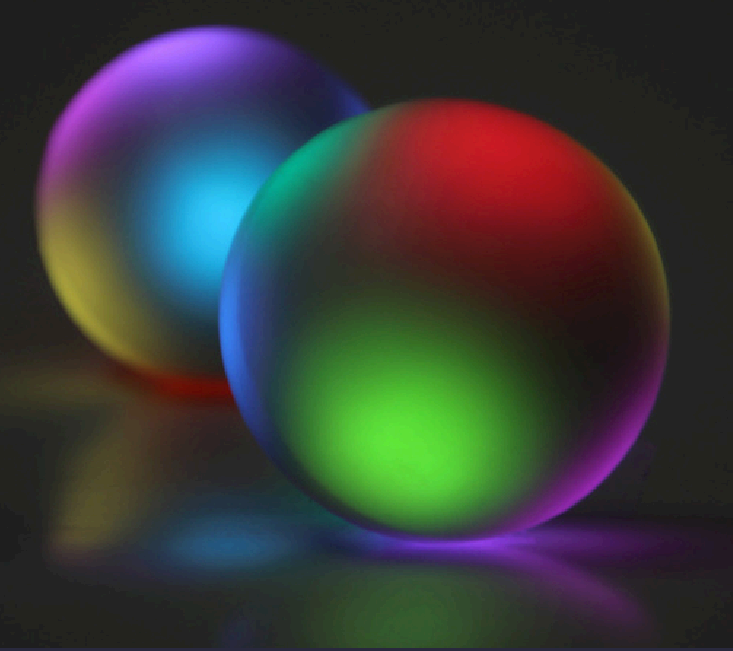


qolour

Interactive Quantum Activities

This document outlines a set of activities for both adults and children. They are designed around a set of ambitious learning outcomes related to quantum literacy and workforce development.

Qolour's mission

We want to make quantum science simple, beautiful, and interactive.

We have developed Qubi, the first interactive model of a qubit, to make quantum behavior tangible. Around this new tool, are building a set of learning kits, games, and engaging activities to make quantum fun and easy for all.

More information:

Introduction to Qubi (Video) How to Use Qubi (Video) Case study (Report)

In partnership with:

Unitary Foundation | Quantum Village | QUANTUM STARTUP FOUNDRY | SparQS SPARKING CURIOSITY IN QUANTUM SCIENCE

Sample Games and Activities

Quantum learning made engaging.

The format: These games can be played in a one-versus-one setting, or group-versus-group.

Activity #1: King of the Hill

An introduction to how the Qubis work, with similarities to cup-stacking competitions. Users race to get all the qubits to point upwards using only measurements.

- How do measurements change the qubit state?

Activity #2: What's your fidelity?

A challenge to perform quantum gates better than state-of-the-art quantum computers.

- What are quantum gates?
- What is a fidelity?

Activity #3: Steal the State

A race to figure out the hidden state using quantum teleportation.

- What is a quantum circuit?
- What is entanglement?
- What is quantum teleportation?

Activity #4: Crack the code

A surprisingly simple introduction to Grover's algorithm and quantum circuits. Users first try to crack a password classically, then race to do it quantumly in one shot.

- What does a quantum algorithm look like?
- What exactly makes a quantum computer better than a classical computer?

Get familiar with measurement

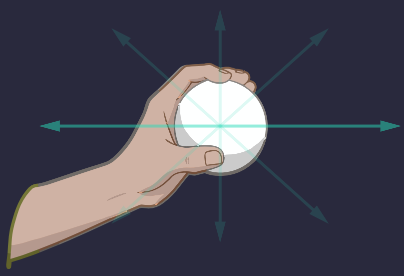
15 minutes

The first activity is modelled around a friendly competition-based format. Each team is given three qubits in the “down” state.

They choose one representative; their goal is to get all the qubits to the “up” state as quickly as possible, only by shaking (measuring) the qubits.

There is an element of strategy: who is chosen as the representative? On what basis do they measure?

There’s a large element of chance in this game - but also of speed. Teams are given points on how quickly they can complete the challenge.



Shake along the X, Y, or Z axes (or any axis in between) to perform measurements in that respective basis.

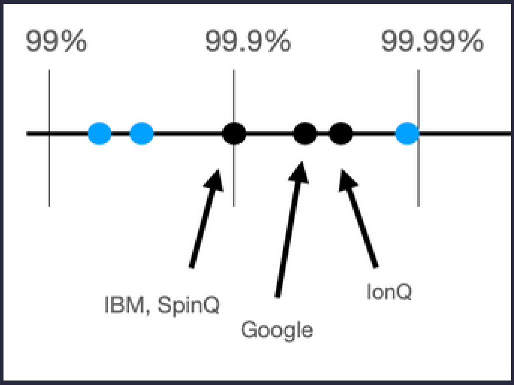
What's your fidelity?

20 minutes

The second activity gets us right into the heart of the quantum computing race: gate fidelities. This game will introduce gates, how they are performed, and why they are hard.

Each team starts out with four qubits. They will also get a tablet, which will allow them to start and stop the "pulse". The pulse will cause a precession of the qubit states. The goal is to get the qubits to go from the bottom to the top using the pulse.

