LEO ZHOU

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CURRENT APPOINTMENT

California Institute of Technology *Pasadena, CA*
DuBridge Postdoctoral Scholar Research Associate in Theoretical Physics 2021–Present

EDUCATION

Harvard University *Cambridge, MA*
Ph.D. in Physics 2014–21
Thesis: Complexity, Algorithms, and Applications of Programmable Quantum Many-Body Systems
Advisor: Mikhail D. Lukin

Massachusetts Institute of Technology *Cambridge, MA*
B.Sc. in Physics and Mathematics; Minor in Economics; GPA: 5.0/5.0 2010–14
Thesis: Error-Suppression by Energy-Gap Protection for Quantum Computation in Open Systems
Advisor: Edward Farhi

RESEARCH EXPERIENCE

California Institute of Technology – Walter Burke Institute for Theoretical Physics *Pasadena, CA*
DuBridge Postdoctoral Scholar with Prof. John Preskill 2021–Present

- Lead independent research in quantum algorithms for inference and optimization problems
- Investigated the complexity of finding local minima in quantum systems and the computational power of cooling
- Managed graduate and undergraduate students in multiple research projects

Harvard University – Department of Physics *Cambridge, MA*
Graduate Research Fellow with Prof. Mikhail D. Lukin 2014–21

- Analyzed performance and mechanism of QAOA, and invented powerful heuristics for optimizing its parameters
- Designed realistic schemes of quantum information processing applications in cold atoms with error analysis
- Developed specialized software libraries for simulating many-body physics using matrix product state ansatz

Google AI Quantum *Venice, CA*
Research Intern with Prof. Edward Farhi Summer 2019

- Studied noise-resilience and error-mitigation of the Quantum Approximate Optimization Algorithm (QAOA)
- Calculated the typical-case performance of the QAOA applied to spin glass problems in the thermodynamic limit
- Developed software tools in Google's code base for running quantum algorithms on their quantum processors

Hebrew University – Department of Computer Science and Engineering *Jerusalem, Israel*
Visiting Researcher with Prof. Dorit Aharonov Summers 2014 & 2015

- Initiated the study of resource requirements of analog quantum simulation of complex systems by simpler ones
- Proved separation of classical vs. quantum systems on the possibility of reducing the degree of connectivity

Massachusetts Institute of Technology *Cambridge, MA*
Undergraduate Researcher 2010–14

- Proved that the energy penalty method can suppress errors in Hamiltonian-based computations with Prof. Farhi
- Investigated hydrodynamic pilot-wave analogues of quantum systems with Prof. John W.M. Bush
- Built graphene and transition-metal dichalcogenide-based nanoelectronics with Prof. Pablo Jarillo-Herrero
- Analyzed high energy heavy ion collisions from RHIC and LHC with Dr. George S.F. Stephans

AWARDS AND HONORS

- Outstanding Paper Award at the 17th Conference on Theory of Quantum Computation, Communication and Cryptography (TQC'22) — 2022
- Grant Winner ($5k) for Excellent Contributed Talk at QC40: Physics of Computation Conference — 2021
- Burke Prize Fellowship at the California Institute of Technology — 2021
- Martin & Beate Block Award (for best poster presented by co-author S.-T. Wang) at the Aspen Conference on Advances in Quantum Algorithms and Computation — 2018
- National Science Foundation (NSF) Graduate Research Fellowship — 2014–17
- Phi Beta Kappa (Academic Honor Society), MIT Xi Chapter — 2014
- MIT Junior Lab Edward C. Pickering Award for Outstanding Original Project, Honorable Mention — 2013

