ICQIF-2022

Book of Abstracts

February 14-24, 2022

INTERNATIONAL CONFERENCE ON QUANTUM INFORMATION AND FOUNDATIONS

Physics & Applied Mathematics Unit, Indian Statistical Institute, Kolkata

University of Calcutta

S. N. Bose National Centre for Basic Sciences

Bose Institute, Kolkata

This page intentionally left blank (for pagination purpose)

Contents

Invited Speakers

Antonio Acín

Group Leader, ICREA Professor,

The Institute of Photonic Sciences(ICFO), Spain

Title: Network quantum information processing

Abstract:

Small quantum networks consisting of several nodes sharing entangled states are within reach with current and near-term technologies. They offer new possibilities for quantum information processing beyond what achievable in standard point-to-point configurations. In this talk, quantum networks are considered in the device-independent scenario where devices are seen as quantum back boxes processing classical information. We first show how the characterization of correlations in quantum networks is related to the study of causal networks. We then present several results illustrating the possibilities these networks offer in the foundations of quantum physics or in quantum information theory. In particular, we discuss methods for self-testing quantum states or revealing the non-locality of single-photon entangled states exploiting network geometries.

References:

Bounding the sets of classical and quantum correlations in networks, Alejandro Pozas-Kerstjens, Rafael Rabelo, Łukasz Rudnicki, Rafael Chaves, Daniel Cavalcanti, Miguel Navascues, Antonio Acín; Phys. Rev. Lett. 123, 140503 (2019)

Quantum Inflation: A General Approach to Quantum Causal Compatibility, Elie Wolfe, Alejandro Pozas-Kerstjens, Matan Grinberg, Denis Rosset, Antonio Acín, Miguel Navascues; Phys. Rev. X 11, 021043 (2021)

Quantum networks reveal single-photon nonlocalit, Paolo Abiuso, Tamás Kriváchy, Emanuel-Cristian Boghiu, Marc-Olivier Renou, Alejandro Pozas-Kerstjens, Antonio Acín; arXiv:2108.01726

Quantum networks self-test all entangled states, Ivan Šupić, Joseph Bowles, Marc-Olivier Renou, Antonio Acín, Matty J. Hoban, arXiv:2201.05032

Satyabrata Adhikari

Delhi Technological University, India

Title: Graph theoretical approach to detect the $d_{1}\otimes d_{2}$ dimensional bipartite entangled system

Abstract:

In this talk, we will talk about the entanglement detection criterion developed using the concept of graph theory. We have constructed a unital map ϕ such that $\phi(\rho)=L_{\rho}+\rho$, where the quantum state is described by the density operator ρ and L_{ρ} denote the Laplacian corresponding to the density matrix ρ. The entries of L_{ρ} depends on the entries of the quantum state ρ and the entries are taken in such a way that L_{ρ} satisfies all the properties of the Laplacian. This make possible to design a simple connected weighted graph. We show that the constructed unital map ϕ characterize the quantum state with respect to its purity. Here, we also talk about the positive partial transpose (PPT) criterion in terms of eigenvalues of the constructed Laplacian and its partial transpose. We will show that if the minimum eigenvalue of the density matrix is greater than a quantity depends on the weight of the edges of the simple connected weighted graph then we can say that the $d_{1} \otimes d_{2}$ dimensional bipartite quantum states is entangled.

References:

1. S. L. Braunstein, S. Ghosh, T. Mansour, S. Severini, and R. C. Wilson, Phys. Rev. A 73, 012320 (2006).

2. S. L. Braunstein, S. Ghosh, and S. Severini, Annals of Combinatorics 10, 291 (2006).

3. Rohit Kumar, Satyabrata Adhikari, Detection of $d_{1}\otimes d_{2}$ dimensional bipartite entangled system: A Graph Theoretical Approach, Manuscript under preparation.

Pankaj Agrawal

Institute of Physics, India

Title:

Abstract:

Reference:

S. Aravinda

IIT Tirupati, India

Title: On the maximally entangled and entangling unitary operators and its role in constructing a quantum ergodic hierarchy

Abstract:

Entanglement of unitary operators quantified in terms of operator entanglement, and average entanglement created by the unitary operator acting on an ensemble of pure product states, quantified as entangling power, has paramount importance in quantum information theory as well as in many-body physics. The unitaries that maximize entangling power are useful in constructing absolutely maximally entangled (AME) states and perfect tensor states.

The operators having maximum operator entanglement plays an important role in the many-body circuits and facilitates the construction of a quantum ergodic hierarchy and it is called as “dual-unitary” in the many-body literature. We extend this to include the apex of a putative quantum ergodic hierarchy which is Bernoulli, in the sense that correlations of single and two-particle observables vanish at space-time separated points. We derive a condition based on the entangling power of the basic two-particle unitary building block of the circuit, that guarantees mixing, and when maximized, corresponds to Bernoulli circuits. Additionally we show, both analytically and numerically, how local-averaging over single-particle unitaries leads to an identification of the average mixing rate as being determined solely by the entangling power. We provide several, both analytical and numerical, ways to construct dual-unitary operators covering the entire possible range of entangling power. We construct a coupled quantum cat map which is dual-unitary for all local dimensions and a 2-unitary or perfect tensor for odd local dimensions, and can be used to build Bernoulli circuits.

References:

1. “ From dual-unitary to quantum Bernoulli circuits: Role of the entangling power in constructing a quantum ergodic hierarchy ”, S. Aravinda, Suhail Ahmad, Arul Lakshminarayan, Phys. Rev. Research.3, 043034 (2021).

2. "Creating ensembles of dual unitary and maximally entangling quantum evolutions", Suhail Ahmad Rather,S. Aravinda, Arul Lakshminarayan, Phys. Rev. Lett. 125,070501 (2020)

Subhashish Banerjee

IIT Jodhpur, India

Title:

Abstract:

Reference:

Manik Banik

IISER Thiruvananthapuram, India

Title: Classical superdense coding and communication advantage of a single quantum

Abstract:

We analyze the communication utility of a single quantum system when the sender and receiver share neither any entanglement nor any classical shared randomness. To this aim, we propose a class of two-party communication games that cannot be won with a noiseless 1-bit classical channel, whereas the goal can be perfectly achieved if the channel gets assisted with classical shared randomness. This resembles an advantage similar to the quantum superdense coding phenomenon where pre-shared entanglement can enhance communication utility of a perfect quantum communication line. Quite surprisingly, we show that a qubit communication without any assistance of classical shared randomness can achieve the goal, and hence establishes a novel quantum advantage in the simplest communication scenario. In pursuit of a deeper origin of this advantage we show that an advantageous quantum strategy must invoke quantum interference both at the encoding step by the sender and at the decoding step by the receiver. A subclass of these games has been shown to be perfectly winnable if the sender communicates some non-classical toy systems described with symmetric polygonal state spaces. We then proceed to design a stricter variant of the game that can be won neither with 1-bit communication nor with any polygon system, but 1-qubit communication yields a perfect strategy, establishing a strict quantum nature of the advantage. To this end, we show that the quantum advantages are robust against imperfect encodings-decodings, making the protocols implementable with presently available quantum technologies.

Manabendra Nath Bera

IISER Mohali, India

Title: Bounding Quantum Advantages in Postselected Metrology

Abstract:

Weak value amplification and other postselection-based metrological protocols can enhance precision while estimating small parameters, outperforming postselection-free protocols. In general, these enhancements are largely constrained because the protocols yielding higher precision are rarely obtained due to a lower probability of successful postselection. It is shown that this precision can further be improved with the help of quantum resources like entanglement and negativity in the quasiprobability distribution. However, these quantum advantages in attaining considerable success probability with large precision are bounded irrespective of any accessible quantum resources. Here we derive a bound of these advantages in postselected metrology, establishing a connection with weak value optimization where the latter can be understood in terms of geometric phase. We introduce a scheme that saturates the bound, yielding anomalously large precision. Usually, negative quasiprobabilities are considered essential in enabling postselection to increase precision beyond standard optimized values. In contrast, we prove that these advantages can indeed be achieved with positive quasiprobability distribution. We also provide an optimal metrological scheme using a three-level non-degenerate quantum system.

Reference:

Sourav Das, Subhrajit Modak, and Manabendra Nath Bera, *Bounding Quantum Advantages in Postselected Metrology*, arXiv:2108.09220.

Samyadeb Bhattacharya

IIIT Hyderabad, India

Title: Detecting Multipartite entanglement by harnessing non-Markovianity

Abstract:

We devise a novel protocol to detect genuinely multipartite entangled states by harnessing quantum non-Markovian operations. We utilize a particular type of non-Markovianity known as the eternal non-Markovianity to construct a non-complete positive map to filter out the bi-separable states and detect genuine multipartite entanglement. We further propose a dynamical procedure to detect genuinely multipartite entangled states in real-time based on this theory. Our study sheds light on a hitherto unexplored connection between entanglement theory and quantum non-Markovianity.

Reference:

Sougato Bose

UCL, UK

Title:

Abstract:

Reference:

Cyril Branciard

Institut Néel, France

Title: Quantum processes with indefinite causal order : demonstrating causal nonseparability with relaxed assumptions

Abstract:

Quantum theory allows certain processes to apply operations in some indefinite causal order -- the paradigmatic example being the so-called "quantum switch", where the order of two operations is coherently controlled by the state of a qubit. Such processes can be studied in the framework of process matrices, within which indefinite causal order is formalized as "causal nonseparability".

Causal nonseparability can be verified in a "device-dependent" manner using "causal witnesses" (in analogy with entanglement witnesses). The framework also predicts that certain causally nonseparable processes can generate "noncausal correlations", which can be observed in a "device-independent" manner through the violation of

"causal inequalities" (in analogy with Bell inequalities). However, it is known that the quantum switch cannot violate causal inequalities ; in this talk I will present some possible "semi-device-independent" approaches to demonstrate causal nonseparability -- and more specifically, one with quantum inputs (in analogy with "Buscemi nonlocality").

Reference:

H. Dourdent, A. A. Abbott, N. Brunner, I. Šupić, C. Branciard, arXiv:2107.10877.

Adán Cabello

U de Sevilla, Spain

Title: What is new in quantum contextuality?

Abstract:

Quantum contextuality is a feature of the phenomenology of quantum mechanics whereby measurements of quantum observables cannot simply be thought of as revealing pre-existing values. Here, we will report some recent results in this field, including (but not only), a general method which converts any form of quantum contextuality into a quantum violation of a bipartite Bell inequality [*] and the first observation of quantum contextuality simultaneously free of the detection, sharpness, and compatibility loopholes [**].

References:

[*] A. Cabello, "Converting contextuality into nonlocality", Phys. Rev. Lett. 127, 070401 (2021).

[**] P. Wang, J. Zhang, C.-Y. Luan, M. Um, Y. Wang, M. Qiao, T. Xie, J.-N. Zhang, A. Cabello, and K. Kim, "Significant-loophole-free test of Kochen-Speckercontextuality using two species of atomic-ions", arXiv:2112.13612.

Indranil Chakrabarty

Associate Professor, International Institute of Information Technology, Hyderbad, India

Title: Conditional Entropy: A resource

Abstract:

Quantum states that possess negative conditional von Neumann entropy provide quantum advantage in several information-theoretic protocols including superdense coding, state merging, distributed private randomness distillation and one-way entanglement distillation. While entanglement is an important resource, only a subset of entangled states have negative conditional von Neumann entropy. Despite this utility, a proper resource theory for conditional von Neumann entropy has not been developed, unlike that of entanglement. In this lecture I will tell about how we pave the way for such a resource theory by characterizing the class of free states (density matrices having non-negative conditional von Neumann entropy) as convex and compact. This allows us to prove the existence of a Hermitian operator (a witness) for the detection of states having negative conditional entropy for bipartite systems in arbitrary dimensions. I will also tell about our work where we examine the effect of global unitary operations on the conditional entropy of the system. We start with the set containing states with non-negative conditional entropy and find that some states preserve the non-negativity under unitary operations on the composite system. We call this class of states as Absolute Conditional von Neumann entropy Non Negative class ACVENN. We are able to characterize such states for $2\otimes2$ dimensional systems. On a different perspective the characterization accentuates the detection of states whose conditional entropy becomes negative after the global unitary action. Interestingly, we are able to show that this ACVENN class of states forms a set which is convex and compact. This feature enables for the existence of hermitian witness operators the measurement of which could distinguish unknown states which will have negative conditional entropy after the global unitary operation. This has immediate application in super dense coding and state merging as negativity of conditional entropy plays a key role in both these information processing tasks. In the presentation some illustrations are also provided to probe the connection of such states with Absolute separable (AS) states and Absolute local (AL) states

Giulio Chiribella

U of Hong Kong, Hong Kong

Title: Quantum and Classical Data Transmission Assisted by Indefinite Causal Order

Abstract:

Completely depolarising channels are often regarded as the prototype of physical processes that are useless for communication: any message that passes through them along a well-defined trajectory is completely erased. However, when two such channels are used in a quantum superposition of two alternative orders, it has been shown [1] that they become able to transmit some amount of classical information. Still, no quantum information can pass through them. Here [2] we show that the ability to place N completely depolarising channels in a superposition of N alternative causal orders enables a high-fidelity, heralded transmission of quantum information with error vanishing as 1/N. This phenomenon highlights a fundamental difference with the N = 2 case, where completely depolarising channels are unable to transmit quantum data, even when placed in a superposition of causal orders. The ability to place quantum channels in a superposition of orders also leads to an increase of the classical communication capacity with N, which we rigorously prove by deriving an exact single-letter expression. Our results highlight the more complex patterns of correlations arising from multiple causal orders, which are similar to the more complex patterns of entanglement arising in multipartite quantum systems.

References:

[1] D. Ebler, S. Salek, and G. Chiribella, Enhanced communication with the assistance of indefinite causal order, Phys. Rev. Lett. 120, 120502 (2018).

[2] G. Chiribella, M Wilson, and H. F. Chau, Quantum and Classical Data Transmission Through Completely Depolarizing Channels in a Superposition of Cyclic Orders, Phys, Rev. Lett. 127, 190502 (2021).

Nilanjana Datta

U of Cambridge, UK

Title: Determining whether a quantum channel has positive quantum capacity

Abstract:

The task of determining whether a given quantum channel has a positive capacity to transmit quantum information is a fundamental open problem in quantum information theory. Using elementary techniques from analytic perturbation theory of Hermitian matrices, we devise a simple strategy to detect positive quantum capacities of quantum channels and their complements. We exhibit the utility of our method by analysing some noteworthy examples of quantum channels, such as the depolarizing- and transpose-depolarizing channels (including the Werner-Holevo channel), and Hadamard channels.

Reference:

https://arxiv.org/abs/2105.06327; This is joint work with Satvik Singh.

A. R. Usha Devi

Bangalore University, India

Title: Heat exchange and fluctuation in Gaussian thermal states -- Wigner function approach

Abstract:

The celebrated exchange fluctuation theorem—proposed by Jarzynski and Wójcik (Phys. Rev. Lett. 92 (2004) 230602) for heat exchange between two systems in thermal equilibrium at different temperatures—is explored here for quantum Gaussian states in thermal equilibrium. We employ the Wigner distribution function formalism for quantum states, which exhibits a close resemblance to the classical phase-space trajectory description, to arrive at a formal Jarzynski– Wójcik result. For two Gaussian states in thermal equilibrium at two different temperatures kept in contact with each other for a fixed duration of time, we show that the Jarzynski–Wójcik relation reduces to the corresponding classical result in the high temperature limit.

