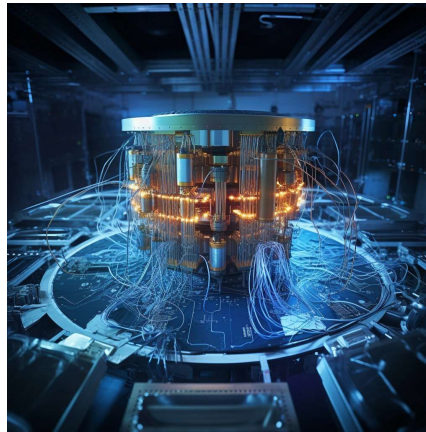


Quantum Computing

A New Realistic Paradigm



Prashant CISSP, CCSP, AZURE, CTMA, CSOCP, GCIH
Senior Cyber Security Advisor
<https://www.linkedin.com/in/prashantprofile/>
Twitter: @prashant_geek
GitHub: <https://github.com/prashant-iiitm/Conference-Talks>

Disclaimer: Views, thoughts, and opinions expressed in the talk belong solely to the author(s), and not necessarily to the author's employer, organization or any committee.

Agenda

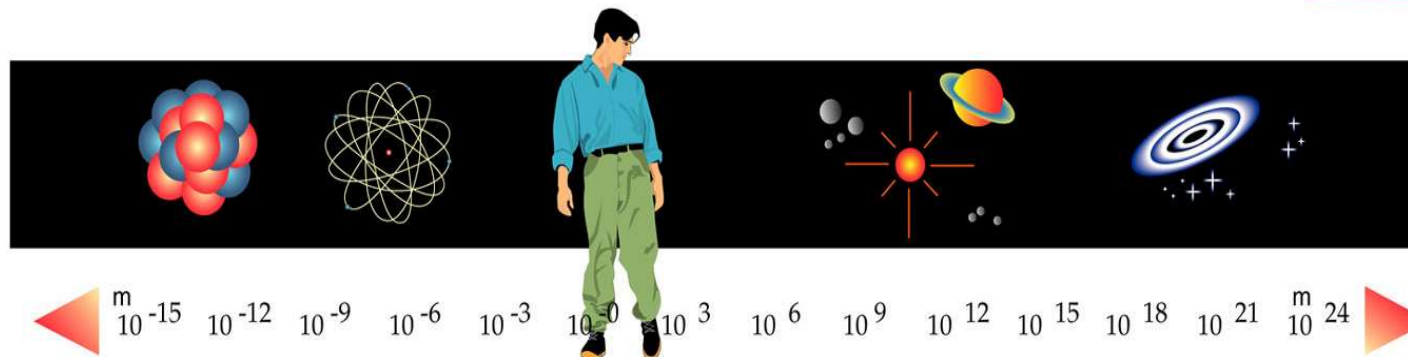
- 1. Introduction to Quantum Computing**
- 2. Problem Domains: Quantum Computing Benefits**
- 3. Business Applications**
- 4. Quantum Computing in Canada/Alberta**
- 5. Silicon Valley Giants take on Quantum Computing**

Building Blocks of Matter- Particles



Particle physics looks at matter in its smallest dimensions.

Astrophysics looks at matter in its largest dimensions.



Microscopes
Microscopes

Jumelles
Binoculars

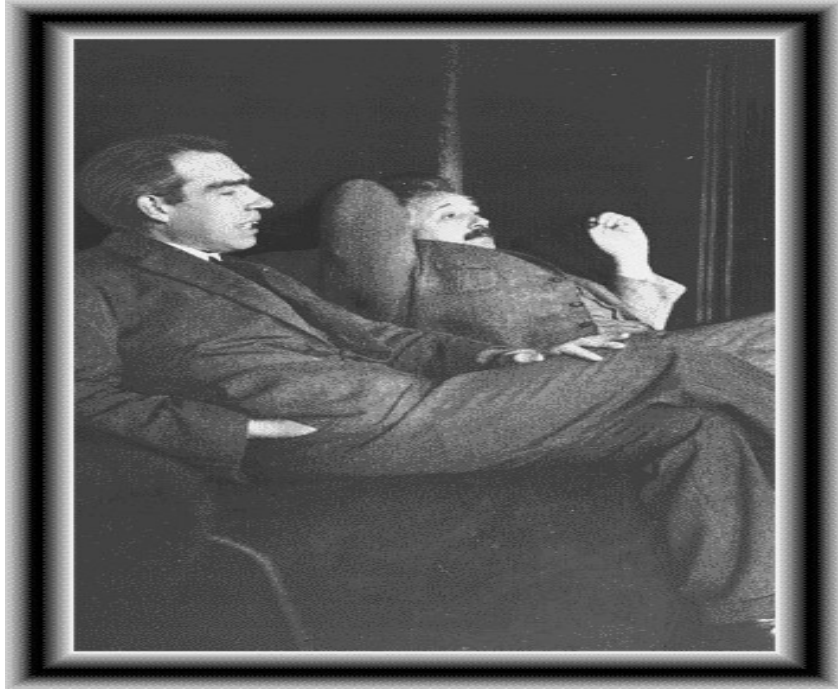
Telescopes optiques & radio
Optical & radio telescopes

