

2021 Annual Report

Unitary Fund

Because evolution is unitary.

MISSION

Unitary Fund is a 501(c)(3) non-profit whose mission is to create a quantum technology ecosystem that benefits the most people. We believe that expanding the pool of people working on quantum technologies is a way to ensure that the benefits of these tools are widely, swiftly, and equitably distributed.

VISION

We hope to create a more inclusive quantum, open source community by supporting new and innovative projects, while also researching and developing tools to further accelerate a quantum technology ecosystem for all.

Table of Contents

- 3** MESSAGE FROM THE PRESIDENT
- 4** 2021 AT A GLANCE
- 5** COMMUNITY STORIES
- 6** MICROGRANT PROGRAM
- 8** UNITARY HACK 2021
- 9** COMMUNITY UPDATES
- 11** UNITARY FUND | THE WITTEK QUANTUM PRIZE
- 12** RESEARCH 2021
- 14** MITIQ
- 15** UNITARY FUND | QUTIP
- 16** FUNDING
- 18** WE ARE UNITARY FUND
- 21** WHAT'S NEXT FOR UNITARY FUND

MESSAGE FROM THE PRESIDENT

2021 was a year of rapid growth across quantum technology. Steady technical progress was matched with a completely new level of resources and funding for the space. The \$2.5Bn+ invested in quantum computing companies just last year is more than the total across the previous decade combined. The vision for a robust quantum technology industry increasingly resonates with scientists, engineers, investors, and customers.

Still, there are challenges to overcome. New capital in our space must be deployed to fill gaps in the quantum ecosystem. We need to develop error correction, scalable hardware technologies, useful algorithms with provable advantages, ways to benchmark and project the performance of heuristic algorithms, and more. Some of these challenges are well addressed by academic and industry players. However, others are public goods that help everyone but that don't stand alone as businesses. These are the open development tools, standards, benchmarks, interfaces, educational and training materials, skill-sharing networks, open source communities, mentorship networks and more that form the soil from which a rich industry and ecosystem can grow.

Unitary Fund helps build these crucial public goods.

These tools and communities lower the barrier to entry for new people and ideas. They form the ecosystem that companies will hire from and sell into. We believe that investment in public goods and open communities will get us both to a quantum tech future faster and to a future that benefits more people.

And we aren't the only ones. Our supporters, advisors, grants winners, open source contributors, hackathon participants have all come together to form the growing Unitary Fund community.

I'm thrilled by the diversity of the talent that I get to work with across the community. From experts with decades of experience at the largest global companies to high school students to developing countries. I am inspired by the creativity and drive that I see everyday. It is a joy to share a passion for quantum technologies with all of you.

As you will see in the following pages of our annual report, we are growing rapidly and are excited for what comes next.

Thanks to all of you who have joined us in this mission.



A handwritten signature in black ink, appearing to read "WILLIAM ZENG".

WILLIAM ZENG
President, Unitary Fund

2021 AT A GLANCE



As we end 2021, we look forward to growing of our organization, community, and our mission in supporting the quantum ecosystem to benefit more people. This year we were able to support 19 new projects from 10 different countries across the world and are looking forward to expanding our global reach even further with our Microgrant Program in 2022. Our new Member Program also grew to now have two Core Members and six Supporting Members to support this growth. To round off our programs, Unitary Fund also launched our Ambassador Program which highlights contributors that go above and beyond in their quantum open source projects.

2021 has been the year that Unitary Fund increased participation in industry events and hosted regular virtual events. One of the biggest is the first edition of **unitaryHACK**, a decentralized hackathon with bounties on 19 open source quantum projects. Additionally, we hosted workshops, weekly calls, and collaborative meet-ups online. Mitiq being one of our regular calls, continues to develop with new features in the global open source community, while also receiving recognition from industry publications.

As our work evolves, our mission to create an inclusive and accessible quantum technology ecosystem continues to develop different branches as our community grows around the world. We are committed to staying true to our core beliefs and ensuring that the benefits of our supported projects are widely, swiftly, and equitable distributed.

