Özet Kitapçığı

Kuantum Optiği ve Bilişimi Toplantısı

31 Ocak - 1 Şubat, 2019

Ankara Üniversitesi

KURULLAR

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KOBİT-3'E HOŞGELDİNİZ!

Kuantum Optiği ve Bilişimi Toplantısı

Kuantum Optiği ve Bilişimi 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 ve 2018'de Mimar Sinan Güzel Sanatlar Üniversitesinde düzenlendi. Serinin dördüncü toplantısı KOBİT-3, 31 Ocak - 1 Şubat 2019 tarihlerinde Ankara Üniversitesinde düzenleniyor.

Düzenleme Komitesi

ANA KONUŞMACILAR

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A3 What do we learn about the world from the problem of quantum correlations?

Fedor Jelezko *(Institute of Quantum Optics, Ulm University, Germany)*

A2 Diamond quantum sensors

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Frequency stabilized quantum oscillator and applications

Ç2 ***Sergey Borisenok*** *(Abdullah Gül University)*
Controlled qubits for computation and sensoring

Ç3 ***Ali Mostafazadeh*** *(Koç University)*
Dynamical reformulation of scattering theory, broadband invisibility, and new exactly solvable scattering potentials in two-dimensions

Ç4 ***Ricardo Ancheyta*** *(Koç University)*
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Ç5 ***H. Gül Yağlıoğlu*** *(Ankara University)*
Ultrafast dynamics: pump probe spectroscopy technique in broad range of materials

Ç6 ***M. Cengiz Onbaşlı*** *(Koç University)*
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Ç7 ***Burak Şahinoğlu*** *(Caltech)*
Asymptotic error correction in nature

Ç8 ***Mustafa Gündoğan*** *(University of Cambridge)*
Transform-limited single photons from a tin-vacancy spin in diamond

KOBİT |3⟩ Kuantum Optiği ve Bilişimi Toplantısı
Ankara Üniversitesi, 50. Yıl Salonu (Eczacılık Fak.)
31 Ocak 2019, Perşembe / 31 January 2019, Thursday

08:15-09:00		**KAYIT / REGISTRATION**	
09:00-09:15			Açılış / Opening
Başkan/Chair		Z. Gedik (Sabancı)	
09:15-10:00	**A1**	Adan Cabello (Sevilla)	Quantum nonlocality and contextuality
10:00-10:35	**Ç1**	Ramiz Hamid (TÜBİTAK UME)	Frequency stabilized quantum oscillator and applications
10:35-11:15		*Çay Arası / Coffee Break*	
Başkan/Chair		Ö. E. Müstecaplıoğlu (Koç)	
11:15-11:50	**Ç2**	Sergey Borisenok (AGÜ)	Controlled qubits for computation and sensoring
11:50-12:25	**Ç3**	Ali Mostafazadeh (Koç)	Dynamical reformulation of scattering theory, broadband invisibility, and new exactly solvable scattering potentials in two-dimensions
12:25-14:00		*Öğle Yemeği / Lunch*	
Başkan/Chair		N. Ghazanfari (MSGSÜ)	
14:00-14:20	**S1**	Onur Pusuluk (İTÜ)	Quantum computation using classical conformational changes of biomolecules
14:20-14:40	**S2**	Kadir Durak (Özyeğin)	Optimization of an entangled photon source for quantum key distribution
14:40-15:00	**S3**	Aslı Tuncer (Koç)	Work and Heat Value of Bound Entanglement
15:00-15:20	**S4**	Morteza Vafadar (GTE)	Microwave-optic conversion for quantum information technologies via optomagnonics
15:20-16:00		*Çay Arası / Coffee Break*	
Başkan/Chair		G. B. Bağcı (Mersin)	
16:00-16:35	**Ç4**	Ricardo Ancheyta (Koç)	Dynamical Casimir effect in stochastic systems: photon-harvesting through noise
16:35-16:55	**S5**	Oğuzhan Yücel (ODTÜ)	Quantum Optics with Single-Photon Nanoantenna
16:55-17:15	**S6**	S. Seyyare Aksu (MSGSÜ)	Yapay manyetik alan altında farklı yüklü bozonik üstün akışkanlar karışımı
17:15-17:35	**S7**	Mojde Fadaie (Koç)	Quantum heat engine with topological phase transition
18:30		**Konferans Yemeği (Conference Dinner)**	

KOBİT |3❭ Kuantum Optiği ve Bilişimi Toplantısı
Ankara Üniversitesi, 50. Yıl Salonu (Eczacılık Fak.)
1 Şubat 2019, Cuma/ 1 February 2019, Friday

