment, the method uses interaction as a communication protocol with environment that is used as a "memory" for storage of quantum information.

29. Frolov Valeri

University of Alberta, Canada

Title: Limiting curvature gravity and the problem of singularities

Abstract: I shall discuss a recently proposed limiting curvature theory of gravity and its application to the problem of singularities in cosmology and inside black

holes. In this theory the growth of the curvature is suppressed by specially chosen inequality constraints included in the gravity action. In this model the Universe has a bounce instead of the initial Big Bang singularity. We also consider a case of a spherically symmetric four-dimensional black hole and demonstrate that imposed curvature constraints modify a solution in the black hole interior. Instead of forming the curvature singularity the modified metric describes a space which is exponentially expanding in one direction and oscillating in the other two directions. The spacetime is complete and its polynomial curvature invariants are uniformly bounded.

30. Gough John

Aberystwyth University, United Kingdom

Title: Möbius Transformations and Quantum Stochastic Models

Abstract: This talk will look at fractional linear transformations (non-commutative Möbius transformations) associated with Hudson-Parthasarathy quantum stochastic evolutions. The transformations arise naturally for feedback problems in quantum engineering.

31. Holevo Alexander

Steklov Mathematical Institute, Russia

Title: Generalizations of logarithmic Sobolev inequality arising from quantum information theory

Abstract: We suggest a method of computation of the classical capacity of quantum measurement channel based on principles of convex programming. It is targeted to solve the problem of Gaussian Maximizers for models out of the scope of the "threshold condition" which ensures that the upper bound for the capacity as a difference between the maximum and the minimum output entropies is attainable on Gaussian encodings. The method is illustrated by the cases of noisy Gaussian homodyning and heterodyning in quantum optics. Rather remarkably, for both models the method reduces the solution of the optimization problem to new generalizations of the celebrated log-Sobolev inequality.

32. He Song

Center for Theoretical Physics and College of Physics, Jilin University, China & Max Planck Institute for Gravitational Physics, Germany

Title: Probing QCD critical point and induced gravitational wave by black hole physics

Abstract: Locating the critical endpoint of QCD and the region of a first-order transition at finite baryon chemical potential is an active research area for QCD matter. We provide a gravitational dual description of QCD matter at finite baryon chemical potential μ_B and finite temperature using the non-perturbative approach from gauge/gravity duality. After fixing all model parameters using state-of-the-art lattice QCD data at a zero chemical potential, the predicted equation of states and QCD trace anomaly relation are in quantitative agreement with the latest lattice results available. We then give the exact location of the critical endpoint and the first-order transition line that can actually be probed by experimental facilities in the near future. Moreover, using the data from our model at finite μ_B, we calculate the spectrum of the stochastic gravitational wave background associated with the first-order QCD transition in the early universe, which is found to be detected by IPTA and SKA, while NANOGrav is less likely.

33. Ilyn Nikolay

Skolkovo Institute of Science and Technology, Russia

Title: Quantum adiabatic theorem with energy gap regularization

Abstract: The talk deals with the adiabatic approximation of quantum dynamics. It is usually believed that one of the principal factors determining its stability is the structure of the spectrum. As the adiabatic theorem states in its usual formulation, deviations from the adiabatic evolution can be estimated from above by the ratio of Hamiltonian change rate to the energy gap size in the spectrum. The talk is devoted to discussing this dependence and, in particular, to theorems showing that the efficiency of the adiabatic approximation is more influenced by the eigenvectors change rate than by the size of energy gap.

34. Ivanchenko Mikhail

Lobachevsky University, Russia

Title: Quantifying dissipative quantum chaos

Abstract: Irregular, chaotic dynamics of nonlinear systems is deeply studied and well understood. Dynamical chaos also arises in the classical approximation of quantum systems, modeled by nonlinear differential equations. However, quantum systems can either be in an essentially non-classical regime, or not allow a classical description at all. Here lies the terra incognita of modern physics of complex systems: can linear (by definition) mathematical models of dissipative quantum systems exhibit the properties of nonlinear chaotic systems (probably yes - as suggested by the correspondence principle)? What are the "fingerprints" of classical deterministic chaos in these systems? How can one "see" quantum bifurcations and measure dissipative quantum chaos? The answers to these questions are not only of fundamental interest, but are also extremely important in the field of quantum

computing for solving the problem of stable processing of quantum information on long time scales.

35. Katanaev Mikhail

Steklov Mathematical Institute, Russia

Title: Spin distribution for the ‘t Hooft-Polyakov monopole in the geometric theory of defects

Abstract: Recently the 't Hooft--Polyakov monopole solutions in Yang--Mills theory were given new physical interpretation in the geometric theory of defects describing continuous distribution of dislocations and disclinations in elastic media. It means that the 't Hooft--Polyakov monopole can be seen, probably, in solids. To this end we need to compute the corresponding spin distribution on lattice sites of crystals. We describe one of the possible spin distributions. The Bogomol'nyi--Prasad--Sommerfield solution is considered as an example.

36. Khramtsov Mikhail

Vrije Universiteit Brussel & The International Solvay Institutes, Belgium

Title: Delicate windows into evaporating black holes

Abstract: In this work we revisit the model of AdS$_2$ black hole in JT gravity evaporating into an external bath. We study when and how much information about the black hole interior can be accessed in these models through different portions of the Hawking radiation collected in the bath, and we obtain the corresponding full quantitative Page curves. As a refinement of previous results, we describe the island phase transition for a semi-infinite segment of radiation in the bath, establishing the interior access for times within the regime of applicability of the model. For finite sizes segments in the bath, one needs to include the purifier of the black hole microscopic dual together with the radiation segment in order to access the

interior information. We identify four scenarios of the entropy evolution in this case, including a possibility where interior reconstruction window keeps appearing and disappearing as time evolves. Analyzing the phase structure of the entropy evolution depending on the parameters of the model, we demonstrate that unlike the semi-infinite segment Page curve which accounts for almost all of the radiation, the finite segment Page curve is very fragile to changes of the parameters. We also discuss the evolution of the subregion complexity of the radiation during the black hole evaporation.

