

Quantum Computing: A New Realistic Paradigm

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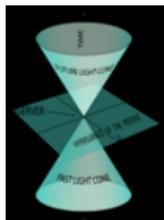


UNIVERSITY OF
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Theme of the talk

- ① Building blocks of matter- Particles
- ② Era of great debate on quantum mechanics:
Metaphysics
- ③ Fundamental principles of quantum mechanics:
Resources
 - Superposition principle- Schrodinger's CAT paradox
 - Non-Orthogonality: Heisenberg's uncertainty principle
 - Entanglement- Einstein Podolsky Rosen Paradox (EPR)
- ④ Physics meets computing sciences- Moore's Law
- ⑤ Quantum mechanics version of information:
Quantum Informatics
- ⑥ Silicon valley giants take on quantum computing



Can particle physics explain the universe?



Particle physics looks at matter
in its smallest dimensions.



Astrophysics looks at matter in its
largest dimensions.



Microscopes
Microscopes

Jumelles
Binoculars

Telescopes optiques & radio
Optical & radio telescopes

Accélérateurs
et détecteurs
Accelerators
and detectors

L'oeil nu.
Naked eye

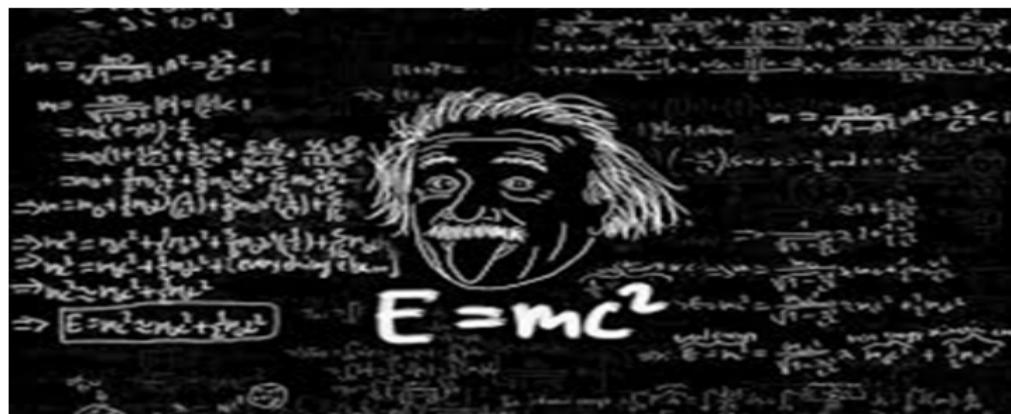
THE TWO FRONTIERS OF PHYSICS

The great Einstein Bohr debate



Einstein Quote of the Day

"Great spirits have often encountered violent opposition from mediocre minds."



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Theme
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Particles
o

Metaphysics
o•o

Fundamental principles
oooooo

Moore's Law
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Quantum Informatics
oooooooo

Silicon Valley Giants
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God does not play dice with the universe!!



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Reality is what is observed. (Bohr)

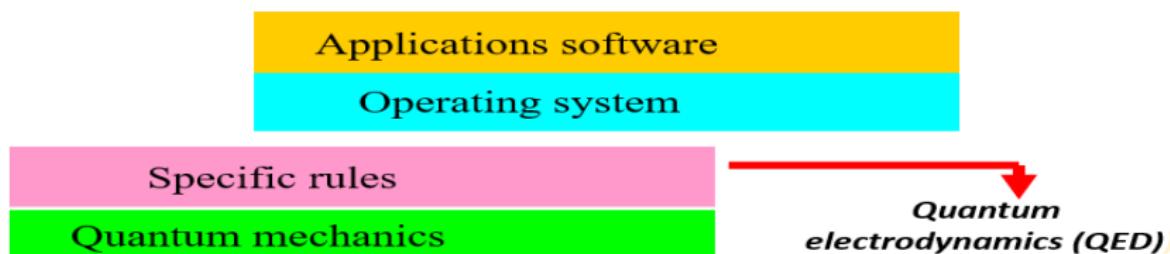


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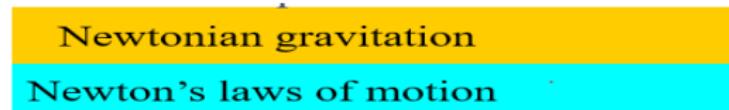
Reality is what it is. (Einstein)

What is Quantum Mechanics (QM)?