Başkan/Chair		A. U. Yılmazer (Ankara)	
09:00-10:00	**A2**	Fedor Jelezko (Ulm)	Diamond quantum sensors
10:00-10:40	**A3**	Adan Cabello (Sevilla)	What do we learn about the world from the problem of quantum correlations?
10:40-11:20		*Çay Arası / Coffee Break*	
Başkan/Chair		S. Ateş (İYTE)	
11:20-11:55	**Ç5**	H. Gül Yağlıoğlu (Ankara)	Ultrafast dynamics: pump probe spectroscopy technique in broad range of materials
11:55-12:15	**S8**	Elif Yunt (Koç)	Topological phase transition in quantum heat engine cycles
12:15-14:00		*Öğle Yemeği / Lunch*	
Başkan/Chair		A.L. Subaşı (İTÜ)	
14:00-14:35	**Ç6**	M. Cengiz Onbaşlı (Koç)	Integrated spintronic-diamond nitrogen vacancy hybrid quantum systems at room temperature
14:35-14:55	**S9**	Gökhan Torun (İTÜ)	Optimal distillation of quantum coherence with reduced waste of resources
14:55-15:15		Serkan Üçer (TÜBİTAK)	Kuantum Amiral Gemisi
15:15-15:35	**S10**	Zeki Seskir (ODTÜ)	Quantum technologies: current conditions around the globe and in Turkey
15:35-16:15		*Çay Arası / Coffee Break*	
Başkan/Chair		A. Bek (ODTÜ)	
16:15-16:50	**Ç7**	Burak Şahinoğlu (Caltech)	Asymptotic error correction in nature
16:50-17:25	**Ç8**	Mustafa Gündoğan (Cambridge)	Transform-limited single photons from a tin-vacancy spin in diamond
17:25-17:45		**Kapanış (Closing)**	

POSTER SUNUMLARI

31 Ocak 2019, Perşembe / 31 January 2019, Thursday 10:30-16:00

1 Şubat 2019, Cuma/ 1 February 2019, Friday 10:40-16:15

Emre Köse *(Koç University)*
Algorithmic Quantum Heat Engines

Ekrem Taha *Güldeste (Bilkent University)*
Many-body Nuclear Spin Bath Decoherence based on Cluster Correlation Expansion: A General Framework

Gamze Gül *(Koç University)*
Fluorescence-Based Detection of Magnetoreception

Mohsen Izadyari *(Koç University)*
The Evolution of Quantum Graph State in Noisy Channels

Utku Yekta Gürel *(Boğaziçi University)*
Performance Analysis of Solid State Qubit Circuits

Yağız Oyun *(İYTE)*
Electromagnetically Induced Transparency via Three Photon Excitation In Cold Rydberg Atoms

Yusuf KARLI *(İYTE)*
2-D Quantum Walk with Entangled Coins

KONUŞMA ÖZETLERİ

A1

Quantum nonlocality and contextuality

Adan Cabello
University of Seville, Spain

Abstract

In 1926, in the same paper where the probabilistic interpretation of the wave function was proposed, Max Born anticipated two possibilities to explain quantum theory: (i) there are hidden variables, (ii) there is no causal explanation. Between 1960 and 1967, two results shown the impossibility of explaining quantum theory with certain types of hidden variables: the Kochen-Specker theorem (against non-contextual hidden variables) and Bell's theorem (against local hidden variables). Between 1990 and 2014, the paradigm of quantum contextuality lead to a unifying picture of these two theorems and defined a very specific problem: How the universe should be so that the physical correlations between the outcomes of certain experiments will be exactly those predicted by quantum theory. In this first talk, we will summarize all these developments.

References

N. D. Mermin, Hidden variables and the two theorems of John Bell, Rev. Mod. Phys. 65, 803 (1993); ibid. 88, 039902 (2016).
A. Cabello, Experimentally testable state-independent quantum contextuality, Phys. Rev. Lett. 101, 210401 (2008).
A. Cabello, S. Severini, and A. Winter, Graph-theoretic approach to quantum correlations, Phys. Rev. Lett. 112, 040401 (2014).

Ç1

Frequency Stabilized Quantum Oscillator and Applications

Ramiz Hamid
TÜBİTAK, National Metrology Institute (UME), Gebze - Kocaeli, Turkey

Abstract

As a result of needs and developments in areas such as science, technology, metrology and navigation, the relative frequency stability of oscillators that produce electromagnetic signals have improved from 10^{-8} to 10^{-18} level. Quartz oscillators with relative frequency stability of **(Δf /f)** = 10^{-8} (which is approximately the stability of Earth rotation period) are an indispensable part of many electronic devices and they are known as the heart of atomic clocks. To satisfy needs for stable signals in applications such as measurement of physical constants, detection of gravitational waves, geodesy, space applications, high-speed communication and navigation, atomic clocks have been built by locking the frequency of quartz oscillators to atomic transitions. The frequency stability of H-masers, Rb and Cs atomic clocks are on the order of 10^{-11} - 10^{-16} and they are based on quantum interactions between microwave EM waves, atoms and lasers. SI unit "second" and the timescale "UTC" are realized by Cs and Rb atomic fountain clocks with 1x 10^{-16} stability, which is based on cooling of atoms by stable lasers. Optical clocks have begun to be built after development of technologies enabling locking of laser frequency to very narrow (~1 mHz) atomic transitions. Nowadays, the state-of-the-art optical clocks, which are based on cooled Sr atoms and lasers locked to ultra-stable Fabry-Perot cavities, can reach 10^{-18} level frequency stability, which makes them the most precise devices ever built. Generation of 10 MHz and 1 pps clock signals from optical clocks are achieved by phase-locking a femtosecond frequency comb to the clock laser.

In this seminar, I will present microwave and optical clock technologies and application of these clocks in science and technology including our related activities in TÜBİTAK National Metrology Institute (UME). Presentation consists of three main parts. In the first and second parts, I will discuss the problems and applications related to the frequency and period of EM wave, which is possible to measure and generate with an uncertainty of 10^{-13} – 10^{-14}. In the third part I will discuss the amplitude of EM waves which is measured with a high uncertainty (10^{-1} – 10^{-2}) that needs to be improved.