37. Korepin Vladimir

C. N. Yang Institute of Theoretical Physics, USA

Title: Number theory and spin chains

Abstract: Correlation functions in completely integrable spin chains can be expressed in terms of number theory.

38. Koshelev Alexey

Universidade da Beira Interior, Portugal

Title: Stability of analytic infinite derivative theories in curved space-times

Abstract: TBA

39. Kozyrev Sergei

Steklov Mathematical Institute, Russia

Title: Amplification of Quantum Transfer and Quantum Ratchet

Abstract: Quantum transfer model with time dependent Hamiltonian and decoherence is considered. Application of the vibronic resonance with a transition and decoherence tuning makes it possible to enhance the quantum transfer and make it directional. Directionality of the transtion can be discussed as quantum ratchet. Application of this mechanism in quantum photosynthesis is discussed.

40. Kuksin Sergey

Paris Diderot University, France

Title: On the 2/3- and 4/5-laws of the Kolmogorov theory of turbulence and their rigorous 1d versions

Abstract: In three papers, published in 1941, A.N.Kolmogorov built his celebrated heuristic theory of turbulence. Postulating that the velocity u(t,x) of a turbulent flow is a random field, stationary in time and homogeneous in space, he examined the second and third moments of the increments u(t,x+r)-u(t,x), when the Reynolds number of the flow is large and the increments r are "short, but not too short". I will talk about fictitious 1d fluid, described by the stochastic Burgers equation, consider increments of its velocity field, and will rigorously derive for their second and third moments natural analogies of the corresponding laws from Kolmogorov's theory. The talk is based on results from my joint book with A.Boritchev (AMS, 2021) and on some their recent development.

41. Latune Camille

Ecole Normale Supérieure de Lyon, France

Title: Steady state in the regime of ultra strong system-bath coupling and high temperature

Abstract: Understanding better the dynamics and steady states of systems strongly coupled to their environment (idealized as bosonic thermal baths) is a great theoretical challenge with promising applications in several fields of quantum technologies. Among several strategies to gain access to the steady state, one consists in obtaining approximate expressions of the mean force Gibbs state – the reduced state of the global system-bath thermal state – largely credited to be the steady state. Here, we present analytical expressions of corrective terms to the ultrastrong coupling limit of the mean force Gibbs state [1], which has been recently derived [2]. We find that the first order term

coincides precisely with the first order correction obtained from a dynamical approach [3] – master equation in the strong-decoherence regime. This strengthens the identification of the reduced global thermal state with the mean force Gibbs state. Additionally, we also compare our expressions with an other recent result obtained from a high temperature expansion of the mean force Gibbs state [4]. We observe good numerical agreements for ultra strong coupling as well as for high temperatures. This confirms the validity of all these results. In particular, we show that, in term of coherences, all three results allow one to sketch the transition from ultrastrong coupling to weak coupling. Finally, we briefly sketch a method to obtain higher order terms, and provide an upper bound of the error between the approximated expression containing terms up to order n, and the exact expression. We present additional numerical simulations containing terms up to fifth order with the corresponding error bound. This allows one to evaluate the range of validity of the above techniques.

42. Luchnikov Ilia

Russian Quantum Center, Russia

Title: Non-Markovian quantum dynamics identification and control

Abstract: Non-Markovian quantum dynamics simulation and control is a notoriously difficult problem frequently met in the field of quantum technologies. One typically tries to avoid dealing with non-Markovianity in the context of quantum technologies by using approximations of Born-Markov type or by considering systems that are almost Markovian in nature. However, non-Markovianity is a resource, that can be used for improvement of the current generation of NISQ devices. In this talk, we will demonstrate our recent progress in understanding of quantum non-Markovianity from "engineering" view point.

We will demonstrate new methods for data-driven non-Markovian dynamics identification, data-driven quantum environment model reconstruction and finally a control method allowing usage of non-Markovianity as a valuable resource

43. Lychkovskiy Oleg

Skolkovo Institute of Science and Technology & Steklov Mathematical Institute, Russia

Title: A refined Eigenstate Thermalisation Hypothesis that evades known counterexamples

Abstract: The Eigenstate Thermalization Hypothesis (ETH) essentially asserts that an eigenstate of a quantum many-body system is indistinguishable from the microcanonical mixed state at the corresponding energy if measured locally. Any attempt to prove the ETH in this simple (and widely used) formulation would likely stumble at the very first step - defining a class of systems it applies to. There are systems where the ETH is known to be invalid - integrable systems and systems with quantum many-body scars. A precise mathematical definition for quantum many-body integrability remains, however, elusive, despite decades of discussions. The situation is even worse for the scarring phenomenon that has come into focus very recently. Thus one is not able to precisely characterise the set of Hamiltonians where the ETH is invalid. As a consequence, the complementary set of Hamiltonians where the ETH can be valid remains also obscure. In this talk I circumvent this difficulty by proposing a refined version of the ETH. It formalises an intuitive understanding that the integrable and scarred systems are rare exceptional points in the parameter space of many-body Hamiltonians, and a generic perturbation of a Hamiltonoian destroys integrability and scars and restores the validity of the ETH.

44. Magnot Jean-Pierre

University of Angers, France

Title: On generalized KP hierarchies: well-posedness and related (t2,t3) Zakharov-Shabat equations

Abstract: We prove well-posedness of the KP hierarchy on any diffeological differential algebra, and give some examples where the corresponding KP equations carry very different forms. This talk is mostly based on joint works with Enrique G. Reyes and Vladimir Rubtsov.

