Academic Report (2020-21)

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Pinaki Majumdar

Research Summary:

I have been working on mainly two aspects of correlated systems. These are (i) the effect of geometric frustration on the dynamics of these systems, and (ii) the nonequilibrium response, to strong voltage bias, temperature difference, etc. The primary tool for this is the Langevin dynamics approach, which retains the advantages of the earlier static path based Monte Carlo and additionally is free of any "cluster" approximation. Much of the focus has been on magnetic and phonon modes. We are working to understand the effect of the slow dynamics of these modes on the electronic spectrum.

Publications:

1. Arijit Dutta and Pinaki Majumdar, *Spatial behavior in a Mott insulator near the voltage-driven resistive transition*, Phys. Rev. B **101**,245155 (2020).

Preprints:

1. Arijit Dutta and Pinaki Majumdar, *Thermal fluctuation driven nonequilibrium resistive and magnetic transitions in a voltage biased Mott insulator*, arXiv:2009.04533v1

2. Sauri Bhattacharyya and Pinaki Majumdar, *Dynamics of magnetic collective modes in the square and triangular lattice Mott insulators at finite temperature*, arXiv:2009.01833v1

3. Dheeraj Kumar Singh, Samrat Kadge, Yunkyu Bang, and Pinaki Majumdar, *Fermi arcs and pseudogap phase in a minimal microscopic model of d-wave superconductivity*, Submitted.

Other Activities:

1. Taught Statistical Mechanics, Condensed Matter Physics 2, and parts of Quantum Mechanics 3 and Advanced Statistical Mechanics.

2. Participated in the Vaibhav Summit organised by the Govt of India.

Arun Kumar Pati

Research Summary:

Estimating quantum coherence by noncommutativity of any observable and its incoherent part: We establish an inequality involving the quantum coherence of an arbitrary quantum state, possibly nonpure, in arbitrary dimension and a noncommutativity estimator of an arbitrary observable. The noncommutativity estimator uses the commutator of the observable and its incoherent or classical part. The relation provides a direct method of obtaining an estimate of the quantum coherence of an arbitrary quantum state, without resorting to quantum state tomography or the existing witness operators

Creation of quantum coherence with general measurement process: Quantum measurement usually destroys the coherence of a quantum system. On the contrary, we show that a complete measurement process with an arbitrary measurement basis can also create coherence. Thus, quantum measurement which is thought to be hindrance for quantumness can also be used to create the quantum resource. Based on this observation, we characterize the measurements into two categories, namely, the measurements with the ability to induce coherence and the ones without this ability. We also find a trade-off relation between the coherence creation, entanglement (between system and apparatus), and the mixedness of the system in a general measurement setup.

Classical Communications with Indefinite Causal Order for N completely depolarizing channels: If two identical copies of a completely depolarizing channel are put into a superposition of their possible causal orders, they can transmit non-zero classical information. Here, we study how well we can transmit classical information with N depolarizing channels put in superposition of M causal orders via quantum SWITCH. We calculate Holevo quantity if the superposition uses only cyclic permutations of channels and find that it increases with M and it is independent of N. For a qubit it never reaches 1 if we are increasing M. On the other hand, the classical capacity decreases with the dimension d of the message system. Further, for $N = 3$ and $N = 4$ we studied superposition of all causal orders and uniformly superposed causal orders belonging to different cosets created by cyclic permutation subgroup.

Reverse Quantum Speed Limit: How Slow Quantum Battery can Discharge?: We introduce the notion of reverse quantum speed limit for arbitrary quantum evolution, which answers a fundamental question: "how slow a quantum system can evolve in time?" Using the geometrical approach to quantum mechanics the fundamental reverse speed limit follows from the fact that the gauge invariant length of the reference section is always greater than the Fubini-Study distance on the projective Hilbert space of the quantum system. We illustrate the reverse speed limit for two-level quantum systems with an external driving Hamiltonian and show that our results hold well. We find one practical application of the reverse speed limit in discharging process of quantum batteries which answers the question: "how slow quantum batteries can discharge?" Also, this provides the lower bound on the discharging power of quantum batteries

Dismantling Wave-Particle Duality with Quantum Cheshire Cat: The quantum Chesire

3. Sk Sazim, Michal Sedlak, Kratveer Singh, Arun K Pati, *Classical Communications with Indefinite Causal Order for N completely depolarizing channels*, arXiv:2004.14339 .

4. Brij Mohan, Arun K Pati, *Reverse Quantum Speed Limit: How Slow Quantum Battery can Discharge?*, arXiv:2006.14523 .

5. Pratyusha Chowdhury, Arun K Pati, Jing-Ling Chen, *Dismantling Wave-Particle Duality with Quantum Cheshire Cat*, arXiv:2009.00545

6. Jasleen Kaur, Shrobona Bagchi, Arun K Pati, *Remote Creation of Quantum Coherence via Indefinite Causal Order*, arXiv:2103.04894 .

Invited Lectures/Seminars:

1. Delivered a Seminar on five day Online Symposium on Quantum information and Computation during June 29- July 3, 2020 at IIIT, Hyderabad.

2. Delivered a Keynote talk in the International Webinar on Fundamental Sciences and Quantum Technologies using Atomic Systems (FSQT 2020), held at PRL, Ahmedabad from 28th September to 1st October, 2020.

3. Delivered a popular talk to motivate College students in Hinjilicut College, Odisha on October 3, 2020.

4. Delieverd two talks at Faculty Development Program on Quantum Information and Computation, held at NIT, Sikkim during 5th to 17th October 2020.

5. Delivered physics online colloquium at IIT Gandhinagar on 21st October, 2020 4:30 PM (IST) on " Conservation of Quantum Information".

6. Delivered a special Webinar at Department of Physics, University of Kerala on "Quantum Information Technology" on 14th Dec 2020 at 3:30pm, as a part of the Webinar series to celebrate the 50th anniversary of the Department.

7. Delivered a Plenary talk in Young Scientists' Conference(YSC), IISF on Dec 23, 2020 held at NPL, Delhi from 22-24 Dec 2020. Plenary session was on Frontier Areas of Basic and Applied Sciences-Physical Science.

8. Delivered an online Seminar on "Mysteries in Quantum Physics" to motivate College students at Gunupur College, Odisha on 15 Jan 2021 at 4.00 pm.

Academic recognition/Awards:

- Ranks in top 1% Scientists in the world in General Physics and in top 2% Scientists in the world from all branches of Science– a study conducted by the Stanford University in 2020.

- Received "Distingushed Alumni Award" from Berhampur University, Berhampur, Odisha in January 2021.