

**Unitary
Fund**



**G R O W I N G
T H E O P E N
S O U R C E
Q U A N T U M
S O F T W A R E
C O M M U N I T Y**

DR. SARAH KAISER





whoami.md

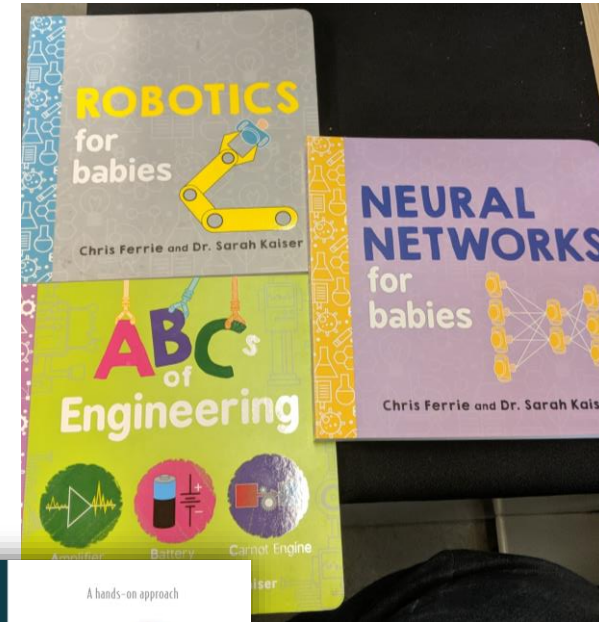
Quantum Software Talks

Dr. Sarah Kaiser

Dan Strano

Unitary Fund

discord.unitary.fund



Quantum Office Hours

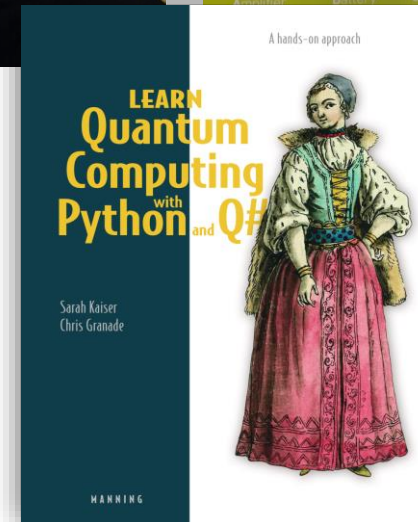
WITH DR Sarah Kaiser

ekaiser.dev

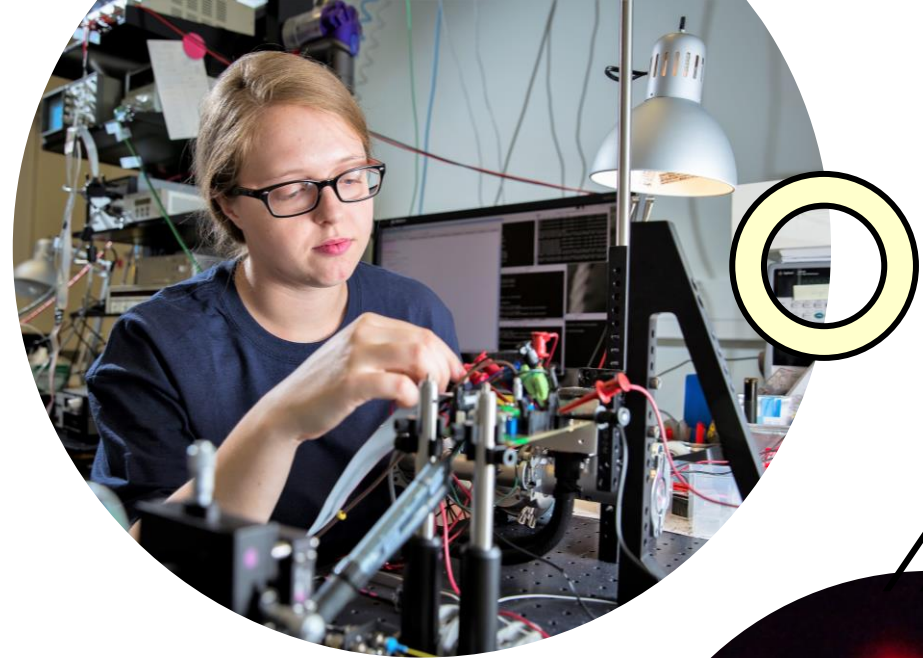
@sarahkaiser14