45. Malyshev Kirill

St. Petersburg Department of Steklov Mathematical Institute of RAS, Russia

Title: Gauge-translational theory of dislocations with finite-sized cores and renormalization of elastic moduli

Abstract: After geometric preliminaries, a gauge-translational field theory is developed which enables the dislocations with finite-sized cores in elastic body. Self-energy of the dislocation cores is accounted for by means of the translational part of the Riemann-Cartan gauge Lagrangian. The Hilbert-Einstein gauge equation plays the role of non-conventional incompatibility law. The partition function of straight screw dislocations is written in the path integration form, and the steepest descent approximation results in the dislocations with finite- sized core. The representation of two-dimensional Coulomb gas with smoothed-out coupling enables to calculate the stress-stress correlation functions. Renormalization of the shear modulus caused by the proliferation of dipoles of screw dislocations is considered. Implications are demonstrated for the shear modulus near the melting transition which are due to the singularityless character of the dislocations.

46. Merkli Marco

Memorial University of Newfoundland, Canada

Title: Correlation Decay and Markovianity in Open Systems

Abstract: A finite quantum system S is coupled to a thermal, bosonic reservoir R. Initial SR states are possibly correlated, obtained by applying a quantum operation taken from a large class, to the uncoupled equilibrium state. We show that the full system–reservoir dynamics is given by a Markovian term plus a correlation term, plus a remainder small in the coupling constant, uniformly for all times. The correlation term decays polynomially in time. After this, the Markovian term becomes dominant, where the system evolves according to the completely positive, trace-preserving semigroup generated by the Davies generator, while the reservoir stays stationary in equilibrium. This shows that (a) after initial SR correlations decay, the SR dynamics enters a regime where both the Born and Markov approximations are valid, and (b) the reduced system dynamics is Markovian for all times, even for correlated SR initial states.

47. Mikhailov Andrei

Title: Classical and relativistic functional mechanics

Abstract: The report will consider the approach to solving the problem of the foundations of thermodynamics proposed by I.V.Volovich – the functional mechanics. The main idea of functional mechanics is the postulation of time–irreversible equations as fundamental laws of microscopic dynamics. Thus, Hamiltonian mechanics is reformulated in terms of the Liouville or Fokker-Planck equations, and the variances of the observables are assumed to be nonzero. Such a reformulation of classical mechanics leads to the appearance of corrections to the equations of dynamics of observables, since the trajectory averaged by initial data differs from the trajectory with average initial data. Averaging over the initial data destroys almost periodicity of the trajectories of a dynamical system obeying the conditions of the Poincare return theorem. The general formula for the evolution of the moments of the distribution function under the action of the phase flow is presented in the report. The questions of infinite motion in functional mechanics, including scattering problems, are also considered. Small inaccuracies in the measurement of the initial data taken into account by functional mechanics significantly change the asymptotic behavior of the trajectories of motion, eliminating singularities in part of the observed ones. The Liouville equation for geodesic flow on manifolds is discussed as a relativistic formulation of functional mechanics and the behavior of observables is described for some special cases.

48. Missarov Moukadas

Kazan Federal University, Russia

Title: Transformation of the renormalization group in generalized fermionic hierarchical model

Abstract: We consider a two-dimensional hierarchical lattice, in which an elementary cell is represented by the vertices of a square. In the generalized hierarchical model, the distance between opposite vertices of a square differs from the distance between adjacent vertices and is, in fact, a new parameter of the model. The Gaussian part of the Hamiltonian of the 4-component generalized fermionic hierarchical model is invariant under the block-spin transformation with a given value of the renormalization group parameter. The Grassmann-valued density of the free measure in this model is described as the sum of forms of the 2nd and 4th degrees. The transformation of the renormalization group in the space of the coefficients of this density is calculated explicitly as a homogeneous mapping of the fourth degree in a two-dimensional

projective space. The properties of this mapping are described.

49. Modi Kavan

Monash University, Australia

Title: Quantum Chaos = Volume-Law Spatiotemporal Entanglement

Abstract: Chaotic systems are highly sensitive to a small perturbation, be they biological, chemical, classical, ecological, political, or quantum. Taking this as the underlying principle, we construct an operational notion for quantum chaos. Namely, we demand that the whole future state of a large, isolated quantum system is highly sensitive to past multitime operations on a small subpart of that system. This immediately leads to a direct link between quantum chaos and volume-law spatiotemporal entanglement. Remarkably, our operational criterion already contains the routine notions, as well as the well-known diagnostics for quantum chaos. This includes the Peres-Loschmidt Echo, Dynamical Entropy, and Out-of-Time-Order Correlators. Our principle therefore unifies these existing diagnostics within a single structure. Within this framework, we also go on to quantify how several mechanisms lead to quantum chaos, such as unitary designs. Our work paves the way to systematically study exotic many-body dynamical phenomena like Many-Body Localisation, many-body scars, measurement-induced phase transitions, and Floquet dynamics. We anticipate that our work may lead to a clear link between the Eigenstate Thermalization Hypothesis and quantum chaos.

50. Morzhin Oleg

Steklov Mathematical Institute, Russia & National University of Science and Technology "MISiS", Russia

Title: On optimization of coherent and incoherent controls in one- and two-qubit open systems

Abstract: The talk considers some one- and two-qubit open quantum systems driven by coherent and incoherent controls with control goal of maximizing the Hilbert-Schmidt overlap and minimizing the Hilbert-Schmidt distance between the final density matrix and a given target density matrix. The talk discusses several directions related to these control problems. First, for the problem of minimizing the Hilbert-Schmidt distance for one-qubit system, based on the work [Morzhin O.V., Pechen A.N. On optimization of coherent and incoherent controls for two-level quantum systems. Izv. RAN. Ser. Mat. 87:5 (2023) (In press)], we discuss a modification of the two-stage method [Pechen A., Phys. Rev. A., 84, 042106 (2011)] by using the two-step gradient projection method, where at the cost of complicating the first (incoherent) stage we obtain the possibility to decrease duration of this stage at the cost of losing the simplicity of the original method. Second, for the both problems and two-qubit systems, we outline the use of the Pontryagin maximum principle and gradient projection methods [Morzhin O.V., Pechen A.N. Optimal state manipulation for a two-qubit system driven by coherent and incoherent controls (Submitted)], paying the attention on singular controls, etc. Third, for the problem of maximizing the overlap for the two-qubit case, we present a construction, in the terms of density matrices, for the two Krotov's type methods based on the special exact formulas for the increment of the objective functional [Morzhin O.V., Pechen A.N. Nonlocal improvement methods of coherent and incoherent controls for maximizing the overlap of quantum states for an open two-qubit system (Submitted)].

