Quantum Computing → Big Data

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2 December 2021

Quantum-data nexus

DATA SCIENCE: CAPTURE, MAINTAIN, PROCESS, ANALYZE & COMMUNICATE DATA

QUANTUM (Q) COMPUTING: REPLACE BINARY INFORMATION AND BOOLEAN LOGIC BY Q INFORMATION & PROCESSING

GOAL: RADICALLY TRANSFORM ASPECTS OF DATA SCIENCE BY EXPLOITING POTENTIALLY DISRUPTIVE CAPABILITIES OF Q COMPUTING

NOW: Q COMPUTERS AVAILABLE COMMERCIALLY AS WELL AS SOFTWARE FRAMEWORKS TO EVALUATE PERFORMANCE AND BECOME Q READY

bit.ly/3ozT6kp

Classical computing

Information: 0011001

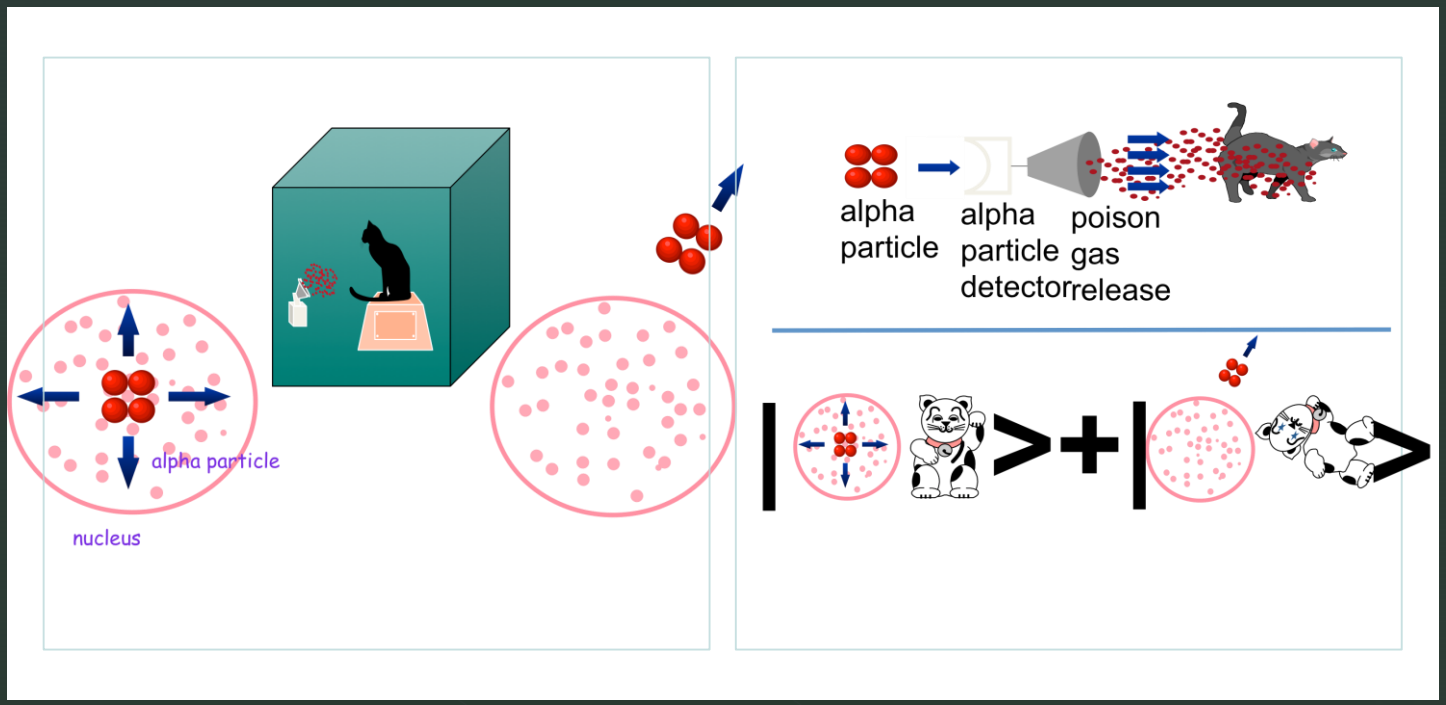
Processing: OR, NAND, NOT

Q computing

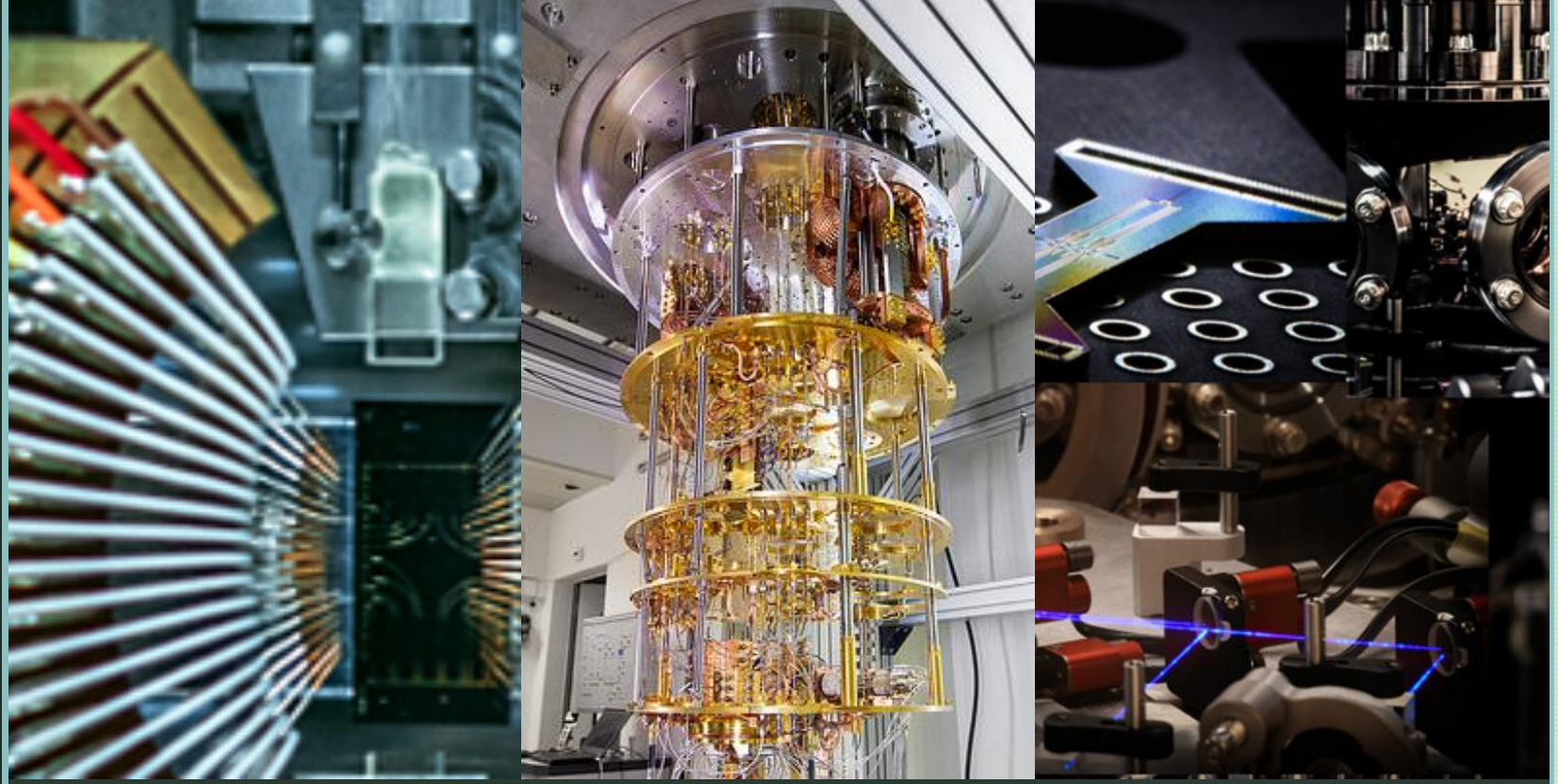
Q Info: $|0011001\rangle+|1100110\rangle$

Q Processing: Quantum logic

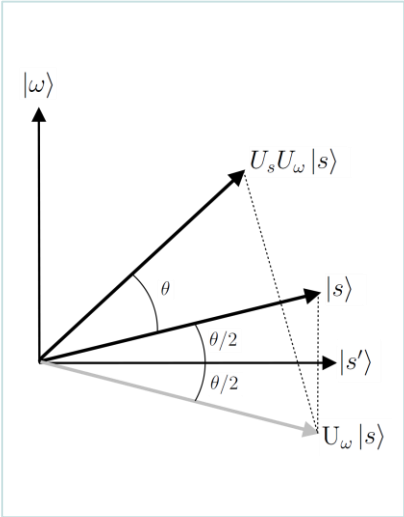
Detection: $|0011001\rangle\langle 0011001|$

