Barış Malcıoğlu

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Please fill out the consent & schedule form!!!

Instructors

- Zeki Seskir
- Cenk Tüysuz
- Berat Yenilen
- Barış Malcıoğlu

Important links:

- ODTÜClass
- obm.physics.metu.edu.tr
- metu-physics.github.io/Quantum-Computing-101/
- metu-physics.github.io/HPC/
- qiskit.org/textbook/

What this course is , what this course is not

Introduction

The COLOSSUS computer:

en.wikipedia.org/wiki/Colossus_computer

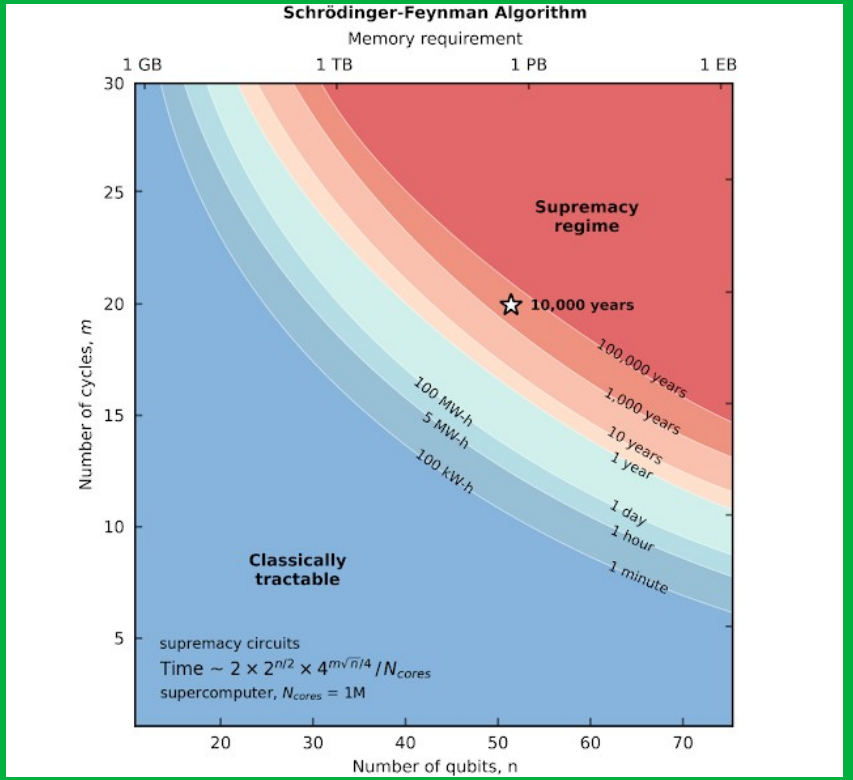
First computer was built in 1943, kept a secret until 1970s. Used to decipher German communications.

The “Discrete logarithm problem” “RSA problem” (computationally intractable)

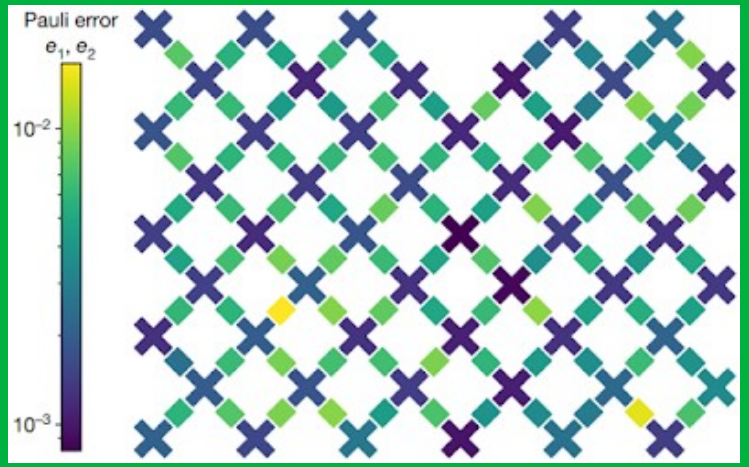
All truth passes through three stages. First, it is ridiculed. Second, it is violently opposed. Third, it is accepted as being self-evident.
Arthur Schopenhauer

