

# Prem Kumar

Ph.D. Student

The Institute of Mathematical Sciences (IMSc), Chennai, India

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## Education and Training

### Ph.D. in Theoretical Physics

2021-Present

Institute of Mathematical Sciences (IMSc), Chennai, India

PhD supervisor: [Prof. Sibasish Ghosh](#)

### M.Sc. in Physics

2019-2021

Institute of Mathematical Sciences (IMSc), Chennai, India

MSc project supervisor: [Prof. Sibasish Ghosh](#)

### B.Sc. in Physics, Maths, Electronics

2016 - 2019

Christ (Deemed to be University), Bangalore, India

## Research Highlights

- Analytical derivation of the 4th-order Time-Convolutionless (TCL4) generator for Spin-Boson models, benchmarking it against exact numerical methods. We also studied the corrections to the steady state and non-Markovianity of the dynamics. [1, 2]
- Analytical extension of the ultra-strong coupling quantum mean force Gibbs state (the generalization of the Gibbs state when the system-environment coupling is non-negligible) for a large class of anharmonic environments. [3]

## Research Interests

My main research interest lies in the areas of open quantum systems. This includes its theoretical study as well application to physically/experimentally relevant models like those found in chemical, biological or other many-body systems. I am interested in studying both analytical and numerical techniques useful in the study of these systems. I am also interested in related topics like non-Markovianity, Quantum Thermodynamics and other topics in quantum information theory.

Other than this, I am keen on exploring systems with indistinguishable particles and many body quantum systems. I am also open to exploring other interesting topics in theoretical physics.

## Publications

### Refereed Journal Publications

- [1] Prem Kumar, K. P. Athulya, and Sibasish Ghosh. “Equivalence between the second order steady state for the spin-boson model and its quantum mean force Gibbs state”. In: *Physical Review B* 111.11 (2025), p. 115423. DOI: [10.1103/PhysRevB.111.115423](https://doi.org/10.1103/PhysRevB.111.115423).
- [2] Prem Kumar, K. P. Athulya, and Sibasish Ghosh. “Asymptotic TCL4 Generator for the Spin-Boson Model: Analytical Derivation and Benchmarking”. In: *Physical Review B* (2025). DOI: [10.1103/69y3-x6vh](https://doi.org/10.1103/69y3-x6vh).

- [3] Prem Kumar and Sibasish Ghosh. “Ultrastrong coupling limit to quantum mean force Gibbs state for anharmonic environment”. In: *The Journal of Chemical Physics* 161.17 (2024). DOI: [10.1063/5.0223734](https://doi.org/10.1063/5.0223734).

### Pedagogical Reviews

- [4] Prem Kumar. “Local harmonic approximation to quantum mean force Gibbs state”. In: (2024). arXiv: [2401.11595](https://arxiv.org/abs/2401.11595).

## Technical Skills

- Computational Physics & ML:

- **Tensor Networks:** Implementation of algorithms for simulating open quantum system dynamics using Feynman-Vernon influence functional formalism and tensor network framework.
- **Machine Learning:** PyTorch for machine learning and designing transformer models.
- **Languages:** Python (QuTiP, NumPy, SciPy).

- Symbolic Computing (Mathematica):

- Developed **spin-boson-tcl4**: An open-source package for the symbolic derivation and implementation of 4th-order Time-Convolutionless (TCL) master equations.

## List of presentations and participations at conferences

1. Poster presentation on “*Asymptotic TCL4 Generator for the Spin-Boson Model: Analytical Derivation and Benchmarking*”, Quantum Foundations Technology and Applications (QFTA-2025), IISER Mohali, India, 4–8 December 2025.
2. Poster presentation on “*Ultrastrong coupling limit to quantum mean force Gibbs state for anharmonic environment*”, Second DPG Fall Meeting: 100 Years of Quantum Physics, Georg-August-Universität Göttingen, Germany, 8–12 September 2025.
3. Poster presentation on “*Equivalence between the second order steady state for the spin-boson model and its quantum mean force Gibbs state*”, “100 Years of Quantum Mechanics”, IISER Kolkata, India, 18–21 December 2024.
4. Poster presentation on “*Ultrastrong coupling limit to quantum mean force Gibbs state for anharmonic environment*”, QCMC-24: International Conference on Quantum Communication, Measurement and Computing, IIT Madras, Chennai, India, 26–30 August 2024.

## Talks and Seminars

1. “*Quantum mean force Gibbs state in weak and ultra-strong coupling limits*”, Academic visit, “Department of Mathematical Physics, Nicolaus Copernicus University, Torun, Poland”, Sept 15-19,
2. Seminar on “*Equilibrium state and dynamics of an open quantum system in weak and strong coupling limits*”, Academic visit, IIT-H, May 7-9 2025.
3. Seminar on “*The Approximate Thermal State for a Quantum System*”, Institute Seminar Days 2024, IMSc, Chennai, India, Jan 23 & 31, 2024.

## Achievements

- JEST 2019: All India Rank 75, Percentile: 98.89
- JAM 2019: All India Rank 146, Percentile: 99.06
- During BSc, won 1st prize in State level Inter-Collegiate Fest, Jyoti Nivas College, Bangalore, February 2018 for building a 20-bit programmable computer on breadboard.

## Professional References

### Dr. Sibasish Ghosh

Professor

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The Institute of Mathematical Sciences  
Chennai - 600113, India  
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### Prof. Arul Lakshminarayan

Professor, Department of Physics  
Indian Institute of Technology Madras  
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