

# Prem Kumar

Ph.D. Student

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## Education and Training

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| <b>Ph.D. in Theoretical Physics</b><br>Institute of Mathematical Sciences (IMSc), Chennai, India<br>Supervisor: <a href="#">Prof. Sibasish Ghosh</a> | 2021-Present |
| <b>M.Sc. in Physics</b><br>Institute of Mathematical Sciences (IMSc), Chennai, India<br>Supervisor: <a href="#">Prof. Sibasish Ghosh</a>             | 2019-2021    |
| <b>B.Sc. in Physics, Maths, Electronics</b><br>Christ (Deemed to be University), Bangalore, India  | 2016 - 2019  |

## Research Highlights

- Developed an analytical 4th-order Time-Convolutionless (TCL4) generator for Spin-Boson models, benchmarking it against exact numerical methods.
- Generalized the ultra-strong coupling limit quantum mean force Gibbs state to a large class of anharmonic environments.

## Publications

### *Refereed Journal Publications*

1. Prem Kumar, K. P. Athulya, and Sibasish Ghosh. “Asymptotic TCL4 Generator for the Spin-Boson Model: Analytical Derivation and Benchmarking.” *Physical Review B* (accepted, 2025).
2. 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.” *Physical Review B* 111, 115423 (2025).
3. Prem Kumar, and Sibasish Ghosh. “Ultrastrong coupling limit to quantum mean force Gibbs state for anharmonic environment.” *The Journal of Chemical Physics* 161, 17 (2024).

### *Pedagogical Reviews*

- Prem Kumar. “Local harmonic approximation to quantum mean force Gibbs state” [arXiv:2401.11595](https://arxiv.org/abs/2401.11595) (2024).  
*Note: A unified derivation and review of the harmonic approximation method for mean force Gibbs state.*

## Technical Skills

- **Computational Physics & ML:**
  - **Tensor Networks:** Implementation of algorithms for simulating open quantum system dynamics.

- **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 “*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.
2. 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.
3. 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.

### Research visits 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.

### 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](#).