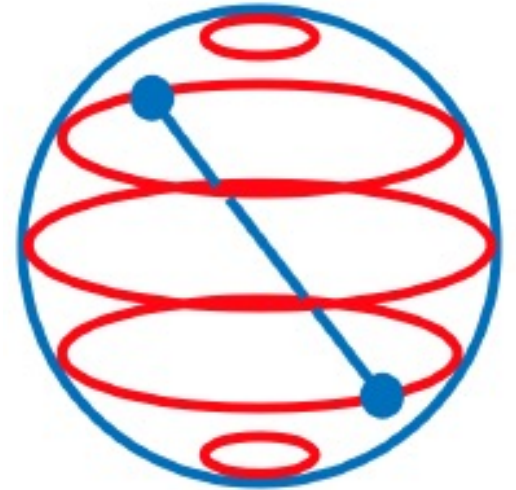




IBM Quantum Computing

Jean-Michel Torres
IBM Quantum France Team, Qiskit Advocate
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25 août 2021





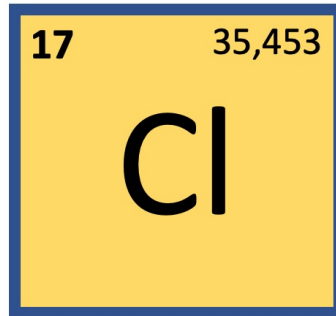
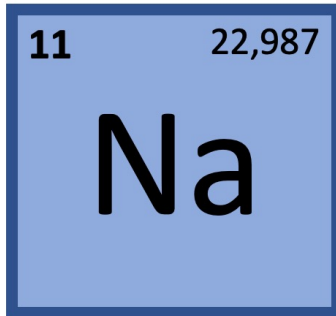
Jean-Michel Torres

IBM Quantum, qiskit advocate, PMP©

torresjm@fr.ibm.com

Mes connaissances en chimie :

métal explosif + gaz toxique = sel de table ... ?



Agenda

- 14h : introduction, premiers pas, visite guidée des machines.
- 14h40 : qiskit crash course
- 15h20 : premiers algorithmes, et Grover
- 16h : pause
- 16h20 : VQE (Lena Pérennès)
- 17h20 : QPE
- 18h : quizz, cocktail (« Itinéraire Bis »)
- 22h : fin

<https://github.com/jmit34/RFCT>

*Pas de boisson/nourriture dans l'amphithéâtre,
L'amphithéâtre fermera à 19h30 : ne rien y laisser après la session, utiliser le vestiaire.*

The road to Quantum Advantage

Quantum Science

Create the fundamental theoretical and physical building blocks of quantum computing.

1900s

Quantum Ready

Engage the world to prepare for the quantum computing era.

Launch of the IBM Q Network

2016

Quantum Advantage

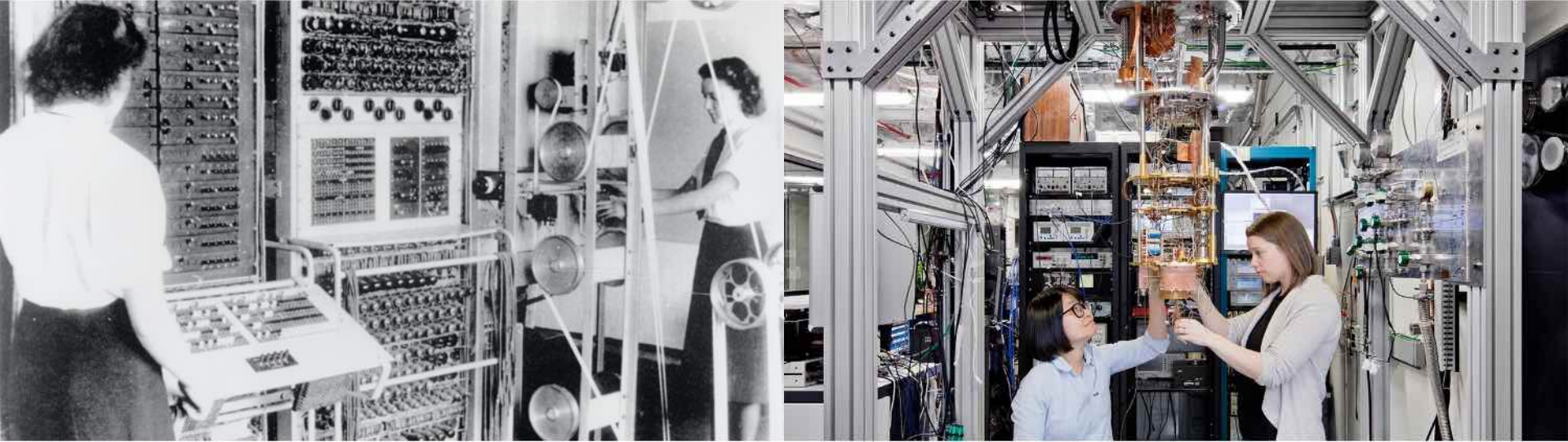
Commercial advantage to solving real world problems with quantum computing systems.

