

Xiaodi Wu

Assistant Professor

ATL 3247 / AVW 3257
University of Maryland, College Park, MD 20742
☎ +1 (734) 355 7905
✉ xwu@cs.umd.edu
🌐 <https://www.cs.umd.edu/~xwu/>

Research interests

- Quantum Algorithms for Optimization and Machine Learning, Formal Methods and Programming Languages in Quantum Computation, Quantum Computational Complexity, Quantum Cryptography, Mathematical Optimization, Theory of Computation

Research positions

- 06/2017–present **Assistant Professor**, *University of Maryland*, College Park, MD.
Department of Computer Science and Institute for Advanced Computer Studies
Fellow of the Joint Center for Quantum Information and Computer Science (QIICS)
- 09/2015–06/2017 **Assistant Professor**, *University of Oregon*, Eugene, OR.
Department of Computer and Information Science.
- 09/2013–09/2015 **Postdoctoral Associate**, *Massachusetts Institute of Technology*, Cambridge, MA.
Advisor: Aram Harrow and Scott Aaronson.
- 01/2014–05/2014 **Simons Research Fellow**, *Simons Institute for the Theory of Computing*, *University of California*, Berkeley, CA, Advisor: Umesh Vazirani.
- Summer 2009, 2010 **Research Assistant**, *Institute for Quantum Computing*, *University of Waterloo*, Waterloo, Canada, Advisor: John Watrous.

Education

- 09/2008–12/2013 **Ph.D. in Computer Science**, *University of Michigan*, Ann Arbor, MI, *GPA: 4.0/4.0*.
Thesis title: *Space-efficient Simulations of Quantum Interactive Proofs*. Advisor: Prof Yaoyun Shi.
- 08/2004–07/2008 **B.S. in Mathematics and Physics**, *Tsinghua University*, Beijing, China, *GPA: 91/100*.
Thesis title: *Structure Properties of Codeword Stabilized Quantum Error-Correcting Codes*

Honors & Awards

- 02/2018 NSF CISE Research Initiation Initiative (CRII) Award, 2018.
- 02/2014 Plenary talk at the 17th Conference on Quantum Information Processing (QIP 2014).
- 02/2013 Simons-Berkeley Research Fellowship (Spring 2014).
- 06/2012 Special issue of the 27th Conference on Computational Complexity (CCC 2012).
- 11/2011 Featured talk at the 15th Conference on Quantum Information Processing (QIP 2012).
- 06/2008 Distinguished Undergraduate Degree Thesis, *Tsinghua University*.
- 06/2008 Chi-Sun YEH Prize (highest award to undergraduate physics majors), *Tsinghua University*.
- 06/2007 Microsoft Young Fellow Scholarship, *Microsoft Research*, Asia.

Funding

Total grants received (my share): \$2.23 million (\$887K as PI and \$1.34M as Co-PI)

- NSF CRII: AF: Theoretical Problems in Quantum Computation. Sole PI. \$175,000. NSF-CCF-1755800, 2018-2020.
- DOE ASCR: Quantum Algorithms from the Interplay of Simulation, Optimization, and Machine Learning (17-020469): Co-PI, \$1.35 M (UMD part), my share: \$225,000, 2017-2020.
- NSF AF: Small: Provable Quantum Advantages in Optimization. Sole PI. \$450,000. NSF-CCF-1816695, 2018-2021.
- NSF NSF Student Travel Grant for 2019 Annual Conference on Quantum Information Processing (QIP). Sole PI. \$10,000. NSF-CCF-1840547, 2018-2019.
- DOE ASCR: Efficient and Reliable Mapping of Quantum Computations Onto Realistic Architectures in Quantum Testbed Pathfinder Program. Co-PI, with Andrew Childs, Alexey Gorshkov, and Michael Hicks. \$4.47 M in total (my share \$1.12M), 2018-2023.
- AFOSR MURI: Semantics and Structures for Higher-level Quantum Programming Languages. PI at UMD. \$262,380. 2018-2020.

Patent

- Oct. 2016 **“Physical Randomness Extractors”**, *Kai-Min Chung, Yaoyun Shi, Xiaodi Wu, US Patent 9,471,280.*

Professional service

- PC Member
 - ◇ The 9th Conference on the Theory of Quantum Computation, Communication and Cryptography (TQC 2014).
 - ◇ The 20th Annual Conference on Quantum Information Processing (QIP 2017).
 - ◇ The 21th Annual Conference on Quantum Information Processing (QIP 2018).
- Reviewer
 - ◇ *Conferences*: STOC, FOCS, QIP, SODA, CCC, ICALP, ITCS, CRYPTO, CCS, AsiaCrypt, TCC, and ISAAC for multiple years.
 - ◇ *Journals*: SIAM Journal of Computing, Nature Communications, Quantum Information and Computation, International Journal of Quantum Information, Theoretical Computer Science, Theory of Computing, IEEE Transaction on Information Theory, Physical Review Letter, and npj Quantum Information.
 - ◇ *Grants*: Natural Sciences and Engineering Research Council of Canada (NSERC)
- Organizer
 - ◇ QulCS's Workshop on Quantum Machine Learning, 09/24 - 09/28, 2018.