PUBLICATIONS

- C.-F. Chen, H.-Y. Huang, J. Preskill, **L. Zhou**†. *Local minima in quantum systems*. arXiv:2309.16596.
- J. Basso, D. Gamarnik, S. Mei, **L. Zhou**†. *Performance and limitations of the QAOA at constant levels on large sparse hypergraphs and spin glass models*. In Proceedings of the 63rd Symposium on Foundations of Computer Science, FOCS'22 (2022). arXiv:2204.10306.
- S. Ebadi, …, **L. Zhou**, …, M.D. Lukin. *Quantum Optimization of Maximum Independent Set using Rydberg Atom Arrays*. Science 376, 1209 (2022). arXiv:2202.09372.
- J. Basso, E. Farhi, K. Marwaha, B. Villalonga, **L. Zhou**†. *The Quantum Approximate Optimization Algorithm at High Depth for MaxCut on Large-Girth Regular Graphs and the Sherrington-Kirkpatrick Model.* In Proceedings of the 17th Conference on the Theory of Quantum Computation, Communication and Cryptography, TQC '22 (2022), Outstanding Paper Award. arXiv:2110.14206.
- **L. Zhou**, D. Aharonov. *Strongly Universal Hamiltonian Simulators*. QIP'21 (2021). arXiv:2102.02991.
- M.P. Harrigan, …, **L. Zhou**, …, R. Babbush. *Quantum Approximate Optimization of Non-Planar Graph Problems on a Planar Superconducting Processor*. Nature Physics 17, 332 (2021). arXiv:2004.04197.
- S.H. Cantu, A.V. Venkatramani, W. Xu, **L. Zhou**, B. Jelenković, M.D. Lukin, V. Vuletić. *Repulsive photons in a quantum nonlinear medium*. Nature Physics 16, 921 (2020). arXiv:1911.02586.
- Z. Eldredge, **L. Zhou**, A. Bapat, J.R. Garrison, A. Deshpande, F.T. Chong, A.V. Gorshkov. *Entanglement bounds on the performance of quantum computing architectures*. Phys. Rev. Research 2, 033316 (2020). arXiv:1908.04802.
- E. Farhi, J. Goldstone, S. Gutmann, **L. Zhou**†. *The Quantum Approximate Optimization Algorithm and the Sherrington-Kirkpatrick Model at Infinite Size*. Quantum 6, 759 (2022). Also in QIP'21. arXiv:1910.08187.
- **L. Zhou***, S.-T. Wang*, S. Choi, H. Pichler, and M.D. Lukin. *Quantum Approximate Optimization Algorithm: Performance, Mechanism, and Implementation on Near-Term Devices*. Phys. Rev. X 10, 021067 (2020). arXiv:1812.01041.
- H. Pichler*, S.-T. Wang*, **L. Zhou**, S. Choi, and M.D. Lukin. *Quantum Optimization for Maximum Independent Set Using Rydberg Atom Arrays*. Preprint on arXiv:1808.10816, (2018). Submitted to Phys. Rev. Lett.
- H. Pichler*, S.-T. Wang*, **L. Zhou***, S. Choi, and M.D. Lukin. *Computational complexity of the Rydberg blockade in two dimensions*. Preprint on arXiv:1809.04954, (2018). Submitted to Phys. Rev. A.

- D. Aharonov and **L. Zhou**†. *Hamiltonian Sparsification and Gap-Simulation*.In Proceedings of the 2019 ACM Conference on Innovations in Theoretical Computer Science, ITCS'19 (2019). arXiv:1804.11084.
- **L. Zhou***, S. Choi*, and M.D. Lukin. *Symmetry-protected dissipative preparation of matrix product states*. Phys. Rev. A (2021). arXiv:1706.01995.
- A.D. Bookatz, E. Farhi, and **L. Zhou**†. *Error suppression in Hamiltonian based quantum computation using energy penalties*. Phys. Rev. A 92, 022317 (2015). arXiv:1407.1485.
- **L. Zhou** and G.S.F. Stephans. *Energy and centrality dependence of particle multiplicity in heavy ion collisions from* $\sqrt{s_{NN}}$ *= 20 to 2760 GeV*. Phys. Rev. C 90, 0149902 (2014). arXiv:1312.3656.

* indicates that authors contributed equally
† indicates alphabetical ordering of authors