- Hybrid classical-quantum systems and solutions
- Extract commercial value
- Enable scientific discovery
- Demonstrate an advantage for using quantum computing for real problems of interest

~2020s

2050+

We are in the early stages of a rapidly advancing new computing technology

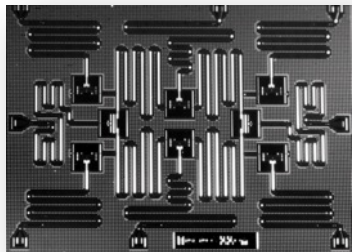


Classical Computer 1944

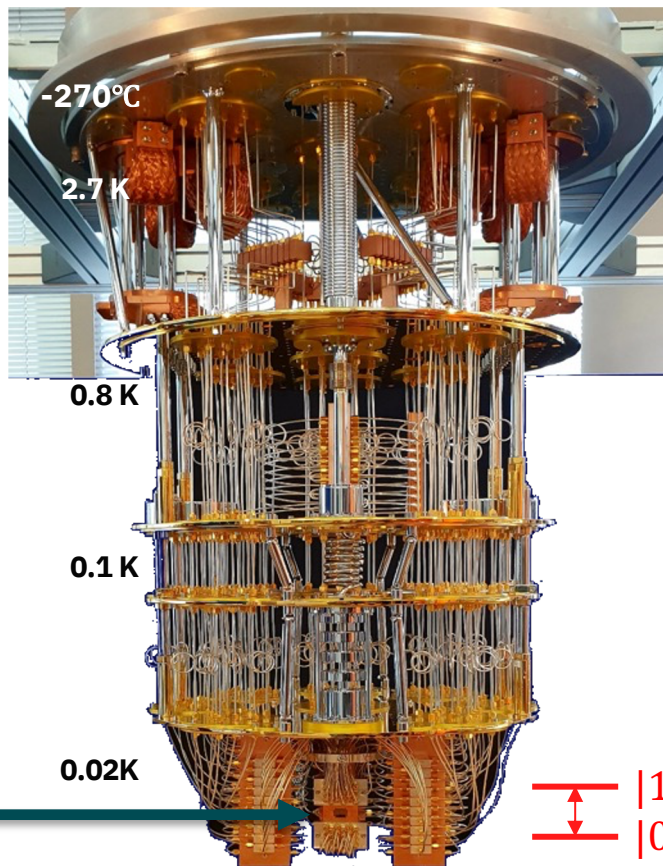
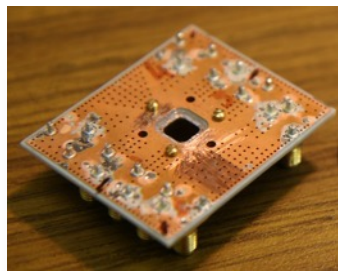
Quantum Computer 2019

