March 30

What are Quantum Temporal Correlations ?

Hai Wang and Junde Wu

School of Mathematical Sciences, Zhejiang University, Hangzhou, PR China

Space and time are crucial twins in physics. In quantum mechanics, spatial correlations already reveal nonclassical features, such as entanglement, and have bred many quantum technologies. However, the nature of quantum temporal correlations still remains in vague. In this talk, based on the entangled-history formalism, we prove rigorously that temporal correlations can be equivalently characterized by spatial correlations. The effect of temporal correlations corresponds to a quantum channel. The resulting can quantify the quantum temporal correlations in a natural way. Our proposed procedures also show how to determine temporal correlations completely. Multi-stages iterative process for conservative economical finite-difference schemes realization for the problemы of nonlinear laser pulse interaction with a medium

Multi-stages iterative process for conservative economical finite-difference schemes realization for the problem of nonlinear laser pulse interaction with a medium

V.A. Trofimov(1), M.M. Loginova(2), V.A. Egorenkov(2)

(1) South China University of Technology, Guangzhou, China
(2) Lomonosov Moscow state University, faculty VMK

We consider a few problems of the laser pulse interaction with a medium. Among them, we highlight the laser pulse self-action in the 3D case and the pulse interaction with a semiconductor under the light energy nonlinear absorption. Strongly nonlinear effects accompany such interaction, and those require using conservative finite-difference schemes for their numerical simulation. As a rule, the conservative finite-difference schemes are non-economical ones. This fact leads to wide using of split-step method for numerical simulation of the laser pulse interaction with a matter despite this method possesses well-known disadvantages. However, this method is an economical one.
We joint advantages of both methods by developing original multi-stage iteration process for the conservative finite-difference scheme realization. In the current report we demonstrate feasibility of the proposed approach.
M. Loginova and V. Egorenkov thank Russian Science Foundation for financial support (grant 19-11-00113).

Social Laser

A. Yu. Khrennikov

Linnaeus University, Vaxjo, Sweden

In the framework of quantum-like modelling - application of quantum apparatus outside physics- we present the social laser model: a general scheme for generating giant waves of social action: 1) pumping the human medium with social energy; 2) stimulating concerted social action by injecting a batch of homogeneous messages into the agitated medium. The scheme is applicable to the widest range of events, regardless of national, cultural, geopolitical, and economic specifics. The basic concepts of our theory: social energy, information field, social atom, active pumping medium, spontaneous and stimulated generation of social actions, a cascade process of amplifying social activity. With the help of these concepts, we formalize the process of social lasing, then quantize parameters, for example, the power of the information field, write and solve equations.

Quality of Control in the Tavis-Cummings-Hubbard Model

Rafael Dull (1), Alexei Kulagin (2), Wanshun Lee (2),Yuri Ozhigov (2);(3), Miao Huei-huei (2), Zheng Keli (2),

(1) Technical University Munich, Munich, Germany.
(2) Moscow State University of M.V.Lomonosov, Faculty VMK
(3) K.A.Valiev Institute of physics and technology RAS, Moscow, Russia

The quality of controlling a system of optical cavities in the Tavis-Cummings-Hubbard (TCH) model is estimated with the examples of quantum gates, quantum walks on graphs, and of the detection of singlet states. This type of control of complex systems is important for quantum computing, for the optical interpretation of mechanical movements, and for quantum cryptography, where singlet states of photons and charges play an essential role. It has been found that the main reason for the decrease of the control quality in the THC model is due to the nite width of the atomic spectral lines, which is itself related to the time energy uncertainty relation. This paper evaluates the quality of a CSign-type quantum gate based on asynchronous atomic excitations and
on the optical interpretation of the motion of a free particle.

Quantum nonlocality and control on the distributed computations,

Y.I.Ozhigov (1),(2), I.Pluzhnikov, (1),

(1) Moscow State University of M.V.Lomonosov, Faculty VMK,
(2) (2) K.A.Valiev Institute of physics and technology RAS

The synthesis of 4 abstract polymer chains divided into two sexes is considered, where the quality of the result is determined by the pairing of opposite-sex pairs of chains. It is shown that the use of some types of entangled photon quartets in control gives a result that is unattainable with classical control, as well as unattainable with a pair of control biphotons. The appendix additionally provides an interpretation of quantum nonlocality through the pre-programmed propagation of the wave function of several photons.

