Justin Yirka

Ph.D. Candidate in Computer Science, Graduating in 2025

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arXiv.org/a/yirka_j_1.html
linkedin.com/in/justinyirka
scholar.google.com/citations?user=UxIpR_UAAAAJ
youtube.com/@JustinYirka/playlists

Research Interests

Quantum computing and Theoretical computer science
Computational complexity theory, Hamiltonian complexity, Quantum algorithms

Education

Ph.D. in Computer Science | The University of Texas at Austin (UT) Expected May 2025
Advised by Scott Aaronson

M.S. in Computer Science | The University of Texas at Austin 2022

B.S. in Computer Science | Virginia Commonwealth University (VCU) 2018
B.S. in Mathematical Sciences Concurrent degrees
Specialization in Data Science & Concentration in Pure Math
Minor in Physics
University Honors

Research Positions

R&D Intern | Sandia National Laboratories June 2023–present
Advised by Ojas Parekh and John Kallaugher
Topic: Hardness of estimating optimal product states of local Hamiltonians. Quantum Max-Cut, Vector Max-Cut, and Quantum constrained optimization problems. Alternative query models.

Summer School Fellow | Los Alamos National Laboratories Summer 2019
Advised by Yiğit Subaşı
Topic: Near-term (NISQ) quantum algorithms. Studied use of mid-circuit measurements and resets to construct circuits for entanglement spectroscopy which were noise-resilient *and* low-width.
Implemented noisy simulations with Qiskit, Python, Unix, Jupyter. Managed project with git. Tested algorithms on Honeywell quantum hardware.

Research Assistant | Graph Theory Computational Discovery Lab, VCU Summer 2018
Supervised by Craig Larson
Topic: Automated conjecturing software applied to graph theory.
Maintained database of graphs, their properties, and known theorems. Managed open-source project and programmed using git, GitHub, and Sage/Python.

NSF REU Researcher | QuICS, University of Maryland Summer 2017
Advised by Andrew Childs, Jianxin Chen, and Amir Kalev
Topic: Quantum tomography. Investigated minimum number of Pauli observables necessary to identify a quantum pure state.

Research Assistant | Quantum Computing Lab, VCU 2015–2016

Advised by Sevag Gharibian
Topic: Complexity theory. Studied quantum oracle classes (e.g. $\mathrm{P}^{\mathrm{QMA}[\log]}$) and Hamiltonian complexity. Helped develop a "quantum PH" and "quantum Toda's Theorem" ($\mathrm{QCPH} \subseteq \mathrm{P}^{\mathrm{PP}^{\mathrm{PP}}}$).

Research Papers and Talks

Authors are listed alphabetically, as is standard in TCS, unless marked *.
∘ denote talks and ▷ denote posters. Filled labels •,▸ indicate I gave the presentation.
– denote manuscripts without accompanying talks.
Visit my website for links to recordings, slide pdfs, etc.

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

S. Grewal and J. Yirka. The Entangled Quantum Polynomial Hierarchy Collapses.
∘ Proceedings of *39th Computational Complexity Conference* (*CCC*), Ann Arbor, MI, USA, July 2024. doi:10.4230/LIPIcs.CCC.2024.6.
▸ 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 Innovations in Theoretical Computer Science conference (ITCS), New York, NY, January 2025.
• Contributed talk at Conference on Quantum Information Processing (QIP), Taipei, Taiwan, January 2024.
– arXiv:2401.06725, January 2024.

J. Yirka and Y. Subasi.* 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.
∘ 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.
▹ Poster at Conference on the Theory of Quantum Computation, Communication, and Cryptography (TQC), College Park, MD, USA, 2019.
▸ 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.
- ▹ Poster at Conference on Quantum Information Processing (QIP), Boulder, CO, USA, 2019.
- ○ Contributed talk at Asian Quantum Information Science Conference (AQIS), Nagoya, Japan, 2018. — **"Long"/plenary talk: top 7% of submissions**.
- ○ 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.
- ○ 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"**

Other Research Experience

Workshops and Visits

All-hands meeting | Quantum Systems Accelerator, a DOE QIS Research Center June 2024

Workshop | Simons Institute for the Theory of Computing March 2024
Quantum Complexity: Quantum PCP, Area Laws, and Quantum Gravity

Invited Workshop | Schloss Dagstuhl June 2021
Quantum Complexity: Theory and Application

Visiting Researcher | University of Paderborn, Germany November 2018
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.

