Abstracts of Contributed Presentations

Nonclassical properties of finite dimensional coherent states

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Finite dimensional coherent states or qudit coherent states (QCS) can be constructed in various ways. Two of the most discussed QCS are (a) nonlinear QCS which obtained by applying finite dimensional displacement operator on vacuum state[1], and (b) linear QCS which is construccted by truncating the Hilbert space and renormalizing [2]. With the help of a set of witnesses and measures of nonclassicality, it is established that the QCSs are highly nonclassical in nature. The witnesses of the nonclassicality investigated here are Klyshko's and Agarwal-Tara criteria [3] and criteria for lower-order and higher-order order antibunching, squeezing, and sub-poissonian photon statics [3]. In fact, using various operator ordering techniques, analytic expressions for witnesses of lower-order and higher-order order antibunching, squeezing, and sub-poissonian photon statics are obtained. Further, quantification of the nonclassicality present in the QCSs is performed using two measure, namely entanglement potential and anticlassicality [3]. The amount of nonclassicality is compared and it is observed that the amount of nonclassicality increases with the increase in

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Quantum entanglement indicators

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We examine bipartite entanglement in the double-well Bose-Einstein condensate system [1] and in a model of a multi-level atom interacting with a radiation field [2]. We investigate the roles played by classical and quantum correlations in determining the extent of entanglement at various instants during dynamical evolution of the concerned system. For this purpose, we compare standard measures of entanglement such as subsystem von Neumann entropy (SVNE) and subsystem linear entropy (SLE) with two tomographic entropy-based indicators that we have developed. We have shown that in the two systems considered, one of these indicators, namely, tomographic entanglement indicator (TEI) is in fair qualitative agreement with SVNE and SLE [3]. We have improved it to obtain the other indicator which we refer to as the

`dominant tomographic entanglement indicator' (DTEI). We emphasize that while both these indicators primarily capture the classical correlations, for certain regions of nonlinearity and interaction strength parameters in the respective Hamiltonian and for certain initial states, they compare very favourably with SVNE and SLE. We also perform a time-series analysis on the difference between standard entanglement measures and TEI to understand the nature of the source of the discrepancy.

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Demonstration of DPS QKD with single photon interference of a weak coherent pulse in telecommunication wavelength with APD detectors

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We demonstrate differential-phase-shift (DPS) quantum key distribution (QKD) protocol using superposition state of a weak coherent pulse in prepare and measure scheme. The two main characters of QKD, Alice and Bob are 40 km apart. Alice creates a superposition state of the photon by allowing multiple paths, encodes her key in the relative phase of the superposed state and sends it to Bob. The different pathways constituting the superposition cause the pulse to interfere with itself in Bob's interferometer and we observe interference pattern at the output of the delay line interferometer (DLI). The relative phase between successive pulses is modulated with a phase modulator at Alice's station and we retrieve the key at the end of the Bob's station. In this work we report the results of the experiment performed indigenously built single photon Gated APD detectors. It is well established that DPS QKD is robust against photon number splitting attack and its security has been proven for individual attacks. Here, we prove that such a multi-pulse scheme is more robust than conventional DPS QKD against intercept resend attack and beam splitter attack.

New family of bound entangled states residing on the boundary of PPT set

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Abstract: Bound entangled (BE) states are strange in nature: non-zero amount of free entanglement is required to create them but no free entanglement can be distilled from them

under local operations and classical communication (LOCC). However, usefulness of such states have been shown in several information processing tasks. Still, there is no simple method to characterize all these states for an arbitrary composite quantum system. Here we present a (d-3)/2-parameter family of BE states each with positive partial transpose (PPT). These families of PPT-BE states are introduced by constructing a class of unextendible product bases (UPBs) in $\mathbf{C}^d\otimes\mathbf{C}^d$ with d odd and $d \geq 5$. We also provide the `tile structures' corresponding to these UPBs. The range of each such PPT-BE state is contained in a 2(d-1) dimensional entangled subspace whereas the associated UPB-subspace is of dimension $(d-1)^2+1$. We further show that each of these PPT-BE states can be written as a convex combination of (d-1)/2 rank-4 PPT-BE states. Moreover, we prove that these rank-4 PPT-BE states are extreme points of the convex compact set $\boldsymbol{P}$ of all PPT states in $\mathbf{C}^d\otimes\mathbf{C}^d$. An interesting geometric implication of our result is that the convex hull of these rank-4 PPT-BE extreme points -- the (d-3)/2-simplex -- is sitting on the boundary between the set $\boldsymbol{P}$ and the set of non-PPT states. We also discuss consequences of our construction in the context of quantum states discrimination by LOCC.

Quantum uncertainty relation: Engaging the median when mean is not licit

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The uncertainty relation in quantum mechanics is traditionally written in terms of mean as the measure of central tendency and standard deviation as the measure of dispersion. It puts a constraint on the product of the spreads of position and momentum of quantum states, a feature that is absent in classical mechanics. Based on a different statistical concept, namely the median, we propose a quantum uncertainty relation between the semi-interquartile ranges of the position and momentum distributions of arbitrary quantum states, going beyond the mean-based uncertainty. We find that unlike the mean-based uncertainty relation, the median-based one is not saturated for Gaussian distributions in position. Instead, the Cauchy distributions in position turn out to be the most classical among the distributions that we have studied.

Paper reference: arXiv:1706.00720

Experimental certification and quantification of entanglement in a novel spatially correlated bipartite qutrit system.

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One of the long standing open problems for quantum correlation in higher dimensional systems is to certify and quantify entanglement in the experimental scenario. Study of higher dimensional systems is interesting because we can access larger Hilbert space and hence computational power by using such systems than qubits, which are two-level quantum systems. In qubit systems, Negativity is one of the most used quantity to measure entanglement but it provides necessary and sufficient condition to certify entanglement for $2 \otimes 2$ and $2 \otimes 3$ dimensions only. However, this approach involves full state tomography and hence the number of required measurements increase with the size of the system. In a recent paper, Maccone et. al. [1] suggested the use of Pearson correlation coefficient (PCC) for entanglement certification. In our work [2] , we extend this criteria for PCC based certification upto dimension 5. We also propose a scheme to quantify entanglement using PCCs. This is interesting particularly because PCCs are directly measurable quantities and it requires a very small number of measurements. In another recent experimental work [3], we develop a novel spatially correlated bipartite qutrit source using pump beam modulation techniques, and successfully measure and quantify the amount of entanglement using the PCCs. In this poster, I will primarily discuss this experiment on the preparation of spatially correlated bipartite qutrit source and certification and quantification of entanglement using our newly developed theoretical scheme based on PCCs.