Shor’s algorithm:
en.wikipedia.org/wiki/Shor's_algorithm
(Efficient factorization of Integer primes)
RSA / ECDSA

Quantum supremacy

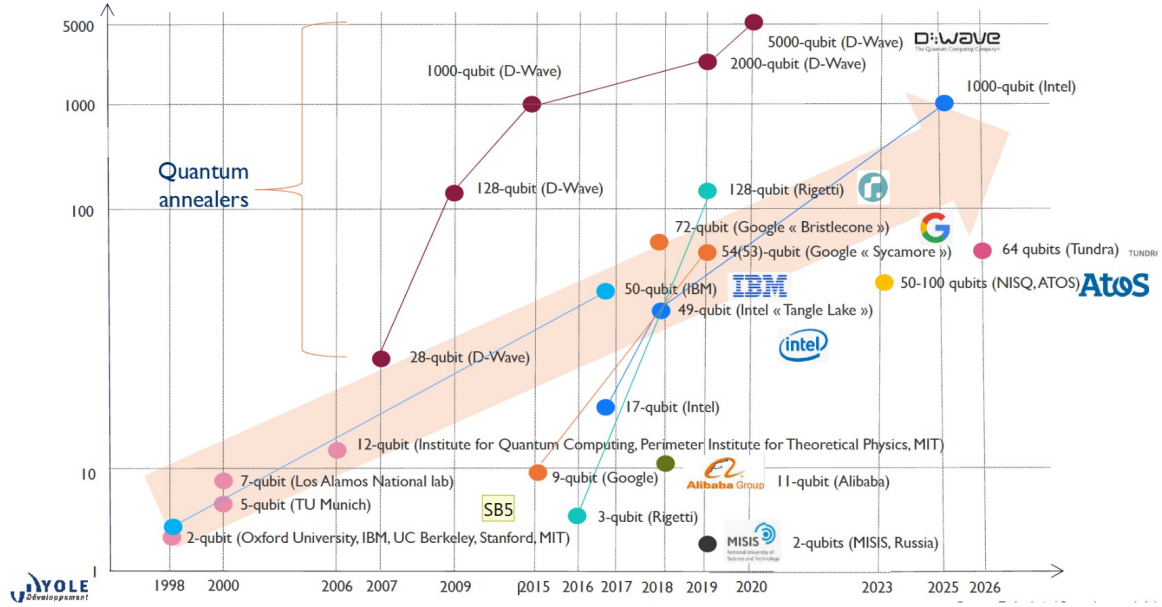