COMMUNITY STORIES



Misty Wahl

Software Engineering
Project Manager and
Quantum Computing
Enthusiast

"I wish to emphasize that as a Mitiq contributor, I have been able to connect directly with the development team and raise improvement suggestions. In response, the team added support for pyQuil parametric programs as mentioned earlier, as well as some improvements to facilitate contributing to Mitiq for Windows users. The Mitiq team also provided many helpful suggestions during the development of the example, and I am grateful for their support. It is my hope that this iterative and collaborative approach will encourage more contributors to join the quantum OSS community and help build the ecosystem." Read more about Misty's journey in quantum computing in [this blog post](#).

"I have learned very much about Error Mitigation throughout the course of this project while being able to contribute to Mitiq and the field as a whole. I want to thank the Unitary Fund team for their continued help and support. I'd especially like to thank Ryan LaRose for being my advisor throughout this project and consistently guiding me and providing advice." Read more about Danny's grant and work on Mitiq in [this blog post](#).



Danny Samuel

High School student and
Quantum Computing
Enthusiast

UNITARY HACK 2021 STORIES

Here's what our participants say about the event:

"I was able to learn some details of quantum computing and quantum science. I also learned about contributing to open-source projects and the best practices."

"Love the quantum community, hope to see more events like this in the future!"

"My main purpose was to get to know people and have fun. That was accomplished, so I am very very happy. Rest, relax, and enjoy that the word was spread to many on all sorts of levels and backgrounds."

"A supportive community that allows you to achieve great things!"

MICROGRANT PROGRAM

Our microgrant program funds explorers across the world to work on quantum technologies. We give \$4k cash grants to quantum tech projects. Projects could be open source quantum software, educational materials and workshops, a new quantum sensor prototype, or much more.

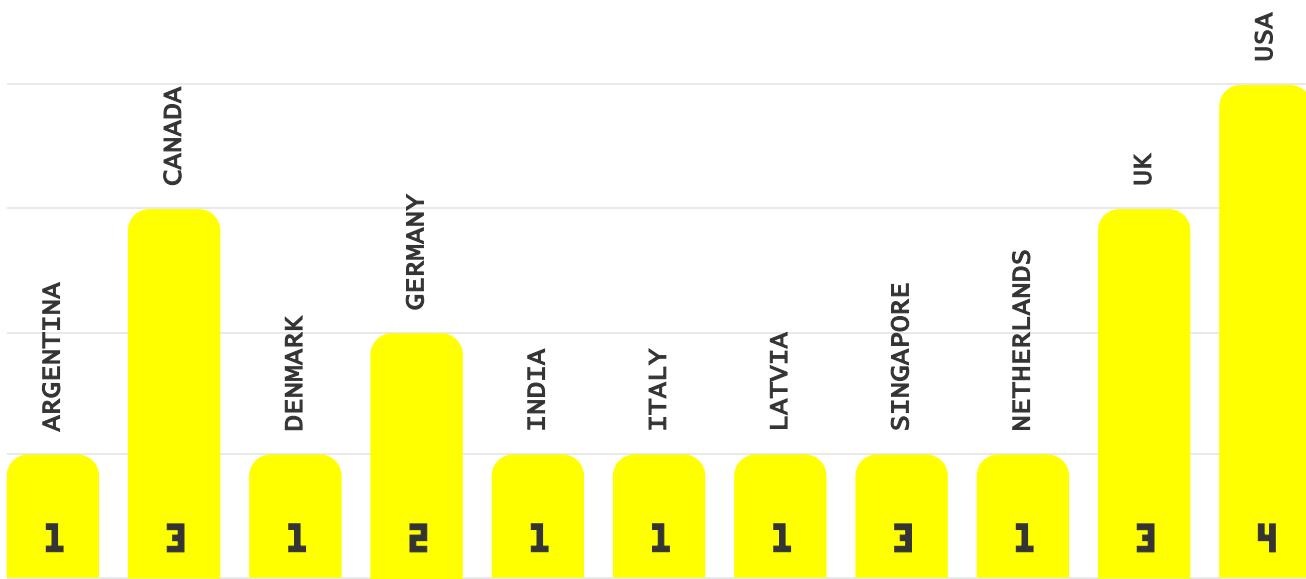
Our program is designed to be as simple as possible. No organizational affiliation required. Just a short form and a two minute video. The program supports bottoms up investment in the quantum technology community and ecosystem.