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Universal quantum uncertainty relations between non-ergodicity and loss of information

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Abstract: We establish uncertainty relations between information loss in general open quantum systems and the amount of non-ergodicity of the corresponding dynamics. The relations hold for

arbitrary quantum systems interacting with an arbitrary quantum environment. The elements of the uncertainty relations are quantified via distance measures on the space of quantum density matrices. The relations hold for arbitrary distance measures satisfying a set of intuitively satisfactory axioms. The relations show that as the non-ergodicity of the dynamics increases, the lower bound on information loss decreases, which validates the belief that non-ergodicity plays an important role in preserving information of quantum states undergoing lossy evolution. We also consider a model of a central qubit interacting with a fermionic thermal bath and derive its reduced dynamics, to subsequently investigate the information loss and non-ergodicity in such dynamics. We comment on the "minimal" situations that saturate the uncertainty relations.

Minimal Measurement Setup to Manifest Quantum Nonlocality

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John Bell, in the seminal *1964* paper, proved the existence of quantum correlations among distant observers that cannot be simulated by any *local-realistic* model. To manifest such quantum correlation, quantum nonlocality namely, it requires, in the simplest scenario, two measurements to be performed randomly by each of the two distant observers. In this letter, we propose a novel scheme to reveal quantum nonlocality where only three measurements, two on Alice's side and one on Bob's side are used. Our scheme is based on an experimentally realized naive quantum information theoretic protocol called minimal error state discrimination. The proposed scheme overcomes the experimental challenges in generating random measurement directions on Bob's side and hence circumvents the Bell computability loophole. This, in turn, constitutes an economic entanglement detection scheme, which uses a less number of entangled states compared to all such existing schemes. Moreover, our method applies to a class of generalized probability theories containing quantum theory as a special example.

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An Entropic Measure of Single Mode Quantum Optical Nonclassicality

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Nonclassical states of a quantized electromagnetic field are described by phase-space distributions beyond the scope of classical theory. Despite several attempts, it is yet an open task to define a uniform and consistent measure to quantify such nonclassical character. Here, we propose a measure for the single mode quantum optical states in terms of the *Wehrl entropy*. Our measure is based on the Husimi-Kano distribution, a classical like distribution that could be

retrieved experimentally by optical heterodyne detection. We show that our measure quantifies the nonclassicality for a broad class of states, even in presence of *competing nonclassicalities*, reasonably.

Generalized Formalism for Information Backflow in assessing Markovianity and its equivalence to Divisibility

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Abstract: We present a general framework for the information backflow (IB) approach of Markovianity, that not only includes a large number, if not all, of IB prescriptions proposed so far, but also is equivalent to CP-divisibility for invertible evolutions. Following the common approach of IB, where monotonic decay of some physical property or some information quantifier is seen as the definition of Markovianity, we propose, in our framework, a general description of what should be called a proper 'physicality quantifier' to define Markovianity. We elucidate different properties of our framework, and use them to argue that an infinite family of non-Markovianity measures can be constructed, which would capture varied strengths of non-Markovianity in the dynamics. Moreover, we show that generalized trace-distance measure in 2 dimension serve as a sufficient criteria for IB-Markovianity for a number of prescriptions suggested earlier in literature.

Quantum Heat Machines

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Quantum heat engine (QHE) employs a quantum system as the working fluid that is expected to give rise to large work efficiency, beyond the limit for classical heat engines. Existing proposals for implementing quantum heat engines require that the system interacts with the hot bath and the cold bath (both modeled as a classical system) in an alternative fashion and therefore assumes the ability to switch off and on the interaction with the bath during a certain stage of the heat- cycle. However, it is not possible to decouple a quantum system from its 'always-on interaction' with the bath without the use of complex pulse sequences. It is also hard to identify two different baths at two different temperatures in the quantum domain that sequentially interact with the system. Here, we demonstrate how the reciprocating heat cycle of a quantum Otto engine (QOE) can be implemented using a trapped ions as the working substance, in presence of a thermal bath. The electronic states of the ions act like a working substance, while the vibrational mode is modeled as the cold bath. The heat exchange with the cold bath is mimicked by the projective measurement of the electronic states. The local magnetic field is adiabatically changed during the heat cycle. In our model, the coupling to the hot and the cold baths is never switched off in an alternative fashion during the heat cycle, unlike other existing proposals of quantum heat engines. This makes our proposal experimentally realizable using current tapped-ion technology.

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Quantification of Quantum Coherence In Special Relativistic Scenario.

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Abstract: We consider the effect of relativistic boosts on single-particle Gaussian wave packets. The coherence of the wave function as measured by the boosted observer is studied as a function of the momentum and the boost parameter. Using various formulations of coherence, it is shown that in general the coherence decays with the increase of the momentum of the state, as well as the boost applied to it. Employing a basis-independent formulation, we show, however, that coherence may be preserved even for large boosts applied on narrow uncertainty wave packets. Our result is exemplified quantitatively for practically realizable neutron wave functions.

Operational characterization of quantumness of unsteerable bipartite states.

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Recently, the quantumness of local correlations arising from separable states in the context of a Bell scenario has been studied and linked with superlocality [Phys. Rev. A 95, 032120 (2017)]. Here we investigate the quantumness of unsteerable correlations in the context of a given steering scenario. Generalizing the concept of superlocality, we define as super-correlation, the requirement for a larger dimension of the preshared randomness to simulate the correlations than that of the quantum states that generate them. Since unsteerable states form a subset of Bell local states, it is an interesting question whether certain unsteerable states can be super correlated. Here, we answer this question in the affirmative. In particular, the quantumness of certain unsteerable correlations can be pointed out by the notion of super-unsteerability, the requirement for a larger dimension of the classical variable that the steering party has to preshare with the trusted party for simulating the correlations than that of the quantum states which reproduce them. This provides a generalized approach to quantify the quantumness of unsteerable correlations in convex operational theories.

Protecting temporal correlations of two-qubits using quantum channel with memory

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Quantum correlations are non-increasing under the interaction with environment. Quantum temporal correlations by means of violation of Leggett-Garg Inequality(LGI) and Temporal Steering Inequality(TSI) are found to be decreasing under decoherence channels, like Amplitude damping, Phase-damping and Depolarising channels when are probed on two-qubit pure entangled states. We show that, if partial memory to these channels are introduced, i.e. two consecutive uses of the channels are time-correlated, then the violations of temporal inequalities can be protected against the action of decoherence.

Superposing pure quantum states with partial prior information

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The principle of superposition is an intriguing feature of quantum mechanics, which is regularly exploited in many different circumstances. A recent work [1] shows that the fundamentals of quantum mechanics restrict the process of superimposing two unknown pure states, even though it is possible to superimpose two quantum states with partial prior knowledge. The partial prior knowledge is in the form of the overlaps between each of the states to be superimposed and a fixed referential state. We discuss an experimentally feasible protocol to superimpose multiple pure states of a d-dimensional quantum system and carry out an explicit experimental realization for two single-qubit pure states with partial prior information on a two-qubit NMR quantum information processor [2]. Desired superpositions are experimentally obtained in the given framework, covering all possible aspects, i.e. (i) creation of arbitrary pairs of single-qubit states and obtaining their superposition, (ii) superposition with arbitrary weights, and (iii) superposition of single-qubit states in the presence of assumed overall phases. All the experimental results have been obtained with fidelities over 0.97. We also analyze the enhancement in the success probabilities associated with the desired superpositions for different prior information.