Reference:

Author(s): A R Usha Devi, Sudha, A K Rajagopa and A M Jayannavar

Runyao Duan

Baidu Research, China

Title:

Abstract:

Reference:

Christopher A. Fuchs

U of Massachusetts Boston, USA

Title: Quantum mechanics? It's all fun and games until someone loses an i

Abstract: QBism is a foundational program for quantum mechanics premised on the idea that quantum probabilities must be understood as Bayesian probabilities—that is, quantified degrees of belief or gambling attitudes. Philosophers hate it. "Wah, wah, wah, your quantum states are not objective features of the world; they have to be [*because my philosophy says so*]." What the philosophers have never appreciated (or perhaps cared about) is that this turn in thinking has motivated a significant number of theorems and constructions in quantum information science that might not have been discovered otherwise (from the quantum no-broadcasting theorem, to the quantum de Finetti theorem, to the first criterion for certifiable continuous-variable quantum teleportation and plenty more than that). In this talk, I will outline QBism's most ambitious technical project yet: Rewriting the quantum formalism so that it wears its Bayesian nature on its sleeve. As a vehicle for introducing concepts (and just for fun), I'll turn the formalism toward demonstrating how ugly quantum theory would be through a QBist lens if it were based on real, rather than complex, numbers. How wrong was Schrödinger when he wrote to Lorentz, "What is unpleasant here … is the use of complex numbers. ψ is surely a fundamentally real function." As our mothers warned us, losing an i is nothing to joke about!

Reference:

Nirman Ganguly

BITS-Pilani Hyderabad, India

Title: A-unital operations and their relation to quantum conditional entropy

Abstract:

Negative quantum conditional entropy states are key ingredients for informationtheoretic tasks such as superdense coding and state merging. Pertaining to it, we introduce the class of A-unital channels, which we showare the largest class of conditional entropy non-decreasing channels. We prove that A-unital channels are precisely the completely free operations for theclass of states with non-negative conditional entropy. Relationship of A-unital channels with other channels are probed. We then examine similar resultsfor ACVENN: a previously defined, relevant class of states.

Reference:

Quantum 6, 641 (2022)[arXiv:2110.12527v3], with Mahathi Vempati , Saumya Shah , Indranil Chakrabarty

Saikat Ghosh

IIT Kanpur, India

Title:

Abstract:

Reference:

Sibasish Ghosh

IMSc. Chennai, India

Title: Quantum homogenization in non-Markovian collisional model

Abstract:

Collisional models are a category of microscopic framework designed to study open quantum systems. The framework involves a system sequentially interacting with a bath comprised of identically prepared units. In this regard, quantum homogenization is a process where the system state approaches the identically prepared state of bath unit in the asymptotic limit. Here, we study the homogenization process for a class of non-Markovian collisional models generated via additional bath-bath interaction. With partial swap operation as both system-bath and bath-bath unitaries, we show that homogenization is

achieved irrespective of the initial states of the system or bath units. This is reminiscent of the Markovian scenario, where partial swap is the unique operation for a universal quantum homogenizer. On the other hand, we observe that -- in this case -- the rate of homogenization is slower than its Markovian counter part. Interestingly, a different choice of bath-bath unitary speeds up the homogenization process but loses the universality, being dependent on the initial states of the bath units.

Reference:

arXiv:2201.08412 (quant-ph); Joint work with: Tanmay Saha and Arpan Das

Debabrata Goswami

IIT Kanpur, India

Title: Subtle interplay of thermal and nonlinear processes for spatiotemporal control: Towards an 'open' quantum environment

Abstract:

Quite a few of the present-day quantum computing efforts have been directed towards the use of cold atoms as it provides a controllable and addressable qubit environment for demonstrating quantum computing developments. While such model experiments and environments are helpful, it is important to have more practicable scenarios for realistically scalable implementations. Here a laser-directed experimental environment is presented under standard room temperature and pressure conditions for an 'open' laboratory condition that could provide many advantages as the 'cold atom' experimental conditions. Achieving such a spatially and temporally controlled environment is a result of a subtle interplay of thermal and nonlinear processes arising from femtosecond laser interactions in a liquid.

References:

D. Goswami, "On the spatiotemporal control with a single beam femtosecond optical tweezer", SPIE Proc. 11798, 11798Y-5 (2021).

D. Goswami, "Understanding femtosecond optical tweezers: the critical role of nonlinear interactions", Journal of Physics: Conference Series, 1919(1), 12013 (2021).

Gilad Gour

Professor, Department of Mathematics & Statistics

Institute for Quantum Science and Technology

University of Calgary, Canada

Title: From Static to Dynamic Divergences

Abstract:

In this talk I will introduce an axiomatic approach for channel divergences and channel relative entropies that is based on three information-theoretic axioms of monotonicity under superchannels (i.e. generalized data processing inequality), additivity under tensor products, and normalization. I will show that these axioms are sufficient to give enough structure, leading to numerous properties that are applicable to all channel divergences. These include faithfulness, continuity, a type of triangle inequality, and boundedness between the min and max channel relative entropies. In addition, I will present a uniqueness theorem showing that the Kullback-Leibler divergence has only one extension to classical channels. For quantum channels, with the exception of the max relative entropy, this uniqueness does not hold. Instead, I will prove the optimality of the amortized channel extension of the Umegaki relative entropy, by showing that it provides a lower bound on all channel relative entropies that reduce to the Kullback- Leibler divergence on classical states. If time permits, I will also introduce the maximal channel extension of a given classical state divergence and discuss its properties.

References:

1. Gilad Gour, “Uniqueness and Optimality of Dynamical Extensions of Divergences”, PRX Quantum 2, 010313 (2021).

2. Gilad Gour and Marco Tomamichel, “Entropy and relative entropy from information-theoretic principles” IEEE Transactions on Information Theory (2021).

Otfried Gühne

U of Siegen, Germany

Title: Characterizing Quantum Correlations with Randomized Measurements

Abstract:
If only limited control over a multiparticle quantum system is available, a viable method to characterize correlations is to perform random measurements and consider the moments of the resulting probability distribution. We present systematic methods to analyze the different forms of entanglement with these moments in an optimized manner. First, we find the optimal criteria for different forms of multiparticle entanglement in three-qubit systems using the second moments of randomized measurements. Second, for higher-dimensional two-particle systems and higher moments, we provide criteria that are able to characterize various examples of bound entangled states, showing that detection of such states is possible in this framework. Finally, we analyze the resources needed for a statistically significant test.

Reference:
S. Imai, N Wyderka, A. Ketterer, O. Gühne, Phys. Rev. Lett. 126, 150501 (2021)
A. Ketterer, S. Imai, N. Wyderka, O. Gühne, arXiv:2012.12176

Lucien Hardy

Perimeter Institute, Canada

Title:

Abstract:

Reference:

Masahito Hayashi

Southern U of Science and Technology, China

Title: Estimation of quantum state and quantum channel

Abstract:

Reference:

Michał Horodecki

Professor, International Centre for Theory of Quantum Technologies

U of Gdańsk, Poland

Title: Reconciliation of thermalization property and complete positivity of evolution of open systems

Abstract:

Almost every quantum system interacts with large environment, so that exact quantum mechanical description of its evolution is impossible. One had to resort to approximate description, resulting in a master equation. There are two basic requirements for such description: first of all, it should preserve positivity of probabilities, second, it should reproduce the wisdom coming from thermodynamics, that systems coupled to a single thermal bath thermalize to a proper state, which is partial state of the joint Gibbs state of the system plus bath.

Existing two wide spread descriptions of the evolution fail to satisfy at least one of those conditions.

The so called Davies master equation, while preserving positivity of probabilities (due to Gorrini-KOssakowski-Sudarshan-Lindblad form), fails to describe properly themralization. On the other hand, the Bloch-Redfield master equation violates positivity of probabilities. On a positive side, the latter equation for severla important scenarios properly desribes equilibration. Yet, general proof is still lacking.

Thus a basic question appears - can we have a description of open system dynamics that would share both features?

In this paper we resolve this question. In the first step, we provide a general proof, that the Bloch-Redfield evolution properly thermalize, up to second order in coupling

strength. Next, we consider a so called cumulant equation (called also refined weak couling limit) which is explicitly completely positive, and show that up to second order, its steady state is the same as one of Redfield dynamics. In this way, we reconciliate two basic requirements for dynamical description of quantum open systems.

Reference:

Based on joint work with Marcin Łobejko, Marek Winczewski, Gerardo Suarez and Robert Alicki

Marcus Huber

Group Leader, Huber Group

Institute for Quantum Optics and Quantum Information(IQOQI) - Vienna

Austrian Academy of Sciences, Austria

Title:

Abstract:

Reference:

Janek Kolodynski

U of Warsaw, Poland

Title: Quantum metrology with imperfect measurements

Abstract:

The impact of measurement imperfections on quantum metrology protocols has not been approached in a systematic manner so far. In this work, we tackle this issue by generalising firstly the notion of quantum Fisher information to account for noisy

detection, and propose tractable methods allowing for its approximate evaluation. We then show that in canonical scenarios involving N probes with local measurements undergoing readout noise, the optimal sensitivity depends crucially on the control operations allowed to counterbalance the measurement imperfections—with global control operations, the ideal sensitivity (e.g. the Heisenberg scaling) can always be recovered in the asymptotic N limit, while with local control operations the quantum-enhancement of sensitivity is constrained to a constant factor. We illustrate our findings with an example of NV-centre magnetometry, as well as schemes involving spin-1/2 probes with bit-flip errors affecting their two-outcome
measurements, for which we find the input states and control unitary operations sufficient to attain the ultimate asymptotic precision.

Reference: https://arxiv.org/abs/2109.01160

Barbara Kraus

Principal Investigator & Head of the Institute for Theoretical Physics,

U of Innsbruck, Austria

Title: Protocols for testing and verifying quantum devices- theory and experiment

Abstract:

I will discuss several protocols designed for the verification and the characterization of quantum devices. I will focus one a recently developed protocol to verify the output of a quantum computer using only classical means. I will present a minimal example for realizing such a verification protocol and present its experimental implementation.

Reference:

"Towards experimental classical verification of quantum computation"
R. Stricker, J. Carrasco, M. Ringbauer, L. Postler, M. Meth, C. Edmunds, Ph. Schindler, R. Blatt, P. Zoller, B. Kraus, and Th. Monz, in preparation.

"Theoretical and Experimental Perspectives of Quantum Verification"
J. Carrasco, A. Elben, C. Kokail, B. Kraus, and P. Zoller,
PRX Quantum 2, 010102 (2021)

Arul Lakshminarayan

IIT Madras, India

Title:

Abstract:

Reference:

Maciej Lewenstein

Quantum Optics Theory Group ICFO, ICFO and ICREA, Spain

Title: The Coming Decades of Quantum Simulation

Abstract:

In my lecture "The Coming Decades of Quantum Simulation" I will review the current status of the area. I will start discussing various challenges, things to be computed and simulated, and various experimental platforms. Relation to machine learning will also be reported. I will then focus on quantum simulations with ultracold atoms and ions, and discuss various verification, validation and certification of quantum simulators.

References:

[1] M. Lewenstein, A. Sanpera, and V. Ahufinger, Ultracold Atoms in Optical Lattices: Simulating Quantum Many-Body Systems", (Oxford University Press, Oxford, 2017).

Stefano Mancini

School of Science & Technology,

University of Camerino, Italy;

and

INFN Sezione di Perugia, I-06123 Perugia, Italy

Title: Quantum capacities of bosonic dephasing channel

Abstract:

We study the unassisted and classically-assisted quantum capacities of continuous-variable dephasing channel, which is a notable example of a non-Gaussian quantum channel [1].

Regarding the unassisted quantum capacity, we prove that a single letter formula applies. The optimal input state is found to be diagonal in the Fock basis and with a distribution that is a discrete version of a Gaussian. Relations between its mean/variance and dephasing rate/input energy are put forward. We then show that by increasing the input energy, the capacity saturates to a finite value. We also show that it decays exponentially for large values of dephasing rates [2].

For the classically-assisted quantum capacity, we focus on the upper bound provided by the energy-constrained squashed entanglement of the channel. We prove that the optimal input state is also in this case diagonal in the Fock basis. Furthermore, we prove that the optimal squashing channel in the set of weakly-degradable and anti-degradable channels is a weakly-self-complementary channel. Restricting the search for optimal squashing channel to the set of weakly-self-complementary one-mode Gaussian quantum channels, we derive explicit upper and lower bounds for the energy-constrained LOCC-assisted quantum capacity of the bosonic dephasing channel in terms of its (unassisted) quantum capacity with different noise parameters. Thanks to the tightness of these bounds we provide a very good estimation of the classically-assisted quantum capacity of bosonic dephasing channel [3].

Reference:

[1] L. Memarzadeh, S. Mancini. Minimum output entropy of a non-Gaussian quantum channel. Physical Review A 94, 022341 (2016).

[2] A. Arqand, L. Memarzadeh, S. Mancini. Quantum capacity of bosonic dephasing channel. Physical Review A 102, 042413 (2020).

[3] A. Arqand, L. Memarzadeh, S. Mancini. Energy-constrained LOCC-assisted quantum capacity of bosonic dephasing channel. arXiv:2111.04173

Prabha Mandayam

IIT Madras, India

Title: On Optimal Cloning and Incompatibility

Abstract:

We investigate the role of symmetric quantum cloning machines (QCMs) in quantifying the mutual incompatibility of quantum observables. Specifically, we identify a cloning-based incompatibility measure whereby the incompatibility of a set of observables maybe quantified in terms of how well a uniform ensemble of their eigenstates can be cloned via a symmetric QCM. We show that this new incompatibility measure is faithful since it vanishes only for commuting observables. We prove an upper bound for any set of observables in a finite-dimensional system and show that the upper bound is attained if and only if the observables are mutually unbiased. Finally, we use our formalism to obtain the optimal quantum cloner for a pair of qubit observables. Our work marks an important step in formalising the connection between two fundamental concepts in quantum information theory, namely, the no-cloning principle and the existence of incompatible observables in quantum theory.

Reference:

Arindam Mitra and Prabha Mandayam, J. Phys. A: Math. Theor. 54, 405303 (2021).

Miguel Navascues

IQOQI, Austria

Title: The world is not real

Abstract:

Although most theories of physics are based on real numbers, quantum theory was the first to be formulated in terms of operators acting on complex Hilbert spaces. This has puzzled countless physicists, including the fathers of the theory, for whom a real version of quantum theory, with real operators and states, seemed much more natural. In fact, previous works showed that such

a "real quantum theory" can reproduce the outcomes of any multipartite experiment, as long as the parts share arbitrary real quantum states. In this talk I will show that real and complex quantum theory make different predictions in network scenarios comprising independent states and measurements. This allows us to devise a Bell-like experiment whose successful realization would disprove real quantum theory, just as standard Bell experiments disproved classical physics.

Alok Kumar Pan

NIT Patna, India

Title:

Abstract:

Reference:

Prasanta K. Panigrahi

IISER Kolkata, India

Title: Multi-party entanglement: A geometric perspective

Abstract:

A geometric perspective on entanglement is provided, based on wedge product and Lagrange-Brahmagupta identity that quantifies it, for both discrete and continuous variables

Apoorva D. Patel

IISc. Bangalore, India

Title: Software simulator for noisy quantum circuits

Abstract:

We have developed a software library that simulates noisy quantum logic circuits. We represent quantum states by their density matrices, and incorporate possible errors in initialisation, logic gates, memory and measurement using simple models. Our quantum simulator is implemented as a new backend on IBM's open-source Qiskit platform. In this talk, we describe its ingredients and its implementation. Such simulators are needed for efficient design and benchmarking of any quantum device.

Reference:

H. Chaudhary, B. Mahato, L. Priyadarshi, N. Roshan, Utkarshand A. Patel, A Software Simulator for Noisy Quantum Circuits, [arXiv:1908.05154] to appear in Int. J. Mod. Phys. C.

Tomasz Paterek

U of Gdańsk, Poland

Title: Entangling life to external world

Abstract:

Two biophysics experiments will be reviewed where teams take active steps to demonstrate that the subject animals were not dead during the process and at the same time arguments are put forward for entanglement between parts of the animal and external degrees of freedom.