Accélérateurs
et détecteurs
Accelerators
and detectors

L'oeil nu.
Naked eye

THE TWO FRONTIERS OF PHYSICS

God does not play dice with the Universe!!



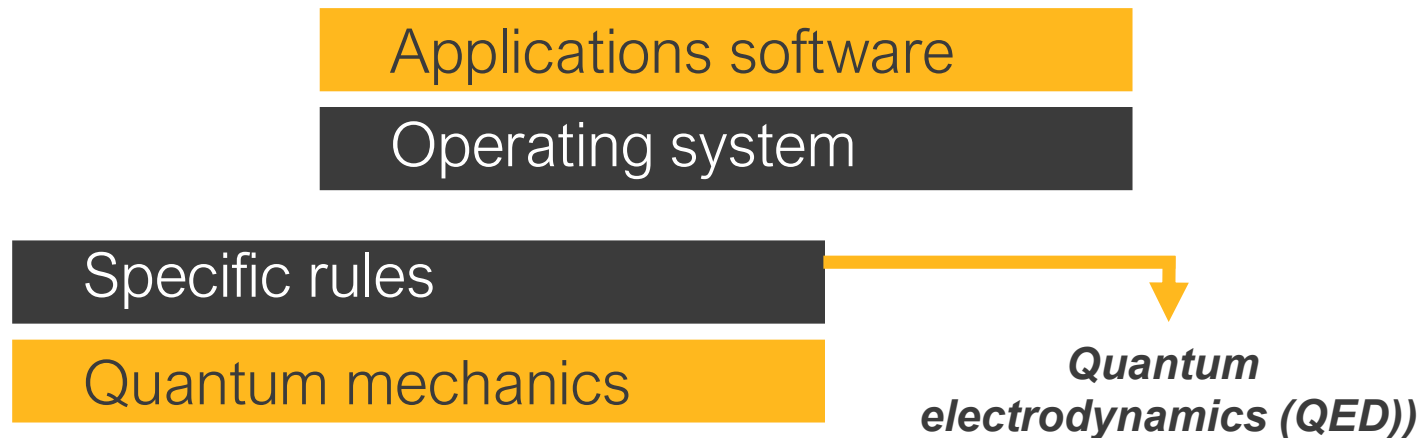
Everything we call real is made of things that cannot be regarded as real. Niels Bohr.



If [quantum theory] is correct, it signifies the end of physics as a science. Albert Einstein.

Fundamentals of Quantum Mechanics?

It is a complete physical theory in its own right.