March 31

Quantum Algorithms for Constructing Text from Dictionary Problem

K.R. Khadiev (1) (2), V. S. Remidovskii (1)

(1) Kazan Federal University, Kazan, Russia
(2) Kazan E. K. Zavoisky Physical-Technical Institute, Kazan, Russia

We study algorithms for solving the problem of constructing a text (long string) from a dictionary (a sequence of small strings). We interesting in two kind of the problem - with possible intersections and with no intersections. The problem has an application in bioinformatics and has a connection with the Sequence assembly method for reconstructing a long DNA sequence from small fragments. The problem is constructing a string t of length n from strings $s^1,\dots, s^m$ with no intersections. We provide a quantum algorithm with running time $\tilde{O}\left(n +\sqrt{m\cdot L}\right)$ for the first problem sand similar result for the second problem. Additionally, we show that the lower bound for a classical (randomized or deterministic) algorithm is $\Omega(n+L)$. Thus, our quantum algorithm shows speed-up comparing to any classical (randomized or deterministic) algorithm in the case of non-constant length of strings in the dictionary. The algorithm is based on modifications of Grover's search algorithm and advanced data strucure and algorithms like segment tree and others.

Semiclassical Model of Quantum Computing for Solid State NMR

M.M. Kucherov

Siberian Federal University, School of Space and Information Technologies

An extension of the concepts, which previously led to spectroscopically convenient formulation and implementation of quantum-computational procedures, is proposed. The usage of polarization operators makes it possible to describe precisely quantum computing in spin Liouville space of quantum coherences connected by truncated dipole Hamiltonian. By using a symmetry-adapted basis operator set, the density matrix equation is decoupled into finite number of equations for the isochromat components that yields the observed signal. The states of a quantum computer can be identified by transitions between energy levels of spins immersed in classical local magnetic fields. The readout step consists of a single nonselective pulse followed by the detection of the FID. A calculation of entanglement for a spin cluster illustrates the proposal.

Clustering by quantum annealing on three level quantum elements - qutrits

V.E. Zobov, I. S. Pichkovskiy

Kirensky Institute of Physics Federal Research Center KSC Siberian Branch Russian Academy of Sciences, Laboratory of Radiospectroscopy and Spintronics.

Clustering is operation of artificial neural network that groups "similar" data points based on their characteristics. In this work we simulate clustering on two, three and four clusters using quantum annealing technics by "One hot encoding" algorithm and k-means++ algorithm. For encoding data points we use eigenstate of qutrits. To encode the four groups, we used the eigenstates of the two-element systems instead of different single elements.This approach allows to reduce the number of elements required to solve the clustering task.

Qudit-based quantum information processing

E.O. Kiktenko (1),(2), A.S. Nikolaeva (1),(2), A.K. Fedorov (1),(2)

(1) Russian Quantum Center

(2) Moscow Institute of Physics and Technology

We study the reduction of the number of quantum operations and the improvement of the circuit depth for the realization of quantum gates by using multilevel quantum systems (qudits). The suggested method is based on a combination of several approaches. One of the approaches uses a general relation between the dimensionality of qudits and their topology of connections for a scalable multiqudit processor, where higher qudit levels are used for substituting ancillas. A complimentary method uses a decomposition of multilevel systems on a number of two-level systems. We discuss an application of our approach in ongoing experiments with quantum information processing systems. The research is supported by the Russian Science Foundation (Grant No. 20-42-05002; the general theoretical framework), the grant UMNIK (Agreement 103GUCEC8-D3/56361 form 21.12.2019; applications to quantum algorithms), and Leading Research Center on Quantum Computing (Agreement No. 014/20; applications of this approach for the analysis of quantum computing experimental platforms).

Tri-state Quantum Information Model

Ed Gerck

Planalto Research, CA, USA

Classically, information processing and communication are described by a tri-state system. This has replaced the Boolean algebra of a two-state system, also in gate construction with physical systems. The most fundamental entity in today`s quantum theory of information is, however, still a two-state system, the qubit. This work corrects this stance, shows how a tri-state superposition system (called qtrust) can be formulated in quantum mechanics, reduces the influence of errors, improves the signal, connects to the Einstein A and B coefficients of the radiation model, and explains the formation of an atomic spectral line.