The contestants will realize that they have to time the pulse perfectly to get the state to the top - which is exactly what a quantum computer does.



The team is given a fixed amount of time to get as close to perfect as they can, after which all of their "fidelities" are summed and the team scores compared to find the winner.

Often, participants tend to get extremely high scores on this game, which makes it exciting.

There is also an opportunity to add extra variables for accuracy, such as a tunable laser frequency, power, or noise.

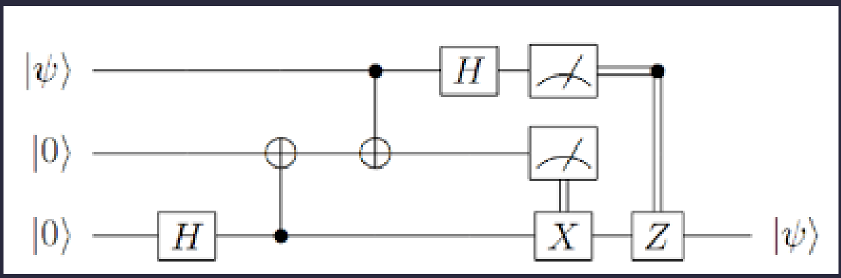
Steal the State

40 minutes

The third activity allows people to understand how quantum teleportation works.

Each team is given a qubit in the same state. This qubit is in "realistic mode" - meaning its state cannot be seen. They are also given two qubits whose state is visible. The team's goal is to "steal" the state by teleporting it into one of the visible qubits.

This can be done by following a three-qubit circuit:



Teams will race to extract their state, bumping the qubits in order. They will compare to the reference to know if they have won. They will repeat this several times to get points. They'll develop a strategy - and the fastest way is with teamwork.

ACTIVITY

Crack the code

30 minutes

This game shows the difference between classical and quantum algorithms. Each team has a lockbox with a two-bit passcode. **Teams race to figure out the passcode the fastest.**

Each team will be given 2 “input” qubits and 1 “lockbox” qubit. They will all start in the “0” (or “up”) position. The “lockbox” qubit is “locked” when it is up, and “unlocked” when it is down. The moderator can perform an “lock-check” (bit-flip oracle) which will flip the lockbox qubit if the input qubits have the correct passcode. Demonstrations will make this obvious.

The first part of the game will be the classical algorithm. A random passcode will be selected, and the teams will make a guess on their input qubits. When time is up, the moderator performs the lock-check. If a team guessed the passcode correctly, their lockbox qubit would flip. Big cheers. If they didn’t guess it correctly, reset and try again. It will take maximum 4 tries to get it; average 2.5 tries. No points awarded for this.

The second part of the game will be the quantum algorithm. The teams prepare their input qubits in the plus states, and the lock-check is performed once, creating an entangled state which encodes the correct answer. A diagram of the grover diffusion operator is placed far away from the qubits, face down. The team rushes to the circuit diagram, memorizes the circuit, then heads back to their tablet to perform the grover circuit. Once they do it, their input qubits should now show the correct passcode. First to do it wins!

The second part of this game resembles a “water bucket challenge”, where team members can strategize on who memorizes the circuit, who enters the gates, and in what manner the circuit is memorized.

This will teach quantum circuits and give a clear demonstration of quantum computers solving a problem in fewer steps.

EXTRA ACTIVITY

Quantum Trivia

20 minutes

This game adds context to all the concepts learned in the games above. Questions will be drawn from public investments, technical announcements, and internal corporate drama. Example questions are:

- What is the highest single-qubit fidelity recorded in a lab?
- Which company raised $600M in 2025?
- What is the name of IBM's 133-qubit chip?
- What are the most promising applications of quantum computing so far?

The questions will be light and humorous at times, but also expose people to a variety of topics in the field of quantum.

Catch the eavesdropper

40 minutes

The third activity allows people to understand how participants in QKD protocols detect eavesdroppers.

One round per team. Every round, one or two teams will be assigned the “eavesdropper” role. Every non-eavesdropper team will be given a shared basis, e.g X, Y, or Z. Their goal is to find the eavesdropper(s) - the teams that don’t know the shared basis. If the eavesdropper survives, they get a point. If the eavesdropper gets caught, the rest of the teams win a point.

One qubit will be passed around and measured by each team. Their measurement results will be recorded, then announced by the teams afterwards (perhaps in reverse order). Based on the results, the teams will have to figure out who the eavesdropper(s) are.

For example, if all the non-eavesdroppers measure in the right basis, and the results are 0,0,0,1,0,0 - then we know an eavesdropper is team 4. Likewise, there are measurement results which are not so obvious, and might allow the eavesdroppers to convince the others that someone else is the eavesdropper... especially when there are two, and the eavesdroppers can lie about their measurement results.

This game illuminates the way that BB84 participants can catch eavesdroppers - by noticing that they recieved different results, when they should have been the same!

What is Qubi?

1

A full quantum simulator for N qubits.

