Chief Science Officers Leadership Training Institute

Quantum for High School & College Students

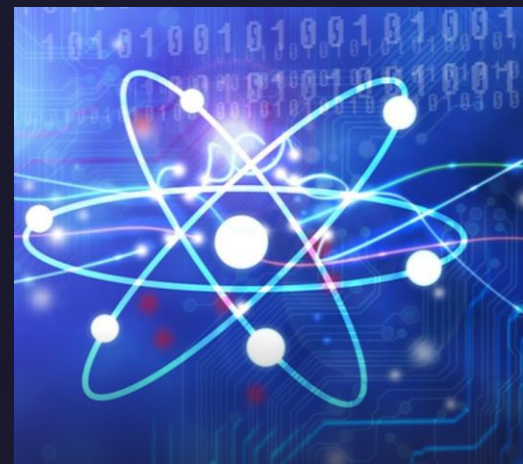
Education & Career Pathways

Leading Advanced STEM People

Donn Silberman

Quantum Optics Institute of Southern California

http://qoisc.org



Agenda

1. Introduction – Getting Oriented & Critical thinking
2. What is **Advanced STEM** & why should you care?
3. Building an **Advanced STEM Ecosystem**
4. Leading **Advanced STEM People**
5. Pathways for High School & College Students
6. On-line and In-Person Resources
7. Questions & Answers







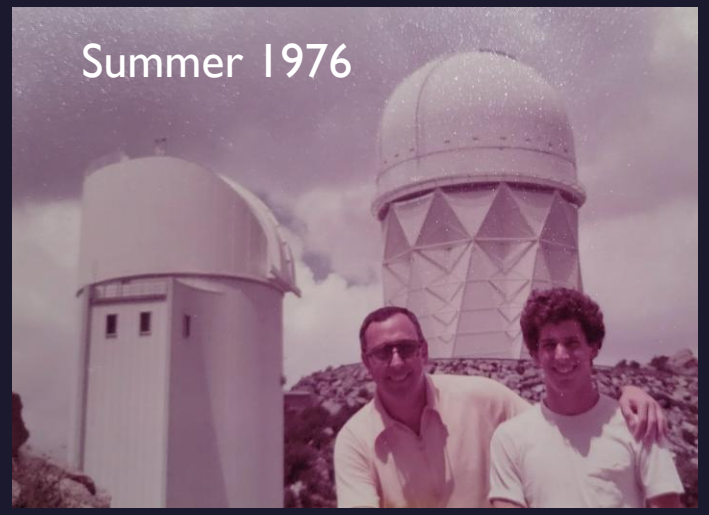
Introduction

Who am I? And Why am I here talking to you?











OISC 2003- 2023
QOISC
QUANTUM OPTICS INSTITUTE OF SOUTHERN CALIFORNIA

PCC
LASERTECH
Pasadena City College
Irvine Valley College
1992 - 2007

SPS
1981
1984
Society of Physics Students



1982

THE UNIVERSITY OF ARIZONA
Astronomy & Steward Observatory — 1977
Physics — 1979
HONORS UA COLLEGE 50 years Founded 1962 — 1981 1983
COLLEGE OF OPTICAL SCIENCES
COLLEGE OF ENGINEERING — 1981 1983
PEPPERDINE Graziadio Business School Technology Manatement — 1992 1994
UCI Division of Continuing Education
Optical Engineering & Optical Instrument Design — 2009 2026
SPIE Fellow
OPTICA SENIOR MEMBER — 2019
OSSC Optical Society of Southern California
FELLOW — 1992 2025
eLas Americas — 2017
OptoBotics℠ Robots need eyes too — 2012
vital link — 2014



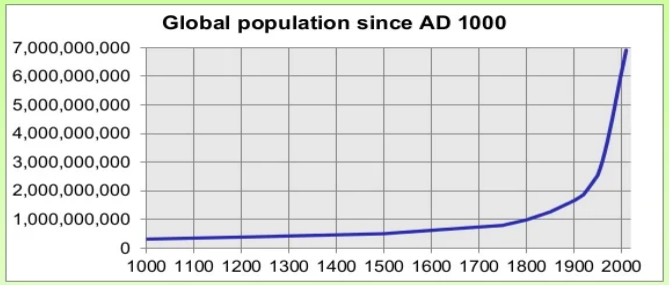
1290 1390 1490 1590 1690 1790 1890 1990

Sailing ship Steamship Airplane Rocket

EARTH ORBIT IN MAN MADE ENVIRONMENT CONTROL: PRODUCT OF SUCCESSFUL APPLICATION OF HIGH PERFORMANCE PER UNIT OF INVESTED RESOURCES

