



## Weekly Seminar

### Tensor Network Variational Monte Carlo Approach for 2D Quantum Many-body System: Algorithms and Applications

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**Time: 3:00 pm, Mar.5, 2025 (Wednesday)**

**时间: 2025年3月5日 (周三) 下午3:00**

**Venue: Room w563, Physics building, Peking University**

**地点: 北京大学物理楼, 西563会议室**

#### Abstract

Tensor networks, grounded in quantum entanglement, have emerged as a fundamental theoretical and numerical framework for studying strongly correlated systems. Matrix product states (MPS) serving as the variational space of the celebrated density matrix renormalization group (DMRG) method, have been the most powerful approach for 1D and quasi-1D quantum many-body problems. Their natural extension to higher dimensions, projected entangled pair states (PEPS), offers great potential for resolving challenging two-dimensional quantum systems. However, the computational complexity of PEPS has historically limited the development of practical and precise implementation methods.

In this talk, I will introduce a PEPS approach through combining variational Monte Carlo. I will show that this method achieves unprecedented accuracy across multiple challenging systems: frustrated spin models, the Fermi-Hubbard model, and (2+1)D lattice gauge theories, thus establishing itself as a powerful tool for solving longstanding quantum many-body problems. Furthermore, I will present a new perspective on tensor networks---tensor network function, which expands the application of tensor networks into new directions and bridges the gap between pure neural networks and tensor networks.

References:

- (1) Wen-Yuan Liu et al, PRB 95, 195154 (2017)
- (2) Wen-Yuan Liu et al, PRB 103, 235155 (2021)
- (3) Wen-Yuan Liu et al, Sci. Bull. 67, 1034 (2022)
- (4) Wen-Yuan Liu et al, PRX 12, 031039 (2022)
- (5) Wen-Yuan Liu et al, Sci. Bull. 69, 190 (2024)
- (6) Wen-Yuan Liu et al, PRL 133, 026502 (2024)
- (7) Wen-Yuan Liu et al, PRB 109, 235116 (2024)
- (8) Wen-Yuan Liu et al, PRL 133, 026502 (2024)
- (9) Wen-Yuan Liu et al, arXiv:2502.13454 (2025)
- (10) Yantao Wu, Wen-Yuan Liu, to appear soon. "Accurate Gauge-Invariant Tensor Network Simulations for (2+1)D Alelian Lattice Gauge Theory"

#### About the speaker

刘文渊, 浙江大学百人计划研究员, 博士生导师。2012年四川大学本科毕业, 2017年中国科学技术大学博士毕业, 之后在香港中文大学、香港大学和加州理工学院从事博士后研究, 2024年10月加入浙江大学物理高等研究院。长期从事张量网络等量子多体计算方法的发展, 研究兴趣包括量子阻挫磁性, 强关联电子体系, 格点规范场论, 量子模拟, 机器学习等。