Ishaun Datta

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EDUCATION

Stanford University   2019 – Present
Ph.D. Candidate in Computational and Mathematical Engineering
Advisor: Professor Adam Bouland, Computer Science

Research interests: *Quantum complexity*, esp. quantum {*advantage, simulation, learning theory*}.

Passed 6/6 qualifying exams September 2020

Relevant Coursework: CS 259Q Quantum Computing, Phys 234 Quantum Computation & Information
Theory, CME 305 Discrete Math and Algorithms, CS 265 Randomized Algorithms, CS 254B Complexity
Theory II, CS 359A Research Seminar in Complexity Theory, CME 302 Numerical Linear Algebra.

Teaching Assistant: CS 359D Quantum Complexity Theory, Spring 2023.

Massachusetts Institute of Technology   2014 – 2018
B.S. in Mathematics with Computer Science and B.S. in Physics

Montgomery Blair High School, Maryland   2010 - 2014
Science Talent Search Finalist, National Merit Scholar, National AP Scholar, Debate Team Captain

RESEARCH

Ph.D. Research

· Advisor: Prof. Adam Bouland. **My work bridges the "asymptopia" of complexity theory with
real-world experiments, in the contexts of quantum advantage, simulation, and learning.**
This ranges from pure mathematics (in the form of proving theorems) to analytically-tractable modeling
(in the form of pen-and-paper calculations).

· Recent work providing evidence that BosonSampling is classically hard in the experimental regime of
linearly many optical modes in the number of photons. Accepted talk at QIP 2024.

· Proving best-known noise robustness for hardness of sampling in Random Circuit Sampling (RCS)
and BosonSampling. This work takes steps towards proving the approximate average-case quantum
supremacy conjecture and the Permanents-of-Gaussians conjecture.

Quantum Research Scientist Summer Intern   Summer 2022
IBM Almaden, Demonstrations Team   *San Jose, CA*

· Under the auspices of David Layden, analyzed noise propagation in Trotter circuits, and in particular
sought to prove sharp bounds on optimal Trotter numbers and circuit depths for product formulas in
the presence of corrupting noise. This contributes to a lineage of papers on "a theory of Trotter error,"
but in the NISQ setting of gate-wise noise (both entropy increasing and non-increasing models). Our
findings provide a source of optimism for near-term applications of digital Hamiltonian simulation. Aim
to submit to QSim 2024 and publish thereafter.

Visiting Ph.D. Student   March 2022 – June 2022
QMATH, Københavns Universitet   *Copenhagen, Denmark*

· Working with Profs. Matthias Christandl and Albert Werner. Project: establishing a mathematical
framework for analog quantum simulation. The main results were that existing attempts to capture
analog simulation using perturbative gadgets from Hamiltonian complexity necessarily produce unphys-
ical, system-size dependent scalings in the interaction terms. Therefore, any mathematical theory of
analog simulation must go beyond the Hamiltonian complexity toolkit. As a first step toward building
that toolkit, we provide an experimentally-realizable protocol using the quantum Zeno effect that can
evade these lower bounds. Work in review at *Nature*.

Quantum Research Scientist Summer Intern June 2019 – December 2019
Intel Labs *Santa Clara, CA*

· Designed and implemented novel algorithm to simulate random "Instantaneous Quantum Polynomial" (IQP) circuits, a prominent candidate for quantum supremacy. The algorithm exploited neural network quantum states (NQS) to simulate quantum circuits both with and without experimental noise.

PUBLICATIONS

By default, authorship is alphabetical, esp. in theoretical computer science and high energy physics.

Two forthcoming works, one on BosonSampling, another from research at IBM.

A. Bouland, D. Brod, **I. Datta**, B. Fefferman, D. Grier, F. Hernández, M. Oszmaniec. Complexity-theoretic foundations of BosonSampling with a linear number of modes. Accepted to QIP 2024.

D. Harley, **I. Datta**, F.R. Klausen, A. Bluhm, D.S. França, A. Werner, M. Christandl. Going beyond gadgets: the importance of scalability for analog quantum simulators. Accepted to QIP 2024.
In review at *Nature*. arXiv:2306.13739.

> Invited talk at UT Sydney QSI Seminar, Oct. 2023

M.C. Caro, **I. Datta**.[†] Pseudo-dimension of quantum circuits. *Quantum Mach. Intell.* **2**, 14 (2020).
† Equal contributors.