51. Mukhamedov Farrukh

United Arab Emirates University, United Arab Emirates

Title: Non-homogeneous Gibbs measures for the Ising model on the Cayley trees

Abstract: In the present talk, we discuss the classical Ising model on the Cayley tree. For this model on the Cayley tree of order $k\geq 2$, a sequence $\{h_n\}$ of boundary conditions is constructed depending on an initial value h which defines a Gibbs measure μ_h. By investigating the dynamical behavior of the renormalization group map associated with the model, it will be discussed properties of each measure μ_h. The obtained result is closely related to the classical result by Kakutani which asserts that any two locally-equivalent probability product measures are either equivalent or mutually-singular.

52. Pechen Alexander

Steklov Mathematical Institute, Russia & National University of Science and Technology "MISiS", Russia

Title: On controllability of some quantum systems

Abstract: Consider dynamics of a quantum system driven by some controls (external actions) which belong to some admissible set. If the system is closed, then it is called completely controllable if any unitary operator can be realized as an evolution with some admissible control. If the system is open, then it is called controllable in the set of density matrices if any initial density matrix can evolve into any target density matrix under some admissible controls. If the system is uncontrollable, its reachable sets are the sets of density matrices which can be obtained starting from a given initial state and using all admissible controls of arbitrary duration. Controllability and reachable sets are among the main properties which should be established when studying a given controlled quantum

system. In this talk, we will discuss some results about controllability of closed four-level systems with degenerate Hamiltonians, which are controllable or not depending on values of some parameters in the Hamiltonian [1,2], and about controllability in the set of density matrices and reachable sets for a qubit interacting with the environment and driven by coherent and incoherent controls, where there exist unreachable sets of points in the Bloch ball [3]. Finally we discuss the use of speed gradient approach for finding optimal coherent and incoherent controls for energy transfer in a quantum oscillator interacting with the environment. Partial support Priority 2030, K2-2022-025, RSF 22-11-00330.

[1] S.A. Kuznetsov, A.N. Pechen, On controllability of a highly degenerate four-level quantum system with a "chained" coupling Hamiltonian, Lobachevskii J. Math., 43:7, 1683–1692 (2022).

[2] A.A. Myachkova, A.N. Pechen, Some controllable and uncontrollable degenerate four-level quantum systems (at press).

[3] L. Lokutsievskiy, A. Pechen, Reachable sets for two-level open quantum systems driven by coherent and incoherent controls, J. Phys. A: Math. Theor., 54, 395304 (2021).

[4] A.N. Pechen, S. Borisenok, A.L. Fradkov, Energy control in a quantum oscillator using coherent control and engineered environment, Chaos Solitons & Fractals 164, 112687 (2022).

53. Petrukhanov Vadim

Steklov Mathematical Institute, Russia & National University of Science and Technology "MISiS", Russia

Title: Optimization of state transfer and exact dynamics for the open two-level quantum system.

Abstract: We consider the state-to-state transfer control problem for the open two-level quantum system (qubit) with evolution governed by the master equation with coherent and incoherent controls. General form of the GKSL master equation in the absence of controls was derived in particular in the weak coupling limit and in the stochastic limit of quantum theory. We introduce the specific model of the such master equation, include coherent and incoherent controls, and for the state-to-state transfer problem study the complexity of the GRAPE optimization method. Moreover we derive exact expressions for the dynamics of the system and for the gradient of the objective functional necessary for optimization.

54. **Poletti Damiano**

Polytechnic University of Milan, Italy

Title: The decoherence-free subalgebra of Gaussian Quantum Markov Semigroups

Abstract: Gaussian Quantum Markov semigroups (QMSs) have been used in the literature also under the name of quasi-free semigroups. They are semigroups on the set of bounded operators on the symmetric Fock space $\mathcal{H} = \Gamma_s(\mathbb{C}^d)$. Notable operators on this set are annihilation and creation operators $a_j, a_j^\dagger$ for $j=1, \dots, d$, which are not bounded but are used in many applications and in the very definition of gaussian QMSs. Indeed we introduce gaussian QMSs by their generator in the GKLS form $$ \mathcal{L}(x) = i [H, x] -\frac{1}{2} \sum_{\ell \geq 1} \left(L_\ell^* L_\ell x - 2 L_\ell^* x L_\ell + x L_\ell^* L_\ell \right), $$ with H a quadratic polynomial in $a_j,a_j^\dagger$ and L_ℓ a linear polynomial in $a_j, a_j^\dagger$. We show that the decoherence-free subalgebra, i.e. the biggest von Neumann subalgebra of $\mathcal{B}(\mathcal{H})$ on which the semigroup acts

as a *-homomorphism, of this class of semigroups is always unitarily equivalent to $$ L^\infty(\mathbb{R}^{d_c}; \mathbb{C}) \overline{\otimes} \mathcal{B}(\mathbb{C}^{d_f}), $$ for some $d_c, d_f \geq 0$ with $d_c+d_f \geq d$.

55. Pozdeeva Ekaterina

Skobeltsyn Institute of Nuclear Physics, Russia

Title: De Sitter solutions in Einstein-Gauss-Bonnet gravity

Abstract: We consider de Sitter solutions in models with the Gauss–Bonnet term, including $L(R,G)$ gravity models. We investigate evolution equations of a scalar field nonminimally coupled both with the curvature and with the Gauss–Bonnet term and look for the fixed points of scalar field dynamics which correspond to de Sitter solutions. We show that, in the case of a positive coupling function, it is possible to introduce an effective potential V_{eff} which can be expressed through the function U of nonminimal coupling with the curvature, the scalar field potential V, and the coupling function with the Gauss–Bonnet term denoted by F. We show that it is convenient to investigate the structure of fixed points using the effective potential because the stable de Sitter solutions correspond to minima of the effective potential. We have found de Sitter solutions in a few $L(R,G)$ models to demonstrate the effective potential method.