Seminars

- PhD Proposal. UT Department of Computer Science, 2024.
- Complexity Classification of Product State Problems for Local Hamiltonians. UT Department of Computer Science, 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. VCU Department of Computer Science, 2016. (Only undergraduate invited in previous 5 years.)

Teaching Positions

Head Teaching Assistant | UT Spring 2022, 2023, 2024
Quantum Information Science (Web-based for M.S. program) (CS 388Q)

Adapted and led entire course except for pre-recorded lectures.
I was responsible for all other content and logistics, handling office hours, student concerns, academic integrity, and final grades nearly autonomously. Supervised 4 other teaching assistants.
Spring 2022: 200 students, 1500 discussion board posts. Course evaluation 4.1 / 5.
Spring 2024: Course evaluation 4.91 / 5.

Teaching Assistant | UT — Fall 2021
Introduction to Quantum Information Science (Honors course) (CS 358H)
With Scott Aaronson. Taught recitation and graded assignments.

Instructor | UT International Academy — Summer 2021
Introduction to Software Engineering (Java)
Virtual. Developed entire course including lectures and assignments. Course evaluation 4.88 / 5.

Teaching Assistant | VCU — (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.

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

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

Scholarships and Funding

(all dollar amounts in USD)

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 app: Android, iOS, RasberryPi, AWS, Bluetooth LE.

VCU Presidential Scholarship — 2014–2018
$110,000, Virginia Commonwealth University
Awarded to 0.6% of admitted students.
Full cost of 4-year tuition, room, and board.

WPI Presidential Scholarship [declined] — 2014
$80,000, Worcester Polytechnic Institute

Rensselaer Medal Merit Scholarship [declined] — 2014
$100,000, Rensselaer Polytechnic Institute

Travel grants

- $600 for CCC 2024 in Ann Arbor, MI, USA. CCC travel allowance / NSF.
- $1,425 for Simons Institute workshop in Berkeley, CA, USA. CIQC (an NSF Quantum Challenge Institute), 2024.
- $500 for QIP 2024 in Taipei, Taiwan. UT Graduate School.
- $1,600 for QIP 2024 in Taipei, Taiwan. QIP student stipend.
- $1,100 for QIP 2020 in Shenzhen, China. QIP student support / NSF.
- $400 for QIP 2019 in Boulder, CO, USA. QIP student support / NSF.
- $500 for QIP 2017 in Seattle, USA. VCU Honors College.

Awards

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

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

University Student Scholar Award | Virginia Commonwealth University 2015

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

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

Service

Journal reviewer: *Quantum* (2024, 2022, 2020)

PC Member: YQIS 2021

Conference subreviewer: STOC 2025, QIP (2025, 2024, 2022), TQC (2023, 2022), ITCS 2023, RANDOM 2023, CCC 2022

Extended commitments (> 1 month)

Chair | UT Graduate Representative Association of Computer Science Spring 2020–Fall 2021
- 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.

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

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.

Mentor | VCU Honors College freshman mentorship program Fall 2016

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

Mentor for middle School robotics team (FIRST robotics) Fall 2014
| Wilder Middle School, Richmond, VA

Short-term commitments (< 1 month)

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

Committee Member | UT CS GradFest (admitted Ph.D. visit day) Spring 2020, Spring 2021

Lead Dossier Reader | VCU Honors College graduation dossiers Spring 2016, Spring 2017

Assessed dossiers and coordinated other readers.

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

Talks and Panels

- **Panelist** at Grad school discussion for underrepresented undergraduates. UT CS student organizations, 2020.
- Meeting with U.S. Army Operations Group. I was asked to share my observations from AQIS 2018. November 2018.
- **Talk**: Computer Science theory *is* fun. VCU RamDev software development club, 2018.
- **Panelist** at Career workshop for freshman mentorship program. VCU Department of Computer Science, 2017.
- **Panelist** at Undergraduate conference preparation workshops. VCU Honors College, 2017.
- **Talk**: Quantum programming (e.g. IBM Q, LIQ$Ui|\rangle$). VCU RamDev software development club, 2017.