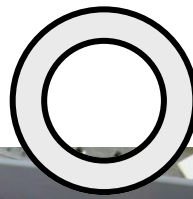
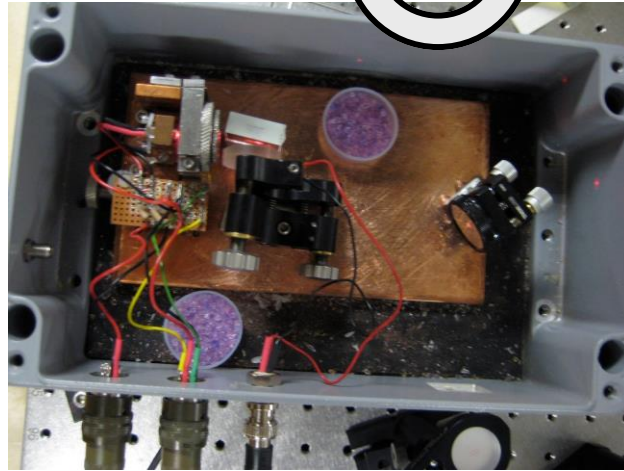
@sarahkaiser14

Sarah Kaiser



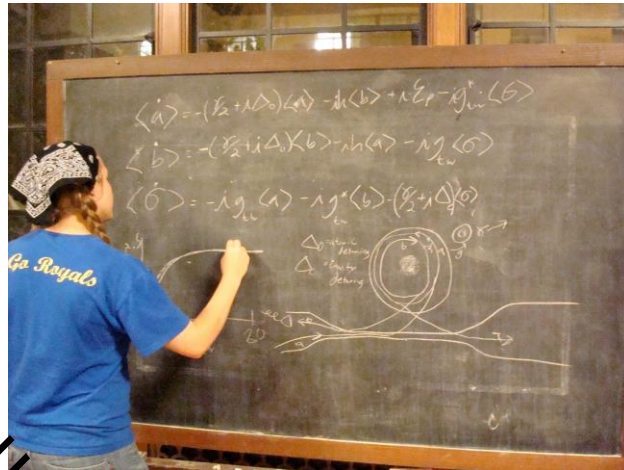
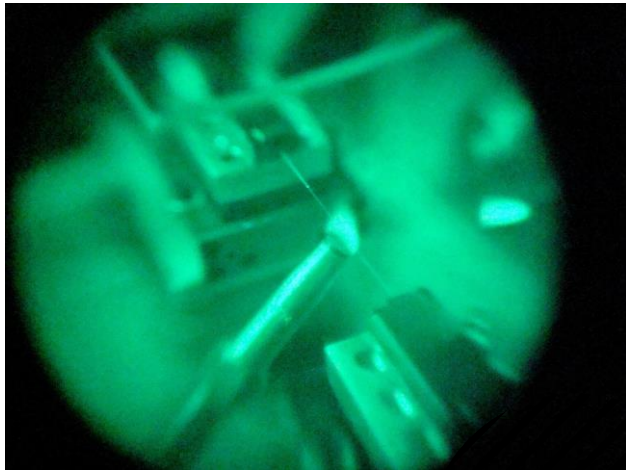
HOW
DID I
GET
HERE?





Undergrad : learning what I liked

- ▶ Studied both Physics and Math
- ▶ Couldn't decide between theory and experiment
- ▶ Knew I liked **LASERS**
- ▶ Learned a lot about what grad school would be like





