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Talk

Coupled semiconductor quantum dots

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Abstract:

We investigate the optical properties of coupled InAs/GaAs self-assembled quantum dots. The coupling mechanism is studied through photon correlation measurements and through the magnetic-field dependent emission spectra.

Talk

Entanglement and squeezing of a four qubit system via two-axis counter twisting Hamiltonian

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Abstract:

We study the entanglement and squeezing properties of a spin system of 4 qubits under the influence of the two-axis counter twisting Hamiltonian. Our initial spin state is a coherent one in the z-direction, which evolves in time. We choose the squeezing parameters given by Wineland and Kitagawa as the criteria of spin squeezing. The criterion of pair-wise entanglement is chosen to be the concurrence and that of the bipartite entanglement, the linear entropy. We will study and plot the time dependence of the squeezing and entanglement parameters and also determine the time domains in which squeezing and entanglement properties can or can not exist simultaneously.

Talk

Entanglement and quantum phase transitions in matrix product spin-one chains

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Abstract:

We consider a one-parameter family of matrix product states of spin one particles on a periodic chain and study in detail the entanglement properties of such a state. In particular we calculate exactly the entanglement of one site with the rest of the chain, and the entanglement of two distant sites with each other and show that the derivative of both these properties diverge when the parameter g of the states passes through a critical point. Such a point can be called a point of quantum phase transition, since at this point, the character of the matrix product state which is the ground state of a Hamiltonian, changes discontinuously. We also study the finite size effects and show how the entanglement depends on the size of the chain. This later part is relevant to the field of quantum computation where the problem of initial state preparation in finite arrays of qubits or qutrits is important. It is also shown that entanglement of two sites has scaling behavior near the critical point.

Poster

Quantum random walk in 2 dimensions

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Abstract:

I took a new type of translation operator and calculate the standard deviation of 2D random walk for different initial state. This translation operator instead of Coin (DFT, Grover or separable H) could affect the standard deviation (time of spread). I simulated this random walk and plotted results and compared them.

Entanglement and quantum phase transition in 1D, 2D, and 3D spin models

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Abstract: (*poster*)

We study the properties of multi-qubit entanglement in quantum phase transition using information theoretic measure for genuine multi-qubit entanglement and global entanglement for several spin models. We determine the behavior and critical points of multi-qubit entanglement for different parameter regions. As an example, we determine the critical points of 4-qubit models in 1D and 2D (a quantum dot). We find the genuine multi-qubit entanglement is maximum for ground state and fall at for Ising and Heisenberg XX models and for anti-ferromagnetic Heisenberg XXX model in 1D. The corresponding values in 2D are twice their 1D value. Anisotropic models are also investigated where we determine genuine multi-qubit entanglement as a function of anisotropy. We also find a genuine three qubit entanglement in specific mixed states, show its critical points and conjecture its form for more general mixed states. In the end we use finite-size scaling theory to investigate the behavior of these systems for large number of qubits in various dimensions. These results help us in a better understanding of the ground state properties including entanglement sharing in these models.

Thermal effects on quantum cloning and entanglement broadcasting

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Abstract: Quantum cloning in the vicinity of a thermal environment is analyzed. First of all, we consider the situation in which only the initial state of our machinery, because of weak coupling to its surroundings, deviates from its purity. Later on, we inspect how the fidelities of symmetric universal and phase covariant cloning are modified when a simple dissipating spin one-half particle is duplicated. Finally, cloning of the entanglement associated with thermally diluted qubit pairs, via three (one local and two nonlocal) scenarios, is studied. Depending on which scenario is being used, we get some temperature and state dependent inequalities over which our clones are inseparable. “Joint work with A. T. Rezakhani”

State Transferring through Quantum Channels

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Abstract: It's predicted that the quantum computers will be built by the solid state technology. So in that dimension communication between different nodes is very important and hard technologically. Thus sending the states by natural time evolution of a chain of spins has been interested during these recent years. In this scheme a quantum state is generated at the first site of the ferromagnetic chain and by time evolution of the system the state of the last site will be similar to the initial state. In the algorithm the ferromagnetic system is generated in its ground state which means that we should use zero temperature to run this algorithm but here we have studied the effect of nonzero but low temperature on the quality of state transferring. Another problem that is considered here is entanglement distribution, which means that we generate an entangled pair at the start of the chain and we keep one particle out of the chain and the other is sent through the chain and it can be shown that the entanglement between the noninteracting particle and the last site of the chain has a significant value. As another problem we have investigated the dependence of the state transferring on the dimension of Hilbert space of each site in the chain. The results show that the quality of state transferring comes dawn by increasing the dimension and saturates a specific value. In contrast in the case of entanglement distribution the efficiency is increased for higher dimensions.

