Justin Yirka

Graduating in 2025 Ph.D. Student in Computer Science

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Research Interests

Quantum computing, Theoretical computer science, Complexity theory and Hamiltonian complexity

Education

University of Texas at Austin (UT)

Ph.D. in Computer Science — Expected graduation: May 2025
Adviser: Scott Aaronson

M.S. in Computer Science — 2022

Virginia Commonwealth University (VCU)

B.S. in Computer Science — Specialization in Data Science — 2018

B.S. in Mathematical Sciences — Concentration in Pure Mathematics — Concurrent degrees
Minor in Physics, University Honors College

Research Papers

Authors listed alphabetically unless noted. Filled labels indicate I gave the presentation.

J. Yirka.
Even quantum advice is unlikely to solve PP.
- arXiv:2403.09994 and ECCC:TR24-052, March 2024.

S. Grewal and J. Yirka.
The Entangled Quantum Polynomial Hierarchy Collapses.
- To appear in Proceedings of *39th Computational Complexity Conference (CCC)*, Ann Arbor, MI, USA, July 2024.
- Poster at Conference on Quantum Information Processing (QIP), Taipei, Taiwan, January 2024.
- arXiv:2401.01453 and ECCC:TR24-006, January 2024.

J. Kallaugher, O. Parekh, K. Thompson, Y. Wang, and J. Yirka.
Complexity Classification of Product State Problems for Local Hamiltonians.
- Contributed talk at Conference on Quantum Information Processing (QIP), Taipei, Taiwan, January 2024.
- arXiv:2401.06725, January 2024.

J. Yirka and Y. Subasi. (authors not ordered alphabetically)
Qubit-efficient entanglement spectroscopy using qubit resets.
- *Quantum*, 5:535, 2021. doi:10.22331/q-2021-09-02-535.
- Contributed talk by J. Yirka at Conference for Young Quantum Information Scientists (YQIS), Virtual, 2021.
- Contributed talk at APS March Meeting, Virtual, 2021.
- Contributed talk at 20th Asian Quantum Information Science Conference (AQIS), Virtual, 2020.
- arXiv:2010.03080, 2020.

S. Gharibian, S. Piddock, and J. Yirka.
Oracle complexity classes and local measurements on physical Hamiltonians.
- o In Proceedings of *37th Symposium on Theoretical Aspects of Computer Science* (*STACS*), Montpellier, France, 2020. doi:10.4230/LIPIcs.STACS.2020.20.
- • Contributed talk at Conference on Quantum Information Processing (QIP), Shenzhen, China, 2020.
- o Poster at Conference on the Theory of Quantum Computation, Communication, and Cryptography (TQC), College Park, MD, USA, 2019.
- o Poster at Workshop on Quantum Computing Theory in Practice (QCTIP), Bristol, UK, 2019.
- • Poster at Conference on Quantum Information Processing (QIP), Boulder, CO, USA, 2019.
- • Contributed talk at Asian Quantum Information Science Conference (AQIS), Nagoya, Japan, 2018.
- – arXiv:1909.05981, 2019.

S. Gharibian, M. Santha, J. Sikora, A. Sundaram, and J. Yirka.
Quantum generalizations of the polynomial hierarchy with applications to QMA(2).
- – *Computational Complexity*, 31:12, 2022. doi:10.1007/s00037-022-00231-8.
- o Poster at Conference on Quantum Information Processing (QIP), Boulder, CO, USA, 2019.
- o Contributed talk at Asian Quantum Information Science Conference (AQIS), Nagoya, Japan, 2018. — **"Long"/plenary talk: top 7% of submissions**.
- o In Proceedings of *43rd Symposium on Mathematical Foundations of Computer Science* (*MFCS*), Liverpool, UK, 2018. doi:10.4230/LIPIcs.MFCS.2018.58.
- – arXiv:1805.11139, 2018.

S. Gharibian and J. Yirka.
The complexity of simulating local measurements on quantum systems.
- – *Quantum*, 3:189, 2019. doi:10.22331/q-2019-09-30-189.
- o In Proceedings of *12th Conference on the Theory of Quantum Computation, Communication, and Cryptography* (*TQC*), Paris, France, 2017. doi:10.4230/LIPIcs.TQC.2017.2.
- • Poster at Conference on Quantum Information Processing (QIP). Seattle, USA, 2017.
- – arXiv:1606.05626, 2016.