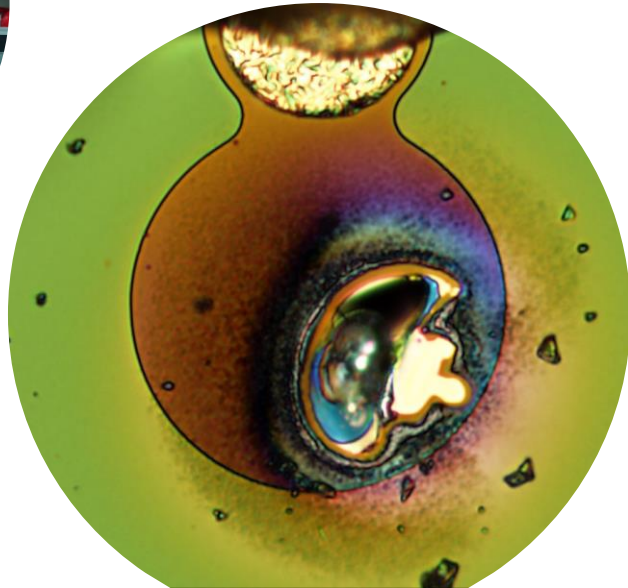
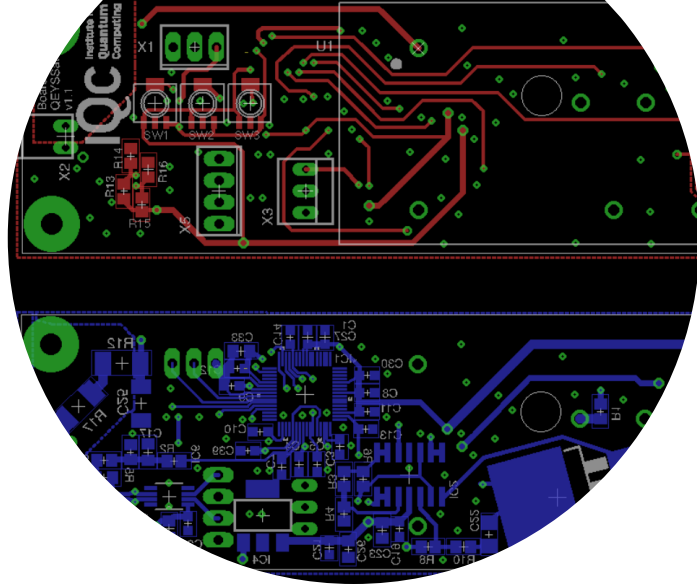
~~grad school,~~ software developer

- ▶ Didn't do well on GRE exam, didn't get into any grad school programs.
- ▶ Needed to save up for GRE and applications the next year.
- ▶ Got a job as a **software developer** at Wolfram Research working on Mathematica



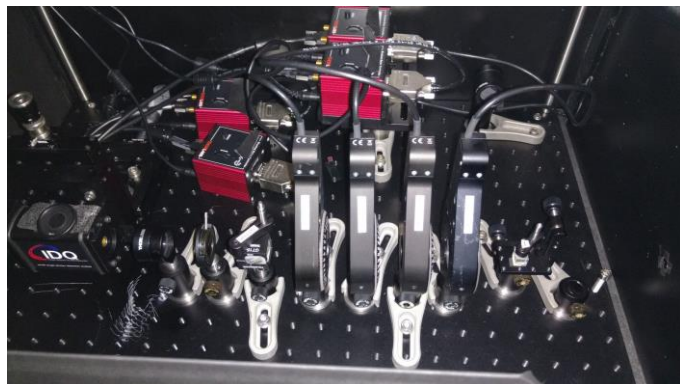
WOLFRAM





Gradschool!

- ▶ Found projects that incorporated lasers and quantum information!
- ▶ Studied **Quantum Key Distribution** and built (and broke!) commercial devices for exchanging secure keys.
- ▶ Struggled with lack of university support against harassment and discrimination issues.



Down under Postdoc

- ▶ worked on NV centers in nanodiamonds for medical sensing.

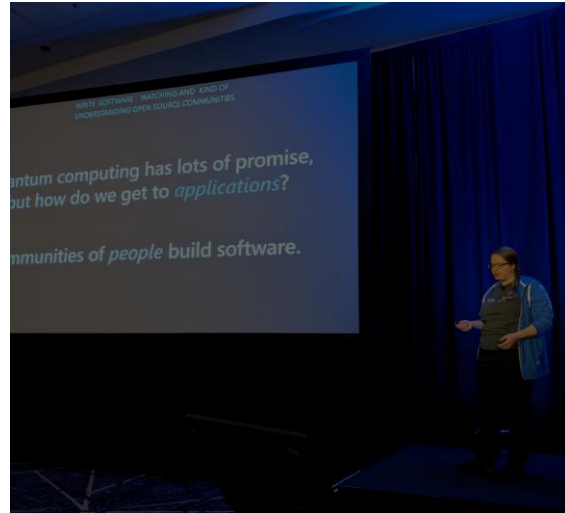
- ▶ Natural disasters happen, was unable to replace equipment after flood.

→ Back to software dev,
now with quantum in
Seattle!