PROFILE OF THE INDUSTRIAL REVOLUTION AS EXPOSED BY THE CHRONOLOGICAL RATE OF ACQUISITION OF THE BASIC INVENTORY OF COSMIC ABSOLUTES—THE 92 ELEMENTS

Dimensions of Growth: Population



World Population:
from 1 billion in 1800 to 7 billion in 2012

Steel Dynamo Radio Automobile Flight Electronics Talky

Leonardo De Vinci Columbus Copernicus Galileo Boyle Newton Watt Washington Avogadro Lincoln

800 years chart

9 ELEMENTS

CARBON	*6	C
LEAD	*82	Pb
TIN	*50	Sn
MERCURY	*80	Hg
SILVER	*47	Ag
COPPER	*29	Cu
SULPHUR	*16	S
GOLD	*79	Au
IRON	*26	Fe

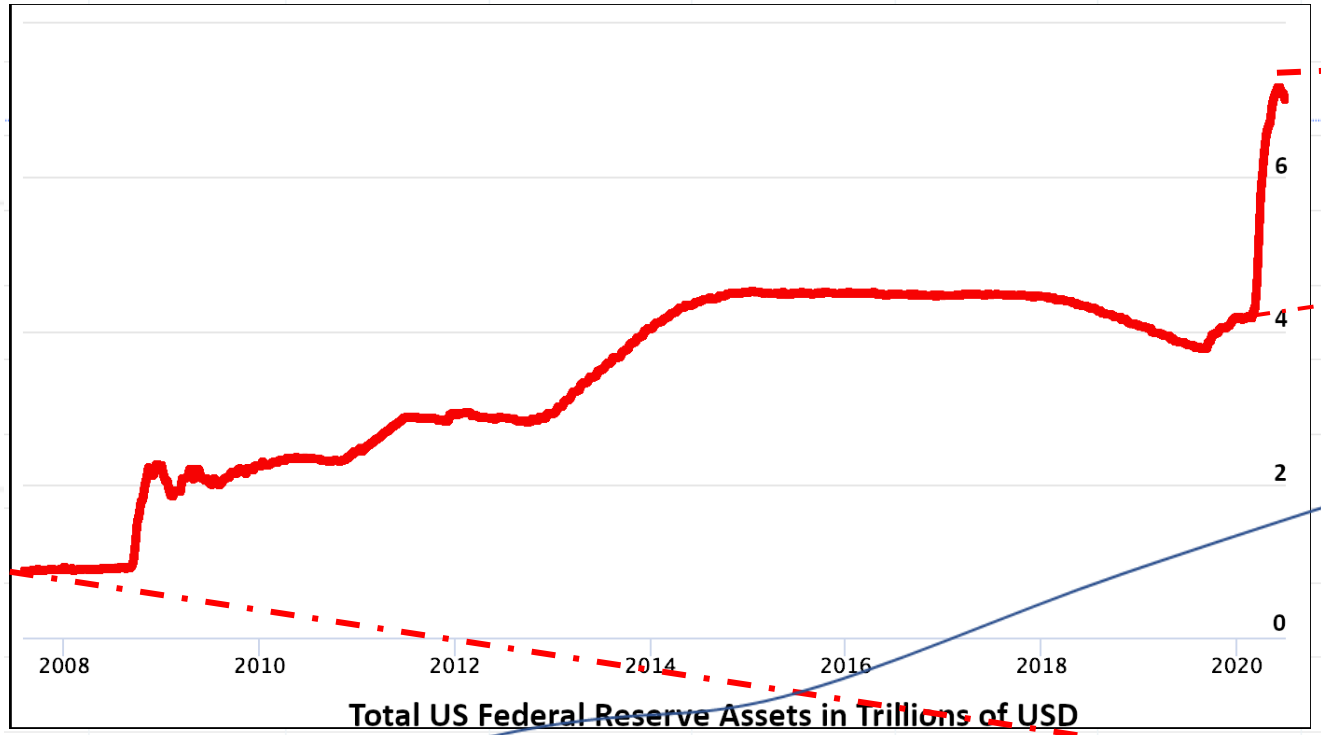
Who learns science and why?

Buckminister Fuller, Synergetics, 1975

US30 1M

United States Stock Market Index (US30) 33000.14 -1056.91 (-3.1%)

US Stock Market Index



Quantitative easing

Q4 – March 2020
Q3 – Sept 2012
Q2 – Nov 2010
Q1 – Nov 2008

US Population

100 years chart

Donn's college years
1977-1983

400M
300M
200M
100M
0

40000
37500
35000
33000
30000
27500
25000
22500
20000
17500
15000
12500
10000
7500
5000
2500