Evaluation of bounds of codes defined over hexagonal and honeycomb lattices via linear programming based on association schemes

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Abstract: While we can say much about codes without talking about association schemes, the algebraic structure they provide, gives us a more complete picture of how codes interact with the set they belong to. So far, Delsarte has used this algebraic structure to give one of the strongest bounds on the size of codes. Typically, the most of works on Delsarte's linear programming bound have been developed for the underlying codes of distance regular association schemes (distance-regular codes). In this work, by using underlying graphs of association schemes and Delsarte's linear programming bound, a way has been introduced for calculating some new bounds for more general codes which are not distance regular. Some upper bounds on underlying codes of association schemes with two commuting generators derived from finite root lattices corresponding to the lie algebra su(n), have investigated by using Delsarte's linear programming bound. In these cases, despite the distance regular ones, distance between any two arbitrary code-words is not equal to the number of steps needed for going from one codeword to the other. Hence, for achieving upper bound for a given code with minimum distance d, the number of steps needed for covering all code-words in distance d from an arbitrary codeword (called reference codeword), is determined via the structure of the corresponding underlying graph of association scheme. Also in these cases, some new perfect codes have been introduced. Similarly, we have introduced some upper bounds for GF(4) quantum codes.

Information gain and approximate reversibility of quantum measurements

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Abstract: We give a new and simple entropic definition, based on quantum relative entropy, of information gain in quantum measurements. Our definition contains the usually adopted one in all the cases in which the latter is well-behaved, while it solves all the problems existing in the general setting. In particular, the puzzling argument about possibly negative information gain disappears, and a sensible analysis becomes feasible also in the single-outcome case. We moreover provide a general entropic information-disturbance tradeoff which is tight and exactly quantifies the amount of classical randomness introduced by the apparatus in the general case. Finally we show how a quantum measurement can be robustly inverted, by applying an assisted correction scheme, when the information gain approaches zero.

An abstract approach to entanglement

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Abstract: Reasoning about quantum entanglement is fundamental to understanding many quantum systems and, in particular, measurement-based models of quantum computation. I demonstrate how entangled systems can be represented in a high level categorical setting and use a graphical representation of this language to prove the equivalence of some one-way programs to quantum circuit.

Why Nature obeys from Quantum Mechanics?

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Abstract: Bell's theorem states that any local realistic view of the world is incompatible with quantum mechanics, while, this is often interpreted as demonstrating the existence of non-locality in quantum mechanics. Even though these correlations are stronger than anything classically achievable, they cannot be harnessed to make instantaneous (faster than light) communication possible. There exist some types of models that simulate quantum correlation function. In these models, quantum correlation function simulate exactly all possible projective measurements that can be performed on the singlet state of two qubits, by using local hidden variables augmented by just one bit of classical communication. Hence, Popescu and Rohrlich have shown that even stronger correlations can be defined, under which instantaneous communication remains impossible. This raises the question: What are the implications of the quantum restrictions, and what are the principles at the origin of these restrictions? In this talk, we would like to respond to this question, we show that if we take some conservation laws as axiom, it had to be impossible to construct a consistent hidden variable theories augmented by classical communication or a single use of non-local box.

Designing quantum optical gates using micro-cavities

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Abstract: In this project which is done as a part of MSc thesis, an efficient method for using weak nonlinearities in micro-cavities for implementing quantum optical gates is proposed. Using micro-cavities and photonic crystals the efficient time of interaction is enhanced and so the desired effect for implementing Hadamard gate is gained.

Manipulating Multi-partite Entanglement Witnesses Using Linear Programming

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Abstract: An alternative method to detect entanglement is to construct so-called entanglement witnesses (EWs). Entanglement witnesses are physical observables that can detect the presence of entanglement. Recently many attempts have been made to use the convex optimization methods as a robust tool in most quantum information areas. From a different point of view, a very useful approach to construct EWs is the linear programming (LP), a special case of convex optimization. In addition to simplicity, the source of this usefulness comes from the fact that some of the problems can be converted to the (approximate) LP ones. Indeed in most cases determining feasible regions needs to use numerical calculation and consequently the problem is solved approximately. Therefore to figure out the problems which can be easily solved exactly in an optimal way and also can be generalized to an arbitrary number of particles with different Hilbert spaces is the main purpose. To this aim we introduce a new class of parameterized multi-qudit EWs acting on tensor product of arbitrary dimensional Hilbert spaces called reduction type EWs this paper. Furthermore, we have linked the stabilizer theory and the Clifford group operations with structure of new type EWs, so-called stabilizer EWs and we show the computational difficulty in such problems reduced to LP ones. On the other hand we show that the EWs corresponding to the hyperplanes surrounding the feasible regions are optimal in the most cases.