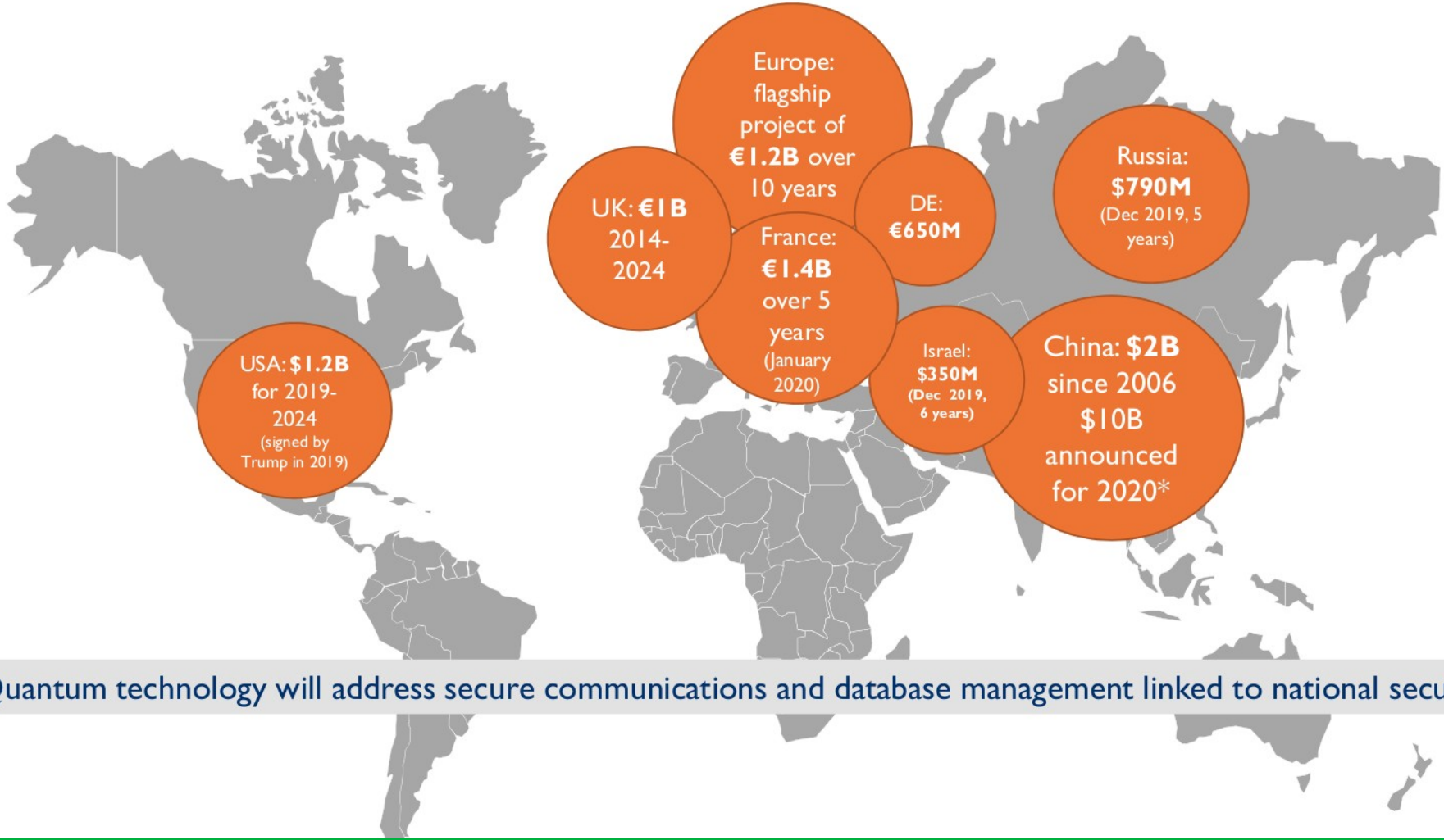
The Sycamore Processor



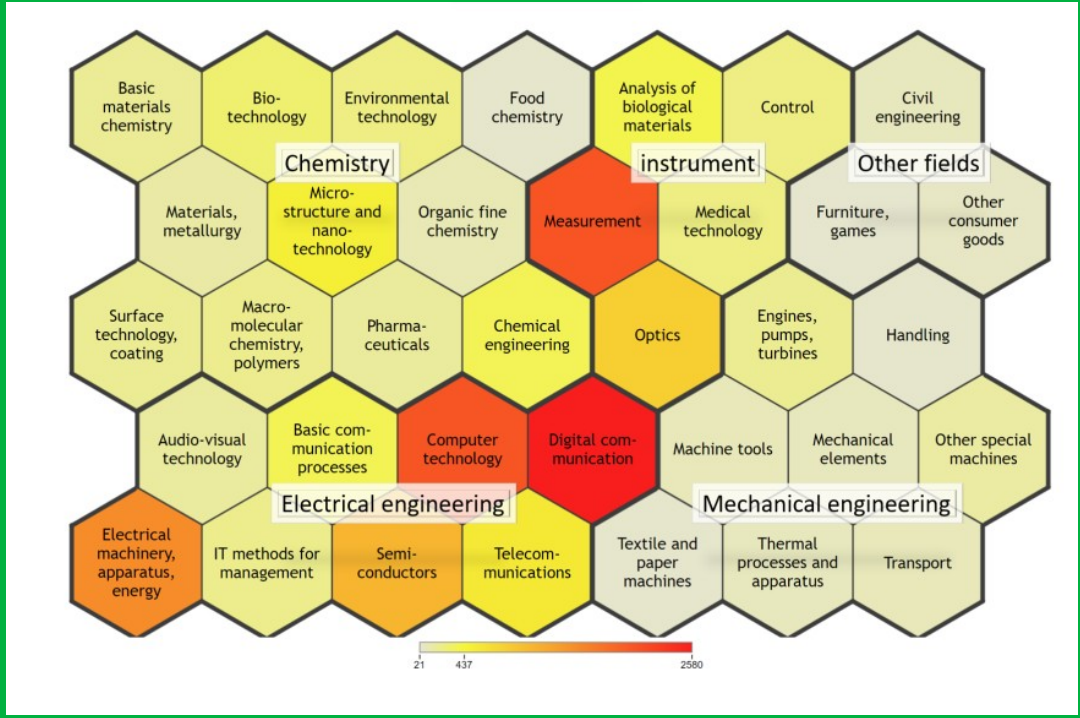
RACE TO QUANTUM ADVANTAGE

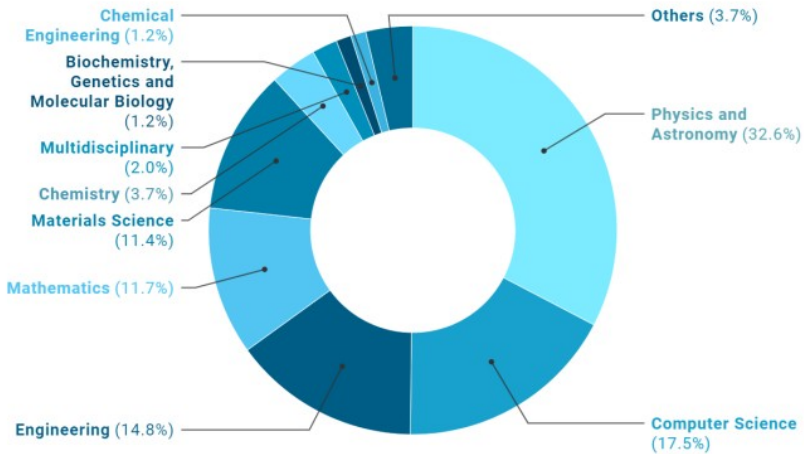
