# No-one used my software

## A tale of quantum software development

**Aleksander Wennersteen**

Quantum computing devroom @ FOSDEM

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# Overview

- Background
- Motivation
- Why no one uses your software
- Open-source ecosystem

# Lessons learned from building quantum software

- 3.5 years building quantum software professionally
  - First at pure quantum software startup Qu & Co
  - Then at full-stack hardware startup -> scaleup Pasqal
- In the past: high performance computing (HPC) and machine learning
- Today:
  1. Integrating quantum computing with classical HPC systems
  2. Programming languages and libraries
  3. Analog and digital quantum computing

# How did I end up here?

## CFP main ideas

- Quantum programming languages and tools
- Compilation, transpilation, and optimization of quantum programs
- Error mitigation, correction, and making noisy qubits work

- Too much for me on a Sunday

## "Off the beaten track topics"

- **Lessons learned from building quantum software**
- **Insights on building open quantum communities**
- **Surprising and fun** uses of quantum hardware or software
- Long-shot ideas and ambitious **visions for the future of quantum software**

## Help, my talk was accepted

- Google: "why no one used my software"

# Why no one uses your software [1]

1. Your employees have too many software tools
2. Your users don't see your tool's added value
3. Your employees want a practical software training
4. Your employees want a tailor-made training
5. Your teams need to be supported in real time
6. Your employees don't feel heard

Holds just as much for quantum software as enterprise software!

# Too many software tools with no added value

- How many SDKs do we really need?
    - Every company, big lab, and quite possibly your neighbour has their own
- What is the value-add?

Cf. qosf/awesome-quantum-software, Unitary foundation survey

According to users, only a few are worth using

# My first SDK

- Built "on top of" mainly Qiskit
- Abstract re-usable components of our algorithm libraries

```
class Backend:
    ...
    @cache
    def dfdx(self, x: float, circuit: Circuit, obs: Observable) -> float:
        ...

    def expectation(self, state: State, obs: Observable) -> float:
        ...

    def run(self, state: State, circuit: Circuit) -> State:
        ...
```

# My first SDK

```
class Backend(ABC):
    ...

class LocalBackend(Backend):
    ...

class RemoteBackend(Backend):
    ...
```

# How multiple inheritance killed my SDK

```
class LocalBitstringBackend(Backend, LocalBackend, BitstringBackend):
  ...

class LocalWaveFunctionBackend(Backend, LocalBackend, WFBackend):
  ...
```

# How multiple inheritance killed my SDK

```
class LocalQiskitBitstringBackend(Backend, LocalBackend, QiskitBackend, BitstringBackend):
    ...
```

- This was getting out of hand.
- Hard to onboard people on, required solid understanding of OOP
- Hard to extend
- Slow for our QML workloads

# We needed better performance

- So we wrote the numerical backend in Julia
- We wanted "GPU goes BRRRR", so we did the required CUDA.jl work
- We weren't happy enough with Julia AutoDiff so we
    - Made it a PyTorch function
    - With a custom AutoDiff override
    - Didn't go well with the aforementioned inheritance pattern...
- Clearly it was time to start from scratch

