SAJAG KUMAR

sajag.kumar@niser.ac.in

+91 7849008258

sajag-kumar7.github.io

EDUCATION

National Institute of Science Education and Research (NISER) *2020 - 2025*
Integrated M. Sc., Physical Sciences (Major), Computer Sciences (Minor)
CGPA - 9.35/10, Rank - 1/55.

Hope Hall Foundation School *2020*
Central Board of Secondary Education, 12th Standard.
Mathematics, Physics, Chemistry, English, Physical Education, **93.4%**.

Kendriya Vidyalaya, No. 1, AF Station, Darbhanga *2018*
Central Board of Secondary Education, 10th Standard.
Mathematics, Science, English, Social Science, Sanskrit, **96.8%**.

RESEARCH EXPERIENCE

Aspects and Applications of Chern-Simons Theories *August 2024 - May 2025*
Advisor: *Dr. Shamik Banerjee, NISER Bhubaneswar* *(Master's Thesis)*

- Studied differential geometry and representations of Lie groups and algebras as prerequisites. Acquainted myself with $2D$ conformal field theory techniques and with the basics of gauge theories and topological quantum field theories.

- Reviewed the geometrical settings and quantization of Chern-Simons theories on three-dimensional manifolds. Computed Feynman diagrams of Chern-Simons matter theories coupled to bosons.

- Discussed the application of these theories in the quantum mechanics of non-Abelian anyons and as effective field theories of fractional quantum Half effects.

Neural Belief Propagation Decoding of Sparse Quantum Codes *May 2024 - July 2024*
Advisor: *Prof. Markus Müller, RWTH Aachen* *(ML4Q Internship)*

- Learned about message-passing based decoders for quantum error correcting codes and got acquainted with Stim (a Python package for stabilizer circuits).

- Implemented neural belief propagation algorithm for decoding quantum error correcting codes under realistic noise models using PyTorch.

- Achieved better decoding performance than belief propagation on surface codes and recovered the threshold theorem scaling.

Prethermalization in Aperiodically Driven Classical Spins *May 2023 - July 2023*
Advisor: *Dr. Sayan Choudhury, HRI Prayagraj* *(Visiting Student Fellowship)*

- Numerically studied the non-equilibrium dynamics of aperiodically driven classical spins on a two-dimensional lattice. Established the presence of a long-lived prethermal regime and discovered a novel prethermalization time scaling.

- Established the presence of classical discrete time-crystalline non-equilibrium phases of matter called time rondeau crystals in these systems.

- *Sajag Kumar and Sayan Choudhury, Prethermalization in aperiodically driven classical spin systems,* [Phys. Rev. E 110, 064150](.).

Geometric Phases in Optics *May 2022 - July 2022*
Advisor: *Dr. Ashok Mohapatra, NISER Bhubaneswar*

- Learned about geometric phases in classical optics, quantum mechanics and condensed matter physics. Studied the geometric origin of these phases using fiber bundle theory.

- Explored the possibility of experimentally demonstrating geometric phase in angular momentum space of light using Laguerre-Gaussian beams.

- Designed an undergraduate experiment to demonstrate the Panchratnam-Berry phase using a Mach-Zehnder interferometer.

COURSE PROJECTS

DMRG Study of the Kitaev Chain *(Semester - IX)*
Course: *Many-Particle Physics*, Instructor: *Dr. Anamitra Mukherjee*

- We calculated the **Resonant Inelastic X-Ray Scattering (RIXS)** spectrum of the Kitaev Chain, using the **density matrix renormalization group (DMRG)** algorithm.

Scrambling Dynamics in Classical and Quantum Systems *(Semester - VIII)*
Course: *Computational Physics*, Instructor: *Dr. Subhasish Basak, Dr. Anamitra Mukherjee*

- Computed the decorrelator for classical systems, using **Monte Carlo** and **Runge-Kutta** methods for Kauffman cellular automaton and classical Heisenberg model, respectively. Used **time evolving block decimation (TEBD)** and **time dependent variational principle (TDVP)** algorithms to calculate out-of-time-ordered correlators (OTOC) for interacting quantum spin models.

Topological Quantum Error Correction *(Semester - VIII)*
Course: *Quantum Information and Quantum Computation*, Instructor: *Dr. Anamitra Mukherjee*

- Learned the **stabiliser formalism** and braiding of anyons in the **toric code** for quantum error correction. Simulated repetition codes in **Qiskit**.