Entanglement in single-neutron system

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Abstract: Non-local correlations between subsystems sufficiently separated in space-time have been extensively discussed in the light of the Einstein, Podolsky, and Rosen (EPR) paradox, together with the Bell's inequality. Within quantum terminology, such a non-locality can be interpreted as a consequence of the entanglement of subsystems as well as commuting observables due to the different position. Thus, a more general concept, i.e., contextuality, compared to non-locality can be introduced to describe other striking phenomena predicted by quantum theory. As an example of quantum contextuality, we report a neutron interferometer experiment which clearly demonstrates the violation of a Bell-like inequality. Entanglement is achieved not between particles, but between the degrees of freedom i.e., spin and path, in this case, for a single-particle. Appropriate combinations of the direction of spin analysis and the position of the phase shifter allow an experimental verification of the violation of a Bell-like inequality. In addition, experimental results of so-called state tomography, tomographic analysis of the density matrix of a quantum system, are presented to characterize neutrons¡Ç entangled states. These experiments manifest high fidelities, up to 91%, of the entangled neutrons¡Ç states. Finally, we are going to describe new possibilities to implement a multi-entanglement in single-neutrons.

Y. Hasegawa et al., Nature 425 (2003) 45-48.

Y. Hasegawa et al., Phys. Rev. Lett. 97 (2006) 230401.

MPS approach to spin-1 ladder

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Abstract:

Renormalization of Entanglement in quantum spin models

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Abstract:

In recent years, the characterization of certain many-body condensed matter systems has received some attention from quantum information theory. Entanglement as one of the most intriguing feature of quantum theory has attracted much attention due to its nonlocal connotation that is regarded as a valuable resource in quantum information theory. To find the connection between entanglement and quantum phase transition, the behavior of entanglement in the vicinity of quantum critical point in many systems has been revisited. We have examined the behavior of entanglement in different steps of renormalization group (RG) for different couplings close to critical point. The one dimensional S = 1/2 Ising model in transverse field (ITF) and anisotropic Heisenberg model (XXZ) model have been considered by implementing the quantum renormalization group (QRG) approach . For ITF model we have calculated the renormalized Hamiltonian in standard QRG scheme using two sites blocking. The present scheme allows us to have the analytic RG equations, which give a better understanding of the behavior of system by running of coupling constants. The evolution of entanglement and its first derivative in each block has been studied in RG steps. After few RG steps the entanglement acts as an order parameter, i.e., for the paramagnetic phase the entanglement is zero and for the ferromagnetic phase the entanglement is equal one. Moreover, the QRG scheme with 3-sites blocking has been used to get the renormalized Hamiltonian in a self similar manner for the XXZ model.

In each block we evaluate the amount of entanglement of one spin with the other two remaining ones and also between two arbitrary spins. For the former Shannon entropy and for the latter concurrence has been considered as a measure of entanglement. Similar to the case of ITF model, the evolution of entanglement and its first derivative with RG steps has been studied. The entanglement shows a critical behavior such as discontinuity at the quantum phase transition point and after some RG steps, the concurrence acts as an order parameter like the entanglement in ITF model.

Mohammad Ali Jafarizadeh

Noisy Teleportation

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Abstract: Entanglement is a key resource in many quantum information applications. One of these applications is quantum teleportation. The purpose of teleportation is sending qubits across quantum channels. In general these quantum channels are noisy and therefore limit the fidelity of transmission. In this paper we consider the effect of noise on teleportation and finally find the fidelity of teleportation in presence of noise.

Long distance entanglement in spin chains

Mear Muhammad Reza Koochakie

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Abstract: I'm studying long distance entanglement between two inserted probes in XY spin chain model, now.

Entropic information-disturbance tradeoff

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Abstract: We show the flaws found in the customary fidelity-based definitions of disturbance in quantum measurements and evolutions. We introduce the ``entropic disturbance" D and show that it adequately measures the degree of disturbance, intended essentially as an irreversible change in the state of the system. We also find that it complies with an information--disturbance tradeoff, namely the mutual information between the eigenvalues of the initial state and the measurement results is less than or equal to D.
This work is based on the publication Europhys. Lett. 77, 40002 (2007).