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Theoretical Investigation of four-qubit C-NOT gate equivalence Quantum Logic Circuits

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Recently, Starek et al., Sci. Rep. **6**, 33475(2016) have experimental realized two photon four-qubit linear optical quantum logic circuit by employing encoded two qubits into a single photon, which is an important implementation beyond two and three qubit linear optical quantum gates. In the present work, we have proposed and, theoretical computed three different equivalence of four qubit quantum logic circuits from C-NOT quantum gate working qubit (q1) to qubit (q4) and there is no any type of gate is working on qubit-q2, qubit-q3 (or I is working on qubit-q2 and qubit q3). In these equivalence, we equated the C-NOT (q1-q4 qubit) line gate to Direct Sum Quantum Gate .In the first equivalence topmost q1-qubit acts as control qubit whereas downward q2-qubit, q3-qubit and q4-qubit act as target qubits. The matrix element of direct sum matrix are three qubit quantum gate are A = I and B = I . This equivalence may be expressed as C-NOT(q1 to q4)=. In second type of equivalence same C-NOT(1to 4th qubit) equated to controlled Direct Sum Quantum Circuit where topmost 1st and 2nd qubit acts as control qubit and downward 3rd and 4th qubit acts as target qubits. Here two times two qubit gates C = I,and D = I acts on target qubits. This equivalence may be express as C-NOT (q1 to q4)= In last 3rd type of equivalence ,from topmost qubit to downward 1st, 2nd and 3rd qubits acts as controlled qubits while 4th qubits acts as target qubit. Here single qubit gate E = I and F = acts on target qubit each by four times in a series. This equivalence may be expressed as C-NOT (q1 to q4) = Overall equivalence can be defined as C-NOT(q1 to q4) .

An extensive study on a class of non-maximally entangled mixed states constructed by S. Adhikari, A. S. Majumdar, S. Roy, B. Ghosh and N. Nayak, Quant. Inf. Comp., 10, 0398, (2010)

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We constructed a class of non-maximally entangled mixed states [S. Adhikari, A. S. Majumdar, S. Roy, B. Ghosh and N. Nayak, Quant. Inf. Comp., **10**, 0398, (2010)] and extensively studied its entanglement properties and also their usefulness as teleportation channels. In this article, we revisited our constructed state and have studied it from a different perspective. Since every entangled state is associated with an witness operator, we have found a suitable entanglement as well as teleportation witness for our non-maximally entangled mixed states. We considered the

noisy channel's effects on our constructed states to see how much it affects the states' capacities as teleportation channels. For this purpose, we have mainly focussed on amplitude damping channel. A comparative study on concurrence and quantum discord of our constructed state has also been carried out here.

Ref. : A revisit to non-maximally entangled mixed states: teleportation witness, noisy channel and discord. Quantum Information Processing 16(4): 108 (2017)

Self-testing of any pure two qubit entangled state through quantum steering

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Recently, self-testing of maximally entangled two qubit state in a 1-sided device-independent way (in which one can do state tomography on one side and the other side is treated as black-box device) was proposed by Supic et. al. [New J. Phys. 18, 075006 (2016)] via quantum steering. Further, it was shown that quantum steering provides certain advantage over fully device-independent self-testing in which the observation of Bell nonlocality is required. In this work, we consider the problem of self-testing of any pure entangled two qubit state through quantum steering. We note that in the two-setting steering scenario, the maximal violation of a fine-grained steering inequality can be used to witness certain extremal steerable correlations, which certify all pure two qubit entangled states. Motivated by this observation, we are interested in self-testing of any pure entangled state with these extremal steerable correlations. We demonstrate that by using the fine-grained steering inequality and analogous CHSH inequality of steering, one can self-test any pure maximally as well as non-maximally entangled two qubit state in a 1-sided device-independent way.

Consistency between thermal and completely passive states depending on the structure of the Hamiltonian

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In recent times the connection between quantum information theory and quantum thermodynamics has become one of the most fascinating areas of research. The amount of maximal work extraction is a primary issue of consideration in this topic. Given any arbitrary state what will be the maximum amount of the extractable work under the unitary action commuting with the time varying Hamiltonian is considered in [1]. If from the single copy of a given state no unitary can extract any amount of work, then the state is said to be passive in single copy. But one can ask what about the higher copies with the action of the global unitary. If it's not possible to extract any amount of work even with infinite copies of the state, then the state is referred to as a completely passive state. A thermal state (Gibbs state) following Gaussian probability distribution is a state with maximum (minimum) entropy (energy) but constant energy (entropy). In [2,3] it was shown that if the state follows the Gaussian probability distribution decreasing with the increase of energy, then no work can be extracted even with infinite copies of the state without considering any special structure in the governing Hamiltonian. In this work we have tried to find out the consistency between the definition of completely passive state and thermal state. We have obtained a sufficient criterion for the linearly spaced Hamiltonian structure (mostly used in quantum thermodynamics literature, viz., linear harmonic oscillator) depending on the probability structure of the state, to be completely passive. Structure for thermal states become one of the special case under this criterion. Hence a sharp distinction between thermal state and completely passive state is presented with a suitably chosen Hamiltonian structure. Ref: [1] Maximal work extraction from finite quantum systems A. E. Allahverdyan, R. Balian and Th. M. Nieuwenhuizen EPL (Europhysics Letters), Volume 67, Number 4 [2] Thermodynamical proof of the Gibbs formula for elementary quantum systems A. Lenard Journal of Statistical Physics December 1978, Volume 19, Issue 6, pp 575–586 [3] Passivity, complete passivity, and virtual temperatures Paul Skrzypczyk, Ralph Silva, and Nicolas Brunner Phys. Rev. E 91, 052133 – Published 19 May 2015

GENERATION OF QUANTUM CORRELATIONS BETWEEN TWO BOSONIC MODES IN A THERMAL ENVIRONMENT

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In the framework of the theory of open systems based on completely positive quantum dynamical semigroups, we analyze the time evolution of continuous variable quantum correlations (quantum entanglement, quantum discord and quantum steering) in a system consisting of two coupled bosonic modes interacting with a thermal reservoir. We solve the Markovian master equation which determines the dynamics of the considered system and describe the quantum correlations in terms of the covariance matrix for Gaussian initial states. Depending on the values of the parameters characterizing the initial state of the system (squeezing parameter, average thermal photon numbers), coefficients describing the interaction of the system with the environment (temperature, dissipation constant), and depending also on the strength of the coupling between the two bosonic modes, one can observe the generation of quantum correlations, their sudden suppression, temporary revivals and suppressions, or an asymptotic decay of quantum correlations in the limit of large times.

