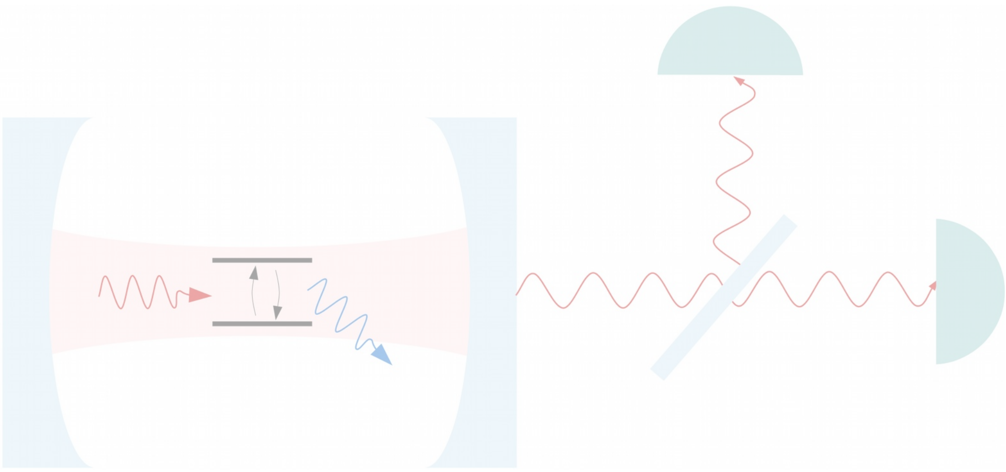
Özet Kitapçığı

Kuantum Optiği ve Bilişim Toplantısı

1-2 Şubat 2018

Mimar Sinan Güzel Sanatlar Üniversitesi



Kuantum Optiği ve Bilişim Toplantısı 2 (KOBİT-2)
http://fen.bilkent.edu.tr/~kobit
1-2 Şubat 2018
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KOBİT-2'ye hoşgeldiniz!

Kuantum Optiği ve Bilişim Toplantısı

Kuantum Optiği ve Bilişim Toplantısı (KOBİT) serisinin temel amacı, Türkiye'de kuantum optiği ve bilişim alanlarında çalışmakta olan veya çalışmayı hedefleyen araştırmacıları bir araya getirmek, paylaşım ve işbirliği temelli bir kuantum optiği ve bilişim topluluğunun oluşumuna katkıda bulunmaktır. 2016 yılında Hacettepe Üniversitesindeki bir hazırlık toplantısıyla başlatılan KOBİT, 2017'de İzmir Yüksek Teknoloji Enstitüsünde düzenlendi.

Serinin üçüncü toplantısı KOBİT 2, İstanbul Teknik Üniversitesi ve Koç Üniversitesinin desteğiyle 1-2 Şubat 2018 tarihlerinde Mimar Sinan Güzel Sanatlar Üniversitesinde düzenleniyor.

TOPLANTI PROGRAMI

1. Gün - 1 Şubat 2018 Perşembe

08:30-09:15 Kayıt

09:15-09:30 Açılış

09:30-10:30 1. Oturum

1 *Vlatko Vedral*
Quantum Physics in the Macroscopic Domain

10:30-11:00 Ara

11:00-12:30 2. Oturum

2 *İlke Ercan*
Energetic Cost of Information Processing at the Quantum Precipice: A Physical-Information-Theoretic Approach

3 *Chiara Marletto*
An Entanglement-based Test of Quantum Gravity Using Two Massive Particles

4 *G. Barış Bağcı*
Quantum Thermodynamics with Renyi Entropy: Is It Possible?

12:30-13:30 Yemek Arası

13:30-14:30 Poster Sunumları

14:30-16:00 3. Oturum

5 *Menderes Işkın*
Exposing the Quantum Geometry of Spin-orbit Coupled Fermi Superfluids

6 *Cem Yüce*
Topological Insulating Phase

7 *Fırat Yılmaz*
Artificial Magnetic Flux Quenches in Synthetic Dimensions

8 *Ferhat Nutku*
Statistical Complexity Study of q-Deformed Harmonic Oscillator and Morse Potentials

16:00-16:30 Ara

16:30-17:30 4. Oturum

9 *Ferdi Altıntaş*
Special Coupled Quantum Heat Engines

10 *Çağan Aksak*
Optimal Entanglement for Many-Body Systems via Quantum Correlations

11 *Adem Türkmen*
Açık Kuantum Sistemlerinde Karşılıklı Bilişim ve Veri İşleme Eşitsizliği

18:30 Konferans Yemeği

2. Gün - 2 Şubat 2018 Cuma

09:30-10:30 5. Oturum

12 *Vlatko Vedral*
The Quantum and Time from Correlations

10:30-11:00 Ara

11:00-12:30 6. Oturum

13 *Serkan Ateş*
Quantum Optics with Defects in Hexagonal Boron Nitride

14 *Elif Özçeri*
Quenching of Single Photon Emission from Defects in Hexagonal Boron Nitride

15 *Emre Togan*
Strong Interactions Between Dipolar Polaritons

12:30-13:30 Yemek Arası

13:30-14:30 Poster Sunumları

14:30-16:00 7. Oturum

16 *Tekin Dereli*
Quantum Geometry of 3-qubit Entanglement and Normed Division Algebras in Physics

17 *Kadir Durak*
Towards a Quantum Communication Network

18 *Aygül Koçak*
Quantum Group Symmetry and Quantum Information for Kaleidoscope of Coherent States in Quantum Optics

19 *Canberk Şanlı*
Using Topological Stability to Process Quantum Information

16:00-16:30 Ara

16:30-17:30 8. Oturum

20 *Barış Çakmak*
Thermal Production, Protection and Heat Exchange of Quantum Coherences

21 *İskender Yalçınkaya*
Kuantum Sistemlerinde Klasik Olmayan Zamansal İlintiler

17:30-17:45 Kapanış

Poster Sunumları

QUANTUM PHYSICS IN THE MACROSCOPIC DOMAIN

Vlatko Vedral
University of Oxford

ABSTRACT

I will present a wide range of research aimed at understanding quantum physics of large objects and their dynamical and thermodynamical behavior in the far-from-equilibrium domain. The first fundamental question is what kind of quantum correlations survive in this domain and how we can quantify and measure them. The second question asks if these correlations affect the macroscopic properties of matter. This leads us naturally to investigating how we should phrase the laws of thermodynamics in the far-from-equilibrium domain, and the scenario where we are consider individual (rather than ensemble) behavior. I will discuss how techniques from information theory, quantum and statistical physics, can all be combined to elucidate the physics of macroscopic objects. This question is of fundamental importance to the development of future quantum technologies, whose behavior takes place invariably in the macroscopic non-equilibrium quantum regime.

