Justin Yirka

Ph.D. Student 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

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. $P^{QMA[\log]}$) and Hamiltonian complexity.
Helped develop a "quantum PH" and "quantum Toda's Theorem" ($QCPH \subseteq P^{PP^{PP}}$).

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

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.
(authors not ordered alphabetically)
- *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.

- 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"**

Other Research Experience

Workshops and Visits..

All-hands meeting | Quantum Systems Accelerator, a DOE QIS Research Center   June 2024
  Attended on behalf of my advisor at UT Austin

Workshop | Simons Institute for the Theory of Computing   Mar. 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..

- • 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 online M.S. program)

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)
    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 mobile app.

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

o $600 for CCC 2024 in Ann Arbor, MI, USA. CCC travel allowance / NSF.

o $1,425 for Simons Institute workshop in Berkeley, CA, USA. CIQC (an NSF Quantum Challenge Institute).

o $500 for QIP 2024 in Taipei, Taiwan. UT Graduate School.

o $1,600 for QIP 2024 in Taipei, Taiwan. QIP student stipend.

o $1,100 for QIP 2020 in Shenzhen, China. QIP student support / NSF.

o $400 for QIP 2019 in Boulder, CO, USA. QIP student support / NSF.

o $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.