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
Supervisor: Prof. Sibasish Ghosh

M.Sc. in Physics 2019-2021
Institute of Mathematical Sciences (IMSc), Chennai, India
Supervisor: Prof. Sibasish Ghosh

B.Sc. in Physics, Maths, Electronics 2016 - 2019
Christ (Deemed to be University), Bangalore, India

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. **"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).
2. 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).

Submitted Work & Preprints

3. Prem Kumar, K. P. Athulya, and Sibasish Ghosh. **"Asymptotic TCL4 Generator for the Spin-Boson Model: Analytical Derivation and Benchmarking."** arXiv preprint arXiv:2506.17009 (2025).

Pedagogical Reviews

- Prem Kumar. **"Local harmonic approximation to quantum mean force Gibbs state"** arXiv: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.