List of Abstracts (Oral)

Quantum Information Processing by NMR: Progress, Challenges and Recent Results

Anil Kumar
IISc, Bangalore

After a brief introduction to Quantum Information Processing (QIP) by NMR, the achievements and challenges of NMR based QIP will be highlighted. Following this the early achievements such as Pseudo-Pure States (PPS), Quantum Gates, use of Geometric phase using transition selective pulses will be mentioned. Later recent results from our laboratory will be described. These will include (i) Experimental proof of No-Hiding Theorem (ii) Use of Nearest Neighbour (NN) Heisenberg XY interaction for creation of entanglement in a linear chain of 3-qubits (iii) Study of frustration dynamics in a quantum Ising spin system in a triangular configuration, (iv) Mirror-inversion operation in an XY spin chain and (v) the use of Genetic Algorithm in NMR QC. These developments will be described.

Expected evolution and megachallenges of information processing driven future

Jozef Gruska
Masaryk University, Czech Republic

Extrapolated developments in information processing, at which quantum ones is to play an important role, leads to a new view of evolution and allows to put before society new megachallenges that seems both futuristic and realistic at the same time, and lead to not very distant future of mankind that may have hard to imagine features.

Quantum computers - is the future here?

Tal Mor
Technion, Israel

About thirty years ago Richard Feynman and David Deutsch came up with the quantum computer. A decade later Peter Shor had shown the incredible power of quantum computers: He showed their ability to factorize large numbers, an ability whose technological consequences for the world of internet encryption and banking can be devastating.
In the last four years the Wolf Prize and the Nobel Prize were given to researchers promoting quantum computing technologies, and the (only existing) startup has sold "quantum simulators" to Lockheed Martin, as well as to Google and NASA. Is the future here? Or will we have to wait for it for a few more decades? The answer depends upon whom you ask.
In this presentation I will try to clearly present the current situation of this field. I will also

present the important notion of semi-quantum computing also called sub-universal quantum computing.

An Analytical Condition For The Violation Of Mermin's Inequality By Any Three Qubit State

Satyabrata Adhikari
BIT, Mesra

Mermin inequality is the generalization of the Bell-CHSH inequality for three qubit state. The violation of the Mermin inequality guarantees the fact that there exist quantum non-locality either between two qubit or three qubit in a three qubit system. To find the violation of three qubit pure state one has to tackle the optimization problem numerically because there does not exist any analytical formula that gives the maximal violation of the Mermin inequality for a given pure three qubitstates. We derive an analytical formula for the maximum value of the expectation of the Mermin operator in terms of eigenvalues of the symmetric matrices that gives the maximal violation of the Mermin inequality for not only pure states but also for mixed states.

Quantum information processing of binary coherent states

Ulrik Lund Andersen
TUD, Denmark

Suppose that you are randomly given one of two overlapping coherent states. What is the probability in figuring out which state you are given? How well can you clone the state? And how well can you measure the state without disturbing it too much? These questions will be addressed in my presentation.

Revisiting the Elitzur-Vaidman bomb paradox

Colin Benjamin
NISER, Bhubaneswar

The Elitizur-Vaidman bomb paradox problem is a thought experiment applied to photons in a Mach-Zehnder interferometer which brings to the fore neatly the fact that interaction free measurement can take place. In this work we apply this to electrons and analyze the consequences.

Quantum processes with no definite causal order

Cyril Branciard
Neel Institute, France

In standard models of quantum computation, e.g. the quantum circuit model, operations are typically assumed to be performed one after another, in a definite causal order. However, quantum theory actually allows us to go beyond the framework of causally ordered circuits; it allows one to perform operations in some kind of "superposition of orders”. In this talk, I will present the new formalism of “process matrices” introduced by Oreshkov, Costa and Brukner [Nat. Commun. 2012] and illustrate how to use it to characterise the new resource of so-called “causally nonseparable processes” offered by quantum theory, and investigate their possible applications.

