# 2nd International Conference on Quantum Foundations 2016 (ICQF16)

(17-21 October, 2016)

## Conference Program

## Venue: Panache hotel, Patna

| 17th October 2016 | | | |
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| **Event** | | **Timing (IST)** | |
| Registration | | 09:00 - 10:00 | |
| Inauguration | | 10:00 – 10:30 | |
| Tea break | | 10:30 -11:00 | |
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| **Name of the speaker** | **Title of the talk** | **Timing (IST)** | **Duration* (min)** |
| **Chair:** A. Cabello | | | |
| P. Grangier** | Contexts, Systems and Modalities: a new ontology for quantum mechanics | 11:00-11:50 | 50 |
| T. Heinossari | Quantum Incompatibility - a review of recent results | 11:50-12:30 | 40 |
| **Lunch (12:30-14:00)#** | | | |
| **Chair:** P. Ghose | | | |
| C. Budroni | Causal structures and marginal problems | 14:00-14:40 | 40 |
| U. Sinha | A tale of three slits: From Superposition to Correlated qutrits | 14:40-15:20 | 40 |
| **Tea break(15:20-16:00)** | | | |
| **Chair:** A. R. Usha Devi | | | |
| P. Agrawal | Bell Nonlocality and Entanglement | 16:00-16:40 | 40 |
| J. Kofler | No Fine theorem for macrorealism | 16:40-17:20 | 40 |
| **Dinner(19:00 – 21:00) ##** | | | |
| **18th October 2016** | | | |
| **Chair:** D. Home | | | |
| A.Cabello** | Approaching Tsirelson's bound from theory and experiment | 09:30-10:20 | 50 |
| S. Ghosh | Study of nonlocal correlations in macroscopic measurement scenario | 10:20-11:00 | 40 |
| **Tea Break (11:00-11:30)** | | | |

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| **Chair:** G. Kar | | | |
| Y.-C. Liang | Quantifying quantum steerability and measurement incompatibility using uncharacterized devices | 11:30-12:10 | 40 |
| S. Banerjee | Evolution of coherence, concurrence and Fisher information under global environmental interaction | 12:10-12:50 | 40 |
| **Lunch (12:50-14:00)** | | | |
| **Chair:** A. Patel | | | |
| D. Home** | Unified Treatment of Non-locality in Teleportation and Remote State Preparation | 14:00-14:50 | 50 |
| Y. Shikano | Visualizing Quantum State by Weak Measurement | 14:50-15:30 | 40 |
| **Tea break (15:30-16:00)** | | | |
| **Chair:** P. Agrawal | | | |
| A. R. Usha Devi | Thermodynamic state-to-state tranforma-tion and work extraction | 16:00-16:40 | 40 |
| T. Qureshi | Wave-Particle Duality: Going Beyond Two Slits | 16:40-17:20 | 40 |
| **Dinner (19:00 – 21:00)** | | | |
| **19th October 2016** | | | |
| **Chair:** P. Grangier | | | |
| L. Vaidman** | The meaning of weak values | 09:30-10:20 | 50 |
| A.Patel | Weak Measurements, Quantum State Collapse and the Born Rule | 10:20-11:00 | 40 |
| **Tea Break (11:00-11:30)** | | | |
| **Chair:** U. Sinha | | | |
| M. Gramegna | Measuring non-commuting observables of a photon via sequential weak values evaluation | 11:30-12:10 | 40 |
| K. Edamatsu | Quantum measurement and uncertainty relations in photon polarization | 12:10-12:50 | 40 |
| **Lunch (12:50 - 14:00)** | | | |
| **Chair:** S. Ghosh | | | |
| R. Dumke | Superconducting Atom Chips | 14:00-14:40 | 40 |
| U. Sen | Quantum devices using systems with impurities | 14:40-15:20 | 40 |

**POSTER SESSION**
**(15:30-18:00)**

## Conference Dinner*#

(19:00 – 23:00)

## 20th October 2016

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| **Chair:** L. Vaidman | | | |
| G.Kar | Nonlocality and its relation with measurement incompatibility and uncertainty | 09:30-10:10 | 40 |
| M. Pawlowski | Detection efficiency loophole in tests of quantumness | 10:10-10:50 | 40 |
| **Tea Break (10:50-11:30)** | | | |
| **Chair:** T. Qureshi | | | |
| P. K. Panigrahi | Uncertainty relation and inseparability | 11:30-12:10 | 40 |
| D. Sarkar | Nonlocality in three qubit systems | 12:10-12:50 | 40 |
| **Lunch (12:50 – 14:00)** | | | |
| **Chair:** K. Edamatsu | | | |
| A. K. Pati | Products of weak values: uncertainty relations, complementarity and incompatibility | 14:00-14:40 | 40 |
| A. Abbott | A bridge from (entropic) preparation uncertainty relations to measurement uncertainty relations | 14:40-15:20 | 40 |
| **Tea break (15:20-16:00)** | | | |
| **Chair:** Y.-C. Liang | | | |
| P. Ghose | Continuous Transitions between Quantum and Classical Motions | 16:00-16:40 | 40 |
| Arvind | Contextuality, foundations of quantum mechanics, and quantum information processing | 16:40-17:20 | 40 |
| **Dinner(19:00 – 21:00)** | | | |

| 21st October 2016 | | | |
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| **Chair:** M. Pawlowski | | | |
| L. P. Garcia-Pintos | How does a continuously measured qubit really evolve? | 09:30-10:10 | 40 |
| S. Bandyopadhay | Entanglement cost of LOCC state discrimination | 10:10-10:50 | 40 |
| **Tea Break (10:50-11:20)** | | | |
| **Chair:** Arvind | | | |
| R. Rahaman | Quantum digital signatures based on multiparty Hardy type correlations | 11:20-12:00 | 40 |
| E. Haapasalo | Optimal measurements and extreme observables in quantum theory | 12:00-12:25 | 25 |
| S. Bhattacharya | Nonlocal correlations: Fair and Unfair Strategies in Bayesian Game | 12:25-12:50 | 25 |
| **Closing remarks** (12 :50 - 13 :00) | | | |
| **Lunch (13:00 - 14:30)** | | | |

*Duration includes the time for discussions. The duration of discussions is 10 minutes for keynote speakers and 5 minutes for rest of the speakers.

** Keynote speaker

[#] Lunches will be served in the Conference Hotel (Panache Hotel) for all participants.

[##]Dinners will be served at the same hotel/guest house where the participant is accommodated.

*[#]Conference Dinner will be served in the Hotel panache. All participants are invited to join.