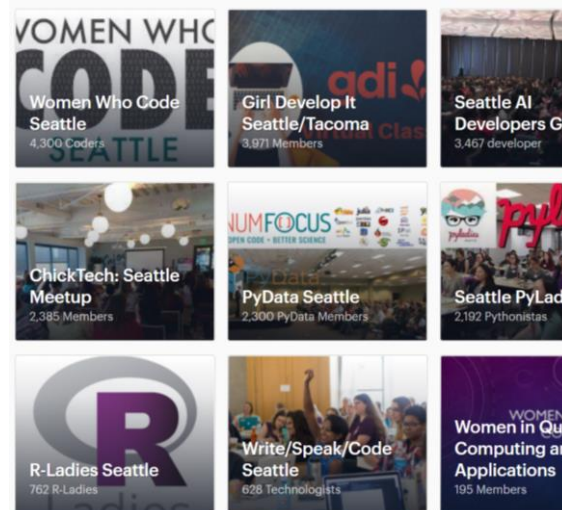


Quantum developer + advocate

```
operation Teleport (msg : Qubit, target : Qubit) : Unit {  
    using (register = Qubit()) {  
        // Create some entanglement that we can use to send our mes  
        H(register);  
        CNOT(register, target);  
  
        // Encode the message into the entangled pair,  
        // and measure the qubits to extract the classical data  
        // we need to correctly decode the message into the target  
        CNOT(msg, register);  
        H(msg);  
        let data1 = M(msg);  
        let data2 = M(register);  
  
        // decode the message by applying the corrections on  
        // the target qubit accordingly:  
        if (data1 == One) { Z(target); }  
        if (data2 == One) { X(target); }  
  
        // Reset our "register" qubit before releasing it.  
        Reset(register);  
    }  
}
```



- I wanted to learn how to be a better programmer
- **Open source meetup groups** were amazing communities, I wanted to help build one for quantum computing.
- I started giving lots of conference talks, and demos of quantum programming on twitch.





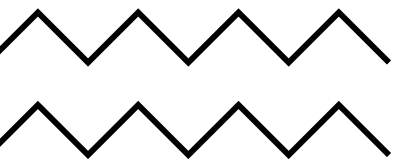
**How can we learn quantum
development together?**



The challenges of learning quantum development:

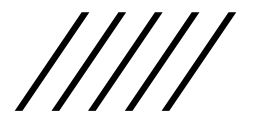


- ▶ Targeted learning materials for particular backgrounds
- ▶ Cross-disciplinary concepts
- ▶ Tons of options for language and platform



We have our classical computers... ?

what *software tools* can we use **right now** to help us learn about quantum computers?



Open Source: For software, knowledge, research

► Open Source Software (OSS)

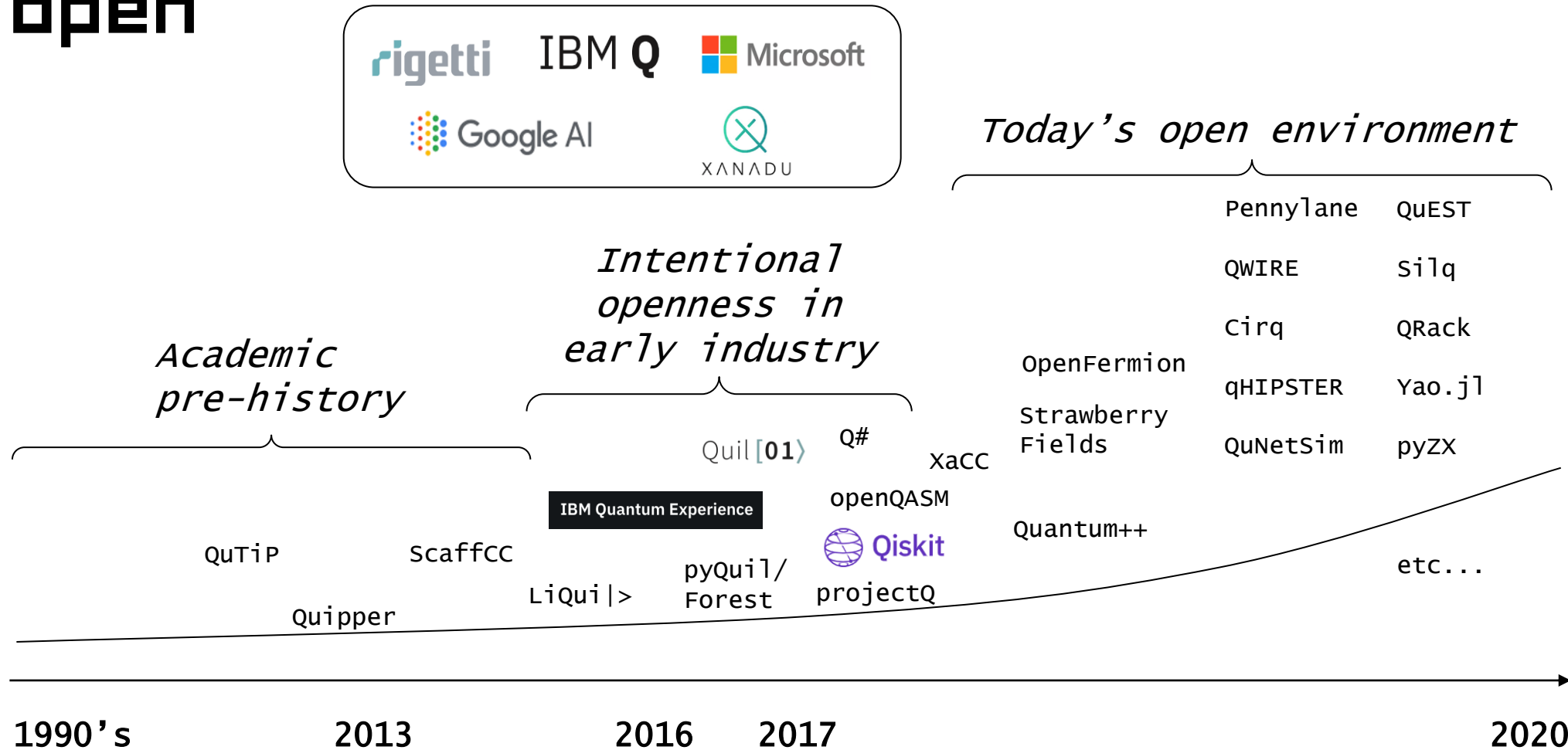
- Software that can be freely accessed, used, changed, and shared (in modified or unmodified form) by anyone.