Quantum simulations using split-step discrete-time quantum walk

C. M. Chandrashekar
IMSc, Chennai

Simulations of one quantum system by an other system has an implications in realization of quantum machine that can imitate any quantum systems and solve problems that are not accessible to classical computers. In this talk I will present a quantum algorithm in the form of split-step discrete-time quantum walk (DTQW) that will efficiently simulate both, the free field Dirac equation discretized in space and time (high energy system)[1] and topological bound state (low energy system) [2]. With qubit as a base in the algorithm we present the entanglement properties and the role in can play in identifying regimes with physical significance paving way to explore the high energy and low energy system from the principles of quantum information theory. Thus, unique definition of DTQW along with the parameter tunebaility demonstrated in various experimental implementation establishes DTQW as an efficient tool to design quantum simulator.

References : [1] arxiv :1509.08851
[2] arxiv: 1502.00436

Characterization of local quantum processes by Local Quantum Uncertainty

Indrani Chattopadhyay
Calcutta University

Entanglement is treated as a kind of resource in quantum information theory like energy in general physics. The nature of local quantum processes that preserves entanglement or vanish entanglement in different composite quantum systems is an important field of research for a long time. Recent advances of non-classical correlations beyond entanglement further widen the scope of the above research. In this talk we would like to explore the nature of local quantum processes on bipartite quantum systems through the new discord like resource, the local quantum uncertainty.

Trade-off relation between generalized which-way information and fringe visibility

A.R.Usha Devi
Bangalore University

Quantum-mechanical wave-particle duality is quantified in terms of a trade-off relation between the fringe visibility and the which-way distinguishability in an interference experiment. Banaszek et al. [Nat. Commun. 4, 2594 (2013)] analyzed the complementarity between interference visibility and which-path distinguishability for a quantum particle possessing an internal structure (such as spin or polarization). The internal degree of freedom could play a manipulative role in controlling the information about which path in the interferometer arms is taken by the particle. The trade-off between the amount of which-way information encoded in the detector system and the fringe visibility is captured in terms of a generalized complementarity relation, where the notion of fringe visibility is generalized (by including the internal structure of the particle as well as the interaction of internal state with the detector system). In this talk, I discuss our work [Phys. Rev. A 89, 062116 (2014)], where we generalize the trade-off relation in a further broadened scenario, where the detector system is entangled with an ancillary degree of freedom.

On witnessing arbitrary bipartite entanglement in a measurement device independent way

Sibashis Ghosh
IMSc, Chennai

Experimental detection of entanglement of an arbitrary state of a given bipartite system is crucial for exploring many areas of quantum information, and even to judge the quality of entanglement producing source. We combine here the ideas of Branciard et al.'s measurement device independent protocol [Phys. Rev. Lett. 110, 060405 (2013)] and Augusiak et al.'s universal entanglement witness scheme for two-qubit case [Phys. Rev. A. 77, 030301 (2008)], and aim at generalizing it for the case of two-qudits. We provide a set of universal witness operators to check NPT-ness (negative under partial transpose) of two-qudit states in a measurement device independent way. We conjecture that no such entanglement witness exists for PPT (positive under partial transpose) entangled states. We also analyze the robustness of a entanglement witnessing process in the presence of noise in the inputs as well as in the measurement operators.

Towards Quantum Information Processing with Femtosecond Laser Pulse Induced Manipulation of Matter

Debabrata Goswami
IIT, Kanpur

Matter under the influence of abrupt and extreme perturbation can behave quite differently as compared to their regular properties. Using femtosecond lasers that are tailored to a desired situation, we have developed conditions towards controlled laser-matter interaction. Most recent in this connection, we present the construction and working of two specific femtosecond pulse shapers, one that is based on Fourier approaches, while the other is based on interferometric principle. The shaped pulses are probed by the means of cross correlation with the starting laser pulses. Such light-matter interactions are of large benefit in unraveling many hitherto unseen phenomena, of which I present a few of examples from our recent work that encompass optical microscopy, nano-material manipulation under optical field, nano-scale probe temperature sensor, coherent oscillations from micro-heterogeneity, as well as demonstrating the molecular nature of thermal lens spectroscopy. Theoretical understanding of these new prospects provides further importance to such ultrashort time-scale interactions, which will also be presented. Last but not the least, connection of all these experimental and theoretical developments to Quantum Information Processing will be emphasized.