In the first part, I will speak about the importance of EM waves with a high stability and frequency precision in science and technology. Here, I will present the results of the generation of the National Time and Frequency scale with an uncertainty of 10^{-13} – 10^{-14} using Cs atomic clocks and frequency standards operated at RF – MW spectrum and GPS satellite systems. Besides, time and frequency dissemination and its applications will be discussed.

In the second part, I will present our laser sources in the optical spectral range of 532 nm – 3390 nm, laser frequency stabilization on atomic (Cs, Rb) and molecular (I_2, CH_4) transitions with an uncertainty of 10^{-11} – 10^{-14}, influence of magneto-optical effects on the saturated atomic absorption spectrum. I will give our latest results related to Rb clock, frequency stabilized Yb-fiber femtosecond frequency comb and also low phase noise microwave generation based on femtosecond comb. The results related to the application of stabilized lasers for length and displacement measurement with a nanometer uncertainty will also be discussed.

In the third part, different methods for generation and amplitude measurement of RF-MW fields will be presented. Here, I will also discuss microwave-atom-laser interaction in the atomic cell and measurement of MW field using the laser spectroscopy technique. I will discuss the importance of the EM field measurement uncertainty in Electromagnetic Compatibility (EMC) applications and electromagnetic pollution.

Ç2

Controlled Qubits for Computation and Sensoring

Sergey Borisenok[1,2]
[1] *Department of Electrical and Electronics Engineering, Abdullah Gül University, Kayseri, Turkey*
[2] *Feza Gürsey Center for Physics and Mathematics, Boğaziçi Univesity - Kandilli Campus, İstanbul, Turkey*

Abstract

Qubits driven by quantum gates serve as basic elements for quantum computation. In standard approach each quantum gate performs only one certain logical operation. We propose an alternative paradigm, where the gate is dynamical and controlled via the external field such that it represents the sequence of elementary operations developing in time. Thus, the set of different quantum operations sequent in time could be performed with the dynamical transformation just of few quantum gates.

Recently optimal and sub-optimal algorithms have been successfully applied to two-level quantum system driven via quantum coherent and incoherent control. Here we invent the feedback control to the external fields serving as logical operators to design dynamical logical gates with the wide spectrum of their target properties. We demonstrate the efficiency of our approach for some basic set of gates used in quantum computations: Pauli set, Hadamard, Fredkin and others. Another application of our approach is quantum sensoring. The extreme sensitivity of quantum systems towards the external perturbations and in the same time their ability to be strongly coupled to the measured target field makes them to be stable under the environmental noise. A high quality quantum sensor can be engineered even on the platform of a single trapped qubit.

We discuss the opportunity to improve the efficiency of the external field quantum sensor based on a trapped single qubit via its feedback tracking. We compare few alternative control approaches and discuss pros and cons for each of them. Our algorithmic approach could be realized experimentally in a set of physical systems, like nitrogen vacancy centers in diamonds, ultracold atoms in magnetic fields and others.

Ç3

Dynamical reformulation of scattering theory, broadband invisibility, and new exactly solvable scattering potentials in two-dimensions

Ali Mostafazadeh
Departments of Mathematics and Physics, Koç University, İstanbul, Turkey

Abstract

We outline a newly developed dynamical formulation of time-independent scattering theory in two-dimensions [1,2] and discuss two of its applications in achieving perfect broadband invisibility [3] and constructing new exactly solvable scattering potentials. Specifically, we establish a general invisibility theorem with immediate applications in designing permittivity profiles that are perfectly and omnidirectionally invisible for both TE and TM waves with frequencies below a tunable cutoff. Furthermore, we report the discovery of two classes of scattering potentials in two dimensions whose scattering amplitude admits an exact and closed-form expression in terms of classical functions. The first of these consists of delta-function potentials in two dimensions whose support is a subset of a line [4]. It includes finite linear arrays of delta-function potentials in two dimensions, as well as delta-function potentials supported on a line and having an arbitrary periodic spatial dependence along this line. The second class contains complex potentials whose support is an infinite strip in the x-y plane [5]. They have a specific periodic y-dependence and an essentially arbitrary x-dependence. These potentials model certain active optical slab systems. We comment on their possible applications in generating quantum states with entangled momentum along one direction and quantized momentum along the other. Our results also suggest means for devising directional and multimode lasers.

References

[1] F. Loran and A. M., arXiv:1511.01404, Phys. Rev. A 93, 042707 (2016).
[2] F. Loran and A. M., arXiv:1605.01225, Proc. R. Soc. A 472, 20160250 (2016).
[3] F. Loran and A. M., arXiv:1705.00500, Opt. Lett. 42, 5250 (2017).
[4] F. Loran and A. M., arXiv:1708.06003, J. Phys. A. 51 335302 (2018).
[5] F. Loran and A. M., arXiv:1711.01132, Phys. Rev. A 96, 063837 (2017).

S1

Quantum computation using classical conformational changes of biomolecules

Onur Pusuluk [1,2], Berk Üstündağ [3], Nezih Hekim [4]

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[2] *Department of Physics, Koç University, İstanbul, Turkey*

[3] *Department of Computer Engineering, Faculty of Computer and Informatics Engineering, İstanbul Technical University, İstanbul, Turkey*

[4] *Department of Clinical Biochemistry, School of Medicine, Sivas Cumhuriyet University, Sivas, Turkey*

Abstract

To achieve their biological functions, almost all biomolecules use hydrogen bonding at some point, which involves the sharing of a proton between two molecules. Under some circumstances, the shared proton can be found in a quantum superposition of two spatially separated locations. From the viewpoint of the hydrogen-bonded molecules, this phenomenon corresponds to the formation of non-classical intermolecular correlations like quantum entanglement. Our previous information-theoretical studies show that biomolecules can

i) amplify the amount of quantum correlations shared in hydrogen bonds,
ii) transfer these correlations into different atom pairs,
iii) and use them as a resource in biological functions

as a result of completely classical conformational changes [1, 2].