ENERGETIC COST OF INFORMATION PROCESSING AT THE QUANTUM PRECIPICE: A PHYSICAL-INFORMATION-THEORETIC APPROACH

İlke Ercan
Boğaziçi University

ABSTRACT

We present a physical-information-theoretic methodology developed to obtain fundamental efficiency limitations of information processing at the quantum precipice for nanoscale systems that can process classical and quantum information. The unifying approach presented here is designed to address fundamental energy requirements in complex computing structures and reveal how minimising dissipation is traded off against other key variables. The computational and physical features of emerging technologies are studied on an equal footing by using this physical-information-theoretic approach. Current applications of our methodology reveal that the lower bounds on energy dissipation significantly depend on the physics as well operation of nanocomputing circuits. Such fundamental analyses provide valuable insights into how far the efficiency of a computing technology can be improved in principle and how much room there is at the bottom. Here, we apply our methodology to a two-atom micromaser system which allows us to include coherences and quantum correlations. In this system, information is encoded in the initial states of the two-atom cluster, and once the cluster is injected into a single-mode cavity, information is partially lost due to interaction between the cluster and cavity. The-physical-information-theoretic approach we employ allows us to capture the fundamental lower bounds on energy dissipated as a result of this quantum information loss. This study provides a basis for comparison of classical and quantum information processing applications of the proposed physical-information methodology. In pursing this research, we aim to strengthen the ties between well-established fields of classical and quantum information theory, and inform the strategic development and performance assessment of emerging technologies that take effective strides forward in the realisations of post-CMOS computing paradigms.

AN ENTANGLEMENT-BASED TEST OF QUANTUM GRAVITY USING TWO MASSIVE PARTICLES

Chiara Marletto
University of Oxford

ABSTRACT

All existing quantum gravity proposals share the same deep problem. Their predictions are extremely hard to test in practice. Quantum effects in the gravitational field are exceptionally small, unlike those in the electromagnetic field. The fundamental reason is that the gravitational coupling constant is about 43 orders of magnitude smaller than the fine structure constant, which governs light-matter interactions. In this seminar I shall discuss a recent proposal (arXiv:1707.06036), which is based on a radically different, quantum-information-theoretic approach to witness non-classical features of the gravitational field. The proposal consists of two parts. The first part is an argument showing that any system (e.g. a field) capable of mediating entanglement between two quantum systems must itself be quantum. The second part is a proposed experiment to detect the entanglement generated between two masses via gravitational interaction. By the argument presented in the first part, the degree of entanglement between the masses is an indirect witness of the quantisation of the field mediating the interaction. Remarkably, this experiment does not require any quantum control over gravity itself. It is also closer to realisation than other proposals, such as detecting gravitons or detecting quantum gravitational vacuum fluctuations.

QUANTUM THERMODYNAMICS WITH RENYI ENTROPY: IS IT POSSIBLE?

G. Barış Bağcı
TOBB University of Economics and Technology

ABSTRACT

Quantum thermodynamics is a recent attempt based mainly on the use of von Neumann entropy. In this talk, I explore whether quantum thermodynamics is universal by extending the entropy definition to the Renyi entropy. A formalism in terms of relative entropy is also offered along the way. As I will show, the use of Renyi entropy in quantum thermodynamics is not free of some pitfalls.

EXPOSING THE QUANTUM GEOMETRY OF SPIN-ORBIT COUPLED FERMI SUPERFLUIDS

Menderes Işkın
Koç University

ABSTRACT

The coupling between a quantum particle's intrinsic angular momentum and its center-of-mass motion gives rise to the so-called helicity states that are characterized by the projection of the spin onto the direction of momentum. In this paper, by unfolding the superfluid-density tensor into its intra-helicity and inter-helicity components, we reveal that the latter contribution is directly linked with the total quantum metric of the helicity bands. We consider both Rashba and Weyl spin-orbit couplings across the BCS-BEC crossover, and show that the geometrical inter-helicity contribution is responsible for up to a quarter of the total superfluid density. We believe this is one of those elusive effects that may be measured within the highly-tunable realm of cold Fermi gases.

TOPOLOGICAL INSULATING PHASE

Cem Yüce
Anadolu University

ABSTRACT

Topological insulators in which electrons can move along the surface without dissipation even in the presence of impurities are hot topic in recent years and supposed to bring a wealth of potential applications. In this work, after presenting a historical perspective and the underlying principles of topological insulating phase, we discuss how topological effects can be realized in photonics systems. We give a summary on Floquet topological insulators and extend the idea of topological phase to systems with gain and loss. A summary is given for possible ways to confirm the topological nature in a candidate material. Various synthesis techniques as well as the defect chemistry that are important for realizing bulk-insulating samples are discussed. Characteristic properties of topological insulators are discussed with an emphasis on transport properties. In particular, the Dirac fermion physics and the resulting peculiar quantum oscillation patterns are discussed in detail. It is emphasized that proper analyses of quantum oscillations make it possible to unambiguously identify surface Dirac fermions through transport measurements. The prospects of topological insulator materials for elucidating novel quantum phenomena that await discovery conclude the review.

ARTIFICIAL MAGNETIC FLUX QUENCHES IN SYNTHETIC DIMENSIONS

Fırat Şerif Yılmaz & *M. Özgür Oktel*
Bilkent University

ABSTRACT

Recent cold atom experiments have realized models where each hyperfine state at an optical lattice site can be regarded as a separate site in a synthetic dimension. In such synthetic ribbon configurations, manipulation of the transitions between the hyperfine levels provide direct control of the hopping in the synthetic dimension. This effect was used to simulate a magnetic field through the ribbon. Precise control over the hopping matrix elements in the synthetic dimension makes it possible to change this artificial magnetic field much faster than the time scales associated with atomic motion in the lattice. In this paper, we consider such a magnetic flux quench scenario in synthetic dimensions. Sudden changes have not been considered for real magnetic fields as such changes in a conducting system would result in large induced currents. Hence, we first study the difference between a time varying real magnetic field and an artificial magnetic field using a minimal six site model. This minimal model clearly shows the connection between gauge dependence and the lack of on site induced scalar potential terms. We then investigate the dynamics of a wavepacket in an infinite two or three leg ladder following a flux quench and find that the gauge choice has a dramatic effect on the packet dynamics. Specifically, a wavepacket splits into a number of smaller packets moving with different velocities. Both the weights and the number of packets depend on the implemented gauge. If an initial packet, prepared under zero flux in a n–leg ladder, is quenched to Hamiltonian with a vector potential parallel to the ladder; it splits into at most n smaller wavepackets. The same initial wavepacket splits into up to n^2 packets if the vector potential is implemented to be along the rungs. Even a trivial difference in the gauge choice such as the addition of a constant to the vector potential produces observable effects. We also calculate the packet weights for arbitrary initial and final fluxes. Finally, we show that edge states in a thick ribbon are robust under the quench only when the same gap supports an edge state for the final Hamiltonian.

STATISTICAL COMPLEXITY STUDY OF Q-DEFORMED HARMONIC OSCILLATOR AND MORSE POTENTIALS

Ferhat Nutku, K. D. Sen & Ekrem Aydıner
Istanbul University

ABSTRACT

We have studied the variation of statistical complexity measure based on the exponential Shannon information entropy and the disequilibrium using the 1-normalized probability density derived from solutions of the Schrödinger equation corresponding to the q-deformed harmonic oscillator and Morse potentials. With increase of the q deformation parameter, the statistical complexity is found to increase for the considered potentials. An analysis of our results in terms of Shannon information entropy and disequilibrium measure will be presented.