56. Przhiyalkovskiy Yan

Kotelnikov Institute of Radioengineering and Electronics of RAS, Russia

Title: Dynamics of open quantum systems in symplectic tomography

Abstract: The symplectic tomography has not only succeeded to become a self-consistent picture of quantum mechanics, but also has the practical significance for controlling the quantum state in applications. In this talk, the methods of symplectic tomography are considered in relation to the quantum systems interacting with the environment. It is shown how the common formalism of open system dynamics is projected onto the symplectic tomography. In particular, the counterparts of evolution equations have been derived to describe both the Markovian and non-Markovian evolution of tomograms.

57. Pushkarev Vasilii

Steklov Mathematical Institute, Russia

Title: Regular and irregular dynamics after local quenches in massive scalar field theory

Abstract: We study the energy density dynamics following the operator local quench in the theory of a free massive scalar field. In our setup, the local quench is defined as insertion of a field operator at some spacetime point. This produces a local excitation taking the system out of equilibrium. The known results state that in two-dimensional CFT, such perturbation propagates as a soliton along the light cone. We generalize this model to the simplest non-conformal cases. We obtain that the dynamics of the energy density occurs in several regimes with transition governed by the scalar field mass. We also consider the theory in finite volume with the background spacetime represented by a two-dimensional cylinder. In this model, the character of the perturbation evolution is regular on large time scales if the mass is small compared to the circumference of the cylinder. However, with increase of the mass parameter, it changes to complicated behaviour, showing chaotic-like interchange of damping and revival of the energy density amplitude.

58. Rastegin Alexey

Irkutsk State University, Russia

Title: Some applications of equiangular tight frames in quantum information

Abstract: Finite tight frames are interesting in their own rights as well as for applications including quantum information topics. Each complex tight frame leads to a non-orthogonal resolution of the identity in the Hilbert space. In many respects, equiangular tight frames (ETFs) are similar to the maximal sets that provide symmetric informationally complete measurements. Using known ETFs, new ones can be generated via the method related to Naimark's extension. For a measurement assigned to an ETF, the index of coincidence is estimated from above. Hence, several uncertainty relations follow. As is well known, uncertainty relations can lead to some criteria useful in quantum infomation processing. In particular, we consider the use of ETFs to detect entanglement and steerability.

59. Rivas Angel

Complutense University of Madrid, Spain

Title: Robust nonequilibrium edge currents with and without band topology

Abstract: We study a two-dimensional lattice system under nonequilibrium conditions corresponding to a sharp gradient of temperature imposed by two thermal baths. In particular, we consider a lattice model with broken time-reversal symmetry that exhibits both topologically trivial and nontrivial phases. Using a nonperturbative approach, we characterize the nonequilibrium current distribution in different parameter regimes. We find chiral edge currents that are robust against coupling to reservoirs and to the presence of defects on the boundary or in the bulk. This robustness not only originates from topological

effects at zero temperature but, remarkably, also persists as a result of dissipative symmetries in regimes where band topology plays no role. Interestingly, chirality of the edge currents implies that energy locally flows against the temperature gradient without any external work input.

60. Rozikov Utkir

Institute of Mathematics, Tashkent, Uzbekistan

Title: Gibbs measures for p-adic Hard-Core model with a countable set of spin values

Abstract: In the talk we discuss generalized Gibbs measure (GGM) for p-adic Hard-Core (HC) model with a countable set of spin values on a Cayley tree of order $k \geq 2$. This model is defined by a countable set of p-adic parameters. We analyze p-adic functional equation which provides the consistency condition for the finite-dimensional generalized Gibbs distributions. Each solutions of the functional equation defines a GGM by p-adic version of Kolmogorov's theorem. Under some conditions on parameters of the model we give the number of translation-invariant and two-periodic GGMs for the p-adic HC model on the Cayley tree of order two.

61. Rusalev Timofei

Steklov Mathematical Institute, Russia

Title: Entanglement Islands and Infrared Anomalies in Schwarzschild Black Hole

Abstract: We check the complementarity property of entanglement entropy which was implicitly assumed in previous studies for semi-infinite regions. This check reveals the emergence of infrared anomalies after regularization of a Cauchy surface. A naive infrared regularization based on“mirror symmetry” is considered and its failure is shown. We introduce an improved regularization that gives a correct limit agreed with the semi-infinite results from previous studies. As the time evolution goes, the endpoints of a finite region compatible with the improved regularization become separated by a timelike interval. We call this phenomenon the “Cauchy surface breaking”. Shortly before the Cauchy surface breaking, finite size configurations generate asymmetric entanglement islands in contrast to the semi-infinite case. Depending on the size of the finite regions, qualitatively new behaviour arises, such as discontinuous evolution of the entanglement entropy and the absence of island formation.