- Munich Conference on Quantum Science and Technology 2020 Best Poster Award
- Conference on the Theory of Quantum Computation (TQC) 2020 Poster

Shapes of Possibility: Interview between Felicitas Rohden and Shaun Datta about Quantum Computing, *Unbag Magazine* **3** (2018). Discussed our collaboration on an art exhibit conveying key principles of quantum information, which premiered in Oct. 2017 at Kunst im Tunnel Museum in Düsseldorf.

Quantum Mechanics as a Stimulus for American Theoretical Physics, *APS News* **27**, 7 (2018). Published as APS History of Physics Essay Contest Winner.

P. Adhikari, T.D. Cohen, **I. Datta**. Density of saturated nuclear matter at large N_c and heavy quark mass limits. *Phys. Rev. C* **89**, 065201 (2014).

AWARDS

ICME Student Leadership Award 2022

· Received $1,500 award for founding and leading ICME's student advocacy group.

NSF Graduate Research Fellowship 2019 – 2022
National Science Foundation

· $138,000 over three years. Approx. 2,000 fellowships awarded among more than 12,000 applicants.

German Academic Exchange Service (DAAD) Research Fellowship 2018 – 2019
Technische Universität München

· Quantum learning theory under the auspices of Prof. Michael Wolf. See Publications.
· One of only two bachelor's students to receive award; all others were Ph.D.s or postdoctoral fellows.

MIT Memorial Scholar 2016

Tenth Place nationally at Intel Science Talent Search 2014

· Received $21,000 scholarship among $\sim 3,000$ applicants and 40 national finalists as a result of my nuclear physics research and five rounds of judging interviews on broader scientific knowledge and creativity.

VOLUNTEERING & SERVICE

Conference Subreviewer

Reviewed papers for ITCS 2024, QIP 2024, TQC 2024.

ICME Student Action Group   September 2020 - Present

· Created and led ICME's student advocacy group. Accomplishments: wrote and disseminated the first comprehensive student survey for ICME, implemented Ph.D. Individual Development Plan, streamlined core curriculum and qualifying exams, refocused CME 300 seminar on aligning with research advisor.

MIT Interviewer   September 2018 – Present

· Interview undergraduate applicants to MIT and submit detailed evaluations to Admissions Committee.

Stanford Engineering Graduate Advisory Council   September 2019 – August 2021

Physics and Mathematics Secondary School Teacher   January 2018

· Taught students at Institut Salvador Espriu in Barcelona. Created from scratch lessons on special relativity, particle physics, radioactivity, and other topics. Materials available upon request.

Associate Academic Advisor at MIT   2016 – 2018
Mathematical Problem Solving Seminar

· Offered counsel to freshmen, connecting students with academic, social, and mental health resources.

Volunteer teacher   2015 – 2018
MIT Educational Studies Program

· Developed original curriculum for the High School Studies Program (summer 2016), annually for Splash.
· Courses: Books I Wish I'd Read Before College – Need-to-Know Topics for the Aspiring Scientist, Paradoxes in Physics, Quantum Bomb-Detection (Elitzur-Vaidman bombs), Special Relativity Primer.

CONFERENCES & SUMMER SCHOOLS

- Long-term Visitor by invitation, Program on Quantum Algorithms, Complexity, and Fault Tolerance, Simons Institute for the Theory of Computing, January – May 2024

- Conference on Quantum Information Processing (QIP), Taipei, Taiwan, 2024. Two accepted talks.

- IPAM Program on Mathematical Aspects of Quantum Learning, UCLA, 2023

- Park City Mathematics Institute/IAS Graduate Summer School on Quantum Computation, 2023

- IPAM Winter School on Contemporary Quantum Algorithms and Applications, UCLA, 2023

- Conference on Quantum Information Processing (QIP), Pasadena, CA, 2022

- Conference on Quantum Information Processing (QIP), online, 2021

- The Quantum Wave in Computing Workshop, Simons Institute, 2020

- Workshop on Machine Learning Techniques for Many-Body Quantum Systems, International Max Planck Research School for Quantum Science and Technology, Munich, 2019

- Quantum Computation, Princeton Summer School on Condensed Matter Physics, 2017

- Undergraduate School on Quantum Information Processing, Institute for Quantum Computing (IQC), 2017