It is a complete physical theory in its own.



QM consists of **four mathematical postulates** which lay the ground rules for our description of the world.

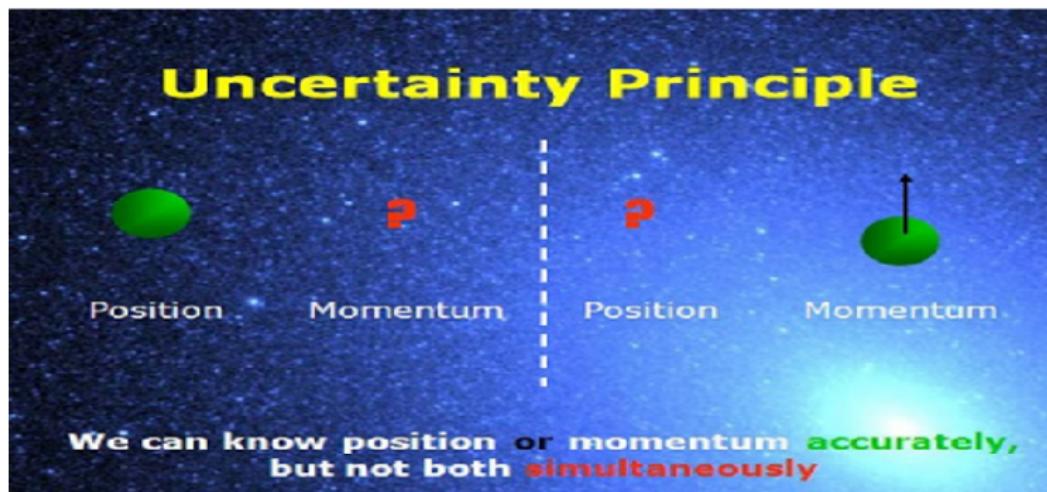


Schrodinger's CAT paradox!! (superposition principle)



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Heisenberg's uncertainty principle (non-orthogonality)

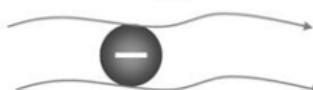


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Wave particle duality

Matter as Waves

$$\lambda = \frac{h}{mv}$$



Note: v is for velocity and not for frequency as shown before.



Louis de Broglie

<https://bit.ly/3Ash9s0>

Wave - particle Duality

Waves

→ could behave as particles (Photons of light)

Similarly,

Matter/Particles → could behave as a wave.
(Electron)



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Einstein Podolsky Rosen Paradox (Entanglement)



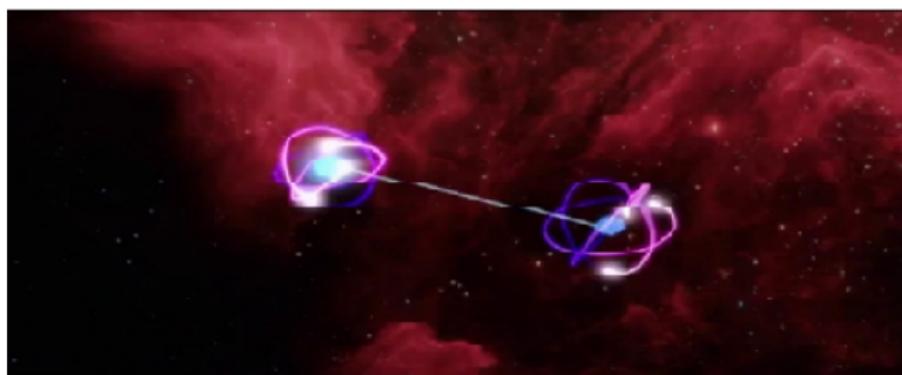
A. Einstein



B. Podolsky



N. Rosen



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Spooky Action at a Distance.