Insight into the “Cool” Quantum World

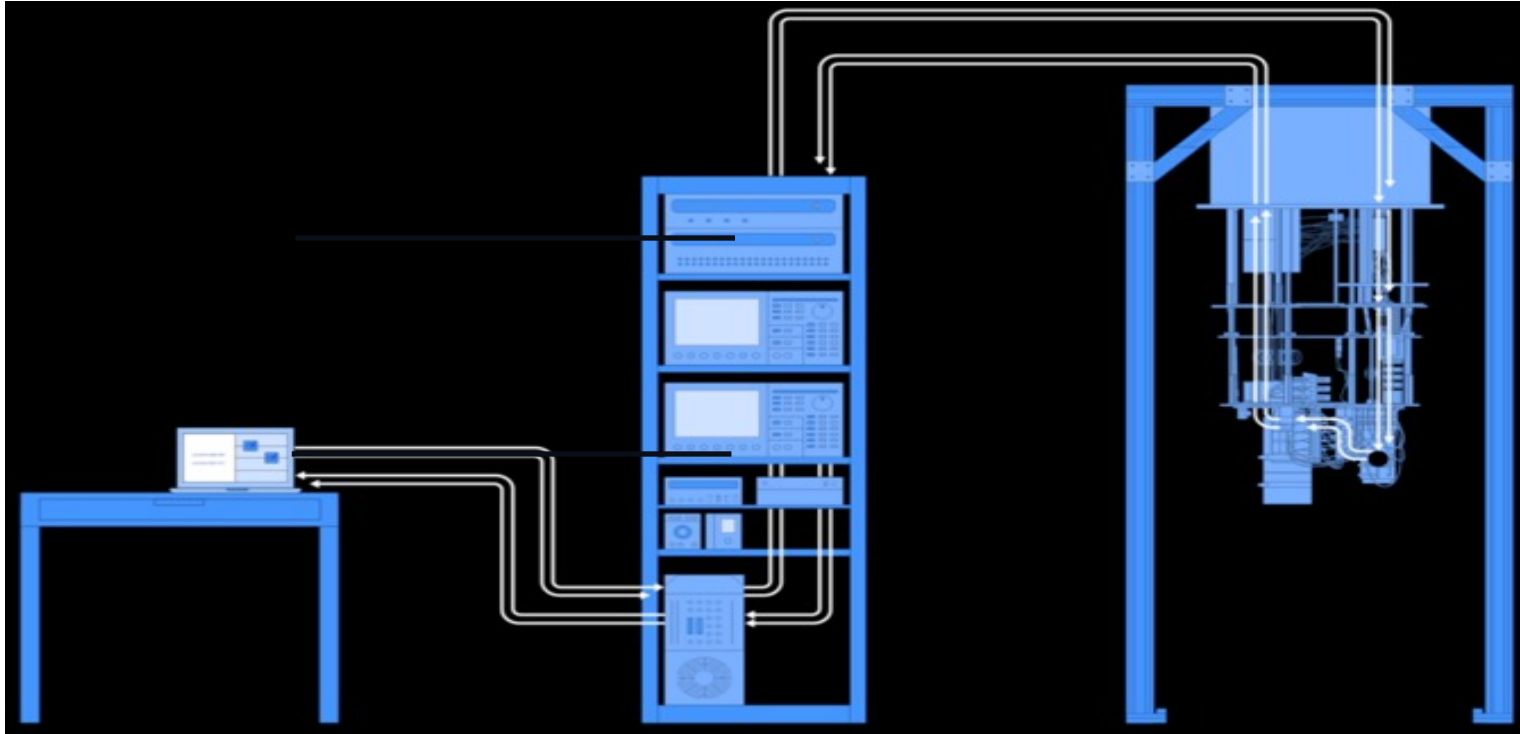
Superconducting chip



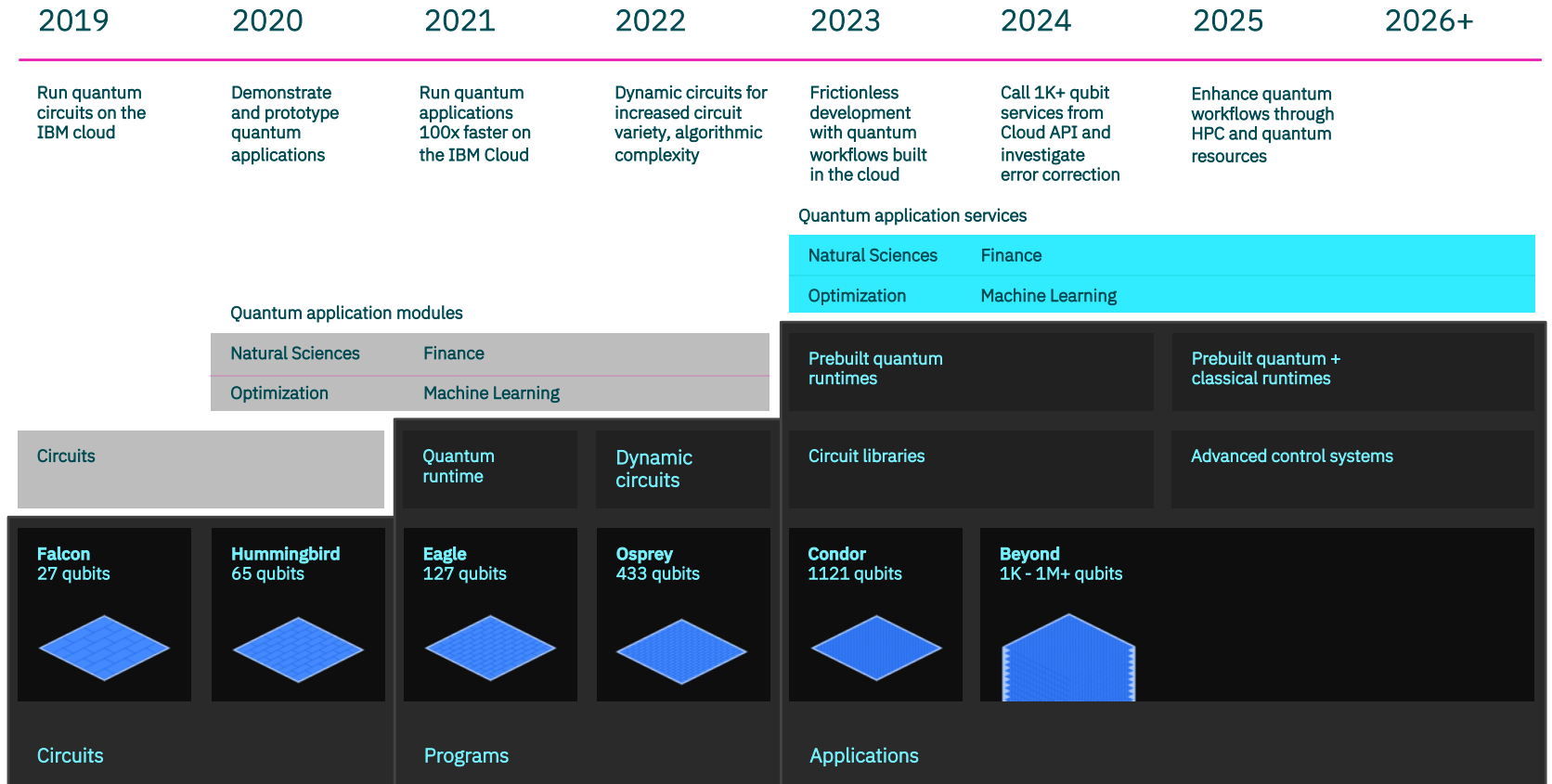
Circuit board with qubit-Chip at 20mK



IBM Q Quantum Computing System Accessible in the Cloud



IBM Quantum Development Roadmap



IBM Quantum Systems in the Cloud

ibmq_montreal System status ● Online Processor type Falcon r4 27 Qubits 128 Quantum volume	ibmq_mumbai System status ● Online Processor type Falcon r5.1 27 Qubits 128 Quantum volume	ibmq_kolkata System status ● Online Processor type Falcon r5.11 27 Qubits 128 Quantum volume	ibmq_dublin System status ● Online Processor type Falcon r4 27 Qubits 64 Quantum volume	ibmq_hanoi System status ● Online Processor type Falcon r5.11 27 Qubits 64 Quantum volume
ibmq_cairo System status ● Online Processor type Falcon r5.11 27 Qubits 64 Quantum volume	ibmq_manhattan System status ● Online Processor type Hummingbird r2 65 Qubits 32 Quantum volume	ibmq_brooklyn System status ● Online Processor type Hummingbird r2 65 Qubits 32 Quantum volume	ibmq_toronto System status ● Online Processor type Falcon r4 27 Qubits 32 Quantum volume	ibmq_sydney System status ● Online Processor type Falcon r4 27 Qubits 32 Quantum volume
