Hyeongjin Kim

PhD Student · Condensed Matter Theory · Computational Physics

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Education

Boston University — *Boston, MA*

Ph.D. in Physics | GPA: 3.95 | Anticipated graduation date: May 2026 — *2021 - present*

Advisor: Anatoli Polkovnikov

Williams College — *Williamstown, MA*

B.A. in Physics | GPA: 3.98 — *2017 - 2021*

Advisor: Frederick Strauch
Thesis: *Optimal Control and Circuit Synthesis of Quantum Gates*
Academic Honor Societies: Phi Beta Kappa, Sigma Xi

Publications

** denotes equal contribution*

Hyeongjin Kim*, Robin Schäfer*, David M. Long, Anatoli Polkovnikov, and Anushya Chandran. (2024). Chaotic prethermal regimes in nearly integrable classical systems. Manuscript in preparation.

Cedric Lim, Kirill Matriko, **Hyeongjin Kim**, Anatoli Polkovnikov, Michael O. Flynn. (2024). Defining classical and quantum chaos through adiabatic transformations. *URL* | *PDF*

Hyeongjin Kim, Matthew T. Fishman, and Dries Sels. (2024). Variational Adiabatic Transport of Tensor Networks. PRX Quantum **5**, 020361. *URL* | *PDF*

Hyeongjin Kim and Anatoli Polkovnikov. (2024). Integrability as an attractor of adiabatic flows. Phys. Rev. B **109**, 195162. ✎ **Editors' Suggestion**. *URL* | *PDF*

Research Experience

Ph.D. Research Assistant – Boston University — *Boston, MA*

Advisor: Anatoli Polkovnikov — *2022 - present*

- Researched the classical-quantum correspondence of chaos and energy density in many-body spin systems.
- Investigated the time scales associated with chaos and thermalization in classical many-body spin systems, discovering a universal description of thermalization for systems with exponential relaxation.
- Developed a scaling theory for the transition between integrability and chaos in quantum many-body systems by studying quantum geometric tensors, establishing that integrability acts as an attractor of adiabatic flows.
- Extensive numerical experience by performing exact diagonalization and linear algebra operations on large matrices ($d = 10^6 \times 10^6$), parallelized numerical integrations, and organization and analysis of total 1TB+ of data.

Summer Research Associate – CCQ, Flatiron Institute, Simons Foundation — *New York, NY*

Advisors: Matthew Fishman, Dries Sels — *2022*

- Developed a novel tensor network method to propagate matrix product states of many-body quantum spin systems over the parameter space via the adiabatic gauge potential. The software is publicly available as a Github repository in ITensorAGP.jl.
- Utilized our method to improve the density matrix renormalization group (DMRG) calculations of low-lying excited states in many-body quantum spin chains, decreasing errors by two orders of magnitude and halving the runtime.

Undergraduate Research Assistant – Department of Physics, Williams College *Williamstown, MA*

Advisor: Frederick Strauch *2019 - 2021*

- Analytically developed and numerically optimized gate pulses for fast, high-fidelity two-qubit gates using MATLAB, achieving gate errors (including leakage effects) below 10^{-3} for any gate times between 5 ns and 60 ns.

Undergraduate Research Assistant – Department of Physics, Williams College *Williamstown, MA*

Advisor: Katharine Jensen *2018*

- Investigated the mechanics of adhesive contacts of rigid glass spheres with silicone gel surfaces using MATLAB.

Invited Talks

Center for Computational Quantum Physics, Simons Foundation *New York, NY*

Adiabatic evolution of matrix product states with the adiabatic gauge potential *April 2023*

Department of Physics, New York University *New York, NY*

Computing Excited States via Adiabatic Transformations *March 2023*

Talks

March 2024. *Connecting Lyapunov exponents and spectral functions in central spin models*. Minneapolis, MN

March 2024. *Universality in relaxation dynamics of systems near integrability*. Minneapolis, MN

May 2023. *Adiabatic evolution of matrix product states with the adiabatic gauge potential*. Boston University, MA.

March 2023. *Integrable Attractors in the Adiabatic Landscape of Chaotic Systems*. APS March Meeting. Las Vegas, NV.

May 2021. *Optimal Control and Circuit Synthesis of Quantum Gates*. Williams College, MA.

July 2018. *Dynamics of adhesive wetout and detachment*. UMass Amherst Soft Matter Day. Amherst, MA.

Projects

Simple DMRG *Github repository link*

Skills: C++, CUDA, Tensor Networks *August 2024 – October 2024*

- Created a simple implementation of the density matrix renormalization group (DMRG) in C++ to compute the ground states and energies of many-body quantum systems by using matrix product states and operators.
- Utilized CUDA by using cuTENSOR for tensor contractions and cuSOLVER for singular value decompositions.

ITensorAGP.jl *Github repository link*

Skills: Julia, Tensor Networks *June 2022 – November 2023*

- Developed a Julia package that computes the adiabatic gauge potential as a matrix product operator.

Awards and Honors

2021 **Phi Beta Kappa Induction**, PBK

2018-2020 **Summer Science Research Fellowship**, Williams College

Skills

Languages **Python, Julia, C++, MATLAB**

Libraries **Numpy, Scipy, ITensor, cuTENSOR, cuSOLVER**

Tech **Git, Linear Algebra, High Performance Computing, Parallel Computing, Tensor Networks, MySQL, CUDA**