PRESENTATIONS

- *Quantum Advantages in Minimizing Energy of Classical and Quantum Systems*
  - Invited talk at the IPAM "Mathematical and Computational Challenges in Quantum Computing" program at the University of California Los Angeles (expected) 11.2023
- *Exploring Quantum Advantages in Optimization Problems*
  - Invited talk at the NISQ Algorithms and Hardware (NISQAH 2023) conference [video] 06.2023
- *Quantum computing with Rydberg atom arrays*
  - Tutorial talk at the 2023 APS March Meeting 03.2023
- *Performance and limitations of the QAOA at constant levels on large sparse hypergraphs and spin glass models*
  - Accepted talk, 18th Conference on Theory of Quantum Computation, Communication and Cryptography (TQC) [video] 07.2023
  - Accepted talk, 63rd Annual Symposium on Foundations of Computer Science (FOCS) 11.2022
- *Advantages and Limitations of the Quantum Approximate Optimization Algorithm*
  - Invited talk at the 2023 Information: Theory and Applications (ITA) workshop 02.2023
  - Invited talks at the MIT Center for Theoretical Physics and QuEra Computing, Inc. 06.2022
- *The QAOA at High Depth for MaxCut on Large-Girth Regular Graphs and the SK Model*
  - Outstanding Paper Award talk at the 17th Conference on Theory of Quantum Computation, Communication and Cryptography (TQC) [video] 07.2022
- *Quantum Approximate Optimization: Challenges and Opportunities*
  - Invited talk at the 2021 INFORMS Annual Meeting 10.2021
- *Strongly Universal Hamiltonian Simulators*
  - Invited talk at the Simons Institute Quantum Wave in Computing Reunion Workshop 07.2021
  - Accepted talk at QC40: Physics of Computation Conference 40th Anniversary 05.2021
  - Invited talk at the QCDA (Quantum Code Design and Architecture) seminar 04.2021
  - Accepted talk, 24th Annual Conference on Quantum Information Processing (QIP) [video] 02.2021
- *The QAOA and the Sherrington-Kirkpatrick Model at Infinite Size*
  - Accepted talk, 24th Annual Conference on Quantum Information Processing (QIP) [video] 02.2021
- *Quantum Simulation and Optimization in Near-Term Quantum Computers*
  - Invited talk at the Stanford Q-FARM Special Seminar 12.2020
  - Invited talk at the MIT Center for Theoretical Physics 12.2020
  - Invited talk at the QM seminar, UC Berkeley [video] 12.2020
  - Invited talk at the Institute for Quantum Information (IQI) Seminar, Caltech 12.2020

- *Hamiltonian Sparsification and Gap-Simulation*
  - Accepted talk, 22nd Annual Conference on Quantum Information Processing (QIP) [video] 01.2019
  - Accepted talk, 10th Innovations in Theoretical Computer Science conference (ITCS) 01.2019
- *Quantum Approximate Optimization: Performance and Applications with MaxCut and Maximum Independent Set Problems*
  - Talk at the 50th Meeting of APS Division of Atomic, Molecular & Optical Physics 05.2019
  - Poster at the Quantum Science Gordon Research Conference 08.2018
  - Poster at the Aspen Conference on Advances in Quantum Algorithms and Computation 03.2018
- *Symmetry-protected dissipative preparation of matrix product state*
  - Invited talk at the Mathematical Picture Language Project Seminar, Harvard University 11.2019
  - Poster at the 48th Meeting of APS Division of Atomic, Molecular & Optical Physics 06.2017
  - Talk at the Quantum Science: Implementation workshop in Benasque, Spain 07.2016
- *Robust quantum information processing with atomic cat states*
  - Poster at the Atomic Physics Gordon Research Conference 06.2015

ADDITIONAL EXPERIENCES

Teaching

- Guest lecturer for the "Rydberg Computers" tutorial at the 2023 APS March Meeting 2023
- Supporting Teaching Fellow for Physics of Quantum Information (Physics 271) at Harvard University 2020
- Teaching Fellow for Electrodynamics (Physics 153) at Harvard University 2018
- Teacher & Mentor at MIT China Development Initiative's Service Leadership Program 2013
- Teacher at Schenk-von-Limpurg-Gymnasium in Gaildorf, Germany through MISTI Global Teaching Lab 2012

Service

- Program committee member for TQC'23 (18th conference on Theory of Quantum Computation) 2023
- Referee for Physical Review journals 2022–23
- Reviewer for leading quantum computer science conferences (including: QIP, TQC, STOC, SODA) 2019–23
- Referee for *Quantum* (journal) 2019–22
- Referee for ACM Transactions on Quantum Computing 2021
- MIT Society of Physics Students, Executive Council 2011–14

Mentorship

Graduate Students:

- Chi-Fang (Anthony) Chen, Hsin-Yuan (Robert) Huang, William (Robbie) King, Joao Basso, Katherine van Kirk, Beatrice Nash, Madelyn Cain

Undergraduate Students:

- Ishaan Kannan, Amir Shanehsazzadeh, Dylan Li, Abhishek Anand

Software

- MATLAB, Python, Julia, Mathematica, Java, C++, GPGPU computing