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Adaptive quantum error correction over disordered 1-d spin chains

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We study the problem of quantum state transfer over a spin chain, involving the transfer of one qubit worth of information from one site to the other. In the ideal case of 1-d spin chain with Heisenberg nearest-neighbour interactions, it is known that the qubit dynamics can be modelled as a completely positive trace-preserving (CPTP) map, namely, the “amplitude damping channel" [1]. For such a model, we show that using techniques from approximate or adaptive quantum error correction (QEC) [2, 4], it is possible to sustain higher fidelity of state transfer over longer spin chains.

We extend our study to the more realistic case of spin chains with disorder and show that the quantum channel arising from such dynamics is of a more general form than amplitude damping noise. It is well known that disorder affects the propagation of quantum information due to localization [3]. Here, we show that it is possible to transmit quantum information in such disordered systems over distances beyond localization length with high fidelity using adaptive QEC. Our analysis also gives us an explicit relation between fidelity and localization length. Our techniques are applicable to the larger class of 1-d spin Hamiltonians which preserve the total excitations on the spin chain.

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Operational nonclassicality of local multipartite correlations

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For a bipartite local quantum correlation, superlocality refers to the requirement for a larger dimension of the random variable in the classical simulation protocol than that of the quantum states that generate the correlations. In this work, we consider the classical simulation of local tripartite quantum correlations P among three parties A, B and C. If at least one of the bipartitions (A|BC), (B|AC) and (C|AB) is superlocal, then P is said to be absolutely superlocal, whereas if all three bipartitions are superlocal, then P is said to be genuinely superlocal. We present specific examples of genuine superlocality for tripartite correlations derived from three-qubit states. It is argued that genuine quantumness as captured by the notion of genuine discord is necessary for demonstrating genuine superlocality. The notions of absolute and genuine superlocality are also defined for multipartite correlations. References [1] J. M. Donohue and E. Wolfe, “Identifying nonconvexity in the sets of limiteddimension quantum correlations,” Phys. Rev. A 92, 062120 (2015). [2] C. Jebaratnam, S. Aravinda, and R. Srikanth, “Nonclassicality of local bipartite correlations,” Phys. Rev. A 95, 032120 (2017)

Efficient schemes for the quantum teleportation of a sub-class of tripartite entangled states

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In this paper we propose two schemes for teleportation of a sub-class of tripartite states, the first one with the four-qubit cluster state and the second one with two Bell pairs as entanglement channels. A four-qubit joint measurement in the first case and two Bell measurements in the second are performed by the sender. Appropriate unitary operations on the qubits at the receiver's end along with an ancilla qubit result in the perfect teleportation of the tripartite state. Analysis of the quantum circuits employed in these schemes reveal that in our technique the desired quantum tasks are achieved with lesser quantum cost, gate count and classical communication bits compared with other similar schemes.

Geometric phase of a symmetric two-qubit state

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Sir Michael Berry (Proc. R. Soc. A 392, 45 (1984)) discovered geometric phase as-sociated with the solution of time dependent Schrodinger wave equation under adiabatic, cyclic and unitary evolution of a quantum system, when initial state happens to be one of the eigenstates of the time-dependent Hamiltonian. Aharonov and Anandan (Phys. Rev. Lett. 58, 1593(1987)) broadened the notion by relaxing the adiabaticity condition. Further-more, Samuel and Bhandari (Phys.Rev. Lett. 60, 2339(1988)) generalized it by dropping cyclic condition on the Hamiltonian and highlighted the geometric nature of the phase. It is Mukunda and Simon (Annals. Phys. 228, 205-268(1993)), who put forth an elegant approach to the theory of geometric phase, based on the kinematic machinery of the Hilbert space of a quantum system. In this work we consider the example of a pure symmetric two-qubit state and explore the geometric phase of the system via dierent approaches. More specically, we consider a symmetric two qubit system interacting with a time dependent magnetic eld and derive the geometric phase (a) using adiabatic approximation and (b) by using the Aharanov-Anandan approach. We then obtain an expression for the geomet-ric phase for a general smooth curve of unit vectors of a three-level quantum state (which is equivalent to a two qubit symmetric state) using the kinematic approach of Mukunda and Simon. We also discuss the signicance of geometric phase of a three level system in quantum optics, especially in the e-cient population transfer problem in three-level systems (N.V. Vitanov and S. Stenholm, Opt. Comm. 135, 394 (1997)) where we establish the relation between the geometric phase and the detuning factor of the intermediate level.

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Quantum Information Transfer using Weak Measurements and Any Non-product Resource

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Information about an unknown quantum state can be encoded in weak values of projectors belonging to a complete eigenbasis. We present a protocol that enables one party – Bob – to remotely determine the weak values corresponding to weak measurements performed by another spatially separated party – Alice. The particular set of weak values contains complete information of the quantum state encoded on Alice's ancilla, which enacts the role of the preselected system state in the aforementioned weak measurement. Consequently, Bob can determine the quantum state from these weak values, which can also be termed as remote state determination or remote state tomography. A combination of non-product bipartite resource state shared between the two parties and classical communication between them is necessary to bring this statistical scheme to fruition. Significantly, the information transfer of a pure quantum state of any known dimensions can be effected even with a resource state of low dimensionality and purity with a single measurement setting at Bob's end.

Theoretical Equivalence Quantum Circuit of SWAP (1 to 3rd qubit) Gate

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Abstract

Recently, Yan Liang et. Al..Laser Physics Letters.[Volume 12 Number 11] proposed alternative method to realize SWAP Gate using shortcuts to adiabatic passage and combing Quantum Zeno Dynamics. But we proposed and theoretically computed the above equivalence. In this equivalence, we equated SWAP (1to 3rd qubit) Gate to Quantum Circuit in which three

SWAP Gates are acts on different qubits in horizontal direction. In SWAP (1to3rd) Gate, no any type of quantum gate is acting on q2 .Qubits counts from top to bottom as q1, q2 and q3. First SWAP Gate acts on q2to q3. Second SWAP Gate acts on q1 to q2 and third SWAP Gate acts on q2 to q3.Hence mathematically this equivalence can be written as

SWAP (1to 3rd) = $[I_2 \otimes SWAP\ (q2toq3)][SWAP(q1toq2) \otimes (I_2)]\ [I_2 \otimes SWAP\ (q2toq3)]$

Improved quantum violation of macrorealist and noncontextual inequalities

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In a recent paper [1], it is shown that for a qutrit system the maximum quantum violation of a three-time Leggett-Garg inequalites (LGIs) can exceed the L$\acute{u}$der bound if von Neumann collapse rule is invoked. Even, the violation can approach to the algebraic maximum in the asymptotic limit of system size. We show that for the case of qutrit system the quantum violation can be further improved by suitably choosing the intermediate unitary evolutions between two measurements. We then pointed out that the choice of basis for invoking the von Neumann projective rule is not unique, if relevant observable is degenerate. We found that choice of basis can improve the maximum quantum violation of LGIs. We further show that the simplest non-contextual inequalities (NCIs) can also violated if von Neumann rule is used as apposed to the reasoning given in [1]. We provide a discussion about the experimental verifiability of our results using optical setup.