62. Sakbaev Vsevolod

Moscow Institute of Physics and Technology, Russia

Title: Invariant measures of infinite dimensional Hamiltonian systems and properties of Koopman groups

Abstract: We study the class of finite additive measures on the real separable Hilbert space E endowed with a shift-invariant symplectic form. Any measure from this class is invariant with respect to the group of symplectomorphisms preserving two-dimensional symplectic subspaces (see [1]). A Hamiltonian flow in a real separable Hilbert space preserving two-dimensional symplectic subspaces is presented by the Koopman unitary group in the space of functions that are quadratically integrable by invariant measure. The spectrum of the generator of a Koopman group is described. The invariant subspace of strong continuity of Koopman group is determined. References [1] Glazatov V. A., Sakbaev V. Zh. Measures on Hilbert space invariant with respect to Hamiltonian flows // Ufa Math. J. 2022. Vol. 14. No 2. P.3—21

63. Shamarov Nicolai

Moscow Institute of Physics and Technology, Russia

Title: On L2-realization of Guichardet infinite Hilbert tensor product and Smolyanov measure
Abstract: TBA

64. Shavgulidze Evgeny

Moscow State University, Russia

Title: Functional Integrals of Quantum 2D Gravity

Abstract: A class of functional Integrals measures quasiinvariant under the actions groups of diffeomorfisms is proposed. The common feature of the measures consists in the existence of nonlinear nonlocal substitutions that transform the measures to the Wiener one. The method is applied to calculation of path integrals in quantum 2d gravity models, including Schwarzian and some other path integrals.

65. Shu Fu-Wen

Nanchang University, China

Title: Island for one-sided Schwarzschild black hole

Abstract: In this talk, I will give a brief introduction to recent progress on information loss paradox of one-sided Schwarzschild black hole. asymptotically flat black hole formed by gravitational collapse. Instead of Hartle-Hawking state, which is usually used in eternal black hole, we discuss island and page curve of "in" vacuum state which describes one-sided asymptotically flat black hole formed by gravitational collapse.

66. Sinayskiy Ilya

University of KwaZulu-Natal, South Africa

Title: Quantum Simulation of Markovian and non-Markovian channel addition on NISQ devices and in the Quantum Optics Lab

Abstract: Studying memory effects in quantum channels helps develop characterization methods for open quantum systems and strategies for quantum error correction. Two main sets of channels exist, corresponding to system dynamics with no memory (Markovian) and with memory (non-Markovian). Interestingly, these sets have a nonconvex geometry, allowing one to form a channel with memory from the addition of memoryless channels and vice versa. Here, we use the NISQ device and photonic set-up to investigate this nonconvexity by subjecting a single qubit to a convex combination of Markovian and non-Markovian channels. Our results highlight some practical considerations that may need to be considered when using memory criteria to study system dynamics given by the addition of Markovian and non-Markovian channels in experiments.

67. Slepov Pavel

Steklov Mathematical Institute, Russia

Title: Anisotropic holographic models supported by Einstein-dilaton-four-Maxwell action

Abstract: This talk considers the five-dimensional gravitational solutions that arise within the framework of holographic quantum chromodynamics anisotropic models. These holographic models are supported by the Einstein action with the dilaton field and four Maxwell fields. Maxwell's first field is associated with the introduction of a chemical potential. The second field is responsible for the spatial anisotropy. The third and fourth fields describe the anisotropy associated with an external magnetic field. It is shown that we have only 6 independent equations out of 7 in the fully anisotropic case due to the Bianchi identity and EOM connection. The scheme of finding a solution is presented.

68. Stepanenko Daniil

Steklov Mathematical Institute, Russia

Title: Schwarzschild Black Holes, Islands and Virasoro algebra

Abstract: Discussed a possible modification of the island formula for the Schwarzschild black hole by applying the mechanism of dependence of the central charge on the black hole mass. The results are obtained which describe the von Neumann finite-value entropy curve for the island configuration. The island-free approach, which reproduces a curve similar to the Page curve, is also discussed.

69. Sukochev Fëdor, Zanin Dmitriy

University of New South Wales, Australia

Title: New approach to continuity/smoothness of the spectral shift function

Abstract: TBA

70. Teretenkov Alexander

Steklov Mathematical Institute & Moscow State University, Russia

Title: Hyperprojectors and master equations for quantum dynamical maps

Abstract: The widely used approaches for the derivation of quantum master equations are based on projection methods which lead to Nakajima-Zwanzig master equations or time-convolutionless master equations and their perturbative approximations. Our results are based on such methods, but we apply them to the dynamical maps instead of density matrices. In particular, we use projection operators which map superoperators to superoperators, so we call them "hyperprojectors". In this talk we discuss a very simple hyperprojector, which corresponds to the averaging with respect to fast free dynamics. One of obvious advantages of such an approach is that the initial conditions are always consistent with such a hyperprojector. Using such an approach, we obtain second

order master equations and their Bogolubov-van Hove limit. We also consider an analog of stroboscopic limit for such a hyperprojector. This work was funded by Russian Federation represented by the Ministry of Science and Higher Education (grant number 075-15-2020-788).

71. Thingna Juzar
University of Massachusetts Lowell, USA
Title: Beyond weak-coupling quantum master equations
Abstract: The theory of open quantum systems studies the dynamics of a system of interest under the influence of an uncontrolled random noise. The main goal is to obtain the reduced system dynamics in presence of an infinitely large environment that randomly influences the quantum system. This objective is typically achieved using a wide variety of perturbative quantum master equations with applications ranging from quantum optics, chemical physics, statistical physics, and more recently quantum information and thermodynamics. In this talk, I'll introduce some of the most common quantum master equations such as the Redfield and Lindblad and elucidate on the common misconceptions and pitfalls. I'll focus on the accuracy of such equations and discuss some recent ideas on correcting these approaches that help going beyond the weak coupling approximation. I'll introduce a Canonically Consistent Quantum Master Equation (CCQME) that utilizes the information about the strong-coupling equilibrium state, i.e., a mean-force Gibbs state [1], to correctly steer the quantum dynamics [2]. The approach goes beyond weak coupling methods and we corroborate the CCQME with the exactly solvable (Hu-Paz-Zhang) quantum dissipative harmonic oscillator and the numerically exact Hierarchy Equation Of Motion (HEOM) approach for the spin-boson model. The approach could be used in a wide range of applications where quantum noise

does not weakly influence the system of interest. [1] J. Thingna, J.-S. Wang, and P. Hänggi, J. Chem. Phys. 136, 194110 (2012). [2] T. Becker, A. Schnell, and J. Thingna arXiv:2205.12848 (2022).