Teaching experience

- Instructor **Introduction to Quantum Information Processing (CMSC 657)**, *University of Maryland*, graduate-level CS course, Fall 2018.
- Instructor **Introduction to Quantum Computation (CMSC 457)**, *University of Maryland*, undergraduate-level CS course, Spring 2018.
- Instructor **Complexity Theory (CMSC 652)**, *University of Maryland*, graduate-level CS major course, Fall 2017.
- Instructor **Intermediate Data Structure (CIS 313)**, *University of Oregon*, undergraduate-level CS major course, Winter 2016, Fall 2016, Winter 2017.
- Instructor **Introduction to Quantum Information Processing (CIS 410/510)**, *University of Oregon*, undergraduate/graduate level course, Spring 2016, Spring 2017.

Publications

(The authors of papers in theoretical computer science are listed alphabetically, whereas in other fields are listed by contribution where the last is usually the corresponding author.)

Journals

- ◇ Tongyang Li and **Xiaodi Wu**, *Quantum query complexity of entropy estimation*, IEEE Transaction on Information Theory, DOI 10.1109/TIT.2018.2883306. Also available at arXiv: 1710.06025.
- ◇ Aram W. Harrow, Anand Natarajan, and **Xiaodi Wu**, *Limitations of semidefinite programs for separable states and entangled games*, accepted by Communications in Mathematical Physics, 2018.
- ◇ Jeongwan Haah, Aram W. Harrow, Zhengfeng Ji, **Xiaodi Wu** and Nengkun Yu, *Sample-optimal tomography of quantum states*. IEEE Transaction on Information Theory, Volume: 63, Issue: 9, pp. 5628 – 5641, 2017.
- ◇ (by contribution) Mingsheng Ying, Shenggang Ying, and **Xiaodi Wu**, *Invariants of Quantum Programs: Characterizations and Generation*. ACM SIGPLAN Notices - POPL '17 Volume 52 Issue 1, January 2017, Pages 818-832, 2017.
- ◇ Aram W. Harrow, Anand Natarajan, and **Xiaodi Wu**, *An improved semidefinite programming hierarchy for testing entanglement*, Communications in Mathematical Physics, Volume 352, Issue 3, pp 881–904, 2017. Also available at arXiv:1506.08834.
- ◇ Yaoyun Shi and **Xiaodi Wu**, *Epsilon-net method for optimizations over separable states*. Theoretical Computer Science, 598:51–63, 2015.
- ◇ Gus Gutoski and **Xiaodi Wu**, *Parallel approximation of min-max problems with applications to classical and quantum zero-sum games*. Computational Complexity, 22(2):385-428, 2013, the **special issue** of CCC 2012.
- ◇ (by contribution) **Xiaodi Wu** and Runyao Duan, *Exact Quantum Search by Parallel Unitary Discrimination Schemes*, Physical Review A, **78**, 012303 (2008). Selected for the July 2008 issue of Virtual Journal of Quantum Information.
- ◇ (by contribution) **Xiaodi Wu** and Gui Lu Long, *Verifier-based Algorithm for Unsorted Database Search Problem*, International Journal of Quantum Information, vol.**5** no.**4**, pp **597 - 604** (2007).
- ◇ (by contribution) **Xiao-di Wu**, Yong-tao Huang, Xin-kun Ma, *Data processing and software realization of wave-lengths of spectrum during CCD measurement*, Experimental Technology and Management, vol.**24**, no.**4** p**48-51** (2006).

Peer-reviewed Conferences with Published Proceedings

- ◇ (by contribution) Shih-Han Hung, Kesha Hietala, Shaopeng Zhu, Mingsheng Ying, Michael Hicks, and **Xiaodi Wu**. *Quantitative Robustness Analysis of Quantum Programs*. To appear in the proceedings of the 46th ACM SIGPLAN Symposium on Principles of Programming Languages (POPL 2019).
- ◇ (by contribution) Mingsheng Ying, Shenggang Ying, and **Xiaodi Wu**, *Invariants of Quantum Programs: Characterizations and Generation*. In Proceedings of the 44th ACM SIGPLAN Symposium on Principles of Programming Languages (POPL 2017).
- ◇ Jeongwan Haah, Aram W. Harrow, Zhengfeng Ji, **Xiaodi Wu** and Nengkun Yu, *Sample-optimal tomography of quantum states*. In Proceedings of the ACM 48th Annual Symposium on the Theory of Computing (STOC 2016), available at arXiv:1508.01797.

