Pranav **Kairon**

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Summary

For my PhD, I plan to specialize in the application and theoretical exploration of advanced computational tools such as quantum Monte Carlo, tensor networks, and machine learning, with a focus on their applications in quantum computing, condensed matter physics and AMO. My research is driven by a keen interest in understanding and innovating within these domains, aiming to bridge the gap between theoretical frameworks and practical applications in complex physical systems.

Education

University of British Columbia — *Vancouver, Canada*

MS Physics under Prof. Roman Krems — *2021 - August 2024*

- CGPA: 3.65/4
- Teaching Assistant for PHYS 100 (Classical Mechanics) and PHYS 131 (Electromagnetism)

Delhi Technological University — *New Delhi, India*

Bachelor of Technology in Engineering Physics — *2017 - 2021*

- CGPA: 8.94/10

St. Xavier's Senior Secondary School — *New Delhi, India*

Grade 12 (Senior Secondary Level) — *2017*

- Percentage: 89.2%

Publications and Posters

Extrapolation of polaron properties to low phonon frequencies by multi-fidelity Bayesian machine learning — *Vancouver, Canada*

Conference Talk/Journal submission — *August, 2023*

- The talk and the poster were presented at **RTGdyn Conference (UBC, Freiburg)**.The slides for the event can be found here (Slides).
- The preprint is available by end of December 2023. To be submitted to Physics Review B

Equivalence between Barren plateaus and kernel concentration problem — *Vancouver, Canada*

Manuscript under preparation — *August, 2023*

- Demonstrated how the training bounds for Barren Plateaus, in quantum neural networks can be transferred to solve the Exponential Concentration problem in quantum kernels and vice versa.
- Proved that symmetry encoded quantum kernels suffer from lower rates of exponential concentration, using concepts from Weingarten Calculus and Lie algebra
- The preprint is available by January 2024

Coherence-based inequality for the discrimination of three-qubit GHZ and W class

Journal Article — *January, 2022*

- Kairon, P., Singh, M., Adhikari, S. Coherence-based inequality for the discrimination of three-qubit GHZ and W class. Quantum Inf Process 21, 173 (2022) (Link)

Noisy three-player dilemma game: robustness of the quantum advantage

Journal Article — *April, 2020*

- Kairon, P., Thapliyal, K., Srikanth, R. et al. Noisy three-player dilemma game: robustness of the quantum advantage. Quantum Inf Process 19, 327 (2020) (Link)

COVID-19 Outbreak Prediction Using Quantum Neural Networks — *DoSIER 2020 (Virtual)*

Conference Paper — *June, 2021*

- Kairon, P., Bhattacharyya, S. (2021). COVID-19 Outbreak Prediction Using Quantum Neural Networks. In: Bhattacharyya, S., Dutta, P., Datta, K. (eds) Intelligence Enabled Research. Advances in Intelligent Systems and Computing, vol 1279. Springer, Singapore (Link)

Simulation of 2019-nCoV envelope formation as a platform for screening therapeutics which may interfere with viral protein-protein interactions

Abstract presented at International Conference on Complex Systems, 2020 — *May, 2020*

- The abstract is available at (Link)

Experimental test of quantum advantage 3- player noisy dilemma game — *Munich, Germany (Virtual)*

Poster presented at MCQST — *July, 2020*

- The poster is available at (Link)

Thesis Projects

Bayesian extrapolation of quantum observables in Hamiltonian parameter spaces *UBC, Canada*

Graduate Research Project at UBC

- I used Gaussian process regression with kernel selection algorithm to extrapolate polaron dispersion relations in hamiltonian parameter space such as phonon frequency, momentum, and coupling. Using Green's function cluster expansion for data acquisition in the adiabatic regime, the model accurately predicted phase transitions at lower phonon frequencies and explored the extreme adiabatic regime of Peierls polaron physics, addressing challenges in high-temperature superconductivity research.

Equivalence between Barren plateaus and kernel concentration problem *UBC, Canada*

Graduate Research Project at UBC

- Derived conditional relations that can transfer the bounds derived for Barren plateaus in quantum neural networks to quantum kernels .
- Dervied strict lower bounds for covariant quantum kernels, and showed how they can avoid exponential concentration

Additional unpublished projects *UBC, Canada*

Graduate Research Project at UBC

- Worked on designing an experimental proposal using quantum dot based analogue simulator for simulating **attosecond physics** in atoms, specifically HHG spectra in 1D hydrogen atom. I used tools like COMSOL (to desing quantum dots), PETSc (large scale parallel simulation)
- Applied ML to predict **the topological phase transition and Dirac Cones in twisted multilayer cuprates** by training Gaussian process model with data from trivial phase. Further extended it to predict Conical Intersections in CH_2NH potential energy surface.
- Writing my own **DMRG code** for electron-phonon models based on pseudo-site method.

Coherence based inequality for state discrimination *DTU, India*

Bachelor's Thesis under Dr. Satyabrat Adhikari and Dr. Mukhtiyaar Singh

- Studied the relationship between coherence and entanglement measures in discrete/continuous quantum systems.
- Developed coherence based inequality for the classification of GHZ class and W class of three-qubit states.
- Extended it further to possible implementation of the scheme in an experiment, to reduce the number of projective measurements.

Experience

Mitacs Accelerate *Canada*

Research Internship *October, 2023 - August, 2024*

- Using quantum machine learning methods to perform feature selection for a biomedical dataset with millions of dimensions.
- Wrote a grant proposal in collaboration with my supervisor and the company for 30k CAD.

