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. K. Sen, C. Srivastava, S. Mal, A. Sen (De), and U. Sen, *Noisy quantum input loophole in measurement-device-independent entanglement witnesses*, arXiv:2012.09089.

7. A. Ghoshal, S. Das, A.K. Pal, A. Sen (De), and U. Sen, *Three cooling off in two baths: Beyond two-body system-bath interactions in quantum refrigerators*, arXiv:2012.08399.

8. S. Roy, S. Mal and A. Sen(De), *Gain in Performance of Teleportation with Uniformity-breaking Distributions*, arXiv:2010.14552.

9. S. Mal and A. Sen(De), *Unifying Two Notions of Nonlocality in Quantum Theory*, arXiv:2009.04245.

10. L. G. C. Lakkaraju, S. Ghosh, S. Roy and A. Sen(De), *Distribution of entanglement with variable range interactions*, arXiv:2006.09257.

11. S. Ghosh, T. Chanda, S. Mal and A. Sen(De), *Fast charging of quantum battery assisted by noise*, arXiv:2005.12859.

12. R. Gupta, S. Gupta, S. Mal and A. Sen(De), *Constructive Feedback of Non-Markovianity on Resources in Random Quantum States*, arXiv:2005.04009.

Conference/Workshops Attended:

1. *Online Symposium on Quantum information and Computation (Quantum Talks)*, IIIT Hyderabad, June 2020.

2. *Indo-Japan webinar on quantum technologies*, July 2020.

3. *Quantum Foundations, Technology and Applications 2020*, IISER Mohali, December 2020.

4. *IPA50 Webinar series*, India, November 2020- March 2021.

Invited Lectures/Seminars:

1. *Quantum Technologies*, Vigyan Vidushi programme, Tata Institute for fundamental research, June, 2020.

2. *Aspects of Quantum Technologies: Research at HRI*, Indo-Japan webinar on "Quantum Technologies", Science and Technology Wing, Embassy of India in Tokyo, July, 2020.

3. *Recent developments in Quantum Technologies* , inauguration of the Center for Atomic, Molecular, and Optical Sciences and Technologies (CAMOST), IIT Tirupati and IISER Tirupati, August, 2020.

4. *Quantum Technologies*, Vigyan Jyoti Programme(DST), Jawahar Navodaya Vidyalaya , Bangalore, August, 2020.

5. *Quantum communication Network*, Qiskit YouTube Quantum Seminar series, IBM, September, 2020.