Besides this, it is well known in the literature that the conformation of a biomolecule can be externally controlled in vitro, e.g. using a time-dependent electromagnetic field [3]. In this respect, although our findings were obtained using prototypical systems, they open up the possibility of developing new quantum computing devices based on molecular electronics.

References

[1] Pusuluk, O., Torun, G., Deliduman, C. 2018. Quantum entanglement shared in hydrogen bonds and its usage as a resource in molecular recognition. Modern Physics Letters B 32 (26): 1850308. (doi: 10.1142/S0217984918503086, arXiv: 1807.00647 [quant-ph])

[2] Pusuluk, O., Farrow, T., Deliduman, C., Burnett, K., and Vedral, V. 2018. Proton tunneling in hydrogen bonds and its possible implications in an induced-fit model of enzyme catalysis. Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences 474 (2218): 20180037. (doi: 10.1098/rspa.2018.0037, arXiv: 1703.00789 [physics.chem-ph])

[3] Chen, Y., Cruz-Chu, ER, Woodard, JC, Gartia, MR, Schulten, K, Liu, L. 2012. Electrically induced conformational change of peptides on metallic nanosurfaces. ACS Nano. 6 (10): 8847 – 56. (doi: 10.1021/nn3027408)

S2

Optimization of an Entangled Photon Source for Quantum Key Distribution

Melis Pahalı, Şafak Özçimen, Kadir Durak
Özyeğin University, İstanbul, Turkey

Abstract

In this work, optimization of an entangled photon pair source based on type-1 phase matching spontaneous parametric down-conversion (SPDC) phenomenon in collinear geometry is studied to be exploited in quantum communication applications. The relation between nonlinear crystal length and brightness (entangled photon pairs per second per mW pump power) is examined by directly imaging of down-converted photons with a CMOS camera. The collection of signal and idler modes to a single mode fiber (SMF) is quantified by comparing it to the overall emitted power. An experimental technique is proposed for this analysis. It has been observed that the brightness has a linear relationship with the crystal length. However, the fraction of the pairs that can be collected (coupled) to a SMF reduces with increasing crystal length due to the dispersion of the pump (and therefore down-converted modes) within the nonlinear crystal. It has also been observed that the aspheric lens has better collection efficiency compared to achromat and spherical lenses. Finally, we propose an experimental configuration that works the best for maximum brightness, collection efficiency and entanglement fidelity.

S3

Work and Heat Value of Bound Entanglement

Aslı Tuncer, Özgür E. Müstecaplıoğlu
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Abstract

Quantum entanglement has recently been recognized as an energy resource which can outperform classical resources in case of relatively low decoherences. BE states which are a special class of entangled states and resource value of these states in information applications has been under critical study and a few cases where they can be useful have been identified. We explore the energetic value of typical BE states. Maximal work extraction is determined in terms of ergotropy. We propose a scheme in which an ensemble of atomic clusters are subject to a thermal noise before they are randomly injected to a cavity one at a time. Steady state temperature of the cavity is used as the quantifier of the maximal heat exchange with the ensemble. We found that the ergotropy and the cavity temperature exhibit different monotonicity with a parameter of distillability, controlling the BE or free entangled (FE) character of the cluster state [1].

References

[1] Fatih Özaydın, Ceren B. Dağ, Aslı Tuncer, Özgür E. Müstecaplıoğlu. Work and Heat Value of Bound Entanglement. arXiv preprintarXiv:1809.05085.

S4

Microwave-Optic Conversion for Quantum Information Technologies via Optomagnonics

Morteza Vafadar Yengejeh[1], Fikret Yıldız[1], Bulat Rami[1,2],
[1] *Physics Department, Gebze Technical University, Gebze/Kocaeli, Turkey*
[2] *E. Zavoisky Kazan Physical-Technical Institute, Kazan, Russian Federation*

Abstract

For achieving high-performance quantum computing, quantum information processed by qubits should be stored in quantum memory for sufficient long time and transmitted between different quantum computers via coherent "quantum networks". Besides, quantum memories are considered to be essential elements of quantum repeaters for long distance (>500 km) communication. Clock frequencies of superconducting quantum processors are within microwave range; and ultra-low temperatures are required to prevent decoherence effects by thermal noise. On the other hand, traveling photons in optical frequency domain through fibers are the best carriers of quantum information for long-range communication because of high fidelity at room temperature. To connect these two worlds, i.e., cryo-cooled microwave quantum processors and robust optical networks, quantum systems for up/down coherent conversion of quantum signals from the optic frequencies to the microwave domain and vice versa, are extensively pursued [1]. Hybrid optomagnonic systems have recently emerged as promising candidates for such a coherent converter [2] which are also very attractive from the viewpoint of enlarging the potential of the superconducting qubits [3].

In this work, we propose use of magnon-based (the quanta of spin waves) planar converter from microwaves to optics. In general, the microwave-magnon-photon conversion consists of three major coupling steps (Fig.1): 1) the coupling between itinerant microwave and the microwave cavity, 2) the coupling between microwave cavity and spin waves (or uniform magnetization precession) of a magneto-optic material like yttrium iron garnet (YIG), and 3) the coupling between traveling optical photons and magnons. The key issue is to increase the conversion efficiency (i.e., to enhance all the involved coupling strengths).