Reference:

D. Coles et al, Small 13, 1701777 (2017).

T. Krisnanda et al, npj QI 4, 60 (2018).

K. S. Lee et al, arXiv:2112.07978

Anirban Pathak

JIIT Noida, India

Title: A random journey into the world of randomness

Abstract:

Origin, applicability and other facets of randomness (or random numbers) will be explored from the perspective of the hierarchical axioms for quantum mechanics [1]. Here hierarchy of axioms implies that succeeding axioms can be regarded as a superstructure constructed on top of a structure built by the preceding axioms. The axioms to be considered in our theory are [1] : (Q1) incompatibility and uncertainty; (Q2) contextuality; (Q3) entanglement; (Q4) nonlocality and (Q5) indistinguishability of identical particles. Relevant toy generalized probability theories (GPTs) will be constructed and it will be shown that the origin of random numbers in different type of quantum random number generators (QRNGs) known today are associated with different layers of nonclassical theories and all of them do not require all the features of quantum mechanics. To elaborate this existing QRNGs will be reviewed critically with specific attention to randomness expansion capabilities of semi-device-independent (SDI) prepare and measure protocols [2]. Further, in view of several protocols for secure quantum communication and computation designed by us [3], we will show that intrinsic randomness of a theory is inherently used in performing various tasks related to secure quantum computation and communication, and security of different protocols originate at different layers of nonclassical theories [1].

References:

[1] Aravinda S, Pathak A, Srikanth R. Hierarchical axioms for quantum mechanics. The European Physical Journal D. 2019 Sep;73(9):1-7.

[2] Mannalath V, Pathak A, Bounds on semi-device-independent quantum random number expansion capabilities. Phys. Rev. A (2022) In Press

[3] Shenoy-Hejamadi A, Pathak A, Radhakrishna S. Quantum cryptography: key distribution and beyond. Quanta. 2017 Jun 18;6(1):1-47.

Arun Kumar Pati

HRI, India

Title:

Abstract:

Reference:

Martin B. Plenio

Ulm University, Germany

Title:

Abstract:

Reference:

Tabish Qureshi

Jamia Millia Islamia, India

Title: Coherence, Interference and Complementarity

Abstract:

Multipath interference with a path-detector is theoretically analyzed to find the connection between predictability and distinguishability. It is shown that entanglement is what quantitatively connects distinguishability with predictability. Thus, a duality relation between distinguishability and coherence can also be viewed as a triality between predictability, entanglement, and coherence. There exist two different kinds of duality relations in the literature, which pertain to two different kinds of interference experiments, with or without a path-detector. Results of this study show that the two duality relations are quantitatively connected via entanglement. The triality relations obtained here may also be used to measure bipartite entanglement in some experiments.

Reference:

T. Qureshi, *Opt. Lett.* 46, 492 (2021)

Ashutosh Rai

KAIST, Korea

Title: Self-testing Quantum States via Non-maximal Bell Violation

Abstract:

Self-testing protocols enable certification of quantum devices without demanding full knowledge about their inner workings. A typical approach in designing such protocols is based on observing nonlocal correlations which exhibit maximum violation in a Bell test. We show that in Bell experiment known as Hardy's test of nonlocality not only the maximally nonlocal correlation self-tests a quantum state, rather a non-maximal nonlocal behavior can serve the same purpose. We, in fact, completely characterize all such behaviors leading to self-test of every pure two qubit entangled state except the maximally entangled ones. Apart from originating a novel self-testing protocol, our method provides a powerful tool towards characterizing the complex boundary of the set of quantum correlations.

Reference: Ashutosh Rai, Matej Pivoluska, Souradeep Sasmal, Manik Banik, Sibasish Ghosh, and Martin Plesch; arXiv:2112.06595 [quant-ph]

Shasanka Mohan Roy

TIFR Mumbai, India

Title: Rigorous quantum limits on monitoring higher order photon quadratures

Abstract:

Anna Sanpera

UAB, Spain

Tittle: The volume of parent Hamiltonians

Abstract:

We compute volumes of parent Hamiltonians to give general benchmarks on how hard it is to simulate, within a given precision, a particular non trivial many-body

ground state. The strength of our measure-theoretical approach resides in that it is independent of the specific form of the Hamiltonian, and relies only on dimensionality and symmetries.

That allows to provide a universal minimal bound that is fully platform-independent, purely in terms of the number of particles and their local dimension. We show that the relative volume of all Hamiltonians with a fixed ground state actually increases with the number of particles. Contrary to what one might expect, having more parameters to control actually helps in front of unavoidable experimental errors. Deriving a similar result under a locality assumption would be highly desirable, since the overwhelming majority of the dynamics that we observe in nature are governed by local Hamiltonians. The problem is notably (and expectedly) difficult, since computing the volume of local Hamiltonians compatible with a given ground state is closely tied to the problem of computing the ground state of a given local Hamiltonian, known to be NP-hard. Yet, we approach this question by considering the relevant subclass of traslationally invariant Hamiltonians, for which we provide a nontrivial upper bound for their relative volume and a numerical procedure to estimate it in physically relevant models. Our analysis thus brings a novel and promising perspective to the so-called “local Hamiltonian problem”, key not only for the field of quantum simulation but also for the foundations of physics.

References:

1. Maria Garcia Diaz, Gael Sentis, Ramon Muñoz-Tapia, and Anna Sanpera, On the volume of parent Hamiltonians arXiv:2111.13734 (us)

2. I. Bengtsson and K. Zyczkowski, Geometry of Quantum States: An Introduction to Quantum Entanglement, (Cambridge University Press, 2006)

Flavio Del Santo

Faculty of Physics, University of Vienna and IQOQI-Vienna

Title: Fundamental indeterminism in classical mechanics and special relativity

Abstract:

Reference:

Nicolas Gisin and Flavio Del Santo

Valerio Scarani

CQT, Singapore

Title: Irreversibility as "irretrodictability"

Abstract:
Both classical and quantum theory hold that every change is reversible at the fundamental level, although we perceive almost everything as irreversible processes. Yet, physicists are not urging to label that perception as illusory: for most, the Second Law of thermodynamics is untouchable, so aberrant the idea of inexhaustible energy is. Building on a narrative pioneered by Watanabe in the 1960s, I shall present an approach to the Second Law as a form of statistical inference given partial information. Irreversibility is unavoidable because it translates the asymmetry between prediction and retrodiction on a given process. This viewpoint applies to both classical and quantum systems. Applied to the "fluctuation relations" that have been the preferential tools to address irreversibility in the last two decades, it both simplifies their derivation and vastly expands their scope.

References:

F. Buscemi, V. Scarani, Phys. Rev. E 103, 052111 (2021)

C. Aw, F. Buscemi, V. Scarani, AVS Quantum Sci. 3, 045601 (2021)
https://avs.scitation.org/doi/10.1116/5.0060893

Aditi Sen De

HRI, India

Title: Quantum Thermal Machines

Abstract:

Microscopic thermodynamic devices are shown to provide a remarkable precision in thermometry, thereby contributing to the field of quantum thermodynamics. To explore and model the quantum thermal machines such as quantum refrigerators,

quantum batteries, modified definitions of work, heat, and entropy are introduced that can take into account the effects of quantumness in the system. I will report some of our recent works on designing quantum batteries and quantum refrigerators which are robust against impurities and noise.

Reference:

1. S. Ghosh, T. Chanda, and A. Sen(De), Phys. Rev. A 101, 032115 (2020).
2. S. Ghosh, T. Chanda, S. Mal and A. Sen(De), Phys. Rev. A 104, 032207 (2021).
3. T. Konar, S. Ghosh, A. K. Pal and A. Sen(De), arXiv: 2107.11668.
4. T. Konar, Leela Ganesh Chandra Lakkaraju, S. Ghosh, and A. Sen(De), arXiv:2109.06816

Ritabrata Sengupta

IISER Berhampur, India

Title: A Szegő type theorem, distribution of symplectic eigenvalues, and its applications in for chains of Gaussian states

Abstract:

We study the properties of stationary G-chains in terms of their generating functions. In particular, we prove an analogue of the Szegő limit theorem for symplectic eigenvalues, derive an expression for the entropy rate of stationary quantum Gaussian processes, and study the distribution of symplectic eigenvalues of truncated block Toeplitz matrices. We also introduce a concept of symplectic numerical range, analogous to that of numerical range, and study some of its basic properties, mainly in the context of block Toeplitz operators.

Anil Shaji

IISER Thiruvananthapuram, India

Title: Can a mixed state quantum computer use the computational resources of its environment also?

Abstract:

The relation between genuine multipartite entanglement in the pure state of a collection of N qubits and the nonclassical correlations in its two-qubit subsystems is studied. Quantum discord is used as the quantifier of nonclassical correlations in the subsystem while the generalized geometric measure (GGM) is used to quantify global entanglement in the N-qubit state. While no definite discernible dependence between the two can be found for randomly generated global states, for those with additional structure like weighted graph states we find that local discord is indicative of global multipartite entanglement. Global states that admit efficient classical descriptions like stabilizer states furnish an exception in which despite multipartite entanglement, nonclassical correlation is absent in two qubit subsystems. We discuss these results in the context of mixed state quantum computation where nonclassical correlation is considered a candidate resource that enables exponential speedup over classical computers.

Reference:

The talk is based on the recent arXiv post: arXiv: 2112.15373

Ravindra Pratap Singh

Physical Research Laboratory, India

Title: Free-space quantum communication: Effect of atmospheric aerosols

Abstract:

Free-space quantum communication assumes importance as it is a precursor for satellite-based quantum communication needed for secure key distribution over longer distances. Prepare and measure quantum key distribution (QKD) protocols like BB84 consider the satellite as a trusted device, which is fraught with security threat looking at the current trend for satellite-based optical communication. Therefore, entanglement-based protocols must be preferred, so that one can consider the satellite as an untrusted device too. The current work reports the effect of atmospheric aerosols on the key rate obtained with BBM92 QKD protocol, an entanglement-based QKD protocol over 200 m distance, using an indigenous facility developed at Physical Research Laboratory (PRL), Ahmedabad, India. Our results show that concentration and extinction coefficient of atmospheric aerosols play a

major role in the observed sift key rate, and eventually, the secure key rate. Such experiments are important to validate the models to account for the atmospheric effects on the key rates achieved through satellite-based QKD.

Reference:

arXiv:2112.11961 - BBM92 quantum key distribution over a free-space dusty channel of 200 meters

Urbasi Sinha

RRI, Bangalore, India

Title:

Abstract:

Reference:

Robert W. Spekkens

Perimeter Institute, Canada

Title:

Abstract:

Reference:

R. Srikanth

Poornaprajna Institute of Scientific Research, India

Title: Non-invertibility of maps and the quantum dynamical semigroup

Abstract:

We characterize the channels obtained as mixtures of maps within the class of Pauli channels, in qubit and higher dimensions. A first result is that for the resultant channel to be a semigroup, non-invertibility is necessary for most of the input channels. Next, we study the case of mixing of (d+1) Pauli channels that have the same decoherence function given by a 2-parameter family, with the parameters ranging continuously through the invertible and non-invertible regions.We show that when all input channels are invertible, then so is the resultant. In the non-invertible input range, we derive the fraction of invertible channels as a function of the family parameters.

References:

[1] Measure of invertible channels under mixing of non-invertible channels: Vinayak Jagadish, RS, Francesco Petruccione , arXiv:2201.03258

[2] Non-invertibility as a requirement for creating semigroup under convex combinations of channels Vinayak Jagadish, RS, Francesco Petruccione , arXiv:2111.09264

[3] Convex combinations of CP-divisible Pauli channels that are not semigroups , Jagadish, RS, Francesco Petruccione, Physics Letters A 384(35) 126907 (2020)

[4] Convex Combinations of Pauli Semigroups: Geometry, Measure and an Application, Vinayak Jagadish, RS, Francesco Petruccione , Phys. Rev. A 101, 062304 (2020)

Alexander Streltsov

Group Leader

Centre of New Technologies, University of Warsaw, Poland

Title: Catalytic Transformations of Pure Entangled States

Abstract:

Quantum entanglement of pure states is usually quantified via the entanglement entropy, the von Neumann entropy of the reduced state. Entanglement entropy is

closely related to entanglement distillation, a process for converting quantum states into singlets, which can then be used for various quantum technological tasks. The relation between entanglement entropy and entanglement distillation has been known only for the asymptotic setting, and the meaning of entanglement entropy in the single-copy regime has so far remained open. Here we close this gap by considering entanglement catalysis. We prove that entanglement entropy completely characterizes state transformations in the presence of entangled catalysts. Our results imply that entanglement entropy quantifies the amount of entanglement available in a bipartite pure state to be used for quantum information processing, giving asymptotic results an operational meaning also in the single-copy setup.

Reference: T. V. Kondra, C. Datta, A. Streltsov, Phys. Rev. Lett. 127, 150503 (2021).

Armin Tavakoli

IQOQI, Austria

Title: Entanglement In Quantum Communications

Abstract:

Prepare-and-measure scenarios are ubiquitous for understanding the role of quantum theory in communications. Here, we investigate such experiments when the involved devices also can share entanglement. We show that higher-dimensional entanglement enables correlations that go beyond the predictions of the paradigmatic quantum dense coding protocol. This leads us to investigate the set of quantum correlations obtained when the shared entanglement is unlimited and the devices communicate either classical or quantum d-dimensional systems. In any prepare-and-measure scenario, we show that such correlations can be characterized by a converging hierarchy of semidefinite programming relaxations. We also develop another such hierarchy which is non-converging but efficient for computing accurate bounds on quantum correlations. These techniques are applied towards device-independent tests of classical and quantum dimension that, in contrast to previous results, do not make implicit assumptions that Alice and Bob share no entanglement.

Reference:

“Correlations in Entanglement-Assisted Prepare-and-Measure Scenarios”, Armin Tavakoli, Jef Pauwels, Erik Woodhead, and Stefano Pironio; PRX Quantum 2, 040357 – Published 22 December 2021

Vlatko Vedral

U of Oxford, UK

Title: All quantum phases are acquired locally

Abstract:

In the Aharonov-Bohm (AB) effect, a superposed charge acquires a detectable phase by enclosing an infinite solenoid, in a region where the solenoid's electric and magnetic fields are zero. This effect is therefore sometimes claimed to show some kind of non-locality in quantum physics. In other words, its local generation can only be explained by the action of gauge-dependent potentials, not of gauge-independent fields. In my talk I will argue that the AB phase is mediated locally by the entanglement between the charge and the quantized EM field, like all other electromagnetic phases. A consequence of this is that there is a gauge-invariant value for the phase difference at each point along the charge's path. I will present experiments to measure this phase difference locally, by partial quantum state tomography on the charge and without closing the interference loop. This will involve explaining the concept of "single particle entanglement". I will then end by speculating about whether even the fermionic exchange phase is acquired locally.

Reference:

1. C. Marletto, V. Vedral, Phys. Rev. Lett. 125, 040401 (2020);

2. Chiara Marletto, NicetuTibau Vidal, and VlatkoVedral. Phys. Rev. D 104, 065013 (2021);

3. C. Marletto, C., V. Vedral, Journal of Physics Communications 3 (11) : 111001 (2019).

Rajamani Vijayaraghavan

TIFR Mumbai, India

Title:

Abstract:

Reference:

Sai Vinjanampathy

IIT Bombay, India

Title: Algorithmic Primitives for Quantum-Assisted Quantum Control

Abstract:

There has been recent interest in implementing quantum control and machine learning algorithms on NISQ computers. Here we present two primitive algorithms to evaluate overlaps and transition matrix time series, which are then used to construct several quantum-assisted quantum control algorithms. Unlike previous approaches, our method bypasses tomographically complete measurements and instead relies solely on single qubit measurements. We discuss circuit complexity of composed algorithms and sources of noise arising from Trotterization and measurement errors.