50+
TEAMS

20+
COUNTRIES

15+
PUBLICATIONS

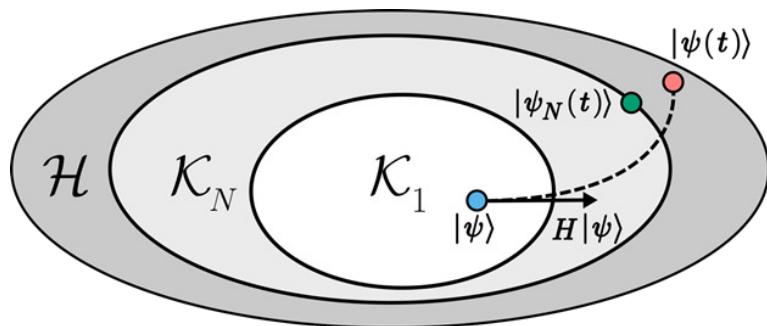
We are proud to have supported 19 new projects, spanning from software to education and new community development across 10 different countries.



SUPPORTED PROJECTS PER COUNTRY IN 2021

Some highlights include:

- **qLEET**, a tool for exploring and visualizing the training of variational circuits developed by Utkarsh Azad and Animesh Sinha.
- **Qdot**, the leading quantum library for Scala used to write quantum programs developed by Brian Shi.
- Research and example code for **improving VQE performance with error mitigation**, by a very talented highschooler Danny Samuel.
- **QWorld** for curriculum development for a graduate level course on quantum programming.
- Living open textbook on quantum algorithms called **quantumalgorithms.org**, built by Alessandro Luongo and Armando Bellante.
- **PyKrylovSolver Python package**: an efficient approximation method for simulating the time-evolution of quantum systems developed by Diego Ariel Wisniacki, Martin Larocca, and Emiliano Manuel Fortes.



Schematic of Krylov Approximation Method

- To Daniel Stilck França to develop a software package that will help benchmark the **limitations of optimization algorithms on noisy quantum devices**. ☕

For further information on our microgrant program, visit <https://unitary.fund/grants.html>



370

PARTICIPANTS

64

QUANTUM OSS
CONTRIBUTIONS

26

CASH BOUNTIES
AWARDED

1

COMMUNITY



CONCEPT

Unitary Hack is an open source contribution event where participants make pull requests (PRs) to community repositories and get swag + cash bounties for particular issues. Participants learn both quantum and OSS skills and maintainers get contributions that make their projects better.



RESULTS

Between May 14-30th, 2021, contributors helped library maintainers close issues in 13 participating quantum open-source projects: Mitiq, PennyLane, Strawberry Fields, The Walrus, toqito, SciRate, QuNetSim, Interlin-q, QRAND, Qrack, QuTiP, Pulser, QCOR, XACC, QOSF Monthly Challenges, Yao, Quantify, QQCS, Q#.



SPONSORS

Unitary Fund, Xanadu, Dorahacks, PASQAL.

"During unitaryHACK, we were super impressed by both the high quality of the participant's contributions, and also their enthusiasm – we've seen several become ongoing contributors long after the event! It's been a fantastic way to source applicants for our quantum software roles at Xanadu."

-Josh Izaac at Xanadu

COMMUNITY UPDATES

HIGHLIGHTS

- Starting in October, we partnered with the [Quantum Open Source Foundation](#) to host monthly Quantum Software Meetups. These events help participants meet the people and projects behind quantum software and learn how they can get involved. We also organized the second edition of the [Wittek Prize](#), recognizing outstanding contributions to the quantum open-source community from an individual.
- Our slate of quantum software project community calls on our Discord grew in 2021. Similar to Mitiq community calls, QuTiP and PennyLane now hold their community calls on the Unitary Fund Discord server, in the [#community-call](#) voice channel. You can find more information in the text channels [#qutip](#) (quarterly on Tuesday at 8am ET / 2pm CET), [#pennylane](#) (weekly on Wednesdays at 11am ET / 5pm CET) and [#mitiq](#) (weekly on Fridays at 12pm ET / 6pm CET). These video calls help bring the community closer to the on-going development of quantum software projects and make it easier for individuals to ask questions and get feedback from maintainers.