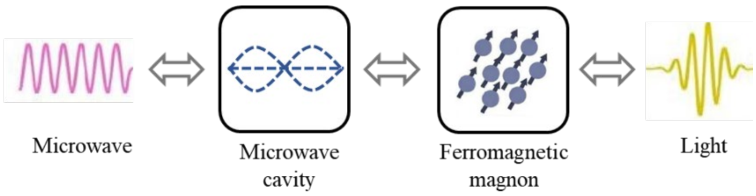

Fig.1. *Couplings involved in the magnon- based microwave-optic conversion.*

References

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[2] R. Hisatomi, A. Osada, Y. Tabuchi, T. Ishikawa, A. Noguchi, R. Yamazaki, K. Usami, and Y. Nakamura, "Bidirectional conversion between microwave and light via ferromagnetic magnons," *Phys. Rev. B*, vol. 93, no. 17, 2016.

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Ç4

Dynamical Casimir effect in stochastic systems: photon-harvesting through noise

Ricardo Ancheyta
Koç University, İstanbul, Turkey

Abstract

We theoretically investigate the dynamical Casimir effect in a single-mode cavity endowed with a driven off-resonant mirror. We explore the dynamics of photon generation as a function of the ratio between the cavity mode and the mirror's driving frequency. Interestingly, we find that this ratio defines a threshold-which we referred to as a metal-insulator phase transition-between exponential growth and low photon production. The low photon production is due to Bloch-like oscillations that produce a strong localization of the initial vacuum state, thus preventing higher generation of photons. To break localization of the vacuum state and enhance the photon generation, we impose a dephasing mechanism, based on dynamic disorder, into the driving frequency of the mirror. Additionally, we explore the effects of finite temperature on the photon production. Concurrently, we propose a classical analog of the dynamical Casimir effect in engineered photonic lattices, where the propagation of classical light emulates the photon generation from the quantum vacuum of a single-mode tunable cavity.

S5

Quantum Optics with Single-Photon Nanoantenna

Oğuzhan Yücel
Center of Solar Energy Research and Applications, METU, Ankara, Turkey

Abstract

Quantum light sources are at the core of quantum technologies and single-photon sources (SPSs) are perfect components with their purely non-classical light emissions for the demand. In this connection; quantum dots, diamond N-V centers, trapped-ions are some of the examples for SPSs which have been investigated in the literature. However, practicality of on-chip applications of two-dimensional materials, room temperature operation, high brightness and photostability features make hexagonal Boron Nitride (hBN) defect centers a hot topic for research. In this work, defect centers embedded in hexagonal Boron Nitride (hBN) multilayers are studied. Their emission properties are modified using plasmonic nanoantennae. Computational investigations are performed in order to characterize nanocavity parameters. In the quantum emitter part, hBN defect emission characteristics are studied experimentally and demonstrated to have bright and stable quantum emitter features. For the coupling part, first, hBN flakes spread over a vast area are surveyed and spotted emissive defect centers were spatially marked and characterized using angle-, power-, time-resolved photoluminescence spectroscopy and HBT interferometer. After fabricating nanoantennae on hBN multilayers, defect centers are re-found and measurements are repeated. As a result, depending on size of the nanoantennae, quenching and enhancement of photon emission effects are observed. It is also shown that sub-Poissonian photon statistics of a defect is not affected by a plasmon cavity. Finally, the experimental findings are confirmed via simulation results.

S6

Yapay manyetik alan altında farklı yüklü bozonik üstün akışkanlar karışımı

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Abstract

Bu çalışmada, halka geometrisinde tuzaklanmış, etkileşimli ve farklı yüklü iki bozonik üstün akışkan karışımı üzerinde manyetik alanın etkileri incelenmiştir. Bu sistemde odaklandığımız temel konular açısal momentum aktarımı, sistemin sergilediği kararsızlıklar ve girdap oluşumu koşullarıdır. Yüklerdeki eşitsizlik, uyarılmış parçacıkların açısal momentum durumları üzerindeki dağılımını, eşit yüklü karışımın dağılımına göre nitel olarak değiştirmektedir. Bu nitel değişiklik, etkileşim vasıtasıyla karışımdaki üstün akışkanlar arasında açısal momentum aktarımına sebep olmaktadır. Özel bir durum olarak yüklü bir üstün akışkan ile yüksüz bir üstün akışkan karışımı dikkate alındığında, akışkanlar arasındaki açısal momentum aktarımı sonucunda, manyetik alanı görmeyen yüksüz üstün akışkanda bir girdap yaratılabilir. Bu doğrultuda, çeşitli durumlar için karışımın sergilediği enerjetik ve dinamik kararsızlıkları inceleyerek girdap oluşumu koşullarını araştırdık. Bu kararsızlıklar girdap endükleme olayının, akışkanlar arasındaki etkileşim ile manyetik alanın rekabetine bağlı olduğunu ortaya koymaktadır.