[1] *Statistical Complexity: Applications in Electronic Structure*, Ed. K.D. Sen, Springer, UK, 2011.
[2] H. Hassanabadi, *et al.*, Adv. High Energy Phys. 1-4 (2017).
[3] M. Sebawe Abdalla, and H. Eleuch, J. Appl. Phys. 115 (23), 234906 (2014).

SPECIAL COUPLED QUANTUM HEAT ENGINES

Ferdi Altıntaş
Abant İzzet Baysal University

ABSTRACT

In this presentation, we study the Carnot and Otto heat engines in the quantum domain [1]. We first study the isothermal, isochoric and adiabatic processes for an arbitrary quantum system. Based on these results, the Carnot and Otto cycles are defined for quantum mechanical systems. The properties of the corresponding quantum engines are studied and compared for a special case of the external parameter changes where all the energy gaps of the working substance are altered by the same ratios in the two quantum adiabatic stages of the cycles. Under such changes, the thermal efficiencies of the cycles are found to be equivalent to its classical counterparts based on an ideal gas as the working substance. The role of the quantumness of working substance on the performance of the quantum Otto and Carnot cycles are revealed by investigating the work output. Special coupled two spins, one is an arbitrary spin-s and the other is a fixed spin-1/2, is considered as the working substance for the illustration [2, 3]. The quantum adiabatic stages are considered the simultaneous changes of the frequencies of the spins ω and the interaction strength J obeying the proportionality $J/\omega = r$ (where r is a constant in the cycle). The condition is found to make all the energy gaps to be changed by the same ratios in the adiabatic branches. The role of the spin-s and quantum interactions on the harvested work is investigated in detail. The work outputs of the cycles are found to be significantly enhanced by the quantum interactions. The concept of local thermodynamics and the role of inner friction will also be discussed briefly.

[1] H.T. Quan, Y.-X Liu, C.P. Sun, and F. Nori, Phys. Rev. E 76, 031105 (2007).
[2] S. Cakmak, D. Turkpence, and F. Altintas, Eur. Phys. J. Plus 132, 554 (2017).
[3] F. Altintas and O.E. Mustecaplioglu, Phys. Rev. E 92, 022142 (2015).

OPTIMAL ENTANGLEMENT FOR MANY-BODY SYSTEMS VIA QUANTUM CORRELATIONS

Çağan Aksak & Sadi Turgut
Middle East Technical University

ABSTRACT

In Quantum Information Science, an operational i.e. resource-theoretical approach is usually adopted towards the quantification and definition of entanglement. Although it is known that entanglement can exist between subsystems regardless of whether those subsystems are occupied, experimental quantification (measurement) of such mode entanglement in many-body systems is difficult. Also, there is the issue of whether this entanglement is experimentally accessible or how much of it is accessible. There are different opinions about how one should define entanglement in identical-particle systems. While some authors prefer mode entanglement as it captures the true nature of entanglement, there are other, significantly different approaches. Some of these consider the many-body correlations between particles as a form of entanglement. Although this approach is open to debate, we show that the well-established "entanglement witness" formalism can be modified via computing the maximal expectation value over the separable state space, for detecting and quantifying many-body correlations in identical-particle systems. In this talk, some theoretical calculations in fermionic and bosonic systems will be discussed.

AÇIK KUANTUM SİSTEMLERİNDE KARŞILIKLI BİLİŞİM VE VERİ İŞLEME EŞİTSİZLİĞİ

Adem Türkmen& Abdullah Verçin *Solmaz Yılmaz*
Ankara Üniversitesi Amasya Üniversitesi

ÖZET

Kuantum karşılıklı bilişim (quantum mutual information) ve veri işleme eşitsizliği (data processing inequality); açık kuantum sistemi, bu sistemin çevresi ve pasif bir referans sisteminden oluşan üç parçalı durumlar için incelenmiştir. Kuantum karşılıklı bilişimin artması, azalması ve korunması için gerek ve yeter koşullar; başlangıç durumunda herhangi bir kısıtlama olmadan, sistem ve çevresi üzerine etkiyen her bileşik üniter gelişim için elde edilmiştir. Üç parçalı başlangıç durumu, kuantum entropiler için güçlü alt toplanabilirlik (strong subadditivity) bağıntısında eşitliği sağlayan, Markov durumlarıysa veri işleme eşitsizliğinin her bileşik üniter gelişim için geçerli olduğu da gösterilmiştir. Ayrıca veri işleme eşitsizliğinin sağlanması için giriş durumunun Markov durumu olmasının gerek koşul olmadığı örneklerle ortaya konulmuştur.

THE QUANTUM AND TIME FROM CORRELATIONS

Vlatko Vedral
University of Oxford

ABSTRACT

We will explore the possibility that both quantum physics and time emerge from the classical probability distributions describing observed measurement outcomes by requiring global states of composite systems to be incompatible with given marginal distributions. In particular, there are marginal probability distributions that do not admit a classical global probability distribution and yet could be derived from a global quantum state. Thus, quantum physics could be seen as arising from the requirement that such marginal can exist. This is in fact at the base of the so-called quantum contextuality. In the same spirit, there are quantum marginal states which do not admit a global quantum description. However, it turns out that they could arise out of states pertaining to many-instant temporal quantum correlations. This would suggest that time itself could be a consequence of the requirement that there are marginal quantum states that are incompatible with a global quantum state. In other words, inconsistencies in classical probabilities give rise to the quantum, while inconsistencies in statistics of quantum states give rise to time.

QUANTUM OPTICS WITH DEFECTS IN HEXAGONAL BORON NITRIDE

Serkan Ateş
Izmir Institute of Technology

ABSTRACT

Photonics technology has reached a stage in which complex functional devices for the generation and detection of light signals can be routinely produced for a variety of scientific, medical, and military applications. Especially, the search for novel computation and communication schemes has created applications in which the manipulation and detection of extremely weak optical signals at single-photon level are crucial. Among several systems, quantum emitters in atomically thin 2D based materials, i.e., transition metal di-chalcogenides and defects in hexagonal boron nitride (hBN), have recently attracted a great interest as potentially bright and stable solid-state single-photon sources. In this talk, I will present our recent activities on optical properties of hBN. Because of its large bandgap (5.995 eV), hBN is known to be a good insulator, which also becomes an ideal candidate for exploring optically active defects with energies from UV to NIR. Isolated defect centers in hBN are especially important to develop on-chip room temperature single photon sources. However, the emission properties of defects in hBN are not well understood yet, due to its complicated band structure. To gain insight about the optical properties, we study the temperature dependent properties of zero-phonon line (ZPL) emission from isolated defect centers. The lineshape of the ZPL and its phonon sidebands in the emission spectrum show chracteristic features governed by the phonon density of states of the host hBN, which has contributions from both acoustic and optical phonons, and a phonon gap. Our results show that an optically active defect in hBN is an ideal system to study different types of electron-phonon interactions at a single quantum emitter level even at room temperature.