# Qadence

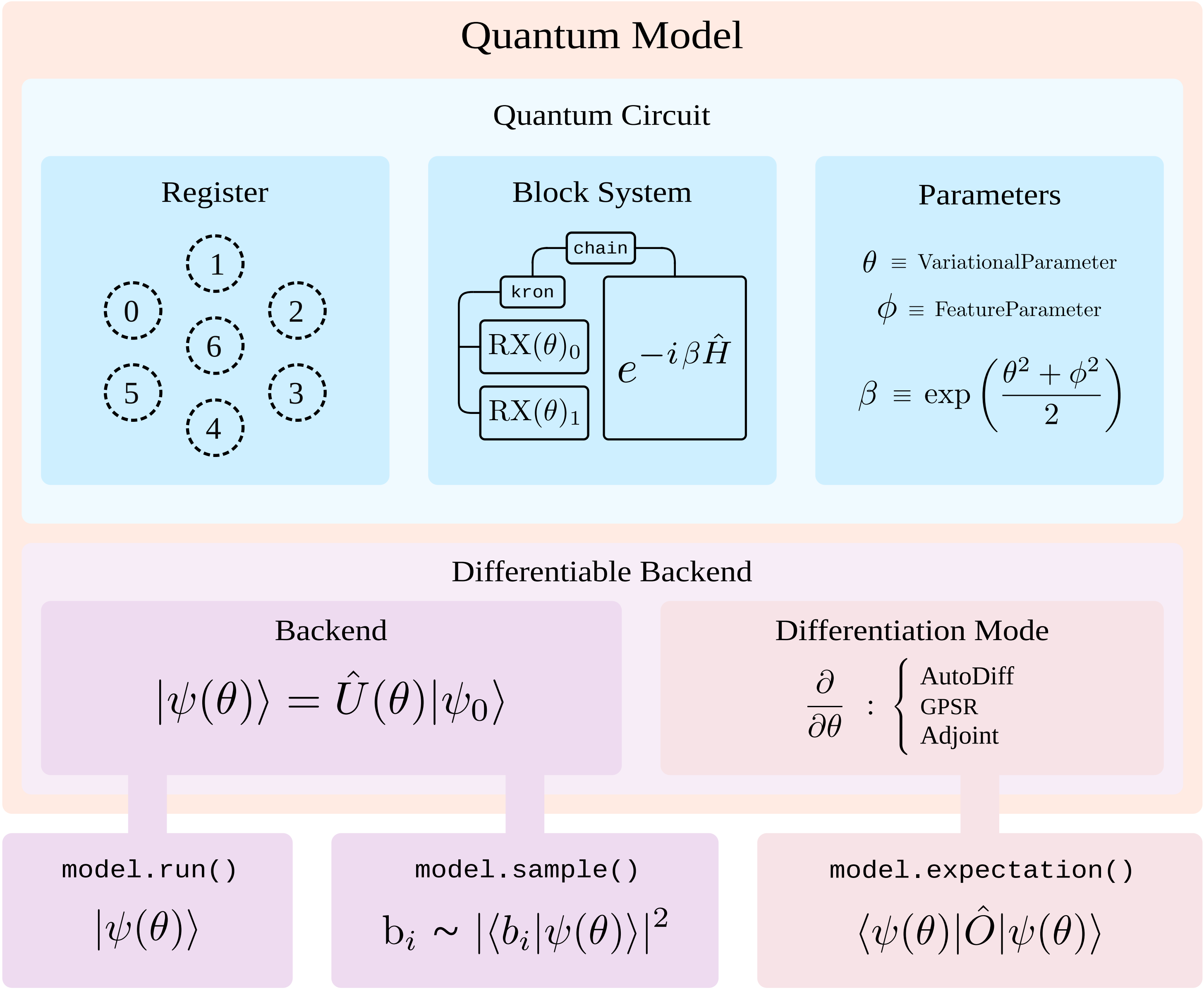
## Return of the SDK

A **differentiable** DSL for analog, digital and **digital-analog** paradigms

Geared towards **Rydberg atom devices**, yet generic

Focused on **hardware-realisable** programs

**Designed** according to **algorithm**-design needs



# Analog programming of Neutral Atom QPUs

$$\hat{H}(\Omega,\delta,\phi;t) = \sum_{\text{atom } i} \left( \overbrace{\frac{\Omega}{2}\left[\cos(\phi)\hat{\sigma}_i^x - \sin(\phi)\hat{\sigma}_i^y\right] - \delta\hat{n}_i}^{\text{Programmable laser pulse, global interaction}} + \underbrace{\sum_{j<i} \frac{C_6}{|\mathbf{r}_{ij}|^6}\hat{n}_i\hat{n}_j}_{\text{Programmable register, atom-atom interaction}} \right)$$