J. Yirka.
Evaluation of TCP header fields for data overhead efficiency.
- • Poster at National Conference on Undergraduate Research (NCUR), Asheville, NC, USA, 2016.
- • Poster at VCU Symposium for Undergraduate Research and Creativity, Richmond, VA, USA, 2015. — **Awarded "Launch Award for Outstanding Research Poster"**

Research Experience

Positions

R&D Intern — June 2023–present
Sandia National Laboratories
Supervisors: Ojas Parekh and John Kallaugher
Topic: Hardness of estimating optimum product states of local Hamiltonians. Quantum constrained optimization problems.

Summer school / Research Assistant — Summer 2019
Los Alamos National Laboratories Quantum Computing Summer School
Supervisor: Yiğit Subaşı
Topic: Near-term (NISQ) quantum algorithms. Studied use of qubit resets to construct circuits for entanglement spectroscopy which were noise-resilient *and* low-width.

Research Assistant — Summer 2018
Graph Theory Computational Discovery Lab, Virginia Commonwealth University
Supervisor: Craig Larson
Topic: Automated conjecturing and graph theory. Studied conditions for graph Hamiltonicity. Assisted with programming and open-source project management.

Undergraduate Researcher (NSF REU C.A.A.R.) — Summer 2017
Joint Center for Quantum Inform. and Computer Science (QuICS), University of Maryland
Supervisor: Andrew Childs
Topic: Quantum tomography. Investigated minimum number of Pauli observables necessary to identify a quantum pure state.

Undergraduate Research Assistant — 2015–2016
Quantum Computing Lab, Virginia Commonwealth University
Supervisor: Sevag Gharibian
Topic: Complexity theory. Studied quantum oracle classes (e.g. $\mathrm{P}^{\mathrm{QMA}[\log]}$) and complexity of simulating local measurements. Helped develop a "quantum PH" and "quantum Toda's Theorem" ($\mathrm{QCPH} \subseteq \mathrm{P}^{\mathrm{PP}^{\mathrm{PP}}}$).

Workshops and Visits

All-hands meeting — June 2024
Quantum Systems Accelerator (a Dept. of Energy Quantum Research Center)
Attended on behalf of my advisor at UT Austin

Workshop on Quantum Complexity: Quantum PCP, Area Laws, and Quantum Gravity — Mar. 2024
Simons Institute for the Theory of Computing

Invitation-only workshop — June 2021
Schloss Dagstuhl — Quantum Complexity: Theory and Application

Visiting Researcher — November 2018
University of Paderborn, Germany
Collaboration with Sevag Gharibian
Topic: Complexity theory and algorithms. Studied QMA_1-hardness of the quantum satisfaction problem (k-QSAT) given qudits of lower dimensions.

Research Seminars

Research Preparation Exam on "Complexity Classification of Product State Problems for Local Hamiltonians".
UT Computer Science department. 2024.

Intro to Quantum Hamiltonians with old, new classical, and open questions.
UT theory student seminar. 2023.

Pure state tomography with Pauli observables.
QuICS, University of Maryland. 2017.

Quantum complexity of estimating local physical quantities.
Department of Computer Science, VCU. 2016. (Only undergraduate invited in previous 5 years.)

Teaching Experience

The University of Texas at Austin (UT)

Head Teaching Assistant — Spring 2022, 2023, 2024
Quantum Information Science (Web-based for online M.S. program)
All lecture content was pre-recorded by S. Aaronson. I was responsible for all other content and logistics, handling office hours, student concerns, academic integrity, and final grades nearly autonomously, with S. Aaronson as instructor of record. Supervised 4 other teaching assistants.
For the first run of the course, I was fully responsible for modifying the homework, exams, and grading for the online format and for ensuring a successful addition to the growing MSCS program at UT.
Spring 2022: 200 students, over 1500 discussion board posts. Course evaluation 4.1 / 5.
Spring 2024: Course evaluation 4.91 / 5.

Teaching Assistant — Fall 2021
Introduction to Quantum Information Science (Honors course)
With Scott Aaronson. Taught recitation and graded assignments.

Instructor — Summer 2021
UT International Academy: Software Engineering
Virtual. Introductory course for international undergraduate students. I independently designed the entire course. Course evaluation 4.88 / 5.

Virginia Commonwealth University (VCU)

Teaching Assistant — (2 semesters) 2016–2017
Algebra with Applications (MATH 141)
Assisted with daily in-class exercises, offered tutorials, graded assignments.
Average student evaluation scores — Fall 2016: 4.78 / 5.0; Spring 2017: 4.36 / 5.0.

