Quantum Computing

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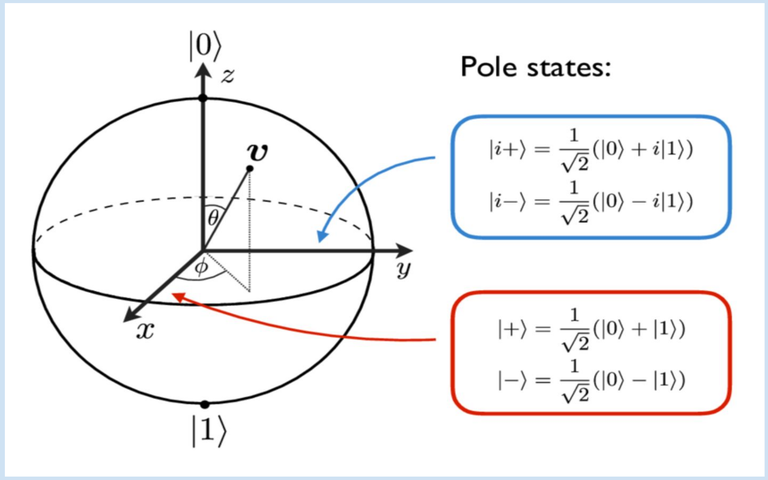
Background

- David Deutsch is the Father of quantum computing [3]
- Deutsch proposed the mathematical concept of the Turning machine in the 1970s [4]
- Quantum computers use qubits instead of bits, which lead to greater computing power over current computers

Quantum Computers	Regular Computers
Use qubits = {00, 10, 01, 11} Super dense coding	Use bits = {0, 1}
In prototype phase, not widespread	Currently exists, very popular
Faster integer integration via Schor's algorithm (polynomial time) [4]	Slow integer factorization (sub-exponential time, unknown if it can ever be faster)



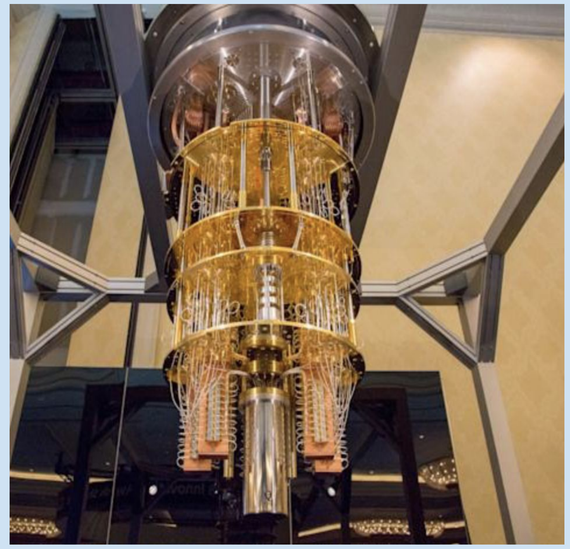
Mathematics

Qubits start in a $|0\rangle$ state, but we can apply quantum gates to them [2]

$\|\Psi\rangle = i\|0\rangle - (1+i)(\|0\rangle + \|1\rangle)$	The qubit state as a two-dimensional vector [5]
$\|+\rangle = 1/\sqrt{2}\,(\|0\rangle + \|1\rangle)$ and $\|-\rangle = 1/\sqrt{2}\,(\|0\rangle - \|1\rangle)$ $\|i+\rangle = 1/\sqrt{2}\,(\|0\rangle + i\|1\rangle)$ and $\|i-\rangle = 1/\sqrt{2}\,(\|0\rangle - i\|1\rangle)$	There are 3 different bases used in the Bloch sphere [2]
$\|\psi\rangle = \alpha\|0\rangle + \beta\|1\rangle$	- Equation for a qubit in superposition is shown as a linear combination - Where α and β are the probability amplitudes, always add up to 1 [2]
$1/\sqrt{2}(\|0\rangle + \|1\rangle)$	A qubit in superposition has this expression [2]

The Future

40% of startup companies are working on quantum computers, will that percentage rise?
Which company or companies will create the most intelligent quantum computer?
33% of universities are working on quantum computers, will more universities start doing this?
[6]



Applications

- **Artificial intelligence**
- **Pharmaceuticals**
- **Factorization**
- **Optimization**
- Encryption
- Quantum tunnelling
- **Simulation**

[1]

Citations

[1] Jackson, Mark, and Jackson. "6 Things Quantum Computers Will Be Incredibly Useful For." *Singularity Hub*, 16 Nov. 2017, singularityhub.com/2017/06/25/6-things-quantum-computers-will-be-incredibly-useful-for/.
[2] Laforest, Martin. "The Mathematics of Quantum Mechanics." *University of Waterloo*, Institute for Quantum Computing, 2015, uwaterloo.ca/institute-for-quantum-computing/sites/ca.institute-for-quantum-computing/files/uploads/files/mathematics_qm_v21.pdf.
[3] Norton, Quinn. "The Father of Quantum Computing." *Wired*, Conde Nast, 15 Feb. 2007, www.wired.com/2007/02/the-father-of-quantum-computing/.
[4] Montanaro, Ashley. *The Past, Present, and Future History of Quantum Computing*, School of Mathematics, University of Bristol Bristol, UK, 25 Nov. 2015, people.maths.bris.ac.uk/~csxam/teaching/history.pdf.
[5] DeCross, Matt, and Satyabrata Dash. "Quantum Computing." *Brilliant Math & Science Wiki*, 3 May 2021, brilliant.org/wiki/quantum-computing/.
[6] Kantarci, Atakan. "Quantum Computing Statistics: Forecasts & Facts [2021]." *AIMultiple*, 1 Jan. 2021, research.aimultiple.com/quantum-computing-stats/.