QUENCHING OF SINGLE PHOTON EMISSION FROM DEFECTS IN HEXAGONAL BORON NITRIDE

Elif Özçeri, Ozan Arı, Sinan Balcı & Serkan Ateş
Izmir Institute of Technology

ABSTRACT

Single photon sources are the key resource for various applications in quantum technologies. In recent years two dimensional materials, such as transition metal dichalcogenides (TMDCs) and defects in hexagonal boron nitride (hBN) have attracted most of the attention. In contrast to TMDCs, single photon emission from defect centers in hBN is observed within a large spectral range from UV to NIR. Furthermore, it has high photostability, high quantum efficiency and short decay time at excited state. Although, single photon emission from hBN defects is demonstrated at various temperature conditions, control of the emission properties is still under investigation. Due to its 2D nature, hBN also can be integrated with several other 2D materials to modulate the emission properties. In this work, we study the effect of graphene, which has a similar honeycomb structure, on the optical properties of the single photon emission from defects in hBN in the visible band. To this aim, we first focus on a single photon emission from a single defect in hBN and characterize its all dipole properties, such as excitation power and polarization dependencies. Afterwards, a graphene layer is placed on pre-analyzed hBN structure. Placing a graphene layer to the near field distance (< 50 nm) from the defect center in hBN yields a strong quenching of the emission due to nanradiative energy transfer between the emitter and the graphene. A second and third graphene layers are also placed on the same hBN and emission behavior is analyzed after each treatment. After 3 layers, almost 99% of single photon emission is quenched, as opposed to the Raman signals observed on the same spectrum strength of which is not influenced by graphene layers. In order to control the quenching dynamically, we work on a device design to be able to control the fermi level of the graphene electrically. Changing the Fermi level with respect to the emission energy of the defect under study will lead us a reversible control (open/close) of the nonradiative quenching channel dynamically.

STRONG INTERACTIONS BETWEEN DIPOLAR POLARITONS

Emre Togan
ETH Zurich

ABSTRACT

Realization of a strongly interacting photonic systems is one of the central ideas of quantum optics. Recent progress in several experimental platforms led to demonstration of interactions that are significant at a single photon level. These experiments have paved the way to use strongly interacting photonic systems as quantum simulators. In the solid-state, a promising experimental platform is the exciton polariton system, consisting of a cavity photon and a quantum well exciton. The short range, exchange based, interactions among excitons lead to interactions among polaritons. These interactions were employed in manifestation of a number of intriguing collective phenomena ranging from formation of spontaneous coherence, to realization of polariton Josephson effect. However, a mean field approach could be used to accurately describe all of these observations. Increasing polariton-polariton interaction further is crucial to explore physics beyond mean-field and to explore a new regime of strongly correlated photons. In structures where photon absorption leads to creation of excitons with aligned permanent dipoles, elementary excitations, termed dipolar polaritons, are expected to exhibit enhanced interactions. In this talk, I will report on a dramatic increase in interaction strength between dipolar polaritons as the size of the dipole is increased by tuning the applied gate voltage. To this end, we use coupled quantum well structures embedded inside a microcavity where coherent electron tunneling between the wells controls the size of the excitonic dipole. Factor of 6 increase in the interaction strength to linewidth ratio that we obtain indicates that dipolar polaritons could be used to demonstrate a polariton blockade effect and thereby form the building blocks of many-body states of light.

QUANTUM GEOMETRY OF 3-QUBIT ENTANGLEMENT AND NORMED DIVISION ALGEBRAS IN PHYSICS

Tekin Dereli
Koç University

ABSTRACT

This is going to be an introductory talk on the entanglement of 3-qubits. First, a brief description of 2-qubit and 3-qubit states shall be given. This will be followed by a short account of normed division algebras through the Cayley-Dickson process. Then the bi-partite entanglement of 3-qubits can be discussed in terms of Hopf fibrations of spheres by spheres while their 3-partite entanglement can be related with Cayley's hyperdeterminant.

TOWARDS A QUANTUM COMMUNICATION NETWORK

Kadir Durak
Özyeğin University

ABSTRACT

Public key cryptography schemes are commonly used in today's information security systems. However, quantum computers can effectively use Shor's algorithm to find the key in these systems. The fact that a global quantum computer is a concept that is at the threshold of existence in real life today, makes it compulsory to look for alternative cryptography schemes. Quantum key distribution provides a solution to this problem; however, this technology has distance limitations due to the losses within the fibers and at free-space optical links. Many approaches are being interrogated in parallel and experimentally all around the world to find a way to achieve the ultimate goal of a global quantum network. Comparison of these approaches and their scalability potential to become a network will be discussed. In this talk, all the techniques which are tested so far will be analyzed in details and also a new method will be proposed that is to be implemented in the near future.

QUANTUM GROUP SYMMETRY AND QUANTUM INFORMATION FOR KALEIDOSCOPE OF COHERENT STATES IN QUANTUM OPTICS

Aygül Koçak & Oktay K. Pashaev
Izmir Institute of Technology

ABSTRACT

Superposition of Glauber coherent states, related with roots of unity is constructed as the kaleidoscope of quantum coherent states. This kaleidoscope is determined by geometry of regular polygon and admits quantum symmetry in the form of quantum group. By notions of operator q-number and (mod n) exponential function, we obtain the set of orthonormal quantum states, as eigenstates of the dilatation operator. The specific phase factor dependence in superposition of coherent states appears in the form of quantum Fourier transform, with normalization constants expressed by (mod n) exponential functions. We show that these states describe quantum q-oscillator with q as a primitive root of unity, corresponding to a finite dimensional quantum system. For particular cases $n = 2$, 3 and 4, our states can be used as qubit, qutrit and ququat units of quantum information, respectively. We find that our kaleidoscope coherent states are eigenstate of higher power of the annihilation operator and we calculate the photon distribution in these states in terms of (mod n) exponential functions. The general case with arbitrary n, associated with qudit quantum states and corresponding quantum algebra symmetry are discussed.

This work is supported by TÜBİTAK Grant 116F206.

USING TOPOLOGICAL STABILITY TO PROCESS QUANTUM INFORMATION

Canberk Şanlı
Boğaziçi University

ABSTRACT

Topological superconductors are of interest in quantum information as a coherent qubit. For this purpose, we presented a review of Josephson junctions from topological considerations, together with some examples of recently developed readout schemes that this perspective yields for JJ based quantum devices. The aim of this study is to show that fluxons indeed correspond to (topological) solitons of sine-Gordon theory. This enables to comprehend the underlying topological reason for the magnetic field being quantized in Josephson junctions (JJ), and provides an original pathway to build new read-out schemes for JJ-based quantum circuits by studying fluxon dynamics governed by sine-Gordon equation.

THERMAL PRODUCTION, PROTECTION AND HEAT EXCHANGE OF QUANTUM COHERENCES

Barış Çakmak
Koç University

ABSTRACT

Quantum coherence is typically considered to be a resource for the quantum information devices. More recently, it is understood that it can also be used as a “fuel” for quantum heat engines (QHEs). Such a profound QHE, which can convert quantum coherence to useful work, can be practically appealing only if the abundant coherence is produced and protected either naturally or by energetically cheap artificial methods. Moreover, it is necessary to be able to have a scheme that can harvest stored coherences as heat to produce work in a genuine heat engine cycle. In this work, we show that an ensemble of initially incoherent two level atoms can develop large amount of many body quantum coherence by collective coupling to a thermal environment. We find that this coherence exhibits a superlinear scaling with the number of ensemble atoms. In addition, we propose a scheme in which a single two level atom is used as a working medium to harvest these coherences by randomly and repeatedly interacting with similarly prepared coherent atomic clusters (pairs). The working atom reaches to a steady state that can be described by a thermal equilibrium state whose temperature depends on the amount of coherence in the clusters. The intriguing point is that only certain coherences can be produced by collective heating and only those that can be converted back to heat. These coherences share the characteristic property of belonging to the energy degenerate subspaces which are classified as heat exchange coherences. Collective heating can “charge” such “flammable” coherences even if they are not present initially and preserve them in steady state so that they can be “discharged” back to heat by the initiation of harvesting scheme.