ibmq_guadalupe System status ● Online Processor type Falcon r4P 16 Qubits 32 Quantum volume	ibmq_casablanca System status ● Online Processor type Falcon r4H 7 Qubits 32 Quantum volume	ibmq_lagos System status ● Online Processor type Falcon r5.11H 7 Qubits 32 Quantum volume	ibmq_nairobi System status ● Online Processor type Falcon r5.11H 7 Qubits 32 Quantum volume	ibmq_santiago System status ● Online Processor type Falcon r4L 5 Qubits 32 Quantum volume
ibmq_manila System status ● Online Processor type Falcon r5.11L 5 Qubits 32 Quantum volume	ibmq_bogota System status ● Online Processor type Falcon r4L 5 Qubits 32 Quantum volume	ibmq_jakarta System status ● Online Processor type Falcon r5.11H 7 Qubits 16 Quantum volume	ibmq_quito System status ● Online Processor type Falcon r4T 5 Qubits 16 Quantum volume	ibmq_belem System status ● Online Processor type Falcon r4T 5 Qubits 16 Quantum volume
ibmq_lima System status ● Online Processor type Falcon r4T 5 Qubits 8 Quantum volume	ibmq_armonk System status ● Online Processor type Canary r1.2 1 Qubit 1 Quantum volume			

simulator_stabilizer