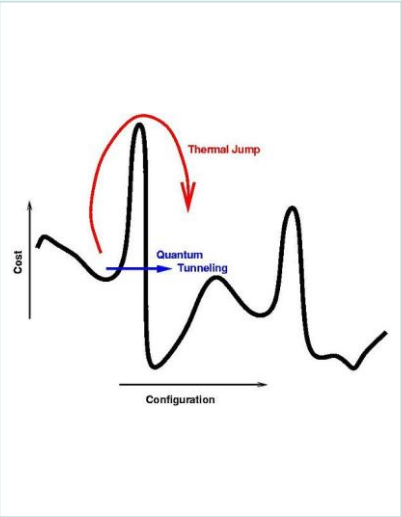


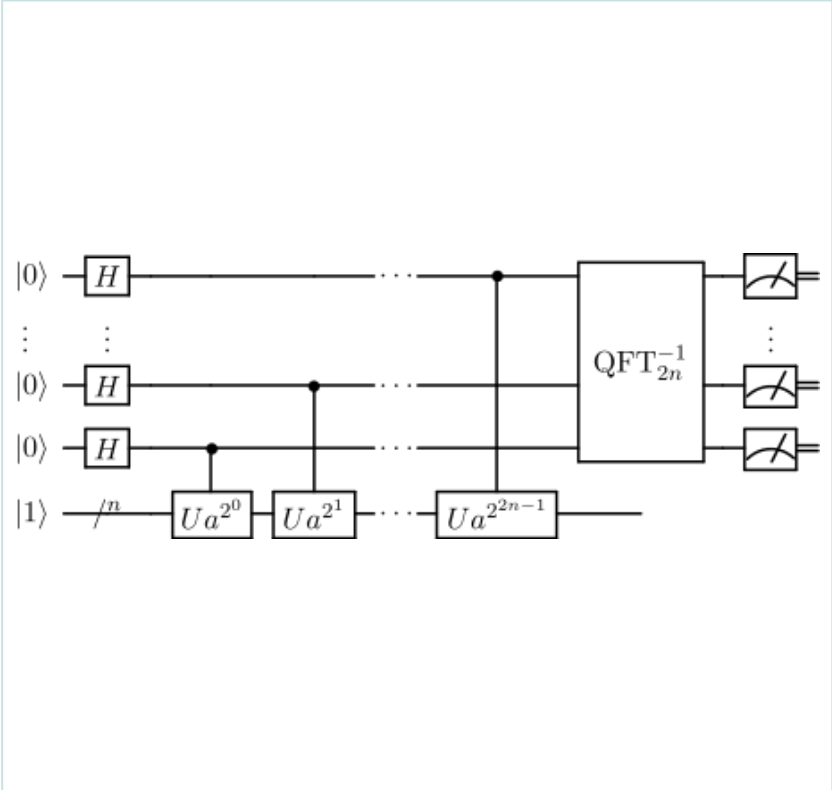
Schrödinger’s cat paradox



Q computers (eg, Xanadu, IBM, Honeywell) doi.org/cr58







Key q algorithms

Quantum Algorithm Zoo

This is a comprehensive catalog of quantum algorithms. If you notice any errors or omissions, please email me at stephen.jordan@microsoft.com. Your help is appreciated and will be acknowledged.

Algebraic and Number Theoretic Algorithms

Algorithm: Factoring
Speedup: Superpolynomial
Description: Given an *n*-bit integer, find the prime factorization. The quantum algorithm of Peter Shor solves this in $\widetilde{O}(n^3)$ time [82,125]. The fastest known classical algorithm for integer factorization is the general number field sieve, which is believed to run in time $2^{\widetilde{O}(n^{1/3})}$. The best rigorously proven upper bound on the classical complexity of factoring is $O(2^{n/4+o(1)})$ via the Pollard-Strassen algorithm [252, 362]. Shor's factoring algorithm breaks RSA public-key encryption and the closely related quantum algorithms for discrete logarithms break the DSA and ECDSA digital signature schemes and the Diffie-Hellman key-exchange protocol. A quantum algorithm even faster than Shor's for the special case of factoring “semiprimes”, which are widely used in cryptography, is given in [271]. If small factors exist, Shor's algorithm can be beaten by a quantum algorithm using Grover search to speed up

Q machine learning 10/gg73nf

Q-enhanced machine learning

- Fewer computational steps for training or classifying
- Lower sample complexity
- Rich set of data models
- Q optimize test loss function

Q device to classify or extract features

- Q Boltzmann & QNeural net
- Q algorithm, eg for principal component analysis
- Quadratic time reduction for q invertible data-training

