

# Hao Shi, Graduate Student

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## Education

Ph.D. Physics, College of William and Mary, Williamsburg, VA, USA, 2016 (expected).

M.S. study, Computational physic, Renming University, Beijing, China, 2008-2011.

B.A. Physics, Nanjing University, Nanjing, China, 2004-2008.

## Research Experience

*College of William and Mary    W&M Computational Materials Physics Group    2011-2015*

Research focuses on studying strongly correlated systems by Auxiliary Field Quantum Monte Carlo (AFQMC) and other numerical methods.

- Developed a variety of new AFQMC methods [7,11,12].
- Used these developments to study the two dimensional Hubbard model; work has served as benchmark in the Simons Foundation Many Electron Collaboration [9].
- Studied the two-dimensional strongly interacting Fermi atomic gas, provided valuable benchmarks for future studies, and allowed precise comparisons with experiments [8].
- Made first exact numerical study to determine the ground state properties of the 2D Fermi gas with Rashba spin-orbit coupling [6].
- Current research includes:
  - studying three band Hubbard model.
  - calculating dynamic information in AFQMC.
  - combining Hartree-Fock-Bogoliubov theory with AFQMC.

*Renming University    Strongly Correlated Physics Computational Group    2008-2011*

- Worked on Exact Diagonalization for the topological phase transition in interacting Haldane model.

- Research experience in Dynamic Mean Field Theory, Continuous Time Quantum Monte Carlo and Density Matrix Renormalization Group.

## Honors

- Roy L. Champion Research award, awarded to graduate student in physics who has demonstrated outstanding research achievement, May 2016
- The Materials Computation Center travel award of \$1900 for “4th Les Houches school in computational physics,” Les Houches, France, June 2014
- The Materials Computation Center travel award of \$950 for “Quantum Monte Carlo methods at work for novel phases of matter,” Trieste, Italy, Jan 2012

## Presentations

- **Invited talk:** “Ground-state properties of the two-dimensional strongly interacting Fermi atomic gas and the interplay between superfluidity and spin-orbit coupling ”  
XVIII International Conference on Recent Progress in Many-Body Theories, Niagara Falls, NY, August 2015 .
  - **Invited talk:** “Recent developments in auxiliary-field quantum Monte Carlo: magnetic orders and spin-orbit coupling”  
ES2015 Workshop: Developments in electronic structure theory and excited states beyond ground state DFT, Seattle, WA, June 2015.
  - Contributed talk: APS March Meeting 2012-2016, Simons Collaboration on the Many Electron Problem Annual Meeting, 2015.
- More presentations can be found at: [www.boruoshihao.com/research](http://www.boruoshihao.com/research)

## Publications

1. Quantum Monte Carlo simulation with Hartree-Fock-Bogoliubov wave function  
*Hao Shi* and Shiwei Zhang, in preparation.
2. Coupling quantum Monte Carlo and independent-particle calculations: self-consistent constraint for the sign problem based on density or density matrix  
Mingpu Qin, *Hao Shi*, and Shiwei Zhang, [arXiv:1608.07154 \(2016\)](https://arxiv.org/abs/1608.07154).
3. Cluster size convergence of density matrix embedding theory with an auxiliary field quantum Monte Carlo solver: cellular and dynamical cluster formulations

- Bo-Xiao Zheng, Joshua S. Kretchmer, *Hao Shi*, Shiwei Zhang, and Garnet Kin-Lic Chan, [arXiv:1608.03316 \(2016\)](#).
4. Computation of dynamical correlation functions for many fermions systems with auxiliary-field quantum Monte Carlo  
*Ettore Vitali, Hao Shi, Mingpu Qin, and Shiwei Zhang*, **editors' suggestion**, [Phys. Rev. B 94, 085140 \(2016\)](#).
  5. A benchmark study of the two-dimensional Hubbard model with auxiliary-field quantum Monte Carlo method  
*Mingpu Qin, Hao Shi, and Shiwei Zhang*, PRB in print, [Phys. Rev. B. 94, 085103 \(2016\)](#).
  6. Rashba spin-orbit coupling, strong interactions, and the BCS-BEC crossover in the ground state of the two-dimensional Fermi Gas  
*Hao Shi, Peter Rosenberg, Simone Chiesa, and Shiwei Zhang*, [Phys. Rev. Lett. 117, 040401 \(2016\)](#).
  7. Infinite Variance in Fermion Quantum Monte Carlo Calculations  
*Hao Shi and Shiwei Zhang*, [Phys. Rev. E 93, 033303 \(2016\)](#).
  8. Ground-state properties of strongly interacting Fermi gases in two dimensions  
*Hao Shi, Simone Chiesa, and Shiwei Zhang*, [Phys. Rev. A 92, 033603 \(2015\)](#).
  9. Solutions of the Two Dimensional Hubbard Model: Benchmarks and Results from a Wide Range of Numerical Algorithms  
*J. P. F. LeBlanc, Andrey E. Antipov, Federico Becca, Ireneusz W. Bulik, Garnet Kin-Lic Chan, Chia-Min Chung, Youjin Deng, Michel Ferrero, Thomas M. Henderson, Carlos A. Jiménez-Hoyos, E. Kozik, Xuan-Wen Liu, Andrew J. Millis, N. V. Prokof'ev, Mingpu Qin, Gustavo E. Scuseria, Hao Shi, B. V. Svistunov, Luca F. Tocchio, I. S. Tupitsyn, Steven R. White, Shiwei Zhang, Bo-Xiao Zheng, Zhenyue Zhu, and Emanuel Gull*, [Phys. Rev. X 5, 041041 \(2015\)](#).
  10. CPMC-Lab: A Matlab package for Constrained Path Monte Carlo calculations  
*Huy Nguyen, Hao Shi, Jie Xu and Shiwei Zhang*, [Computer Physics Communications 185, 12 \(2014\)](#).  
Details about the CPMC-Lab package at <http://cpmc-lab.wm.edu/>
  11. Symmetry-projected wave functions in quantum Monte Carlo calculations  
*Hao Shi, Carlos A. Jiménez-Hoyos, R. Rodríguez-Guzmán, Gustavo E. Scuseria, and Shiwei Zhang*, [Phys. Rev. B 89, 125129 \(2014\)](#).
  12. Symmetry in Auxiliary-Field Quantum Monte Carlo Calculations

*Hao Shi* and Shiwei Zhang, [Phys. Rev. B 88, 125132 \(2013\)](#).

13. Charge-density-wave and topological transitions in interacting Haldane model

Lei Wang, *Hao Shi*, Shiwei Zhang, Xiaoqun Wang, Xi Dai, and X. C. Xie, [ArXiv:1012.5163 \(2010\)](#).