1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020

1D 1W 1M 6M 1Y 5Y 10Y 25Y 50Y All

Critical Thinking









Mentors



Frank Memmer
High School
Astronomy Teacher



Ke Chiang Hsieh



William Bickel

College Physics Professors



Steve Jacobs
Univ. of Rochester
Optics Suitcase
Light Outreach



Brian Lula



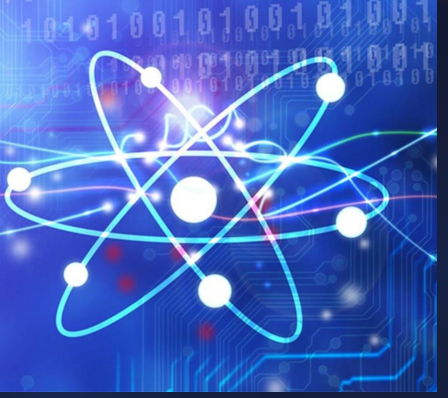
Jim Trolinger**



Mark Arenal**

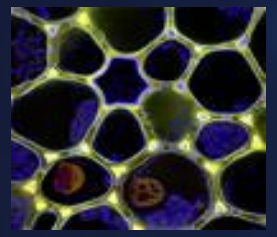


My wife, Mom* & Dad*



What is Advanced STEM

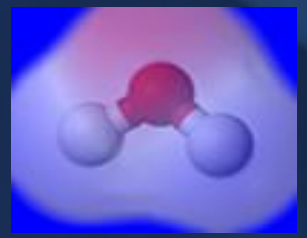
& why should you care?



Biology



Physics



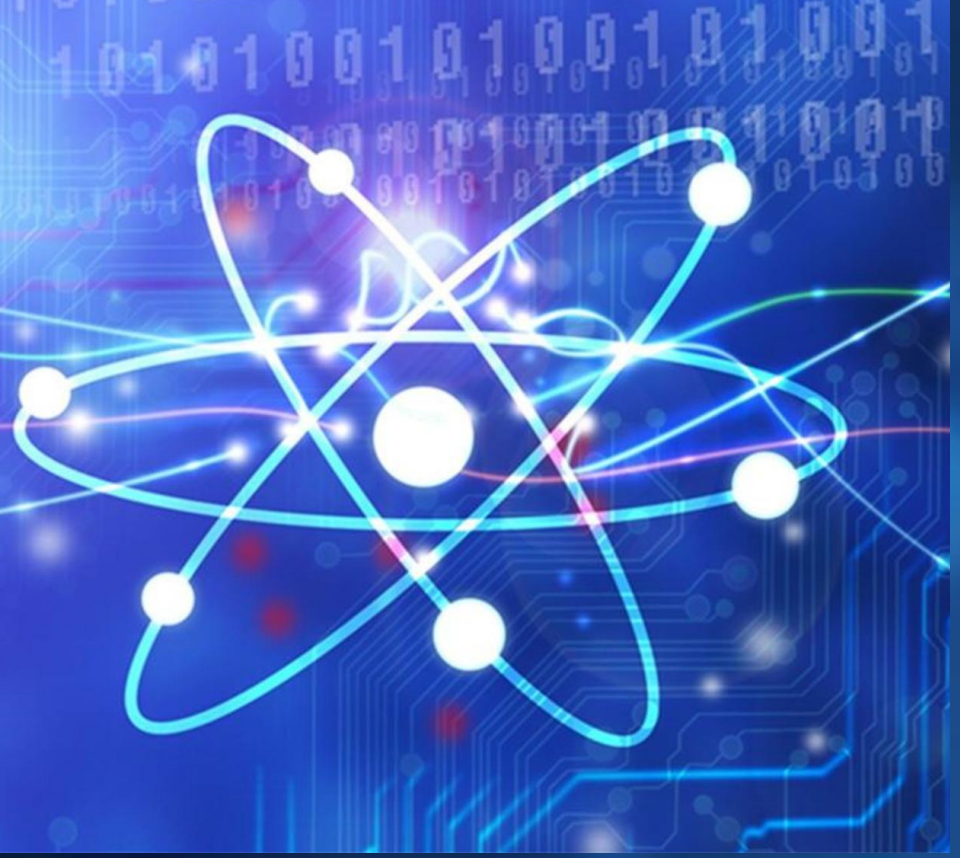
Chemistry



Engineering and Technology

Why are these different than other STEM fields?

These are fundamental Science, Engineering & Technology fields Quantum can have Advanced roles in these areas.



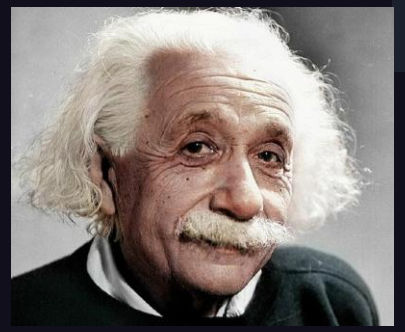
Quantum is Key

Things at the Atomic Scale are very different than at the human scale.