Theme
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Particles
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Metaphysics
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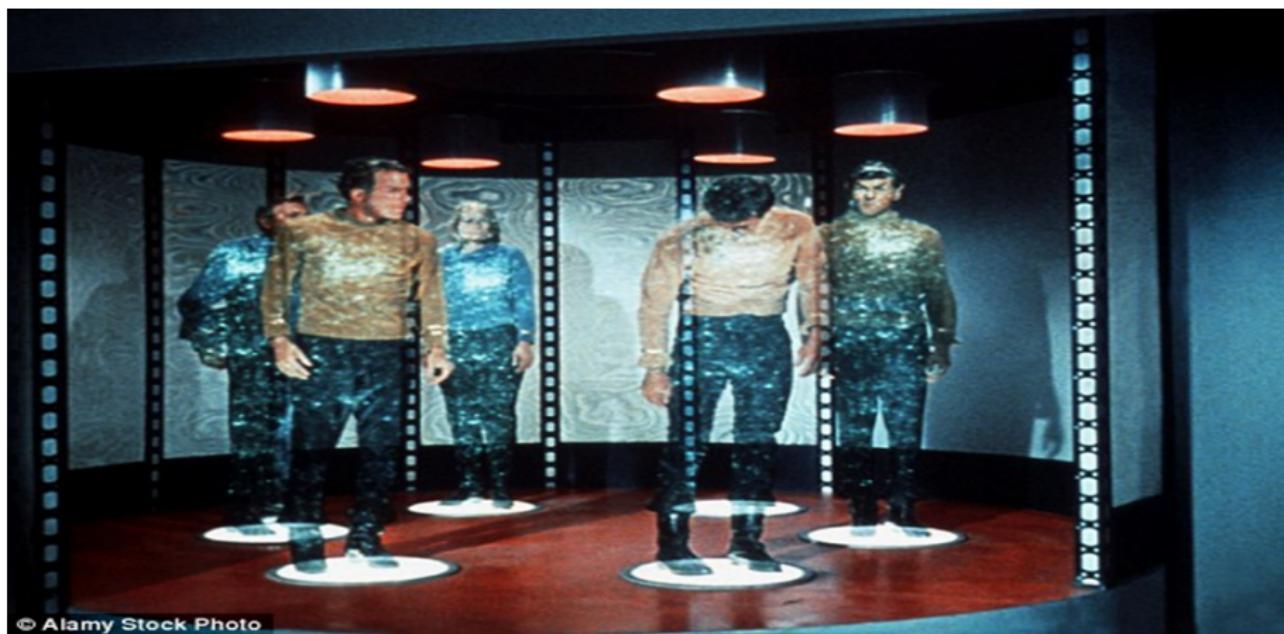
Fundamental principles
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Moore's Law
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Quantum Informatics
oooooooo

Silicon Valley Giants
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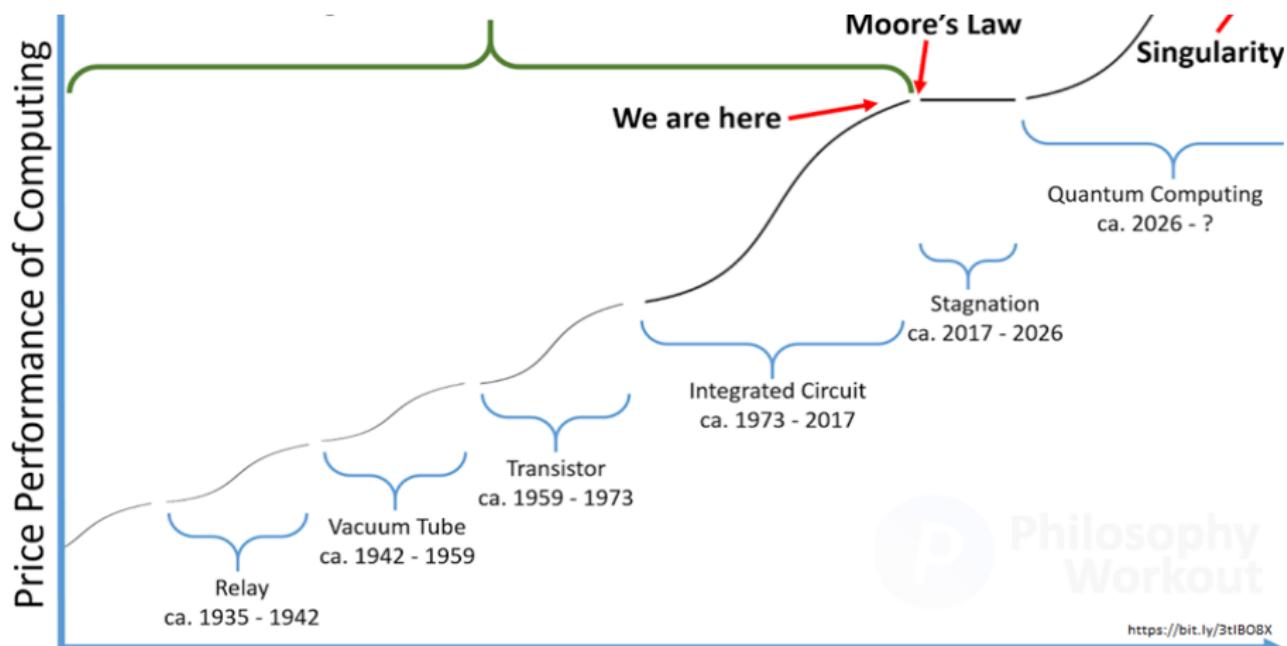
Beam me up Scotty!!