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Nonclassical properties of entangled quantum systems

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We have examined two quantum systems, namely, a Λ atom interacting with two radiation fields and a basic optomechanical system with a two-level atom placed inside the Fabry-Perot cavity. In both systems, we investigate the roles played by field nonlinearity and intensity-dependent coupling in determining the extent of quadrature and entropic squeezing of relevant subsystem states, during temporal evolution. The extent of entanglement and the time duration over which the entanglement collapses to a constant non-zero value (in contrast to sudden death) are sensitive to the extent of nonlinearity, the precise nature of the initial unentangled state and the extent of decoherence.
A wide range of squeezing properties are estimated directly from appropriate optical tomograms [1], without carrying out explicit quantum state reconstruction. Lessons learnt from our preliminary tomographic analysis on a wide class of states including `Janus-faced' partner states [2] are used in extending the tomographic analysis to the two tripartite quantum systems [3].
A detailed time-series analysis of the mean photon number reveals very interesting ergodicity properties.

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Tighter Einstein-Podolsky-Rosen steering inequality based on the sum-uncertainty relation.

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We consider the uncertainty bound on the sum of variances of two incompatible observables in order to derive a corresponding steering inequality. Our steering criterion, when applied to discrete variables, yields the optimum steering range for two-qubit Werner states in the two-measurement and two-outcome scenario. We further employ the derived steering relation for several classes of continuous-variable systems. We show that non-Gaussian entangled states such as the photon-subtracted squeezed vacuum state and the two-dimensional harmonic-oscillator state furnish greater violation of the sum steering relation compared to the Reid criterion as well as the entropic steering criterion. The sum steering inequality provides a tighter steering condition to reveal the steerability of continuous-variable states.

Ref : Phys. Rev. A ,96,052326 (2017)

Probing hierarchy of temporal correlation requires either generalised measurement or nonunitary evolution

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Temporal steering and violation of the Leggett-Garg inequality are two different ways of probing the violation of macro-realistic assumptions in quantum mechanics. It is shown here that under unitary evolution and projective measurements the two types of temporal correlations lead to similar results. However, their inequivalence is revealed if either one of them is relaxed, i.e., by employing either generalized measurements, or noisy evolution, as we show here usingrelevant examples.

Simulating Curvature effect on Dirac Particle by Quantum Walk

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Dirac particle represents a fundamental constituent of our nature. Simulation of Dirac particle dynamics by a controllable quantum system will allow us to investigate non-classical nature of our physical world. In this work, starting from a modified version of one-spatial dimensional general inhomogeneous split-step discrete quantum walk we derive an effective Hamiltonian which mimics a single massive Dirac particle dynamics in curved (1 + 1) space-time dimension coupled to U(1) gauge potential---which is a forward step towards the simulation of the unification of electromagnetic and gravitational forces in lower dimension and at the single particle level. Implementation of this simulation scheme in simple qubit-system has been demonstrated. We show that the same Hamiltonian can represent (2 + 1) space-time dimensional Dirac dynamics when one of the spatial momentum remains fixed. The role of curvature on the two-particle split-step quantum walk has also been investigated while the particles are interacting through their entangled coin operation

Role of quantum error correction in preserving entanglement

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We examine the question of how well quantum error correction (QEC) preserves entanglement in bipartite quantum states, in terms of measures such as concurrence and negativity. In particular, we compare the entanglement present in arbitrary bipartite states before and after a quantum process and bound the fall in entanglement as a function of the fidelity between the initial and final states. Past work has been entirely numerical and addressed this issue only for specific states and channels [1,2]. Here, we obtain analytical bounds for a large class of channels using techniques from approximate [3] or adaptive QEC [4]. Our bounds show that, as long as an error correction procedure can restore the state with high enough fidelity, the entanglement does not drop any faster than fidelity. Our bounds are further validated by numerical studies for the amplitude damping channel, leading us to conclude that the so-called entanglement sudden death [5] phenomenon does not manifest within the noise threshold relevant for quantum computing.

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Entanglement dynamics of pure and mixed states for two particles in a double-well

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We investigate the coherent entanglement dynamics of a closed system of two particles in a double well in the presence of contact interaction. When the strength of the contact interaction becomes much larger than the tunneling strength, the eigenstates of the system become approximately Bell states. We study the time evolution of general pure states and mixed "X" states and compare the time dependence of coherence, concurrence and Shannon entropy and show that for the case of pure states, all three quantities have similar time dependence. Depending upon the choice of initial states, the case of mixed "X" states shows a departure from this trend. We see that while the Shannon entropy and coherence show similar time dynamics, the entanglement dynamics can show a sudden vanishing of concurrence (akin to entanglement sudden death- ESD) followed by a sudden revival (entanglement sudden rebirth ESB). Additionally, we observe that for a class of initial mixed states entanglement never develops in time even though the underlying Hamiltonian is nonlocal due to the interaction term. Our system is akin to the Hubbard model and can be physically implemented in a variety of physical set-ups such as optical lattices, double quantum dots, quantum magnets and charge coupled Josephson junctions. We show that when applied to these real systems, the timescales for ESD and ESB can be controlled by real physical parameters like tunneling and contact interaction strength as well as by the choice of initial states. Moreover, similarities in the time dependence of coherence, Shannon entropy and concurrence offer alternative ways of measuring entanglement dynamics in real systems - a possibility which can be of considerable significance in many systems currently being explored for applications in entanglement engineering and scalable quantum computation.

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Title: Quantum speed limit constraints on a nanoscale autonomous refrigerator

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Quantum speed limit, furnishing a lower bound on the required time for the evolution of a quantum system through the state space, imposes an ultimate natural limitation to the dynamics of physical devices. Quantum absorption refrigerators, on the other hand, have attracted a great deal of attention in the last few years. In this rapid communication, we discuss the effects of quantum speed limit on the performance of a quantum absorption refrigerator. In particular, we show that there exists a trade-off relation between the steady cooling rate of the refrigerator and the minimum time taken to reach the steady state. Based on this, we define a figure of merit called "bounding second order cooling rate" and show that this scales linearly with the unitary interaction strength among the constituent qubits. We also study the increase of bounding second order cooling rate with the thermalization strength. We subsequently demonstrate that coherence in the initial three qubit system can significantly increase the bounding second order cooling rate. We study the efficiency of the refrigerator at maximum bounding second order cooling rate and, in a limiting case, we show that the efficiency at maximum bounding second order cooling rate is given by a simple formula resembling the Curzon-Ahlborn relation.

