Weiguo Ma

Phone: +86 131-6169-3095
Email: weiguo.m@iphy.ac.cn
Profile: WeiguoMa.github.io
Address: Institute of Physics, Chinese Academy of Sciences, Haidian, Beijing

Education

Ph.D. Candidate| Institute of Physics, Chinese Academy of Sciences — Sep. 2021 – Present
Condensed Matter Physics | Advisor: Dr. Prof. 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.

Machine Learning for Quantum Computing

Machine-Learning Enhanced Quantum Sensing with Superconducting Qubits — June 2025 – Aug. 2025

Developed models that optimize measurement protocols and improve sensitivity in detecting weak signals, demonstrating significant advancements in quantum metrology applications.

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

Front Pinning and Dynamical Phases 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-traditional dynamical behaviors, including density wave front pinning, chaos, and boundary absorbing states, 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.

Publications

[1] **Ma, W.-G.**, Fan, H. Front Pinning and Dynamical Phases in a Driven-Dissipative Bose-Hubbard Lattice (In preparation for submission).

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

[3] Wang, Z. T., Zhou, S.-Y., Shi, Y.-H., Huang, K., Yang, Z. H., Zhang, J., Zhao, K., Xu, Y., Li, H., Zhao, S. K., Feng, Y., Xue, G., Liu, Y., **Ma, W.-G.**, Fang, C.-P., et al. Observing Two-Particle Correlation Dynamics in Tunable Superconducting Bose-Hubbard Simulators. arXiv:2509.02180.

[4] 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.** 2025, 24, 034064.

[5] Wang, Z., Ge, Z.-Y., Shi, Y.-H., Wang, Z.-A., Zhou, S.-Y., Li, H., Zhao, K., Xu, Y.-S., **Ma, W.-G.**, Liu, H.-T., et al. Observation of Inelastic Meson Scattering in a Floquet System using a Digital Quantum Simulator. arXiv:2508.20759.

[6] 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 a Superconducting Qubit. arxiv:2508.14409.

[7] 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).

[8] 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.

[9] 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.

[10] **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.

[11] 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.

[12] 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.

[13] 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.

[14] 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, 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