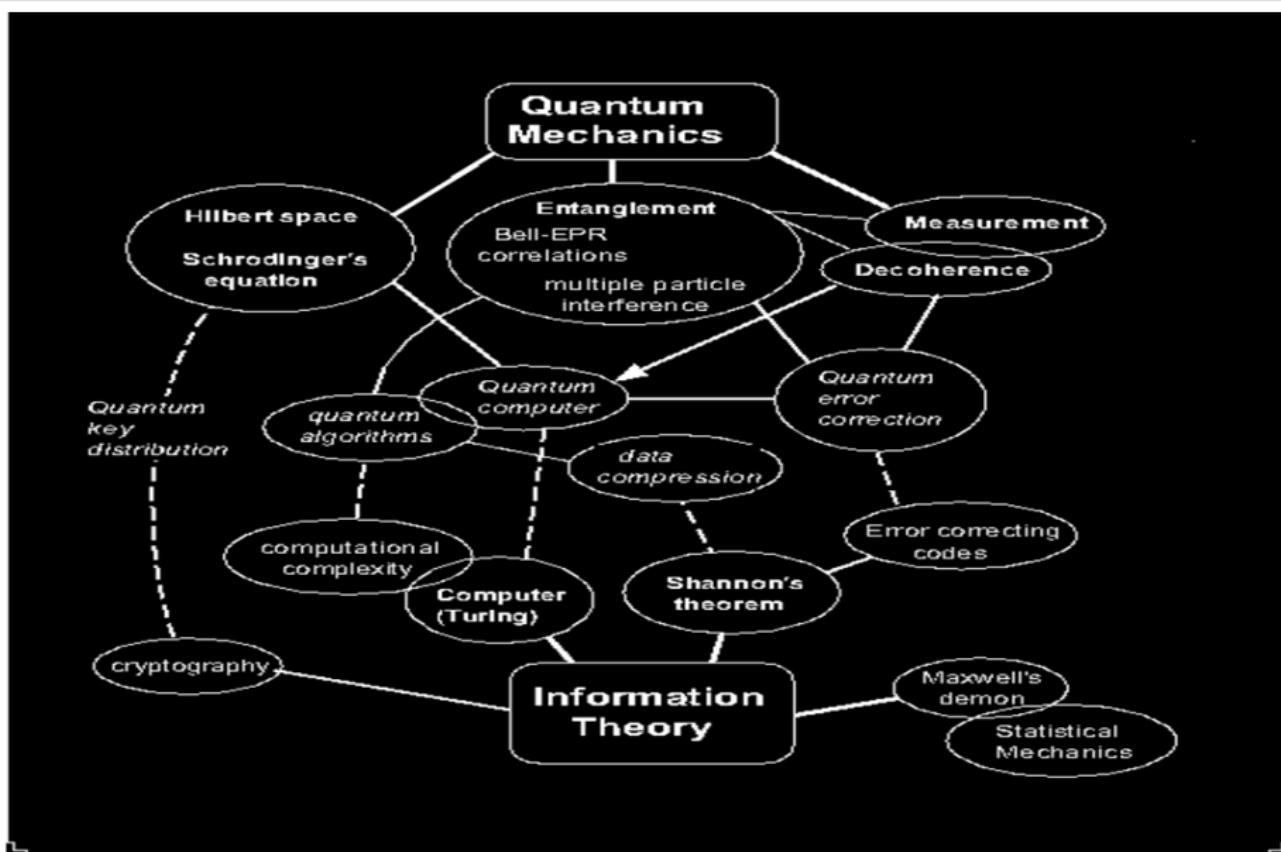


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Physics meets computing sciences- Moore's Law