On The Physical Representation Of Quantum Systems

Ed Gerck

Planalto Research, CA, USA

The Schrodinger equation for bound states (SEBS) depends on a second derivative, that only exists iff the solution is continuous, which is -- by itself -- contradictory, and cannot be digitally calculated. Physical representations of quantum systems, cannot, thus, follow some computational aspects of quantum mechanics. This is solved by considering the SEBS depending on the curvature, which is expressed exactly as a difference equation, and variationally solved for natural numbers, representing the quantum energy levels. Exact representations are calculated for common and any potentials, including the Rydberg condition, associating any potential with a spectrum.

Indistinguishability of quantum states and rotation counting

Dmitri V. Averin

Department of Physics and Astronomy, Stony Brook University, SUNY, Stony Brook, NY, USA

Current experimental activity in quantum computing is providing a strong boost to the development of quantum technologies that can be used to study artificial "macroscopic" quantum systems characterized by phenomena that do not exist in traditional quantum mechanics. In the presentation, I will discuss an example of one such system, two coupled rings, that demonstrates a controlled violation of the planar rotation symmetry, caused by one of the rings serving as a monitor of the rotation of the other one. In this system, the winding number of rotation, which is usually considered only as a formal tool for the description of rotations in quantum mechanics, becomes a real physical observable, and can extend the rotation period to several full rotations. All quantum properties of the ring, including its energy spectrum, are modified by this extended periodicity. I will also discuss possible applications of this model in other contexts.

April 1

Algorithm for quantum computer that simulates multiple quantum NMR dynamics in systems of particles with spin 1/2

A.A. Belova (1), A.V. Fedorova (2), E. I. Kuznetsova (2)

(1) Lomonosov Moscow state University, Faculty of Fundamental Physical and Chemical Engineering,
(2) Institute of Problems of Chemical Physics, Russian Academy of Sciences

Multiple quantum (MQ) NMR is a powerful tool for studying the structural properties of solids.
In this paper, we consider low-temperature MQ NMR, which makes it possible to obtain spectra less distorted by the thermal motion of molecules in comparison with high-temperature and to study phenomena with collective correlation of spins.The aim of this work was to develop the algorithm for a quantum computer that simulates the multiple quantum NMR dynamics in systems of particles with spin 1/2 and based on the data obtained to analyze the intensities of MQ coherences of the zero and ± second orders at low temperatures.

Full-stack software solution for the currently developed quantum computer

G. I. Struchalin (1), (2), A. D. Moiseevskiy (lecturer) (1), (2), F. I. Medvedev (2), I. V. Kondratyev (1), (2), and S. P. Kulik (1), (2)

(1) Lomonosov Moscow State University, Faculty of Physics
(2) MSU Quantum Technology Centre

Creating a quantum computer with an original architecture requires solving several problems, starting from developing a quantum instruction language and compiler up to the secure remote access system. We present an original software solution for quantum computers developed at the MSU Quantum Technology Centre. The software includes a compiler for the original quantum instruction language, an API for C++ and Python, a remote access system, a command-line interface, an operating system that provides task management for quantum hardware, and a web interface. It is expected that this software solution will be used to provide public access for MSU Quantum Technology Centre quantum computers.

Unambiguous state discrimination attack on a quantum key distribution line

D. B. Horoshko, S. Ya. Kilin

B. I. Stepanov Institute of Physics, NASB, Minsk, Belarus

A successful unambiguous discrimination of quantum states in a quantum channel gives the adversary full control over the information exchanged by the users of a quantum cryptography link. It was shown recently [Phys. Lett. A 383, 1728 (2019)] that the maximal probability of equiprobable unambiguous discrimination of a set of pure quantum states is given by the minimal eigenvalue of the Gram matrix of this set. We show how this result allows one to easily calculate the probability of successful eavesdropping for various protocols of quantum cryptography, in particular, for the BB84 protocol realized with weak coherent states of light and decoy states.

Spectral properties of a photonic molecule designed from one-dimensional chain of coupled Fabry-Perot cavities under mechanical control

A.V. Tsukanov (1), Y.V. Garev (2)

(1) Valiev Institute of Physics and technology, Russian Academy of Sciences
(2) Moscow Institute of Physics and Technology, School of Electronics, Photonics and Molecular Physics

