

Shelby Kimmel

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Education

2009-2014 **Massachusetts Institute of Technology (MIT)**, Cambridge, MA
Ph.D. in Physics. Advised by Edward Farhi.
Thesis Title: Cumulative Effects in Quantum Algorithms and Quantum Process Tomography

2004-2008 **Williams College**, Williamstown, MA
B.A. in Astrophysics. Advised by William Wootters. GPA 3.96/4.0
Thesis Title: Quantifying the Entanglement Cost of Nonlocal Measurements.

Research Experience

2014-present **Hartree Postdoctoral Fellow at the Joint Center for Quantum Information and Computer Science (QuICS), University of Maryland.** *College Park, MD.*

- With QuICS postdoc Bill Fefferman, proved an oracle separation between QMA and QCMA (two quantum versions of NP).
- With QuICS fellow Yi-Kai Liu, combined compressed sensing with robust process tomography to create a new efficient and accurate process characterization procedure.
- With Caltech postdoc Stacey Jeffery, explored the connection between quantum algorithms for formula evaluation problems and graph connectivity
- With Sandia National Labs researcher Kenneth Rudinger, analyzed new techniques for architecture-independent process tomography
- With QuICS postdoc Cedric Lin and others, created procedures for simulating quantum Hamiltonians given a quantum description of the Hamiltonian.
- With Berkeley postdoc Henry Yuen and others, investigated a triply quantum version of the complexity class NP (with a quantum problem, quantum verifier, and a quantum proof).
- With U. Sydney postdoc Chris Granade, created a procedure to accurately characterize quantum states without well-characterized measurements.

2009-2014 **Center for Theoretical Physics, MIT.** *Cambridge, MA.*

Advised by Edward Farhi

- Created quantum algorithms for classes of Boolean formula evaluation problems and quantum satisfiability problems.
- Created a technique for non-constructively proving the existence of a quantum algorithm; using it, you can determine an algorithm with certain properties must exist, but might not know what the algorithm is.

- Summers, 2012, 2013 **Raytheon BBN Technologies. Cambridge, MA.**
 Advised by Marcus P. da Silva
- Designed and analyzed new procedures for robust quantum process characterization.
 - Implemented procedures on a superconducting qubit system and analyzed the results of experiments using MATLAB.
- Summer, 2011 **Institute for Quantum Computing at the University of Waterloo. Waterloo, ON.**
 Advised by Andrew Childs
- Developed quantum algorithms for Boolean formulas using quantum search subroutines.
 - Studied semi-definite programs that characterize query complexity.
- 2007-2008 **Williams College. Williamstown, MA.**
 Advised by William Wootters
- Studied the entanglement resources needed to perform measurements on a quantum state shared by two separated parties.

Teaching

- Fall 2016 **Discussion Section Teacher, Object Oriented Programming, University of Maryland, College Park, MD**
- Taught Java to 40 undergraduate students for 2 hours a week.
 - Classes included a mix of short lectures, small group discussions, and coding activities.
 - Taught the lecture (3 sections of 140 students) when the head lecturer was away.
- Fall 2016 **Co-Teacher, Introduction to Quantum Information Processing, University of Maryland, College Park, MD**
- Taught 12 hours of lecture to 40 first-year graduate physics and computer science students.
 - Incorporated active learning exercises.
 - Organized peer editing system for project paper to encourage students to refine their writing.
- Springs 2012, 2014 **Writing Assistant, Undergraduate Quantum Mechanics, MIT, Cambridge, MA**
- Guided ~15 students through the process of writing an academic style research report on a topic of the student's choosing within quantum mechanics.
 - Led peer-review meetings where students critiqued each other's work in a supportive environment
- Spring 2011 **Teaching Assistant, Undergraduate First Year Electricity and Magnetism, MIT, Cambridge, MA**
- Taught weekly problem solving sessions to 45 students.

- Participated in active learning lessons three times a week, leading students through concept questions and experiments.

2010-2011 **Graduate Teaching Certificate Program, MIT, Cambridge, MA**

- Attended 8 workshops on pedagogy, curriculum planning, and classroom best practices, and gave a lecture that was critiqued by the class and instructor.

2010-2013 **Middle School Tutor for Tutoring Plus, Cambridge MA**

- Worked with one student for an hour a week over the course of the school year to help him with essays, math homework, and the development of critical reading skills.