Continuous variable quantum cryptography using a bidirectional quantum channel

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Abstract: In recent years, quantum cryptography has been developed into the continuous variable framework where it has been shown to fully exploit the potentialities of quantum optics. In this framework, we introduce novel “transform and measure” protocols which generalize, and are proven to outperform, the previous “prepare and measure” protocols. In these new protocols the secret information is encoded via random unitary transformations onto a quantum state which is transmitted forward and backward by the trusted parties. Thanks to this multiple quantum communication, Alice and Bob make an iterated use of the uncertainty principle which may lead to a security enhancement.
Our analysis investigates the simplest and non-trivial transform and measure protocol, i.e. the ones based on a bidirectional use of a quantum channel, and show a superadditive behavior of the security threshold.

Entanglement and group symmetries: stabilizer, symmetric and antisymmetric states

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Abstract: We study distance-like entanglement measures of multipartite states with certain symmetries. Using group averaging we show general conditions for which the relative entropy of entanglement, the geometric measure of entanglement and the logarithmic robustness are equal. We then consider specific sets of states important in quantum information and many-body physics. We show equivalence of these measures for all stabilizer states, symmetric basis and antisymmetric basis states. We also calculate the explicit value of these measures for symmetric and antisymmetric basis states, indicating that antisymmetric states are generally more entangled.

Entanglement and optimal strings of qubits for memory channels

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Abstract: We investigate the problem of enhancement of mutual information by encoding classical data into entangled input states of arbitrary length and show that while there is a threshold memory or correlation parameter beyond which entangled states outperform the separable states, resulting in a higher mutual information, this memory threshold increases toward unity as the length of the string increases. These observations imply that encoding classical data into entangled states may not enhance the classical capacity of quantum channels.

Relations between quantum entanglement, tomography and wavelet

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Abstract: In this paper the intimate connection is established between the wavelet transform method on homogeneous spaces and projective. Finally we consider separability criteria for any state with group theoretical wavelet transform.

Entanglement and quantum phase transition in 1D, 2D, and 3D spin models

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Abstract: We study the properties of multi-qubit entanglement in quantum phase transition using information theoretic measure for genuine multi-qubit entanglement and global entanglement for several spin models. We determine the behavior and critical points of multi-qubit entanglement for different parameter regions. As an example, we determine the critical points of 4-qubit models in 1D and 2D (a quantum dot). We find the genuine multi-qubit entanglement is maximum for ground state and fall at for Ising and Heisenberg XX models and for antiferromagnetic Heisenberg XXX model in 1D. The corresponding values in 2D are twice their 1D values. Anisotropic models are also investigated where we determine genuine multi-qubit entanglement as a function of anisotropy. We also find a genuine three qubit entanglement in specific mixed states, show its critical points and conjecture its form for more general mixed states. In the end we use finite-size scaling theory to investigate the behavior of these systems for large number of qubits in various dimensions. These results help us in a better understanding of the ground state properties including entanglement sharing in these models.

Generation of Entanglement in a Quantum Wire and Application to Single-Electron Transmittivity

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Abstract: We present a novel method to generate entanglement between two fixed impurities in a 1D metallic/semiconductor chain without them having to interact directly, and then show how this entanglement can actually be used to control the electron transmittivity along the wire. First, we study how two magnetic impurities embedded in a solid can be entangled by an injected electron scattering between them and by subsequent measurement of the electron's state. We obtain the entanglement between the impurities as a function of the interaction strength of the electron-impurity coupling, and find that our scheme allows us to entangle the impurities maximally with a significant probability. While much work has been done on entangling spins in mesoscopic solid state systems, this is the first proposal for entangling stationary spins, which can be well separated, using a reduced control method. We then reverse to problem to analyze the electron transmittivity along the wire in the presence of entanglement between the impurity spins. We find that, for suitable values of the electron momentum, different entangled states of the impurities can: either make the wire fully transparent for the electron (independently of its spin state); either strongly inhibits the electron transmission. These striking predicted effects could be experimentally observed. Moreover, they could be applied to interfacing quantum computer registers, as well as to detect entanglement between solid state qubits.