[1] B. Çakmak, A. Manatuly, and Ö. Müstecaplıoğlu, Phys. Rev. A 96, 032117 (2017).

KUANTUM SİSTEMLERİNDE KLASİK OLMAYAN ZAMANSAL İLİNTİLER

İskender Yalçınkaya
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ÖZET

"Bir sistemin önceden belirlenmiş olan mümkün hallerden bir anda en fazla bir tanesinde bulunabilmesi" ve "bu halin sistemin sonraki zamansal değişimini etkilemeden ölçülebilmesi", makro ölçekteki gerçeklik anlayışımızı ifade eder. A. J. Leggett ve A. Garg, bu ifadelerin doğru olduğunu varsaydığımızda, bir sistem üzerinde farklı zamanlarda aynı ölçümün tekrarlanmasıyla elde edilen değerler arasındaki ilintilerin bir azami ve asgari değeri olacağını göstermişlerdir [1]. Günümüzde Leggett-Garg (LG) eşitsizliği olarak bilinen bu sınırlamanın bir fiziksel sistem tarafından ihlal edilmesi, bu varsayımların en az bir tanesinde bir problem olduğunun deneysel ispatı olarak kabul edilir. LG eşitsizliği ilk olarak her ne kadar makro ölçekteki sistemleri bir kuantum özelliği taşıyıp taşımadıklarına dair incelemek için ortaya atılsa da, zaman içinde bu yönde kayda değer deneysel bir çalışma gerçekleşmemiştir. Öte yandan, kuantum sistemler kullanılarak eşitsizliklerin ihlalini gösteren çok sayıda deney yapılmış ve elde edilen ihlaller sistemin zamanla değişiminin klasik mantıkla kavranamayacağının bir delili olarak yorumlanmıştır [2]. Ancak bu deneylerden çoğu, kuantum ölçümlerin genel olarak yıkıcı özellikte olması dolayısıyla ikinci varsayımı alenen sağlamamakla eleştirilmiş ve geçersiz sayılmışlardır [3]. Son zamanlarda "negatif ölçümler" olarak adlandırılan bir sonradan seçim ile, ölçüm cihazının sistemle "doğrudan etkileşmediği" deneyler yapılarak bu gedik kapatılmaya çalışılmaktadır [4-6]. Bu çalışmamızda, söz konusu negatif ölçümlerin büyük bir hassasiyetle yapılabildiği mevcut bir fotonik deneysel sistemden bahsedilecek ve bu sistemde kuantum yürüyüşü gerçekleştiren bir foton [7] üzerinde yapılan negatif ölçümlerle LG eşitsizliklerinin ihlal edilebildiği gösterilecektir.

[1] A. J. Leggett ve A. Garg, Phys. Rev. Lett 54, 857 (1985).
[2] C. Emary, Rep. Prog. Phys. 77, 016001 (2014).
[3] M. M. Wilde ve A. Mizel, Found. Phys. 42, 256 (2011).
[4] H. Katiyar *vd.*, Phys. Rev. A 87, 052102 (2013).
[5] A. Knee *vd.*, Nat. Commun. 3, 606 (2012).
[6] C. Robens *vd.*, Phys. Rev. X 5, 011003 (2015).
[7] A. Schreiber *vd.*, Phys. Rev. Lett. 104, 050502 (2010).

REMOTE GENERATION OF POLARIZATION ENTANGLED PHOTONS

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ABSTRACT

Quantum correlations such as entanglement are crucial for the implementation of quantum technologies. However, entanglement is fragile and is quickly destroyed in the presence of external noise, making it difficult to distribute over long distances. The main focus of research in quantum technologies has been the protection of quantum properties against noise. Here, we take instead the opposite strategy, that is, rather than focusing on how to protect the system from noise, we ask how noise can help. Indeed, our theoretical results show that noise, which acts during the distribution, drives the quantum system to a state which eventually leads to the creation of entanglement between two particles far away from each other. Differently from the previously developed approaches, which rely on the preparation of an entangled pair and its subsequent distribution, we demonstrate how a pair of quantum particles can be first distributed and then be entangled. In particular, we present a method to create polarization entanglement between the photons remotely, making the traditional enemy of quantum computation and communication, i.e., decoherence, redundant.

RYDBERG ATOMLARINDA ATOMİK UYARILMANIN DİFÜZYONU VE DİFÜZYON SÜRESİNİN FARKLI ETKİLER ALTINDA İNCELENMESİ

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ÖZET

Lazer ile güdümlenen artalan gazları içine gömülmüş, ultrasoğuk Rydberg atomları dizisi için uyarılmanın taşınması dinamikleri çalışılmıştır. Rydberg atomları dizisinin "küme" olarak adlandırılan tek boyutlu bir zincir oluşturduğu varsayılmıştır [1]. İlgilendiğimiz sistemde, küme atomları temel "s" durumunda veya uyarılmış olarak "p" durumunda bulunabilir. Sadece tek bir küme atomu p durumunda olabilir ve bu uyarılmış durum sadece komşu atomlarla etkileşim ile taşınabilir. Bahsi geçen artalan gaz atomları da küme atomları gibi Rydberg düzeyine uyarılmıştır ancak daha düşük kuantum sayısına sahip Rydberg atomlarıdır ve bu atomlar "elektromanyetik olarak indüklenmiş geçirgenlik" (EIT) göstermektedirler [2]. Küme atomları yakınındayken, artalan gaz atomunun bu geçirgenliği bozulur ve küme atomları "etkileşim kuvvetinin büyüklüğü" ile belirlenen yarıçapa sahip bir gölge oluşturur. Uyarılmış durumdaki küme atomunun gölgesi diğer küme atomlarına kıyasla daha büyüktür, bu sayede deneysel olarak uyarılmış durumun nerede olduğu takip edilebilir [1]. Bu çalışmada, iki farklı model kullanılmıştır. Bu modellerin ilkinde, her bir küme atomunun bir artalan gaz atomu ile etkileştiği varsayılmış ve küme atomları ile artalan gazı atomları arasındaki mesafenin difüzyon süresi üzerindeki etkisi incelenmiştir. İkinci modelde ise, her bir küme atomunun yakınlarındaki tüm artalan gaz atomları ile etkileşimi "etkin model"[1,3] yardımı ile artalan gaz yoğunluğu ile orantılı tek bir değişken haline indirgenmiş ve artalan atom yoğunluğunun difüzyon süresi üzerindeki etkisi çalışılmıştır. Birinci modelde küme atomları ile artalan atomları arasındaki mesafe azaldıkça, ikinci modelde ise artalan atom yoğunluğu arttıkça sistemin Zeno rejimine girdiği ve difüzyon süresinin arttığı gözlemlenmiştir. Bu sistem baz alınarak oluşturulan örgü yapıları üzerinde, yapay manyetik alan etkileri ile birlikte difüzyon hızının değişimi incelenmektedir.