Reference: arXiv:1711.10813

EXCLUSIVITY PRINCIPLE AND UNPHYSICALITY OF GARG-MERMIN CORRELATION

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arXiv: 1710.05825

The question concerning the physical realizability of a probability distribution is of quite importance in Quantum foundations. Specker first pointed out that this question cannot be answered from Kolmogorov's axioms alone. Lately, this observation of Specker has motivated simple principles (exclusivity principle/ local orthogonality principle) that can explain quantum limit regarding the possible sets of experimental probabilities in various nonlocality and contextuality experiments. We study Specker's observation in the simplest scenario involving three inputs each with two outputs. Then using only linear constraints imposed on joint probabilities by this principle, we reveal unphysical nature of Garg-Mermin (GM) correlation. Interestingly, GM correlation was proposed to falsify the following suggestion by Fine: if the inequalities of Clauser and Horne (CH) holds, then there exists a deterministic local hidden-variable model for a spin-1/2 correlation experiment of the Einstein-Podolsky-Rosen type, even when more than two observables are involved on each side. Our result establishes that, unlike in the CH scenario, the local orthogonality principle at single copy level is not equivalent to the no-signaling condition in the GM scenario.

Quantum repeater architecture using two-species trapped ions

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Two-species trapped ions with one memory qubit and one communication qubit provides a promising platform for the realization of quantum repeaters and future quantum networks. We analyze quantum repeater architecture based on two-species trapped ions using Yb ion as a memory qubit and Ba ion as communication qubit in the context of long-distance quantum key distribution. Optimization of swapping operation between memory and communication qubits and overcoming the single-shot measurement limitation of the communication qubit is considered. We examine the maximal achievable rates for various quantum repeater architectures using two-species trapped ions as building blocks. We derive the dependence of the quantum key distribution rate on coupling efficiency, gate infidelity, operation time and length of the elementary links.

Measurement induced nonlocality based on fidelity and robustness against depolarizing noise

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Measurement induced nonlocality (MIN) - a quantum correlation measure of a bipartite system, captures nonlocal effects of states due to local projective measurements. It is originally introduced by S. Luo and S. Fu as maximal square of Hilbert-Schmidt norm of difference between pre- and post- measurement states. This quantity is easily computable and also experimentally realizable. However, it can change arbitrarily and reversibly through actions of the unmeasured party - local ancilla problem. In this work, in order to resolve the local ancilla

problem, we modify the definition of MIN based on fidelity induced metric (F-MIN). We compute F-MIN analytically for pure state and $2 \times n$dimensional mixed state. Further, we provide two upper bounds of F-MIN for an arbitrary mixed state. A study on bipartite state dynamics under depolarizing channel shows that MIN and F-MIN are more robust against noise than the entanglement.

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Cooperative communication protocols

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Quantum entanglement find its profound application in teleportation, quantum secret sharing, quantum key distribution and many other protocols. Here we have considered the scenario where a multipartiteentangled state has been shared between more than two parties. Alice wants to teleport a unknown **n**-qubit state with **m** terms to Bob via Charlie, Danish and so on. The success of the protocol depends on wheather each of them can find suitable measurement basis on each step. We will show that it is possible for some particular types of multipartite entangled state. We also find that these multipartite states are also useful resource for quantum secret sharing, quantum key distribution.

Entanglement as a correlation measure in few-body states

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Recent advances in ultracold gases experiments have offered the opportunity to study systems of a few trapped atoms with specifically tailored interactions in strongly-correlated regime. Within such experimental environments, the direct measurements of correlation characteristics have become feasible. This provided new impetus for theoretical studies of entanglement spectra, i.e. the eigenvalues of the reduced density matrix of systems partitioned into two subsystems and the asociated entanglement entropies, which are now considered the most important characteristics of many-body systems.
I will study the entanglement spectra of systems effectively described by few-body Schrödinger equation with interactions depending on various powers of the distance between the constituents. The linear entropy and von Neumann entropy will be discussed in dependence on the interaction type and strength, especially in the neighborhood of critical points. In particular, the dimensional crossover from two to one dimensions will be explored, by observing how

confining a transverse spatial dimension influences entanglement. The relationship of entanglement and quantum chemical correlation measures will be shown for He isoelectronic series with varying nuclear charge. I will also consider open few-body systems, which may have resonant states. Their stability properties will be studied by examining the behavior of entanglement entropies at the border between the regimes of bound and resonant states.

Photon-photon correlations and correlated photon-pairs by cavity QED

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We present a theoretical study on photon-photon correlations by a cavity QED setup. We consider a model V-type three level emitter with non degenerate excited states, confined in a weakly driven double crossed cavity setup. The cavity supports mode frequencies resonant to the corresponding ground to excited state transitions. The excited states are considered to be metastable so that the level decay rates can be neglected in comparison to cavity decay rate. We show that for different input probe detuning in strong emitter-cavity coupling regime, the output photon correlation can be made to change from super-Poissonian (bunching) to Sub-Poissonian (antibunching) statistics. We also show that this setup can be used to generate correlated or entangled photon-pairs.

Entangling power of time evolution in a many-body system

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In this work we look at the entangling power of time evolution operator in the kicked Ising model. For a generic non-integrable system, entanglement entropy of a state evolved from a product state after a quench grows ballistically and saturates to a value corresponding to a random state in the bipartite space. One thus expects for such a case, the entangling power to quickly increase and saturate to a value corresponding to that of a random unitary chosen from an appropriate circular ensemble. We find however that the growth rate very much depends on the time between kicks and magnetic field configuration. Surprisingly, even certain integrable cases show a growth of entangling power which is close to that of the non-integrable case though they saturate at a lower value. We consider a simple random-matrix model consisting of repeated applications of a nonlocal unitary interlaced on one side with locals chosen from the Haar measure. This rather simple RMT model seems to be able to capture the growth of entangling power for certain combinations of time between kicks and magnetic fields in the kicked Ising model. Surprisingly, even some integrable cases shows a growth matching prediction from the model for short times.The time evolution operator for the kicked Ising model for a single kick can be decomposed in a similar fashion, with the nonlocal being a two-qubit gate. We show that the discrepancy of the actual rate from the predicted rate correlates well with the randomness of the locals in the kicked Ising model as measured by the spacing distribution of the phases of their eigenvalues.

Optimal Entropy Compression and Purification in Quantum Bits

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Unitary transformations (optswaps) that optimally increase the bias of a mixed computation qubit towards a particular state of the computational basis which, in effect, increases its purity are presented. Quantum circuits that achieve this by implementing the above data compression technique – a generalization of the 3B-Comp used before – are described. These circuits enable purity increment in the computation qubit by maximally transferring part of its entropy to any number of surrounding qubits starting with arbitrary initial biases. Using the optswaps, a practicable new method to algorithmically cool an engineered quantum register – composed of an array of qubits partially adhering to a star symmetry – to its limit is delineated. Apart from quantum thermodynamic interests, this work represents a crucial development towards satisfying the DiVincenzo criterion for qubit initialization in a wide variety of quantum computing architectures.

