

Ziqi Xu

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SUMMARY

Physics M.Sc. (University of Waterloo, 2026) with research experience in neural quantum states and quantum many-body numerics. I build and test research software in Python (PyTorch, NetKet, JAX, TeNPy) for variational Monte Carlo, tensor networks and exact diagonalization. Seeking quantum software engineering roles.

EDUCATION

M.Sc. in Physics, University of Waterloo, Waterloo, ON 2024 – 2026

Associate Graduate Student, Perimeter Institute for Theoretical Physics (2024 – 2026)

Supervisors: Prof. Robert Mann; co-supervisor Prof. Timothy Hsieh

Thesis: *Conditional Information Flow and Neural Representability of One-Dimensional Rotated Cluster States*

B.Sc. in Theoretical Physics, Nankai University, Tianjin, China 2020 – 2024

Culture and Sports Merit Scholarship (2023); University First-Class Athlete certification

RESEARCH EXPERIENCE

Graduate Researcher, University of Waterloo and Perimeter Institute 2024 – 2026

- Studied what makes a quantum state learnable by neural networks, using 1D rotated cluster states: the exact MPS bond dimension is 2 at every angle, yet measurement outcomes can stay conditionally dependent over many sites (conditional mutual information, CMI, up to 1 bit).
- Designed an MPS-induced recurrent ansatz whose hidden state is the MPS bond vector, with separate even/odd sublattice tensors that match the state's alternating structure. With 48 real parameters it reached the $N = 64$ ground state in all 5 random initializations (median energy-density error $1.6e-13$); a bond-dimension-1 (product-state) control stayed at total energy error 32.
- Implemented complex RBM, tanh-RNN (variational Monte Carlo) and GRU models in NetKet and PyTorch and compared them on the same state: the RBM reached median energy-density error $6e-8$ at $N = 8$ but relies on exact summation that does not scale; the best RNN run was at total energy error 0.57 at $N = 64$, still decreasing when a time limit stopped it; a GRU trained on 8192 bitstrings learned the Born distribution (fidelity 0.90) but not the phases. The results indicate that learnability depends on matching the model's hidden update to the state's structure rather than on hidden-state size.
- Wrote exact transfer-matrix code for CMI from a bond-dimension-2 MPS, validated against brute-force state-vector calculations (agreement to $1e-12$) and the analytic AKLT result; tested in CI.
- Manuscript in preparation: *Conditional Information Flow and Neural Representability of 1D Rotated Cluster States*.

Undergraduate Researcher, Computational Astrophysics 2023 – 2024

Supervisor: Prof. Yu-Qing Lou, Department of Physics, Tsinghua University

- Explored nonlinear solution families of the Lane–Emden equation for polytropic stars ($n = 1, 3.5, 4, 4.5, 5$) with MATLAB ODE solvers; tested mass-integral hypotheses with Simpson quadrature and step-size convergence checks.
- Later re-implemented the solver in Python (SciPy) with analytic-solution tests and GitHub Actions CI.

Undergraduate Researcher, Machine Learning for Nuclear Physics 2023 – 2024

Supervisor: Prof. Jinniu Hu, Nankai University

- Implemented Twin Neural Network Regression (Wetzel, *Machine Learning* 115(7):163) to invert non-injective functions; ran numerical fits across families of non-injective equations and compared k-nearest-neighbor search strategies for resolving ambiguous inverses.

Project Manager, Super-Resolution Single-Molecule Imaging 2021 – 2023

Prof. Leiting Pan's group, Nankai University; Tianjin Municipal Undergraduate Innovation Project

- Used ImageJ and SMAP for single-molecule localization microscopy; performed cross-correlation analysis and drift correction across roughly 30,000 acquired images.

PROJECTS

Collective AC Quantum Sensing Simulation 2026

- Python package modelling an entangled sensor array; showed that phase disorder turns the linear growth of the collective signal with sensor count N into square-root growth (fitted exponent 0.495 for $N = 4$ to 1024); pytest suite and CI.

Embedded Systems 2026

- Arduino UNO R4 WiFi and ESP32 prototypes in C/C++, including an LED-matrix state machine.
- Assembled and programmed a Freenove 4WD smart car: GPIO/PWM motor control, sensor integration, and iterative hardware/software debugging.

TEACHING

Teaching Assistant, PHYS 111, University of Waterloo Fall 2024

Tutorials, grading and office hours.

Teaching Assistant, Nankai University 2021 – 2023

Electromagnetism, C++ programming and computational physics.

AWARDS AND COMPETITIONS

- Mathematical Contest in Modeling (MCM/ICM), Problem A, *Power Profile of a Cyclist* – Finalist Award, 2022
- China Undergraduate Mathematical Contest in Modeling (CUMCM), wave-energy converter optimization – Provincial Second Prize, 2022
- Shenzhen Cup Mathematical Modeling Challenge, 3D horizontal-well trajectory design – Second Prize, 2022
- National College Student Statistical Modeling Competition – Tianjin Municipal First Prize, 2022
- CUPT, team member responsible for *Saving Honey* and *Water Spiral* – National Second Prize, 2022

SKILLS

Programming: Python, C++, MATLAB, LaTeX; Git, GitHub Actions, Linux, Jupyter

Scientific computing: NumPy, SciPy, PyTorch, JAX, NetKet, TeNPy, PennyLane, Matplotlib, pytest

Methods: variational Monte Carlo, neural quantum states (RBM, RNN), tensor networks (MPS, DMRG), exact diagonalization, ODE integration, numerical quadrature

Hardware: Arduino, ESP32

Languages: English, Mandarin (native)