[1] D. W. Schönleber, A. Eisfeld, M. Genkin, S. Whitlock, ve S. Wüster, Phys. Rev. Lett. 114, 123005 (2015).

[2] S. Sevinçli *vd.*, J. Phys. B: At. Mol. Opt. Phys. 44, 184018 (2011).

[3] F. Reiter and A. S. Sorensen, Phys. Rev. A 85, 032111 (2012).

PHONON INDUCED BROADENING AND DEPHASING OF QUANTUM EMISSION FROM DEFECT CENTERS IN HEXAGONAL BORON NITRIDE

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ABSTRACT

Quantum emitters in 2D materials had attracted great attention for quantum information and communication applications, owing to their strong photoluminescence (PL) even at room temperature. Specifically, the optically active defect centers in hexagonal boron nitride (hBN) has emerged as a promising candidate for single photon sources with bright and narrow zero-phonon line (ZPL) emission stable up to 800 K. Despite the novel properties, the ZPL emission from the hBN seems to be greatly affected by the electron-phonon interaction. In this work, we present a quantitative study on the acoustic phonon sidebands observed in the emission spectra of a point defect in hBN. We perform temperature dependent photoluminescence measurement and compare the spectra with the theoretical results. With acoustic phonons couple to electronic states of a defect through the deformation potential, we show that the emission linewidth broadens with the temperature as $aT + bT^5$. A natural linewidth (Γ_0) of ZPL emission is extracted as 0.83 μeV (20 Mhz). A redshift in the energy of the emission line with temperature as T^3 is also observed. At temperatures below 123 K, the temperature dependent lineshape of the PL is modeled by the linear electron-phonon coupling theory. An excellent agreement between the experimental and theoretical calculations reveal that the relevant theoretical model can be used to accurately calculate the Debye-Waller and Huang-Rhys factors which both are commonly used to determine the potential of ZPL as single photon sources.

INFLUENCE OF ANHARMONICITY ON STATISTICAL COMPLEXITY OF DILUTE BOSE GASES UNDER CYLINDRICAL TRAPS

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ABSTRACT

We report the calculations of statistical complexity [1] for the Bose condensates in the ground state under the cylindrical trap perturbed by two widely different anharmonic potentials in the x-y plane with varying strengths. In particular, the Henon-Heiles potential, $V_{HH}^{anh}(x,y) = \alpha(x^2y - 1/3y^3)$, and the four-leg potential, $V_F^{anh}(x,y) = \alpha(x^2y^2)$, with α as the strength of potential, have been considered. Results of our calculations on the 1000 atom condensates using the parameters of the JILA experiment [2], reveal interesting opposite trends in their statistical complexity. Interpretation of our results in terms of the structural aspects of the condensates will be presented using the estimates of statistical complexity along with its constituent informational theoretical measures of Shannon entropy and disequilibrium.

[1] *Statistical Complexity: Applications in Electronic Structure*, Ed. K.D. Sen, Springer, UK, 2011.

[2] M.H. Anderson, J.R. Ensher, M.R. Matthews, C.E. Wieman, and E.A. Cornell, Science 269, 198 (1995).

NUMERICAL ANALYSIS OF THE NONLINEAR QUANTUM HARMONIC OSCILLATOR

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ABSTRACT

The quantum harmonic oscillations are of the fundamental phenomena studied in the field of quantum mechanics. Quantum harmonic oscilllator is used for the explanation of the vibrations of the diatomic molecules, but has implications far beyond than those systems. It is the basis of our understanding of complex vibrations in larger molecules, the motion of atoms in solid lattices and the theory of heat capacity just to name a few. Generally extensions of the Schrödinger equation including the classical spring potential is used to model quantum harmonic oscillations. However the analytical solutions of the quantum harmonic oscillator under the effect of stronger electric fields are not extensively studied, yet alone its numerical solutions. In this paper we propose a numerical solution technique for the nonlinear quantum simple harmonic oscillator. The numerical scheme we propose is the split-step Fourier scheme. We use simple solutions as benchmark problems to test the accuracy of the numerical scheme. We analyze the modulational instability and rogue wave formation in the frame of the nonlinear quantum simple harmonic oscillator using the split-step scheme we proposed. Our procedure and findings can be used to model various atomic phenomena including but not limited to the motion of atoms in solid lattices and breaking of atomic bonds.

ENHANCED RKKY INTERACTION BY WHISPERING GALLERY MODES IN GRAPHENE

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ABSTRACT

After successful production of graphene, its popularity has increased dramatically in recent years. Unique optical and electrical properties contain great potential for applications [1]. Besides of many materials, graphene has linear energy dispersion which makes the effective mass of the electrons zero. Thus, electrons in graphene behave like photons and Fermi velocity is an analogue for the speed of light. Since the effective mass of electrons is zero, one must use massless Dirac equation to describe their motion. The application of this equation for potential step problems leads a phenomenon called Klein tunneling [2]. Even though it is difficult to confine electrons in a region due to Klein tunneling, it is experimentally shown that electron waves form whispering gallery modes under an applied circular electrical potential [3]. This can be thought as quantum optical cavities. We claim that if two magnetic impurities are located on these modes, the interaction between their spins must enhance. RKKY (Ruderman-Kittel-Kasuya-Yosida) interaction is an indirect exchange interaction mediated by conduction electrons in material [4]. In bulk graphene, the interaction strength is proportional to $1/R^3$ cubed, where R is the distance between the magnetic impurities [5]. In this work, we use tight binding method to calculate the interaction strength. We apply Gaussian potential on the graphene and fix the position of one of the impurities. Then, we move the other impurity on the edge of the potential well and calculate the interaction strength between the impurities. We found that, for some modes, the interaction strength does not decay as in the bulk graphene and survives at long distances.

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[1] A. H. Castro Neto, F. Guinea, N. M. R. Peres, K. S. Novoselov, and A. K. Geim, Rev. Mod. Phys. 81, 109 (2009).

[2] M. I. Katsnelson, K. S. Novoselov, and A. K. Geim, Nat. Phys. 2, 620 (2006).

[3] Yue Zhao *et al.* , Science 348, 672 (2015).

[4] M. A. Ruderman and C. Kittel , Phys. Rev. 96, 99 (1954).

[5] E. Kogan, Phys. Rev. B 84, 115119 (2011).

A SINGLE ARBITRARY DRIVEN SPIN AS A QUANTUM OTTO ENGINE: THE ROLE OF INTERNAL FRICTION

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ABSTRACT

In this presentation, we propose an arbitrary driven spin as the working substance of a quantum Otto cycle [1]. The adiabatic branches of the cycle are generated by different time-dependent control field profiles which are found to lead to irreversibility and dissipation. Such an effect is named as internal friction and is a fully quantum mechanical phenomena. It is characterized by the increase in the Shannon entropy and is quantitatively determined by the use of quantum relative entropy. The role of internal friction on the harvested work and the operational efficiency of the quantum Otto cycle are analyzed in detail. We have found that the internal friction negatively affect the harvested work and the operational efficiency. The non-monotone dependence of the work, efficiency, Shannon entropy and the internal friction on the total allocated time of the adiabatic stages are found. Complete frictionless solutions, the possible experimental implementation in liquid state NMR platform and the estimated power output have also been given.