Simulator status ● Online
 Simulator type Clifford simulator

5000 Qubits

simulator_mps

Simulator status ● Online
 Simulator type Matrix Product State

100 Qubits

simulator_extended_stabilizer

Simulator status ● Online
 Simulator type Extended Clifford (e.g. Clifford+T)

63 Qubits

ibmq_qasm_simulator

Simulator status ● Online
 Simulator type General, context-aware

32 Qubits

simulator_statevector

Simulator status ● Online
 Simulator type Schrödinger wavefunction

32 Qubits

IBM Quantum Systems in the Cloud

ibmq_manhattan

Details

65 Qubits	Status: ● Online	Avg. CNOT Error: 3.005e-2
32 Quantum Volume	Total pending jobs: 92 jobs	Avg. Readout Error: 4.223e-2
	Processor type ⓘ: Hummingbird r2	Avg. T1: 63.51 us
	Version: 1.21.12	Avg. T2: 73.04 us
	Basis gates: CX, ID, RZ, SX, X	Providers with access: 0 Providers ↓
	Your usage: 0 jobs	

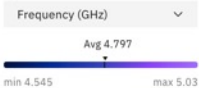
Your upcoming reservations 0

Calibration data

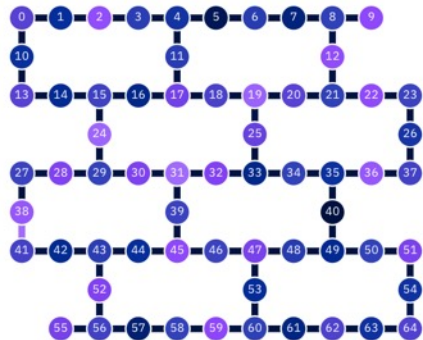
Last calibrated: an hour ago

Map view Graph view Table view

Qubit:



Connection:



ibmq_kolkata

You do not have access to this system To learn more about access options, [click here](#)