1.6K

TWITTER
FOLLOWERS



11.1K

YOUTUBE
IMPRESSIONS



1.4K

DISCORD
MEMBERS

- We further hosted the [Quantum Software Talks](#): Shahnawaz Ahmed on QuTiP, the quantum toolbox in Python [🔗](#). Stephen DiAdamo on QunetSim, a Framework for Quantum Networks [🔗](#). Loic Henriet on Pulser, Design and simulation of pulse sequences [🔗](#). Goutam Tamvada on VeriFRODO, Post-quantum cryptographic software [🔗](#). Erik Nielsen and Kenneth Rudinger on pyGSTi, a toolkit for quantum characterization [🔗](#). Pedro Riveiro on QRAND, a quantum random number generation framework [🔗](#).
- The Unitary Fund team helped organize workshops for the IEEE Quantum Week event on [Open Quantum Hardware](#) and [Quantum Intermediate Representations](#).
- We attended Q2B 2021, with a booth and talk by Dr. Sarah Kaiser.

LAUNCH OF THE AMBASSADOR PROGRAM

- We launched the [Unitary Fund Ambassadors Program](#).

The Unitary Fund Quantum Ambassadors Program recognizes individuals that are directly addressing the challenges of the growing quantum community. It brings people together to learn new skills, develop open source tools, and build the open quantum community all over the world. Our ambassadors are model citizens of the quantum open source ecosystem, contributing in more ways than code to help grow the community.



ANDRE ALVES



MISTY WAHL



AARON ROBERTSON

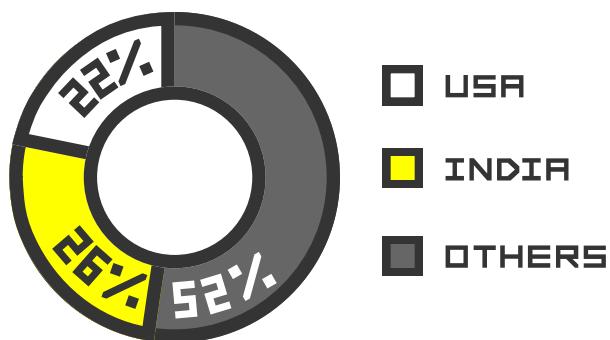


PURVA THAKRE

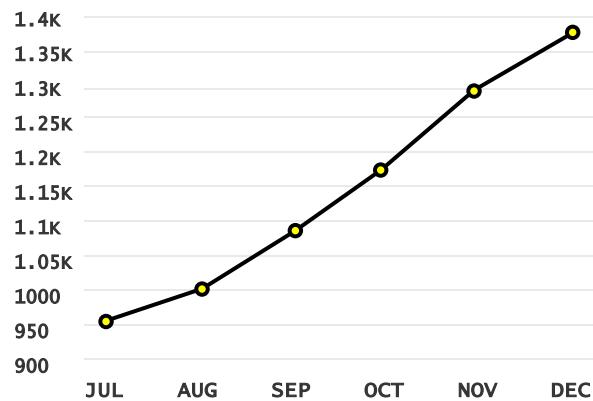


DISCORD STATISTICS

GLOBAL COMMUNITY MEMBERS



MEMBER GROWTH





THE WITTEK QUANTUM PRIZE

The Wittek Quantum Prize is awarded annually by the [Quantum Open Source Foundation](#) (QOSF) and Unitary Fund and its aim is to reward underrepresented individuals for their outstanding and impactful contribution to the field of quantum open-source software.

For the second time, Unitary Fund has collaborated with the Quantum Open Source Foundation (QOSF) to award Victory Omole the [2021 Wittek Quantum Prize](#) for his work on Google's Cirq library and other open-source projects.



“Since 2018, Victory has contributed more than 120 pull requests to Cirq in his free time. Next to his continuous efforts with Cirq, Victory is also working on open source software as part of his job at Super.tech where he develops [SuperstaQ](#) – an API for optimizing quantum programs for various hardware backends to make them capable of execution on existing noisy intermediate scale (NISQ) hardware.

The three runners-up (in no particular order) are Kesha Hietala who led the design of the SQIR quantum programming language, Paul Nation who co-created QuTiP and Robert Smith who started the Quil ecosystem and open-sourced large parts of the Rigetti software stack.”