S7

Quantum Heat Engine with Topological Phase Transition

Mojde Fadaie and Özgür E. Müstecaplıoğlu
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Abstract

We investigate a quantum heat engine (QHE) composed of two isothermal and isoelectric processes with a two-dimensional topological insulator, stanene, as its working substance. We examine the effect of electric field and temperature on the efficiency of this cycle. Changing the magnitude of electric field controls the band gap and causes topological phase transition (TPT) in stanene. Considering full energy band structure of stanene, work is done for all values of the electric field at room temperature and there is no sign of TPT in efficiency graph. Decreasing the temperature, efficiency decreases and goes to zero rapidly. For more investigations, a voltage bias is applied to limit the energy band to electronic levels. At both room and low temperatures work and efficiency go to zero exactly at TPT point. This makes possible to probe the TPT. Our results also propose that this cycle is experimentally realizable at room and low temperature with suitable magnitudes of the electric field.

A2

Diamond Quantum Sensors

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Abstract

Diamond is not only the king gemstone, but also a promising material in quantum technologies. Optically active impurities (colour centers) in diamond show unique coherence properties under ambient conditions. Their quantum state can be readout and manipulated using a combination of single molecule spectroscopy and magnetic resonance. In this talk, it will be shown how implanted spins in diamond can be used for creation of non-classical (entangled) quantum states. I will also demonstrate the potential of atomic magnetometers based on single centers for nanoscale sensing of magnetic field. We will also show new photoelectric detection technique allowing efficient readout of quantum states if single color centers.

A3

What do we learn about the world from the problem of quantum correlations?

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Abstract

How "there is no causal explanation" can be an explanation? In the 1980's, John Wheeler conjectured that the universe is "a self-synthesizing system," where "everything is built on the unpredictable outcomes of billions upon billions of elementary quantum phenomena," that are, themselves, "lawless events." Wheeler was obsessed by the question of "where does quantum theory come from." We will prove that the success of quantum theory in accounting for the results of correlation experiments should be taken as empirical evidence of the absence of laws governing or restricting the outcomes of these experiments. Our proof runs as follows: Suppose a universe in which there are scientists who select those experiments (aka measurements) that: (i) yield the same outcome when repeated, (ii) only disturb the outcome statistics of other experiments that cannot be jointly performed, and (iii) all their coarse-grainings have realizations satisfying (i) and (ii). The existence of such experiments is granted in any universe in which scientists can identify sets of experiments that can be jointly performed and whose outcome statistics can be described using classical probability theory. Now suppose a universe that has no law whatsoever restricting how the outcomes of these particular experiments occur. As a consequence, every behavior (i.e., set of outcome probability distributions, each one for a set of experiments that can be jointly performed) that is not forbidden can take place. Forbidden means forbidden within the framework scientists impose themselves, namely, (a) the rules of probability and (b) the assumption that there are statistically independent experiments. We will show that the sets of behaviors that are feasible in such a universe are identical to those predicted by quantum theory.

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Ç5

Ultrafast Dynamics: Pump Probe Spectroscopy Technique in Broad Range of Materials

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Abstract

Primary events in natural systems or devices occur in ultrafast time scales, which determine the output of the systems or final performance of the devices. Therefore, research in ultrafast science has an impact in both fundamental research as well as its applications. Ultrafast dynamics addresses questions such as the role of excess energy in electron injection at photovoltaic interfaces, the dynamics in quantum-confined structures (e.g. multi carrier generation), or electron/energy transfer mechanisms in novel compounds. Ultrafast pump probe spectroscopy technique is used to track ultrafast dynamics of the systems or devices. In this technique, a first light pulse (IR, Vis, EUV or X-ray) initiates dynamics, like a chemical reaction, a phase transition, spin, orbital, or charge-density waves in solids and a second pulse, impinging at a variable but well-defined time delay, probes the motion.

In this talk, ultrafast pump probe spectroscopy technique applied for various materials or devices at the Engineering Physics Department in Ankara University with the collaboration of other universities will be summarized:

- Electrochemically tunable ultrafast optical response of graphene oxide [1]
- Encapsulation of dye molecules in self-assembled peptide nanofibers [2,3]
- Probing ultrafast energy transfer between excitons and plasmons [4,5]
- Inter/intra molecular electron/energy transfers in BODIPY molecules for photosensitizer applications [6]
- The effect of charge transfer on the ultrafast and two photon absorption properties of various compounds [7]
- Enhancement of water oxidation under visible light by enhancing the electron transfer [8]
- Electron injection dynamics in dye sensitized solar cells
- Ultrafast magnetization dynamics.

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S8

Topological Phase Transition in Quantum Heat Engine Cycles

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Abstract

The signs of topological phase transitions in the work output and efficiency of a quantum heat engine are explored [1]. Specifically, a single layer of topological insulator, namely stanene in an external electric field is considered as the working substance of the quantum thermodynamic cycles. The band gap induced by intrinsic spin-orbit coupling in stanene enables topological phase transition at room temperature. The band structure and topological phase transition of stanene can be controlled by adjusting the external electric field [2]. Implementing this idea by considering a quantum Otto cycle [3] and a Stirling cycle [4], topological phase transition point in the work output and efficiency in these cycles manifests itself as an extremum.