72. Trushechkin Anton

Steklov Mathematical Institute, Russia

Title: Derivation of the Bloch-Redfield quantum master equation by Bogoliubov's method and generalization of the Born approximation

Abstract: The choice between the Bloch-Redfield quantum master equation and various forms of the GKLS quantum master equations can be considered to be the main problem of the weak-coupling theory for open quantum systems. The Bloch-Redfield equation, being not of the GKLS form, predicts the unphysical behaviour, e.g., negative probabilities. In this talk, another view on the Bloch-Redfield equation will be given, which is based on the derivation of its equation by the Bogoliubov method. From this point of view, the Bloch-Redfield equation assumes not a product initial system-bath state (which is usually assumed in theory of open quantum systems), but a correlated initial system-bath state that is formed during their previous common evolution. This may explain unphysical predictions of this equations if we apply this equation to the product initial system-bath state. The talk is based on the paper A. S. Trushechkin, “Derivation of the Redfield Quantum Master Equation and Corrections to It by the Bogoliubov Method”, Proc. Steklov Inst. Math., 313 (2021), 246–257, arXiv: 2108.03128

73. Turilova Ekaterina

Kazan Federal University, Russia

Title: Transformations preserving the spectral order

Abstract: TBA

74. Usova Marina

Steklov Mathematical Institute, Russia

Title: Holographic RG flows in 3d supergravity and their stability analysis

Abstract: TBA

75. Vacchini Bassano

University of Milan, Italy

Title: Role of quantum divergences in non-Markovian dynamics

Abstract: An interesting approach for the description of memory effects in the reduced quantum dynamics of an open system is based on the notion of information exchange between the open system and its environment. This exchange has typically been quantified studying the variation in time of the trace distance between distinct initial system states. We point to the fact that such an information exchange can actually be described by a large class of quantum divergences, including not only distances, but also entropic quantifiers. We consider in particular regularized versions of quantum relative entropy. We derive general upper bounds on the revivals of quantum divergences conditioned and determined by the formation of correlations and changes in the environment.

76. Vedyushkina Victoria

Moscow State University, Italy

Title: Modeling bifurcations of Liouville foliations of integrable Hamiltonian systems by billiard books

Abstract: Consider a two-dimensional cell complex whose two-dimensional cells are flat billiards bounded by arcs of confocal quadrics. We enumerate all two-dimensional cells and assign to each one-dimensional edge of the complex -

the so-called spine of the book - a cyclic permutation of the numbers of sheets adjacent to this edge. Project all billiard sheets isometrically onto a plane. If the edges of the complex under this projection fall into one arc of the quadric, then we combine the cycles assigned to them into one permutation. We require that the permutations assigned to two arcs of quadrics that have a common point commute with each other. We call such a two-dimensional complex with assigned permutations a billiard book. The construction of billiard books made it possible not only to significantly extend the class of integrable billiard systems, but also to discover new Liouville foliations. These Liouville foliations (encoded by the Fomenko-Zieschang invariants), on the one hand, have not previously been encountered in classical problems of dynamics, and on the other hand, the billiard systems corresponding to them have a visual description. In this regard, A.T.Fomenko formulated a program conjecture on the realizability by integrable billiards of arbitrary Liouville foliations (i.e. labeled molecules) of nondegenerate integrable systems with two degrees of freedom (in the class of Liouville equivalence). In particular, it was proved that the Liouville foliations of billiard books contain all bifurcations of the Liouville tori of non-degenerate Hamiltonian systems, as well as arbitrary bases of Liouville foliations.

77. Vernov Sergey

Skobeltsyn Institute of Nuclear Physics, Russia

Title: Extensions of the Starobinsky R^2 inflationary model

Abstract: We study several extensions of the Starobinsky model of inflation, which obey all observational constraints on the inflationary parameters, by demanding that both the inflaton scalar potential in the Einstein frame and the F(R) gravity function in the Jordan frame have the explicit dependence upon fields and parameters in terms of elementary functions. Our models are continuously connected to the original Starobinsky model via changing the parameters. We modify the Starobinsky (R + R2) model and calculate the inflationary observables and the allowed limits on the deformation parameters by using the latest observational bounds. The talk is based on the paper V.R. Ivanov, S.V. Ketov, E.O. Pozdeeva, S.Yu. Vernov, JCAP 03 (2022) 058 and recent investigations.

78. Vidiella-Barranco Antonio

University of Campinas, Brazil

Title: Minimal Environments

Abstract: In this talk, I will discuss some aspects of the interaction of simple quantum systems with environments having a small number of degrees of freedom. I will consider two models of coupled quantum systems affected by minimal noisy environments: i) a two-qubit system in contact with a single-mode field, and ii) a qubit-field system in contact with a single qubit. I will address the dynamics of quantities such as the quantum state purity and quantum coherence of the systems of interest, as well as in which way those properties depend on the features of the small environments. The above-mentioned models admit non-perturbative analytical solutions, allowing the use of a wide range of values of coupling constants. The study of the influence of environments with a size comparable to the quantum systems of interest may be relevant to the development of quantum technologies.

79. Volkov Boris

Moscow Institute of Physics and Technology, Russia & Steklov Mathematical Institute of Russian Academy of Sciences, Moscow & National University of Science and Technology "MISiS", Russia

Title: Higher order traps in quantum control landscapes

Abstract: Mathematical analysis of quantum control landscapes, which includes proving either absence or existence of traps for quantum control objective functionals, is an important topic in the quantum control theory. Traps are points of local but not global extrema of the objective functional. Traps of n-th order are singular controls defined by the Taylor expansion of the objective functional up to the n-th order. Their existence in quantum landscape can reduce the performance of local search optimal control protocols. In this talk, we discuss the presence of n-th order traps for the control problem of some closed multilevel systems.