Superconducting Circuit Design and Fabrication *Canada*

Research Workshop by CMC Microsystems *June, 2022 - July, 2022*

- Gained hands-on experience in designing, simulating, and fabricating superconducting circuits, including resonators, SQUIDs, and qubits, utilizing CMC-provided CAD tools.
- Conducted advanced testing of superconducting chips using a 4K probe station and a dilution refrigerator, demonstrating proficiency in low-temperature experimental techniques crucial for quantum information science. Participated in the Quantum Fab Lab at Institut quantique, enhancing skills in the practical application of quantum devices and experimental setup.

HCL Technologies *Bengaluru, India*

Research Internship *August, 2021 - September, 2021*

- Benchmarked various methods present for solving electronic structure problem on DWave quantum annealer (AWS Amazon Braket).
- Presented a report on error mitigation schemes for variational quantum eigensolver, where error is mitigated by exploiting the symmetries in Hamiltonian.

Conduit Computing *Boston, USA (Remote)*

Research Internship *March, 2020 - January, 2021*

- Worked on drug development for Covid-19 by simulating proteins using NAMD and VMD with help of Fronterra supercomputer.
- Project selected for White House HPC consortium and Nvidia Supercomputers.
- Literature survey for using Quantum tensor network methods to perform Quantum Monte Carlo simulations for applications to risk analysis.
- Full research proposal presented at Quantum British Columbia, Virtual Poster Presentation on quantum computing.

Qnu Labs {India's first Quantum Company} *Bengaluru, India*

Research Internship under Dr. Anindita Banerjee *December, 2019 - January, 2020*

- Worked on discrete phase randomization of Differential Phase shift QKD and COW protocol.
- Developed MATLAB/Mathematica programs to calculate key rate deterioration with distance for various DPS protocols.
- Developing reports on high throughput Quantum random number generators which can be simulated experimentally in the lab, that rely on random generation using phase noise of LASER.

Solid State Physics Laboratory - DRDO *Delhi, India*

Research Internship *May, 2019 - August, 2019*

- Worked on characterizing Gold, HOPG, MCT, GaAs samples using Scanning Tunnelling Microscopy and Electrical characterization AlN thin films on Si(111) by fabricating MIS structures.
- Renewed a broken 40K $ worth of table top STM and configured the software re-installation and hardware setup by myself.

Solid State Physics Laboratory - DRDO *Delhi, India*

Research Internship *Dec, 2018 - February, 2019*

- MATLAB modelling of Thin film characterization using X-ray reflectivity.
- Composition, Stress & Strain determination of AlGaN/GaN multilayer for HEMT devices

Laser Science and Technology Center – DRDO *Delhi, India*

Research Internship *May, 2018 - August, 2021*

- Worked on development of optical resonator for high power Lasers using Nd-doped PoCl3 as the gain medium Developed MATLAB program for the same.
- Surveyed various optical coatings for laser grade mirrors.

Honours, Grants & Scholarships

2023 **Mitacs Accelerate Grant**, Obtained a grant for a 10 month internship in collaboration with Biomedical startup to find usecases quantum machine learning on their dataset

2022 **IBM Error correction summer school**, Selected for in person IBM summer school in New York, out of hundreds of applicants

2022 **Commendable Research Award at DTU**, Won the commendable research award and a cash prize of Rs. 50k for publishing a journal article as part of my bachelor's thesis.

2022 **Quantum BC Roadmapping Workshop**, Won first place in Roadmapping workshop, Developed quantum based solution for an industrially relevant genomics problem

2021 **QuEST Fellowship**, Stewart Blusson Quantum Matter Institute, University of British Columbia, Canada

2021 **NSERC Quantum Computing CREATE Scholarship**, University of British Columbia, Vancouver, Canada

2021 **MCQST Summer School 2021**, Shortlisted among 20 students among 500 applicants all over the world for first Munich Center of Quantum Science and Technology Summer School

2020 **Cornerstone Models of Quantum Computing online summer school**, Selected for summer school conducted by Quantum British Columbia among 130 undergraduate & graduate candidates

2017 **All India Rank - 4922**, JEE Main, taken by approximately 1.5 million students.

Skills

Programming Languages	Python, C++, MATLAB, Mathematica
Packages and Environments	Qiskit, Pennylane, IBMQ Experience, JAX, Tensorflow, Pytorch, ITensor, dmrgpp
Utilities	Git/Github, Linux Shell, VScode, Jupyter

Extracurricular Activity

NSERC Quantum Computing, CREATE *Vancouver, Canada*

Mentor and Judge at High School Engineering and Design Competition *November 2022*

- Mentored two groups of five high school students each. Students were supposed to show how can quantum computing be used in inter-planetary communication. Later we judged the final presentations

Deltech Engineering Physics Technological Hub, Delhi Technological University *Delhi, India*

Vice-President, Lecturer for the term 2020-21 *2017 - 2021*

- DEPTH is an undergraduate society which organizes seminars, debates, guest lectures, paper presentations intended at enhancement in knowledge of and unfolding of various scientific fields before its members.
- Conducted lectures on various topics not covered in university courses.
- Mentored beginners in the field to explore the various topics systematically.

Student Mentorship Programme *Delhi, India*

Mentor *2019 - 2021*

- Personally mentored five freshmen from the Engineering Physics Department.
- Individually guided them through personal and academic problems for the entire year.