Guang-Hao Low

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Current Position

Microsoft, Quantum Architectures and Computation Group **Redmond, WA**
Researcher *Feb 2018–Current*

- Investigating a variety of problems in quantum computation as follows.
  - Algorithms for quantum simulation and quantum state preparation
  - Quantum speedups for classical computational problems
- Led development of Microsoft Quantum Chemistry Library, released Oct 2018, in collaboration with Pacific Northwest National Labs.

Education

Massachusetts Institute of Technology **Cambridge, MA, United States of America**
Ph.D, Department of Physics *2012– 2017*
Thesis: Quantum Signal Processing by Single-Qubit Dynamics, Advisor: Isaac L. Chuang

Research in the applied theory of quantum information and computation. Results include algorithms, metrology, control, and fault-tolerance, with an emphasis on schemes implementable in emerging quantum computers, and models of computation natural to the underlying physics.

University of Cambridge **Cambridge, United Kingdoms**
B.A with Honors and M.Sci, 1st Class, Department of Physics *2008 – 2012*
Member of Christ's college. Participated in the Cambridge-MIT Exchange Program 2010. Performed theoretical and experimental research into trapped-ion quantum computation.

Experience

Research

Microsoft, Quantum Architectures and Computation Group **Redmond, WA**
Post-Doctorate, Advisor: Matthias Troyer *Oct 2017–Feb 2018*
Investigated quantum algorithms, primarily related to the simulation of physical systems. Implemented quantum algorithms and tutorials for the inaugural release of the Microsoft Quantum Development Kit.

MIT, Department of Physics **Cambridge, MA**
Graduate Student, Advisor: Isaac L. Chuang *Sep 2012–Aug 2017*
Investigated a variety of problems in quantum computation, with notable works as follows.

- Quantum algorithms:
  - General Hamiltonian simulation with extremely small overhead (arXiv)
  - Sparse Hamiltonian simulation with optimal performance in all parameters (PRL'17)

- Quantum search with fixed-point and optimal complexity (PRL'14, Featured in Physics)
- Method for speeding up for Bayesian inference (PRA'14)

- Quantum metrology:
  - Protocol to rapidly evaluate quantum gate performance with low overhead (PRA'15)
  - Microscopy technique to image objects at the Heisenberg limit (PRL'15, Featured in Physics)
- Quantum control and fault-tolerance:
  - Characterization and efficient design of composite quantum gates (PRX'16)
  - Composite quantum gates with arbitrary robustness to systematic noise (PRA'14)

University of Cambridge, Cavendish Laboratory **Cambridge, United Kingdoms**
Masters Student Part III Tripos Project, Advisor: Michael Köhl *Jan 2012–Apr 2012*
Designed and built a laser diode system with frequency stabilized by an external resonant optical cavity.

MIT, Department of Physics **Cambridge, MA**
Undergraduate Student, Advisor: Isaac L. Chuang *Sep 2010–Sep 2011*
Investigated noise sources in trapped-ion quantum computation. Research from this work expanded the theoretical understanding of electric field fluctuations in relation to electrode geometries. Assisted in experimental work by designing and building high quality-factor radio-frequency Helical resonators.

CERN, CMS Group **Geneva, Switzerland**
Research Associate, Advisor: Steve McMahon *Jun 2010–Aug 2010*
Wrote fast C++ code to simulate the response of silicon detectors to high energy particle trajectories. This work was for understanding systemic errors in data from the Compact Muon Solenoid experiment in the Large Hadron Collider.

Teaching

MIT, Department of Physics **Cambridge, MA**
Undergraduate Research Opportunity. Direct Advisor *Feb 2014–Jun 2016*
Proposed research projects for a few undergraduate students and provided mentorship leading to publications.

MIT, Department of Physics **Cambridge, MA**
Quantum Information Science. Teaching Assistant *Jun 2014–Aug 2014*
Prepared teaching material for some lectures. Presented some lectures. Assisted students individually with questions on material and homework problems. Provided suggestions for course research component.

Publications

[1]Berry, D. W., M. Kieferova, A. Scherer, Y. R. Sanders, G. H. Low, N. Wiebe, C. Gidney, and R. Babbush, "Improved techniques for preparing eigenstates of fermionic hamiltonians", Npj Quantum Information **4**, 22 (2018).

[2]Gilyén, A., Y. Su, G. H. Low, and N. Wiebe, "Quantum singular value transformation and beyond: exponential improvements for quantum matrix arithmetics", arXiv **1806**, 01838 (2018).

[3]Haah, J., M. B. Hastings, R. Kothari, and G. H. Low, "Quantum algorithm for simulating real time evolution of lattice hamiltonians", arXiv **1801**, 03922 (2018).

[4]Low, G. H., "Hamiltonian simulation with nearly optimal dependence on spectral norm", arXiv **1807**, 03967 (2018).

[5]Low, G. H., V. Kliuchnikov, and L. Schaeffer, "Trading T-gates for dirty qubits in state preparation and unitary synthesis", arXiv **1812**, 00954 (2018).

[6]Low, G. H. and N. Wiebe, "Hamiltonian simulation in the interaction picture", arXiv **1805**, 00675 (2018).

[7]Sanders, Y. R., G. H. Low, A. Scherer, and D. W. Berry, "Black-box quantum state preparation without arithmetic", arXiv **1807**, 03206 (2018).

[8]Gutierrez, M. S., G. H. Low, R. Rines, and H. Zhang, "Parallel position-controlled composite quantum logic gates with trapped ions", arXiv **1702** (2017).