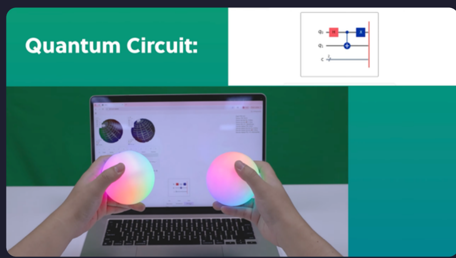
The simulator is hosted by the devices, and states are synchronized over a bluetooth network.

[Ψ]

2

An intuitive controller for quantum operations.

Perform operations by shaking, rotating, and bumping.



3

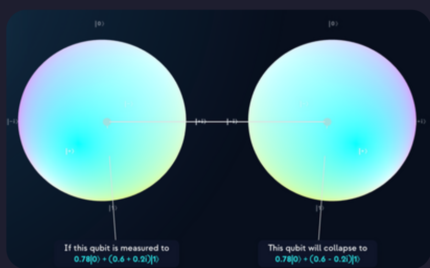
An intuitive display for measurement results.

Measurements show up on the bloch spheres of the respective qubits.

4

A vibrant visualization of the quantum state.

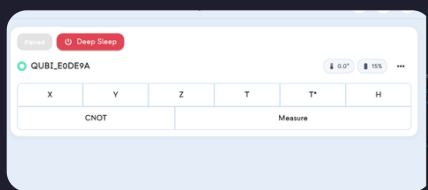
Colors represent potential correlated measurements.



5

Software and Guides

Everything needed to play games, host labs, and run workshops.



Modes of Interaction

Learn quantum by doing quantum.

Instead of using lasers and pulses to manipulate qubits, users use **buttons**, an **app**, an **API**, or **gestures**. Qubi is a full-featured quantum computer simulator. Watch the feature overview here.

On-stand buttons: Depending on your choice of on-stand interactivity, this could be:

- An attached tablet with touch buttons
- A tactile button panel in front of each qubit

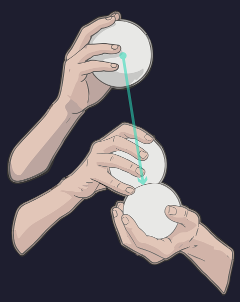
Mobile app: Connect via Bluetooth to control the qubits, execute quantum gates and operations, and explore arbitrary Hamiltonians.

Qiskit API: Install our Python API to your laptop, and send your Qiskit circuits and algorithms to the Inspire system via Bluetooth.

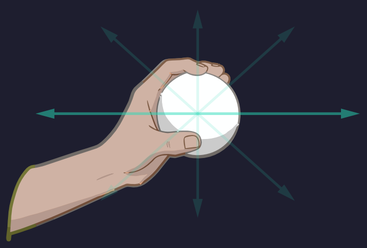
Direct Physical Manipulation: Pick up the qubits and twist, bump, and shake to perform a universal set of quantum computing operations.

Three actions correspond to the three core quantum computation operations:

Rotate the qubits to perform single-qubit quantum gates.



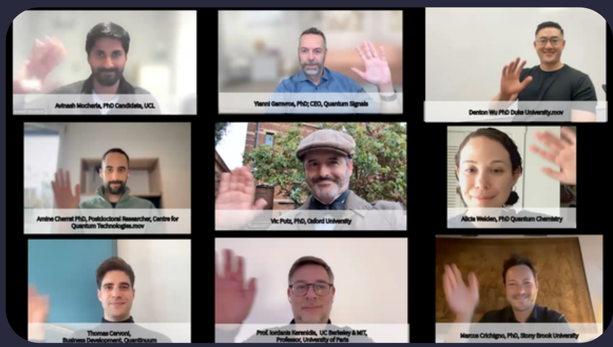
Bump the qubits together to perform two-qubit gates (like CNOT).



Shake along the X, Y, or Z axes (or any axis in between) to perform measurements in that respective basis.

Qolour's Quantum Advisory Panel

Qubi was designed with the active input of a panel of dozens of scientists and industry experts, actively working to shape curricula, design the interactions, and test the system.



Scientific Advisors

"Qubi is the world's most beautiful qubit"

John Preskill

Professor of Theoretical Physics at Caltech

Director, IQIM

"It's time to stop calling quantum 'counterintuitive.' Qubi makes it make sense."

Iordanis Kerenidis

PhD UC Berkeley, Postdoc MIT

Founder, Paris Center for Quantum Computing

Team:

Sohum Thakkar - President
Formerly: Software Engineer at Apple

Yasser Omar - Education Lead
Professor of Physics at Univ. of Lisbon
President, Portugese Quantum Initiative

Andrew Chen - Quantum Software Lead

Roger Mao - Operations Lead

Ozer Ozdemir - Software Engineer
Formerly: Senior Engineer at Microsoft

Advisors:

Denise Ruffner - Business Advisor
Founder, DiviQ
Former Head of Business Development @ IonQ

Yianni Gamvros - Business Advisor
CEO at Quantum Signals
Formerly: Head of Business @ QC Ware, Lead organizer for Q2B

Iordanis Kerenidis - Scientific Advisor
Founder, Paris Center for Quantum Computing
Formerly: PhD at UC Berkeley, Postdoc at MIT

John Preskill - Scientific Advisor
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