– Mark Fingerhuth, QOSF from the [prize announcement](#).

The prize is awarded annually by the Quantum Open Source Foundation (QOSF) and Unitary Fund. This year, the Unitary Fund advisory board, which serves as review panel, reviewed over 35 candidates from a worldwide community. The 2020 Quantum Wittek Prize has been awarded to Roger Luo for his work on Yao.jl. You can read more [here](#) and watch Roger’s interview with Sarah from the Unitary Fund.

RESEARCH 2021

Unitary Fund believes that research is important for quantum open source. We focus not only on our own research interests but also on building tools to enable others, like those in our microgrant program.

We continue to perform research with open-source software in quantum technology.

- **Mitiq**: A software package for error mitigation on noisy quantum computers. The Mitiq whitepaper got a major update in 2021, in which we added new sections and co-authors from the open-source project.
Ryan LaRose, Andrea Mari, Sarah Kaiser, Peter J. Karalekas, Andre A. Alves, Piotr Czarnik, Mohamed El Mandouh, Max H. Gordon, Yousef Hindy, Aaron Robertson, Purva Thakre, Nathan Shammah, William J. Zeng. arXiv preprint arXiv:2009.04417 (2021).
- **Digital zero noise extrapolation for quantum error mitigation**. Tudor Giurgica-Tiron; Yousef Hindy; Ryan LaRose; Andrea Mari; William J. Zeng. arXiv:2005.10921. 2020 IEEE Int. Conf. Quant. Comp. Eng. (2021).
- **Pulser**: An open-source package for the design of pulse sequences in programmable neutral-atom arrays.
Henrique Silvério, Sebastián Grijalva, Constantin Dalyac, Lucas Leclerc, Peter J. Karalekas, Nathan Shammah, Mourad Beji, Louis-Paul Henry, Loïc Henriet. Quantum 6, 629 (2022).
- **Extending quantum probabilistic error cancellation by noise scaling**. Andrea Mari, Nathan Shammah, and William J. Zeng. Physical Review A 104, 052607 (2021).
- **Pulse-level noisy quantum circuits with QuTiP**. Boxi Li, Shahnawaz Ahmed, Sidhant Saraogi, Neill Lambert, Franco Nori, Alexander Pitchford, Nathan Shammah. Quantum 6, 630 (2022).
- **VAQEM: A Variational Approach to Quantum Error Mitigation**. Gokul Subramanian Ravi, Kaitlin N. Smith, Pranav Gokhale, Andrea Mari, Nathan Earnest, Ali Javadi-Abhari, Frederic T. Chong. arXiv preprint arXiv:2112.05821 (2021).

For further information on our research program, visit <https://unitary.fund/research.html>

ADVANCING RESEARCH WITH ACADEMIC AND INSTITUTIONAL PARTNERS

The development of Mitiq is partly supported by an ARQC grant from the U.S. Department of Energy, within the TEAM collaboration – *Tough Errors Are no Match*



DARTMOUTH



Unitary Fund is also involved in Superconducting Quantum Materials and Systems Center ([SQMS](#)), a National Quantum Initiative (NQI) Center led by Fermilab. Unitary Fund's CTO Nathan Shammah seats in the Ecosystem Task Force that develops projects to strengthen the quantum information science (QIS) ecosystem.





Starting in 2020, Unitary Labs began developing the world's first error-mitigating quantum compiler: **Mitiq**. Mitiq is open source, supported on all major quantum hardware platforms, and includes advances from Unitary Labs' own research publications.



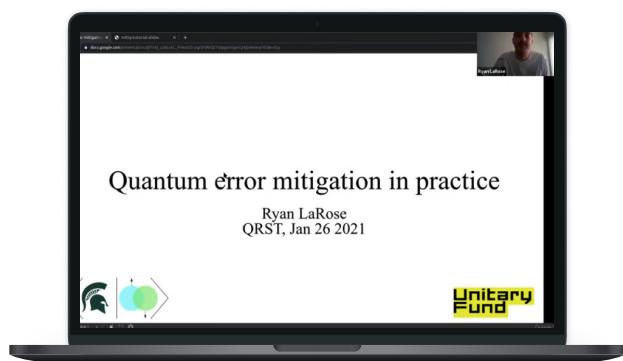
Highlights from Mitiq development in 2021:

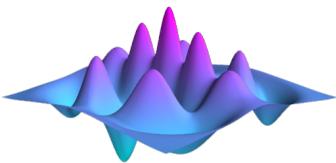
- Error mitigation techniques supported: [Zero-noise extrapolation](#), [Probabilistic Error Cancellation](#) (new 2021), [Clifford Data Regression](#) (new 2021).
- An updated [Mitiq whitepaper](#) describing the new techniques of probabilistics error cancellation and clifford data regression.
- New version releases up to version 0.11.1.
- 34 contributors, 27 not at Unitary Fund (up from 6 last year).
- 24k total downloads: 1K per month; 144 github stars; 61 github forks.
- Platforms supported: Cirq, Qiskit, pyQuil, [Amazon Braket](#) (2021), [PennyLane](#) (2021).

MITIQ'S GROWING COMMUNITY

- We conduct regular meetings every Friday on UF's Discord which has over 1K reach.
- We have a weekly Wednesday meeting on Discord where social coding, journal club, and talks are done.

See here for more information on our talks and events: <https://github.com/unitaryfund/mitiq/wiki/Mitiq-Talks-and-Events>





QuTiP

In 2020, Unitary Fund began supporting QuTiP by formally establishing its open-source [governance](#). Since then, QuTiP has been a Unitary Fund affiliated project.

In 2021, Unitary Fund strengthened its support for QuTiP's community by funding grants to assist the project and by enabling discussion and communication on Unitary Fund's social media platforms.

We celebrated [QuTiP's 10-year anniversary](#) on Unitary Fund's Discord server on the 29th of July 2021, inaugurating what have now become recurring quarterly community calls.

On October 22nd, 2021, we held the Q4 2021 Community Call, with talks from three students that worked at Google Summer of Code. A preview of QuTiP v.5 major version update was also featured in one of the talks. [🔗](#)

PLUGINS

- [Pulse-level noisy quantum circuits with QuTiP](#) on the open journal for quantum science Quantum.
- [Pulser](#): An open-source package for the design of pulse sequences in programmable neutral-atom arrays, a software that leverages QuTiP on which we worked together with the PASQAL team.

AWARDED MICROGRANTS

- Diego Wiskniacki and his students to build [PyKrylovSolver](#).
- Ben Braham for an undergoing project on [Variational Quantum Algorithms + quantum optimal control](#) (supervised by Daniel Burgarth).

FUNDING

MEMBER PROGRAM

Our members give annual recurring contributions that support all of Unitary Fund's work.

The program has two Tiers:

- Tier 1: Core members contribute at least \$100k annually
- Tier 2: Supporting members contribute at least \$25k annually

Core members are each allotted one seat on Unitary Fund's Strategic Board. The Strategic Board meets twice annually to review Unitary Fund's strategy, budget, and impact, and to make recommendations on Unitary Fund's programs.

CORE SPONSORS



SUPPORTING MEMBERS



OTHER SPONSORS



Our members play a pivotal role in supporting our mission, ensuring that the quantum technologies that the community develops benefit everyone. The quantum ecosystem has benefitted from generous annual corporate gifts as well as company matches of employee donations and volunteer hours.

INDIVIDUAL SPONSORS

Steve Willis & NYC Quantum Meetup

Peter Johnson

Christophe Jurczak

John Hering

Guillaume Verdon

George Umbrarescu

Jeff Cordova

Rishi Sreedhar

Greg Ramsay

Nima Alidoust

Travis L. Scholten

William Zeng

Travis Humble

Amir Ebrahimi

We thank our sponsors for investing in our mission to support the open source quantum ecosystem.

FINANCIAL FORECAST

REVENUE

We forecast about \$950K revenue in 2021.



\$ 645,753



\$ 309,417

EXPENDITURES

In 2021, we are forecasting about \$700K in expenditures.



\$ 617,613



\$ 86,459



\$ 5,382

WE ARE UNITARY FUND

UNITARY FUND TEAM

The Unitary Fund team grew in 2021 as we welcomed Dan and Vincent, to become members of the technical staff, Olivia in administration, and Alowina and Frances to boost our marketing and communications.