► Open Source Community

- Everything *except* the code
- Licences
- Processes and governance
- Funding
- Blogging and Social Media
- Diversity
- etc.



○ Our quantum environment is intentionally open



* This is a figurative timeline and not meant to be exact or exhaustive



THE UNITARY FUND

CREATING A QUANTUM
TECHNOLOGY ECOSYSTEM
THAT BENEFITS THE MOST
PEOPLE.

The logo graphic consists of a large, light yellow rectangle with a black border. Inside this rectangle, the words "Unitary" and "Fund" are stacked vertically in a bold, black, sans-serif font. The word "Unitary" is on the top line, and "Fund" is on the bottom line. The letters are slightly offset to the right, creating a layered effect. The entire logo is contained within a larger, thin black rectangular frame that has a small yellow circle at the bottom-left corner and a larger yellow circle at the top-right corner, resembling a binder or a folder.

Unitary
Fund

○ Developing the open quantum tech ecosystem

Microgrant Program

- ▶ \$4k grants to open quantum tech projects
- ▶ Compilers, simulators, educational tools, visualizers, and more!

Supporters



Unitary Labs: open source research team

- ▶ Building **Mitiq**, an open source error-mitigating compiler
- ▶ Supporting **QuTiP**, >30k annual downloads, Paper >2500 citations: widely used

Collaborators



**Small
microgrants
=> big impact**



\$90k

30 projects:

14 countries, 4 continents
8 publications



1 venture funded startup
>12 open source libraries
7 new folks FT in the field

Open source metrics:

>950 stars
>150 forks

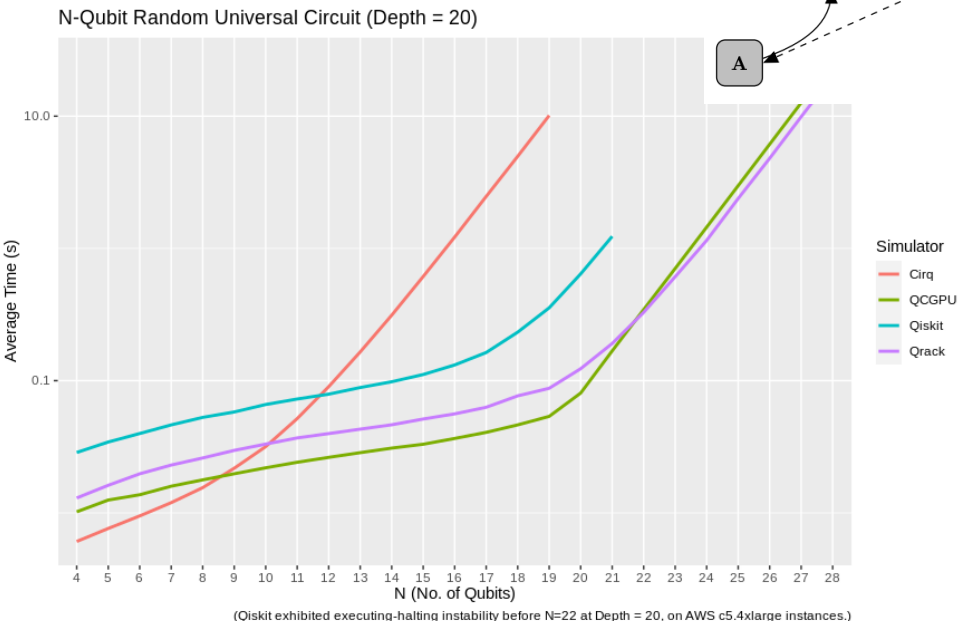


Building state-of-the-art open software

QRack

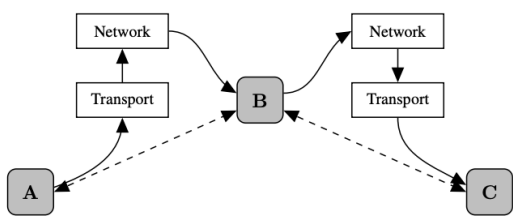
an open source, comprehensive, GPU-accelerated framework for simulating universal quantum processors.

Better performance than industry options.



QuNetSim

To Stephen DiAdamo to develop the first full features software stack for quantum network protocols.

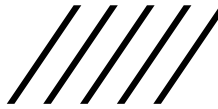


OLSQ

To Daniel Tan to develop and open source the Optimal Layout Synthesizer for Quantum Computing, OLSQ. This compiler beats other benchmarks on optimal layout of computational qubits onto physical qubits.

Table 4. Evaluation of QAOA-OLSQ

M	t ket>	TB-OLSQ	Depth	SWAP	QAOA-OLSQ	Depth	SWAP	Depth	SWAP	Depth	SWAP
	Depth										
10	16	7.3	6.9	7.3	56.7%	0	6.5	5.5	59.3%	23.6%	23.6%
12	17.8	11.7	8.5	9.3	52.3%	20.4%	5.6	5.8	67.3%	46.2%	46.2%
14	19.0	13.2	9.0	12.3	52.6%	6.8%	6.0	6.6	68.3%	48.0%	48.0%
16	21.7	20.2	9.1	13.6	58.2%	32.7%	6.4	6.9	70.2%	62.6%	62.6%
18	25.5	26.7	8.9	14.5	64.9%	45.7%	6.0	8.3	75.5%	65.7%	65.7%
20	30.6	37.5	9.3	16.3	68.9%	57.7%	7.2	10.8	75.7%	68.8%	68.8%
22	29.8	38.4	10.3	17.8	65.4%	53.6%	7.8	14.2	73.7%	61.8%	61.8%
Geometric Mean					59.5%	29.4%			70.2%	53.8%	53.8%





Unitary Labs: Mitiq

- ▶ Quantum computers have **errors**.
- ▶ Mitiq is a cross-platform compiler that makes your programs **robust** to those errors.



Mitigating errors with Cirq

```
from cirq import Circuit, LineQubit, X

qbit = LineQubit(0)
circ = Circuit(X(qbit) for _ in range(100))
expectation = noisy_simulation(circ)

print(f"Error is {1 - expectation:.{3}}")
```



Mitigating errors with Qiskit

```
from qiskit import QuantumCircuit

circ = QuantumCircuit(1, 1)
for __ in range(120): circ.x(0)
circ.measure(0, 0)

expectation = qskt_noisy_sim(circ)
print(f"Error is {1 - expectation:.{3}}")
```

R. LaRose, A. Mari, P.J. Karalekas, N. Shammah, W.J. Zeng, [Mitiq: A software package for error mitigation on noisy quantum computers](#), 2020.

T. Giurgica-Tiron, Y. Hindy, R. LaRose, A. Mari, W.J. Zeng, [Digital zero-noise extrapolation for quantum error mitigation](#), 2020.