Quantum violations of variants of LGIs upto algebraic maximum for qutrit system

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Motivated by the Bell's theorem [1], in 1985, Leggett and Garg [2] formulated an inequality which provides an elegant scheme for empirically testing the incompatibility between the classical world view of macrorealism and quantum mechanics (QM). The notion of macrorealism consists of two main assumptions [2] which are in principle valid in our everyday world are the following;

Macrorealism per se (MRps): If a macroscopic system has two or more macroscopically distinguishable ontic states available to it, then the system remains in one of those states at all instant of time.

Non-invasive measurability (NIM): The definite ontic state of the macrosystem is determined without affecting the state itself or its possible subsequent dynamics.

Let the measurement of ^M is performed on the macroscopic system at three diffrent times t1, t2 and t3(t3 > t2 > t1) which can be considered to be the measurement of the observables ^M1, ^M2 and ^M3 respectively. Based on these assumptions, the standard Leggett-Garg inequality (LGI) was derived is given by_LGs = hM1M2i + hM2M3i □ hM1M3i _ 1 (1) Such inequalities can be shown to be violated in certain circumstances, thereby implying that either or both the assumptions of MRps and NIM are not compatible with all the quantum statistics.

However, for the three-time LG scenario, the violation is restricted to 1:5 for dichotomic system if Luder projection rule employed for state reduction. But, Budruni and Emary [3] have recently shown that the Eq.(1) can be violated up to its algebraic maximum within the framework of QM.

In particular, by considering von Neumann reduction rule they showed that the maximum quantum violation of the above LGIs can exceed the L• uder bound 1:5 for dichotomic but qutrit system and reaches the algebraic maximum for asymptotically large system.
In this talk, we study interesting variants of LGIs for qubit and qutrit systems. We first formulate new set of LGIs based on the assumptions of MRps and NIM and show the quantum violation can reach up to their algebraic maximum. Such an amount of violation of LGIs was achieved [3] for asymptotically large system and using von Neumann projection rule. In contrast, we provide the quantum violation of our formulated LGIs up to algebraic maximum for qutrit system and by using L• uder rule.

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Revealing hidden genuine tripartite non locality

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ABSTRACT: Nonlocal correlations arising from measurements on tripartite entangled states can be classified into two groups, one genuinely three-way nonlocal and other local with respect to some bipartition. Still, whether a genuinely tripartite entangled quantum state can exhibit genuine three-way nonlocality remains a challenging problem as far as measurement context is concerned. Here we introduce an approach in this regard. We consider three tripartite quantum states, none of which is genuinely three-way nonlocal in a specific Bell scenario (three parties, two measurements per party, two outcomes per measurement), but they can exhibit genuine three-way nonlocality when the initial states are subjected to stochastic local operations and classical communication. So, genuine three-way nonlocality is a resource which can be revealed by using a sequence of measurements.

Hong-Ou-Mandel interference in turbulence using OAM entangled photon pair

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The effect of turbulence on the Hong-Ou-Mandel (HOM) using OAM entangled photon pair is studied experimentally, as well as theoretically. Experimentally, OAM entangled photonic states were generated by spontaneous parametric down-conversion. In our experiment, the entangled photons propagate through different turbulent media, which are simulated using spatial light modulators. In this work, two scenarios have been considered. The first scenario is when only one of the entangled photons is sent through the turbulence and the second scenario is when both the entangled photons are sent through turbulence. For the purpose of the calculations, we use a single phase screen approximation of the turbulent medium and a quadratic structure function to approximate the Kolmogorov theory of turbulence.

Without any turbulence, one finds that symmetric states (anti-symmetric states) produce a dip (peak) in the coincidence counts, after passing through the beam-splitter, thanks to the HOM effect. With the addition of turbulence in one of the photon paths, we found that there is no change in the visibility of the dips or peaks. While in cases where the turbulence affects both photons, the visibility of the dip or peak is reduced. This phenomenon can be explained by the way in which the turbulence in a single-sided or doubled-sided channel affects the symmetry of the input state. Experimental as well as theoretical results for all these various scenarios are presented.

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Wave-particle duality in n-path interference

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Wave-particle duality has been a field of intense research and debate for a long. Bohr's complementarity principle has now been stated quantitatively in terms of duality relations. We extend the concept of wave-particle to n-slit interference, and derive tight duality relations by assuming that coherence quantifies the wave-nature. We also show that coherence can be actually measured in an interference experiment.

Into the Quantum Void: Exploring the corners of the set of quantum correlations

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The set of quantum-correlation (Q) goes beyond the set of local-correlation (L), i.e., correlations constrained by assumptions underlying Bell's theorem. However, the set Q is strictly contained in the set of no-signaling correlation (NS). While the geometry of the sets L and NS is fully understood, little is known about the exact geometry of the set Q. Question like whether nonlocal part of quantum boundary has any flat region, or not, remained unanswered till very recent work by Goh *et al*. (2017). Surprisingly, answer to this question is yes even in the simplest Bell scenario. Along with foundational importance, information about geometry of Q has several applications in quantum cryptography, quantum randomness generation, dimension witness, and self-testing of quantum states. In this work in the simplest scenario of two parties each with two measurement choice and binary outcomes, we study the geometry of Q in the sections defined by fixing the value of at least one joint conditional probability to zero. We call these sections as corners of Q. We note that the Bell-CHSH points do not live in these corners whereas many other quantum nonlocal points like Hardy-point and its several possible variants live in these corners. We find quantum voids in corners having the property that there are no quantum nonlocal points in this section whereas there are post-quantum nonlocal and no-signaling points. We try to explain such a feature in the light of known physical principles and look for possible applications of quantum voids, for example, as a dimension witness. We also try to reveal the exact geometry of the quantum boundary in the corners and look for its applications in self testing.

Majorana invariants of spin-1 MUBs

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Two orthonormal bases sets said to be mutually unbiased if the modulus of inner product of basis state from the first set with any of the basis state from the other set gives $1/\sqrt{d}$. Representation of pure spin-j states geometrically as 2j-points on the Bloch sphere was given by Majorana. We study the Majorana representation of spin-1 MUBs and we examine the associated invariants. Also we investigate whether the Majorana representation provides any insight into the entanglement associated with the spin-1 MUBs.