All-optical quantum information processing beyond single-photon qubits

Hyunseok Jeong
SNU, Korea

Methods for all-optical quantum information processing have been developed mainly using single-photon qubits. Such an approach to quantum computation using single-photon qubits, entangled photon pairs, passive linear optics elements and photodetectors is well known as "linear optics quantum computation." A formidable limitation of this method is that quantum teleportation, which is essential for major quantum gate operations, cannot be performed in a deterministic way, or it can be done only with increasingly large resources. Recently, several approaches have been developed to overcome this obstacle. One of them is based on coherent-state qubits. This scheme enables one to perform the Bell-state measurement, an essential element for quantum teleportation, in a nearly deterministic manner while the requirement of photon-number resolving measurements is a disadvantage. Another one utilizes optical hybrid qubits, where both single-photon states and coherent states are used to construct a logical qubit basis. This method is found to outperform major previous approaches in terms of fault-tolerant limit and resource requirement. Finally, a scheme based on multi-photon qubits was suggested to perform nearly-deterministic quantum teleportation and universal gate operations without photon-number resolving detectors. In this talk, I will review and discuss these schemes that have been suggested and developed to overcome limitations of single-photon qubits, together with some related fundamental issues such as quantum macroscopicity of photonic superposition and entanglement.

Quantum Algorithm for Linear Programming Problems

Pramod Joag
Pune University

The quantum algorithm (PRL 103, 150502, 2009) solves a system of linear equations with exponential speedup over existing classical algorithms. We show that the above algorithm can be readily adopted in the iterative algorithms for solving linear programming (LP) problems. The first iterative algorithm that we suggest for LP problem follows from duality theory. It consists of finding nonnegative solution of the equation for duality condition; for constraints imposed by the given primal problem and for constraints imposed by its corresponding dual problem. This problem is called the problem of nonnegative least squares, or simply the NNLS problem. We use a well known method for solving the problem of NNLS due to Lawson and Hanson. This algorithm essentially consists of solving in each iterative step a new system of linear equations . The other iterative algorithms that can be used are those based on interior point methods (Karmarkar algorithm). The same technique can be adopted for solving network flow problems as these problems can be readily formulated as LP problems. The suggested quantum algorithm can solve LP problems and Network Flow problems of very large size involving millions of variables.

Steering Quantum Dynamics: Some Recent Methods and their Applications

T S Mahesh
IISER, Pune

Precision control over quantum dynamics is one of the important criteria for realizing a quantum processor. In many physical systems, the Hamiltonian consists of some fixed (internal) and some tunable (external) parameters. Steering a multi-qubit system in such a scenario is generally a nontrivial task. We describe our protocol involving two steps: first, to break-down the complex unitary into simpler generalized rotors, and second, to generate the time-dependent parameters of Hamiltonian to realize each of the rotors. The first procedure involves identifying a commuting subset of Pauli operators having a high trace overlap with the target unitary, followed by a numerical optimization of their corresponding phases. The second step is achieved by numerically optimized bang-bang pulses. We illustrate several applications of these control techniques in NMR quantum information processing experiments.

Fine-grained uncertainty and security of key generation

Archan S Majumdar
S. N. Bose Institute, Kolkata

Quantum steering can be used to provide bounds on the key rate of the one-sided device independent quantum key distribution (1s-DIQKD) protocol. We first consider the fine-grained uncertainty relation for discrete variables which leads to an optimal steering inequality for qubits using the monogamy of steering. We then formulate a fine-grained uncertainty relation for continuous variables. The corresponding steering inequality is used to obtain the lower bound on the secret key rate of the 1sDIQKD protocol. Our results show that continuous variables offer the possibility of an in principle higher security of key generation compared to discrete variables.

Correlations between random observables

Tomasz Paterek
CQT, Singapore

We study to which degree are physical systems correlated if random measurements are conducted on them. It turns out that this degree depends on quantum entanglement and provides alternative complete characterisation of entanglement in pure states. Applications to practical entanglement detection will be discussed.