Reference:

Guru-VamsiPolicharla and SV, Phys. Rev. Lett. 127, 220504 (2021)

Naqueeb Ahmad Warsi

ISI Kolkata, India

Title:

Abstract:

Reference:

Reinhard F. Werner

Leibniz Universität Hannover, Germany

Title: Quantum Correlations in the Minimal Scenario

Abstract:

In the minimal scenario of quantum correlations, two parties can choose from two observables with two possible outcomes each. Probabilities are specified by four marginals and four correlations. The resulting four-dimensional convex body of correlations, denoted Q, is fundamental for quantum information theory. It is here studied through the lens of convex algebraic geometry. We review and systematize what is known and add many details, visualizations, and complete proofs. A new result is that Q is isomorphic to its polar dual. The boundary of Q consists of three-dimensional faces isomorphic to elliptopes and sextic algebraic manifolds of exposed extreme points. These share all basic properties with the usual maximally CHSH-violating correlations. These patches are separated by cubic surfaces of non-exposed extreme points. We provide a trigonometric parametrization of all extreme points, along with their exposing Tsirelson inequalities and quantum models. All non-classical extreme points (exposed or not) are self-testing, i.e., realized by an essentially unique quantum model.

Two principles, which are specific to the minimal scenario, allow a quick and complete overview: The first is the pushout transformation, the application of the sine function to each coordinate. This transforms the classical polytope exactly into the correlation body Q, also identifying the boundary structures. The second principle, self-duality, reveals the polar dual, i.e., the set of all Tsirelson inequalities satisfied by all quantum correlations. The convex body Q includes the classical correlations, a cross polytope, and is contained in the no-signaling body, a 4-cube. These polytopes are dual to each other, and the linear transformation realizing this duality also identifies Q with its dual.

Reference:

arXiv:2111.06270W

Mark M Wilde

Louisiana State University, USA

Title: Rains relative entropy as a smallest computable entanglement monotone

Abstract:

The Rains relative entropy of a bipartite quantum state is the tightest known upper bound on its distillable entanglement - which has a crisp physical interpretation of entanglement as a resource - and it is efficiently computable by convex programming. It has not been known to be a selective entanglement monotone in its own right. In this work, we strengthen the interpretation of the Rains relative entropy

by showing that it is monotone under the action of selective operations that completely preserve the positivity of the partial transpose, reasonably quantifying entanglement. That is, we prove that Rains relative entropy of an ensemble generated by such an operation does not exceed the Rains relative entropy of the initial state in expectation, giving rise to the smallest, most conservative known computable selective entanglement monotone. Additionally, we show that this is true not only for the original Rains relative entropy, but also for Rains relative entropies derived from various Renyi relative entropies. As an application of these findings, we prove, in both the non-asymptotic and asymptotic settings, that the probabilistic approximate distillable entanglement of a state is bounded from above by various Rains relative entropies.

Reference:

Joint work with Jens Eisert, https://arxiv.org/abs/2201.00835

Andreas Winter

Universitat Autònoma de Barcelona, Spain

Title: Entropic proofs of Singleton bounds for entanglement-assisted error correcting codes

Abstract:

We show that entirely information theoretic methods, based on von Neumann entropies and their properties, can be used to derive Singleton bounds on the performance of quantum error correcting codes (QECC), entanglement-assisted codes (EAQECC) and even entanglement-assisted hybrid classical-quantum (EACQ) error correcting codes.

Concretely, we show that the triple-rate region of qubits, cbits and ebits of possible EACQ codes over arbitrary alphabet sizes is contained in the quantum Shannon theoretic rate region of an associated memoryless erasure channel, which turns out to be a polytope. By its derivation, this region is robust in the sense that it holds with small corrections even when the

codes only correct most of the low-weight erasure errors.

We show that a large part of this region is attainable by certain EACQ codes, whenever the local alphabet size (i.e. Hilbert space dimension) is large enough, in keeping with known facts about classical and quantum minimum distance separable (MDS, QMDS and EAQMDS) codes: in particular, all of its extreme points and all but one extremal lines. The latter we leave as an intriguing open question.

Reference:

arXiv:2010.07902 (with Markus Grassl and Felix Huber),

arXiv:2202.02184 (w ManideepMamindlapally).

Howard M. Wiseman

Griffith University, Australia

Title: CAN A QUBIT BE YOUR FRIEND?

Why experimental metaphysics needs a quantum computer

Abstract:

Experimental metaphysics is the study of how empirical results can reveal indisputable facts about the fundamental nature of the world, independent of any theory. It is a field born from Bell's 1964 theorem, and the experiments it inspired, proving the world cannot be both local and deterministic. However, there is an implicit assumption in Bell's theorem, that the observed result of any measurement is absolute (it has some value which is not 'relative to its observer'). This assumption may be called into question when the observer becomes a quantum system (the "Wigner's Friend" scenario), which has recently been the subject of renewed interest. Here, building on work by Brukner, we derive a theorem, in experimental metaphysics, for this scenario [1]. It is similar to Bell's 1964 theorem but dispenses with the assumption of determinism. The remaining assumptions, which we collectively call "local friendliness", yield a strictly larger polytope of bipartite correlations than those in Bell's theorem (local determinism), but quantum mechanics still allows correlations outside the local friendliness polytope. We

illustrate this in an experiment in which the friend system is a single photonic qubit [1]. I argue that a truly convincing experiment could be realised if that system were a sufficiently advanced artificial intelligence software running on a very large quantum computer, so that it could be regarded genuinely as a friend. I will briefly discuss the implications of this far-future scenario for various interpretations and modifications of quantum theory.

Reference:

Kok-Wei Bong, AníbalUtreras-Alarcón, Farzad Ghafari, Yeong-Cherng Liang, Nora Tischler, Eric G. Cavalcanti, Geoff J. Pryde and Howard M. Wiseman, “A strong no-go theorem on the Wigner’s friend paradox", *Nature Physics* (2020).

Peng Xue

Beijing Computational Science Research Center, China

Title:

Abstract:

Reference:

Marek Żukowski

U of Gdańsk, Poland

Title:

Abstract:

Reference:

Karol Zyczkowski

Jagiellonian University Cracow, Poland

Center for Theoretical Physics, PAS, Warsaw

Title: Thirty-six entangled officers of Euler: quantum solution of a classically impossible problem

Abstract:

Classical {\sl combinatorial designs} are composed of elements
of a finite set and arranged with a certain symmetry and balance.
A simple example of a combinatorial design is given by a single Latin square:
square array of size d filled with d copies of d different symbols,
each occurring once in each row and in each column.
Such patterns are useful in statistics to design optimal experiments.

Analogous collections of quantum states, called a {\sl quantum design},
determine distinguished quantum measurements and can be applied for
various purposes of quantum information processing.
Negative solution to the famous problem of 36 officers of Euler
implies that there are no two orthogonal Latin squares of order six.
We show that the problem has a solution, provided the officers are entangled,
and construct orthogonal quantum Latin squares of this size.

As a consequence, we find an example of Absolutely Maximally Entangled (AME)
state of four subsystems with six levels each, which deserves
the appellation {\sl golden AME state}, as the golden ratio appears
prominently in its elements. This state enables us to construct a pure
nonadditivequhex quantum error detection code, which allows one to encode
a 6-level state into a triplet of such states. Furthermore,
using such a state one can teleport any unknown, two-dice quantum state,
from any two owners of two subsystems to the lab possessing the two other

dice forming the four-dice system.

References:

[1] S.A Rather, A.Burchardt, W. Bruzda, G. Rajchel-Mieldzioć, A. Lakshminarayan and K. Życzkowski, Thirty-six entangled officers of Euler,preprint arXiv:2104.05122

[2] D. Garisto, Euler's 243-Year-Old 'Impossible' Puzzle Gets a Quantum Solution, Quanta Magazine, Jan. 10, 2022; https://www.quantamagazine.org/

Contributory Speakers

Ibukunoluwa Adebimpe Adisa

Ph.D. student, 1309 John. S. Toll building, College Park 20742, USA

Title: Implementing quantum gates using length-3 dynamic quantum walks

Abstract:
It is well known that any quantum gate can be decomposed into the universal gate set {T, H, CNOT}, and recent results have shown that each of these gates can be implemented using a dynamic quantum walk, which is a continuous-time quantum walk on a sequence of graphs. This procedure for converting a quantum gate into a dynamic quantum walk, however, can result in long sequences of graphs. To alleviate this, in this paper, we develop a length-3 dynamic quantum walk that implements any single-qubit gate. Furthermore, we extend this result to give length-3 dynamic quantum walks that implement any single-qubit gate controlled by any number of qubits. Using these, we implement Draper's quantum addition circuit, which is based on the quantum Fourier transform, using a dynamic quantum walk.
Reference:
https://doi.org/10.1103/PhysRevA.104.042604 (Ibukunoluwa A. Adisa and Thomas G. Wong, 2021)

Srishty Aggarwal

Ph.D. Student, Indian Institute of Science, India

Title: Increased quantum speed limit in non-uniform magnetic field

Abstract:
The propagation of quantum information is benchmarked by quantum speed (QS), which is the transition speed of a particle from one state to the other, that has its roots in the Heisenberg energy-time uncertainty relation. It is known from a relativistic perspective that the upper limit of QS, widely called the quantum speed limit (QSL), for spin-up electron in uniform magnetic field is 0.2407c, ‘c’ being the speed of light. Is this the ultimate limit for QS or can it be further enhanced? The question would have a direct impact on the broad field of quantum computation and technology. We show that variable magnetic fields can be advantageous over constant magnetic fields to achieve higher QSL of electrons. There are many systems ranging from condensed matter, plasma to astrophysics to medical science, where the magnetic field is non-uniform. Examples include nuclear magnetic resonance imaging (NMRI), magnetic nanoparticles, stars and even our Earth. In fact, a recent work brings out the role of the non-uniformity of Earth’s magnetic field in the navigation of migratory birds using quantum physics. use
We develop a computational approach to find an upper bound of QS, augmented by an analytical framework for spin-up electrons, for our proposed magnetic field variation. We also provide a plausible experimental design for laboratory implementation of the ideas developed in this work. We could achieve QS upto 0.4c for spin-up electron and greater than 0.6c for spin-down electron using non-uniform magnetic field in relativistic regime. Hence, the relativistic treatment allows for causality bounds for QS of electrons, which are seen to be dependent on spin and variation of magnetic field.
The present endeavour not only accentuates the use of relativistic dynamics to quantify information theory but also, interestingly, probes into the facets of the former using the latter. We show how adopting a foundational perspective, by using the Bremermann–Bekenstein bound, which constraints the maximal rate of information production, results in the concept of a critical magnetic field. This enables approaching non-relativistic and relativistic treatments from a uniform perspective, with their corresponding relation to stability of matter. Thus, using tools of practical quantum information processing, we are able to address questions ranging from quantum technology to fundamental physics.
The interplay of quantum information theoretic ideas with the field of relativistic quantum physics, highlighting the use of non-uniform magnetic fields, are the main strengths of this work. It has the scope for applications in budding domains, such as quantum computation, relativistic quantum thermodynamics and quantum metrology as well as in fields beyond physics.

Reference:

1.) Aggarwal S., Mukhopadhyay B., Gregori G., “Relativistic Landau quantization in non-uniform magnetic field and its applications to white dwarfs and quantum information”, SciPost Phys. 11, 093 (2021).
2.) Aggarwal S., Banerjee S., Ghosh A., Mukhopadhyay B., Non-uniform magnetic as a booster for quantum speed: faster quantum information processing, https://arxiv.org/abs/2112.04519. "

Ali Ahanj

Faculty, Department of Physics, Khayyam University, Iran.

Title: Three-Spin Systems and the Pusey-Barrett- Rudolph (PBR) Theorem

Abstract:
The fundamental nature of quantum wave function has been the topic of many discussions since the beginning of the quantum theory. It either corresponds to an element of reality (Ψ−ontic) or it is a subjective state of knowledge about the underlying reality (Ψ−epistemic). Pusey, Barrett, and Rudolph (PBR) have shown that epistemic interpretations of the quantum wave function are in contradiction with the predictions of quantum under some assumptions. Here, a laboratory protocol with a triple quantum dot will be introduced as a three-spin interaction system to study the PBR no-go theorem. By this experimental model, we show that the epistemic interpretation of the quantum state is in contradiction with quantum theory, based only on the assumption that measurement settings can be prepared freely and independently from each other.

Reference:

"Three-spin systems and the Pusey–Barrett–Rudolph theorem", ZeynabFaroughi, Ali Ahanj, Samira Nazifkar&KuroshJavidan; The European Physical Journal Plus volume 136, Article number: 941 (2021) Published: 14 September 2021

Md Manirul Ali

Faculty Centre for Quantum Science and Technology, Chennai Institute of Technology, India

Title: Dynamical Crossover from Markovian to Non-Markovian Dynamics in the Strong Coupling Regime

Abstract:
The transient dynamics of quantum coherence of a Gaussian state is investigated. The state is coupled to an external environment which can be described by a Fano-Anderson type Hamiltonian. Solving the quantum Langevin equation, we obtain the Green's functions which is used to compute the time evolved first and second moments of the quadrature operators. From the quadrature operator we construct the covariance matrix which is used to measure the coherence in the system. The coherence is measured using the relative entropy of coherence measure. We consider different classes of spectral densities in our analysis and we study the dynamics of coherence for coherent state, squeezed state, displaced squeezed state and displaced squeezed thermal states. For all these states we observe that when the coupling with the system and the environment is weak, the coherence monotonically decreases with time and vanishes in the long time. Thus all the states exhibit Markovian decay dynamics in the weak coupling limit. In the strong coupling limit, the dynamics for the initial time period is Markovian and after a certain time period it becomes non-Markovian where we observe an environmental backaction on the system. Thus in the strong coupling limit we observe a dynamical crossover from Markovian nature to non-Markovian behavior. This crossover is very abrupt under some environmental conditions and for some parameters of the quantum state. Using quantum master equation approach we verify the crossover from the dynamics

of dissipation and fluctuation parameters and the results endorse those obtained from coherence dynamics.

Reference:

Md. Manirul Ali, ChandrashekarRadhakrishnan, “Dynamical Crossover from Markovian to Non-Markovian dynamics in the strong coupling regime” quant-ph:arXiv:2201.07680 (This work is communicated to Physical Review A)

Mir Alimuddin

Research Associate – I, School of Physics, IISER Thiruvananthapuram, India.

Title: Local Quantum Measurement Demands Type-Sensitive Information Principles for Global Correlations

Abstract:
Physical theories with local structure similar to quantum theory can allow beyond-quantum global states compatible with unentangled Gleason’s theorem. In a standard Bell experiment any such bipartite state produces correlations that are always quantum simulable. In this limited classical-input-classical-output Bell scenario, we show that there exist bipartite beyond-quantum states that produce correlations all of which are in-fact classically simulable. However, if the type of Bell scenario is generalized to consider quantum states as inputs, we then show that any such bipartite beyond-quantum state yields beyond-quantum input-output correlations. We also analyze the implication of this quantum input scenario while studying generic multipartite correlations obtained from local quantum theory but potentially allowing different global structure. Our study suggests the requirement of type sensitive information principles for isolating the quantum correlations from the beyond-quantum ones.

Reference:

arXiv:2111.04002 (Edwin Peter Lobo, SahilGopalkrishnaNaik, Samrat Sen, Ram Krishna Patra, ManikBanik, Mir Alimuddin)

Natasha Awasthi

Faculty, DIT University, India

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

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 interactingwith 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.

Reference:

Natasha Awasthi, Samyadeb Bhattacharya, Aditi Sen(De), and Ujjwal Sen Phys. Rev. A 97, 032103 – Published 8 March 2018

Rajni Bala

Ph.D. student, Department of Physics, India.

Title: Layered semi–quantum key distribution & secret sharing

Abstract:
Distribution of secure information over a quantum network has gained a lot of interest recently due to its utility in realistic situations. In fact, protocols for quantum key distribution [Phys. Rev. A 97(3), 032312 (2018] and quantum secret sharing [IEEE Journal of Selected Topics in Quantum Electronics 26(3), 1–6 (2020)] have already been proposed to distribute information in a network. Both the protocols assume that all the participants have access to quantum resources. However, in a generic situation, some of the participants may be constrained to perform measurement only in the computational basis. Focusing on this aspect, in this work, we harness the potential offered by multidimensional states in secure communication with only one quantum participant. We propose two protocols for–(i) layered semi–quantum key distribution, and (ii) layered semi–quantum secret sharing that distribute information in a network of all the honest and the dishonest participants respectively. Both the protocols facilitate simultaneous distribution of information in all the layers of an arbitrary network. This study opens up possibilities for study of various communication protocols, that may distribute information using minimal quantum resources, as per the requirements of distinct realistic scenarios.