Experimental quantum teleportation between photonic and atomic qubits

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Abstract: Quantum teleportation is central to quantum communication and plays an important role in a number of quantum computation protocols. Here we report an experimental demonstration of quantum teleportation between photonic and atomic qubits. An unknown polarized single photon state is teleported to atomic qubits (consisting 2 atomic ensembles with 10^6 atoms each), which is 7m "away" (fiber based). The atomic ensembles serve also as quantum memory and then the teleported atomic state can be converted back to photonic state for further application of quantum information processing. An optimal Bell-state measurement capable of identifying two of the four Bell-states for polarization entangled photons is used by a feedback circuit. At retrieving time of 0.5 ¦Ìs, the fidelities are 0.865¡À0.017, 0.737¡À0.009 and 0.750¡À0.009 for horizontal polarization, 45 degree polarization and right circular polarization, respectively, well above the classical limit of two-thirds. We also show the teleported state can be stored and successfully converted back to photonic qubit up to about 8 ¦Ìs, which shows the present approach can be scalable for long distance quantum communication and large scale quantum computation networks.

Quantum Information and Quantum Many Body Systems: From Scaling Laws to Implementations

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Abstract: Recently, tools from quantum information have been applied successfully to the analysis of scaling laws in quantum many body systems. Here I will review some results in this area that we have obtained. These scaling laws explain when and why certain methods for the approximation of quantum many body systems fail. Armed with this I present a novel approach that addresses these problems. If time permits I will also present our ideas for the implementation of quantum simulators in coupled arrays of micro-cavities.

MPS spin one on ladder

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Abstract: I would present a poster about MPS spin one half ladder.

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Citizenship: Iranian
Presenting a talk or poster: Yes
Visiting Mainland Iran: Yes
Comments:
Title of presentation: Generation of entanglement and suppression of decoherence in ENDOR-based quantum computing

Abstract: The ultimate goal for the research on quantum computing is construction of a computational machine that deals entirely with quantum properties, such as entanglement, and remains stable and works reliably in the presence of decoherence. In an approach to this task, we use a resonance spectroscopy that involves simultaneously electron spins in addition to nuclear spins, that is called ENDOR. For this system, entanglement was realized between an electron and a nuclear spin [Mehring et al., Phys. Rev. Lett. 90, 153001 (2003), Rahimi et al., Intl. J. Quant. Inf. 3, 197 (2005)].
For making a full computational processor with ENDOR, it should be stabilized against influence of noise. Hence, we study methods with which decoherence in ENDOR would be suppressed. We show the numerical results indicating that the oscillation of the minimum negativity (over all bipartite splittings) due to the spin boson coupling and the decay of the minimum negativity under simple noise written in the Kraus operator sum form are both suppressed by sharp bang-bang pulses on individual spins. The achieved results are to be used for determination of optimum experimental conditions since they are in an operationally possible range. In our presentation, we are going to introduce recent results from our study, as well as giving a short overview on the achieved experimental evidences.

Comments on recent Which-Way experiments proposed by Scully, Englert and Walther introducing the idea of Quantum Erasure

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Abstract: Here, we first survey all possible situations of a recent series of Which-Way (WW) experiments proposed by Scully, Englert and Walther introducing the idea of Quantum Erasure (QE). Since their erasing process is a quantum measurement, we argue that all situations of QE can be statistically described by a given joint probability. So it can be easily concluded that the delayed-mode of measurement has no special importance for QE and the time ordering of measurements has no effect too. This is a consequence of the Bayesian rule for the joint probability of two events when the time ordering of the events is arbitrary. We conclude, then, that none of the QE proposals fulfill the bizarre implications of a delayed-choice experiment including the backward causation and the role and meaning of the arrow of time in quantum mechanics. Subsequently, we suggested a new simple experimental arrangement in which the path information could be erased without measurement. Here, the time ordering of detections has a direct effect on the final pattern. Thus the idea of delayed-choice (and its possible interpretations including the backward causation, non-locality and the role of physical reality) is directly introduced here. In interpreting our thought experiment, we argue that whenever one neglects the role of reality assumption in quantum realm, many misleading attitude and misconceptions may arise. In a realistic perspective, however, the state function in quantum mechanics does not completely describe the physical reality. So, the controversial problems, such as the delayed-choice effect, are interpreted subordinately. For example, in Bohm's approach, all of the bizarre aspects of micro world are resolved by considering the real character of particles guided (and influenced) by waves through a quantum potential. We believe that the controversial problems in quantum domain show that the quantum formalism misses some definite elements of physical reality. Correspondingly, our proposed experiment shows that the reality assumption has a primary role in expounding the peculiar features of WW experiments.