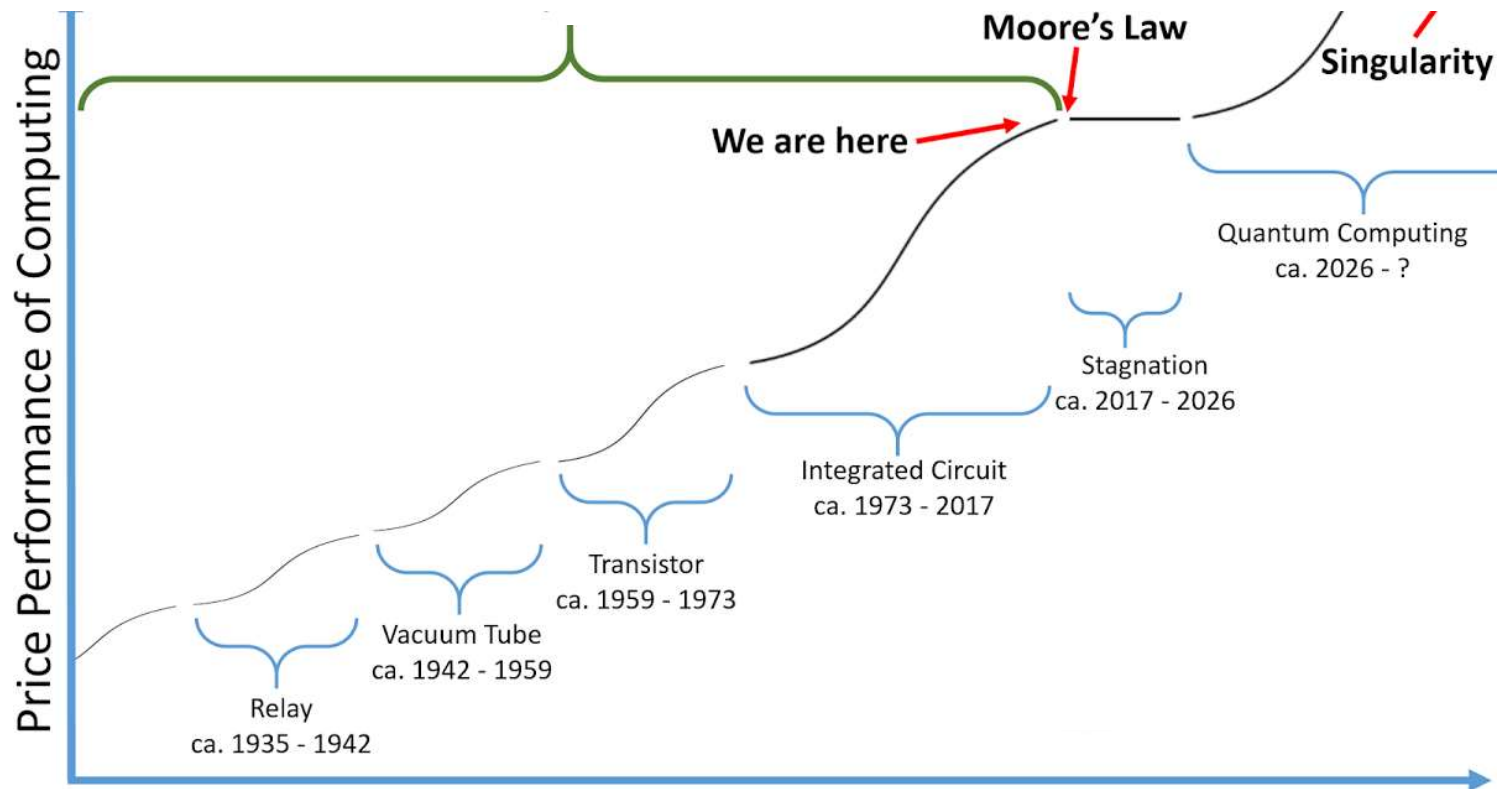
QM consists of ***four mathematical postulates*** which lay the ground rules for our description of the world.

Schrodinger's CAT paradox!! (Superposition Principle)



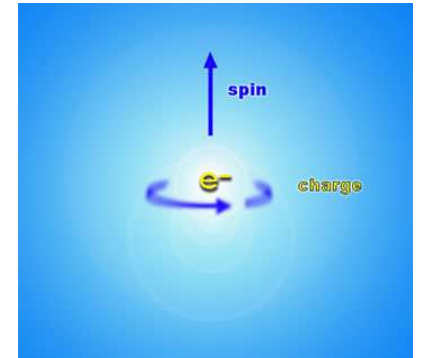
If you are not completely confused by QM, you do not understand it. John Wheeler

Physics meet Computing Sciences - Moore's Law

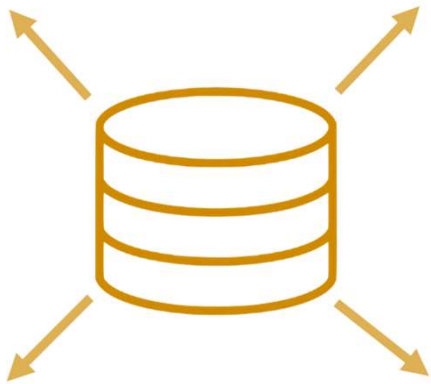


Quantum Mechanics version of Information - Quantum Informatics

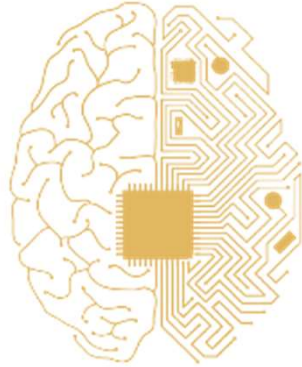
- The basis of information theory is discrete mathematics: **binary digits.**
- Quantum information employs **quantum states as basic elements of information.**
- Examples of quantum bits (qubits) are nuclear spin, motion of trapped ions, photons in optical resonators: each offers a future technology for future quantum information processing.



