INTRO TO QUANTUM COMPUTING

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Outline

- Why quantum?
- Theme and variation
  - *Intuitive introduction*
  - *Mathematical representation*
  - *Programming a quantum computer!*

Why?

- In Industry..
  - *D-Wave annealer*
    - 2011, 128 qubits
    - 2013, 512 qubits
    - 2015, 1000 qubits
    - 2017, 2000 qubits
  - *Universal Gate Model*
    - 2016, IBM, 5 qubits
    - 2017, IBM, 17 qubits
    - 2017, Intel. 17 qubits
    - 2017, IBM, 50 qubits
    - 2018, Intel, 50 qubits
    - 3-5-2018, Google, 72 qubits
  - *Topological('noise-free')*
    - 2017-2018, Microsoft Station Q, Experimental realizations

Why?

A race between Classical simulation and Quantum chips

Classical

0.5 Petabyte Simulation of a 45-Qubit Quantum Circuit

Thomas Häner, Damian S. Steiger

(Submitted on 4 Apr 2017 (v1), last revised 18 Sep 2017 (this version, v2))

later that year (down to 3 terrabytes of memory)..

30 Oct 2017 | 18:00 GMT

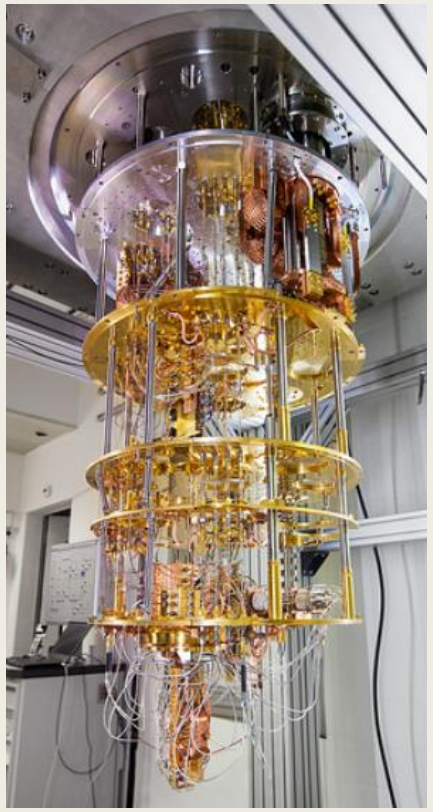
IBM Simulates a 56-Qubit Machine

A supercomputer surpasses the proposed limit of using conventional machines to simulate quantum computers

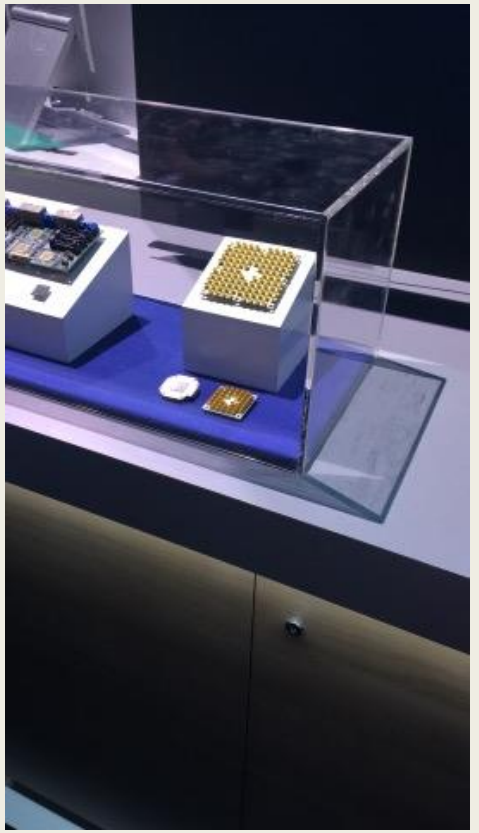
Quantum

15 Nov 2017 | 20:00 GMT

IBM Edges Closer to Quantum Supremacy with 50-Qubit Processor



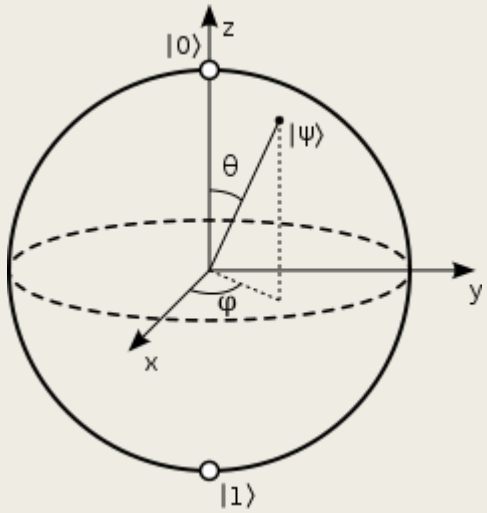
IBM QC



Intel 50 qubit chip – CES 2018

Bit vs Qubit

- Bit
  - *State space {0,1}*
  - *Can clone*
  - *Deterministic measurement*
  - *Measurement does not destroy state*
- Qubit
  - *State space {unit vectors of $\mathbb{C}^2$}*
  - *Can't clone*
  - *Probabilistic measurement*
  - *Measurement destroys state*



Mathematically..

Now in code..

Application: Superdense coding

Quantum Information Software Kit

- Jupyter notebooks

IBM Quantum Experience

Resources

- Active research
  - *https://arxiv.org/archive/quant-ph*
- List of famous quantum algorithms
  - *https://math.nist.gov/quantum/zoo/*
- Books
  - *Quantum Computing and Quantum Information*
  - *Quantum Computer Science*
- Quantum programming languages
  - *QASM, Q#, Quipper*
- Interactive learning
  - *IBM quantum experience, Qskit*
- Purdue groups
  - *Theory group - https://www.chem.purdue.edu/kais/index.html*
  - *Station Q - http://manfragroup.org/*