Bayesian Games, Social Welfare Solutions and Quantum Entanglement

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Entanglement is of paramount importance in quantum information theory. Its supremacy over classical correlations has been demonstrated in a numerous information theoretic protocols. Here we study possible adequacy of quantum entanglement in Bayesian game theory, particularly in social welfare solution (SWS), a strategy which the players follow to maximize sum of their payoffs. Given a multi-partite quantum state as an advice, players can come up with several correlated strategies by performing local measurements on their parts of the quantum state. A quantum strategy is called quantum-SWS if it is advantageous over a classical equilibrium (CE) strategy in the sense that none of the players has to sacrifice their CE-payoff rather some have incentive and at the same time it maximizes sum of all players' payoffs over all possible quantum advantageous strategies. Quantum state yielding such a quantum-SWS is coined as quantum social welfare advice (SWA). Interestingly, we show that any two-qubit pure

entangled states, even if it is arbitrarily close to a product state, can serve as quantum-SWA in some Bayesian game. Our result, thus, gives cognizance to the fact that every two-qubit pure entanglement is the best resource for some operational task.

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Laziness of mixed symmetric states.

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An N-partite state is considered lazy, if the entropy rate of one subsystem with respect to time is zero under any coupling to the other subsystems. We show that all biaxial or purely second rank tensor polarized systems are lazy. Such a system can be produced in the laboratory by the interaction of a spin-1 nuclei with non-zero quadrupole moment like H^2, N^{14} with an external quadrupole field found in suitable crystal lattice. We then investigate the 'laziness'(property of the system to be lazy) of N-qubit mixed symmetric separable states and enumerate the conditions for them to be lazy. Further, we study the laziness of direct product states on application of a global and local noisy channel.

Quantum Complex network geometrics: the Application of Perspectives to Reality

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In the fields of science and engineering, there exist various kinds of complex systems which can be represented as complex networks naturally, such as biological networks in cell, our brains and online social networks. Scientists have discovered that when the understanding of complex networks such as the brain or the Internet is applied to geometry the results match up with quantum behaviour. The emergence of geometric structure from the quantum description of networks is a general mathematical problem that can be not only relevant for understanding the structure of space-time, but might also help to understand general complex network structures under the consequences of random failures of nodes in large networks of differing topology describing biological, social and technological systems.

Optimized swapping schedules for entanglement distribution

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Distributed quantum information processing tasks such as cryptography, networked clocks, high resolution interferometry require shared remote entanglement as a resource. This resource can be obtained by directly charging a pair of quantum memories with an entangled state distributed over smaller distances and then performing entanglement swapping between previously non-interacting memories. The effective remote entanglement generation rate using this approach depends on probability that pairs of memories are successfully charged per attempt, the swapping success probability, lifetime of the quantum memories and cycle-time which is required for the classical control to check if two pairs of quantum memories are successfully charged. We propose an optimized protocol for the classical controls that resets the quantum memories after a finite waiting-time window to mitigate the decoherence in imperfect quantum memories. We show that this protocol can yield both a many-fold increase of distillable entanglement rates and a higher yield using the hashing protocol. The optimal size of the time window depending on the operating point in parameter space is derived.

Steering a single system sequentially by multiple observers.

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Laws of quantum mechanics put a restriction on the number of observers who can simultaneously steer another observer’s system, known as monogamy of steering. In this work we find the limit of number of observers (Bobs) who steer a third party’s (Alice) system invoking a scenario where half of an entangled pair shared between single Alice in one wing and several Bobs on the other wing. When all the observers can measure two dichotomic observables, we find two Bobs can steer Alice’s system going beyond monogamy restriction. Interestingly, we also show three Bobs can steer Alice’s system considering linear three-settings steering inequality. Furthermore, our conjecture is that when steering is probed through linear ‘n’-settings steering inequality utmost ‘n’ number of Bobs can demonstrate steering of Alice’s system.

Quantum constraints stronger than uncertainty relations

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Every statistical operator---that represents a quantum state---must follow the three conditions Hermiticity, normalization, and positivity. These conditions give birth to quantum constraints on the expectation values with the aid of Born's rule, which connects the mean values for any set of operators to a quantum state. The quantum constraints specify a permissible region of the expectation values. For a set of observables, the allowed region is a compact and convex set in a real space, and all its extreme points come from pure quantum states. By defining an appropriate concave function on the permitted region and then finding its absolute minimum at the extreme points, one can establish a tight uncertainty relation. The permissible region resides in every other region bounded by an uncertainty relation. A point outside the admissible region---even if it satisfies a tight uncertainty relation---does not correspond to any quantum state. In that sense, the quantum constraints are optimal.

Dynamics of entanglement in various physical systems

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Possibility of generating two- and multi-mode entangled states in various physical systems, such as nonlinear optical couplers [1,2], hyper-Raman process [3], atom-molecule Bose-Einstein condensates [4], optomechanical and optomechanics-like systems [5], is studied. Specifically, it is established that two (or more) initially separable modes may get entangled under the effect of system/process Hamiltonian. A completely quantum mechanical model has been used to describe all the systems considering all the field modes involved to be weak. Heisenberg's equations of motion for all the modes are obtained and Sen-Mandal perturbative technique was used to obtain closed form analytic expressions of moments-based witnesses of entanglement [1-5]. Further, in case of spin qubits, decay in the entanglement due to dissipative interaction with its surrounding for different two- and three-qubit quantum states relevant in quantum information processing is illustrated with the help of well-known quasiprobability distributions [6].

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Thermodynamics of non-Markovian reservoirs and heat engines

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Thermodynamic features of non-Markovian evolution attracted wide interest in recent years [1–4]. In this work, we study thermodynamics of non-Markovian reservoirs using a model of quantum heat engine. We show that non-Markovian effects of the reservoirs can be used as a resource to extract work from an Otto cycle. We show an apparent violation of second law of thermodynamics unless the cost of non-Markovian effects are considered. From a thermodynamics perspective, we study the cost of non-Markovian effects. We illustrate our ideas with an explicit example of non-Markovian evolution.

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Measurement Induced Nonlocality in anisotropic Heisenberg Spin Models

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Recently, quantum correlation measures beyond entanglement got much attention due to separable state based information processing tasks. Luo and Fu proposed a correlation measure namely measurement induced nonlocality (MIN), which is dual to geometric measure of quantum discord (GMOD),to capture nonlocal effects of quantum state due to local projective measurements. Due to easy computation and experimental feasibility, much attention is paid on both GMOD and MIN. However, they can change arbitrarily and reversibly through actions of unmeasured party - local ancilla problem. To avoid this issue different versions of MIN have been proposed. In this present work, we investigate quantum correlation using measure induced nonlocality (MIN) in anisotropic Heisenberg spin systems using MIN, fidelity based MIN and trace distance MIN and compared with the entanglement. It is shown that Heisenberg interaction is chiefly responsible for the quantum correlation between the spins as measured by the above MINs. The effects of anisotropy in xy-plane and z- axis are also noted in XYZ model. The critical points (points where entanglement vanishes even in the presence of correlation) are computed.

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