We theoretically studied the spectrum and the electric field spatial distribution of a linear optical structure known as a photonic molecule (PM) composed of N = 2 - 42 solid-state Fabry-Perot microcavities (MC). These systems are fabricated from semiconductor heterostructures and have a lot of practical applications, e.g. in the single-photon or photonic pair sources.
We used the transfer matrix approach to calculate the PM spectra while the electric field amplitudes are obtained by finite-difference methods. The sets of PM parameters (i.e., the mirror thicknesses and refractive indices) that allow to concentrate the electromagnetic field energy in two remote MC, as well as the frequencies of corresponding modes, are found. Such a structure of the mode field could enable one to organize a non-local interaction between two stationary quantum bits which reside in those MC. Besides, we investigated a way of spectrum engineering by mechanical variation of the position of the edge mirror (or equivalently, changing of the length of the edge MC). Also, the conditions of switching among spectra corresponding to PMs with different MC numbers are formulated. The numerical simulation results agree well with analytical results obtained earlier under the tight-binding approximation.
Acknowledgments
The investigation was supported by Program No. 0066-2019-0005 of Ministry of Science and Higher Education of Russia for the Valiev Institute of Physics and Technology of RAS.

Diamond photonic molecule with mechanical tuning of the spectrum by a mobile microdisk

M.S. Rogachev, A.V. Tsukanov, I.Yu. Kateev

Valiev Institute of Physics and Technology, Russian Academy of Sciences

Optical properties of a photonic molecule (PM) consisting of three diamond microdisk microresonators (MRs) are studied. The PM spectrum is tuned using an additional mobile microdisk located directly above the central MR. Vertical microdisk movement causes redistribution of the electromagnetic field between the MRs. Frequencies of the PM and the photon population of each MR are calculated depending on various system parameters. The results can be used to develop a device that controls photon transport through a diamond optical quantum network.

On some modifications of finite-dimensional QED models

Vitali Afanasiev (1), Zheng Keli (1), Alexei Kulagin (1), Miao Huei-huei (1), Wanshun Lee (1) , Yuri Ozhigov, (1), (2), Nadezda Victorova (3)

(1) Moscow State University of M.V.Lomonosov, VMK Faculty,
(2) K.A.Valiev Institute of physics and technology RAS,
(3) Russian State University for the Humanities

Modifications of finite-dimensional multi-mode models of electrodynamics, including the spatial movement of charges and the presence of spins in electrons and atomic nuclei, are considered. A model of association - dissociation of artificial atoms into the simplest molecules is proposed, taking into account the interaction with the orbital and spin modes of the field, and the results of numerical experiments for such models performed using the quantum master equation are presented and discussed, in particular, the role of dark states in such reactions is explained. The features of the application of numerical methods for solving such problems on supercomputers are discussed.

April 2

Uncertainty relation "precision of wave function – complexity"

Y.I.Ozhigov (1),(2),

(1) Moscow State University of M.V.Lomonosov,
(2) K.A.Valiev Institute of physics and technology RAS

The complexity C of the quantum state and the accuracy A of its description are in the ratio of uncertainties CA < q. Equivalent form: the total number of qubits needed to identify accuracy and complexity is limited by a certain constant q - this is the number of qubits for which the Grover algorithm works. The amplitude of the wave function is quantized with the grain \e=2^{-q/2}, and this allows us to introduce into quantum dynamics a kind of determinism that is not reduced to quasiclassicism. The constant q is a physical quantity that can be detected experimentally.

Jordan-Wigner qubits with nontrivial exchange rule

Alexander Yu.\ Vlasov (1), (2)

(1) P.V. Ramzaev Research Institute of Radiation Hygiene, Federal Radiology Center
(2) Alexander Friedmann Laboratory for Theoretical Physics

Well-known (spinless) fermionic qubits may need more subtle consideration in comparison with usual (spinful) fermions. Even in standard model with local fermionic modes formally only the `occupied' state $|1\rangle$ is truly relevant for Fermi--Dirac statistics, but `vacuum' state $|0\rangle$ is not. Introduction of exchange rule for such fermionic qubits indexed by some `positions' may look questionable due to general super-selection principle. However, a consistent algebraic construction of such `super-indexed' qubits is presented in this work. Considered method has some relation with construction of super-spaces, but it has some differences with standard definition of supersymmetry sometimes used for generalizations of qubit model.

Quantum register cannot be real.