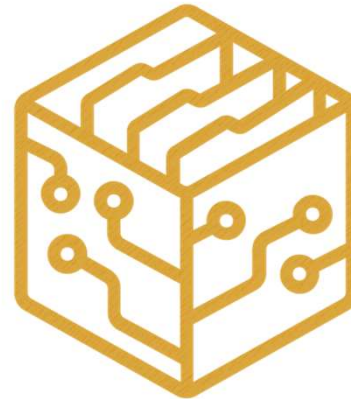
Business Applications



Optimization



Machine Learning



Simulation



Cybersecurity



When classical compute systems reach their limits...



Circuit fault diagnosis

Chemistry

Material discovery

Energy

Signal processing

Machine learning

Scheduling

Routing & logistics

...you can utilize the power of quantum computing to solve some of the world's toughest problems.

Problem Domains: Quantum Computing Benefits

- Simulations to reduce carbon emissions: ESG
- Flow Optimization: *optimal routing of commodity flow (liquid, gas)*
- Scalability of experimentation and dramatic increase in modeling accuracy
- Enables order of magnitude faster iterations: *scheduling nomination batch jobs*
- The *future market price prediction* is an unknown random variable, but profitable trades are possible using an estimate of its probability density function where QC has unique advantage
- Large organizations which have footholds in several countries can waste a lot of money *trading between currencies sub-optimally*. Cross border organizations routinely exchanges vast amounts of USD for CAD and vice versa which can be optimized

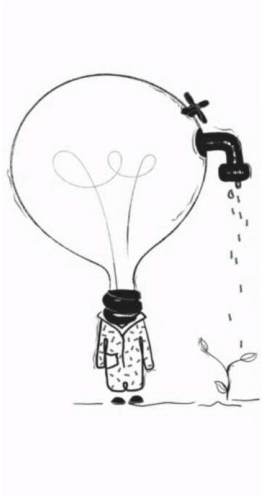
Climate and Energy Crisis: Quantum Computing Application

The slide is titled "why: Climate and Energy Crisis" in large white text on a black background. It features four news snippets arranged in a staggered, overlapping layout:

- Energy Future**: "Energy market: EU countries want to stabilize energy prices. Nevertheless, significant price increases for customers are to be expected here as well. Germany and France also have gas storage facilities that are also ... 1 month ago"
- energiezeitung**: "RWE: Energiewende mit deutlichen Makeln. RWE: Energiewende mit deutlichen Makeln ... 50 Milliarden Euro will RWE investieren. Vor allem Wind- und Solarenergie sollen ..."
- Bloomberg.com**: "Texas Energy Blackout Risks: Grid Remains Vulnerable to ... 'It all must work in tandem.' Power Outages Linger For Millions As Another Icy Storm Looms. People wait in line outside a grocery store in ..."
- The Texas Tribune**: "Power outage leaves Texans desperate for heat and safety. Winter Storm 2021. As Texas faced record-low temperatures this February and snow and ice made roads impassable, the state's electric grid ... Feb 16, 2021"

A small blue logo is visible in the bottom left corner of the slide.

FORECAST
Massively Scalable Forecasts and Predictions
LOW-CODE QUANTUM-CLASSICAL MACHINE LEARNING PLATFORM
Forecasting for the utility market

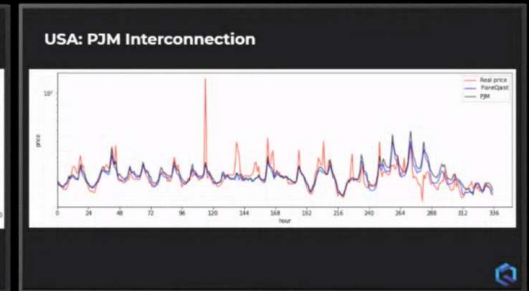
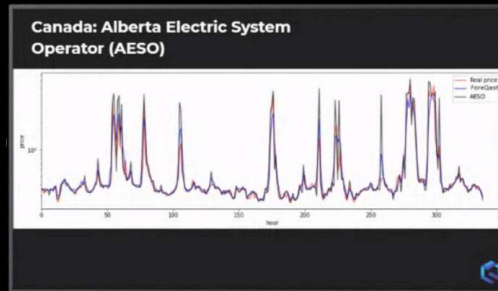