2nd International Conference on

# Quantum Foundations 2016 (ICQF16)

*(17-21 October 2016)*

# Book of Abstracts

# Invited Talks

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|---|---|
| **Name** | **Arvind** |
| **Affiliation** | *IISER Mohali, India* |
| **Title** | **Contextuality, foundations of quantum mechanics, and quantum information processing** |
| **Abstract** | In this talk I will focus on the notion of contextuality in quantum physics. A recent connection between quantum contextuality and quantum information processing (QIP) will be discussed. I will describe our experimental results on the detection of contextuality in a single qutrit, and its use in the parity-finding algorithm. I will also examine this notion from a more fundamental point of view and describe possible alternatives. |
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| **Name** | **Alastair Abbott** |
| **Affiliation** | *Chapman University, Orange,USA* |
| **Title** | **A bridge from (entropic) preparation uncertainty relations to measurement uncertainty relations** |
| **Abstract** | In this talk I will discuss some recent progress on information-theoretic measurement uncertainty relations, and in particular, their connection to more traditional entropic preparation uncertainty relations. In particular, I will overview some recently proposed operational notions of noise and disturbance based on conditional entropies and their use in formulating uncertainty relations for both the joint-measurement noise and the noise-disturbance trade-off for quantum measurements. I will present some general results connecting the set of allowable noise-noise and noise-disturbance values to entropic uncertainty relations, before studying the case of qubits in detail. I present tight uncertainty relations for such systems, and discuss the interesting finding that four-outcome measurements are needed to perform optimal joint-measurements (with respect to the noise-noise trade-off), while three-outcome measurements seem to be optimal with respect to the noise-disturbance trade-off. |
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| **Name** | **Pankaj Agrawal** |
| **Affiliation** | *IOP, Bhubneswar, India* |
| **Title** | **Bell Nonlocality and Entanglement** |
| **Abstract** | We discuss relationship between the entanglement and Bell nonlocality. In the case of pure bipartite states the relationship is straightforward. In the case of bipartite mixed state, the relationship is bit more complicated. We also consider three qubit pure states, and a class of multiqubit states. We find a set of Bell inequalities that are violated by these states. For the states that admit generalized Schmidt Decomposition, these inequalities relate Bell inequality violation with the amount of entanglement in the state. In other cases, one can separate genuinely entangled states from not genuinely entangled states. |
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| **Name** | **Costantino Budroni** |
| **Affiliation** | *University of Siegen, Germany* |
| **Title** | **Causal structures and marginal problems** |
| **Abstract** | We investigate the possibility of distinguishing among different causal relations starting from a limited set of marginals. Our main tool is the notion of adhesivity, that is, the extension of probability or entropies defined only on subsets of variables, which provides additional independence constraints among them. Our results provide a criterion for recognizing which causal structures are indistinguishable when only limited marginal information is accessible. Furthermore, the existence of such extensions greatly simplify the characterization of a marginal scenario, a result that facilitates the derivation of new Bell inequalities both in the probabilistic and entropic frameworks, and the identification of marginal scenarios where classical, quantum, and post-quantum probabilities coincide. |
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| **Name** | **S. Banerjee** |
| **Affiliation** | *IIT Jodhpur, India* |
| **Title** | **Evolution of coherence, concurrence and Fisher information under global environmental interaction** |
| **Abstract** | We discuss a useful global system-environment interaction and study the effect of non-Markovian behaviour on various facets of quantum coherence and correlations. The global part of the environmental interaction acts as a resource to compensate the effect of decoherence. We also talk about the case where the bath has memory. For the memory dependent non-Markovian case, the global interaction is seen to enhance the regeneration of coherence, entanglement and quantumness. This suggests that the global interaction helps the backflow of information from environment to the system via non-Markovian interaction. It is shown that for the case of zero temperature bath, as the strength of the global interaction increases, the unitary interaction between two qubits will dominate the dynamics. The amount of non-classicality generated by global environmental interaction is quantified. The generated quantum Fisher information is lower bounded by the quantumness and upper bounded by the $l_1$ norm of coherence. This gives an intuitive understanding of quantum Fisher information as a measure of non-classicality. Fisher information and the quantumness measure are both based on the non-commutativity of states and this property is precisely understood as the non-classicality of quantum states. The generated coherence, by any arbitrary global operation, is always greater than the created quantumness and Fisher information. |
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| **Name** | **S. Bandyopadhaya** |
| **Affiliation** | *Bose Institute, Kolkata, India* |
| **Title** | **Entanglement cost of LOCC state discrimination** |
| **Abstract** | A set of quantum states is said to be locally indistinguishable if the states cannot be optimally distinguished by means of local operations and classical communication (LOCC). We consider the problem of optimal discrimination of locally indistinguishable states using quantum entanglement as a resource. We will review the known results and discuss open problems. |

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| **Name** | **Adan Cabello**** |
| **Affiliation** | *University of Sevilla, Spain* |
| **Title** | **Approaching Tsirelson's bound from theory and experiment** |
| **Abstract** | We show that in general probabilistic theories, the maximum violation of the CHSH Bell inequality occurs for maximally incompatible local observables. In this case, the exclusivity principle implies the Tsirelson bound. This refines the argument presented in Phys. Rev. Lett. 114, 220402 (2015). On the other hand, Grinbaum has recently argued that Tsirelson's bound is unreachable because there is a previous natural bound. However, a recent experiment performed in Singapore shows a clear violation of Grinbaum's bound and provides the maximum violation of the CHSH Bell inequality ever observed [H. S. Poh et al., Phys. Rev. Lett. 115, 180408 (2015)]. We will discuss the implications of both results. |

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| **Name** | **R. Dumke** |
| **Affiliation** | *Nanyang Technological University, Singapore* |
| **Title** | **Superconducting Atom Chips** |
| **Abstract** | In recent years, microtraps for neutral atoms based on superconductors, i.e. 'superconducting atom chips' have become a subject of intensive research. Motivated by the prediction of extremely low magnetic and thermal noise compared to normal conductors, superconducting atom chips have first been implemented in the expectation of improving the coherence of atomic quantum states close to surfaces by several orders of magnitude. This boost in coherence time holds promising expectations for quantum information processing applications. In particular, superconducting atom chips are ideal candidates for the realization of hybrid quantum systems between atomic and superconducting solid state qubits, merging the fast gate operation times for superconducting qubits with the long coherence times of atomic qubits. In this talk I will discuss our work towards realizaing this hybrid quantun system via coupling ultracold atoms and superconducting circuits. |

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| **Name** | **K. Edamatsu** |
| **Affiliation** | *Tohoku University, Japan* |
| **Title** | **Quantum measurement and uncertainty relations in photon polarization** |
| **Abstract** | Measurement is the most fundamental issue in science and technology. Problems on quantum measurement and accompanying uncertainty relation, i.e., error-disturbance relation (EDR), have long been discussed in fundamental quantum physics. Recent theoretical progress in quantum measurements, including the concept of weak measurement and weak value, has revealed the new aspects of these issues. A photon has two degrees of freedom for its polarization, providing a simple two-level qubit system. However, quantum measurement of even the simplest system has not yet been fully understood. Here we present our recent experiments [1, 2, 3] in which we realize the generalized, strength-variable measurement of the photon polarization qubit and evaluate its EDRs. We evaluated the measurement error in H-V polarization measurement and disturbance in ±45 polarization |

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| | measurement by varying the measurement strength. We found that the experimental data clearly violate Heisenberg's EDR, yet satisfy other recently proposed EDRs [4, 5, 6]. In particular, our experimental data were close to Branciard's bound [5] for a qubit which could be saturated by ideal experiments. It is noteworthy that Heisenberg's EDR would be valid if our generalized measurement was unbiased both in error and in disturbance.<br>**References:**<br>[1] S.-Y. Baek, F. Kaneda, M. Ozawa, and K. Edamatsu, Sci. Rep. 3, 2221 (2013).<br>[2] F. Kaneda, S.-Y. Baek, M. Ozawa, and K. Edamatsu, Phys. Rev. Lett. 112, 020402 (2014).<br>[3] K. Edamatsu, Phys. Scr. 91, 073001 (2016).<br>[4] M. Ozawa, Phys. Rev. A 67, 042105 (2003).<br>[5] C. Branciard, Proc. Nat. Acad. Sci. 110, 6742 (2013).<br>[6] P. Busch, P. Lahti and R.F.Werner, Phys. Rev. A 89, 012129(2014). |
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| **Name** | **Luis Pedro Garcia-Pintos** |
| **Affiliation** | *Chapman University, Orange, USA* |
| **Title** | **How does a continuously measured qubit really evolve?** |
| **Abstract** | We focus on the question of what a quantum system really did during a period of time over which it was continuously monitored. First, we consider the simultaneous monitoring of two noncommuting observables -- as recently implemented by the Siddiqi group at UC Berkeley -- and show the manifest violation of standard inequalities for testing Leggett-Garg macrorealism. Despite this apparent lack of realism, we then construct a realistic, but epistemically restricted, model that exactly reproduces the quantum results. Second, for continuous measurements of a single observable it is widely recognized that the measurement output approximates the expectation value of the observable, hidden by additive white noise. Filtering the measurement readout can thus approximately uncover the dynamics of the expectation value during a single realization. However, using information from the entire output history yields a different, "smoothed", observable estimate, which can be objectively closer to the experimental output than the usual expectation value. |
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| **Name** | **P. Grangier**** |
| **Affiliation** | *Institute of Optics, Palaiseau, France* |
| **Title** | **Contexts, Systems and Modalities: a new ontology for quantum mechanics** |
| **Abstract** | Starting from the Einstein-Bohr debate, we propose a way [1] to make usual quantum mechanics compatible with physical realism, defined as the statement that the goal of physics is to study entities of the natural world, existing independently from any particular observer's perception, and obeying universal and intelligible rules. Rather than elaborating on the quantum formalism itself, we modify the quantum ontology, by requiring that physical properties are attributed jointly to the system, and to the context in which it is embedded. In combination with a quantization principle, this non-classical definition of physical reality sheds new light on counter-intuitive features of quantum mechanics such as the origin of probabilities, non-locality, and the quantum-classical boundary. |