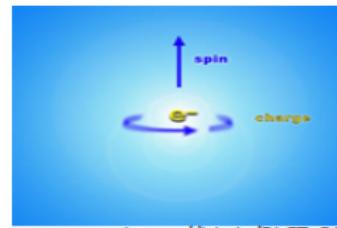
What is Quantum Informatics?

The basis of information theory is discrete mathematics: **binary digits**.

Quantum information employs quantum **states as basic elements of information**.

Examples

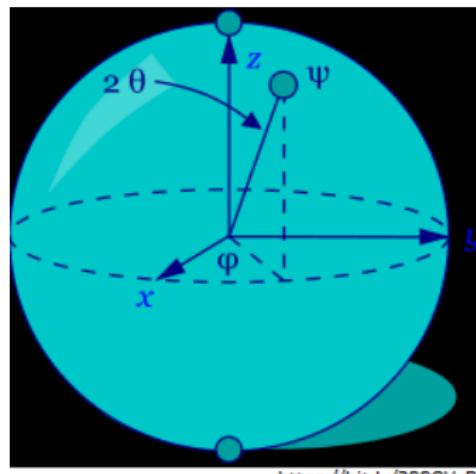
Examples of quantum bits (qubits) are nuclear spin, motion of trapped ions, photons in optical resonators: each offers a future technology for future quantum information processing.



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The Qubit

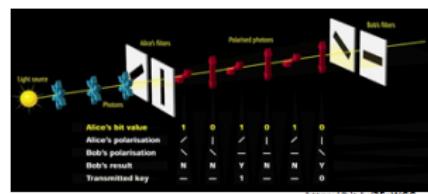
- BIT = Binary digit is basic to information theory.
- QUBIT = Quantum BIT is basic to quantum information theory.



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Consider three aspects

Quantum cryptography: Non-orthogonality



Quantum teleportation: Entanglement

Quantum computation: Superposition

Benefits

Quantum information is “inaccessible” until converted to real information via measurements offers security in quantum cryptography and other sharing protocols, guaranteed by laws of physics rather than assumptions of mathematical difficulty.

“Entanglement” of states makes some incomputable problems computable;

Examples

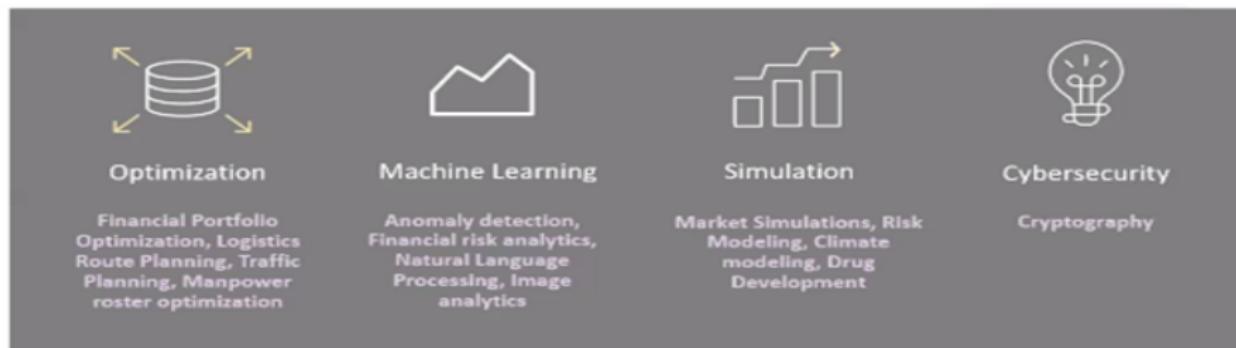
Factorisation, certain simulations.

Challenges



- Quantum cryptography has been achieved but requires further development (sources and detectors).
- Quantum computers not yet developed, but significant efforts are taking place.
- Identification of computing problems for which quantum computing is an advantage.
- Quantum software.