A.V. Nikulov

Institute of Microelectronics Technology, Russian Academy of Sciences, Chernogolovka, Moscow District, Russia. E-mail: nikulov@iptm.ru

The idea of a quantum computer arose and became popular because of a misconception about the subject of describing quantum mechanics. According to Heisenberg's proposal to describe observable and Born's proposal to consider the Schrodinger wave function as a description of the amplitude of the observation probability quantum mechanics describes our knowledge about results of observations. But most physicists have always kept the illusion that quantum mechanics describes a reality. Therefore the transformation of spinors under the rotation of the coordinate axes was deduced from the notion that spin states exists in the real isotropic space. The operators of finite rotations of the coordinate axes are applicable only to non-entangled states and cannot be applicable to entangled states such as the EPR pair and quantum register. Therefore we cannot even think that quantum register can exist in the real three-dimension isotropic space, see the preprint "Logical proof of the absurdity of the EPR correlation" at https://www.researchgate.net/profile/Alexey_Nikulov/research .

Funny mistake of Richard Feynman.

A.V. Nikulov

Institute of Microelectronics Technology, Russian Academy of Sciences, E-mail: nikulov@iptm.ru

Richard Feynman in 1982 and Yuri Manin in 1980 drew attention to the complexity of computing quantum systems and proposed to carry out such calculations using quantum systems. They did not take into account that the complexity of computing increases exponentially with the number of elements, not because the system is quantum, but because the probability of observation is calculated. Schrodinger defined in 1935 the EPR (Einstein - Podolsky Rosen) correlation as entanglement of our knowledge since he understood that quantum mechanics describes our knowledge about results of observation according to the Born proposal. Our knowledge can be entangled not onle about a quantum system but also any other objects and the expression for the EPR pair can describe not only two particles with spin 1/2 but any two objects with two possible results of observations, for example Schrodinger's cats.

Simulation of PT-symmetric systems

Minyi Huang

Department of Mathematical Sciences, Zhejiang Sci Tech University, Hangzhou, China

Simulating PT-symmetric (pseudo-Hermitian) quantum systems with conventional Hermitian quantum mechanics is a useful and important approach to the theory of PT-symmetry. We discuss methods to experimentally realize such non-Hermitian systems, by utilizing the global Hermiticity for both unbroken and borken PT-symmetric case. In addition, we investigate the internal nonlocality in the simulation process, giving different models for the description of the correlations between the subsystems. Different correlation bounds are obtained, which can help in the verification of PT-symmetric systems.

Pseudostochastic representation of quantum dynamics

E.O. Kiktenko (1),(2),(3), V.I. Yashin (1),(2),(3), D.A. Kulikov (1),(2), A.S. Mastiukova (1),(2), A.K. Fedorov (1),(2)

(1) Russian Quantum Center,
(2) Moscow Institute of Physics and Technology,
(3) Steklov Mathematical Institute of Russian Academy of Sciences

An approach for describing the dynamics of finite-dimensional quantum systems in terms of pseudostochastic maps is considered. Within the approach, quantum states are described with fair probability distributions, obtained with minimal informationally complete positive operator-valued measures (MIC-POVMs). Systems dynamics is described by pseudostochastic matrices which are a generalization of stochastic matrices on possibly negative values. We show how the approach allows identifying a transition of dissipative quantum dynamics to a completely classical-like stochastic one. Then we discuss the applicability of the approach to the problem of simulating noisy intermediate-scale quantum (NISQ) devices with classical randomized algorithms.

April 3

Average skew information-based coherence and its typicality for random quantum states

Zhaoqi Wu (1),(4), Lin Zhang (2),(4), Shao-Ming Fei (3),(4), Xianqing Li-Jost (4)

(1) Department of Mathematics, Nanchang University, Nanchang, P R China,
(2) Institute of Mathematics, Hangzhou Dianzi University, Hangzhou, P R China,
(3) School of Mathematical Sciences, Capital Normal University, Beijing, P R China,
(4) Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany

We study the average skew information-based coherence for both random pure and mixed states. The explicit formulae of the average skew information-based coherence are derived and shown to be the functions of the dimension N of the state space. We demonstrate that as N approaches to infinity, the average coherence is 1 for random pure states, and a positive constant less than 1/2 for random mixed states. We also explore the typicality of average skew information-based coherence of random quantum states. Furthermore, we identify a coherent subspace such that the amount of the skew information-based coherence for each pure state in this subspace can be bounded from below almost always by a fixed number that is arbitrarily close to the typical value of coherence.