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| | [1] A. Auffèves and P. Grangier, Found. Phys. 46, 121 (2016); arXiv: 1409.2120. |
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| **Name** | **P. Ghose** |
| **Affiliation** | *National Academy of Sciences, India* |
| **Title** | **Continuous Transitions between Quantum and Classical Motions** |
| **Abstract** | A generalized mechanics is formulated in terms of a wave function satisfying a nonlinear Schrödinger equation that interpolates smoothly between classical and quantum mechanics. Continuous transitions between classical and quantum motions (in terms of Bohmian trajectories) are demonstrated for a double-slit and a 2D harmonic oscillator. The method should be of interest for mesoscopic systems that are neither fully classical nor quantum mechanical. |
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| **Name** | **S. Ghosh** |
| **Affiliation** | *IMSc, Chennai, India* |
| **Title** | **Study of nonlocal correlations in macroscopic measurement scenario** |
| **Abstract** | Nonlocality is one of the main characteristic features of quantum systems involving more than one spatially separated subsystems. It is manifested theoretically as well as experimentally through violation of some local realistic inequality. But, generally it is difficult to deal with individual particles in real experiment. One has to rather address beam of particles which may cause dilution of nonlocal behavior. Moreover, classical behavior of all physical phenomena at macroscopic limit gives a general intuition that any physical theory -- for describing microscopic phenomena -- should resemble classical physics at macroscopic regime. In the 2-2-2 scenario (two parties, each performing two measurements, each measurement with two outcomes), contemplating all the correlations that may be stronger than quantum mechanics in exhibiting nonlocal behavior, yet weak enough to prohibit instantaneous signaling, we characterize which of them exhibit classical (local-realistic) behaviour in the microscopic scale. Interestingly, we find that there exist correlations which indeed remain nonlocal at the macroscopic scale and hence fail to be considered as physical one. Our study thus provides a sufficient criterion to identify some of unphysical correlations. |
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| **Name** | **M. Gramegna** |
| **Affiliation** | *INRIM, Torino, Italy* |
| **Title** | **Measuring non-commuting observables of a photon via sequential weak values evaluation** |
| **Abstract** | Report on the first experimental verification of the peculiar predictions regarding single and sequential weak values on a unique quantum particle, and to be specific related to the simultaneous measure of noncompatible polarization observable of a single photon [1]. This experimental evidence ould result at odd with “one of the canonical dicta of quantum mechanics” [2]: the impossibility of measuring two non-commuting observable at the same time because of the wave function collapse. Nevertheless, in the framework of weak |

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| | measurements (WMs) this impossibility can be partially smoothed if sequential or joint weak values evaluation is taken into account [2–5]. In fact, operating within this quantum measurement paradigm, weak values are obtained extracting only a small amount of information from a single measurement, preventing the collapse of the initial quantum state.<br><br>**References:**<br><br>1. F. Piacentini, et al., arXiv:1508.03220. 2. G. Mitchison, R. Jozsa, and S. Popescu, Phys. Rev. A 76, 062105 (2007).<br>3. K. J. Resch, et al., Phys. Rev. Lett. 92, 130402 (2004).<br>4. Y. Aharonov, D. Z. Albert & L. Vaidman, Phys. Rev. Lett. 60, 1351-1354 (1988).<br>5. A. G. Kofman, S. Ashhab & F. Nori, Phys. Rep. 520, 43-133 (2012). |
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| **Name** | **T. Heinosaari** |
| **Affiliation** | *University of Turku, Finland* |
| **Title** | **Quantum Incompatibility - a review of recent results** |
| **Abstract** | One of the fundamental features of quantum theory is that not all observables are jointly measurable. This observation goes back to the Heisenberg's uncertainty principle and Bohr's notion of complementarity, and has since then been studied extensively. Two observables that do not have a joint measurement are called incompatible. Incompatibility can be defined not only for observables but also for other types of devices, such as quantum channels. The compatibility relation on channels can be characterized in terms of concatenation and conjugation. This reveals that several important quantum phenomena, such as the impossibility of universal broadcasting and measurement disturbance, are implications of quantum incompatibility. In this talk I will present the general definition of incompatibility, discuss several recent results and mention some open questions. |
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| **Name** | **D. Home**** |
| **Affiliation** | *Bose Institute, Kolkata, India* |
| **Title** | **Unified Treatment of Non-locality in Teleportation and Remote State Preparation** |
| **Abstract** | An overarching logical framework for probing non-locality is formulated that encompasses teleportation as well as remote state preparation (RSP).This is done by setting up Bell-CHSH inequalities appropriate for each protocol. It is then shown that for the common resource of non-maximally entangled pure states, the amount of nonlocality involved in the correlations used for the transfer of information in each of these schemes is the same. This implies that the essential difference between teleportation and RSP is the amount of classical information exchanged. Such an analysis can be extended for other information transfer protocols which would enable a systematic study of non-locality as resource for transfer of quantum information. |
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| **Name** | **G. Kar** |
| **Affiliation** | *ISI Kolkata, India* |
| **Title** | **Nonlocality and its relation with measurement incompatibility and uncertainty** |
| **Abstract** | Quantum nonlocality is revealed through the violation of some Bell's inequality. It is known that largest quantum violation of Bell-CHSH inequality is $2\sqrt{2}$. Recently it has been shown that this bound can be derived by optimizing over quantum steering and quantum (fine grained) uncertainty. On the other hand, it has also been shown that the degree of measurement incompatibility of a no-signaling theory provides an upper bound for the violation of Bell-CHSH inequality and this bound is saturated in quantum mechanics by the amount of optimal violation determined by steering and uncertainty relation. Is it true for every no signaling theory if we use its all possible correlations? Spekkens Toy theory is a counter example. We argue that the degree of measurement incompatibility in Spekkens' Toy theory is nontrivial due to existence of steering, but the presence of high uncertainty in the theory does not allow it to reach the bound of Bell-CHSH expression and moreover makes it local. |
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| **Name** | **J. Kofler** |
| **Affiliation** | *Max Planck Institute of Quantum Optics (MPQ), Garching, Germany* |
| **Title** | **No Fine theorem for macrorealism** |
| **Abstract** | Tests of local realism and macrorealism have historically been discussed in very similar terms: Leggett-Garg inequalities follow Bell inequalities as necessary conditions for classical behavior. Here, we compare the probability polytopes spanned by all measurable probability distributions for both scenarios and show that their structure differs strongly between spatially and temporally separated measurements. We arrive at the conclusion that, in contrast to tests of local realism where Bell inequalities form a necessary and sufficient set of conditions, no set of inequalities can ever be necessary and sufficient for a macrorealistic description. Fine's famous proof that Bell inequalities are necessary and sufficient for the existence of a local realistic model, therefore cannot be transferred to macrorealism. A recently proposed condition, no-signaling in time, fulfills this criterion, and we show why it is better suited for future experimental tests and theoretical studies of macrorealism. Our work thereby identifies a major difference between the mathematical structures of local realism and macrorealism.<br><br>Ref: Phys. Rev. Lett. 116, 150401 (2016). |
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| **Name** | **Y-C. Liang** |
| **Affiliation** | *National Cheng Kung University, Taiwan* |
| **Title** | **Quantifying quantum steerability and measurement incompatibility using uncharacterized devices** |
| **Abstract** | We introduce the concept of assemblage moment matrices, i.e., a collection of matrices of expectation values, each associated with a conditional quantum state obtained in a steering experiment. We |

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| | demonstrate how it can be used or quantum state and measurement characterization in a device-independent manner, i.e., without invoking any assumption about the measurement nor the preparation device. Specifically, we show how the method can be used to lower bound the steerability of an underlying quantum state directly from the observed correlation between measurement outcomes. In addition, by proving a quantitative relationship between steering robustness and the recently introduced incompatibility robustness, our approach also allows for a device-independent quantification of the incompatibility (i.e., non-joint-mesurability) between various measurements performed in a Bell-type experiment. |
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| **Name** | **A.K. Pati** |
| **Affiliation** | *HRI, Allahabad, India* |
| **Title** | **Products of weak values: uncertainty relations, complementarity and incompatibility** |
| **Abstract** | The products of weak values of quantum observables are shown to be of value in deriving quantum uncertainty and complementarity relations, for both weak and strong measurement statistics. First, a 'product representation formula' allows the standard Heisenberg uncertainty relation to be derived from a classical uncertainty relation for complex random variables. We show this formula also leads to strong uncertainty relations for unitary operators, and underlies an interpretation of weak values as optimal (complex) estimates of quantum observables. Furthermore, we show that two incompatible observables that are weakly and strongly measured in a weak measurement context obey a complementarity relation under the interchange of these observables, in the form of an upper bound on the product of the corresponding weak values. Moreover, general trade-off relations, between weak purity, quantum purity and quantum incompatibility, and also between weak and strong joint probability distributions, are obtained based on products of real and imaginary components of weak values, where these relations quantify the degree to which weak probabilities can take anomalous values in a given context. |
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| **Name** | **M. Pawłowski** |
| **Affiliation** | *Gdansk University, Poland* |
| **Title** | **Detection efficiency loophole in tests of quantumness** |
| **Abstract** | Tests of quantumness are experiments which enable us to exclude the possibility of modelling them with classical means. They enable us to prove strong statements about the nature of the universe and obtain cryptographic protocols with an unprecedented level of security. One of the biggest problems with these experiments is called "detection efficiency loophole". It refers to the fact that with the current technology most of the results is inconclusive because of the losses in transmission and detection of the particles. In this talk I'll start by presenting the loophole and outlining the dangers it posses both to fundamental research and practical cryptography. Then I'll discuss our latest results on optimization of setups and procedures which increase the critical amount of tolerated losses above which the experiments are inconclusive. |