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Ç6

Integrated spintronic-diamond nitrogen vacancy hybrid quantum systems at room temperature

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Abstract

Experimental development of quantum systems have been enabled by precise control of material properties of superconducting Josephson junctions, microwave oscillators, photonic and micromechanical resonators, quantum dots as well as electronic and nuclear spins in various material platforms such as nitrogen, germanium or silicon-vacancy centers in diamond [1,2]. An outstanding materials platform for implementing quantum systems at room temperature is diamond NV centers whose electronic and atomic spins could store qubit wavefunctions for long lifetimes and with narrow resonance linewidths. Due to the wide electronic band gap and high Debye temperature of diamond, NV spins have long lifetimes and have limited phonon dispersion channels at room temperature. In this presentation, I am going to first introduce how spin waves provide channels for nondissipative qubit initialization and entangled quantum logic gate architectures in hybrid spintronic-diamond NV systems. Then, the essential materials science and engineering of yttrium iron garnet thin films and diamond NV systems is going to be presented based on our recent experimental and modeling results. Finally, I am going to present some of our experimental results on detection of spin chemical potential and spin wave eigenmodes using hybrid yttrium iron garnet-diamond NV systems at room temperature. These results could pave the way for establishing magnon-driven room temperature, integrated and entangled qubit spin logic operators [3,4].

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S9

Optimal distillation of quantum coherence with reduced waste of resources

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Abstract

We present a simple, practical and efficient strategy for optimal one-shot distillation of quantum coherence from pure input states of arbitrary dimension. The key advantage of our protocol lies in its ability to provide a single map--a strictly incoherent operation--to obtain all q-level ($q = 2, 3, \ldots, d$) maximally coherent pure states starting from a d-level coherent input pure state. The probability of success, defined by the outcome $q=d$, is maximal, confirming optimality of the protocol. On the other hand, our protocol only fails when the trivial outcome $q=1$ is obtained, in which case no resource is distilled. We furthermore show how to modify the protocol into a two-step strategy which completely nullifies the failure probability, leading to no waste of coherence in the outputs; this is possible for a subclass of input states that we characterize. Our strategy can also be adapted to entanglement distillation. These results provide practical schemes for efficient quantum resource manipulation.

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S10

Quantum Technologies: Current Conditions around the Globe and in Turkey

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Abstract

Quantum (information) technologies is a rapidly changing field. New developments occur daily not only in the scientific but also in the political and economic areas. As physicists sometimes we get detached from these side of the progress in our field, which may leave us unprepared when game-changing events unfold. This study aims to cover major developments around the world and provide a general political and economic landscape concerning quantum technologies globally. To this end, initially, information on national and international initiatives, companies formed as startups or developed an interest in quantum technologies, publication and patent analyses are provided in a compact form. In the second part, current conditions in Turkey are discussed using data collected from National Thesis Center, and 20 interviews performed with researchers and interested party in quantum technologies. Finally, some anecdotal data on internship, awareness of 'quantum' in Turkey, and the idea of a 'quantum winter' is going to be shared.

Ç7

Asymptotic Error Correction in Nature

Burak Şahinoğlu
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Abstract

Quantum error correction is fundamental for realizing a reliable large scale quantum computer. In addition to the quantum computing applications, it has been proven to be insightful for the kinematics of condensed matter and high energy theories, e.g., topological order and holography, respectively. In this talk, I will present recent results about how widespread quantum error correction is in general physical phenomena. We will see that chaotic systems, translation invariant local Hamiltonians, and certain one dimensional critical systems contain error correcting codes with various parameters in their energy spectrum. Furthermore, we will construct error correcting codes out of the low energy subspace of one dimensional local gapped Hamiltonians. I will further mention questions about simulating dynamics of quantum _eld theories and remark how the techniques that we have developed for the kinematics are also useful for the dynamics. Basics of quantum error correction and various tensor network methods will be reviewed, hence no prior knowledge of these topics is necessary.

Ç8

Transform-limited single photons from a tin-vacancy spin in diamond

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Abstract

Spin-photon interfaces are of central importance in quantum information science for potential quantum networking and distributed quantum computation applications. Group IV (g-IV) colour centres have emerged recently as promising material systems that provide an optically-accessible spin together with narrow-linewidth, bright optical transitions. In this talk I will present our experiments on the recently discovered tin-vacancy centre (SnV^-) in diamond. Through magneto-optical spectroscopy, we first verify that the electronic structure of SnV^- similar to the other g-IV colour centres. We measure optical linewidths consistent with radiative lifetime limit. Lastly, we measure electronic spin lifetimes longer than the other g-IV colour centres, consistent with the larger ground state splitting. Our results indicate that SnV^- is a strong candidate for long-lived optical quantum nodes in a quantum network.

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POSTER SUNUMU ÖZETLERİ

P1

Algorithmic Quantum Heat Engines

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Abstract

We suggest alternative quantum Otto engines, using heat bath algorithmic cooling with partner pairing algorithm instead of isochoric cooling and quantum SWAP operations instead of quantum adiabatic processes. Liquid state nuclear magnetic resonance systems in a single entropy sink are considered as working fluids. The extractable work and thermal efficiency are analyzed in detail for four-stroke and two-stroke type of alternative quantum Otto engines. The role of the heat bath algorithmic cooling in these cycles is to use a single entropy sink instead of two so that a single incoherent energy resource can be harvested and processed using algorithmic quantum heat engine. Our results indicate path to programmable quantum heat engines as analogs of quantum computers beyond traditional heat engine cycles. We find that for our NMR system example, implementation of quantum algorithmic heat engine stages yields more power due to increased cycle speeds.

P2

Many-body Nuclear Spin Bath Decoherence based on Cluster Correlation Expansion: A General Framework

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Abstract

The nuclear spin bath (NSB) (de)coherence and its quantum control are crucial for the storage and processing of quantum information in a solid state matrix [1]. Within the NSB Hamiltonian, it is predominantly the dipole-dipole interaction among nuclear spins that obstructs the exact solutions and results in the exponential growth in the size of the Hilbert space. In this work, we mainly focus on the intrabath interactions governing the long term dynamics of milliseconds range in realistic systems such as quantum dots (QD). We discuss our general framework based on the Cluster-Correlation Expansion (CCE) technique initially introduced by Yang et.al. to quantify coherence of NSB by means of Loschmidt Echo [2]. Our poster presents the basic workflow of the CCE method for multidimensional QD models, that is ultimately geared toward extracting the spin noise spectra.