SARAH KAISER, PhD
Technical Staff & Community Lead. Co-founder of Q# Community, Microsoft MVP, activist for open source and diversity in quantum. Waterloo PhD in quantum computing.
washington, USA



ANDREA MARI, PhD
Technical Staff. >40 peer reviewed scientific publications. Contributor to Pennylane. Fmr. researcher at Xanadu. Univ. of Potsdam PhD in quantum information.
Marche, Italy



VINCENT RUSSO, PhD
Technical Staff. Fmr. Post-quantum security developer at ISARA. Fmr. Lead dev on toqito quantum info package. PhD from Waterloo.
Ontario, Canada



FRANCES POBLETE
UI/UX Designer. Digital media designer and content creator.
Hamburg, Germany



RYAN LAROSE
Technical Staff. NASA Fellowship PhD student at University of Michigan. Fmr at Alphabet X. Wrote first paper benchmarking quantum software packages.
Michigan, USA



DAN STRANO
Technical Staff. Full stack web engineer. Lead developer on the qrack quantum simulator.
New Jersey, USA



ALOWINA YAP
Marketing specialist.
California, USA

ADVISORY BOARD

Over 100 applications were reviewed and over 19 microgrant projects were mentored in the year 2021. Our group of voluntary advisory board, who comes from the quantum technology community, together with the Unitary Fund technical staff, have made this possible. They also served as the review panel for the 2021 Wittek Prize for quantum open source software.

The advisory board helps source and review grant applications, mentor projects, and provide technical advice on Unitary Fund's research program. They bring experience across the quantum technology stack and are all experts in their specific fields: various hardware, programming languages, quantum machine learning, open quantum systems, quantum compilers, and much more.

Many of them have already been helping behind the scenes at Unitary Fund, reviewing applications and mentoring projects. The group also includes Ntwali and Michał, who themselves were some of the first of our grant winners.

Unitary Fund continues to recognize their contribution and is sincerely grateful for all the help they have provided in growing our community.

ADVISORY BOARD MEMBERS

Travis L. Scholten (IBM)

Christa Zoufal (IBM)

Josh Izaac (Xanadu)

Nathan Killoran (Xanadu)

Michał Stechly (Zapata Computing)

Dylan Sukin Sim (Zapata Computing)

Ntwali Bashige (Zapata Computing)

Peter Karalekas (AWS Quantum)

Shahnawaz Ahmed (Chalmers)

Roger Luo (Uni. of Waterloo | Perimeter Institute)

Alex McCaskey (Nvidia)

Mark Fingerhuth (ProteinQure | QOSF)

Tomas Babej (ProteinQure | QOSF)

Amy Brown (USC)

Cassandra Granade (Microsoft)

Stephen Diadamo (Cisco)

BOARD MEMBERS



WILLIAM ZENG, PHD

New York, USA

President. Head of Quantum Research at Goldman Sachs. Fmr. product/sw lead at Rigetti. Oxford quantum algorithms PhD.



NATHAN SHAMMAH, PHD

Milan, Italy

CTO and Head of the Technical Staff. QuTiP admin. Visiting scientist at RIKEN. PhD in quantum physics from Univ. of Southampton.



TRAVIS SCHOLTEN, PHD

New York, USA

Secretary. Quantum computing applications researcher at IBM Quantum. PhD on quantum characterization, validation, and verification from University of New Mexico.



CHRISTOPHE JURCZAK, PHD

Massachusetts, USA

Treasurer. Co-founder and managing partner at Quantonation. PhD in Quantum Physics from Ecole Polytechnique.

WHAT'S NEXT FOR UNITARY FUND

- unitaryHACK 2022.
- **Mitiq project roadmap:** New techniques, benchmarks, and more.
- New project launch: **metriq**



- New quantum open source projects community calls starting on Discord.
- More quantum software talks, meetups, and livestreams.

STAY IN TOUCH WITH US

Subscribe to our quarterly updates from our [🌐](#) website.

You can also join our [discord](#) server, where the quantum open source community comes together to learn, collaborate, and grow.

SHOP

Check out our [shop](#) for Unitary Fund and Unitary Hack merch.



Unitary Fund

Because evolution is unitary.