- ◇ Aram W. Harrow, Anand Natarajan, and **Xiaodi Wu**, *Tight SoS-degree bounds for approximate Nash equilibria*. In Proceedings of the Computational Complexity Conference (CCC 2016).
- ◇ Kai-Min Chung, **Xiaodi Wu**, and Henry Yuen, *Parallel repetition for entangled k -player games via fast quantum search*. In Proceedings of the Computational Complexity Conference (CCC 2015), also available at arXiv:1501.00033, 2015.
- ◇ Yaoyun Shi and **Xiaodi Wu**, *Epsilon-net method for optimizations over separable states*. In Proceedings of the 39th International Colloquium on Automata, Languages and Programming (ICALP 2012), pp. 798–809.
- ◇ Gus Gutoski and **Xiaodi Wu**, *Parallel approximation of min-max problems with applications to classical and quantum zero-sum games*. In Proceedings of the 27th Annual IEEE Conference on Computational Complexity (CCC 2012), pp. 21–31.

Peer-reviewed Conferences without Published Proceedings

- ◇ Shouvanik Chakrabarti, Andrew M. Childs, Tongyang Li, and **Xiaodi Wu**. *Quantum algorithms and lower bounds for convex optimization*, to appear at the 22th Conference on Quantum Information Processing (QIP 2019). Also available at arXiv: 1809.01731.
- ◇ Fernando G. S. L. Brandao, Amir Kalev, Tongyang Li, Cedric Yen-Yu Lin, Krysta M. Svore, and **Xiaodi Wu**, *Quantum SDP Solvers: Large Speed-ups, Optimality, and Applications to Quantum Learning*, to appear at the 22th Conference on Quantum Information Processing (QIP 2019). Also available at arXiv:1710.02581v2.
- ◇ Yi-Hsiu Chen, Kai-Min Chung, Ching-Yi Lai, Salil P. Vadhan, and **Xiaodi Wu**, *Computational Notions of Quantum Min-Entropy*, at the 7th International Conference on Quantum Cryptography (QCrypt 2017). Also available at arXiv: 1704.07309.
- ◇ Aram W. Harrow, Anand Natarajan, and **Xiaodi Wu**, *Limitations of semidefinite programs for separable states and entangled games*, at the 20th Conference on Quantum Information Processing (QIP 2017).
- ◇ Kai-Min Chung, Yaoyun Shi, and **Xiaodi Wu**, *General randomness amplification with non-signaling security*, at the 20th Conference on Quantum Information Processing (QIP 2017).
- ◇ Jeongwan Haah, Aram W. Harrow, Zhengfeng Ji, **Xiaodi Wu** and Nengkun Yu, *Sample-optimal tomography of quantum states*, at the 19th Conference on Quantum Information Processing (QIP 2016), available at arXiv:1508.01797.
- ◇ Kai-Min Chung, Yaoyun Shi, and **Xiaodi Wu**, *Physical Randomness Extractors*, appeared as a **plenary talk** at the 17th Conference on Quantum Information Processing (QIP 2014), also available at arXiv:1402.4797v2.
- ◇ Yaoyun Shi and **Xiaodi Wu**, *Epsilon-net method for optimizations over separable states*. **Contributed talk** at the 15th Workshop on Quantum Information Processing (QIP 2012), also available at arXiv:1112.0808, 2011.
- ◇ Gus Gutoski and **Xiaodi Wu**, *Parallel approximation of min-max problems with applications to classical and quantum zero-sum games*. **Featured talk** at the 15th Workshop on Quantum Information Processing (QIP 2012), available at arXiv:1011.2787, 2010.
- ◇ Zhengfeng Ji and **Xiaodi Wu**, *Non-Identity Check Remains QMA-Complete for Short Circuits*, **contributed talk** at the 9th Asian Conference on Quantum Information Science (AQIS09), also available at arXiv:0906.5416, 2009.