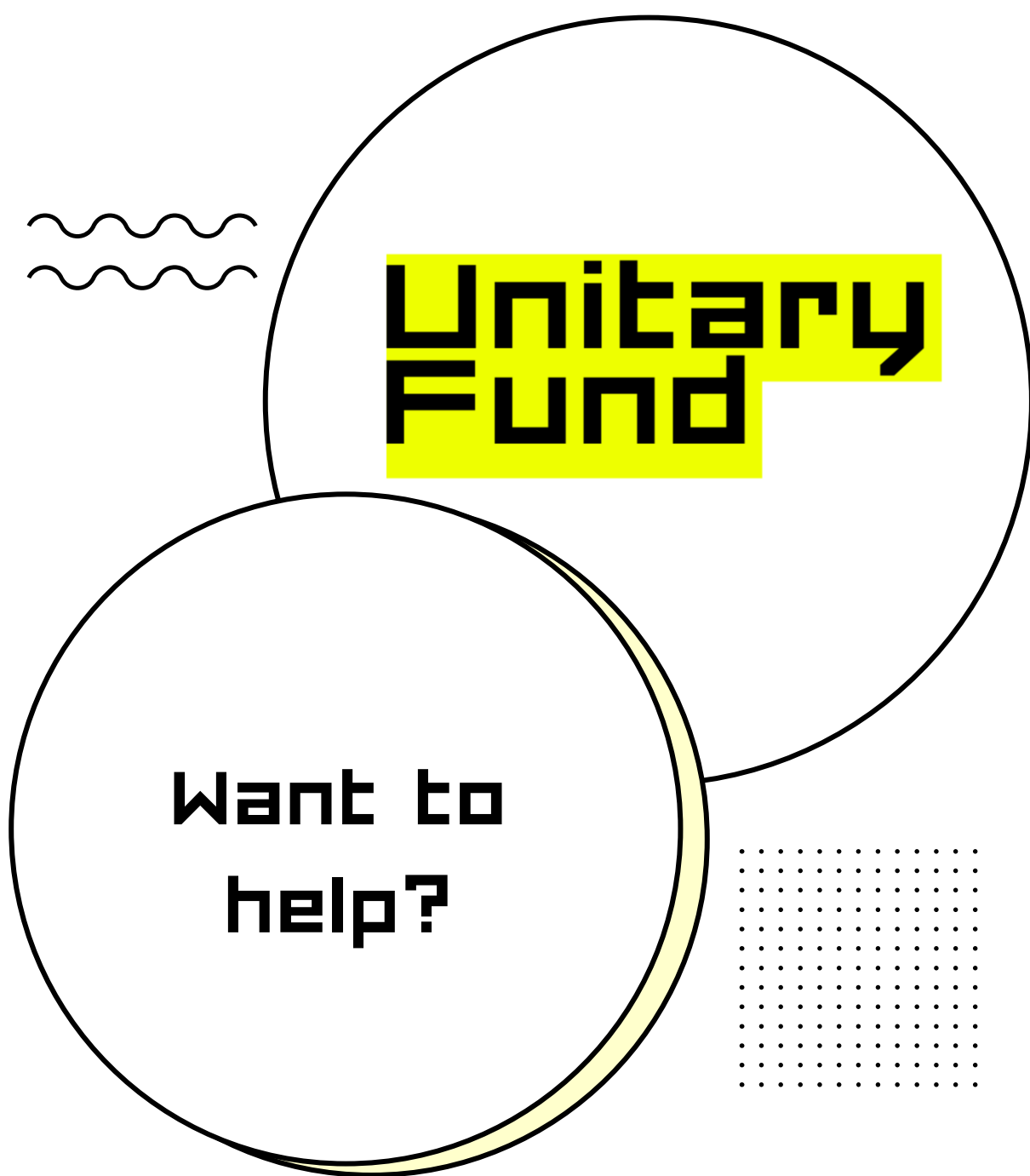




What's next: Unitary Fund Fellows

- **Fellowships:** Year-long ~\$50k fellowships for open quantum science.
- Direct support for researchers and developers:
 - **Focused & Flexible:** Remote working, unlike postdocs. No bureaucracy, resettlement, teaching, visa.
 - **Inclusive:** Provides a new entry point, beyond MSc → PhD → Post Doc track.
 - **Timely:** Covid-19 disruption has highlighted academia's structural issues and new forms of research environment.






- ▶ Spread the word
- ▶ Become a supporter
- ▶ Mentor
- ▶ Contribute code



How can **you** grow the open
quantum community?