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| **Name** | **P.K. Panigrahi** |
| **Affiliation** | *IISER Kolkata, India* |
| **Title** | **Uncertainty relation and inseparability** |
| **Abstract** | Inseparability inequality for a bipartite M N system has been derived using partial transpose on the Casimir operators of the composite system. For the special case of two qubit system, it is shown to be equivalent to the bi-linear entanglement witness operators. Then using Schrodinger-Robertson uncertainty relation a stronger inseparability condition than bi-linear entanglement witness has been derived. |

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| **Name** | **Apoorva Patel** |
| **Affiliation** | *IISc, Bengaluru, India* |
| **Title** | **Weak Measurements, Quantum State Collapse and the Born Rule** |
| **Abstract** | Projective measurement is used as a fundamental axiom in quantum mechanics, even though it is discontinuous and cannot predict which measured operator eigenstate will be observed in which experimental run. The probabilistic Born rule gives it an ensemble interpretation, predicting proportions of various outcomes over many experimental runs. Understanding gradual weak measurements requires replacing this scenario with a dynamical evolution equation for the collapse of the quantum state in individual experimental runs. We revisit the quantum trajectory framework that models quantum measurement as a continuous nonlinear stochastic process. We investigate the restrictions needed on the ensemble of quantum trajectories so as to reproduce projective measurement in the appropriate limit. We can describe the ensemble of quantum trajectories as white noise fluctuations on top of geodesics that attract the quantum state towards the measured operator eigenstates. The Born rule is reproduced when the magnitudes of the noise and the attraction are precisely related, in a manner reminiscent of the fluctuation-dissipation theorem. That implies that the noise and the attraction have a common origin in the system-apparatus measurement interaction. Moreover, the ensemble distribution of quantum trajectories is completely determined in terms of a single evolution parameter, which can be tested in weak measurement experiments. |

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| **Name** | **T. Qureshi** |
| **Affiliation** | *Jamia Milia Islamia University, New Delhi, India* |
| **Title** | **Wave-Particle Duality: Going Beyond Two Slits** |
| **Abstract** | Wave-particle duality, in the context of two-slit experiments, is quantitatively stated by a well-known duality relation. While various attempts have been made to go beyond two slits, a satisfactory solution was elusive. We introduce a new definition of path-distinguishability, based on unambiguous quantum state discrimination (UQSD). Using this distinguishability we derive a new duality relation for the 3-slit experiment, namely, an inequality between distinguishability and interference visibility. We further show that if one quantifies wave-nature by a measure of coherence, a duality relation can be obtained for n-slit interference. This general duality relation is able to recover known results for the 3-slit and 2-slit cases. |

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| **Name** | **R. Rahaman** |
| **Affiliation** | *Allahabad University, Allahabad, India* |
| **Title** | **Quantum digital signatures based on multiparty Hardy type correlations** |
| **Abstract** | Digital signature (DS), a cryptographic scheme, allows to send authentic message(s) from one sender to multiple recipients. A DS ensures that the message was created by a known sender and the sender cannot deny having sent the message. Also, the message was not altered in transit. Classical DS schemes offer security relying on unproven computational assumptions. In contrast, quantum digital signatures offer information-theoretic security based on laws of quantum mechanics. Here, we present a quantum digital signatures (QDS) scheme based on a multiparty non-inequality test know as generalized Hardy-type non-locality argument. Generalized Hardy type argument uses a set of conditions impossible for classical systems, but satisfied by predictions for a unique n-qubit state. Like Bell's inequality it also disproves the possibility of local realistic description of quantum correlations but without inequalities. In our scheme, the bits used for DS do not come from the results of the measurements on an entangled state but from the choices of settings unlike the existing QDS schemes. |
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| **Name** | **D. Sarkar** |
| **Affiliation** | *Calcutta University, Kolkata, India* |
| **Title** | **Nonlocality in three qubit systems** |
| **Abstract** | Nonlocal correlations arising from measurements on tripartite entangled states can be classified into two groups, one genuinely 3-way nonlocal and other local with respect to some bipartition. Still, whether a genuine tripartite entangled quantum state can exhibit genuine 3-way nonlocality, remains a challenging problem so far as measurement context is concerned. Here we introduce a novel approachin this regard. We consider three genuine tripartite mixed entangled quantum states none of which is genuinely 3-way nonlocal in original Bell scenario, but they can exhibit genuine 3-way nonlocality when distributed in some suitable measurement context. So, genuine 3-way nonlocality is a nonadditive resource, which can be revealed. Our result implies that genuine 3-way nonlocality of quantum states strongly depends on the measurement context contrary to the belief that genuine 3-way nonlocality can be exhibited only in original Bell scenario. Lastly, we will discuss about the nonlocality of GHZ symmetric states. We will show, genuine entanglement of GHZ-symmetric states is necessary to reveal standard nonlocality. However, it is not sufficient to exploit the same. |
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| **Name** | **U. Sen** |
| **Affiliation** | *HRI, Allahabad, India* |
| **Title** | **Quantum devices using systems with impurities** |
| **Abstract** | Using quantum mechanical rules can help us to greatly improve our abilities to communicate and compute. To realize such quantum-enabled devices requires controlling quantum systems and keep it from decohering. Impurities are inevitable in any real system, and can even be engineered. Interestingly, they can also be useful, and we look at this prospect from the perspective of quantum devices. |

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| **Name** | **U. Sinha** |
| **Affiliation** | *Raman Research Institute, Bengaluru, India* |
| **Title** | **A tale of three slits: From Superposition to Correlated qutrits** |
| **Abstract** | This talk will cover two very interesting but widely varying applications of triple slit based aperture systems. The first one deals with a foundational problem in quantum mechanics and classical optics; the second one deals with quantum computing and quantum communication. In a double slit interference experiment, the wave function at the screen with both slits open is not exactly equal to the sum of the wave functions with the slits individually open one at a time. The three scenarios represent three different boundary conditions and as such, the superposition principle should not be applicable. However, most well-known text books in quantum mechanics implicitly and/or explicitly use this assumption that is only approximately true. In this talk, I will discuss recent results [1] in which we have used the Feynman Path Integral formalism to quantify contributions from non-classical paths in quantum interference experiments that provide a measurable deviation from a naive application of the superposition principle. A direct experimental demonstration for the existence of these non-classical paths is difficult to present. We find that contributions from such paths can be significant and we propose simple three-slit interference experiments [2] to directly confirm their existence. I will also describe more recent work [3] in which we have gained an analytical handle on the problem. I will end the first part with showing some exciting new results from ongoing experiments in my lab which are aimed at testing these theories. While two dimensional quantum systems known as qubits are traditionally used for experiments in Quantum Computation, in our lab we are exploring higher dimensional quantum systems called qudits. Maximally entangled qudits are subjects of interest in many quantum information protocols and fundamental tests of quantum mechanics. Transverse spatial correlation obtained from spontaneous parametric down converted photons is one of the simplest methods that could be readily implemented using slit based interferometric systems. Recently, it was shown that, the angular spectrum of the incident pump can be transferred to the signal-idler bi-photon pair in SPDC process. Tapping on to this, we attempt to harness qutrit- qutrit correlations in spatial degrees of freedom by making the pump have a profile of a triple slit. We study how the idler profile is correlated with a given signal and establish the qutrit-qutrit correlations for different experimentally viable parameters [5]. This principle of generating spatially entangled photon qutrits could be easily extended to n dimensional space and find wide applications, especially in Quantum Computing. Demonstrating spatial correlations between two qutrits paves the way for using the spatial degree of freedom in experiments based on long distance Quantum Communication. While our experiment is a proof of principle experiment which demonstrates that spatial correlations can be quantified between qutrits, the result will also be applicable when the photons are in larger physical separation than inside the lab domain.<br><br>[1] R.Sawant, J.Samuel, A.Sinha, S.Sinha, U.Sinha, Non classical paths |