Manuscripts

- ◇ (by contribution) Tongyang Li, Shouvanik Chakrabarti, and **Xiaodi Wu**. *Quantum algorithms for training linear and kernelized classifiers*, manuscript, 2018.
- ◇ (by contribution) Tongyang Li, Furong Huang, and **Xiaodi Wu**. *Quantum algorithms for leading eigenvector computation*, manuscript, 2018.
- ◇ (by contribution) Tianyi Peng, Aram Harrow, Maris Ozols, and **Xiaodi Wu**, *Simulating large quantum circuits on a small quantum computer*, manuscript, 2018.
- ◇ **Xiaodi Wu**, Penghui Yao, and Henry Yuen, *Raz-McKenzie simulation with the inner product gadget*, under submission, 2017. also available at ECCC TR17-010.
- ◇ **Xiaodi Wu** and Henry Yuen, *On the limits of communication with non-local resources*, manuscript, 2015.
- ◇ Kai-Min Chung, Xin Li, and **Xiaodi Wu**, *Multi-Source Randomness Extractors Against Quantum Side Information, and their Applications*, manuscript, also available at arXiv:1411.2315, 2014.
- ◇ Yaoyun Shi, Wei Yu, and **Xiaodi Wu**, *Limits of Quantum One-way Communication by Matrix Hypercontractive Inequalities*, manuscript, 2013.
- ◇ **Xiaodi Wu**, *Parallelized Solution to Semidefinite Programmings in Quantum Complexity Theory*, Technical Report, also available at arXiv:1009.2211, 2010.
- ◇ **Xiaodi Wu**, *Equilibrium Value Method for the proof of QIP=PSPACE*, manuscript, available at arXiv:1004.0264, 2010.

Invited Talks

- 11/2018 **Quantum algorithms for semidefinite programs and convex optimization.**
Capital Area Theory Day, 2018.
- 10/2018 **Quantum algorithms for convex optimization and leading eigenvalue computation.**
Quantum Information Processing Seminar, MIT.
- 05/2018 **Quantum algorithms for semidefinite programs.**
Workshop on "Quantum Computing & Optimization of large Power Systems", Stanford.
- 05/2018 **Algorithms for quantum computers.**
CCC Workshop on Next Steps in Quantum Computing, D.C.
- 07/2017 **Quantum query complexity of entropy estimation.**
Microsoft Quantum Algorithms Workshop, Redmond.
- 04/2017 **Quantum query complexity of entropy estimation.**
Microsoft Research, Redmond.
- 03/2017 **General randomness amplification with non-signaling security.**
IQI Seminar, Caltech.
- 01/2017 **General randomness amplification with non-signaling security.**
The 20th Workshop on Quantum Information Processing (QIP 2017).
- 08/2016 **Limitations of monogamy, Tsirelson-type bounds, and other semidefinite programs in quantum information.**
QMA(2) Workshop, QUICS, University of Maryland
- 02/2016 **Device-independent Quantum Cryptography.**
Oregon Crypto Meeting, Oregon State University

- 12/2015 **Limitations of monogamy, Tsirelson-type bounds, and other semidefinite programs in quantum information.**
IQI Seminar, Caltech
- 06/2015 **Randomness Extraction in the Presence of Quantum Side Information.**
1st Trustworthy Quantum Information Workshop, Ann Arbor, USA
- 05/2015 **New Upper and Lower Bounds for Entanglement Testing.**
Microsoft Research, Redmond.
- 05/2015 **Randomness Extraction in the Presence of Quantum Side Information.**
Simon's Institute for the Theory of Computing, UC Berkeley.
- 11/2014 **Improved Entanglement Detection with Tools from Algebraic Geometry.**
Colloquium, Institute for Quantum Computing, University of Waterloo.
- 11/2014 **Multi-Source Randomness Extractors Against Quantum Side Information.**
Theory Seminar, Virginia Commonwealth University, Richmond.
- 07/2014 **Physical Randomness Extractors.**
Gordon Research Seminar, Advances in Quantum Information Science, Stonehill College.
- 03/2014 **Physical Randomness Extractors.**
University of Michigan, Ann Arbor
- 02/2014 **Physical Randomness Extractors.**
IQI Seminar, Caltech.
- 05/2013 **Robust Full Randomness Extraction from Any Weak Source.**
Quantum Information Processing Seminar, MIT.
- 04/2013 **Equilibrium Value Method for Optimization Problems and its Applications in Quantum Computation.**
IQI Seminar, Caltech
- 04/2013 **Applications of Sum of Squares in Quantum Information.**
University of California, San Diego.
- 07/2012 **Epsilon-net method for optimizations over separable states..**
The 39th International Colloquium on Automata, Languages and Programming (ICALP'12).
- 06/2012 **Parallel approximation of min-max problems with applications to classical and quantum zero-sum games. .**
The 27th Annual IEEE Conference on Computational Complexity (CCC'12).
- 03/2012 **Epsilon-net method for optimizations over separable states.**
Tsinghua University.
- 12/2011 **Epsilon-net method for optimizations over separable states.**
The 15th Workshop on Quantum Information Processing (QIP'12).
- 12/2011 **Parallel approximation of min-max problems with applications to classical and quantum zero-sum games.**
The 15th Workshop on Quantum Information Processing (QIP'12).