Mentor for first-year student — Fall 2016
Honors College freshman mentorship program

Teaching Assistant — Fall 2015
Honors Rhetoric (HONR 200) — first-year honors writing and research course

Other

Instructor — 2016–2018
CPR and first-aid courses for lifeguards
Department of Parks and Recreation, Prince William County, VA

Scholarships and Funding

(all dollar amounts in USD)

Co-PI: quantum computing seminar series at UT with invited speakers — Expected fall 2024
approx. $10,000, CIQC (an NSF Quantum Challenge Institute)

Grants for seminar series by VCU RamDev software development club — 2016–2018
$1,900, VCU Student Government Association

Mark A. Sternheimer Capstone Design Award — 2017
$660, VCU School of Engineering
Grant for developing and testing senior project mobile app.

VCU Presidential Scholarship — 2014–2018
$110,000, Virginia Commonwealth University
Awarded to 0.6% of admitted students.

Travel grants

Travel grant to CCC 2024 in Ann Arbor, MI, USA 2024
$600, CCC travel allowance / NSF

Travel grant to a Simons Institute workshop in Berkeley, CA, USA 2024
$1,425, CIQC (an NSF Quantum Challenge Institute)

Travel grant to QIP 2024 in Taipei, Taiwan 2024
$500, UT Graduate School

Travel grant to QIP 2024 in Taipei, Taiwan 2024
$1,600, QIP student stipend

Travel grant to QIP 2020 in Shenzhen, China 2020
$1,100, QIP student support / NSF

Travel grant to QIP 2019 in Boulder, CO, USA 2019
$400, QIP student support / NSF

Travel grant to QIP 2017 in Seattle, USA 2017
$500, VCU Honors College

Awards

Honorable Mention (Awarded twice) 2019, 2020
NSF Graduate Research Fellowship Program (NSF GRFP)
Awarded to top 30% of over 12,000 applicants.

Pure Mathematics Award May 2018
VCU College of Humanities and Sciences
Student in pure math concentration with highest graduating GPA.

Launch Award for Outstanding Research Poster 2015
VCU Symposium for Undergraduate Research and Creativity
For poster *Evaluation of TCP header fields for data overhead efficiency*.

Volunteer of the Year 2014
Grade-school robotics program, Prince William County Schools, VA

Service

Journal reviewer:: *Quantum* (2022, 2020)

PC Member: YQIS 2021

Conference subreviewer: QIP (2024, 2022), TQC (2023, 2022), ITCS 2023, RANDOM 2023, CCC 2022

Chair Spring 2020–Fall 2021
UT Graduate Representative Association of Computer Science (GRACS)
- GRACS representative to UTCS Diversity, Equity, and Inclusion (DEI) Council.
- Co-Organized Graduate Application Assistance Program mentoring under-represented applicants to Ph.D. program. Managed the volunteer mentors. Fall 2020.

Ph.D. application reviewer Fall 2020
UT CS Graduate Admissions Committee

Panelist — Grad school discussion for underrepresented undergraduates August 2020
UT CS student organizations

GradFest (admitted Ph.D. visit day) committee member — Spring 2020
UT Department of Computer Science

Tutor for remedial math students at local high school — Spring 2019
Manchester High School, Midlothian, VA
Up to 4.5 hours per week with several groups of students.

Meeting with U.S. Army Operations Group — November 2018
I was asked to share my observations from AQIS 2018.

Student Advisory Board member — (2 academic years) 2016–2018
VCU Department of Computer Science
- Participated in hiring interviews for new faculty in 2017.

Founder and President — (2.5 academic years) 2016–2018
RamDev: Software Development at VCU
- Coordinated 46 weekly seminars including 9 corporate speakers and several hackathon trips.
- Secured and managed $2400 in funding and resources.
- Increased weekly attendance to 20 students, becoming largest C.S. organization at VCU.

Talk — Computer Science theory *is* fun — April 2018
VCU RamDev software development club

Senior Reader for Honors program graduation dossiers — (2 academic years) 2016–2017
VCU Honors College
Coordinated other readers.

Panelist — Career workshop for freshman mentorship program — 2017
VCU Department of Computer Science

Panelist — Undergraduate conference preparation workshops — 2017
VCU Honors College

Talk — Quantum programming (e.g. IBM Q, LIQ$Ui|\rangle$) — 2017
VCU RamDev software development club

Judge — Launch Award for Outstanding Research Poster — 2016
VCU Symposium for Undergraduate Research and Creativity

Organizer — Local Hack Day of Richmond, VA — 2016
Major League Hacking (MLH) and VCU Department of Computer Science
Co-organized event for 30 students including 12 high school students.

Volunteer for grade school robotics competitions (FIRST, Vex robotics) — 2011–2015
Prince William County Schools, VA
- Awarded "Volunteer of the Year", 2014.

Mentor to middle school robotics team (FIRST robotics) — Fall 2014
Wilder Middle School, Richmond, VA