This work is supported by TUBITAK through Project No. 116F075.

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P3

Fluorescence-Based Detection of Magnetoreception

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Abstract

It has been known that navigation mechanism of birds relies on Earth's magnetic field; however, the primary sensor is still a matter of debate. Radical-pair mechanism is one of the leading theories and is a well-established model that focuses on photoactivated proteins such as cryptochrome and photolyase. In these proteins, the photoexcited flavin-tryptophan radical pairs can undergo coherent singlet-triplet transition which is sensitive to magnetic field changes. Absorption spectroscopy has been predominantly employed to monitor such magnetic field effects. Hovewer, this technique requires relatively high sample concentrations, and the magnetic field sensitivity of individual molecules with different orientations cannot be detected. Recently, fluorescence-based approach has emerged as an alternative experimental strategy which is easier to perform and more sensitive. Despite this, up to now fluorescence-based experiments have focused on revealing the magnetic field effect in the solutions containing flavin and tryptophan, but further research is still needed for the actual photoactivated proteins. In this work, we will first report the parameters that influence the amplitude of magnetic field effect for the solutions of flavin-tryptophan pairs such as pH, strength of the magnetic field, illumination power or concentration of molecules. Then, we will focus on the observation of magnetic field effect for Escherichia coli photolyase and Vibrio cholerae cryptochrome by using fluorescence-based experiments.

P4

The Evolution of Quantum Graph State in Noisy Channels

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Abstract

We study the evolution of quantum graph states during noisy channel. At first, we study the evolution analytically for two and three qubit system in noisy channels and simulate calculations numerically. Then we suggest a method to extend the studies for N-qubit graph state. We consider four different channel types, namely depolarizing, amplitude damping, bit-flip, and bit-phase-flip channel, and identify the classes of initial states leading to state with the minimum decay rate.

P5

Performance Analysis of Solid State Qubit Circuits

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Abstract

In this work, we analyze performance efficiency of charge-based quantum logic circuits. We employ a physical-information-theoretic approach that allows us to study computational and thermodynamic properties of qubit circuits on an equal footing. Our goal is to determine the minimum amount of energy required to process information by solid state qubit circuits. We study structures such as Cooper pairs, Josephson junctions and transmon circuits as illustrative examples and calculate the minimum energy required to perform computation by a range of superconducting qubit circuits. We also perform computer simulations on SIMON 2.0 to reflect the theoretical and computational differences in performance projections of these circuits and study the effect of various factors including temperature and noise.

P6

Electromagnetically Induced Transparency via Three Photon Excitation In Cold Rydberg Atoms

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Abstract

Electromagnetically induced transparency (EIT) is a quantum coherence phenomenon, in which the phase difference in excitation paths are utilized to interfere destructively, canceling out the absorption of the medium for probe laser. EIT was first observed in a two-photon scheme where a modified optical response is achieved by the interference of laser induced atomic state coherences at the resonance of transition [1]. EIT gave rise to many fascinating applications in quantum optics, such as slow light [2]. Rydberg-EIT media have been used to gain better understanding of quantum many body interactions [3,4]. Recently EIT in a four-level scheme was realized experimentally in a dressed state manner with Cs atoms, in which a strong middle state laser allows a transparency window to be opened for probe laser [5].

We investigate three photon EIT in a cold atomic ensemble that has a ladder type excitation scheme, in which the highest energy state is a Rydberg state. In order to include the dissipative dynamics of the system, we used von Neumann equation which involves Lindblad terms, followed by inclusion of Rydberg atom interactions. Starting from steady-state solutions without interactions we analyzed the system by using a self-consistent mean-field calculation to understand the interaction effects. As the interaction strength increases, we observed that transparency weakens, transparency window broadens and shifts away from the resonance as expected.

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P7

2-D Quantum Walk with Entangled Coins

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Abstract

A random walk is the process that objects randomly-move away from where they started. The simplest example of a random walk is the classical motion of a particle on a line, the direction of which is determined by a non-biased coin.[1] Quantum walks are quantum analogues of classical random walks. In contrast to the classical random walk, the direction of motion in a quantum walk depends on the state of a quantum coin. The classical random walk has Markov property that refers to the memoryless property of a process. Therefore, quantum walk has a Non-Markovian property unlike classical random walk. Non-Markovian property refers to the probability distribution of future states of the walk depends initial coin state. One of the simplest realizations of a quantum coin is the Hadamard transform that maps the coin-basis states $|0\rangle$ and $|1\rangle$ to two superposition states with equal weight basis states $|0\rangle$ and $|1\rangle$. $H|0\rangle = (|0\rangle + |1\rangle)/\sqrt{2}$, $H|1\rangle = (|0\rangle - |1\rangle)/\sqrt{2}$ [2]. We present an analysis for a quantum walk with two entangled coins on 2 dimensions. We studied 2-D quantum walk analytically and numerically to investigate the transform of the entanglement in initial coins state to spatial degreees of freedom. We present our results that plots the probability distributions of a 2-D quantum walk whose initial coin states are chosen as one of the Bell states.

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