80. Volovich Igor

Steklov Mathematical Institute, Russia

Title: Entanglement in classical mechanics and quantum gravity

Abstract: TBA

81. Watanabe Noboru

National Institute of Advanced Industrial Science and Technology, Japan

Title: Note on Transmitted complexity for Quantum Compound Systems

Abstract: Ohya proposed the information dynamics synthesizing several ways of studying complex systems. In information dynamics, there are two types of complexities, one is a complexity of state representing system itself and another is a transmitted complexity between two systems. Entropies in classical and quantum systems are examples of these complexities of information dynamics. Transmitted complexity is an important tool to analyse the efficiency of information transmission in communication processes. In order to treat a flow of dynamical process, dynamical entropies were introduced in not only classical but also

quantum systems. \qquad Base on the transition expectation introduced by Accardi to study quantum Markov process, the KOW entropy for completely positive (CP) maps was defined in [3]. The generalized AOW and the AF entropis was constructed by the KOW entropy. The compound states are important tool to define the transmitted entropy [19,22]. The transmitted complexity associated with the separable compound states is defined by using the generalized AOW entropy in [14,23]. \qquad In the talk, we briefly review the generalized AOW entropy formulated by KOW entropy and we define a transmitted complexity (dynamical mutual entropy) given by a modified compound states and we prove the fundamental inequalities of the transmitted complexity by means of the independent dynamical systems.

82. Winter Andreas

Universitat Autonoma de Barcelona, Spain

Title: Towards p-adic quantum bits and angular momentum theory via representations of the p-adic special orthogonal group SO(3)p

Abstract: Developing the theme of p-adic quantum mechanics, where the configuration space is parametrised by p-adic numbers (for a fixed prime p), but wave-functions have the familiar complex amplitudes and Born's rule yields real-valued probabilities, we embark on the development of rotation symmetries of p-adic three- dimensional space, the compact group SO(3)_p and its representation theory as an approach to angular momentum in p-adic quantum mechanics, in particular p-adic spin and p-adic qubits. I will give an overview of the current state of the theory, starting from the description of SO(3)_p and its two-dimensional rotation subgroups, to the construction of the Haar measure, and of its first (simplest) two-dimensional

complex unitary representations. Based on arXiv:2104.06228 and arXiv:2112.03362.

83. Yadav Gopal

Indian Institute of Technology Roorkee, India

Title: Page Curves of Black Holes in Higher Derivative Theories of Gravity and Cosmological Islands

Abstract: My talk is based on arXiv:2204.11882, 2207.04048 and 2210.00331. In this talk, I will discuss how we obtain the Page curves of black holes in higher derivative theories of gravity. First, I will discuss one example (Reissner-Nordström black hole) based on Island proposal and then I will discuss the doubly holographic setup in M theory with inclusion of higher derivative terms. Using this setup we obtained the Page curve of eternal neutral black holes. In this process and in the context of the latter, we will show a hierarchy in the entanglement entropies of the Hartman-Maldacena(HM)-like and Island surfaces(IS) with respect to an exponential-in-N suppression factor at the leading order and with the inclusion of higher derivative corrections. After showing the existence of massless graviton eigenmode of the Laplace-Beltrami differential operator acting on the internal coordinates, we will show that due to an identical exponential-in-N suppression at the leading order in the entanglement entropies of, both, the HM-like and Island surfaces (and larger suppressions of the higher derivatives' contributions), one is able to obtain the Page curve. Finally, I will discuss the application of the Island proposal for Schwarzschild de-Sitter black holes where we introduce cosmological islands to resolve the information problem in a de-Sitter patch.

84. Zagrebnov Valentin

Institute of Mathematics of Marseille, France

Title: Why do bosons condense?

Abstract: After a short review of different mechanisms for that, I discuss a non-conventional (dynamical) Bose condensation which is due to a weak attraction between bosons.

85. Zelenov Evgeny

Steklov Mathematical Institute, Russia

Title: Coherent states of the p-adic Heisenberg group, heterodyne measurements and entropy uncertainty relation

Abstract: A construction of coherent states for the p-adic Heisenberg group is proposed. It turns out that these states are parametrized by elements of the direct product of two copies of the Prufer group and form an orthonormal basis. Such bases are parametrized by a set of self-dual lattices in a two-dimensional vector space over a field of p-adic numbers. The whole family of coherent state bases can be represented as a graph of self-dual lattices. The heterodyne measurement corresponding to this basis is investigated. For a pair of such measurements, the uncertainty relation is obtained in terms of the Wehrl entropy. The lower bound of the sum of the Wehrl entropies for two dimensions is determined by the distance on the lattice graph. It is shown that the bases of coherent states are pairwise mutually unbiased. A complete system of mutually unbiased bases is constructed.

86. Zharinov Victor

Steklov Mathematical Institute, Russia

Title: Dynamics of wave packets in the functional mechanics

Abstract: TBA

87. Zuniga-Gallindo Wilson

University of Texas Rio Grande Valley, USA

Title: p-Adic Neural Networks and Quantum Field Theory

Abstract: The talk aims to discuss the correspondence between Euclidean quantum field theories and neural networks in the p-adic framework as presented in our recent preprint arXiv:2207.13877. In this work we initiate the study of the correspondence between p-adic statistical field theories (SFTs) and neural networks (NNs). In general quantum field theories over a p-adic spacetime can be formulated in a rigorous way. Nowadays these theories are considered just mathematical toy models for understanding the problems of the true theories. We show these theories are deeply connected with the deep belief networks (DBNs). Hinton et al. constructed DBNs by stacking several restricted Boltzmann machines (RBMs). The purpose of this construction is to obtain a network with a hierarchical structure (a deep learning architecture). An RBM corresponds to a certain spin glass, thus a DBN should correspond to an ultrametric (hierarchical) spin glass. A model of such a system can be easily constructed by using p-adic numbers. In our approach, a p-adic SFT corresponds to a p-adic continuous DBN, and a discretization of this theory corresponds to a p-adic discrete DBN. We show that these last machines are universal approximators. In the p-adic framework, the correspondence between SFTs and NNs is not fully developed. We point out several open problems.