[1] S. Cakmak, F. Altintas, A. Gencten and O.E Mustecaplioglu, Eur. Phys. J. D 71, 75 (2017).

DESIGN OF SI-N BASED NANOPHOTONIC DEVICES FOR PHOTON-PAIR GENERATION

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ABSTRACT

Efficient production of entangled photon pairs is an important ingredient for several applications in the field quantum information technologies, such as quantum key distribution (QKD). The production of such photons, especially around the visible and near infrared bands (780 nm), will enable the use of high-performance standard components, thus allowing far-distance quantum coupling through free-space. General trend for efficient photon-pair production is mainly relied on parametric down conversion processes for which a nonlinear crystal, i.e., periodically poled lithium-niobate, is used in bulk waveguide geometry. Alternatively, CMOS-compatible materials such as silicon and silicon nitride materials can also be used as photon pair sources. These materials are not preferred as optical light sources because of their indirect band structure, but they are suitable for photon pair production using their high nonlinear optical properties. The purpose of this work is to design and fabricate SiN based nanophotonic devices in different geometries for efficient photon pair generation at 780 nm band. which is preferred for free-space QKD due to low loss transmission at this band. By using spontaneous four-wave mixing (SFWM) process we would like to show that it is possible to generate narrow-band photon pairs at 780 nm efficiently from a waveguide and ring resonator type nanophotonic devices. In this contribution we will present our initial design geometry that will be used in photon-pair generation.

DERIVATION OF BELL INEQUALITIES WHICH COULD BE VIOLATED WITH TOPOLOGICAL AHARONOV BOHM PHASE

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ABSTRACT

The Aharonov-Bohm (AB) physical process is a milestone in terms of quantum mechanics. The process demonstrates that the potentials are more basic physical quantities than the fields and the effect is a special case of Berry's geometric phase. It is also identical to topological Aharonov-Casher (AC) phase in two dimensional space. Quantum entanglement is one of the most abstruse and considerable aspect of quantum mechanics. In connection with entanglement there are many theoretical and experimental researches in progress to reveal the relationship between different quantum mechanical processes especially quantum mechanical phases. In the first part of this study, effective AB Hamiltonian in two dimensional space in framework of relativistic quantum mechanics will be described entirely without any approximation. Then, with the discussion of Bell inequalities in two and three dimensional spaces, a convenient basis is prepared to investigate AB effect on quantum entangled systems. For completeness, Bell inequalities which could be violated with AB effect will be derived as the main goal of the study. In addition, the identity of the AB and AC effects will be allowed to be eventually tested using experimental setup proposed.

NÖTRİNO OSİLASYONLARININ KUANTUM KORELASYONLAR CİNSİNDEN İNCELENMESİ

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ÖZET

Nötrino çeşni özdurumları (elektron, müon ve tau nötrinosu), kütle özdurumlarına üniter bir dönüşüm matrisiyle bağlı olup bu dönüşüme göre osilasyon yapmaktadırlar. Nötrino çeşni özdurumları kütle özdurumlarının birer karışımları olduklarına göre en az iki parçalı bir sistemin saf durumları olup kuantum korelasyonlar içermelidirler. Bu çalışmada nötrino osilasyonlarının iki çeşnili, üç çeşnili ve dört çeşnili halleri için kuantum korelasyonları incelenmiştir. İki çeşnili durum için nötrino osilasyonlarının Bell-CHSH eşitsizliği ihlali, konkürans, geometrik diskort ve teleportasyon sadakati gibi kavramlarla kuantum korelasyonları incelenirken, üç çeşnili ve dört çeşnili durumlar için nötrino osilasyon olasılıkları ve entropi hesapları yapıldıktan sonra Mathematica programı yardımıyla grafikleri çizdirilerek karşılaştı-rılmıştır. Elde edilen hesap ve grafikler nötrino osilasyonlarının kuantum korelasyonlar içerdiğini göster-miştir.

FILTERING BEHAVIOUR OF TWO LEVEL ATOM-PHOTON SYSTEM INSIDE ONE-DIMENSIONAL DIELECTRIC WAVEGUIDE

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ABSTRACT

In this paper, we propose a new formalism for the real-space Hamiltonian of a two-level atom coupled to a photon in a waveguide. This formalism allows us to incorporate the effect of changing optical media inside the continuum and study the coherent transport of light in one dimensional waveguides using a fully quantum mechanical approach. We illustrate our formalism by exploring the characteristics of the two-level atom inside a one-dimensional waveguide with varying optical media. We also study a high-Q bandreject filter property of this system and discuss the implications of radiative and non-radiative dissipation.

BÜYÜK SPİN HAMAMLARINDA LOSCHMIDT YANKISININ GÖRÜNGE ANALİZİ

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ÖZET

Kuantum noktalarında arka plandaki çekirdeklerin oluşturduğu spin hamamından kaynaklı eşevresizliğin anlaşılmasında aşırı ince (hyperfine) etkileşimi büyük önem arz etmektedir. Bu çalışmada, merkez spin (Central Spin) ile etkileşim halinde olan, çeşitli spin değerlerindeki hamamlarda, bir eşevresizlik ölçütü olan Loschmidt Yankısı için analitik bir ifade önerilmektedir. Ayrıca Loschmidt yankısının ve Overhauser alanının farklı hamamlardaki görünge analizi verilmektedir. Bu sayede kuantum bilginin saklanmasında ve işlenmesinde soruna yol açan spin gürültüsünün frekans bağımlılığı hakkında yararlı bulgular elde edilmiştir.

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HEAT TRANSPORT OVER A QUANTUM NETWORK WITH OPTO-MECHANICAL LIKE COUPLING

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ABSTRACT

Observation of long-lived quantum coherence in photosynthetic systems raised the questions of how these coherences survive in such noisy environments and do they have functional role in the excitation transfer through photosynthetic protein-pigment complexes (PPC). Standard approach to these questions is to model the PPC as quantum networks. With the use of Markovian Quantum Master Equations, it is shown that existence of an optimal noise does support the efficiency of quantum transport. However, in order to explain long-life, non-Markovian approaches are required. Yet, in both approaches, it is still not clear that the coherence has functional importance. In the Markovian Master Equation approaches of quantum transport over PPC, there are two common points, one is the use of dipole-dipole like coupling among the sites of the network and the other is to use a sink to use its population as a measure of efficiency. In our work, we diverge from these two points, firstly because different kinds of couplings can be engineered in the artificial setups in which the role of coherence might be tested. Secondly, introduction of a sink might give thermodynamically inconsistent results if not treated with extra care. Therefore, we introduce a cold bath at 0 K instead of a sink. Other than these two main difference, we use heat currents as our main measure mainly because we have a cold bath as the trap and also so that the thermodynamical characteristics and consistencies of the analysis can be understood easily. By these changes, we investigate the characteristics of these measures and the effects of dephasing on them, both in the steady state and the transient. We show that there exist an optimal temperature for maximized heat current and dephasing for an increase in the transport.