Reference:

arXiv identifier: 2201.06540 (RajniBala, Sooryansh Asthana, V. Ravishankar)

Pratapaditya Bej

Ph.D. student, Bose Institute Kolkata, India

Title: Information-disturbance trade-off in generalized entanglement swapping

Abstract:
We study information-disturbance trade-off in generalized entanglement swapping protocols wherein starting from Bell pairs (1, 2) and (3, 4), one performs an arbitrary

joint measurement on (2, 3), so that (1, 4) now becomes correlated. We obtain trade-off inequalities between information gain in correlations of (1, 4) and residual information in correlations of (1, 2) and (3, 4), respectively, and we argue that information contained in correlations (information) is conserved if each inequality is an equality. We show that information is conserved for a maximally entangled measurement but is not conserved for any other complete orthogonal measurement and Bell measurement mixed with white noise. However, rather surprisingly, we find that information is conserved for rank-2 Bell diagonal measurements, although such measurements do not conserve entanglement. We also show that a separable measurement on (2, 3) can conserve information, even if, as in our example, the post-measurement states of all three pairs (1, 2), (3, 4), and (1, 4) become separable. This implies that correlations from an entangled pair can be transferred to separable pairs in nontrivial ways so that no information is lost in the process.
Reference:
Pratapaditya Bej, Arkaprabha Ghosal, Debarshi Das, Arup Roy, and Somshubhro Bandyopadhyay, PHYSICAL REVIEW A 102, 052416 (2020)

Anindita Bera

Address: Post doc, Nicolaus Copernicus University, Poland

Title: A class of Bell diagonal entanglement witnesses in C^4⊗C^4: optimization and the spanning property

Abstract:
Two classes of Bell diagonal indecomposable entanglement witnesses in C^4 ⊗ C^4 are considered here. Within the first class, we find a generalization of the well-known Choi witness from C^3 ⊗ C^3, while the second one contains the reduction map. Interestingly, contrary to C^3 ⊗ C^3 case, the generalized Choi witnesses are no longer optimal. We perform an optimization procedure of finding spanning vectors, that eventually gives rise to optimal witnesses. Operators from the second class turn out to be optimal, however, without the spanning property. This analysis sheds a new light into the intricate structure of optimal entanglement witnesses.
Reference:
Anindita Bera, Filip A. Wudarski, Gniewomir Sarbicki, Dariusz Chruściński, “A class of Bell diagonal entanglement witnesses in $C^4 \otimes C^4$: optimization and the spanning property”, arXiv:2112.15183 [Submitted on 30 Dec 2021]

Some Sankar Bhattacharya

Post-Doc, ICTQT, Uof Gdansk, Poland

Title: Local Quantum State Marking

Abstract:
We propose the task of local state marking (LSM), where some multipartite quantum states chosen randomly from a known set of states are distributed among spatially

separated parties without revealing the identities of the individual states. The collaborative aim of the parties is to correctly mark the identities of states under the restriction that they can perform only local quantum operations (LO) on their respective subsystems and can communicate with each other classically (CC) -- popularly known as the operational paradigm of LOCC. While mutually orthogonal states can always be marked exactly under global operations, this is in general not the case under LOCC. We show that the LSM task is distinct from the vastly explored task of local state distinguishability (LSD) -- perfect LSD always implies perfect LSM, whereas we establish that the converse does not hold in general. We also explore entanglement assisted marking of states that are otherwise locally unmarkable and report intriguing entanglement assisted catalytic LSM phenomenon.

Reference:

Samrat Sen, Edwin Peter Lobo, SahilGopalkrishnaNaik, Ram Krishna Patra, Tathagata Gupta, Subhendu B. Ghosh, SutapaSaha, Mir Alimuddin, TamalGuha, Some Sankar Bhattacharya, ManikBanik, “Local Quantum State Marking” arXiv:2107.12208[Submitted on 26 Jul 2021]

Bihalan Bhattacharya

Ph.D. student, S. N. Bose National Centre for Basic Sciences, India.

Title: Generating and detecting bound entanglement in two-qutrits using a family of indecomposable positive maps

Abstract:
The problem of bound entanglement detection is a challenging aspect of quantum information theory for higher dimensional systems. Here, we propose an indecomposable positive map for two-qutrit systems, which is shown to detect a class of positive partial transposed (PPT) states. A corresponding witness operator is constructed and shown to be weakly optimal and locally implementable. Further, we perform a structural physical approximation of the indecomposable map to make it a completely positive one, and find a new PPT-entangled state which is not detectable by certain other well-known entanglement detection criteria.

Reference:

J. Phys. Commun. 5, 065008 (2021)

Anandamay Das Bhowmik

Ph.D. student, Indian Statistical Institute, Kolkata, India

Title: From no causal loop to absoluteness of cause: discarding the quantum NOT logic

Abstract:
"The principle of ‘absoluteness of cause’ (AC) assumes the cause-effect relation to be observer-independent and is a distinct assertion than prohibiting occurrence of any causal loop. Here, we study implication of this novel principle to derive a

fundamental no-go result in quantum world. AC principle restrains the 'time order' of two spacelike separated events/processes to be a potential cause of another event in their common future, and in turn negates existence of a quantum device that transforms an arbitrary pure state to its orthogonal one. The present no-go result is quite general as its domain of applicability stretches out from the standard linear quantum theory to any of its generalizations allowing deterministic or stochastic nonlinear evolution. We also analyze different possibilities of violating the AC principle in generalized probability theory framework. A strong form of violation enables instantaneous signaling, whereas a weak form of violation forbids the theory to be locally tomographic. On the other hand, impossibility of an intermediate violation suffices to discard the universal quantum NOT logic."

Reference:

arXiv:2109.09953 [quant-ph] ([Submitted on 21 Sep 2021 (v1), last revised 27 Sep 2021 (this version, v2)]; Anandamay Das Bhowmik, PreetiParashar, GuruprasadKar, ManikBanik)

Atanu Bhunia

Ph.D. student, Department of Applied Mathematics, Uof Calcutta, India.

Title: Nonlocality without entanglement: An acyclic configuration

Abstract:
A set of orthogonal product states of a composite Hilbert space is genuinely nonlocal if the states are locally indistinguishable across any bipartition. In this work, we construct a minimal set of party asymmetry genuine nonlocal set in arbitrary large dimensional composite quantum systems. We provide a local discriminating protocol by using a three qubit GHZ state as a resource. On the contrary, we observe that single-copy of two qubit Bell states provide no advantage for this discrimination task. Recently, Halder et al. [Phys. Rev. Lett. 122, 040403 (2019)], proposed the concept of strong nonlocality without entanglement and ask an open question whether there exist an incomplete strong nonlocal set or not. In [Phys. Rev. A 102, 042228 (2020)], an answer is provided by the authors. Here, we construct an incomplete party asymmetry strong nonlocal set which is more stronger than the set constructed in [Phys. Rev. A 102, 042228 (2020)] with respect to the consumption of entanglement as a resource for their respective discrimination tasks.

Reference:

Atanu Bhunia, Indrani Chattopadhyay, Debasis Sarkar, "Nonlocality without entanglement: Party asymmetric case" https://arxiv.org/abs/2111.14399 [Submitted on 29 Nov 2021]

Tanmoy Biswas

Ph.D. student, International Centre for Theory of Quantum Technologies, Uof Gdansk, Poland

Title: Fluctuation-dissipation relations for thermodynamic distillation processes

Abstract:
The fluctuation-dissipation theorem is a fundamental result in statistical physics that establishes a connection between the response of a system subject to a perturbation and the fluctuations associated with observables in equilibrium. Here we derive its version within a resource-theoretic framework, where one investigates optimal quantum state transitions under thermodynamic constraints. More precisely, we first characterise optimal thermodynamic distillation processes, and then prove a relation between the amount of free energy dissipated in such processes and the free energy fluctuations of the initial state of the system. Our results apply to initial states given by either asymptotically many identical pure systems or arbitrary number of independent energy-incoherent systems, and allow not only for a state transformation, but also for the change of Hamiltonian. The fluctuation-dissipation relations we derive enable us to find the optimal performance of thermodynamic protocols such as work extraction, information erasure and thermodynamically-free communication, up to second-order asymptotics in the number N of processed systems. We thus provide a first rigorous analysis of these thermodynamic protocols for quantum states with coherence between different energy eigenstates in the intermediate regime of large but finite N.

Reference:
Tanmoy Biswas, A. de Oliveira Junior, MichałHorodecki, KamilKorzekwa, "Fluctuation-dissipation relations for thermodynamic distillation processes" arXiv:2105.11759v2 [Submitted on 25 May 2021 (*v1*), last revised 3 Nov 2021 (this version, v2)]

Daniel Burgarth

Faculty, Macquarie University, Australia

Title: One bound to rule them all: from Adiabatic to Zeno

Abstract:
We derive a universal nonperturbative bound on the distance between unitary evolutions generated by time-dependent Hamiltonians in terms of the difference of their integral actions. We apply our result to provide explicit error bounds for the rotating-wave approximation and generalize it beyond the qubit case. We discuss the error of the rotating-wave approximation over long time and in the presence of time-dependent amplitude modulation. We also show how our universal bound can be used to derive and to generalize other known theorems such as the strong-coupling limit, the adiabatic theorem, and product formulas, which are relevant to quantum-control strategies including the Zeno control and the dynamical decoupling. Finally, we prove generalized versions of the Trotter product formula, extending its validity beyond the standard scaling assumption

Reference:
Burgarth, Daniel ,Facchi, Paolo , Gramegna, Giovanni , Yuasa, Kazuya,arXiv:2111.08961; November 2021

Lorenzo Catani

Post doc, Technische Universitaet

Title: Why interference phenomena do not capture the essence of quantum theory

Abstract:
Quantum interference phenomena are widely viewed as posing a challenge to the classical worldview. Feynman even went so far as to proclaim that they are the only mystery and the basic peculiarity of quantum mechanics. Many have also argued that such phenomena force us to accept a number of radical interpretational conclusions, including: that a photon is neither a particle nor a wave but rather a schizophrenic sort of entity that toggles between the two possibilities, that reality is observer-dependent, and that systems either do not have properties prior to measurements or else have properties that are subject to nonlocal or backwards-in-time causal influences. In this work, we show that such conclusions are not, in fact, forced on us by the phenomena. We do so by describing an alternative to quantum theory, a statistical theory of a classical discrete field (the `toy field theory') that reproduces the relevant phenomenology of quantum interference while rejecting these radical interpretational claims. It also reproduces a number of related interference experiments that are thought to support these interpretational claims, such as the Elitzur-Vaidman bomb tester, Wheeler's delayed-choice experiment, and the quantum eraser experiment. The systems in the toy field theory are field modes, each of which possesses, at all times, both a particle-like property (a discrete occupation number) and a wave-like property (a discrete phase). Although these two properties are jointly possessed, the theory stipulates that they cannot be jointly known. The phenomenology that is generally cited in favour of nonlocal or backwards-in-time causal influences ends up being explained in terms of inferences about distant or past systems, and all that is observer-dependent is the observer's knowledge of reality, not reality itself.

Reference:
Lorenzo Catani, Matthew Leifer, David Schmid, Robert W. Spekkens, “Why interference phenomena do not capture the essence of quantum theory” arXiv:2111.13727 [Submitted on 26 Nov 2021]

Priyabrata Char

Ph.D. Student, Department of Applied Mathematics, Uof Calcutta, India.

Title : Catalytic transformation in coherence theory

Abstract :
In 2016, A. Winter et al.(Physical Review Letters 116 (12) (2016) 120404) provided an operational meaning to relative entropy of coherence and coherence of formation by introducing coherence distillation and dilation protocol in asymptotic setup. Though relative entropy of coherence introduced in 2014 by T. Baumgratz(Physical Review Letters 113 (14) (2014) 140401) as a coherence measure but it's operational meaning in single copy setup was unknown so far. Here we have provided relative entropy of coherence (via IO (Incoherent Operations)) and coherence of formation (via IO) and quantum incoherent relative entropy (via LQICC(Local Quantum

Incoherent Operations with Classical Communications)) a clear operational significance in single copy setup using the concept of catalyst. We have proved an existential correspondence between asymptotic and catalytic state transformation using IO, LICC(Local Incoherent Operations with Classical Communications) and LQICC. We have also discussed two very important protocols, assisted distillation and quantum incoherent state merging, in single copy setup using catalyst. Monotone property of relative entropy of coherence, coherence of formation and quantum incoherent relative entropy under the catalytic transformation are also discussed here.

Reference:

arXiv:2111.14645v2

Anubhav Chaturvedi

Ph.D. Student, International Centre for Theory of Quantum Technologies (ICTQT), Uof Gdansk, Poland

Title: Quantum description of reality is empirically incomplete

Abstract:
Empirical falsifiability of the predictions of physical theories is the cornerstone of the scientific method. Physical theories attribute empirically falsifiable operational properties to sets of physical preparations. A theory is said to be empirically complete if such properties allow for a not fine-tuned realist explanation, as properties of underlying probability distributions over states of reality. Such theories satisfy a family of equalities among fundamental operational properties, characterized exclusively by the number of preparations. Quantum preparations deviate from these equalities, and the maximal quantum deviation increases with the number of preparations. These deviations not only signify the incompleteness of the operational quantum formalism, but they simultaneously imply quantum over classical advantage in suitably constrained one-way communication tasks, highlighting the delicate interplay between the two.

Reference:

Anubhav Chaturvedi, Marcin Pawłowski, Debashis Saha, (In communication with PRL https://arxiv.org/abs/2110.13124 [Submitted on 25 Oct 2021])

Debarshi Das

Post doc, S. N. Bose National Centre for Basic Sciences, India

Title: Robust certification of arbitrary outcome quantum measurements without using entanglement

Abstract:
Certification of quantum devices received from unknown providers is a primary requirement before utilizing the devices for any information processing task. Here, we establish a protocol for certification of d-outcome quantum measurements (with d

being arbitrary) in a setup comprising of a preparation followed by two measurements in sequence. We propose a set of temporal inequalities pertaining to different d involving correlation functions corresponding to successive measurement outcomes, that are not satisfied by quantum devices. Using quantum violations of these inequalities, we certify d-outcome measurements under some minimal assumptions which can be met in an experiment efficiently. Our certification protocol neither requires entanglement, nor any prior knowledge about the dimension of the system under consideration. We further show that our protocol is robust against realistic non-ideal realization. Finally, as an offshoot of our protocol, we present a scheme for secure certification of genuine quantum randomness.

Reference:

arXiv:2110.01041 [quant-ph] ("Robust certification of arbitrary outcome quantum measurements from temporal correlations", Debarshi Das, Ananda G. Maity, DebashisSaha, A. S. Majumdar[Submitted on 3 Oct 2021])

Soumya Das

Senior Research Fellow, CSRU, Indian Statistical Institute (ISI), Kolkata, India

Title: Maximum violation of monogamy of entanglement for indistinguishable particles by measures that are monogamous for distinguishable particles

Abstract:

Two important results of quantum physics are the no-cloning theorem and the monogamy of entanglement. The former forbids the creation of an independent and identical copy of an arbitrary unknown quantum state and the latter restricts the shareability of quantum entanglement among multiple quantum systems. For distinguishable particles, one of these results implies the other. In this Letter, we show that in qubit systems with indistinguishable particles (where each particle cannot be addressed individually) a maximum violation of the monogamy of entanglement is possible by the measures that are monogamous for distinguishable particles. To derive this result, we formulate the degree of freedom trace-out rule for indistinguishable particles corresponding to a spatial location where each degree of freedom might be entangled with the other degrees of freedom. Our result removes the restriction on the shareability of quantum entanglement for indistinguishable particles, without contradicting the no-cloning theorem.