2008-2009 **Fulbright Korea: English Teaching Assistant. Gochangbuk High School, Gochang, S. Korea**

- Planned and taught lessons in conversational English at a rural Korean high school and middle school to ~500 students a week

2005-2008 **Writing Tutor. Williams College, Williamstown, MA.**

- Worked one-on-one with ~4 different undergrads a week to help them brainstorm, organize and edit papers.

Advising

Summer 2016 **Undergraduate Research Advising, University of Maryland, College Park, MD**

- Advised Andrew Zhao on a project researching whether compressed sensing techniques can be used to achieve Heisenberg scaling in phase estimation of quantum unitaries.

Spring 2016 **Undergraduate Research Advising, University of Maryland, College Park, MD**

- Advised two students, Andrew Zhao and Mark Hubbert, on a project studying optimal cost strategies for quantum tomography schemes. The students studied the problem analytically and numerically, and won 3rd prize in a physics department undergraduate poster contest.

Summer 2015 **Undergraduate Research Advising, University of Maryland, College Park, MD**

- Advised (with Prof. Andrew Childs) Hardik Bansal, on a project to find optimal ways of measuring a quantum state shared between two physically separated parties.

2014-present **Women in Physics Mentoring Program, University of Maryland, College Park, MD.**

- Participated in a mentoring group that included an undergraduate woman and a graduate woman in physics.

2009-2014 **Women in Physics Mentoring Program, MIT, Cambridge MA**

- Coordinated graduate/undergraduate women in physics mentoring program with undergraduate co-leader.
- Mentored 2 undergraduate women each year. Discussed finding research advisors, time management, and applying to graduate school.
- Organized a networking seminar

Leadership

- Summer 2016 **Co-organizer, Workshop on QMA(2) and the Complexity of Entanglement**, *University of Maryland, College Park, MD.*
- Planned a small, highly specialized workshop in the field of quantum complexity theory. Responsibilities included deciding on scope, format, and attendees; maintaining the website; chairing sessions; and communicating logistics to attendees.
- 2010–2012 **Graduate Women at MIT (GWAMIT)**. *MIT, Cambridge, MA*
- Co-organized mentoring program for graduate women. Helped to recruit 200 alumni, professors, and graduate students to the program, matched participants through surveys, managed a committee of 8 people, and planned bi-yearly dinners.
 - Arranged speakers, advertised, and hosted the Online Personal Branding Event at the GWAMIT Empowerment Conference (2010)
 - Informed the MIT Women in Physics group of various GWAMIT events as the GWAMIT physics liaison.

Awards

- 2014 Hartree Postdoctoral Fellow, QuICS
- 2013 Graduate Women of Excellence Award (1 of 50), MIT.
- 2012 Best Student Paper Track A (1 of 2), ICALP. (For “Quantum Adversary (Upper) Bound.”)
- 2012 Best Scientific Poster (1 of 2), QIP. (For “The Quantum Query Complexity of Read-Many Formulas.”)
- 2011 Best Talk (1 of 3) Women in Physics Canada.
- 2009 American Physical Society Apker Award Finalist (national award for undergraduate research; 1 of 3)

Selected Talks

- 2016 University of Copenhagen QMATH Center Kick-Off Conference. Copenhagen, Denmark. “What does the effective resistance of electrical circuits have to do with quantum algorithms?”
- 2016 Schrodinger Sessions (a workshop to introduce quantum mechanics to science fiction writers). College Park, MD. “Quantum Algorithms.”
- 2016 Last Frontiers in Quantum Information Workshop. Juneau, AK. “Turning States Into Unitaries: Optimal Sample-Based Hamiltonian Simulation.”
- 2015 Sandia National Labs. Albuquerque, NM. “Robust Phase Estimation with Applications to Single-Qubit Process Characterization.”
- 2014 Williams College. Williamstown, MA. “Problems with Multiple Oracles.”

- 2014 APS March Meeting, Invited Talk. Denver, CO. “Randomized Benchmarking Tomography.”
- 2013 Coogee Quantum Information Conference. Sydney, AU. “Problems with Multiple Oracles.”
- 2013 Isaac Newton Institute, Cambridge, UK. “Robust Characterization of Quantum Processes.”
- 2013 Perimeter Institute. Waterloo, Canada “The Quantum Adversary (Upper) Bound.”
- 2012 UC Berkeley. Berkeley, CA. “The Quantum Query Complexity of Read Many Formulas.”
- 2011 Women in Physics Canada. Waterloo, Canada. “Super-polynomial Quantum Speed-ups in Boolean Formulas.”

