Justin Yirka

Ph.D. Student in Computer Science
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Research Interests

Quantum computing & Theoretical computer science:

Complexity theory, algorithms, and connections to applications

Education

University of Texas at Austin (UT)
Ph.D. in Computer Science — 2019 – present
Advisor: Scott Aaronson, Ph.D.
M.S. in Computer Science — 2022

Virginia Commonwealth University (VCU)
B.S. in Computer Science — 2018
B.S. in Mathematical Sciences — Concurrent/Dual degrees
Minor in Physics

Research

Experience

R&D Intern — Summer 2023–present
Sandia National Laboratories
Supervisors: Ojas Parekh, Ph.D. and John Kallaugher, Ph.D.
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, Ph.D.
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, VCU
Supervisor: Craig Larson, Ph.D.
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, Ph.D.
Topic: Quantum tomography. Investigated minimum number of Pauli observables necessary to identify a quantum pure state.

Undergraduate Research Assistant 2015–2016
Quantum Computing Lab, VCU
Supervisor: Sevag Gharibian, Ph.D.
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" ($\mathrm{QCPH} \subseteq \mathrm{P}^{\mathrm{PP}^{\mathrm{PP}}}$).

Invited positions & Workshops

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

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

Preprints

S. Grewal and J. Yirka. The Entangled Quantum Polynomial Hierarchy Collapses. Available at https://arxiv.org/abs/2401.01453. January 2024.

S. Gharibian, S. Piddock, and J. Yirka. Oracle complexity classes and local measurements on physical Hamiltonians. Available at https://arxiv.org/abs/1909.05981. 2019.

Journal Publications

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.

J. Yirka and Y. Subasi. Qubit-efficient entanglement spectroscopy using qubit resets. *Quantum*, 5:535, 2021. DOI: 10.22331/q-2021-09-02-535.

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.

Conference Presentations ..... (grouped by paper)

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

- **Poster by J. Yirka** at 27th Conference on Quantum Information Processing (QIP). Taipei, Taiwan. January, 2024.

J. Yirka and Y. Subasi. Qubit-efficient entanglement spectroscopy using qubit resets.

- **Contributed talk by J. Yirka** at 6th Conference for Young Quantum Information Scientists (YQIS). Virtual, 2021.
- Contributed talk by Y. Subasi at APS March Meeting 2021. Virtual.
- **Contributed talk by J. Yirka** at 20th Asian Quantum Information Science Conference (AQIS).

Virtual, 2020.

S. Gharibian, S. Piddock, and J. Yirka. Oracle complexity classes and local measurements on physical Hamiltonians.

- Contributed talk by S. Piddock at 37th Symposium on Theoretical Aspects of Computer Science (STACS). Montpellier, France, 2020.
- **Contributed talk by J. Yirka** at 23rd Conference on Quantum Information Processing (QIP). Shenzhen, China, 2020.
- Poster by S. Piddock at 14th Conference on the Theory of Quantum Computation, Communication, and Cryptography (TQC). College Park, MD, USA, 2019.
- Poster by S. Piddock at Workshop on Quantum Computing Theory in Practice (QCTIP). Bristol, UK, 2019.
- **Poster by J. Yirka** at 22nd Conference on Quantum Information Processing (QIP). Boulder, CO, USA, 2019.
- **Contributed talk by J. Yirka** at 18th Asian Quantum Information Science Conference (AQIS). Nagoya, Japan, 2018.

S. Gharibian, M. Santha, J. Sikora, A. Sundaram, and J. Yirka. Quantum generalizations of the polynomial hierarchy with applications to QMA(2).

- Poster by A. Sundaram at 22nd Conference on Quantum Information Processing (QIP). Boulder, CO, USA, 2019.
- Contributed talk by A. Sundaram at 18th Asian Quantum Information Science Conference (AQIS). Nagoya, Japan, 2018. — **"Long"/plenary talk: top 7% of submissions**.
- Contributed talk by A. Sundaram at 43rd International Symposium on Mathematical Foundations of Computer Science (MFCS). Liverpool, UK, 2018.

S. Gharibian and J. Yirka. The complexity of simulating local measurements on quantum systems.

- Contributed talk by S. Gharibian at 12th Conference on the Theory of Quantum Computation, Communication, and Cryptography (TQC). Paris, France, 2017.
- **Poster by J. Yirka** at 20th Conference on Quantum Information Processing (QIP). Seattle, USA, 2017. Presented under a different title.

J. Yirka. Evaluation of TCP header fields for data overhead efficiency.

- **Poster by J. Yirka** at 30th National Conference on Undergraduate Research (NCUR). Asheville, NC, USA, 2016.
- **Poster by J. Yirka** at VCU Symposium for Undergraduate Research and Creativity. Richmond, VA, USA, 2015. — **Awarded "Launch Award for Outstanding Research Poster"**.

Departmental Seminars

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

Quantum complexity of estimating local physical quantities. Department of Computer Science, VCU. 2016.

Scholarships and Funding (all dollar amounts in USD)

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

Travel grant to attend QIP 2020 in Shenzhen, China 2020
$1100, QIP student support / NSF

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

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.

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

Travel grant to present at NCUR 2016 in Asheville, NC, USA 2016
$550, VCU Honors College

Awards and Honors

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

Teaching Experience

UT

Head Teaching Assistant — Spring 2022, 2023
Quantum Information Science (Web-based for M.S. program)
QIS course for students in online M.S. program.
All lecture content was pre-recorded by S. Aaronson. I was responsible for all other content and logistics, including modifying the homework, exams, and grading for the online format. I handled student concerns, academic integrity, and final grades nearly autonomously, with S. Aaronson as instructor of record.
Supervised 4 other teaching assistants.

I was tasked with ensuring a successful first iteration of the course for the growing MSCS program at UT.
Spring 2022 course: 200 students, course evaluation 4.1 / 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 software engineering course for international undergraduate students.

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

Service

Refereeing

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

PC Member: YQIS 2021 — 6th Conference for Young Quantum Information Scientists

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

Professional Service

Representative and Chair — Spring 2020–Fall 2021
UT Graduate Representative Association of Computer Science (GRACS)
- GRACS representative to UTCS Diversity, Equity, and Inclusion (DEI) Council, 2020–2021.

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

Lead Mentor — Fall 2020
Graduate Application Assistance Program (GAAP) for UTCS by GRACS
Student-led program for mentoring under-represented applicants to Ph.D. program. As part of GRACS, I helped organize the first year of this program, managed volunteer mentors, and mentored prospective students.

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

GradFest committee member — Spring 2020
UT Department of Computer Science
Helped plan visit weekend for admitted Ph.D. students.

Met 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
Met with department faculty. Participated in hiring interviews for new faculty in 2017.

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

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

Extracurricular Service

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.

Outreach and Community Service

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.

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

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

Organizer — Local Hack Day of Richmond, VA — 2016
Major League Hacking (MLH) and VCU Department of Computer Science
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