Finite-dimensional optical interpretation of charge and field dynamics

Zheng Keli (1), Yuri Ozhigov (1),(2)

(1) Moscow State University of M.V.Lomonosov,
(2) K.A.Valiev Institute of physics and technology RAS

We investigated the interpretation of the finite-dimensional model of chemistry using a multimode modification of the Tavis-Cummings-Hubbard scheme. The meaning of such an optical interpretation is the representation of the movement of charges in terms of the transitions of photons between multilevel artificial atoms. Optical interpretation cannot be an accurate simulation, we assessed its possible accuracy. The movement of photons is much easier to organize than the movement of charges, which makes it important to optically interpret chemistry.

Tighter Monogamy Relations in Multiqubit Systems

Kai Zheng (1), Yuan-Hong Tao (1),(2)

(1) Department of Mathematics, College of Sciences, Yanbian University, China,
(2) Department of Big Data, School of Science, Zhejiang University of Science and Technology, Hangzhou, China

Monogamy property in multipartite systems are the most striking features of the quantum world. We investigate the monogamy relations for multiqubit systems. Monogamy relations related to the concurrence C and negativity Nc are also studied and monogamy inequalities for the α-th power of entanglement have been derived, which are tighter than the existing ones for some classes of quantum states.

Photon statistics for metrology applications: imaging and linear optical circuits characterization

K. G. Katamadze(1),(2), B. I. Bantysh(2), G. V. Avosopiants(1), A. V. Romanova(1), Yu. I. Bogdanov(2), S. P. Kulik(1)

(1) Lomonosov Moscow state University, Faculty of Physics, Quantum Technology Centre
(2) Valiev Institute of Physics and technology, Russian Academy of Sciences

Historically, light was a main information source for humans, and it is still used in a wide range of metrological applications. But most of them are just based on the intensity measurement. At the same time, photon statistics may give us a lot of additional information. Back in 1956, Robert Hanbury Brown and Richard Q. Twiss proposed using the correlation properties of light to measure the angular sizes of stars. In the current work we give two examples where studying photon statistics of light enables us to precisely characterize the photon source and the transmission channel. We will show, how photon statistics measurement can be used in imaging tasks and how correlation measurements of interfered thermal fields allow us to precisely characterize linear optical circuits, used in quantum computation.

Quantum tomography benchmarking

Chernyavskiy A. Yu., Bantysh B. I., Bogdanov Yu. I.

Valiev Institute of Physics and Technology of Russian Academy of Sciences, Russia

Recent advances in quantum computers and simulators are steadily leading us towards full-scale quantum computing devices. Due to the fact that debugging is necessary to create any computing device, quantum tomography (QT) is a critical milestone on this path. In practice, the choice between different QT methods faces the lack of comparison methodology. Modern research provides a wide range of QT methods, which differ in their application areas, as well as experimental and computational complexity. Testing such methods is also being made under different conditions, and various efficiency measures are being applied. Moreover, many methods have complex programming implementations; thus, comparison becomes extremely difficult.
In this study, we have developed a general methodology for comparing quantum state tomography methods. The methodology is based on an estimate of the resources needed to achieve the required accuracy. We have developed a software library (in MATLAB and Python) that makes it easy to analyze any QT method implementation through a series of numerical experiments. The conditions for such a simulation are set by the number of tests corresponding to real physical experiments. As a validation of the proposed methodology and software, we analyzed and compared a set of QT methods. The analysis revealed some method-specific features and provided estimates of the relative efficiency of the methods.

Robust quantum tomography protocols for ion-based qudits

Bantysh B. I., Bogdanov Yu. I.

Valiev Institute of Physics and Technology of Russian Academy of Sciences, Russia

Quantum tomography makes it possible to obtain a comprehensive information about certain logical elements of a quantum computer. In this regard, it is a promising tool for debugging quantum computers. The practical application of tomography, however, is still limited by systematic measurement errors. Their main source are errors in the quantum state preparation and measurement procedures. In this work, we investigate the possibility of suppressing these errors in the case of trapped-ion-based qudits. To do this, we use quantum tomography protocols that minimize systematic errors by minimizing the number of elementary operations. In particular, we consider a tomography protocol, which uses no more than a single operation per measurement circuit. We will show that the use of such a protocol is informationally complete and can significantly increase the accuracy of the quantum state reconstruction.