Quantum Computing: Business application areas

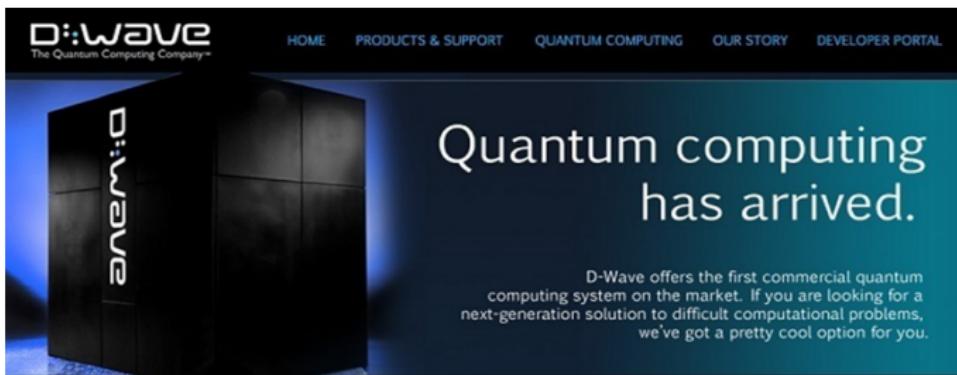


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- QC to provide opportunities/threats on Block Chain. Safety of block chain (proof of work)
- Financial portfolio optimization: juggling between several asset classes, create a risk return tradeoff for certain set of asset classes shows promising results using QC optimization

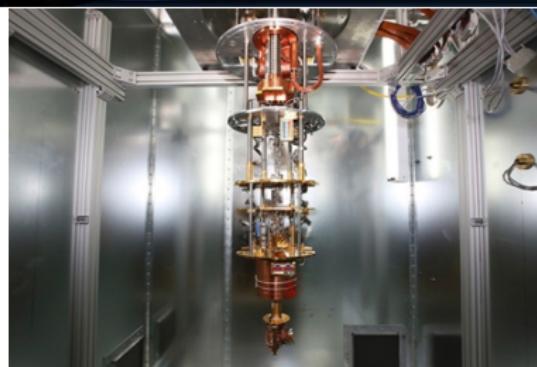
Quantum Computing: Business application areas

- Logistics planning, traffic planning, map power optimization (manage roster of people in airport) Fraudulent credit card transactions: anomaly detection (outlier detection), less false positives.
- Quantum machine learning for trading data: training time for qc systems learn with much lesser training data set
- Cyber Security: cryptography and post quantum cryptography (breaking factorization-based security systems)
- Quantum sensing in Oil and Gas sector. Studying yield from oil reservoirs
- Health data: QC can enhance the accuracy of health data.



The screenshot shows the D-Wave Quantum Computing Company website. At the top, there is a navigation bar with links: HOME, PRODUCTS & SUPPORT, QUANTUM COMPUTING, OUR STORY, and DEVELOPER PORTAL. Below the navigation bar, there is a large image of a dark server rack with the "D-WAVE" logo on it. To the right of the image, the text "Quantum computing has arrived." is displayed in large, white, sans-serif font. Below this text, there is a smaller paragraph of descriptive text.

D-Wave offers the first commercial quantum computing system on the market. If you are looking for a next-generation solution to difficult computational problems, we've got a pretty cool option for you.



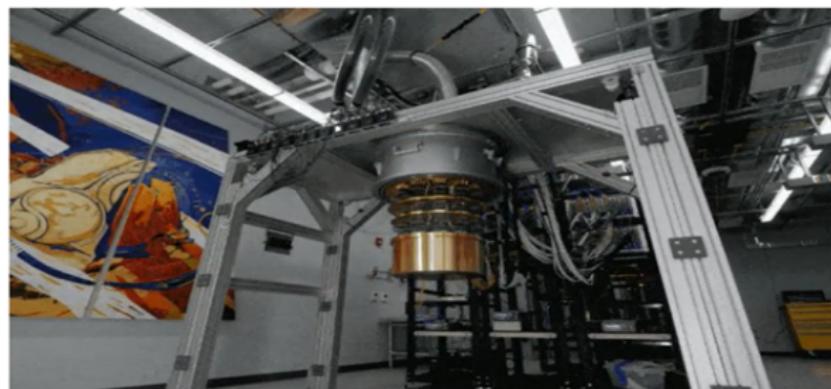
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Google wants to build a useful quantum computer by 2029