US, Canada and China got to an early start



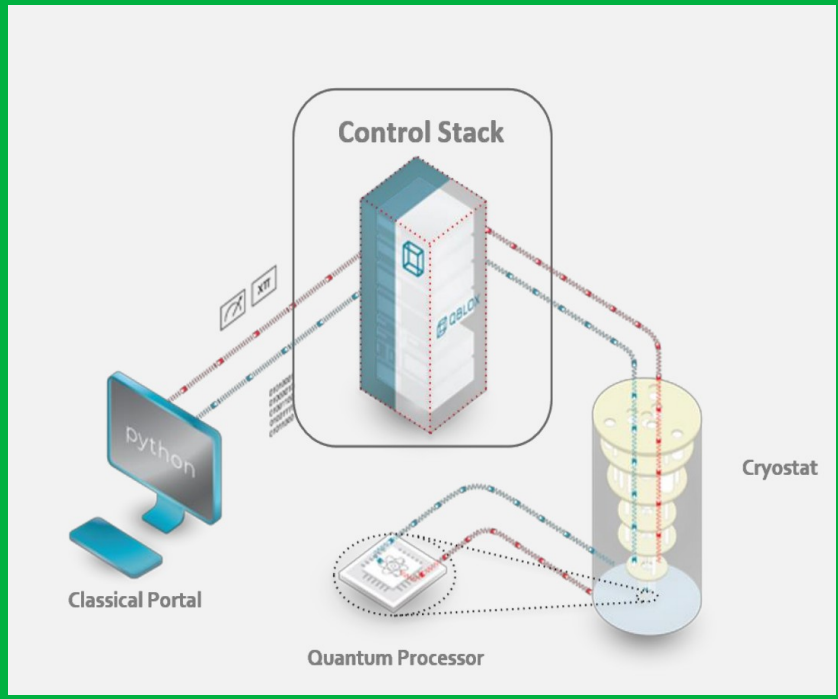


Quantum technology will address secure communications and database management linked to national security.