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| | in quantum interference experiments. Phys.Rev.Lett.113, 120406 (2014).<br>[2] U.Sinha, C.Couteau, T.Jennewein, R.Laflamme, G.Weihs, Ruling out multi-order interference in quantum mechanics. Science 329, 418-421 (2010).<br>[3] A.Sinha, Aravind H.V., U.Sinha, On the Superposition principle in interference experiments. Scientific Reports 5, 10304 (2015).<br>[4] G.Rengaraj, U.Prathwiraj, Surya N.Sahoo, R.Somashekhar and U.Sinha, Experimental measure of the correction term in the Superposition Principle, to be submitted, (2016) .<br>[5] Surya N. Sahoo, D.Ghosh, E.Kaur, T.Jennewein, P.Kolenderski and U.Sinha, Measuring Spatial Correlations in qutrits, to be submitted,(2016). |
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| **Name** | **Y. Shikano** |
| **Affiliation** | *Institute of Molecular Science, Okazaki, Japan* |
| **Title** | **Visualizing Quantum State by Weak Measurement** |
| **Abstract** | When we estimate a quantum state, we normally use the quantum state tomography. However, this needs the post-information processing. Here, we propose a new idea on visualizing technique of the quantum state. Under the specific configuration, in which the optical vortex beam is used, we experimentally demonstrate the visualization of the specific two-dimensional quantum state; the polarized state of light by the weak measurement initiated by Yakir Aharonov and his colleagues. The entangled state can be also visualized via the concurrence as the extension of this idea. |
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| **Name** | **A. R. Usha Devi** |
| **Affiliation** | *Bangalore University, India* |
| **Title** | **Thermodynamic state-to-state tranformation and work extraction** |
| **Abstract** | Quantum information theory helps in understanding fundamental principles governing thermodynamics of small number of particles. A clear formulation of statistically allowed state-to-state transformations under thermodynamic operations and the corresponding optimal extractable work is an important step in this direction. Here, we describe two different approaches formulating maximum extractable work in a thermodynamic transformation $\rho \rightarrow \sigma$. We show that the asymptotic activable work per copy $W_{act}$, achievable in the thermodynamic transformation of ($n \rightarrow \infty$ copies of) a passive state $\sigma_p$ to a completely passive thermal state $\tau_\beta$(Alicki et.al.,Phys. Rev. E 87, 042123 (2013)), approaches the work distance $W(\sigma_p \rightarrow \tau_\beta)$ (the maximum extractable single-shot work in the transition $\sigma_p \rightarrow \tau_\beta$ ) of the resource theory framework (Brandão et. al., PNAS 112, 3275 (2015)) in the thermodynamic limit. This identification gives insights in understanding one approach in terms of the other. We also discuss a variational principle, where energy is minimized for a fixed entropy, so as to identify the completely passive states. |
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| **Name** | **L. Vaidman**** |
| **Affiliation** | *Tel Aviv University, Israel* |
| **Title** | **The meaning of weak values** |
| **Abstract** | The weak value, as an expectation value, requires an ensemble to be found. Nevertheless, we argue that the physical meaning of the weak value is much more close to the physical meaning of an eigenvalue than to the physical meaning of an expectation value. Theoretical analysis and experimental results performed in the MPQ laboratory of Harald Weinfurter are presented. Quantum systems described by numerically equal eigenvalue, weak value and expectation value cause identical average shift of an external system interacting with them during an infinitesimal time. However, there are differences between the final states of the external system. In the case of an eigenvalue, the shift is the only change in the wavefunction of the external system. In case of the expectation value, there is an additional change in the quantum state of the same order, while in the case of the weak value the additional distortion is negligible. The understanding of weak value as a property of a single system refutes recent claims that there exist classical statistical analogue to the weak value. |

# Contributed Talks

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| **Name** | **Some Bhattachareya** |
| **Affiliation** | *Indian Statistical institute, Kolkata, India* |
| **Title** | **Nonlocal correlations: Fair and Unfair Strategies in Bayesian Game** |
| **Abstract** | Interesting connection has been established between two apparently unrelated concepts, namely, quantum nonlocality and Bayesian game theory. It has been shown that nonlocal correlations in the form of advice can outperform classical equilibrium strategies in common interest Bayesian games and also in conflicting interest Bayesian games. Classical equilibrium strategies can be of two types, fair and unfair. Whereas in fair equilibrium payoffs of different players are equal, in unfair case they differ. Advantage of nonlocal correlation has been demonstrated over fair strategies, only. In this work we show that quantum strategies can outperform even the unfair classical equilibrium strategies. For this purpose we consider a class of two players Bayesian games. It becomes that, such games can have only fair equilibrium, both fair and unfair equilibrium, or only unfair ones. We provide a simple analytic method to characterize the nonlocal correlations that are advantageous over the classical equilibrium strategies in these games. We also show that quantum advice provides better social optimality solution (a relevant notion of equilibrium for unfair case) over the classical one.<br>Ref. arXiv:1601.02349 |

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| **Name** | **Erkka Haapasalo** |
| **Affiliation** | *Kyoto University, Japan* |
| **Title** | **Optimal measurements and extreme observables in quantum theory** |
| **Abstract** | This talk is based on the recent PhD work of E.H. dealing with optimal quantum devices, observables, channels, and instruments. Optimality is here linked to convex analysis, and we concentrate on extreme devices within relevant convex sets of quantum devices and their characterization. True convex mixtures of different measuring devices contain inherent classical noise arising from the randomness associated to the mixing. Extreme devices lack this extra noise and can thus be considered to exhibit the relevant quantum properties in their purest form. In addition to studying the entire sets of quantum devices, we also discuss convex extreme points of restricted convex subsets, especially those characterized by certain covariance properties that correspond to the physical symmetries of the system. We also discuss the importance of convex extreme points in quantum compatibility and point out restrictions that the extremality of one device puts on the possible joint devices of the extreme device and other compatible devices. |

# Poster Abstracts

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| **Author** | **Sristy Agrawal** |
| **Affiliation** | *Indian Institute of Science Education and Research, Kolkata* |
| **Title** | **State tomography of an entangled two-qubit system using weak measurements** |
| **Abstract** | Entanglement is a central difference between classical and quantum theory of composite systems. Although fairly well understood in theory, experimentally determining the properties of entangled systems is a difficult task. We propose a novel tomography scheme for entangled two qubit pure states via weak measurements. The virtue of this technique is that it allows us to perform complete tomography even by applying the weak measurement to only one of the subsystems followed by post-selection of both systems independently with subsequent Classical Communication, i.e., it can be performed even when the two entangled qubits are spatially separated. |
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| **Author** | **Raunaq Ahmed** |
| **Affiliation** | *Bangalore University, India* |
| **Title** | **Degree of unsharpness in the optimal violation of the Clauser-Horne-Shimony-Holt (CHSH) and geometric Bell-like steering inequalities** |
| **Abstract** | Nonlocality is seen as a manifestation of both entanglement and incompatibile measurements. In recent years a growing interest has been witnessed in elucidating the relation between non-locality and joint measurability. It was shown by Wolf *et al*. (Phys. Rev. Lett. 103, 230402 (2009)) that measurement incompatibility is both necessary and sufficient for the violation of CHSH-Bell inequality. Further, a quantification of the maximal violation strength of $2\sqrt{2}$ of CHSH-Bell inequality has been established in terms of the *degree of compatibility* of unsharp measurements by Banik *et al.* (Phys. Rev. A, 87,052125 (2013)). Moreover, non-local steering and incompatible measurements are shown to be equivalent. In this work, we bring out a quantification of the *state dependent optimal* violation of the CHSH Bell-like steering inequality with the corresponding degree of joint measurability of a pair of associated dichotomic observables (which depend on the state parameters) in an arbitrary two qubit state. We also report the relation of the threshold value of the *unsharpness* parameter (required for the joint measurability of the corresponding qubit measurements) in bringing out optimal violation of geometric Bell-like steering inequalities. |
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| **Author** | **Anindita Bera** |
| **Affiliation** | *HRI Allahabad, India* |
| **Title** | **XY spin model in joint presence of quenched and annealed disorder** |
| **Abstract** | We investigate equilibrium statistical properties of the quantum XY spin-1/2 model in an external magnetic field when the interaction and field parts are subjected to quenched or/and annealed disorder. The randomness present in the system are termed annealed or quenched |