Quantum Computing
Key Potential Applications

5 Unknown Problems
100,000+ qubits

1 Chemistry
100 – 200 qubits

4 Material Science
100s – 1,000s qubits

2 Optimization
100s – 1,000s qubits

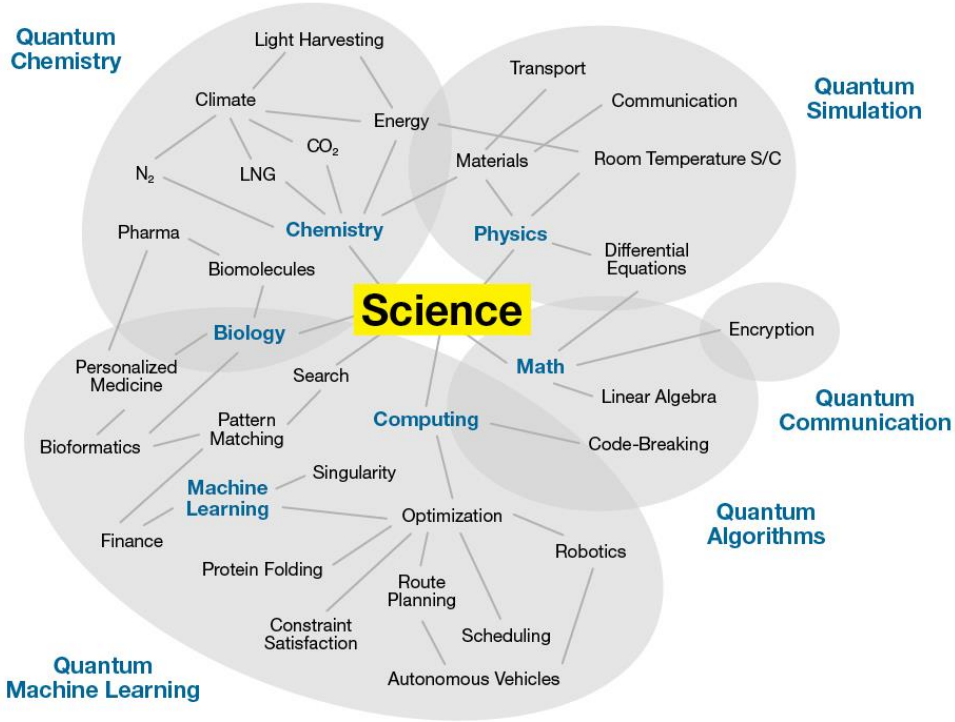
3 Machine Learning
100s – 1,000s qubits

gartner.com/SmarterWithGartner

Source: "Nature," Wikipedia

Gartner®

Quantum Computing
Use Cases



gartner.com/SmarterWithGartner

Source: Adapted from Pete Shadbolt and Jeremy O'Brien

Gartner

Bova et al. *EPJ Quantum Technology* (2021) 8:2
https://doi.org/10.1140/epjqt/s40507-021-00091-1
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EPJ Quantum Technology
a SpringerOpen Journal

COMMENTARY Open Access

Commercial applications of quantum computing

Francesco Bova[1,2], Avi Goldfarb[1,2] and Roger G. Melko[2,3,4*]

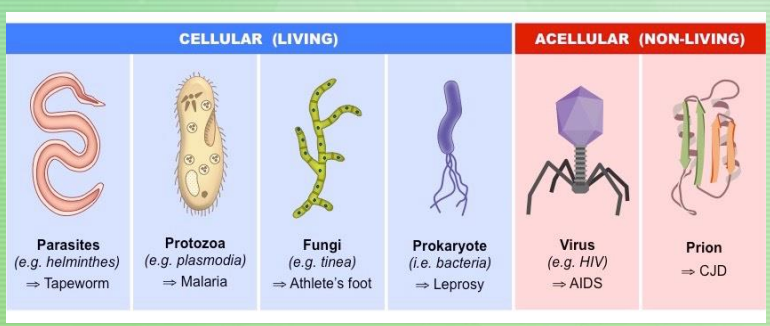
Combinatorial optimization for the verticals:

Materials & pharmaceuticals: Solve lowest-energy molecular configuration

Banking and finance: Portfolio management

Advanced manufacturing: Predict rare failures

Q algorithms in my group



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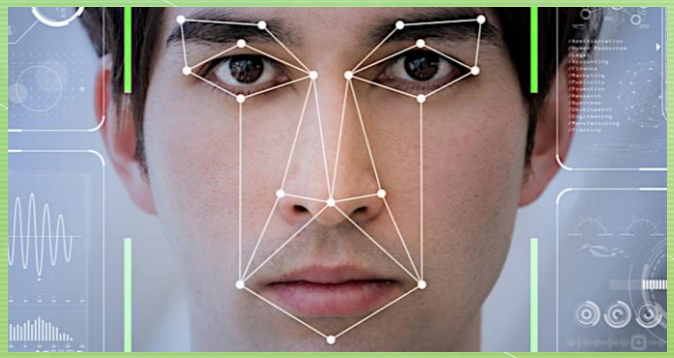
Wikimedia



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techrepublic.com/article/6-experts-share-quantum-computing-predictions-for-2021/

- IBM: 127 qubits with concurrent classical computing
- Gartner: Cloud providers (eg Amazon, Azure) incorporating q capability
- KnowBe4: Q computing breaks traditional public-key crypto
- Lux: Advances in optimizing q hardware to reduce resource needs
- Forrester: Trough of disillusionment