Skills

- Matlab, Mathematica: very experienced
- Java, Julia, Python, html, CSS: proficient

Professional Service

- Reviewer for Symposium on Foundations of Computer Science
- Program Committee for Theory of Quantum Computing Conference
- Reviewer for Quantum Information Processing conference
- Reviewer for Nature Communications
- Program Committee for Asian Quantum Information Science conference
- Reviewer for Theory of Computing
- Reviewer for Theory of Quantum Computing conference
- Reviewer for Quantum Information and Computation
- Sorter for the American Physical Society March Meeting
- Reviewer for Symposium on Theoretical Aspects of Computer Science
- Reviewer for European Symposium on Algorithms
- Reviewer for International Journal of Quantum Information
- Reviewer for Symposium on Discrete Algorithms

Publications

Depending on the topic of the research, I publish in both computer science conference proceedings and in physics journals. Physics journals are more prestigious than physics conference proceedings. Additionally, in physics papers, author order is often important; generally the first author is the lead author.

- S. Jeffery, **S. Kimmel**. Quantum Algorithms for Graph Connectivity and Formula Evaluation. Arxiv:1704.00765. (Accepted talk at TQC 2016)
- K. Rudinger, **S. Kimmel**, D. Lobser, P. Maunz. Experimental demonstration of cheap and accurate phase estimation. Arxiv:1702.01763. (Accepted to *Physical Review Letters*.)
- **S. Kimmel**, C. Y. Y. Lin, G. H. Low, M. Ozols, T. J. Yoder. Hamiltonian Simulation with Optimal Sample Complexity. *Nature Partner Journals Quantum Information*, vol 3, no 13, 2017. Arxiv:1608.00281.
- E. Farhi, **S. Kimmel**, K. Temme. A Quantum Version of Schöning's Algorithm Applied to Quantum 2-SAT. *Quantum Information and Computation*. Vol 16, no 13-14. 2016. pp1212-1227. Arxiv:1603.06985.
- B. Fefferman, **S. Kimmel**. Quantum vs Classical Proofs and Subset Verification. Arxiv:1510.06750.
- **S. Kimmel**, Y.-K. Liu. Quantum Compressed Sensing Using 2-Designs. Arxiv:1510.08887. (Accepted to SAMPTA 2017.)
- **S. Kimmel**, C. Y. Y. Lin, H. H. Lin. Oracles with Costs. *Proceedings of Theory of Quantum Computing 2015*. pp 1-26. Arxiv:1502.02174
- B. R. Johnson, M. P. da Silva, C. A. Ryan, **S. Kimmel**, J. M. Chow, T. A. Ohki. Demonstration of Robust Quantum Gate Tomography via Randomized Benchmarking. *New Journal of Physics* 17 (11), 113019. 2015.
- **S. Kimmel**, G. H. Low, T. J. Yoder. Robust calibration of a universal single-qubit gate set via robust phase estimation. *Phys. Rev. A* 92 (6), 062315.
- **S. Kimmel**, M. P. da Silva, C. Ryan, B. Johnson, T. Ohki. Robust Extraction of Tomographic Information via Randomized Benchmarking. In *Physical Review X*, 2014, vol 4, n 1, pp 011050.
- A. M. Childs, **S. Kimmel**, R. Kothari. The Quantum Query Complexity of Read-Many Formulas. *Proceedings of ESA 2013*, pp 337-348.
- **S. Kimmel**. Quantum Adversary (Upper) Bound. *Chicago Journal of Theoretical Computer Science*, vol 2013 n 4. And *Proceedings of ICALP*. 2012 pp 557-568.
- B. Zhan, **S. Kimmel**, A. Hassidim. Super-polynomial Quantum Speed-ups for Boolean Evaluation Trees with Hidden Structure. *Proceedings of ITCS*, pp 249-265. 2012
- S. Bandyopadhyay, G. Brassard, **S. Kimmel**, W. Wootters. Entanglement Cost of Nonlocal Measurements. *Phys. Rev. A*. vol 80, n 1, pp 012313, 2009.
- J. Pasachoff, **S. Kimmel**, M. Druckmuller, V. Rusin, M. Saniga. The April 8, 2005 Eclipse White-light Corona. *Solar Physics*. vol 238, n 2, pp 261-270, 2006.