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| | depending on the relation between two different time scales - the time scale associated with the equilibriation of the randomness and the time of observation. Within a mean-field framework, we study the effects of disorders on spontaneous magnetization, both by perturbative and numerical techniques. Our primary interest is to understand the differences between quenched and annealed cases, and also to investigate the interplay when both of them are present in a system. We observe in particular that when interaction and field terms are respectively quenched and annealed, critical temperature for the system to magnetize in the direction parallel to the applied field does not depend on any of the disorders. Further, an annealed disordered interaction neither affects the magnetizations nor the critical temperatures. We carry out a comparative study of the different combinations of the disorders in the interaction and field terms, and point out their generic features. |
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| **Author** | **Samyadeb Bhattacharya** |
| **Affiliation** | *HRI Allahabad, India* |
| **Title** | **Exact master equation and entropy production rate for a spin interacting with a fermionic bath** |
| **Abstract** | An exact Master equation of the Lindblad form has been derived for a central spin interacting with a sea of completely unpolarized spins. Complete positivity of the dynamics is thoroughly investigated. The non-Markovianity of the dynamics has also been studied in terms of divisibility breaking of the channel and trace distance fidelity between states. The Kraus operators are also derived and it has been shown that the dynamical map is bistochastic with the maximally mixed state as the only fixed point. The issue of entropy production of the system under the proposed evolution is studied. It has been shown that in general, non-Markovianity is necessary to drive the system out of equilibrium, but not sufficient. But for the specific dynamical evolution considered in this paper, non-Markovian back flow of information always drives the system out of equilibrium. In continuation with the study of witnessing non-Markovianity, it has been shown that the positive rate of change of purity is also a useful indicator of non-Markovian information back flow. Regarding the experimental feasibility of measuring purity of a quantum state, a possibility of directly measuring non-Markovianity has thus been identified. This gives the present work considerable practical importance. |
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| **Author** | **Suman Chand** |
| **Affiliation** | *IIT Ropar, India* |
| **Title** | **Quantum Otto Engine** |
| **Abstract** | Quantum heat engines employ a quantum system as the working fluid, that gives rise to large work efficiency, beyond the limit for classical heat engines. The most crucial part in modelling a quantum heat engine (QHE) is the modelling of two different bath, e.g., a hot bath and a cold bath. Existing proposals for implementing quantum heat engines require that the system interacts with the hot bath and the cold bath (both modelled as a classical system) in an alternative fashion and therefore assumes an ability to switch off the interaction with the bath during a certain stage of the heat-cycle. However, it is not possible to decouple a |

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| | quantum system from its always-on interaction with the bath without the use of complex pulse sequences. Here, we show how to implement a four stroke [2,3] quantum Otto engine (QOE) with the always on bath condition [1] consists of trapped ion as a working substance. The internal vibrational degree of freedom of the trapped ion works a cold bath and the thermal environment works as the hot bath. Two adiabatic branches involve a change in external magnetic field [4] at a fixed value of the coupling constant., and along one of isochoric process we employ a measurement on the electronic state which mimic the heat transfer from the system to the cold bath.<br><br>[1] D. Gelbwaser-Klimovsky, W. Niedenzu, and G. Kurizki, Advances In Atomic, Molecular, and Optical Physics 64, 329 (2015).<br>[2] H. T. Quan, Y.-x. Liu, C. P. Sun, and F. Nori, Phys. Rev. E 76, 031105 (2007).<br>[3] T. D. Kieu, Phys. Rev. Lett. 93, 140403 (2004).<br>[4] G. Thomas and R. S. Johal, Phys. Rev. E 83, 031135 (2011).<br>[5] S. Chand and A. Biswas: arXiv:1603.08375. |
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| **Author** | **Titas Chanda** |
| **Affiliation** | *HRI Allahabad, India* |
| **Title** | **Frozen quantum correlations** |
| **Abstract** | Characterizing correlations between different subsystems of a composite quantum system has been an important field of research in quantum information science. One of the difficulties encountered in realizations of quntum information protocols is that quantum correlations decohere rapidly by interaction with the environment. However, for initial bipartite states following certain special conditions, the correlation freezes, i.e., remains constant over time. We provide necessary and sufficient conditions for freezing of quantum correlations as measured by quantum discord and quantum work deficit in the case of bipartite as well as multipartite states subjected to local noisy channels. |
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| **Author** | **Sreetama Das** |
| **Affiliation** | *HRI, Allahabad, India* |
| **Title** | **Necessarily Transient Quantum Refrigerator** |
| **Abstract** | There has recently been a flurry of interest in identifying fundamental limits on the dimension of self-contained quantum refrigerators. In particular, it has been found that one can have quantum refrigerators in the steady state of an open three-qubit system. We show that one can construct a quantum absorption refrigerator that provides refrigeration only in the transient regime, by using three interacting qubits, each of which is also interacting with a separate local heat-bath. The machine either does not provide cooling in the steady state, or the steady state is achieved after a long time. We claim that such a phenomenon is generic to small-scale quantum absorption refrigerators. We demonstrate that a transient cooling without steady-state cooling is associated with generation of negligible or no bipartite quantum correlations. For one of the models of thermalization, we find that the minimum achievable temperature of the refrigerated qubit can remain almost frozen, i.e., unchanged, for a significant region of the |

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| | parameter space. |
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| **Author** | **Debarshi Das** |
| **Affiliation** | *CAPSS, Physics Department, Bose Institute, Salt Lake, Sector V, Kolkata-700 098, India* |
| **Title** | **Quantum mechanical violation of macrorealism for large spin and its robustness against coarse-grained measurements** |
| **Abstract** | For multilevel spin systems, robustness of the quantum mechanical (QM) violation of macro-realism (MR) with respect to unsharp (coarse-grained) measurements is investigated using three different necessary conditions of MR, namely, the Leggett-Garg inequality (LGI), Wigner's form of the Leggett-Garg inequality (WLGI) and the condition of no signalling in time (NSIT). It is demonstrated that, contingent upon using a suitable measurement scheme, for ideal sharp measurements, the QM violations of all the three aforementioned necessary conditions of MR increase with an increasing value of the spin of the system under consideration, whether the initial state is a pure one or a mixed one. Moreover, for pure initial state, in the asymptotic limit of spin, the algebraic maxima of the QM violations of all these three necessary conditions of MR are attained. Importantly, the QM violations of all these persist in that limit even for arbitrary unsharp measurements, i.e. for any non-zero value of the sharpness parameter characterizing the degree of coarse-graining of the relevant measurements. This, therefore, clearly signifies that classicality does not emerge in the asymptotic limit of spin, whatever be the unsharpness of measurement. |
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| **Author** | **Debmalya Das** |
| **Affiliation** | *Indian Institute of Science Education and Research (IISER) Mohali, India* |
| **Title** | **Equivalence of the W superposition state and the GHZ state under local filtration** |
| **Abstract** | The W superposition state or the $W\overline{W}$ state is a curious case as far as the irreducibility properties of the three qubit pure entangled states are concerned. An intriguing fact unearthed is that the $W\overline{W}$ state, which is equivalent to the GHZ state under an SLOCC transform, is in fact reconstructible from its two-party reduced density matrices unlike the GHZ state. We demonstrate that, the SLOCC that takes the $W\overline{W}$ state to GHZ state can be achieved by means of a local filtration operation |
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| **Author** | **Shounak Datta** |
| **Affiliation** | *S. N. Bose National Centre for Basic Sciences, Block JD, Sector III, Salt Lake, Kolkata 700 098, India* |
| **Title** | **Information processing with states that are separable from spectrum** |
| **Abstract** | Absolutely separable states, also called as states which are separable from spectrum, are states from which no entanglement can be generated with global unitary operations. They form a proper subset of the separable states. Although they have been mathematically characterized in terms of their spectrum, yet their utility in quantum information processing tasks has remained hitherto unexplored. In this work, we probe the efficacy of absolutely separable bipartite qubit states in |