Quantum for Renewables

AI + Quantum + Big Data

Advanced analytic forecasting platform for the energy market

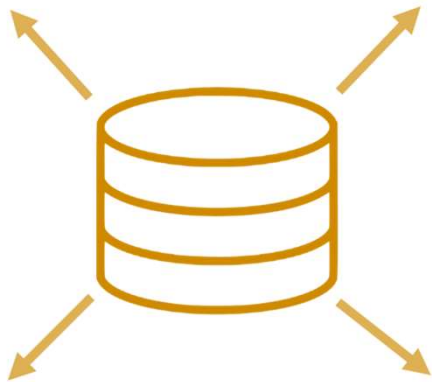
Price forecaster



Outperforms benchmark by 14-26%

Quantum Computing

Business Applications



Optimization

- Increased Cost Savings through Pipelines Capacity Optimization
- Financial Portfolio Optimization
- Logistics Route Planning
- Manpower Optimization

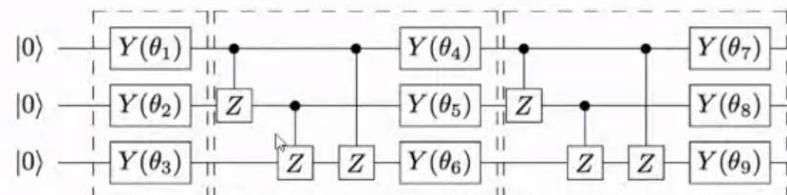
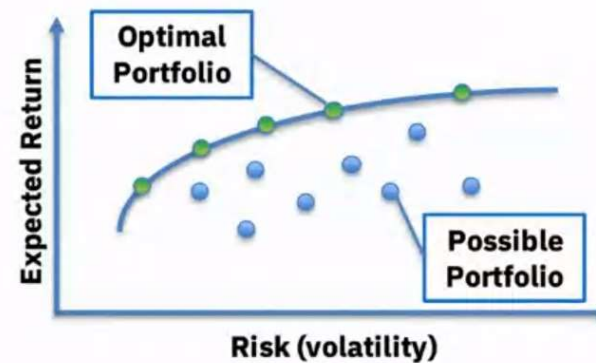
Quantum Approach Example: Portfolio Optimization

IBM Researchers have used hybrid quantum/classical variational algorithms to find solutions for combinatorial optimization problems. Using classical simulation together with quantum hardware can lead to faster and better convergence for combinatorial optimization problems. IBM researchers have provided analytical results to explain the observed difference in performance between different variational algorithms.

Source: <https://arxiv.org/abs/1907.04769>

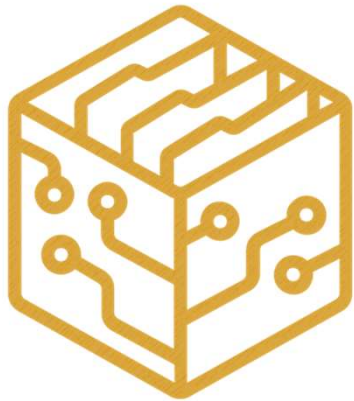
VQE
QAOA

Portfolio Optimization Efficient Frontier



Quantum Computing

Business Applications



Simulation

- Market Simulations
- Risk Modelling
- Increased Revenue through Pipeline Capacity Modelling
- Accurate Gas Distribution & Storage Forecasting

Quantum Computing

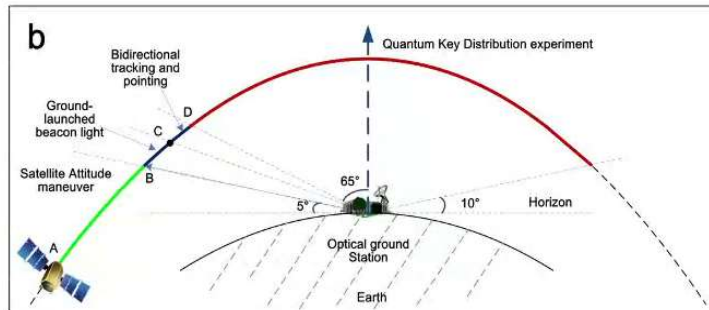
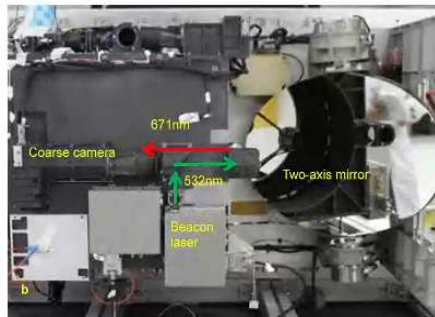
Business Applications