## In Pulser

```
register = Register.square(3, blockade_radius)

program = seq.add(Pulse(
    amplitude = ConstantWaveform(time, delta),
    detuning = RampWaveform(time, Omega_init, Omega_final),
    phase = 0,
), "rydberg-global")
```

## In Qadence

```
register = Register.square(n_qubits=9)

program = chain(            # Compose operations in time
    AnalogRX(pi/2),         # Rotate all qubits, sigma_x term
    AnalogInteraction(time) # Evolve Rydberg system, register term
)

sample(register, program, n_shots=100)  # convenience function
```

# The GPU strikes back

- The algorithm developers said:
  - Need more performance -> GPUs, and auto-differentiable
    - So we wrote PyQTorch and Horqrux in PyTorch and Jax, respectively
  - Qubit count too low
    - So we wrote a tensor network backend, also in PyTorch (Internal)
      - Because AutoDiff and GPU!
- Most day-to-day work too small-scale for GPU speed-up
- Many are scared of approximate methods like tensor networks

# Lessons learnt

- Requirements gathering remains important
    - Algorithm developers will ask for an exact, arbitrary noise, tensor network backend with GPU acceleration
    - But they may not need it, and it may not be possible
        - As engineers we should push back when appropriate

- Crazy OOP - bad, but no contracts enforced also bad

# Bespoke, practical training, and real-time support

- Software a key ingredient for scaling
  - Workforce/Communities and Companies
- The training, documentation, and support must be up to par
- Documentation, examples
- Slack channels, office hours, GitHub/Gitlab
  - Try to always show all the steps required

```
$ srun -N1 -G1 -c32 --pty bash
$ source .venv/bin/activate
$ cd qadence/docs/tutorials/low_level_api.ipynb
$ python3 -m nbconvert --to python low_level_api.ipynb
$ python3 low_level_api.py
```

# Not listening to users / not giving the users what they want

- Application library that didn't fit users need
  - Clean, DRY code, written for software engineers - not algorithm researchers
  - New attempt, beginning with releasing **lean** standalone "Solvers" like github.com/pasqal-io/quantum-evolution-kernel
- One internal library that only became popular after removing "features" aka bloat
  - Users are typically smart - they prefer flexibility
- Julia based tensor network emulator arXiv: 2302:05253
  - Great for engineers, hard to deploy, hard to modify for users
  - PyTorch based emulators at github.com/pasqal-io/emulators
- AWS Batch job submitter / Convenience Script for on-prem cluster
  - Documentation, examples, cloud-platform for emulators

# When my never used software became super popular

- Cloud platform tensor network emulator: arXiv: 2302:05253
    - Didn't get traction at all
    - Until suddenly it did
        - And it crashed and burnt
- Turns out we got the requirements right, but not the UX
    - But the need wasn't there until much later -> bit rot
    - Julia issues - hard for scientists, hard to install in HPC centers
    - PyTorch based emulators at github.com/pasqal-io/emulators to the rescue

# Open-source ecosystem desires

- More modular, re-usable blocks
  - Testing software which makes little/no assumptions about my SDK
    - All the endianness bugs in alpha-release Qadence
  - HPC/Classical computations integration building blocks
- Solve common pain-points
- EC and EuroHPC workshop on quantum software
  - Focus on European open-source software
- No need to end up with "left-pad" type ecosystem

# Summary

- User adoption of Quantum Software just like any other product
    - Training, documentation, value-add, listen to users
- Realistic requirements gathering
    - Push back on requirements is necessary
    - Focus not just on technical requirements, also UX
- More re-usable, widespread, QFOS please

# Thank you

Aleksander Wennersteen

Quantum software technical lead @ Pasqal

aleksander.wennersteen@pasqal.com

github.com/pasqal-io, community.pasqal.com

Sign up for Pasqal community launch webinar