1. import OSS best practices to quantum

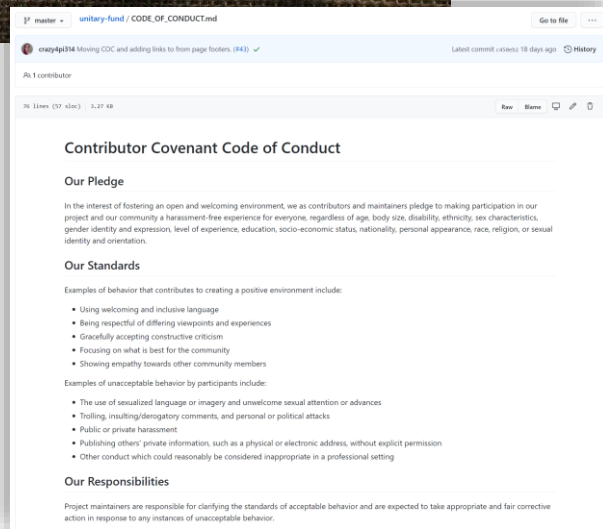
► There are **tons of resources** for building both open source projects and communities from the classical software community:

- opensourcediversity.org/
- opensource.guide/building-community/
- [Talk: Building Open Source Communities - Tierney Cyren](#)





My top OSS community best practices



Codes of conduct

Ask for pronouns

Accessibility

- Event spaces
- Websites
- Tools

Find and support diverse members and contributions

- Financial
- Mentorships



○ 2. Find (or create!) OSS communities in Quantum Computing

- ▶ ♡Qworld♡
- ▶ Unitary Fund
- ▶ QOSF: Quantum Open Source Foundation
- ▶ Q# Community
- ▶ WIQCA: Women in Quantum Computing and Applications
- ...and more!

! we also need to understand how the *quantum research* and *industry* communities influence our communities.

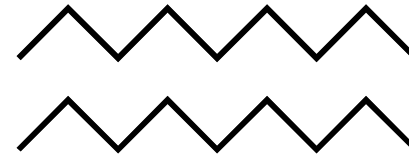


3. Contribute to projects

- Find a project in a language you like, or learn a new one!
- Documentation + bug reporting is contribution


qosf.org/project_list

unitary.fund/mitiq



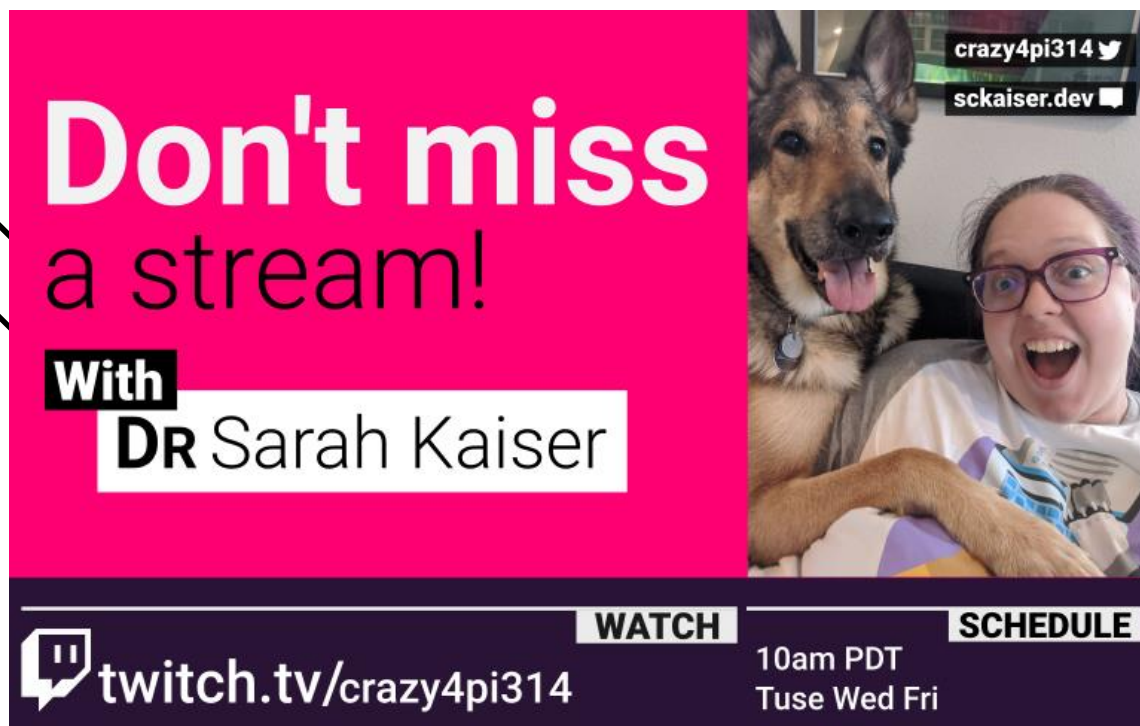


Communities of people make quantum technology.

Let's make it welcoming and safe for everyone to contribute 



Thank you!



Connect with me:

sckaiser.dev
@crazy4pi314

Connect with Unitary Fund:

sarah@unitary.fund
support/mentor/contribute/announce