NON-MARKOVIAN DYNAMICS OF TWO-TIME CORRELATION FUNCTIONS FOR STRONGLY INTERACTING SPIN-BOSON MODEL

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ABSTRACT

Two-time correlation functions (TCF) of quantum systems carry important information about the system state which is not available with single-time correlation functions. While quantum regression theorem (QRT) can be used to derive dynamics of TCFs of Markovian open quantum systems from the dynamics of the single time correlation functions, for the non-Markovian systems there are deviations from the QRT. In this work, we will report the results of a study of two-time correlation functions for strongly interacting spin-boson model. In particular, the dynamics of $\langle \sigma_z(\tau)\sigma_z(0) \rangle$ and violation of QRT in non-Markovian regime will be presented.

FABRICATION OF LARGE AREA PLASMONIC INTERFACES FOR QUANTUM OPTICS EXPERIMENTS

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ABSTRACT

Surface plasmons can confine fields so they can be used to explore the light-matter interactions at the nanoscale and to observe truly quantum phenomena. Recent studies aiming at doing quantum optics experiments with surface plasmons, either deal with single plasmons and aims at observing wave-particle duality, squeezing, and coalescence of plasmons or cavity quantum electrodynamics with localized plasmons in both the weak and the strong coupling regime. Such experiments rely on state of the art nano fabrication and surface nano structuring methods. Electron beam lithography being one of the most versatile and conventional method for plasmonic structure fabrication, the equipment is costly and large area fabrication is not possible. Large are methods like decoration of surfaces with colloidal nano structures yields surfaces with high uncertainty since orientation and positioning of structures are mostly random. Hole mask colloidal lithography on the other hand is a recently introduced novel surface nano structuring method, can be used in large areas with relatively cheap equipment to fabricate highly ordered structures. In this method, plasmonic structures are evaporated on the substrate through the holes separated by a controlled distance from the substrate surface. By rotating the sample during deposition process almost arbitrary 2D even several 3D geometries can be fabricated in parallel fashion; moreover, fabrication of small gaps possible which can be important for quantum optics experiments. Unlike electron beam lithography, parallel fabrication scheme in this method, makes large area fabrication extremely fast. Our development on HMCL enables decoration of holes periodically at different periodicities and crystal structures. Highly uniform nature of such surfaces can make experimental analysis more deterministic, eliminating extra statistical errors introduced in colloidal methods. In this study, various geometries fabricated using hole mask colloidal lithography, some of characterization results and related simulations will be presented with discussion of possible uses in quantum optics experiments.

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RELATIONSHIP OF QUANTUM TELEPORTATION PROTOCOLS

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ABSTRACT

The main items of teleportation are to find quantum channel, basis set for measurement and recovery gates suitable for to-be-teleported state (unknown state). To-be-teleported state of any quantum mechanical system, which has n orthogonal basis states, is teleported by making joint measurement on the unknown state and the sender part of the quantum channel. After the measurement, recovery gates (rotations) are applied to the receiver part of the quantum channel and it is transformed into the unknown state exactly. Hereby, teleportation is completed. Teleportations of the general states of a qubit, qutrit, and ququart are given respectively in [1-3]. The quantum channel and basis set used in the teleportation of general state of any system should be Bell-type entangled states. Because all the basis, that constitute the unknown state, are found at each part of the quantum channel just in the Bell-type entanglement. For this reason, the generalization of Bell-type entanglement is done in the teleportation of general states. In order to identify the relations of different teleportation protocols [1-3], we teleported an effectively low dimensional system via the protocol related to high dimensional system. For example, we teleported originally a ququart but effectively a qubit via the protocol related to ququart. Afterwards we compared to-be-recovered states and recovery gates, that we obtained, with the ones in the original protocols related to ququart and qubit, and we searched that if there is a reduction as in the real dimension. In order to create effective states we assumed that the to-be-teleported state, in one case, has a degeneracy, in other case, has exchange symmetry [4] among two qubits of a ququart, and in another case, has flip and exchange symmetry [4] among two qubits of the ququart. Finally, we confirmed that there is no reduction relationship while passing from high to low dimensional one. Generalized protocols may not be effective. A specific protocol should be written to each case for an effective teleportation and it should be written according to effective state.

[1] C.H. Bennet, G. Brassard, C. Crepeau, R. Jozsa, A. Peres, and W. K. Wootters, Phys. Rev. Lett. 70, 1895-1899 (1993).

[2] Z. You-Bang, Chin. Phys. Soc. 16(9), 2557–2562 (2007).

[3] G. Rigolin, Phys. Rev. A 71, 032303 (2005).

APOLLONIUS REPRESENTATION OF QUBIT STATES

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ABSTRACT

We introduce the qubit representation by complex numbers on the set of Apollonius circles with common symmetric points at 0 and 1, related with computational basis states. For one qubit states we find that the Shannon entropy as a measure of randomness is a constant along Apollonius circles. For two qubit states, the concurence as a characteristic of entanglement is taking constant value for the states on the same Apollonius circle. Geometrical meaning of concurence as an area and as a distance in the Apollonius representation are found. Then we generalize our results to arbitrary n-qubit Apollonius states and show that the fidelity between given state and the symmetric one, as reflected in an axes, is a constant along Apollonius circles. For two qubits it coinsides with the concurence. For generic two qubit states we derived Apollonius representation by three complex parameters and show that the determinant formula for concurence is related with fidelity for symmetric states by two reflections in a vertical axis and inversion in a circle. We introduce the complex concurence and an addition formula for Apollonius states and show that for generic two qubit states its modulus satisfies the law of cosine. Finally, we show that for two qubit Apollonius state in bipolar coordinates, the complex concurence is decribed by static one soliton solution of the nonlinear Schrodinger equation.

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NON-LOCALITY TESTS FOR QUANTUM REPEATER NETWORKS

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ABSTRACT

Quantum repeaters are essential tools for implementing medium to long range quantum communication and distributed computation activities, to build a quantum internet. Traditionally Bell tests are applied to measure the fidelity of channels between nodes and the overall network. This study aims to explore the possibility of developing tests of similar of nature through non-locality tests like Hardy's test. The main difference between Bell test and Hardy test is that in Bell test the combined results are compared and statistical deviance from inequality limits are investigated. If there is a violation of Bell type inequalities, then there are non-local correlations in the system. The degree of these correlations are decided using entanglement measures. In Hardy's test a positive outcome from a single measurement result can detect the existince of non-local correlations. Since the possibility of obtaining this measurement result is probabilistically low it is arguable that implementing Hardy's test instead of Bell test would result in reduced use of quantum resources (i.e. entanglement). However a Hardy's test can provide benefits to reduce the required amount of classical communication required for a Bell test.

QUANTUM NEURAL NETWORKS DRIVEN BY INFORMATION RESERVOIR

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ABSTRACT

This study concerns with the dynamics of a quantum neural network unit in order to examine the suitability of simple neural computing tasks. More specifically, we examine the dynamics of an interacting spin model chosen as a candidate of a quantum perceptron for closed and open quantum systems. We adopt a collisional model enables examining both Markovian and non-Markovian dynamics of the proposed quantum system. We show that our quantum neural network (QNN) unit has a stable output quantum state in contact with an environment carrying information content. By the performed numerical simulations one can compare the dynamics in the presence and absence of quantum memory effects. We find that our QNN unit is suitable for implementing general neural computing tasks in contact with a Markovian information environment and quantum memory effects cause complications on the stability of the output state.

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