Logical irreversibility in non-equilibrium quantum processes

Mauro Paternostro
Queens University, UK

I will discuss the implication of non-equilibrium quantum thermodynamics for logical irreversibility a' la Landauer. I will address mainly two contexts> The first will be an operational one, which will allow us to identify the role of open-system features in the establishment of logical-rreversibility bounds. The second will involve an effective description of open-system dynamics based on a collisional model between system and environment. The flexibility of this model will allow us to investigate the phenomenology of heat fluxes from/to the system.

On the possible metrological advantage of weak measurement post-selection strategy

Alok Pan
NIT, Patna

In recent times, the notion of weak measurement has gained an upsurge of interest for realizing apparently counterintuitive quantum effects. Beside its conceptual interest, eccentric nature of the weak value has been used for several practical applications. In this talk, I examine the possible metrological advantage of eccentric weak values for improving the precision of a measurement in the presence of technical noise.

Quantum Democracy

Anirban Pathak
JIIT, Noida

Since the pioneering work of Bennett and Brassard on quantum key distribution (QKD), several schemes of secure quantum communication have been proposed. Initial studies on secure quantum communication were restricted to QKD, quantum secure direct communication (QSDC), deterministic secure quantum communication (DSQC), etc. However, in the last couple of years several innovative applications of secure quantum communication have been proposed. These recently proposed schemes of secure quantum communications (some of which are also hybrid in nature) have very interesting and important applications in our daily life. Specifically, we would like to note that in today's world most of us live in the democratic countries, where policy makers are chosen by voting, and important policies are decided on the basis of voting. Thus, voting plays an extremely important role in a democratic country. By quantum democracy, we refer to a society where all kinds of voting are performed using quantum technology. We would review existing protocols of quantum-voting, their limitations and possible improvements proposed in some of our recent works. Further, we expect that in a quantum democracy, citizens will use quantum technology for other day to day tasks, like banking, e-commerce and auction. Keeping these possibilities in mind, we will also describe a few schemes of quantum e-commerce and quantum auction.

Wave-Partiicle Duality for Multi-slit Interference

Tabish Qureshi
Jamia Milia University, Delhi

The issue of wave-particle duality is reviewed, and some long standing issues discussed. A new definition of path-distinguishability is introduced, based on Unambiguous Quantum State Discrimination (UQSD). Based on this, new duality relations for 3-slit and 2-slit interference are derived. It is proposed that in a multi-path interference experiments, the wave nature be characterized by a normalized "coherence". A universal wave-particle duality relation is derived in terms of this coherence and path distinguishability. This new relation reduces to known results for 2- and 3-slit cases in appropriate limits.

Quantum protocols based on measurement inputs

Ramij Rahaman
Allahabad University

Many quantum protocols have been proposed over the years and their security are mostly based on the fact that correlations used in the protocols have non-local-realistic feature. Checking violation of Bell-type inequalities are usually used to grantee the non-local-realistic nature of the correlations. But, this is only one possible way. Another option is to verify with some non-inequality paradoxes like Hardy's argument, which uses a set of conditions impossible for classical systems, but satisfied by predictions for a unique quantum two-particle state. Here, we extend this idea and proposed several generalizations of the argument for multipartite systems. Our Hardy-type arguments relying on marginal probabilities and can be resolved only by true multipartite entangled states. By employing this genuineness of Hardy's correlations we have proposed several secure quantum protocols like quantum key distribution, quantum liar detection, quantum Byzantine arguments, quantum digital signatures etc. In our schemes, the bits used for the protocols do not come from the results of the measurements on an entangled state but from the choices of settings unlike the most of the existing quantum protocols based on Bell-type inequalities.

No-go Conversion Witness for Two-Qudit Systems

Debasis Sarkar
Calcutta University

Conversion witness provides a way to detect possible state transformation without computing monotone. The idea is a generalization to the idea of entanglement monotone. Recently, in New. J. Phys., 17 (2015) 093013 Girard et.al., have computed the form of conversion witness. We have extended the computational technique to cover more general orthogonally invariant class of states and compute the form of conversion witness. In this lecture, we will provide few examples regarding state conversion using the new class of witnesses.

Resonating valence bond states: A quantum information perspective

Ujjwal Sen
HRI, Allahabad

A bridge seems to exist between the topics that are broadly referred to as many-body science and quantum information. There are several perspectives to that gangplank, and after briefly discussing about some of the work that we have done in this direction, we will focus about one that involves resonating valence bond states.