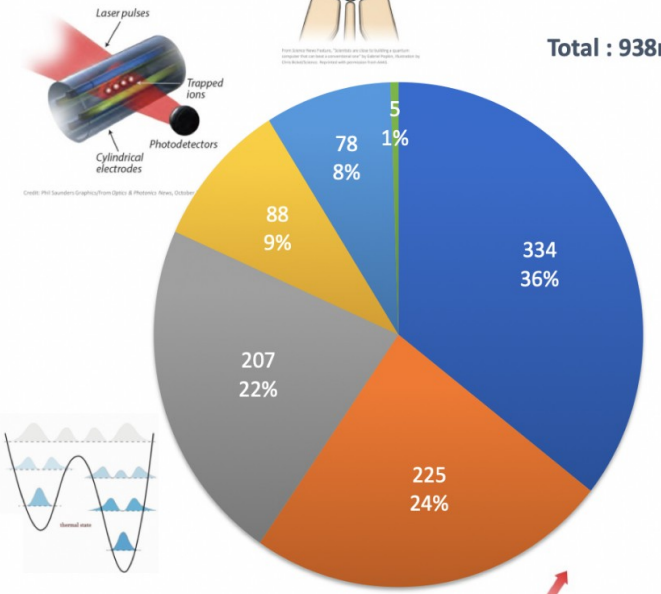

Basic materials chemistry
Bio-technology
Environmental technology
Food chemistry
Analysis of biological materials
Control
Civil engineering
Chemistry
instrument
Other fields
Materials, metallurgy
Micro-structure and nano-technology
Organic fine chemistry
Measurement
Medical technology
Furniture, games
Other consumer goods
Surface technology, coating
Macro-molecular chemistry, polymers
Pharma-ceuticals
Chemical engineering
Optics
Engines, pumps, turbines
Handling
Audio-visual technology
Basic com-munication processes
Computer technology
Digital com-munication
Machine tools
Mechanical elements
Other special machines
Electrical engineering
Mechanical engineering
Electrical machinery, apparatus, energy
IT methods for management
Semi-conductors
Telecom-munications
Textile and paper machines
Thermal processes and apparatus
Transport
21
437
2580



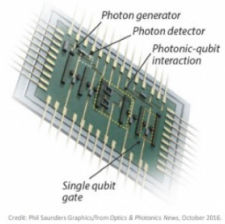
Domain	TP	%TP	TC	CPP
Physics and Astronomy	10,004	32.6%	169,012	16.9
Computer Science	5,388	17.5%	33,011	6.1
Engineering	4,558	14.8%	32,803	7.2
Mathematics	3,583	11.7%	24,315	6.8
Materials Science	3,511	11.4%	40,940	11.7
Chemistry	1,140	3.7%	25,277	22.2
Multidisciplinary	627	2.0%	36,606	58.4
Biochemistry, Genetics and Molecular Biology	383	1.2%	10,125	26.4
Chemical Engineering	354	1.2%	9,177	25.9
Social Sciences	291	0.9%	2,024	7.0

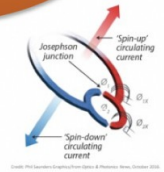

Control Stack
python
Classical Portal
Quantum Processor
Cryostat


Microwaves


Total : 938m$
334
36%
225
24%
207
22%
88
9%
78
8%
5
1%
Photonic
Superconducting
Adiabatic/Annealing
Trapped Ion
Spin/Quantum Dot
Cold/Neutral/Helium Atom

