Weiguo Ma

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Education

Ph.D. Candidate| Institute of Physics, Chinese Academy of Sciences — Sep. 2021 – Present
Condensed Matter Physics | Advisor: Dr. Prof. Heng Fan and Dr. Prof. Kai Xu — Beijing, P.R.China

B.S. | Lanzhou University — Sep. 2017 – June 2021
Theoretical Physics — Lanzhou, Gansu, P.R.China

Research Interests

- Quantum computing with tensor network technologies
- Machine learning for quantum computing, hybrid quantum-classic computing
- Non-equilibrium physics (quantum Mpemba effect, Bose-Hubbard driven-dissipative systems)

Research Projects

Quantum computing and tensor network

Implementation of qudit simulations in *tensorcircuit* — July 2025 – Aug. 2025

- Implemented a qudit simulator for quantum circuits with just-in-time (JIT) compilation and automatic differentiation support.

Tomography-Assisted Noisy Quantum Circuit Simulator using MPDOs — Dec. 2023 – June 2024

- Integrated quantum process tomography (QPT) with the matrix product density operators (MPDOs) framework.
- Extracted Kraus operators from experimental QPT data and embedded them into MPDO simulations.
- Captured complex noise effects, including crosstalk and multi-qubit depolarization.
- Validated on QAOA and MaxCut, achieving closer agreement with Quafu(-cloud) hardware than standard models.
- Studied noise truncation with bond dimension χ and κ, identifying scaling needs for larger and deeper circuits.
- Highlighted applications in pre-experimental testing, error mitigation, and noise modeling.

Machine learning for quantum computing

Automatic calibration of superconducting quantum processors via machine learning — May 2023 – Aug. 2023

- Applied supervised learning to optimize calibration of superconducting quantum chips using real and simulated data.
- Developed decision-tree models enabling fully automated single-qubit calibration workflows.

Non-equilibrium physics

Phase transitions in Bose-Hubbard driven-dissipative systems — May 2025 – Present

- Studied phase transition phenomena in a driven-dissipative lattice system under varying external and dissipative parameters.
- Observed unconventional dynamical features, including shock-like behavior and intermediate regimes.
- Outlined implications for control and manipulation of non-equilibrium quantum systems.

Genuine quantum Mpemba effect in noisy quantum circuits — Mar. 2025 – Present

- Observing a genuine quantum Mpemba effect in noisy quantum circuits.

Patents & Software Copyrights

[1] **Ma, Weiguo**, Kaixuan Huang, Yunhao Shi, Kai Xu, and Heng Fan. "Dilution Refrigerator Temperature and Pressure Monitoring Software V1.0". Chinese Software Copyright Registration No. 2024SR1260882, issued August 28, 2024.

[2] Huang, Kaixuan, **Weiguo Ma**, Yunhao Shi, Kai Xu, and Heng Fan. "Method, Equipment, and Storage Medium for Parameter Standardization of Super-Guided Quantum Bits". Chinese Patent Application CN118095470A, filed January 31, 2024, published May 28, 2024.

Publications

[1] **Ma, W.-G.**, Xu, K., Fan, H. Loss-induced shock front in a driven–dissipative Bose–Hubbard lattice. (In preparation for submission).

[2] Zhao, K., Wang, Z., Liu, Y., Liang, G.-H., Fang, C.-P., Shi, Y.-H., Zhang, L., Zhang, J.-C., Li, T.-M., Li, H., Xu, Y.-S., **Ma, W.-G.**, Liu, H.-T., et al. Microwave engineering of tunable spin interactions with superconducting qubits. **Appl. Phys. Lett.** 127 (6): 064001 (2025).

[3] Zhao, K., **Ma, W.-G.**, Wang, Z., Li, H., Huang, K., Shi, Y.-H., Xu, K. and Fan, H., 2025. A microwave-activated high-fidelity three-qubit gate scheme for fixed-frequency superconducting qubits. **Phys. Rev. Appl.** (accepted).

[4] Wang, Y.-Y.#; Shi, Y.-H.#; Sun, Z.-H.#; Chen, C.-T.; Wang, Z.-A.; Zhao, K.; Liu, H.-T.; **Ma, W.-G.**; Wang, Z., et al. Exploring Hilbert-Space Fragmentation on a Superconducting Processor. **PRX Quantum** 6 (1), 010325.

[5] Liu, Y.#; Zhang, Y.-R.#; Shi, Y.-H.; Liu, T.; Lu, C.; Wang, Y.-Y.; Li, H.; Li, T.-M.; Deng, C.-L.; Zhou, S.-Y.; Liu, T.; Zhang, J.-C.; Liang, G.-H.; Mei, Z.-Y.; **Ma, W.-G.**; Liu, H.-T., et al. Interplay between disorder and topology in Thouless pumping on a superconducting quantum processor. **Nat Commun** 2025, 16, 108.

[6] Shi, Y.-H.#; Sun, Z.-H.#; Wang, Y.-Y.#; Wang, Z.-A.; Zhang, Y.-R.; **Ma, W.-G.**; Liu, H.-T., et al. Probing Spin Hydrodynamics on a Superconducting Quantum Simulator. **Nat Commun** 2024, 15 (1), 7573.

[7] **Ma, W.**; Shi, Y.-H.; Xu, K.; Fan, H. Tomography-Assisted Noisy Quantum Circuit Simulator Using Matrix Product Density Operators. **Phys. Rev. A** 2024, 110 (3), 032604.

[8] Xu, H.-Z.; Zhuang, W.-F.; Wang, Z.-A.; Huang, K.-X.; Shi, Y.-H.; **Ma, W.-G.**; Li, T.-M., et al. Quafu-Qcover: Explore Combinatorial Optimization Problems on Cloud-Based Quantum Computers. **Chinese Phys. B** 2024, 33 (5), 050302.

[9] Jin, Y.-X.; Xu, H.-Z.; Wang, Z.-A.; Zhuang, W.-F.; Huang, K.-X.; Shi, Y.-H.; **Ma, W.-G.**; Li, T.-M., et al. Quafu-RL: The Cloud Quantum Computers Based Quantum Reinforcement Learning. **Chinese Phys. B** 2024, 33 (5), 050301.

[10] Shi, Y.-H.#; Liu, Y.#; Zhang, Y.-R.#; Xiang, Z.#; Huang, K.; Liu, T.; Wang, Y.-Y.; Zhang, J.-C.; Deng, C.-L.; Liang, G.-H.; Mei, Z.-Y.; Li, H.; Li, T.-M.; **Ma, W.-G.**; Liu, H.-T., et al. Quantum Simulation of Topological Zero Modes on a 41-Qubit Superconducting Processor. **Phys. Rev. Lett.** 2023, 131 (8), 080401.

Software Deveolopment

***TensorCircuit*: Next generation of quantum circuit simulatos**
My contribution: Qudit simulator

***Tomography-assisted-MPDO-QCircuit*: Quantum circuit simulator with real noise**
Sole developer

Dilution Refrigerator Temperature and Pressure Monitoring Software
Sole developer; Get national software copyright

Honors & Awards

Merit Student 2024
University of Chinese Academy of Sciences

Director's Commendation Award 2023
Institute of Physics, Chinese Academy of Sciences

Outstanding Graduates 2021
Lanzhou University

First Prize Scholarship 2018, 2019, 2020
Lanzhou University

University Student Scholarship of Chinese Academy of Sciences 2019
University of Chinese Academy of Sciences