


# Justin Yirka


Ph.D. in Computer Science

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JustinYirka.com

arXiv.org/a/yirka\_j\_1.html

 linkedin.com/in/justinyirka

 scholar.google.com/citations?user=UxIpR\_UAAAAJ

 youtube.com/@JustinYirka/playlists

## Research Interests

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Quantum computing and Theoretical computer science

Computational complexity theory, Hamiltonian complexity, Quantum algorithms

## Education

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

Dissertation: *Quantum Complexity of Physically Inspired Problems and Computational Resources*

**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

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**R&D Intern** | Sandia National Laboratories June 2023–May 2025  
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.

**Undergraduate Researcher** | QuICS, University of Maryland Summer 2017

Advised by Andrew Childs, Jianxin Chen, and Amir Kalev

Part of NSF REU CAAR

Topic: Quantum tomography. Investigated minimum number of Pauli observables necessary to identify a quantum pure state.

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 and Talks

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Authors are listed alphabetically, as is standard in TCS, unless marked \*.

Some conference talks are accompanied by published proceedings. Filled labels • indicate I gave the talk.

Links to recordings, slides, etc. are available at justinyirka.com.

B. Holman, R. Ramachandran, and J. Yirka. Quantum search with in-place queries.

- To appear in *Proceedings of Conference on the Theory of Quantum Computation, Communication, and Cryptography (TQC)*, Bengaluru, India, September 2025.
- arXiv:2504.03620, April 2025.

J. Yirka. A note on the complexity of the spectral gap problem.

- Preprint. arXiv:2503.02747, March 2025.

J. Yirka. Even quantum advice is unlikely to solve PP.

- Preprint. arXiv:2403.09994 and ECCC:TR24-052, 2024.

S. Grewal and J. Yirka. The Entangled Quantum Polynomial Hierarchy collapses.

- In *Proceedings of 39th Computational Complexity Conference (CCC)*, Ann Arbor, USA, 2024. doi:10.4230/LIPIcs.CCC.2024.6.
- arXiv:2401.01453 and ECCC:TR24-006, 2024.

J. Kallaughar, O. Parekh, K. Thompson, Y. Wang, and J. Yirka. Complexity classification of product state problems for local Hamiltonians.

- In *Proceedings of 16th Innovations in Theoretical Computer Science conference (ITCS)*, New York, USA, 2025. doi:10.4230/LIPIcs.ITCS.2025.63.
- Contributed talk at *Conference on Quantum Information Processing (QIP)*, Taiwan, 2024.
- arXiv:2401.06725, 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.
- 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.  
 ○ 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.  
 – arXiv:1606.05626, 2016.

## Other Research Experience

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### Non-quantum computing work.....

- N. Bushaw, V. Gupta, C. Larson, S. Loeb, M. Norge, J. Parrish, N. Van Cleemput, J. Yirka, and G. Wu. New conditions for graph Hamiltonicity  
 – *Involve, a Journal of Mathematics*, 18(1):79–89, 2025. 10.2140/involve.2025.18.79.

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”**

### Workshops and Visits.....

- All-hands meeting | Quantum Systems Accelerator, a DOE Research Center June 2021  
 Albuquerque, USA
- Workshop | Simons Institute for the Theory of Computing. Berkeley, USA. March 2024  
 Quantum Complexity: Quantum PCP, Area Laws, and Quantum Gravity
- Invited Workshop | Schloss Dagstuhl. Virtual. June 2021  
 Quantum Complexity: Theory and Application
- Visiting Researcher | University of Paderborn. Germany. November 2018  
 Collaboration with Sevag Gharibian  
 Topic: QMA<sub>1</sub>-hardness of the quantum satisfaction problem ( $k$ -QSAT) on qudits of lower dimensions.

### Posters.....

Filled labels ▶ indicate I presented the poster.

- ▶ J. Kallaughner, O. Parekh, K. Thompson, Y. Wang, and J. Yirka. Complexity classification of product state problems for local Hamiltonians. DOE Quantum Systems Accelerator All-Hands meeting. Albuquerque, USA, 2024.
- ▶ J. Kallaughner, O. Parekh, K. Thompson, Y. Wang, and J. Yirka. Complexity classification of product state problems for local Hamiltonians. Sandia Quantum Information Development Networking Day. Sandia National Laboratories, Albuquerque, USA, 2024.