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| | quantum processing tasks through a protocol. Precisely, we explore the environmental interaction of such states via amplitude damping channel (ADC). We find that, if one or both qubits of a absolutely separable state in 2 2 dimensions interact with the environment locally in terms of ADC, then the state can be transformed into a state that is separable(but not absolutely separable) based on the strength of the decoherence parameter. Subsequently, one can always find a state independent global unitary operator which generates a entangled state from the resultant state useful for different information processing tasks. Through this generic prescription we find that one can generate entanglement from absolutely separable states useful for teleportation. The efficacy of the protocol is further underscored through the generation of steerable and Bell non local states. Furthermore, illustrations both from a generic class of absolutely separable states and some well-known mixed states in two qubits, buttress the utility of the protocol. |
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| **Author** | **Akshay Gaikwad** |
| **Affiliation** | *IISER-Mohali, India* |
| **Title** | **Experimental demonstration of Quantum Process Tomography** |
| **Abstract** | Proper understanding of quantum dynamics of open systems is a very important task in many areas of physics, ranging from quantum optics to quantum information processing. Quantum Process Tomography is the standard method to characterize and quantify quantum process. The standard procedure for quantum process tomography (QPT) requires a series of experiments. Each experiment involves initialization of the system to a particular basis state, applying the quantum process on the system, and finally characterizing the output state by quantum state tomography (QST). The output states collected for a complete set of basis states enable us to calculate the $\chi$ matrix characterizing the process. In this study, we have implemented standard QPT protocol on NMR to characterize quantum processes for single and double-qubit quantum systems, mainly the decoherence process and also calculated fidelity of quantum gates. |
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| **Author** | **Tamal Guha** |
| **Affiliation** | *Physics and Applied Mathematics Unit, ISI Kolkata, India* |
| **Title** | **Work extraction under Von-Neumann measurement scenario** |
| **Abstract** | Thermodynamics is the study of bulk properties of macroscopic systems which merges exactly to the statistical average for thermodynamic limit of large number of particles. Quantum thermodynamics in the other way round asks the question of validity of traditional thermodynamic laws in microscopic regime. Consequently work extraction which is one of the prime notion of studying thermodynamics, gathers importance recently in literature. In Nat. Commun. 5, 4185 (2014) authors have shown that it is possible to extract some amount work from single copy of a given a thermal state using a work storage bit and a thermal bath, which is almost equal to the change in free energy of the system, when the system and bath follows almost same probability structure. In this article we have asked the question to lowered the final state more and tried to look in that scenario from the perspective of Von Neumann measurement |

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| | accounting the involved cost for it. |
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| **Author** | **P. J. Geetha** |
| **Affiliation** | *Kuvempu University, India* |
| **Title** | **An exploration of monogamy in pure and mixed states** |
| **Abstract** | We evaluate the monogamy inequality for symmetric, non-symmetric pure states of importance, in terms of squared entanglement of formation, squared negativity of partial transpose and compare the corresponding tangles. For a special class of mixed entangled states, we evaluate the negativity tangle and show that though concurrence, concurrence tangle is zero for these states, negativity tangle turns out to be non-zero. We compare the non-zero values of tangle in terms of squared entanglement of formation and negativity tangle for the mixed states under consideration. |
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| **Author** | **Sudheer Kumar** |
| **Affiliation** | *IISER Pune, India* |
| **Title** | **Discriminating between Luders and von Neumann measuring devices: An NMR investigation** |
| **Abstract** | Measurement of an observable on a quantum system involves a probabilistic collapse of the quantum state and a corresponding measurement outcome. Luders and von Neumann state update rules attempt to describe the above phenomenological observations. These rules are identical for a non-degenerate observable, but differ for a degenerate observable. While Luders rule preserves superposition within a degenerate subspace under a measurement of the corresponding degenerate observable, the von Neumann rule does not. Recently Hegerfeldt and Mayato [Phys. Rev. A, 85, 032116 (2012)] had formulated a protocol to discriminate between the two types of measuring devices. Here we have reformulated this protocol for quantum registers comprising of system and ancilla qubits. We then experimentally investigated this protocol using nuclear spin systems with the help of NMR techniques, and found that L¨ uders rule is favoured. |
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| **Author** | **Som Kanjilal** |
| **Affiliation** | *Bose Institute, Kolkata, India* |
| **Title** | **Role of pointer state correlation in Weak measurement** |
| **Abstract** | We show that the pointer state correlations in the context of weak measurement can be used to test continuous entanglement as well as to explain the interesting experimental results obtained with Lagurre-Gauss mode as pointer state. Furthermore, we studied an earlier unexplored implication of tuneable interaction strength taking into account pointer state correlations. |
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| **Author** | **Akhilesh Karagadde** |
| **Affiliation** | *University of Mysore, India* |
| **Title** | **Geometric phase for two-level and three-level quantum systems in various cases** |
| **Abstract** | We obtain the expression for geometric phase associated with a general |

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| | smooth curve of unit vectors in a Hilbert space in the case of two-level and three-level quantum systems. We find the expression of geometric phase for a physically realistic quantum system by using our results. |
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| **Author** | **Aiman Khan** |
| **Affiliation** | *IIT-Roorkee, India* |
| **Title** | **Hidden Non-Locality Using Weak Interaction and Post-Selection** |
| **Abstract** | A novel filtration scheme that uses weak interaction and post-selection of the pointer state is discussed for revealing hidden non-locality. Starting with explicitly local bipartite spin-qubit states, we introduce von Neumann-type weak interaction in each wing that couples spin and position degrees of freedom of each qubit. Subsequently, post-selection of the pointer (in this case, position) can be implemented by filtering out the particles pertaining to a given position. Depending upon the choice of this position, the emergent subensemble is filtered out and tested for non-locality. The non-locality thence demonstrated, using local realist inequalities such as the Bell-CHSH inequality and the I3322 inequality in the context of the most general unsharp biased measurements, is an instance of what is known as "hidden" non-locality. We also study the relationship between entanglement and nonlocality for the array of filtered states produced after the weak interaction, each characterized by the value of the pointer variable for which the post-selection is done. Interestingly, the value of the pointer variable for which entanglement is maximum (measured here by concurrence) is found not to coincide with the value for which non-locality (measured by the value of Bell-CHSH operator) is maximum. This shows that states with more entanglement than other states may less violate the locality bound. |
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| **Author** | **Shiladitya Mal** |
| **Affiliation** | *S. N. Bose National Centre for Basic Sciences, Salt Lake, Kolkata 700 098, India* |
| **Title** | **Exploring interplay between unsharpness and biasedness of generalised quantum measurements.** |
| **Abstract** | It is known that unsharpness of measurement reduces the possibility of realizing quantum behavior like demonstration of nonlocality, violation of macrorealism etc. Here we investigate the competing effects of unsharpness and biasedness of most generalized measurement. This kind of behavior is explored for single qubit and two qubit systems in the context of demonstrating violation of macrorealism and nonlocality respectively with biased unsharp measurements while unbiased unsharp measurement cannot. Interestingly we also show hidden nonlocality without filtering operation but with biased unsharp measurements. |
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| **Author** | **Swati Kumari** |
| **Affiliation** | *NIT Patna, India* |
| **Title** | **Leggett-Garg inequalities and macrorealism for unsharp quantum measurements** |
| **Abstract** | Leggett and Garg inequalities (LGIs) were formulated for testing incompatibility between the classical world view of macrorealism and quantum mechanics. In recent times, various other formulations, such as, |

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| | Wigner form LGIs (WLGIs), entropic LGIs (ELGIs) and the no-signalling in time (NSIT) condition have also been proposed. However, it is recently argued that no LGI can provide the necessary and sufficient condition for macrorealism but a suitable conjunction of NSIT conditions provides the same. In this paper, we provide a comparative study of the various formulations for testing macrorealism pertaining to the two different unsharp measurements that provides some important findings which were not previously studied. We show that while the violation of WLGIs are more robust than SLGIs and ELGIs for spin-POVMs, the conclusion is reversed for a different form of POVMs. For a biased POVMs, it is shown that SLGI and ELGI can be violated for any non-zero value of unsharpness parameter thereby providing more robustness than the violation of WLGIs. We further examine the conditions of NSIT for sharp and unsharp measurement scenario. It is shown that, for sharp measurement, except for two states, all WLGIs together provide the necessary and sufficient condition for macrorealism. We have further argued that two three-time NSIT conditions are enough to provide the necessary and sufficient condition for macrorealism. In unsharp measurement scenario, an interesting feature we point out that the amount of violation of a particular NSIT condition can be larger than the sharp measurement. We further investigate whether the pairwise or triple-wise joint measurability of the POVMs has any role in the violation of LGIs and NSITs which reveals that for the case of spin-POVMs, the violation of one of the WLGIs can be obtained if the POVMs are not jointly measurable. However, for other form of POVMs and for other formulations of LGIs and NSITs no such connection is found in agreement of some recent results. |
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| **Author** | **Jaskaran Nirankari** |
| **Affiliation** | *IISER-Mohali, India* |
| **Title** | **Contextuality and Quantum Key Distribution Protocols** |
| **Abstract** | Quantum cryptography is the very first instance where quantum ideas were used in information theory and in the process a secure quantum key distribution protocol was constructed. The security of quantum key distribution hinges upon some features of the quantum world which are uniquely distinct from the classical world. Various parallel interpretations of the underlying quantum features responsible for security of such key distribution have been discussed in the literatures. Some of them are quantum entanglement, uncertainty principle and no cloning theorem. We explore the role of contextuality which is an essential feature of quantum physics in quantum key distribution protocols. We will also present a contextuality based quantum key distribution protocol. |
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| **Author** | **Anantha S Nayak** |
| **Affiliation** | *Kuvempu University, India* |
| **Title** | **One parameter family of N -party d-dimensional Werner-Popescu states: Bipartite separability using Conditional quantum relative Tsallis entropy** |
| **Abstract** | The conditional version of quantum sandwiched Tsallis relative entropy (CSTRE) is employed to study the bipartite separability of one parameter family of Werner- Popescu states of the d N system. (i.e., N - |