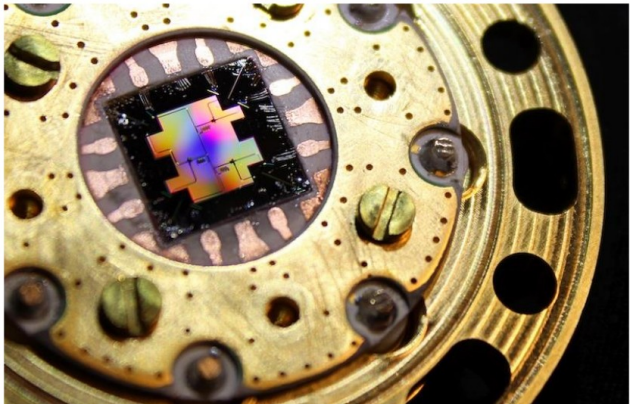
Laser pulses
Trapped ions
Photodetectors
Cylindrical electrodes


Photon generator
Photon detector
Photonic-qubit interaction
Single qubit gate


Josephson junction
'Spin-up' circulating current
'Spin-down' circulating current

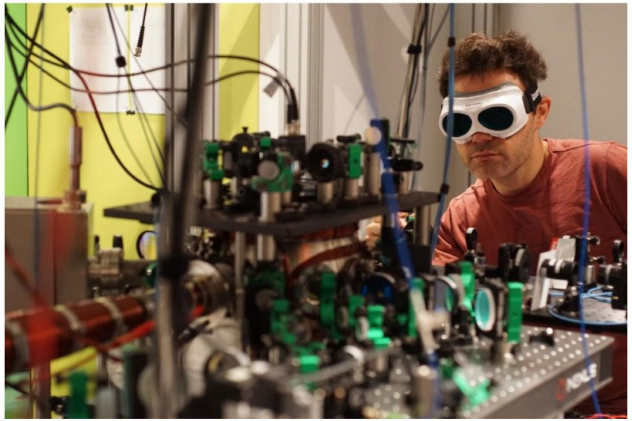
IQM (Finland & Germany)

Fastest superconducting gates in the world



Pasqal (France)

World's leading neutral atom platform



Quantum Tech: Quantum computing

Different platforms and hardware

Graphics: Nathan Shammah

		Advantages	Challenges
Gate-based	 Superconducting circuits	15 years of exponential improvement in extending dephasing time (x10 / 3yrs).	Artificial atoms: defects, off-resonances. Wiring leads to qubit cross-talk. Requires cooling @ micro K Temp.
	 Trapped ions	'Perfect' qubits due to identical ions. Long coherence time even @ room Temp. Long-range interaction: Full connectivity.	Photonic link/ion shuttling needed to create entanglement between distant modules.
	 Photonics	'Flying' qubits for quantum internet. Silicon integrated chips (CMOS industry). Very long coherence time.	Small interaction hampers two-qubit gates. Hard to have identical photons on demand. Requires interface for storing memory.
	 Spins	CMOS and SiMOS integration. Long coherence time. Up to room temperature qubits.	Charge and nuclear spin noise. Weak interaction with controlling fields.
	 Neutral Atoms	Atoms are identical components. Long-range interactions. Recently: two-Rydberg-atom entanglement.	Hard to trap atom and control qubit. Linear optics, low Temp required @ micro K.
Annealing	Superconducting circuits	Encode optimization problems. No error correction required.	Not a universal quantum computer. Unclear implementation of adiabatic QC. Uncertain entanglement role and scalability.

Quantum Tech: Quantum Circuit Simulators

Open-Source Quantum Computing

	Language	Library	Quantum Hardware	Features
D-Wave	Python	qbsolv	Not a circuit-based computer	Optimization problems
IBM Q	**Python**	QISKit	20 qubits*** 53 qubits*	Thousands of experiments from the cloud by online users on the *IBM quantum experience*
Rigetti	**Python**; pyquil	Forest toolkit Grove	**ONLINE!** 19 qubits*** 128 qubits*	Open to research collaborations. Proof-of-concept: clustering
Google	**Python**	Cirq (simulation)	49 qubits*** 72-qubit SC chip: Bristlecone* 53-qubit SC chip: Sycamore*	*Cirq*: an open-source platform for noisy quantum computing Quantum supremacy
Microsoft	**Python**; Q#	Liquid Quantum Dev Kit	NA	Topological quantum computing with Majorana particles
Alibaba	NA	NA	11-qubit SC chip* unknown architecture	Cloud computing announced