

Xu-Cheng Wang

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EDUCATION

Fudan University, Department of Physics

PhD in Theoretical Physics (Condensed Matter Theory)

Shanghai, China

Sept. 2021 – Present

- Elite PhD program (10/125), GPA: 3.82/4.0

- Supervised by Prof. Yang Qi

- Thesis title: *Phase fluctuations and novel phenomena in two-dimensional superconductors*

Fudan University, Department of Physics

B.S. in Physics, GPA: 3.65/4.0 (top 15%)

Shanghai, China

Sept. 2017 – Jun. 2021

- Relative courses: Linear Algebra, Probability Statistics, C/C++ and Python Programming,

Computational Physics, Embodied Intelligence, etc.

ACADEMIC EXPERIENCE

Phase fluctuations, pseudogap, and Fermi arcs in 2D superconductors

- Developed a phenomenological theory of phase-disordered superconductor, combining perturbative expansion and disorder-average technique, which revealed the universal connection among phase fluctuations, pseudogap and Fermi arcs in 2D superconductors.
- Validated the predicted phase-fluctuation-driven pseudogap and Fermi arcs with exact determinant quantum Monte Carlo (DQMC) simulations; Extracted the real-frequency electronic spectra by implementing the stochastic analytic continuation (SAC) algorithm.
- Developed high-performance DQMC and SAC code in modern C++, involving technical aspects such as Eigen-MKL wrapper, numerical stability, and MPI programming; Certain variants of the code are open-sourced at [dqmc-framework.git](#) and [sac.git](#) respectively.

- Related papers:

1. X.-C. Wang and Yang Qi, *Phase fluctuations in two-dimensional superconductors and pseudogap phenomenon*, *Phys. Rev. B*, **107**, 224502 (2023).
2. X.-C. Wang, Xiao Yan Xu, and Yang Qi, *The interplay of phase fluctuations and nodal quasiparticles: ubiquitous Fermi arcs in two-dimensional d-wave superconductors*, [arXiv:2310.05376](#) (2023).

Emergent magnetic pseudogap from phase fluctuations and the coherent enhancement

- Investigated the spin-lattice relaxation rate $1/T_1T$ of phase-disordered superconductors up to bubble graph and leading-order vertex correction; Identified magnetic pseudogap, emerging entirely from normal-state phase fluctuations, and the coherent enhancement of $1/T_1T$ signals in the normal state of s-wave superconductors.
- Leveraged adaptive high-dimensional Monte Carlo integration to compute spin susceptibility; Accelerated the hotspot code with Numba JIT compilation.

- Related paper: X.-C. Wang and Yang Qi, in preparation (2025).

Geometric localization length and criticality of disordered, ideally flat Chern band

- Explored the localization transition of ideally flat Chern band by innovatively constructing the transfer matrix algorithm under hybrid Wannier basis.
- Developed efficient Python code for the transfer matrix calculation; Overcame the numerical instability of transfer matrix multiplications through successive QR factorization; Optimized the CPU and memory usage by leveraging the sparse structure of Wannier basis.

- Related paper: X.-C. Wang and Yang Qi, in preparation (2025).

LANGUAGES & TECHNICAL SKILLS

Languages: Mandarin, English

Computer Science: C/C++, Python, Linux Server/Shell, Git

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教育经历

复旦大学 物理学系 理论物理博士 (凝聚态理论)	2021 年 9 月 – 至今, 上海
- 入选首届卓博计划 (10/125), GPA: 3.82/4.0	
- 指导老师: 戚扬研究员	
- 博士论文题目: 二维超导体中的超导相位涨落和新奇物态	
复旦大学 物理学系 理学学士	2017 年 9 月 – 2021 年 6 月, 上海
- GPA: 3.65/4.0 (Top 15%)	
- 相关课程: 线性代数, 概率统计, C/C++程序设计, Python 程序设计, 计算物理, 具身智能等	

学术经历

二维超导体中的相位涨落, 贲能隙, 和费米弧现象

- 建立了关于二维相位涨落超导体的唯象模型; 结合微扰展开和无序平均技术, 揭示了二维超导体中超导相位涨落, 贲能隙和费米弧之间的普遍联系
- 利用精确的行列式量子蒙特卡洛计算 (Determinant Quantum Monte Carlo, DQMC), 在强关联量子模型中观察并证实了超导相位涨落导致的贲能隙和费米弧现象; 通过随机解析延拓算法 (Stochastic Analytic Continuation, SAC) 计算实频率电子谱函数
- 编写高性能 C++ 代码以实现行列式量子蒙特卡洛和随机解析延拓计算, 其中涉及 MKL 数学库中关键函数的 Eigen 封装、数值不稳定性处理、MPI 并行编程等方面; 相关项目代码分别在 [dqmc-framework.git](#) 和 [sac.git](#) 开源
- 相关文章:
 - X.-C. Wang and Yang Qi, *Phase fluctuations in two-dimensional superconductors and pseudogap phenomenon*, *Phys. Rev. B*, **107**, 224502 (2023).
 - X.-C. Wang, Xiao Yan Xu, and Yang Qi, *The interplay of phase fluctuations and nodal quasiparticles: ubiquitous Fermi arcs in two-dimensional d-wave superconductors*, [arXiv:2310.05376](#) (2023).

二维超导体中相位涨落演生的磁贲能隙和相位相干增强

- 研究了相位涨落超导体理论的自旋晶格弛豫率 $1/T_1 T$, 并从理论上预言了由超导正常态相位涨落演生的磁贲能隙和二维 s 波超导体中超导相位相干导致的 $1/T_1 T$ 增强; 计算了电子自旋磁化率的气泡图贡献和领头阶顶角修正
- 利用自适应高维蒙特卡洛积分计算电子自旋磁化率; 结合 Numba 即时编译技术加速热点代码
- 相关文章: X.-C. Wang and Yang Qi, in preparation (2025).

无序理想拓扑平带中的几何局域化长度和量子临界

- 研究了理想拓扑平带中的局域化相变, 创新性地提出理想拓扑平带中的局域化长度具有量子几何起源; 在混合瓦尼尔波函数 (hybrid Wannier wavefunction) 表象下推广了传统转移矩阵算法
- 开发高性能 Python 代码以实现利用转移矩阵算法计算局域化特征长度; 通过周期性 QR 分解克服了转移矩阵乘法中的数值不稳定问题; 结合瓦尼尔波函数的稀疏性质, 优化 CPU 和内存利用
- 相关文章: X.-C. Wang and Yang Qi, in preparation (2025).

语言和个人技能

语言: 中文, 英文

计算机技能: C/C++, Python, Linux Server/Shell, Git