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| | partite d - dimensional system ) in its 1 : N 1 partition. For all N, the strongest limitation on bipartite separability is realized in the limit q → ∞ and is found to match exactly with the separability range obtained using algebraic method, i.e., the necessary and su-cient condition. The theoretical superiority of using CSTRE method to nd the bipartite separability range over AbeRajagopal (AR) q- conditional entropy is shown by comparing the convergence of the parameter x, obtained through CSTRE and AR q-conditional entropy, with respect to q. |
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| **Author** | **Arup Roy** |
| **Affiliation** | *Indian Statistical Institute, Kolkata, India* |
| **Title** | **The presence of quantum correlations result in non-vanishing ergotropic gap** |
| **Abstract** | The paradigm of extracting work from isolated quantum system through a cyclic Hamiltonian process is a topic of immense research interest. The optimal work extracted under such process is termed as ergotropy [Europhys. Lett., 67 (4), 565(2004)]. Here, in a multi-party scenario we consider only a class of such cyclic processes that can be implemented locally, giving rise to the concept of local ergotropy. Eventually, presence of quantum correlations result in a non-vanishing thermodynamic quantity called ergotropic gap, measured by the difference between the global and local ergotropy. However the converse does not hold in general, i.e. its nonzero value does not necessarily imply presence of quantum correlations. For arbitrary multi-party states we quantify this gap. We also evaluate the difference between maximum global and local extractable work for arbitrary states when the system is no longer isolated but put in contact with a baths of same local temperature.<br>**Ref.** Phys. Rev. E 93, 052140 (2016) |
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| **Author** | **Saptarshi Roy** |
| **Affiliation** | *HRI,Allahabad, India* |
| **Title** | **Activation of Nonmonogamous Multipartite Quantum States** |
| **Abstract** | In a multiparty domain, monogamy of quantum correlations states that it cannot be shared arbitrarily between different partners. In particular, monogamy of entanglement has several practical applications in a variety of areas of quantum information science including quantum cryptography. In this sense, monogamous states can be thought of as a useful resource in quantum communication between several parties. However, there exists multiparty quantum states which are nonmonogamous for a given quantum correlation measure. We prove that an arbitrary quantum state which is nonmonogamous for negativity will become monogamous if a finite number of copies of the same state is provided. We refer this as activation of nonmonogamous states. We also show that multiple copies of a state satisfy monogamy for negativity if it does so for a single copy. The results are true for all quantum states of an arbitrary number of parties. Moreover, we find that two different three-qubit pure states which individually violate monogamy relation for negativity, taken together can satisfy the three-party monogamy relation. This holds for almost all three-qubit pure states while it is true for all three-qubit pure states when a four-party monogamy relation is used to check for their activation. We finally connect monogamy of negativity with genuine multipartite entanglement. |

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| **Author** | **Aravinda S** |
| **Affiliation** | *Poornaprajna Institute of Scientific Research, Bengaluru, India* |
| **Title** | **Geometric construction of ontological models for single systems in the convex framework** |
| **Abstract** | A finite-dimensional single system in the framework of convex operational theories shows a two-level nonclassicality: at the base level, nonclassicality arises from the nonsimpliciality of the state space, due to the pairwise incongruence of observables, and the top level, due to the instransitivity of congruence. Congruence reduces to commutativity for projective measurements in quantum mechanics. Base level nonclassicality gives rise to features like no-cloning and measurement disturbance, while inclusion of the top level is required for contextuality. Here we show that this approach naturally suggests a geometric construction for the ontological model of any operational theory: as an exponentially higher dimensional underlying simplex. The function that maps the ontological model to the operational theory can be expressed as the composition $\phi \equiv \phi \circ \phi_{\nabla}$, where $\phi_{\nabla}$ is a compressive map introducing nonsimpliciality, while $\phi$ is a "crumpling" operation, that introduces uncertainty. The map $\phi$ is not unique, and we show that preparation contextuality and impossibility of certain operational coherent transformations depend on the choice of map $\phi$. We further show that preparation contextuality can arise in a base level nonclassical theory, i.e., one which isn't contextual. |
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| **Author** | **Suma SP** |
| **Affiliation** | *Yuvaraja's College, University of Mysore, India* |
| **Title** | **Multiaxial Representation of Mixed Symmetric Separable State.** |
| **Abstract** | Study of separability of N qubit mixed symmetric states is a long standing open problem as there are no unique standards to classify whether a given state is entangled or separable. In this regard, we take up the N-qubit mixed symmetric states for the detailed study as these classes of states are of experimental importance and offer elegant mathematical analysis since the dimension of the Hilbert space reduces from $2^N$ to N+1. We identify a separability criterion for mixed symmetric states using geometric multiaxial representation of density matrix. Employing Fano statistical tensor operators for the parametrization of density matrix, we show that for a mixed symmetric state to be separable, each of its spherical tensor parameter should be characterized by only two axes . We illustrate our criterion for a 2-qubit mixed symmetric system. |
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| **Author** | **Smitha Rao** |
| **Affiliation** | *Yuvaraja's College, University of Mysore, India* |
| **Title** | **Complete measurement of spin-1 density matrix in mutually unbiased bases** |
| **Abstract** | We have constructed MUBs in the angular momentum basis for spin-1 system. The eight Fano statistical tensor parameters which determine the spin-1 density matrix are extracted and the physical interpretation of the tensor parameters is given in terms of the first and second order |

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| | moments of the spin operators. |
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| **Author** | **Mohd Asad Siddiqui** |
| **Affiliation** | *National Institute of Technology, Patna.* |
| **Title** | **Wave-Particle Duality in N-Path Interference** |
| **Abstract** | Bohr's principle of complementarity, in the context of a two-slit interference experiment, is understood as the quantitative measures of wave and particle natures following a duality relation $D^2 + V^2 \leq 1$. Here D is a measure of distinguishability of the two paths, and V is the visibility of interference. It is shown that such a relation can be formulated for N-slit or N-path interference too, with the proviso that the wave nature is characterized by a measure of coherence ($C$). This new relation, $D^2 + C^2 \leq 1$ is shown to be tight, and reduces to the known duality relation for the case N = 2. A recently introduced similar relation [Bagan et.al., Phys. Rev. Lett. 116, 160406 (2016)] is shown to be inadequate for the purpose. |
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| **Author** | **S. Sasmal** |
| **Affiliation** | *Bose Institute, Kolkata, India* |
| **Title** | **A proposed steering criterion using generalised uncertainty relation** |
| **Abstract** | The Reid steering criterion based on Heisenberg's uncertainty relation fails to detect steerability for the states having higher than second order correlation. Here we have derived a new steering criterion using the generalized uncertainty relation which overcomes this limitation of the Reid steering criterion. Our proposed steering criterion is able to detect steerability of LG beam, NOPA state and photon annihilated NOPA states having higher than 2nd order correlation. Furthermore, the steerability of the two mode Werner state in continuous variable systems is being investigated for all valus of the mixedness parameter. |
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| **Author** | **Surya Narayan Sahoo** |
| **Affiliation** | *RRI, Bengaluru, India* |
| **Title** | **Inferring Weak Values from Visibility in a Mach-Zehnder Interferometer using attenuated lasers and single photons** |
| **Abstract** | Weak values of Pauli operators acting on polarization state vectors are traditionally measured from the shift of the position pointer states which gets coupled to polarization degree of freedom due to the birefringent crystal, in a pre and post selected ensemble [1]. Here, we present an alternative way to infer weak values that takes advantage of interferometric setup. It turns out that the real part of weak values can be inferred from visibility in a Mach Zehnder setup, where the operator, whose weak value is to be inferred, is placed in one arm of the interferometer and the polarization state of the other arm is considered to be the post selected state. The real part of weak values of Pauli operators obtained from this new method agree with the weak values obtained from the traditional method. Inferring weak values from Mach Zehnder can potentially be easily extended to infer the expectation values of Non-Hermitian operators[2].<br>[1]W. M. Ritchie, J. G. Story and R. G. Hulet Phys. Rev. Lett. 66, 1107.<br>[2]A.K. Pati, U. Singh and U. Sinha Phys. Rev. A 92, 052120. |
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