Reference:

Goutam Paul, Soumya Das, Anindya Banerji, doi.org/10.1103, PhysRevA.104.L010402, https://arxiv.org/abs/2102.00780

Arun Kumar Das

Ph.D. student, S.N Bose National Centre for Basic Sciences, Kolkata, India

Title: Resource theoretic efficacy of a two qubit entangled state in a sequential network

Abstract:
How best one can recycle a given quantum resource, mitigating the various difficulties involved in its preparation and preservation, is of considerable importance for ensuring efficient applications in quantum technology. Here we demonstrate quantitatively the resource theoretic advantage of reusing the single copy of a two-qubit entangled state towards information processing. To this end, we consider a scenario of sequential detection of the given entangled state by multiple independent observers on each of the two spatially separated wings. In particular, we consider equal numbers of sequential observers on the two wings. We first determine the upper bound on the number of observers who can detect entanglement employing suitable entanglement witness operators. In terms of the parameters characterizing the entanglement consumed and the robustness of measurements, we then compare the above scenario with the corresponding scenario involving the sharing of multiple copies of identical two-qubit states among the two wings. This reveals a clear resource theoretic advantage of recycling the single copy of a two-qubit entangled state.
Reference:
https://arxiv.org/abs/2109.11433([Submitted on 23 Sep 2021]; Arun Kumar Das, Debarshi Das, Shiladitya Mal, Dipankar Home, A.S. Majumdar)

Sagnik Dutta

Research Project Student, Department of Physical Sciences, India

Title: Operational Characterization of Multipartite Nonlocal Correlations

Abstract:
Nonlocality, one of the most puzzling features of multipartite quantum correlation, has been identified as a useful resource for device-independent quantum information processing. Motivated by the resource theory of quantum entanglement recently an operational framework has been proposed by R. Gallego et al. and J.-D. Bancal et al. that characterizes the nonlocal resource present in multipartite quantum correlations. While bipartite no-signaling correlations allow a dichotomous classification—local vs nonlocal—in a multipartite scenario the authors show the existence of several types of nonlocality that are inequivalent under the proposed operational framework. In this work we present a finer characterization of multipartite no-signaling correlations based on the same operational framework. We also clarify a statement in Gallego et al.'s work that could be misinterpreted and fine-tune the conclusions of that work here.
Reference:
Sagnik Dutta, Amit Mukherjee and ManikBanik, “Operational characterization of multipartite nonlocal correlations”, Phys. Rev. A 102, 052218 – Published 13 November 2020.

Stanislav Filatov

PhD student, Uof Latvia

Title: Ordering the processes with indefinite causal order

Abstract:
We show a method of describing processes with indefinite causal order (ICO) by a definite causal order. We do so by relabeling the processes that take place in the circuit in accordance with the basis of measurement of control qubit. Causal nonseparability is alleviated at a cost of nonlocality of the acting processes. This result highlights the key role of superposition in creating the paradox of ICO. We also draw attention to the issue of growing incompatibility of language in its current form (especially the logical structures it embodies) with the quantum logic.
Reference:
Stanislav Filatov and Marcis Auzinsh, arXiv.org > quant-ph > arXiv:2106.08976

Arkaprabha Ghoshal

Ph.D. student, Bose Institute, India

Title: Characterizing qubit channels in the context of quantum teleportation

Abstract:
Quantum teleportation (QT) is a task by which one can transmit the information contained in an unknown quantum state to any distant lab without transferring the quantum object itself. Such a task requires shared entanglement and Local Operations and Classical Communications (LOCC). It has been shown in J. Phys. A: Math. Theor.53, 145304 that an arbitrary two-qubit state can be appropriately characterized in terms of maximal fidelity and fidelity deviation. Maximal fidelity is the maximal value of average teleportation fidelity achievable within the standard protocol and local unitary strategies, whereas the latter is defined as the standard deviation of fidelity values over all input states. It has been shown in J. Phys. A: Math. Theor. 53, 145304 and Phys. Rev. A 101, 012304 that given a set of two-qubit states, all having the same maximal fidelity greater than the classical bound (useful states for QT), the best performing states from the given set must exhibit zero fidelity deviation (universal states for QT). Any two-qubit state is said to be universal for QT if every unknown input state is teleported equally well with the same fidelity equal with the maximal fidelity. We consider a scenario where a party, say, Alice, prepares a pure two-qubit (either maximally entangled or non-maximally entangled) state and sends one half of this state to another distant party, say, Bob through an arbitrary qubit channel. Finally, the shared state is used as a teleportation resource. In this scenario, we focus on appropriately characterizing the set of qubit channels with respect to the final state's efficacy as a resource of quantum teleportation (QT) in terms of maximal fidelity and fidelity deviation. Importantly, we point out the existence of a subset of qubit channels for which the final state is always useful and universal for QT when the initially prepared state is either useful and universal (i.e., for a maximally entangled state) or useful but not universal (i.e., for a subset of non-maximally entangled pure states). Interestingly, in the latter case, we show that non-unital channels (dissipative interactions) are more effective than unital channels (non-dissipative interactions) in producing useful and universal states for QT from non-maximally entangled pure states.

Reference:
"Characterizing qubit channels in the context of quantum teleportation", ArkaprabhaGhosal, Debarshi Das, and Subhashish Banerjee; Phys. Rev. A 103, 052422 – Published 18 May 2021

Suchetana Goswami

Post doc, Centre of New Technologies, Uof Warsaw, Poland

Title: Coherence in Quantum Computation

Abstract:
Estimation of resources in quantum computation to obtain speed up is a promising arena of study. We consider the Bernstein-Vazirani (BV) algorithm for determining the oracular function f(x) = a·x mod2 while we implement the oracle just once in quantum domain. We show while the algorithm does not introduce any entanglement during the process, the performance can be monotonically related to the robustness of coherence of the initial state. Generalisation of the protocol to higher dimension and in presence of correlated noise yield the similar results. This shows that quantum coherence plays the role of necessary and sufficient resource for the algorithm to give advantage over classical computation while the presence of entanglement above some threshold is disadvantageous for the performance. We also find the exact equivalence between the robustness and l1-norm of coherence with purity of the state while showing that with bounded purity, the best state to initiate BV algorithm is a pseudo-pure maximally coherent state. Altogether it provides an operational meaning of the measure of coherence from a resource theoretic point of view.

Tamal Guha

Post doc, Department of Computer Science, The Uof Hong Kong, Hong Kong

Title: On composition of multipartite quantum systems: perspective from time-like paradigm

Abstract:
Figuring out the physical rationale behind natural selection of quantum theory is one of the most acclaimed quests in quantum foundational research. This pursuit has inspired several axiomatic initiatives to derive mathematical formulation of the theory by identifying general structure of state and effect space of individual systems as well as specifying their composition rules. This generic framework can allow several consistent composition rules for a multipartite system even when state and effect cones of individual subsystems are assumed to be quantum. Nevertheless, for any bipartite system, none of these compositions allows beyond quantum space-like correlations. In this work we show that such bipartite compositions can admit stronger than quantum correlations in the time-like domain and, hence, indicates pragmatically distinct roles carried out by state and effect cones. We discuss

consequences of such correlations in a communication task, which accordingly opens up a possibility of testing the actual composition between elementary quanta.
Reference:
arXiv:2107.08675 [quant-ph]

Tathagata Gupta

Ph.D. student, Indian Statistical Institute, Kolkata, India

Title: Information splitting and recombining: A blindly secure paradigm

Abstract:
A secure transmission of information between the sender and receiver, via a cloud of quantum network, is a challenging task for modern technology. In this letter, we will introduce a framework of secured communication between the sender and receiver, sharing no direct transmission lines but a pre-shared randomness. However, they can communicate respectively via quantum and classical channels, with the intermediate network server. This set-up allows the sender to split an information between the multiple ports of the intermediate server, and then the public message announced by them will help the receiver to recombine the information. Interestingly, in this whole process, the servers are completely blind about the conveying message.

Alexander Hahn

Ph.D. student, Center for Engineered Quantum Systems, Macquarie University, Australia

Title: Unification of Random Dynamical Decoupling and the Quantum Zeno Effect

Abstract:
Periodic deterministic bang-bang dynamical decoupling and the quantum Zeno effect are known to emerge from the same physical mechanism. Both concepts are based on cycles of strong and frequent kicks provoking a subdivision of the Hilbert space into independent subspaces. However, previous unification results do not capture the case of random bang-bang dynamical decoupling, which can be advantageous to the deterministic case but has an inherently acyclic structure. Here, we establish a correspondence between random dynamical decoupling and the quantum Zeno effect by investigating the average over random decoupling evolutions. This protocol is a manifestation of the quantum Zeno dynamics and leads to a unitary bath evolution. By providing a framework that we call equitability of system and bath, we show that the system dynamics under random dynamical decoupling converges to a unitary with a decoupling error that characteristically depends on the convergence speed of the Zeno limit. This reveals a unification of the random dynamical decoupling and the quantum Zeno effect.
Reference:

arXiv:2112.04242 (Alexander Hahn, Daniel Burgarth, Kazuya Yuasa)

Jonte R Hance

Ph.D. student, Quantum Engineering Technology Laboratories, Uof Bristol, UK

Title: Does the Weak Trace Show the Past of a Quantum Particle?

Abstract:
We investigate the weak trace method for determining the path of a quantum particle. Specifically, looking at nested interferometer experiments, when internal interferometers are tuned to destructive interference, we show that the weak trace method gives misleading results. This is as obtaining the weak value of the position operator necessarily perturbs the system, hence the assumption that weak coupling is equivalent to no coupling is incorrect. Further, even if we assume no disturbance, there is no reason to associate the weak value of the spatial projection operator with the classical idea of `particle presence', especially if it has features which go against the classical ideas associated with a particle being present (i.e. a particle having a single, continuous path).
Reference:
arXiv:2109.14060 ([Submitted on 28 Sep 2021], “Does the weak trace show the past of a quantum particle in an unperturbed system?”, Jonte R. Hance, John Rarity, James Ladyman)

A. V. S. Kameshwari

Ph.D. student, Vellore Institute of Technology, India.

Title: Role of entangling operators in Duopoly games

Abstract:
Classical games can be quantized by Eisert-Wilkens-Lewenstein (EWL) scheme and Marinatto-Weber (MW) scheme. However, both quantization schemes have faced a few criticism, one being the inability to explain the quantumness of a quantum game. Recent studies on quantization of classical games, brought a new scheme, namely modified EWL scheme. Unlike the other schemes, modified EWL does not consider a classical game as a subset of a quantum game. This admits a wide range of entangling operators, through which one can appreciate the role of two-qubit nonlocal operators in controlling the game dynamics.
In this work, modified EWL scheme is used to quantize the classical duopoly game, namely Cournot (simultaneous game) and Stackelberg (sequential game). Analysis of duopoly games provides two interesting results. Firstly, the role of entangling operators is insignificant when the firms adapt the same strategies. Secondly, it is found that entangling operators play a significant role in equalizing the profit function of the firms when the strategies of the firms are interchanged. Put together, one can see both significance and insignificance of the entangling operators in the same duopoly game setting using the modified EWL scheme.
Reference:

Kameshwari A V S and Balakrishnan S (2021) Quantum. Inf. Process. 20, 337

Tulja Varun Kondra

Ph.D. student, Centre of New Technologies, Uof Warsaw, Poland

Title: Stochastic approximate state conversion for entanglement and general quantum resource theories

Abstract:
Quantum resource theories provide a mathematically rigorous way of understanding the nature of various quantum resources. An important problem in any quantum resource theory is to determine how quantum states can be converted into each other within the physical constraints of the theory. The standard approach to this problem is to study approximate or probabilistic transformations. Very few results have been presented on the intermediate regime between probabilistic and approximate transformations. Here, we investigate this interme- diate regime, providing limits on both, the fidelity and the probability of state transitions. We derive limitations on the transformation of quantum states which are valid in all quantum resource theories, by providing bounds on the maximal transformation fidelity for a given transformation probability. Furthermore, we completely solve this question in the case of two-qubit entanglement for arbitrary final states, when starting from a pure state. As an application, we demonstrate that in some setups the transformation fidelity can be increased significantly by compromising the transformation probability only slightly.

Reference:

Tulja Varun Kondra, ChandanDatta, Alexander Streltsov, “Stochastic approximate state conversion for entanglement and general quantum resource theories” arXiv:2111.12646 [Submitted on 24 Nov 2021]

Seid Koudis

Ph.D. student, Uof Naples Federico II

Title: **(CAUSAL)-ACTIVATION OF COMPLEX ENTANGLEMENT STRUCTURES IN QUANTUM NETWORKS**

Abstract:
Entanglement represents "the" key resource for several applications of quantum information processing, ranging from quantum communications to distributed quantum computing. Despite its fundamental importance, deterministic generation of maximally entangled qubits represents an on-going open problem. Here, we design a novel generation scheme exhibiting two attractive features, namely, i) deterministically generating genuinely multipartite entangled states, ii) without requiring any direct interaction between the qubits. Indeed, the only necessary condition is the possibility of coherently controlling -- according to the indefinite causal order framework -- the causal order among some unitaries acting on the qubits. Through the paper, we analyze and derive the conditions on the unitaries for

deterministic generation, and we provide examples for unitaries practical implementation. We conclude the paper by discussing the scalability of the proposed scheme to higher dimensional GME states and by introducing some possible applications of the proposal for quantum networks.

Reference:
arXiv:2112.00543 (Seid Koudia, Angela Sera Cacciapouti, Marcello Caleffi)

Anu Kumari

Ph.D. Student, Delhi Technological University, India.

Title: Classification witness operator for the classification of different subclasses of three-qubit GHZ class

Abstract:
Three-qubit system has two kinds of inequivalent genuine entangledclasses under stochastic local operation and classical communication(SLOCC). Theseclasses are called as GHZ class and W class. GHZ class proved to be a very usefulclass for different quantum information processing tasks such as quantum teleportation,controlled quantum teleportation, etc. In this work, we have distributed pure three-qubitstates from GHZ class into different subclasses denoted by S1, S2, S3, S4 and showedthat the three-qubit states either belong to S2 or S3 or S4 may be more efficient than thethree-qubit state belong to S1. Thus, it is necessary to discriminate the states belong
to Si, i = 2, 3, 4 and the state belong to S1. To achieve this task, we have constructeddifferent witness operators that can classify the subclasses Si ,i = 2, 3,4 from S1.
We have shown that the constructed witness operator can be decomposed into Pauli matrices and hence can be realized experimentally.

Reference:
Quantum Inf. Process 20, 316 (2021), arXiv:2104.03679

Asmita Kumari

Post doc, Harish Chandra Research Institute, India

Title: Luders bounds of Leggett-Garg inequalities, quantum channel, PT symmetric evolution and arrow-of-time

Abstract:
We have studied the quantum violations of Leggett-Garginequalities (LGIs) while system evolves under qubit channel and PT symmetric Hamiltonian. In particular, we considered two formulations of LGIs, viz., the standard LGIs and variant of LGIs for our study. We first show for both the evolutions the quantum violations of the above two forms of inequalities beat the respective Luders bounds (unitary case) and even approach algebraic maximum of the inequalities. It is well-known that violation of a LGI requires the no-signalling in time condition in quantum theory but arrow-of-time

condition is satisfied. However, we demonstrate a hitherto unexplored feature that, for the case of variant of LGI and PT symmetric evolution, the quantum violation can even be obtained when only
the arrow-of-time is violated but no-signaling in time condition is satisfied.