- ▶ S. Grewal and J. Yirka. The Entangled Quantum Polynomial Hierarchy collapses. Conference on Quantum Information Processing (QIP), Taipei, Taiwan, 2024.
- ▷ S. Gharibian, S. Piddock, and J. Yirka. Oracle complexity classes and local measurements on physical Hamiltonians. Conference on the Theory of Quantum Computation, Communication, and Cryptography (TQC), College Park, MD, USA, 2019.
- ▶ S. Gharibian, S. Piddock, and J. Yirka. Oracle complexity classes and local measurements on physical Hamiltonians. Workshop on Quantum Computing Theory in Practice (QCTIP), Bristol, UK, 2019.
- ▶ S. Gharibian, S. Piddock, and J. Yirka. Oracle complexity classes and local measurements on physical Hamiltonians. Conference on Quantum Information Processing (QIP), Boulder, CO, USA, 2019.
- ▷ S. Gharibian, M. Santha, J. Sikora, A. Sundaram, and J. Yirka. Quantum generalizations of the polynomial hierarchy with applications to QMA(2). Conference on Quantum Information Processing (QIP), Boulder, CO, USA, 2019.
- ▶ S. Gharibian and J. Yirka. The complexity of simulating local measurements on quantum systems. Conference on Quantum Information Processing (QIP). Seattle, USA, 2017.

## Seminars.....

- PhD Defense. UT Department of Computer Science, 2025.
- PhD Proposal. UT Department of Computer Science, 2024.
- PhD Qualifying Exam talk (RPE). 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

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**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** (2.5 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.

<b>Instructor</b>   Department of Parks and Recreation, Prince William County, VA CPR and first-aid courses for lifeguards	2016–2018
<b>Teaching Assistant</b>   VCU Honors Rhetoric (HONR 200) — first-year honors writing and research course	Fall 2015

## Scholarships and Funding (all dollar amounts in USD)

Quantum seminar and visitor series at UT \$10,000, NSF CIQC Invited speakers: Chinmay Nirkhe (Prof. at Univ. of Washington), Dorian Rudolph (University of Paderborn, Germany), Jackson Morris (UCSD)	Sep 2024–May 2025
Grants for seminar series by VCU RamDev software development club \$1,900, VCU Student Government Association	Sep 2016–May 2018
Mark A. Sternheimer Capstone Design Award \$660, VCU School of Engineering Grant for developing and testing senior project app: Android, iOS, RaspberryPi, AWS, Bluetooth LE.	Nov 2017
VCU Presidential Scholarship \$110,000, Virginia Commonwealth University Awarded to 0.6% of admitted students. Full cost of 4-year tuition, room, and board.	2014–2018
WPI Presidential Scholarship [declined] \$80,000, Worcester Polytechnic Institute	2014
Rensselaer Medal Merit Scholarship [declined] \$100,000, Rensselaer Polytechnic Institute	2014

### Travel grants.....

- \$600 for CCC 2024 in Ann Arbor, USA. CCC travel allowance / NSF.
- \$1,425 for Simons Institute workshop in Berkeley, CA, USA. NSF CIQC, 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

<b>Honorable Mention</b>   NSF Graduate Research Fellowship Program (NSF GRFP) Awarded twice. Granted to top 30% of over 12,000 applicants.	2019, 2020
<b>Pure Mathematics Award</b>   VCU College of Humanities and Sciences Student in pure math concentration with highest graduating GPA.	May 2018
<b>University Student Scholar Award</b>   Virginia Commonwealth University	Aug 2015
<b>Launch Award for Outstanding Research Poster</b>   VCU Symposium for Undergraduate Research For poster <i>Evaluation of TCP header fields for data overhead efficiency</i> .	March 2015
<b>Volunteer of the Year</b>   Grade-school robotics program, Prince William County Schools, VA	2014

## Service

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**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      March 2020–Dec 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**      Sep 2016–May 2018

| VCU Department of Computer Science

- Participated in hiring interviews for new faculty in 2017.

**Founder and President**      Apr 2016–May 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      March 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, LIQU $i$ )). VCU RamDev software development club, 2017.