[9]Kimmel, S., C. Y.-Y. Lin, G. H. Low, M. Ozols, and T. J. Yoder, "Hamiltonian simulation with optimal sample complexity", Npj Quantum Inf. **3**, 13 (2017).

[10]Low, G. H., "Quantum signal processing by single-qubit dynamics", PhD thesis (Massachusetts Institute of Technology, 2017).

[11]Low, G. H. and I. L. Chuang, "Hamiltonian simulation by uniform spectral amplification", arXiv **1707**, 05391 (2017).

[12]Low, G. H. and I. L. Chuang, "Optimal Hamiltonian simulation by quantum signal processing", Phys. Rev. Lett. **118**, 010501 (2017).

[13]Lin, K.-Y., G. H. Low, and I. L. Chuang, "Effects of electrode surface roughness on motional heating of trapped ions", Phys. Rev. A **94**, 013418 (2016).

[14]Low, G. H. and I. L. Chuang, "Hamiltonian simulation by qubitization", arXiv **1610**, 06545 (2016).

[15]Low, G. H., T. J. Yoder, and I. L. Chuang, "Methodology of resonant equiangular composite quantum gates", Phys. Rev. X **6**, 041067 (2016).

[16]McConnell, R., G. H. Low, T. J. Yoder, C. D. Bruzewicz, I. L. Chuang, J. Chiaverini, and J. M. Sage, "Heisenberg scaling of imaging resolution by coherent enhancement", arXiv **1606**, 02188 (2016).

[17]Zhang, H., M. Gutierrez, G. H. Low, R. Rines, J. Stuart, T. Wu, and I. Chuang, "Iterative precision measurement of branching ratios applied to 5 p states in 88 sr +", New J. Phys. **18**, 123021 (2016).

[18]Kimmel, S., G. H. Low, and T. J. Yoder, "Robust calibration of a universal single-qubit gate set via robust phase estimation", Phys. Rev. A **92**, 062315 (2015).

[19]Low, G. H., T. J. Yoder, and I. L. Chuang, "Quantum imaging by coherent enhancement", Phys. Rev. Lett. **114**, 100801 (2015).

[20]Low, G. H., T. J. Yoder, and I. L. Chuang, "Optimal arbitrarily accurate composite pulse sequences", Phys. Rev. A **89**, 022341 (2014).

[21]Low, G. H., T. J. Yoder, and I. L. Chuang, "Quantum inference on Bayesian networks", Phys. Rev. A **89**, 062315 (2014).

[22]Yoder, T. J., G. H. Low, and I. L. Chuang, "Fixed-point quantum search with an optimal number of queries", Phys. Rev. Lett. **113**, 210501 (2014).

[23]Low, G. H., P. F. Herskind, and I. L. Chuang, "Finite-geometry models of electric field noise from patch potentials in ion traps", Phys. Rev. A **84**, 053425 (2011).

[24]Wang, S. X., G. H. Low, N. S. Lachenmyer, Y. Ge, P. F. Herskind, and I. L. Chuang, "Laser-induced charging of microfabricated ion traps", J Appl. Phys. **110**, 104901 (2011).

[25]Low, G. H., Z. Shi, and Y. Yeo, "Effects of collisional decoherence on multipartite entanglement: how entanglement might not be relatively common", Phys. Rev. A **74**, 012307 (2006).

Presentations

1. Hamiltonian simulation in the interaction picture, 22th Annual Conference on Quantum Information Processing, Seattle, Jan 2019.
2. Advances in optimal Hamiltonian simulation and applications to chemistry, Invited talk, Microsoft Station Q Fall Meeting, Dec 2018.
3. Advances in optimal Hamiltonian simulation, Invited talk, National University of Singapore Centre for Quantum Technologies, Sep 2018.
4. Advances in optimal Hamiltonian simulation, 21st Annual Southwest Quantum Information and Technology Workshop, Mar 2018.
5. Introduction to Quantum Computing using Q#, University of Washington, May 2018.
6. Advances in optimal Hamiltonian simulation, 21st Annual Southwest Quantum Information and Technology Workshop, Mar 2018.
7. Advances in optimal Hamiltonian simulation, Invited talk, Maryland University Joint Center for Quantum Information and Computer Science, Mar 2018.
8. Quantum Signal Processing by Single-Qubit Dynamics, Invited talk, Macquarie University Quantum Research Centre, Nov 2017.
9. Optimal Hamiltonian simulation by quantum signal processing. 20th Annual Conference on Quantum Information Processing, Seattle, Jan 2017.
10. Quantum gates with optimal bandwidth in noisy environments. American Physical Society March Meeting, Baltimore, Mar 2016.
11. Parallelized quantum imaging by coherent enhancement. 15th Asian Quantum Information Science Conference, Seoul, South Korea, Aug 2015.
12. Quantum inference on bayesian networks. American Physical Society March Meeting, Denver, Mar 2014.
13. Optimal arbitrarily accurate composite pulse sequences. American Physical Society March Meeting, Denver, Mar 2014.
14. Laser-induced charging of microfabricated ion traps, American Physical Society March Meeting, Dallas, Mar 2011.

Awards and Honors

Martin and Beate Block Award to Promising Young Physicist (2016)
Thomas Frank Fellowship (2013)
Christ's College Graduate Scholarship (2012)
Christ's College Scholarship (2009, 2010)
Kaetrin Simpson Prize, Simon Wilson Prize, Greig Prize, P.J. Fay Prize (2009–2012)
37th International Physics Olympiad Gold Medalist (2006)