Details

27 Qubits	Status: ● Online	Avg. CNOT Error: 1.095e-2
128 Quantum Volume	Total pending jobs: 0 jobs	Avg. Readout Error: 9.893e-3
	Processor type ⓘ: Falcon r5.11	Avg. T1: 122.59 us
	Version: 1.8.22	Avg. T2: 120.01 us
	Basis gates: CX, ID, RZ, SX, X	Providers with access: --
	Your usage: --	

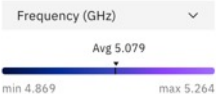
Your upcoming reservations

Calibration data

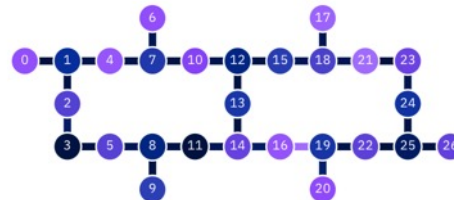
Last calibrated: 42 minutes ago

Map view Graph view Table view

Qubit:



Connection:



IBM Quantum Computing : composer

File Edit Inspect View Share Setup and run

mains00 Saved Visualizations seed 7650

H ⊕ ⊗ ⊗ X I T S Z T† S† P RZ |0⟩ if √X √X† Y RX RY U RXX RZZ + Add

q 0 ⊕ H ⊕ H Z ⊕
q 1 ⊕
+
c2

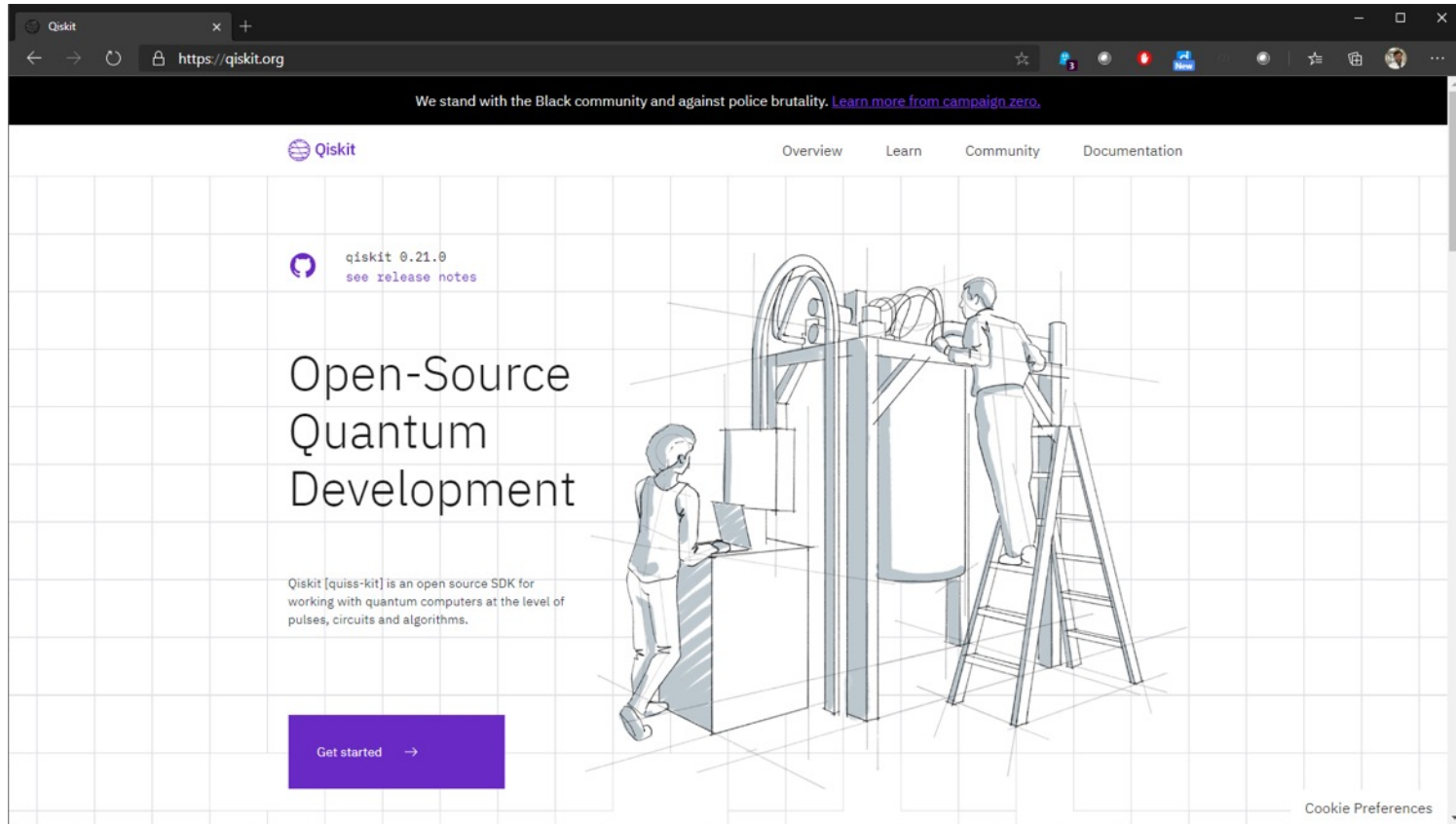
Statevector Q-sphere

Output state
[-1+0j, 0+0j, 0+0j, 0+0j]

```
1 from qiskit import QuantumRegister,  
2 ClassicalRegister, QuantumCircuit  
3 from numpy import pi  
4 qreg_q = QuantumRegister(2, 'q')  
5 creg_c = ClassicalRegister(2, 'c')  
6 circuit = QuantumCircuit(qreg_q, creg_c)  
7  
8 circuit.x(qreg_q[0])  
9 circuit.h(qreg_q[0])  
10 circuit.cx(qreg_q[1], qreg_q[0])  
11 circuit.h(qreg_q[0])  
12 circuit.z(qreg_q[0])  
13 circuit.x(qreg_q[0])
```

qiskit : open source Python Library for quantum computing

qiskit.org



The screenshot shows the qiskit.org website in a browser window. The browser's address bar displays "https://qiskit.org". A black banner at the top of the page contains the text: "We stand with the Black community and against police brutality. [Learn more from campaign zero.](#)". Below the banner is the Qiskit logo and a navigation menu with links for "Overview", "Learn", "Community", and "Documentation". The main content area features a grid background. On the left, the text "qiskit 0.21.0" is displayed with a link to "see release