Weiguo Ma

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Institute of Physics, Chinese Academy of Sciences, Haidian, Beijing

Education

Ph.D.| Institute of Physics, Chinese Academy of Sciences Sep. 2021 – June 2026
Condensed Matter Physics | Advisor: Prof. Dr. Heng Fan Beijing, China

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

Research Interests & Projects

Quantum Computing and Tensor Network

A Qudit-Native Framework for Discrete Time Crystals Sep. 2025 – Dec. 2025

Developed a unified theoretical framework for engineering robust Discrete Time Crystals in high-dimensional quantum systems (qudits, $d > 2$). By implementing "subspace-embedded" kick through symmetric level partitioning, the project successfully suppressed Floquet heating and uncovered unique high-dimensional phenomena, specifically the realization of frequency-multiplexed phases, such as the concurrent 2T and 3T subharmonic oscillations in spin-2 platforms.

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

Developed a Matrix Product Density Matrix (MPDO) simulation framework for quantum circuits that replaces standard noise models with real-world hardware characteristics captured via Quantum Process Tomography (QPT). This approach addresses the gap between idealized simulations and experimental noise, offering an effective tool for evaluating quantum algorithm performance on NISQ-era devices.

Quantum Simulation on Superconducting Processors

Strongly-Correlated Dynamics in Synthetic Electromagnetic Fields Nov. 2025 – Present

Studied bright soliton dynamics in superconducting-transmon Bose-Hubbard arrays under synthetic gauge fields, modeling doublon flux doubling, interaction-sign-dependent transport, doubled Bloch-like oscillations, and field-induced doublon dissociation in ring and chain geometries.

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

Dissipation-Selected Resonant Fronts in a Driven-Dissipative Bose-Hubbard Lattice May 2025 – Dec. 2025

By constructing Stark potentials and spatial dissipation competition in two-dimensional dissipative-driven systems, non-trivial dynamical behaviors, including density wave front pinning, chaos, and minimum-loss localization, are observed, with clear phase boundaries existing between different regimes.

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, published May 28, 2024.

[3] Huang, Kaixuan, **Weiguo Ma**, Hao Li, Kai Xu, and Heng Fan. "Methods and apparatus for estimating the external field parameters of a quantum system". Chinese Patent Application 2026100991971, published January 23, 2026.

Publications

[1] **Ma, W.-G.**, Fan, H. Dissipation-Selected Resonant Fronts in a Driven-Dissipative Bose-Hubbard Lattice. arXiv:2605.21900.

[2] Li, H., Yang, Y., Shi, Y.-H., Wang, Z.-A., Wang, Z., Li, J., Zhang, Y., Zhao, K., Xu, Y.-S., Deng, C.-L., Liu, Y., **Ma, W.-G.**, Li, T.-M., et al. Non-equilibrium criticality-enhanced quantum sensing with superconducting qubits. **Science Bulletin (2026)**.

[3] Zhang, S.-X., Chen, Y.-Q., Li, W., Sun, J., **Ma, W.-G.**, Zheng, P.-L., et al. TensorCircuit-NG: A Universal, Composable, and Scalable Platform for Quantum Computing and Quantum Simulation. arXiv:2602.14167.

[4] **Ma, W.-G.**, Fan, H., Zhang, S.-X. A Qudit-Native Framework for Discrete Time Crystals, arxiv:2512.04577.

[5] Zhao, K., **Ma, W.-G.**, Wang, Z., Li, H., Huang, K., Shi, Y.-H., Xu, K. and Fan, H., 2025. Microwave-activated high-fidelity three-qubit gate scheme for fixed-frequency superconducting qubits. **Phys. Rev. Appl.** 2025, 24, 034064.

[6] 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).

[7] 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.

[8] 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.

[9] **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.

[10] 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.

[11] 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.

[12] 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.

[13] 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 — University of Chinese Academy of Sciences, 2023, 2024

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

Outstanding Graduates — Lanzhou University, 2021

First Prize Scholarship — Lanzhou University, 2018, 2019, 2020