Divergence of Perturbation Theory *(Semester - VIII)*
Course: *Quantum Field Theory - II*, Instructor: *Dr. Yogesh K. Srivastava*

- Read **Dyson's argument** for the divergence of perturbation series in quantum electrodynamics and got acquainted with modern techniques for **resummation** of divergent series.

Gamma Matrix Model for Algebraic Spin Liquid *(Semester - VII)*
Course: *Advanced Solid-State Physics*, Instructor: *Dr. Kush Saha*

- Studied an exactly solved model whose ground state is an **algebraic spin liquid** and computed the dispersion relations. As a pre-requisite, studied **fermionisation** techniques for solving interacting spin systems.

Estimation of Electronic Band Gap Energy From Material Properties Using Machine Learning *(Semester - VI)*
Course: *Machine Learning*, Instructor: *Dr. Subhankar Mishra*

- Used **random forest, gradient boosted trees, XGBoost and k-means** algorithms for various regression, classification and clustering tasks involved in a novel ensemble learning model for band gap estimation from elementary material properties.

Rosenbluth and Pruned-Enriched Rosenbluth method for Simulating Polymers on Lattices *(Semester - V)*
Course: *Computational Physics Laboratory*, Instructor: *Dr. Subhashis Basak*

- Simulated a model of polymers as **self-avoiding random walks** on two- and three-dimensional lattices. Numerically estimated the scaling exponent for the squared end-to-end distance of polymers as a function of their length.

ACADEMIC ACHIEVEMENTS

- Topper in Physics Medal for the highest CGPA in the Integrated M.Sc. Physics program at NISER. *2025*
- Sarat-Chandra Annapurna Medal in Physics. *2025*
- Selected for the **ML4Q Undergraduate Research Program** at RWTH Aachen. *2024*
- Received **Visting Student Fellowship** from Harish-Chandra Research Institute. *2023*
- Offered **Summer Research Fellowship** by the Indian Academy of Sciences. *2023*
- **Academic excellence award** for highest SGPA (Class of 2025) in Semester - IV. *2022*
- **Academic excellence award** for highest SGPA (Class of 2025, Physical Sciences) in Semesters - IV, V and VII. *2022, 2023, 2024*
- **DISHA** (DAE Incentive Scheme for Holistic Science Education and Augmentation) Scholarship from Government of India. *2020 - 2025*

TECHNICAL SKILLS

Programming Languages: Python, C/C++

Scientific Computation Libraries: TeNPy, Stim, QuSpin, Matplotlib, NumPy, SciPy, SymPy

Machine Learning Libraries: PyTorch, scikit-learn, TensorFlow

Markup Languages: LaTeX, Markdown, HTML

SUMMER SCHOOLS/WORKSHOPS/CONFERENCES

Participated and presented a poster at the **ML4Q students and postdocs summer retreat** organised by the ML4Q cluster of excellence at Siegburg, Germany. *July 2024*

Participated in **HSF-India HEP Software Workshop** organized at the National Institute of Science Education and Research, Bhubaneswar. *December 2023*

Participated in **Physics of Life 2023: The 8th Annual Monsoon School** organized by the National Center for Biological Sciences, Bengaluru, India. *June 2023*

Attended (online) school for masters students, **From Quantum Matter to Quantum Computers** organized by the Max Planck Institute for the Physics of Complex Systems (MPI-PKS). *October 2022*

Attended (online) summer school, **Curves and Surfaces: Geometry and Physical Applications** organized by the International Centre for Theoretical Sciences (ICTS). *May 2022*

OUTREACH AND VOLUNTEERING

Batch Representative, Vikiran (Physics Club NISER) *2022 - 2024*
Organised several talks and interactive sessions on contemporary research directions in physics.

Member of Core Committee, Coding Club NISER *2022 - 2024*
Responsible for designing problems for programming contests.

Head of Design, Varnapatt (Issue 01), a magazine by Vaktavya *2022*
Designed the entire magazine in Adobe InDesign.

Co-Founder, Vaktavya (the debating club of NISER) *2021*
Co-founded in sophomore year to foster discussions on pressing issues in science and academia.

Editor, Kshitij (Issue 04), a magazine by NISER Astronomy Club *2022*
Wrote an article on gravitational wave astronomy and edited other articles in the magazine.

Head of Design, Kshitij (Issue 03), a magazine by NISER Astronomy Club *2022*
Led the design team of the magazine.