Quantum Communication: secure, distributed communication

- **Opportunity:** Testbed for q networks leveraging q communication strengths today; growing quantum-device capability in Alberta
- **Alberta:**
 - Ground station communicating with q satellite
 - Contributions to real-world q communication
 - Developing q memory



Cybersecurity



Canadian Center of Cyber Security Update 31st Aug for Energy Sector

Informational

○ **Enhancing TLS Security: Google Adds Quantum-Resistant Encryption in Chrome 116** **(LINK)**

- (U//TLP:CLEAR) Google has announced plans to add support for quantum-resistant encryption algorithms in its Chrome browser, starting with version 116.
- "Chrome will begin supporting X25519Kyber768 for establishing symmetric secrets in TLS, starting in Chrome 116, and available behind a flag in Chrome 115," Devon O'Brien said in a post published Thursday.
- Kyber was chosen by the U.S. Department of Commerce's National Institute of Standards and Technology (NIST) as the candidate for general encryption in a bid to tackle future cyber attacks posed by the advent of quantum computing. Kyber-768 is roughly the security equivalent of AES-192.

- [Google Chrome 116 Update using Quantum Resistant Cryptography in the browser: https://www.thessslstore.com/blog/googles-post-quantum-cryptography-experiment-successful/](https://www.thessslstore.com/blog/googles-post-quantum-cryptography-experiment-successful/)
- CISA Post Quantum Cryptography Roadmap: <https://www.cisa.gov/quantum> , <https://www.dhs.gov/quantum>

Quantum Computing in Canada/Alberta

Supportive ecosystem

National Quantum Strategy

From: [Innovation, Science and Economic Development Canada](#)



[Canada.ca](#) • [Innovation, Science and Economic Development Canada](#) • [Programs](#) • [Innovation Solutions Canada](#)

Quantum Computing-as-a-Service

From: [Innovation, Science and Economic Development Canada](#)



Shared Services Canada (SSC) is seeking a user-friendly solution for using Quantum Computing as a Service (QaaS) to optimize complex problem solving, yielding possible solutions for use in evidence-based decision-making.

Challenge sponsor: Shared Services Canada (SSC)

Funding mechanism: Contract

Opening date: November 9, 2020

Closing date: January 19, 2021, 14:00 Eastern Standard Time

Please refer to the tender notice for this challenge on [Bids and Sell](#)

Applied Quantum Computing Challenge program

From: [National Research Council Canada](#)



Internet of Things: Quantum Sensors Challenge program

From: [National Research Council Canada](#)



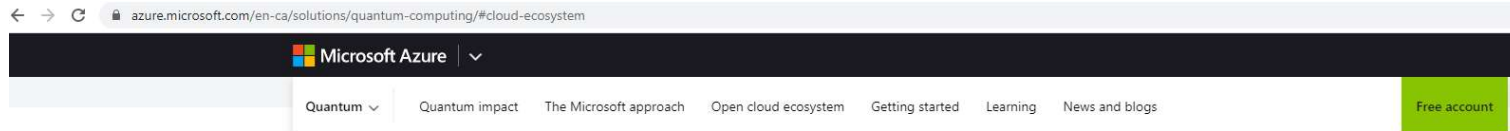
Canadian Gas Association is working with [Quantum Safe Canada](#) to create guidance and framework documents that can be used by CGA members to prepare for the risks that quantum computing will pose to cryptography, cybersecurity and business continuity.

Quantum City Proposal

- Addresses current gaps
 - Fabrication
 - HQP
 - Training
- Expected outcomes
 - 1,000 jobs initially
 - 250-500 jobs per year
 - Training of HQP
 - 3-4 new graduate programs (starting with 1)
 - 20-25% of qtech sector located in Calgary
- Inputs (over 5 years)
 - \$25 million proposal with GoA
 - \$52.75 million from other external and UCalgary investment
 - Federal funding to develop talent, R&D and infrastructure