Reference:

Asmita Kumari, A. K. Pan, “Lüders bounds of Leggett-Garg inequalities, PT-symmetric evolution and arrow-of-time” arXiv:2112.14775 [Submitted on 29 Dec 2021];
AsmitaKumari, A.K.Pan, “Quantum violations of Lüders bound Leggett-Garg inequalities for quantum channel” , arXiv:2112.14543 [Submitted on 29 Dec 2021]

Amit Kundu

Ph.D. student, Department of Applied Mathematics, Uof Calcutta, India

Title: Nonlocality in Quantum Network scenario

Abstract:
Source-independent quantum networks are considered as a natural generalization to the Bell scenario where we investigate the nonlocal properties of quantum states distributed and measured in a network. Considering the simplest network of entanglement swapping, recently Gisin et al. [Phys. Rev. A 96, 020304(R) (2017)] and Andreoli [New. J. Phys. 19, 113020 (2017)] independently provided a systematic characterization of the set of quantum states leading to violation of the so-called bilocality inequality. We will focus on the complexities in quantum networks with an arbitrary number of parties distributed in chain-shaped and star shaped networks and more general triangle network. We will also talk about some other type of joint measurements other than Bell state Measurement. There is maximal violation of the “n-local” inequality that can be achieved by arbitrary two-qubit states for such chain- and star-shaped networks. There is also results for nonlocality with product state in the triangle network. This would further provide a deeper understanding of quantum correlations in complex structures.

Reference:

Amit Kundu, Mostak Kamal Molla, Indrani Chattopadhyay, Debasis Sarkar “Maximal qubit violation of n-local inequalities in quantum network”, doi10.1103/PhysRevA.102.052222, arXiv:2011.03513

Ananda Gopal Maity

Ph.D. student, S. N. Bose National Centre for Basic Sciences, India

Title: Supremay of indefinite causal order in quantum communication

Abstract:
We introduce the task of random-receiver quantum communication, in which a sender transmits a quantum message to a receiver selected from a list of n spatially separated parties. At the moment of transmission, the choice of receiver is unknown to the sender. Later, it becomes known to the n parties, who coordinate their actions

by exchanging classical messages. In normal conditions, random-receiver quantum communication requires a noiseless quantum communication channel between the sender and each of the n receivers. In contrast, we show that random-receiver quantum communication can take place through noisy, entanglement-breaking channels if the order of such channels is coherently controlled by a quantum bit that is accessible through measurements. While this phenomenon is achieved with a single control qubit, it cannot be mimicked by adding a noiseless qubit channel from the sender to any of the receivers, or more generally, from the sender to any subset of k < n parties.

Reference:

Some Sankar Bhattacharya, Ananda G. Maity , TamalGuha, Giulio Chiribella and ManikBanik, “Random-Receiver Quantum Communication”, PRX QUANTUM 2, 020350 (2021)

Ritajit Majumdar

Ph.D. student, Indian Statistical Institute, Kolkata, India

Title: Optimizing Ansatz Design in QAOA for Max-cut

Abstract:

QAOA is studied primarily to find good approximate solutions to combinatorial optimization problems. For a graph G=(V,E), |V|=n, |E|=m, a depth p QAOA for Max-Cut requires 2mp CNOT gates. CNOT is 100x more error prone than single qubit gates. Here we propose two hardware independent methods to reduce the number of CNOT gates in the first iteration of a QAOA circuit for Max-Cut while retaining functional equivalence. We propose a method that constructs the Depth First Search (DFS) on the input graph and eliminates n-1 CNOT gates, but increases the depth of the circuit. We prove that no further CNOT eliminations is possible, and analytically derive the criteria for which the reduction in CNOT gates overshadows this increase in depth, leading to an overall lower error probability. All existing IBM Quantum Hardware satisfy this criteria. Finally, we propose an O(delta.n^2) greedy heuristic algorithm, delta being the maximum degree of the graph, that finds a spanning tree of lower height, thus reducing the overall depth of the circuit while retaining the n-1 elimination of CNOT gates. We numerically show that this algorithm achieves ~ 84.8% reduction in depth from the DFS method. Probable methods to scale this for higher p is under study.

Reference:

arXiv:2106.02812(*[Submitted on 5 Jun 2021 (v1), last revised 28 Jun 2021 (this version, v4)],* Optimizing Ansatz Design in QAOA for Max-cut; RitajitMajumdar, Dhiraj Madan, DebasmitaBhoumik, DhinakaranVinayagamurthy, SheshaRaghunathan, Susmita Sur-Kolay)

arXiv:2110.04637(Depth Optimized Ansatz Circuit in QAOA for Max-Cut; RitajitMajumdar, DebasmitaBhoumik, Dhiraj Madan, DhinakaranVinayagamurthy, SheshaRaghunathan, Susmita Sur-Kolay)

Vaisakh Mannalath

Junior Research Fellow, PMSE, JIIT, India

Title: Bounds on semi-device-independent quantum random number expansion

Abstract:
Randomness plays a vital role in simulation algorithms, cryptographic protocols, etc. Since any process that generates them should be an intrinsically random physical process, certifying them is a nontrivial task. Random number generators based on quantum theory address this issue and have been studied extensively [1]. A semi-device independent (SDI) approach to such problems is used when no assumptions are made about the devices, except for the dimension of the quantum system used [2]. This work explores the randomness generation efficiency of SDI protocols and attempts to derive upper bounds on the generated randomness. A class of prepare and measure protocols is defined along with their corresponding witness values that distinguish between classical and quantum processes. An upper bound is subsequently derived for the maximum entropy generated by this class of protocols. The explicit protocol is formulated which saturates this upper bound while consuming fewer resources compared to the existing protocols. Analytical relationships between the amount of generated randomness and observed statistics were derived, demonstrating noise- robustness. The results can be directly applied for random number generation, self-testing quantum devices.

References:
[1] M. Herrero-Collantes, J. C. Garcia-Escartin, Quantum random number generators, Reviews of Modern Physics 89 (1) (2017) 015004.
[2] H.-W. Li, Z.-Q.Yin, Y.-C.Wu, X.-B.Zou, S. Wang, W. Chen, G.-C.Guo, Z.-F.Han,Semi-device-independent random-number expansion without entanglement, Physical Review A 84 (3) (2011) 034301.
[3] Vaisakh Mannalath, Anirban Pathak, “Bounds on semi-device-independent quantum random number expansion capabilities”, arXiv:2111.14082 [Submitted on 28 Nov 2021].

Arindam Mitra

Optics and Quantum Information Group, The Institute of Mathematical Sciences, C. I. T. Campus, Taramani, Chennai 600113, India.

Title: Layers of classicality in the compatibility of measurements

Abstract:
The term “layers of classicality” in the context of quantum measurements was introduced by T. Heinosaari [Phys. Rev. A 93, 042118 (2016)]. The strongest layer among these consists of the sets of observables that can be broadcast and the weakest layer consists of the sets of compatible observables. There are several other layers in between those two layers. In this work, we study their physical and

geometric properties and show the differences and similarities among the layers in these properties. In particular we show that (i) none of the layers of classicality respect transitivity property, (ii) the concept like degree of broadcasting similar to degree of compatibility does not exist, (iii) there exist informationally incomplete positive operator-valued measures that are not individually broadcastable, (iv) a set of broadcasting channels can be obtained through concatenation of broadcasting and nondisturbing channels, (v) unlike compatibility, other layers of classicality are not convex, in general. Finally, we discuss the relations among these layers. More specifically, we show that a specific type of concatenation relations among broadcasting channels decides the layer in which a pair of observables resides.

Reference:

A. Mitra, Phys. Rev. A 104, 022206 (2021).

Brij Mohan

Ph.D. student, QIC Gp, Harish-Chandra Research Institute, India

Title: Quantum speed limits for information and coherence

Abstract:
The quantum speed limit indicates the maximal evolution speed of the quantum system. In this work, we determine speed limits on the informational measures, namely the von Neumann entropy, maximal information, and coherence of quantum systems evolving under dynamical processes. These speed limits ascertain the fundamental limitations on the evolution time required by the quantum systems for the changes in their informational measures. Erasing of quantum information to reset the memory for future use is crucial for quantum computing devices. We use speed limit on the maximal information to obtain minimum time required to erase the information of quantum systems via some quantum processes of interest.

Reference:

arXiv:2110.13193, 2021 [Brij Mohan, Siddhartha Das, Arun Kumar Pati, Submitted on 25 Oct 2021]

Amit Mukherjee

Post doc, Satyendra Nath Bose National Centre for Basic Sciences, India.

Title: Multiparty orthogonal product states with minimal genuine nonlocality

Abstract:
Nonlocality without entanglement and its subsequent generalizations offer deep information-theoretic insights and subsequently find several useful applications. The concept of a genuinely nonlocal set of product states emerges as a natural multipartite generalization of this phenomenon. The existence of such sets eventually raises the problem concerning their entanglement-assisted discrimination. Here, we construct examples of genuinely nonlocal product states for an arbitrary number of parties. The strength of genuine nonlocality of these sets can be

considered minimal as their perfect discrimination is possible with entangled resources residing in Hilbert spaces having the smallest possible dimensions. Our constructions lead to fully separable measurements that are impossible to implement even if all but one party come together. Furthermore, they also provide the opportunity to compare different multipartite states that otherwise are incomparable under single copy local manipulation.

Reference:
“Multiparty orthogonal product states with minimal genuine nonlocality”, Sumit Rout, Ananda G. Maity, Amit Mukherjee, SaronathHalder, and ManikBanik; Phys. Rev. A 104, 052433 – Published 30 November 2021

Muthumanimaran Vetrivelan

Ph.D. student, Indian Institute of Technology Bombay, India

Title: Near-Deterministic Weak-Value Metrology via Collective non-Linearity

Abstract:
Weak-value amplification employs post-selection to enhance the measurement of small parameters of interest. The amplification comes at the expense of reduced success probability, hindering the utility of this technique as a tool for practical metrology. Following other quantum technologies that display a quantum advantage, we formalize a quantum advantage in the success probability and present a scheme based on non-linear collective Hamiltonians that shows a super-extensive growth in success probability while simultaneously displaying an extensive growth in the weak value. We propose an experimental implementation of our scheme.

Reference:
https://arxiv.org/abs/2012.13749 (MuthumanimaranVetrivelan, Sai Vinjanampathy)

Javid Naikoo

Post doc, Centre of New Technologies, Uof Warsaw, Poland

Title: Multiparameter estimation perspective on EP sensing

Abstract:
Non-Hermitian systems may exhibit a special kind of degeneracy of energy levels that is accompanied by a coalescence of the corresponding eigenvectors and the system is said to be at an exceptional point (EP). An example of such a system involves two coupled optical cavities bearing loss/ and gain. The loss, gain and coupling strength together determined the condition for the occurrence of an EP. Such systems have been reported to exhibit enhanced sensitivity properties [1,2]. Recently the sensing properties of quantum avatars of such systems have been explored in single parameter setting, by perturbing energies of the system, leading to quadratic scaling [3] and enhanced signal to power ratio [4]. However, a realistic situation demands a multiparameter treatment where energies and coupling strength are perturbed simultaneously. Our study reveals that with such a setting, a linear scaling predicted by the quantum Cramer-Rao bound (CRB), is the best one can

achieve. Surprisingly, one can not recover the quadratic scaling even in the single parameter limit of this multiparameter case. Further, a heterodyne measurement of the scattered field quadratures achieves the same sensitivity as predicted by the quantum CRB, thereby proving to be an optimal measurement strategy for this system [5].

Reference:

[1] Weijian Chen, et. al., Exceptional points enhance sensing in an optical microcavity, Nature 548, 192–196 (2017).

[2] Hossein Hodaei, et. al., Enhanced sensitivity at higher-order exceptional points, Nature 548, pages187–191 (2017).

[3] Mengzhen Zhang, et. al., Quantum Noise Theory of Exceptional Point Amplifying Sensors, Physical Review Letters 123, 180501 (2019).

[4] Hoi-Kwan Lau and Aashish A. Clerk, Fundamental limits and non-reciprocal approaches in non-Hermitian quantum sensing, Nature Communications 9, 4320 (2018).

[5] JavidNaikoo, RavindraChhajlany, Jan Kolodynski, Multiparameter estimation perspective on EP sensing [To be communicated]

Sumit Nandi

Post doc, S. N. Bose National Centre for Basic Sciences, India

Title: Genuine multi-partite nonlocality by generalizing Wigner's approach

Abstract:
Wigner had derived a form of local realist (LR) inequality, distinct from Bell's approach, which is quantum-mechanically violated for a bipartite maximally entangled state. Subsequently, Wigner's approach was extended for arbitrary two-qubit states, and then generalized to obtain a multi-partite LR inequality that is violated by all pure entangled states. However, firstly, violation of this multi-partite inequality does not signify what is called genuine multi-partite non-locality, that is, non-locality between any two parties. Secondly, from the violation of such inequality, we can not detect the parties that are non-locally correlated. Our present work overcomes these limitations by formulating an appropriate generalization of Wigner's approach leading to multi-partite LR inequalities. We have obtained a set of LR inequalities that are derived with respect to all possible bi-partitions/cuts of an arbitrary N-party scenario. Violation of the full set of inequalities certifies genuine non-locality of an N-partite quantum state. Moreover, violations of some of the inequalities imply non-locality in the respective bi-partitions/cuts for which those particular inequalities are derived. Thus, the proposed scheme provides a finer characterization of the non-local nature of a multi-partite quantum state. The efficacy of the scheme thus developed is illustrated for the tripartite and quadripartite scenarios.

Reference:

Neha Pathania

Ph.D. student, Centre for Theoretical Physics, Jamia Millia Islamia, INDIA

Title: Quantifying entanglement with Coherence

Abstract:
Quantifying entanglement is a work in progress which is important for the active field of quantum information and computation. We have proposed a measure of bipartite pure state entanglement named “Entanglement Coherence”, which is essentially the normalized coherence of the entangled state in its Schmidt basis. Its value is 1 for maximally entangled state and 0 for separable states, irrespective of the dimensionality of the Hilbert space. So, a maximally entangled state is also the one which is maximally coherent in its Schmidt basis. Quantum Entanglement and Quantum Coherence are thus intimately connected.
We also found out that our measure is closely related to the unified entropy of the reduced state of one of the sub-systems. Additionally, we have shown an interesting relation between entanglement coherence and the Wigner -Yanase skew information of the reduced density operator of one of the subsystems.
Reference:
N. Pathania, T. Qureshi, “Quantifying Entanglement with Coherence”, arXiv:2011.12976

Ram Krishna Patra

Ph.D. Student, IISER Thiruvananthapuram, India

Title: Mutually Unbiased Balanced Functions & Generalized Random Access Codes

Abstract:
Quantum resources and protocols are known to outperform their classical counterparts in variety of communication and information processing tasks. Random Access Codes (RACs) are one such cryptographically significant family of bipartite communication tasks, wherein, the sender encodes a data set (typically a string of input bits) onto a physical system of bounded dimension and transmits it to the receiver, who then attempts to guess a randomly chosen part of the sender's data set (typically one of the sender's input bits). In this work, we introduce a generalization of this task wherein the receiver, in addition to the individual input bits, aims to retrieve randomly chosen functions of sender's input string. Specifically, we employ sets of mutually unbiased balanced functions (MUBF), such that perfect knowledge of any one of the constituent functions yields no knowledge about the others. We investigate and bound the performance of (i.) classical, (ii.) quantum prepare and measure, and (iii.) entanglement assisted classical communication (EACC) protocols for the resultant generalized RACs (GRACs). Finally, we detail the case of GRACs with three input bits, find maximal success probabilities for classical, quantum and EACC protocols, along with the effect of noisy quantum channels on the performance of quantum protocols. Moreover, with the help of this case study, we reveal several characteristic properties of the GRACs which deviate from the standard RACs.
Reference:

Vaisakh M, Ram krishna Patra, MuktaJanpandit, Samrat Sen, ManikBanik, and AnubhavChaturvedi, “Mutually unbiased balanced functions and generalized random access codes”, Phys. Rev. A 104, 012420 – Published 21 July 2021(arXiv:2105.03932).