After claiming quantum supremacy breakthrough in 2019

By Jon Porter | @JonPorty | May 19, 2021, 5:54am EDT

f t e SHARE



One of Google's cryostats, which keeps a quantum computer cold enough to reduce errors. | Image: Google

Google is aiming to build a "useful, error-corrected quantum computer" by the end of the decade, the company [explained in a blog post](#). The search giant hopes the technology will help solve a range of big problems like feeding the world and climate change to developing

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Explore the possibilities of quantum

Google Quantum AI is advancing the state of the art of quantum computing and developing the tools for researchers to operate beyond classical capabilities.

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News

Jan. 8, 2019



ExxonMobil and IBM to advance energy sector application of quantum computing

LAS VEGAS — ExxonMobil said today that it has signed a partnership agreement with IBM to advance the potential use of quantum computing in developing next-generation energy and manufacturing technologies.

- Strategic commitment to advance joint research into quantum computing for energy
- ExxonMobil becomes first energy company to join the IBM Q Network
- Technology could further enhance ExxonMobil's own research and development capabilities

The new partnership was formally announced during the 2019 Consumer Electronics Show (CES) in Las Vegas.

As part of the agreement, ExxonMobil becomes the first energy company to join the IBM Q Network, a worldwide community of Fortune 500 companies, startups, academic institutions and national research labs working to advance quantum computing and explore practical applications for science and business.

"The scale and complexity of many challenges we face in our business surpass the limits of today's traditional computers," said Vijay Swarup, vice president of research and development for ExxonMobil Research and Engineering Company. "Quantum computing can potentially provide us with capabilities to simulate nature and chemistry that we've never had before. As we continue our own research and development efforts in the areas of energy and chemical manufacturing, our agreement with IBM will allow us to expand our knowledge base and potentially apply new solutions in computing to further advance those efforts."

Theme
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Quantum Computing: Tomorrow's computing today

IBM Quantum leads the world in quantum computing, which aims to solve complex problems the world's most powerful supercomputers cannot solve, and never will.

Get started today ↓



Organizations are partnering with IBM Quantum to build their quantum future

Join IBM Research Director Dario Gil to hear how you can access and program quantum computers on the IBM Cloud today.



Apple's New iPhone With Chip Moving Into Quantum Territory

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Photo by Zhiyue Xu on Unsplash

The Smaller, The Better

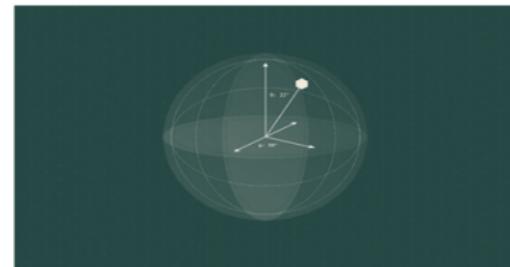
The recent news of Apple's next offering, the long-awaited iPhone 12 Pro later this year, will probably have all Appleheads queuing at the stores for hours in sweet anticipation. And though I use an iPhone



The Microsoft approach to quantum

Microsoft takes a comprehensive approach to delivering all the technology needed to enable commercial impact with quantum – encompassing everything from development to deployment. This approach innovates in parallel at all layers of the computing stack, including controls, software and development tools and services. It also includes a major ongoing focus to develop the **topological qubit** to help make scalable, stable quantum computing a reality.

[Explore Microsoft quantum technology >](#)



The Azure Quantum open cloud ecosystem

Find everything you need to accelerate your application development and quantum computing growth in a single place: including quantum software, hardware and solutions from Microsoft and partners, as well as learning resources for developers, researchers and students. Find pre-built optimisation solvers that borrow from quantum principles running on classical resources, and write quantum algorithms designed to run on quantum hardware.

[Explore Azure Quantum >](#)

Start using Azure Quantum



Now this is not the end. It is not even the beginning of the end. But it is, perhaps, the end of the beginning.

(Winston Churchill)

izquotes.com

The End