notes". To the right of this text is a line-art illustration of two people working on a large, complex quantum computing device. One person is standing at a desk with a laptop, while the other is on a ladder working on the top of the machine. The text "Open-Source Quantum Development" is prominently displayed in the center. Below this, a paragraph states: "Qiskit [quiss-kit] is an open source SDK for working with quantum computers at the level of pulses, circuits and algorithms." At the bottom left, there is a purple button with the text "Get started" and a right-pointing arrow. In the bottom right corner, there is a link for "Cookie Preferences".

Qiskit

Overview Learn Community Documentation

qiskit 0.21.0
[see release notes](#)

Open-Source Quantum Development

Qiskit [quiss-kit] is an open source SDK for working with quantum computers at the level of pulses, circuits and algorithms.

Get started →

Cookie Preferences

Worldwide Qiskit community events



Congrats to our [#qiskithaifa](#) winners for their project, Ghost States: Simulating the speculative paths of the wave-function under measurements. 🏆 Keren Avnery, [@MatanParnas](#), Gilad Pollack, [@galvien](#)



2:24 AM · 29 May 2019 from Israel

7 Retweets 26 Likes



Follow

Our [#qiskitmadrid](#) hackathon was a blast! Thank you to all of the hackers for their contributions to [#qiskit](#)! Check out the fun for yourself 🙌 (1/3)



1:42 PM · 31 May 2019

31 Retweets 64 Likes



Qiskit @qiskit · May 31

Want to learn more about the details of the hackathon projects? Click the link for the full blog recap 🙌 [bit.ly/2WeXyfd](#) [#quantumcomputing](#) (2/3)



Recap: Madrid Hackathon

Qubit-based games, cryptography, random numbers—Madrid went full quantum last weekend at our first international Qiskit hackathon. [medium.com](#)

Merçi pour votre attention