Tapaswini Patro

Ph.D. student, Department of Mathematics, BITS PILANI, India

Title: Absolute fully entangled fraction from spectrum

Abstract:
Fully entangled fraction (FEF) is a significant figure of merit for density matrices. In bipartite d ⊗ d quantum systems, the threshold value FEF > 1/d, dictates prominent implications for tasks like teleportation and entanglement distillation. Like separability, the value of FEF is also related to the choice of global basis of the underlying Hilbert space. A state having its FEF ≤ 1/d, might give a value > 1/d in another global basis. A change in the global basis corresponds to a global unitary action on the quantum state. In the present work, we find that there are quantum states whose FEF remains less than 1/d, under the action of any global unitary i.e., any choice of global basis. Based on the fixed spectrum of density matrices we provide necessary and sufficient criterion in two qubit systems which also proves to be sufficient in any d ⊗ d dimensions, to identify such states. Further we prove that states having their FEF bounded by 1/d under any global unitary, form a convex and compact set. This entails the distinction of states whose FEF can be increased beyond 1/d, through unitary action. The demarcation is of paramount importance as it provides for the identification of states which can prove to be useful in teleportation and entanglement distillation after the action of unitary gates, as underpinned by illustrations in our work.

Martin Plávala

Post doc, Universität Siegen, Department Physik, Emmy-Noether-Campus, Germany

Title: Operational Theories in Phase Space: Toy Model for the Harmonic Oscillator

Abstract:
We show how to construct general probabilistic theories that contains an energy observable dependent on position and momentum. The construction is in accordance with classical and quantum theory and allows for physical predictions, such as the probability distribution for position, momentum and energy. We demonstrate the construction by formulating a toy model for the harmonic oscillator that is neither classical nor quantum. The model features a discrete energy spectrum, a ground state with sharp position and momentum, an eigenstate with non-positive Wigner function as well as a state that has tunneling properties. The toy

model demonstrates that operational theories can be a viable alternative approach for formulating physical theories.

Reference:

Martin Plávala, Matthias Kleinmann, arXiv:2101.08323

Tanumoy Pramanik

Post doc, Institute of Physics, India

Title: Physical interpretation of nonlocal quantum correlation through local description of subsystems

Abstract:
Characterization and categorization of quantum correlations are both fundamentally and practically important in quantum information science. Although quantum correlations such as non-separability, steerability, and non-locality can be characterized by different theoretical models in different scenarios with either known (trusted) or unknown (untrusted) knowledge of the system, such characterization sometimes lacks unambiguous to experimentalist. In this work, we propose the physical interpretation of nonlocal quantum correlation between two systems. In absence of complete local description of one of the subsystems quantified by the local uncertainty relation, the correlation between subsystems becomes nonlocal. Remarkably, different nonlocal quantum correlations can be discriminated from a single uncertainty relation derived under local hidden state (LHS)-LHS model only. We experimentally characterize the two-qubit Werner state in different scenarios.

Arup Roy

A B N Seal College, India

Title: Classical capacity of Quantum Channel: Still an emerging issue in Quantum Information

Abstract:
Shannon's channel coding theorem describes the maximum possible rate of reliable information transfer through a classical noisy communication channel. It, together with the source coding theorem, characterizes lossless channel communication in the classical regime. Lossy compression scenarios require the additional description provided by rate-distortion theory, which characterizes the tradeoff between compression rate and the distortion of the compressed signal. Even in this context, the capacity characterizes the usefulness of a channel—a channel with more capacity will always outperform a channel with less capacity. We show that this is no longer true when sending classical information over a quantum channel. In particular, we find a pair of quantum channels where the channel with the lower capacity causes less distortion than the higher capacity channel when both are used at a fixed rate.

Saptarshi Roy

Post doc, Quantum Information and Computation Initiative, Uof Hong Kong, Hong Kong

Title: Gain in Performance of Quantum Teleportation with Uniformity-breaking Distributions

Abstract:
Prior information about the input state can be utilized to enhance the efficiency of quantum teleportation which we quantify using the first two moments of fidelity. The input knowledge is introduced by relaxing the uniformity assumption in the distribution of the input state and considering non-uniform distributions, namely the polar cap and von Mises-Fisher densities. In both the scenarios, we found analytical forms of average fidelities and their deviations in terms of correlators for arbitrary two-qubit states by following the standard teleportation scheme coupled with an adaptive LOCC (Local Operation and Classical Communication) protocol to utilize the prior information in the best possible way towards fidelity enhancement. For these distributions, depending on the shared resource state between the sender and the receiver, we show that the average fidelity increases while the deviation decreases with the increase of information content about the input ensemble thereby establishing its role as a resource. Our comparative study between these two distributions reveals that for the same amount of information content about inputs, although the average fidelity yield is the same for both, the polar cap distribution is "better" as it offers a smaller deviation.

Moreover, we contrast the resource of prior information with other resources involved in the protocol like shared entanglement and classical communication. Specifically, we observe that unlike uniform distribution, the amount of classical communication required to fulfill the task decreases with the increase of information available for inputs. We also investigate the role of prior information in higher (three) dimensional teleportation and report the signatures of dimensional advantage in prior information-based teleportation.
Reference:
Saptarshi Roy, Shiladitya Mal, Aditi Sen De, “Gain in Performance of Teleportation with Uniformity-breaking Distributions” arXiv:2010.14552[Submitted on 27 Oct 2020] [quant-ph] (to appear in Phys. Rev. A)

Debashis Saha

Post doc, S. N. Bose National Centre for Basic Sciences, India

Title: Unbounded advantage in communication complexity and semi-device independent quantum key distribution based on contextuality proofs

Abstract:

Quantum contextuality is one of the features existing in quantum theory that significantly differs from classical reality. The notion of quantum contextuality, proposed by Bell-Kochen-Specker, forbids us to assign a predetermined value of a quantum observable independent of the context of other observables that can be jointly measured. While quantum contextuality is witnessed on single quantum systems, quantum nonlocality, being particular instances of quantum contextuality, can only be observed on composite (entangled) systems. Unlike nonlocality, entanglement unassisted quantum contextuality has limited applications in the field of quantum communication and computation.

In this work, firstly, we show that any contextuality-proof in minimal dimension on its own offers an advantage over classical systems in a suitably designed one-way communication complexity (or distributed computation) task. In the one-way communication complexity task, the sender and the receiver obtain some inputs, and the receiver wants to compute a function of their received inputs. Moreover, for every state-dependent contextuality proof, the advantage is unbounded in the sense that the dimension of the classical systems required can be arbitrarily large compared to the dimension quantum system to accomplish the task. These communication complexity tasks having unbounded quantum advantage are the so-called 'equality problems' that appear in many practical scenarios. In addition to that, we introduce a semi-device independent protocol to establish quantum key distribution (QKD) between the sender and the receiver. The QKD protocol does not assume any internal working of the measurement device possessed by the receiver. The security of the protocol against any eavesdropper is proven using the monogamy relation of contextuality proofs.

Sutapa Saha

Ph.D. student, Indian Statistical Institute, India

Title: Quantum theory is exclusive: a distributed computing setup

Abstract:
We consider a model of computation where the computing device is comprised of several servers/ports placed at different spacetime locations -- the inputs are distributed among different ports, whereas the output is to be assessed by some other port. Communications among the different ports are limited as the physical systems allowed to be transmitted among them are constrained with information theoretic restrictions. We come up with computing tasks where quantum theory outperforms classical theory as well as a broader class of operational theories allowing states or/and effects more exotic than quantum theory. We also characterize the computations that can be perfectly accomplished in quantum theory but not in other operational theories. The proposed computing model thus provides a new approach to single out quantum theory in the theory space and promises a novel perspective towards the axiomatic derivation of Hilbert space quantum mechanics.
Reference:

Sutapa Saha, Tamal Guha, Some Sankar Bhattacharya, ManikBanik, “Distributed Computing Model: Classical vs. Quantum vs. Post-Quantum” arXiv : 2012.05781 [Submitted on 10 Dec 2020]

Shubhayan Sarkar

Ph.D. student, Center for Theoretical Physics, Polish Academy of Sciences, Poland

Title: Self-testing of any pure entangled state with minimal number of measurements and optimal randomness certification in one-sided device-independent scenario

Abstract:
Certification of quantum systems and their properties has become a field of intensive studies. Here, taking advantage of the one-sided device-independent scenario (known also as quantum steering scenario), we propose a self-testing scheme for all bipartite entangled states using a single family of steering inequalities with the minimal number of two measurements per party. Building on this scheme we then show how to certify all rank-one extremal measurements, including non-projective d^2-outcome measurements, which in turn can be used for certification of the maximal amount of randomness from every entangled bipartite state of local dimension d, that is, 2 log2 d bits. Finally, in a particular case of d = 3, we extend our self-testing results to the fully device-independent setting.
Reference:
arXiv:2110.15176v2 (Shubhayan Sarkar, Jakub J. Borkała, Chellasamy Jebarathinam, Owidiusz Makuta, Debashis Saha, Remigiusz Augusiak)

Tanmay Singal

Post doc, Institute of Physics, Nicolaus Copernicus University, Poland

Title: Approximate 3-designs and partial decomposition of the Clifford group representation using transvections

Abstract:
We study a scheme to implement an asymptotic unitary 3-design. The scheme implements a random Pauli once followed by the implementation of a random transvection Clifford by using state twirling. Thus the scheme is implemented in the form of a quantum channel. We show that when this scheme is implemented k times, then, in the $k\to\infty$ limit, the overall scheme implements a unitary 3-design. This is proved by studying the eigendecomposition of the scheme: the +1 eigenspace of the scheme coincides with that of an exact unitary 3-design, and the remaining eigenvalues are bounded by a constant. Using this we prove that the scheme has to be implemented approximately $O(m+\log 1/\epsilon)$ times to obtain an ϵ-approximate unitary 3-design, where m is the number of qubits, and ϵ is the diamond-norm distance of the exact unitary 3-design. Also, the scheme implements an asymptotic unitary 2-

design with the following convergence rate: it has to be sampled O(log1/ϵ) times to be an ϵ-approximate unitary 2-design. Since transvectionCliffords are a conjugacy class of the Clifford group, the eigenspaces of the scheme's quantum channel coincide with the irreducible invariant subspaces of the adjoint representation of the Clifford group. Some of the subrepresentations we obtain are the same as were obtained in J. Math. Phys. 59, 072201 (2018), whereas the remaining are new invariant subspaces. Thus we obtain a partial decomposition of the adjoint representation for 3 copies for the Clifford group. Thus, aside from providing a scheme for the implementation of unitary 3-design, this work is of interest for studying representation theory of the Clifford group, and the potential applications of this topic. In the end, we provide open questions regarding the scheme and representation theory of the Clifford group.
Reference:
Tanmay Singal, Min-Hsiu Hsieh, “Approximate 3-designs and partial decomposition of the Clifford group representation using transvections”
https://arxiv.org/abs/2111.13678 [Submitted on 26 Nov 2021]

Wojciech Słomczyński

Faculty, Institute of Mathematics, Jagiellonian University, Poland

Title: Morphophoric measurements and Urgleichung in self-dual Generalized Probabilistic Theories

Abstract:
Within the (self-dual) Generalized Probabilistic Theories (GPTs) approach we define the morphophoric measurements as those for which the measurement map transforming states into distributions of the measurement results is a similarity. In quantum case, morphophoric measurements generalise the notion of a 2-design POVM, thus in particular that of a SIC-POVM. We show that the theory built on this class of measurements retains the chief features of the QBism approach to the basis of quantum mechanics. The intrinsic geometry of a generalised qplex is the same as that of the set of quantum states. We explore its external geometry, investigating, inter alia, the algebraic and geometric form of the inner (basis) and outer (primal) polytopes, between which the generalised qplex is sandwiched. Moreover, we show how to extend the primal equation (‘Urgleichung’) of QBism, designed for SIC-POVMs, to the morphophoric case of self-dual GPTs. It then takes a different form but all the quantities that appear in the equation can be interpreted in probabilistic and operational terms, as in the original ‘Urgleichung’.
Reference:
W. Słomczyński, A. Szymusiak, Morphophoric POVMs, generalised qplexes, and 2-designs, Quantum 4 (2020), 338, arXiv:1911.12456v4 [quant-ph]

Sohail

Ph.D. student, HRI, India

Title: Convolution algebra of superoperators and nonseparability witnesses for quantum operations

Abstract:
We define a product between quantum superoperators which is preserved under the Choi-Jamiołkowski-Kraus-Sudarshan channel-state isomorphism. We then identify the product as the convolution on the space of superoperators, with respect to which the channel-state duality is also an algebra isomorphism. We find that any witness operator for detecting nonseparability of quantum operations on separated parties can be written entirely within the space of superoperators with the help of the convolution product.
Reference:
arXiv:2108.08776 (Sohail, Ujjwal Sen; [Submitted on 19 Aug 2021])

Chirag Srivastava

Ph.D. student, Harish-Chandra Research Institute, India

Title: Recycled entanglement detection by arbitrarily many sequential and independent pairs of observers

Abstract:
We investigate the witnessing of two-qubit entangled states by sequential and independent pairs of observers, with both observers of each pair acting independently on their part of the shared state from spatially separated laboratories, and subsequently passing their qubits to the next pair in the sequence. It has previously been conjectured that not more than one pair of observers can detect Clauser-Horne-Shimony-Holt "Bell-nonlocal" correlations in a similar set-up. This is intriguing since it is possible to have an arbitrarily long sequence of Bell-nonlocal correlations when only a single observer is allowed to share a bipartite state with multiple observers at the other end. It is therefore interesting to ask whether such restrictions are also present when entangled correlations are considered in the scenario of multiple pairs of observers. We find that a two-qubit entangled state can be used to witness entanglement arbitrarily many times, by pairs of observers, acting sequentially and independently. We prove the statement to be true when the initial pair of observers in the sequence share any pure entangled state or when they share a state from a class of mixed entangled states. We demonstrate that the phenomenon can also be observed for a certain class of entangled states in which an arbitrarily long sequence of observer pairs witnessing entanglement is reached in the limit of the initial entanglement content tending to a vanishing amount.
Reference:
arXiv:2201.02594 (Mahasweta Pandit, Chirag Srivastava, Ujjwal Sen)

Hari krishnan SV

Undergraduate Student, IISER TVM, India

Title: State space structure of tripartite quantum systems

Abstract:
One key observation on going from bipartite to tripartite quantum systems is that the positive partial transposition (PPT) criterion does not guarantee separability, even for the simplest three-qubit systems. This, along with the existence of biseparable states, leads to many peculiar properties in the state space structure of tripartite quantum systems, which is the focus of this talk.
In particular, it has been shown that the set of states separable across all the three bipartitions (say B-int) is a strict subset of the set of states having positive partial transposition across the three bipartite cuts (say P-int) for all the tripartite Hilbert spaces. The claim is proved by constructing a state belonging to P-int, but not to B-int.
For all tripartite systems other than the three-qubit system, the construction follows from a specific type of multipartite unextendible product bases. However, such construction is not possible for the three qubit case. So a different construction is presented.
Reference:
Phys. Rev. A 104, 022437 (arXiv:2104.06938) - State space structure of tripartite quantum systems, (Hari Krishnan S V, Ashish Ranjan, ManikBanik)

Vimalesh Kumar Vimal

Ph.D. student, Indian Institute of Technology, Kanpur, India

Title: Revival of Magnetization and Quantum correlations in Kitaev spin chain

Abstract:
We investigate the dynamics of a spin chain with Kitaev-type interaction in a transverse magnetic field, for both a constant field and a periodically kicked field. We investigate analytically the revivals in the dynamical behavior of the magnetization, and measures of local quantum correlations, the concurrence measure of the entanglement, and the quantum discord. The magnetization revivals are seen even for larger chain lengths, with reduced revival peaks, both near and away from the critical point at zero magnetic field. The quantum entanglement and correlation measures, contrary to the expected behavior, exhibit reduced quantum correlations in the critical region, compared to the region away from the critical point. The concurrence is larger than the quantum discord away from the critical region. The pair entanglement is near zero for all times in the critical region, though the quantum discord is nonzero, capturing the underlying diagonal correlations. The kicked magnetic field dynamics shows similar evolution for the magnetization and quantum correlations. For special values of the kicking period, the concurrence shows alternates between zero and nonzero values for successive kicks in the noncritical region.