Study of the coherence of multimode states of Schrödinger's cats

D.V. Fastovets, Yu. I. Bogdanov, N.A. Bogdanova, V.F. Lukichev

Valiev Institute of Physics and Technology of Russian Academy of Sciences, Russia

The Schmidt decomposition allows us to evaluate the correlation characteristics between different subsystems of a base physical system. These systems can be both quantum states or classical probability distributions. Two kind of systems are considered in this work: quantum Schrödinger cat states and double-slit interference of microparticles. It is shown that both systems have same internal structure and can be described in terms of interfering alternatives. An efficient approach that allows us to calculate significant optical characteristics (visibility and coherence) has been developed. A natural generalization of the light coherence classical complex parameter, which determines the visibility of the interference is obtained. The interference visibility can be expressed in terms of the Schmidt number, which determines the relationship between the quantum system and its environment. All developed approaches were generalized to the case of multidimensional Schrödinger cat states. Analytical formulas that allows us to modeling and calculating the arising interference patterns and characteristics are obtained within the generalization. The obtained results can be used in the high-dimensional quantum information processing systems development.

April 4

Duistermaat–Heckman measure and the mixture of quantum states

Lin Zhang (1), Yixin Jiang (1), and Junde Wu (2)

(1) Institute of Mathematics, Hangzhou Dianzi University, Hangzhou, PR China,
(2) School of Mathematical Sciences, Zhejiang University, Hangzhou, PR China

In this paper, we present a general framework to solve a fundamental problem in random matrix theory (RMT), i.e. the problem of describing the joint distribution of eigenvalues of the sum $A + B$ of two independent random Hermitian matrices A and B. Some considerations about the mixture of quantum states are basically subsumed into the above mathematical problem. Instead, we focus on deriving the spectral density of the mixture of adjoint orbits of quantum states in terms of the Duistermaat–Heckman measure, originated from the theory of symplectic geometry. Based on this method, we can obtain the spectral density of the mixture of independent random states. In particular, we obtain explicit formulas for the mixture of random qubits. We also find that, in the two-level quantum system, the average entropy of the equiprobable mixture of n random density matrices chosen from a random state ensemble (specified in the text) increases with the number n. Hence, as a physical application, our results quantitatively explain that the quantum coherence of the mixture monotonously decreases statistically as the number of components n in the mixture. Besides, our method may be used to investigate some statistical properties of a special subclass of unital qubit channels.

The limits of scaling of Grover search algorithm on a asynchronous atomic excitations,

A.Kulagin (1), Y.Ozhigov (1),(2),

(1) Moscow State University of M.V. Lomonosov,
(2) K.A.Valiev Institute of physics and technology RAS.

We studied the Grover quantum algorithm, implemented on the basis of asynchronous atomic excitations of atomic ensembles in optical cavities. The main source of decoherence in the Jaynes-Cummings-Hubbard model is the widening of spectral lines due to the energy-time uncertainty ratio, which is critical for our model. We estimated the number of qubits for which the Grover algorithm can be implemented according to our scheme.

On quantum neural networks

A.A. Ezhov

State Research Center of Russian Federation
Troitsk institute for innovation and fusion research

Earlier definition that quantum neural network is a new field which integrates classical neurocomputing with quantum computation is rather vague and can be satisfactory in 2000th. Widespread in 2020th modern definition of quantum neural network as "machine learning model or algorithm that combines the features of quantum computing with artificial neural networks" deprives quantum neural networks their fundamental meaning. We argue that the concept of quantum neural network should be defined via its most general function as the universal tool for representing the amplitude of arbitrary quantum process. Our argumentation is based on the use of the Feynman path integral formulation of quantum mechanics. This approach has been also used in many papers to study the main problem of quantum cosmology – the origin of Universe. Really, the question if our Universe is a quantum computer has been posed (and positively answered) by Seth Lloyd in 2013. We argue that it is possible to consider it as quantum neural network.

Mathematical Models of Quantum Nanoplasmonics Accounting for the Non-local Effect.

Yu.A. Eremin

Lomonosov Moscow State University, faculty VMK

Core-shell nanomaterials have gained a huge popularity due to their multifunctional plasmonic properties. Nanoshells provide great flexibility in tuning plasmon resonance over a wide range of wavelength or realizing the huge enhancement of the elctromagnetic fields. They have emerged as valuable nanomaterials for energy storage and conversion,biosensing, solar cell, cancer treatment, and plasmonic nanolaser. When the characteristic size of a metallic nanofeatures become comparable to the Fermi wavelength the non-local effect of the metal arises. In the presentation we consider the influence of the non-local effect on the optical properties of core-shell nanomaterials applied for a wide variety of practical applications.