Models of wave-function collapse, and their experimental tests

Tejinder Singh
TIFR, Mumbai

We review the phenomenological model of wave-function collapse known as Continuous Spontaneous Localization (CSL). In CSL, the Schrodinger equation is modified to a stochastic non-linear differential equation, which dynamically induces collapse by breaking linear superposition. We review the various ongoing and proposed experiments to test and constrain CSL. We also discuss an underlying fundamental theory which motivates CSL, and the possible role of gravity. [Reference: A. Bassi et al., Reviews of Modern Physics 85 (2013) 471 [arXiv:1204.4325]].

On the nonclassical properties of monopartite systems

R. Srikanth
PPISR, Bangalore

The nonclassicality of monopartite (single) systems in a finite-dimensional operational theory is examined by treating any such system as a composite of individual properties. The basic intuition is that nonclassicality arises from a "tension" in aggregating properties to form a composite. We identify two broad ways in which this tension arises: namely, kinematic and dynamic. In the kinematic type we include the principle of obstruction, according to which in any state a property with a definite value prohibits the simultaneous value definiteness of another property. This gives rise to features such as measurement uncertainty and interference. The second kinematic principle is that of frustration, according to which two properties that are individually non-obstructive with a third, may correlate with contradictory values of the third property. This leads to a lack of joint distribution for all three properties taken together, and is the basis for generalized contextuality. In principle, only obstruction--and not frustration--entails randomness. The dynamic principle is concerned with the random reset of the system's state after measurement, and gives rise to features such as measurement disturbance, the nonsimpliciality of the state space in the convex framework, no-cloning etc. These kinematic and dynamic principles are independent in that we can construct toy operational theories which feature precisely one or two of them. We study the interdependence of these three principles in quantum theory to try to pin down why this theory has its characteristic mathematical structure. We point out the implications of these properties for information security, in particular with regard to the relationship between the protocols BB84 and BBM92.

Quantum Hall Effects and Gravity -- A Copernican View

Unnikrishnan. C. S.
TIFR, Mumbai

One of most spectacular manifestations of quantum dynamics in recent years is the Quantum Hall effect, with both foundational and practical importance. It is the phenomenon of quantization of the value of Hall resistance in a 2D electron gas sample, manifested as robust plateaux in the value of the Hall resistance, at values $R_H = h/\nu e^2$ where ν is an integer. The phenomena is understood as essentially a single particle physical effect due to the Landau level quantization. But, the fractional quantum Hall effect (FQHE), discovered soon after, has quantization of Hall resistance at fractional filling factor $\nu = p/(2p \pm m)$ with *p* and *m* integers. The theoretical description invokes multi-particle effects, strong Coulomb interaction, strong correlations, phase transitions etc. and has a hierarchical phenomenological structure where the physical effects are iterated in a nested fashion. The QHE is very important for fundamental physics as well as applications where 2D multi-electron systems are in use, from semiconductor physics to quantum information processing. However, its present understanding, though computationally 'successful', is still shrouded in mysteries. A unified description of

QHE was obtained in which the FQHE was described as integer QHE of a composite fermions - electrons attaching themselves to an even number of flux quanta of a mysterious gauge field. The present theoretical picture is reminiscent of the epicycles of old planetary models, successful, yet mysterious. A Copernican insight on the phenomena seems possible, and even necessary, by identifying the real nature of the gauge field providing the non-magnetic flux quanta for the electrons, yet enabling them to diminish the real magnetic field. My talk will explore the possibility that the mystery gauge field in QHE is in fact gravity! Essentially, the quantum phase of the de Broglie waves are modified not only by the magnetic field, but also by the cosmic gravitational field, thereby modifying the canonical momentum in the quantization condition $\oint p \cdot dx = 2\pi\hbar$.

I will discuss the fundamental problem of fractional quantum Hall effect and the possible role of cosmic gravity in understanding it as a single particle effect similar to the integer quantum Hall effect. This is equivalent to a true understanding of the conventional spin-orbit effects, with implications to fundamental quantum phenomena ranging from atomic spectra to spin-statistics connection and spintronics, and I will sketch some of these findings.