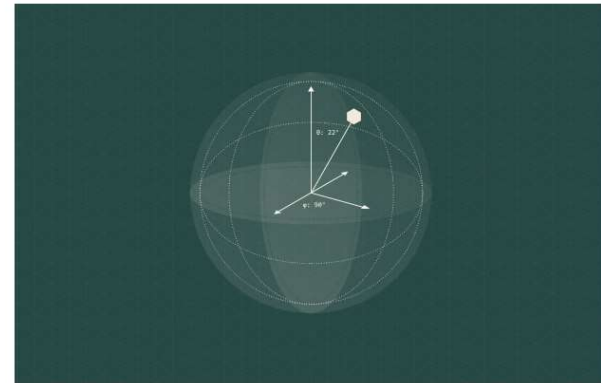
Azure Quantum Open Cloud



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 >](#)



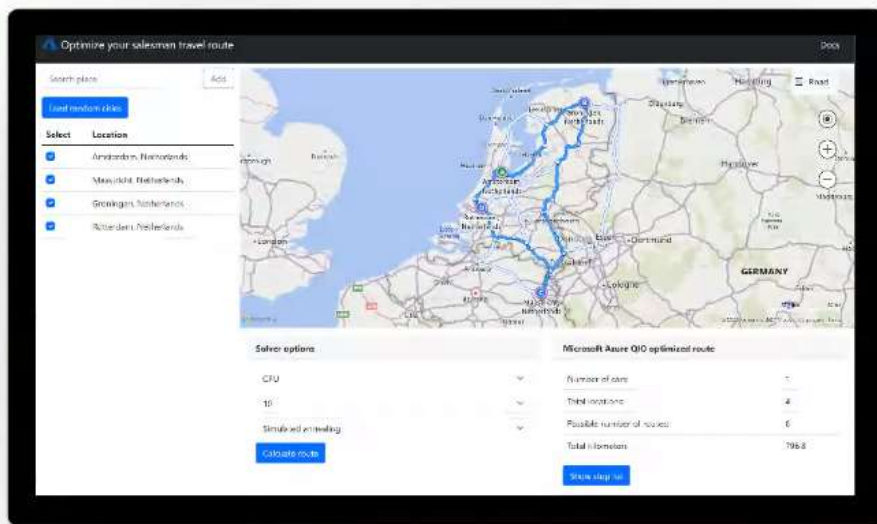
The Azure Quantum open cloud ecosystem

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 >](#)

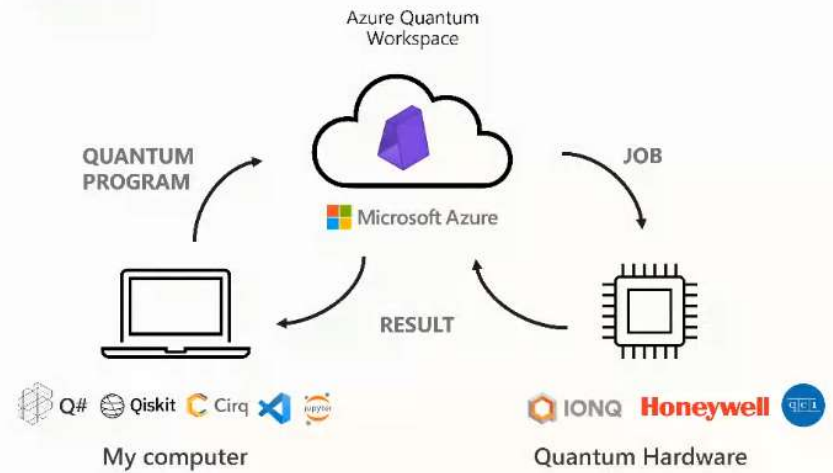
[Start using Azure Quantum](#)

Build your own web app on Azure Quantum



<https://github.com/vivanwin/QIO-TSP-Demo>

You can use Azure Quantum today to run hybrid applications on quantum hardware



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You'll have 30 days to use it—in addition to free services.

Try out Azure Quantum with the Credits Program

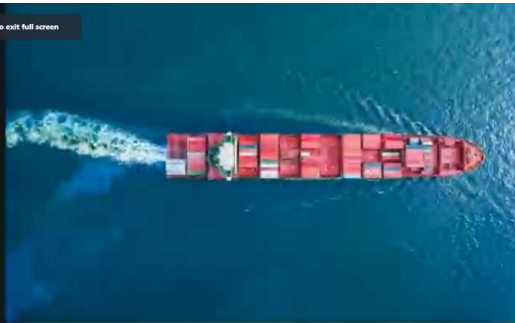


Apply for the \$10k Azure Quantum Credits Program <https://aka.ms/aq/credits>

ExxonMobil & IBM: Quantum Computing

ExxonMobil

Press Esc to exit full screen



Maritime Routing's Mind-Boggling Math

In 2021 more than 500 LNG (liquefied natural gas) ships are used to transport critical fuel supplies across the oceans. Together, they make thousands of journeys per year to destination ports where the LNG is deployed to power critical infrastructure.

