
Academic Report (2020-21)



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Research Summary:

During 2020-21, the main directions of quantum technologies that I have worked on include designing efficient quantum network for information transmission which is robust against noise, characterization of quantumness in multipartite states, investigations of quantum features in the dynamics of quantum many-body systems, understanding multimode correlation in continuous-variable systems.

Towards establishing the quantum network, we design a global and optimal local measurement-based protocol in one- and two-dimensional lattices by which any two or more prefix sites can be connected via entanglement from several copies of bipartite noisy entangled states. In this respect, complete characterization of a noisy multipartite quantum state in terms of entanglement requires full knowledge of how the entanglement content in the state is affected by the spatial distribution of noise in the state. Specifically, we find that if the measurement basis in the protocol of computing localizable entanglement and the basis of the Kraus operator representing the local noisy channel do not commute, the information regarding the noise is retained in the system even after the qubit is traced out after measurement.

To design quantum technologies in physical systems like cold atoms, ion traps, it is important to characterize the many-body system. We study quantum correlations of the dynamical state of the alternating field transverse XY spin chain with Dzyaloshinskii-Moriya interaction. We report that multipartite entanglement of the evolved state has the potential to detect interesting phenomena like a dynamical quantum phase transition in this system. Moreover, we seek suitable information-theoretic quantities, which during dynamics can give prominent response to the quantum critical region in the transverse field quantum XY model.

Although quantum information protocols were originally proposed for discrete variable systems and they have been implemented, e.g., by using the polarization degree of freedom of photons, there are some shortcomings. It turns out that continuous-variable (CV) systems can overcome certain difficulties and hence implementing quantum information processing tasks by using CV states in infinite-dimensional systems can be important. Recently, we propose an efficient way to quantify entanglement in multimode CV states, both for Gaussian as well as non-Gaussian states.

Publications:

1. R. Gupta, S. Gupta, S. Mal and A. Sen(De), *Performance of Dense Coding and Teleportation for Random States –Augmentation via Pre-processing*, Phys. Rev. A **103**, 032608 (2021).
2. K. Sen, C. Srivastava, S. Mal, A. Sen(De), and U. Sen, *Detection loophole in measurement-device-independent entanglement witness*, Phys. Rev. A **103**, 032415 (2021).
3. C. Srivastava, S. Mal, A. Sen(De), and U. Sen, *Sequential measurement-device-independent entanglement detection by multiple observers*, Phys. Rev. A **103**, 032408 (2021).

6. *Quantum info processing with many-body physics*, Lakshmi Raman Memorial Lecture 2020, IIT Madras, September, 2020.
7. *Quantum Technologies*, National Webinar on "Harnessing Quantum Weirdness: Towards New-Age Technologies", Susil Kar College, Kolkata, September, 2020.
8. *Aspects of Quantum Technologies*, Indo-Russia webinar on "Quantum Technologies", SEmbassy of India in Russia, September, 2020.
9. *Quantum Technologies*, Faculty Development Program on Quantum Information and Computation, NIT Sikkim, October, 2020.
10. Quantum technologies with many-body physics, DPS Seminar, IISER Mohali, October, 2020.
11. *Quantum Technologies*, Faculty Development Program on Quantum Information and Computation, University of Goa, November, 2020.
12. *Quantum Technologies*, S N Bose Memorial Lecture at IWCEAMMS-2020, Calcutta Mathematical Society, December, 2020.
13. *Quantum Technologies*, Conference on "Recent advances in Mathematics and related areas, KSCSTE-Kerala School of Mathematics, December, 2020.
14. *Quantum Technologies*, 1st International Conference on Applied Analysis, Computation and Mathematical Modelling in Engineering, National Institute of Technology Rourkela, February, 2020.
15. *Quantum Technologies*, Webinar series for celebrating 50 years of Indian Physics Association, IPA, March, 2021.
16. *Recent Trends in Communication*, NASI organized webinar on Quantum Technologies, Christ Church College, March, 2021.
17. *Quantum Technologies*, Prof. R. Ananthakrishnan' Colloquium, Indian Institute of Tropical Meteorology, March, 2021.
18. *Recent developments in Quantum Technologies*, Colloquium, Defence Research and Development Organisation, March, 2021.

Academic recognition/Awards:

- Awarded Rupa Chakravarty Memorial Silver Medal as a distinguished ex-Bethunite from Bethune College, 2021.

Other Activities:

1. Served as a Thematic group member (TG-Research) in the process of formulating India's new Science, Technology, and Innovation Policy (STIP 2020).
2. Serving as a Member of the Gender in Physics Working Group of Indian Physics Association.