Quantum asymmetry between time and space and the origin of dynamics

Joan Vaccaro
Griffith University, Australia

Dynamics is conventionally assumed to be an elemental part of nature. It is incorporated axiomatically in physical theories through conservation laws and compliant equations of motion. Because conservation laws are constraints over time and not space, this implies that there is an elemental asymmetry between time and space. If, however, the asymmetry was found to be due to deeper causes, this conventional view of dynamics would need reworking. Here I show, using a sum-over-paths formalism, that a violation of time reversal (T) symmetry might be such a cause. If T symmetry is obeyed, then the formalism treats time and space symmetrically such that states of matter are localized both in space and in time. In this case, equations of motion and conservation laws are undefined or inapplicable. However, if T symmetry is violated, then the samesum-over-paths formalism yields states that are localized in space and distributed without bound over time, creating an asymmetry between time and space. Moreover, the states satisfy an equation of motion (the Schrödinger equation) and conservation laws apply. This suggests that the time–space asymmetry is not elemental as currently presumed, and that T violation may be the origin of dynamics.

Symmetric and Asymmetric Multiparty quantum communication

Anindita Banerjee
Bose Institute, Kolkata

We introduce asymmetric and symmetric simultaneous quantum conversation between multiple parties. In constructing the schemes group theoretic structure of the operators usable for quantum dialogue is used. Specifically, here we have used operational definition of Pauli group to obtain various classes of subgroups and show that if Alice and Bob encode their classical information using the operators from the same subgroup of an operational Pauli group, we obtain standard quantum dialogue which is symmetric, whereas if they use operators from different subgroups for the same purpose, then we obtain asymmetric quantum conversation. Here, we coin the term asymmetric quantum conversation because in a strict sense, it is not an asymmetric analogue of the symmetric quantum dialogue, as the encoded messages of Alice and Bob are not encoded in the same qubit(s). Further, we find that there are certain four-qubit states which can be used to realize the schemes described here. We also present a scheme for quantum conferencing where multi party quantum dialogue is implemented. The scheme is a generalized scheme and can be implemented on large number of quantum states.

Measurement-device–independent randomness from local entangled states

Manik Banik
IMSc, Chennai

Nonlocal correlations are useful for device-independent (DI) randomness certification (Pironio S. et al., Nature (London), 464 (2010) 1021). The advantage of this DI protocol over the conventional quantum protocol is that randomness can be certified even when experimental apparatuses are not trusted. Quantum entanglement is the necessary physical source for the nonlocal correlation required for such DI task. However, nonlocality and entanglement are distinct concepts. There exist entangled states which produce no nonlocal correlation and hence are not useful for the DI randomness certification task. Here we introduce the measurement-device independent randomness certification task where one has trusted quantum state preparation devices but the measurement devices are completely unspecified. Interestingly we show that there exist entangled states, with local description, that are a useful resource in such task but are useless in the corresponding DI scenario.

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Controlling quantum state and its coherence

Tanumoy Pramanik
S. N. Bose Institute, Kolkata

A bipartite state is said to be steerable if it does not have single system description, i.e., the bipartite state cannot be explained by local hidden state model. Several steering inequalities have been derived using different local uncertainty relations to verify the ability to control the state of one subsystem by the other party. Here, we derive complementarity relations between coherences measured on mutually unbiased bases using various coherence measures such as the l1-norm, relative entropy and skew information. Using these relations, we formulate steering inequalities to check whether one subsystem has control over the coherence of the other entangled subsystem. We show that all pure entangled states are maximally steerable but for mixed entangled states, coherence steerability needs stronger non-local correlation than the existing state steering inequalities.

Stronger Error Disturbance Relations for Incompatible Quantum Measurements

Namrata Shukla
HRI, Allahabad

We formulate a new error-disturbance relation, which is free from explicit dependence upon intrinsic fluctuations of observables. This error-disturbance relation shows improvement over the one provided by the Branciard inequality and the Ozawa inequality for some initial states and for particular class of joint measurements under consideration. We also prove a modified form of Ozawa's error-disturbance relation. The later relation provides a tighter bound compared to Ozawa's error-disturbance relation and the bound provided by the Branciard inequality for a small number of states.