Finding optimal routes for a fleet of such ships can be a mind-bendingly complex optimization problem.

Quantum computers take a new approach to addressing this sort of complexity, with the potential to find solutions that classical supercomputer alone cannot handle. Industry leaders like Exxon are getting involved now to explore how blending classical and quantum computing techniques might solve big, complex, pressing global challenges.

ExxonMobil

Press Esc to exit full screen

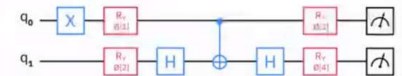
IBM Quantum



Quantum Computing as a Tool for Chemistry and Engineering

Working together, ExxonMobil and IBM recently demonstrated advancements in using quantum computers to accurately calculate thermodynamic observables, demonstrating how quantum can be the next generation tool for chemists and chemical engineers developing advanced energy solutions.

Accurate thermodynamic observables calculation circuit



IBM Quantum Network

IBM Quantum Network Industry: Banking & Financial Services

170 total

12 industry partners

20 hubs

46 members

40 startups

52 academic members
and partners

Goldman Sachs

JP Morgan Chase

Mitsubishi UFJ Financial Group

Mizuho Bank

Sumitomo Mitsui Trust Bank Limited

Wells Fargo

Imagine banking and financial markets capable of:

- Early detection of new patterns of financial crime while reducing false positive rates
- Better adaptation to changes in market conditions in portfolio optimization, capital allocation and trading
- Estimation of more complex risks more accurately and quickly

Allowing banks to react quicker to market pressures, technology disruptions, consumer demands and increasing regulation.



Corporate risk management

Business imperative

More accurately reserve capital for risk-weighted assets by optimizing allocation, freeing up capital for growth.

Current state

Imperfect models of risk exposure require conservative capital buffers. Resource intensive simulations make it necessary to introduce approximations to risk factors requiring conservatism.

Future state

Quantum computers may accelerate simulation, allowing for more risk factors to be considered leading to more efficient capital allocation and profit generation from new business.



D-WAVE Quantum Computing



D:wave
The Quantum Computing Company™

[HOME](#) [PRODUCTS & SUPPORT](#) [QUANTUM COMPUTING](#) [OUR STORY](#) [DEVELOPER PORTAL](#)

Quantum computing has arrived.

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.



Appendix: Quantum Computing Resources

amazon.ca Hello Select your address All dancing with qubits

Books > Computers & Technology > Computer Science

Dancing with Qubits: How quantum computing works and how it can change the world Paperback – Nov. 28 2019
by Robert S. Sutor (Author)
★★★★☆ 102 ratings

See all formats and editions

Kindle Edition \$45.99	Paperback \$65.99
---------------------------	-----------------------------

Read with Our **Free App** 2 Used from \$53.92 6 New from \$65.99

Explore the principles and practicalities of quantum computing

Key Features

- Discover how quantum computing works and delve into the math behind it with this quantum computing textbook
- Learn how it may become the most important new computer technology of the century
- Explore the inner workings of quantum computing technology to quickly process complex cloud data and solve problems

Read more

Print length	Language	Publisher	Publication date	Dimensions	ISBN-10
516 pages	English	Packt Publishing	Nov. 28 2019	19.05 x 2.97 x 23.5 cm	1838827366

See all 2 images

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Robert S. Sutor + Follow

Frequently bought together

Dancing with Qubits	Programming Quantum Computers	Quantum Computing for Dummies
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Total price: \$159.39
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Books > Computers & Technology > Programming

Dancing with Python: Learn to code with Python and Quantum Computing Paperback – Aug. 31 2021
by Robert S. Sutor (Author)
★★★★☆ 3 ratings

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Develop skills in Python and Quantum Computing by implementing exciting algorithms, mathematical functions, classical searching, data analysis, plotting data, machine learning techniques, and quantum circuits.

Key Features

- Create quantum circuits and algorithms using Qiskit and run them on quantum computing hardware and simulators
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Read more

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744 pages	English	Packt Publishing	Aug. 31 2021	19.05 x 4.27 x 23.5 cm	1801077851

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