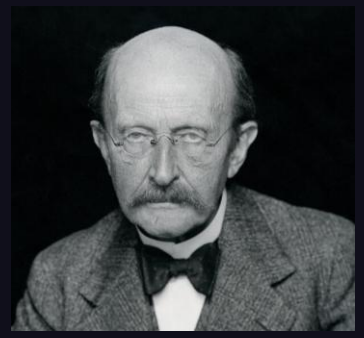
- The Quantum World underlies our modern civilization.
- And Quantum is about take humanity to the next level.
- **You can help make it happen.**

QUANTUM 1.0

The story begins almost 100 years ago
The Solvay International Conference on Electrons & Photons October 1927
The "Quantum All Stars!!"



Albert Einstein



Max Planck



Werner Heisenberg





Niels Bohr

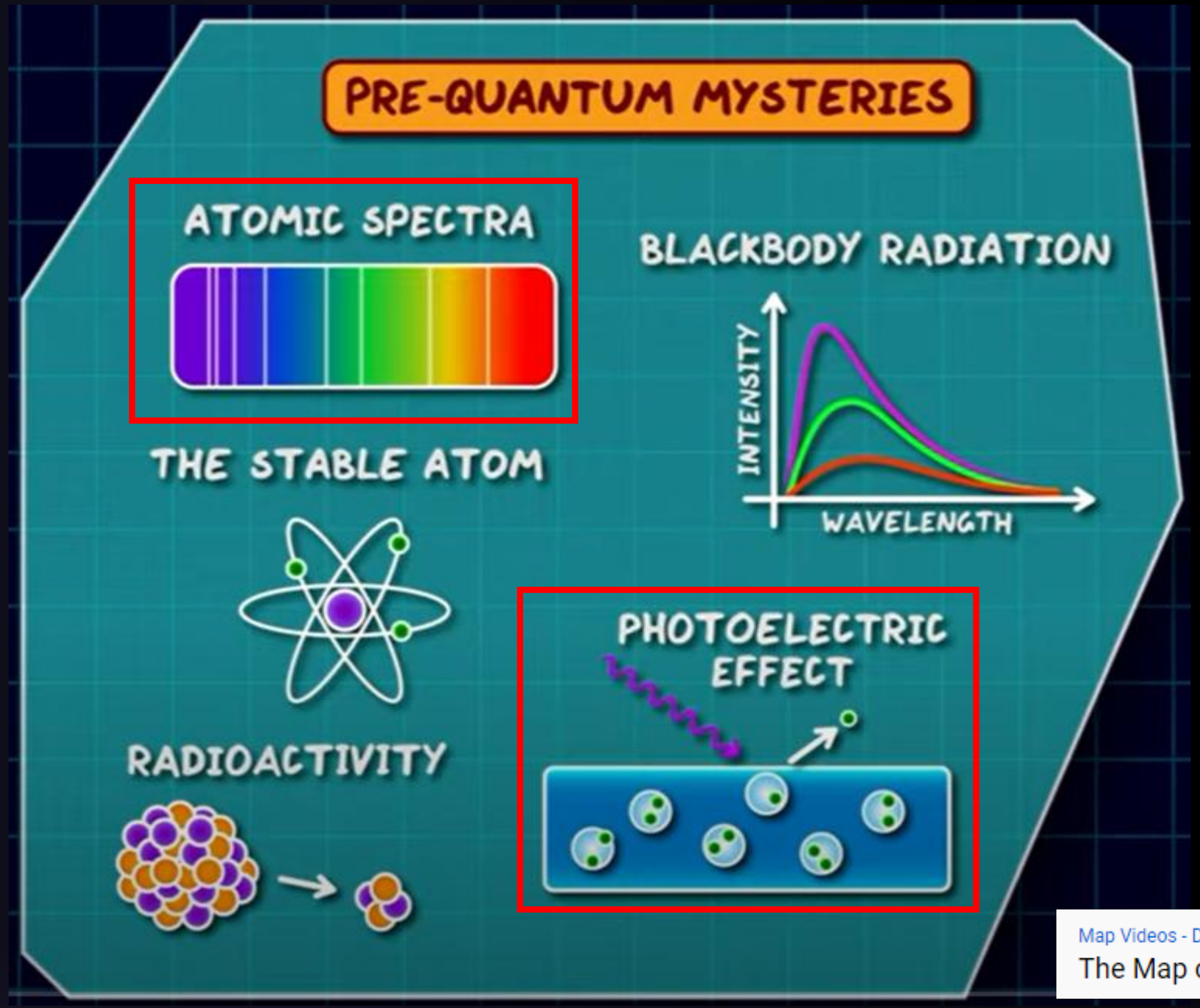


Erwin Schrödinger



Marie Curie

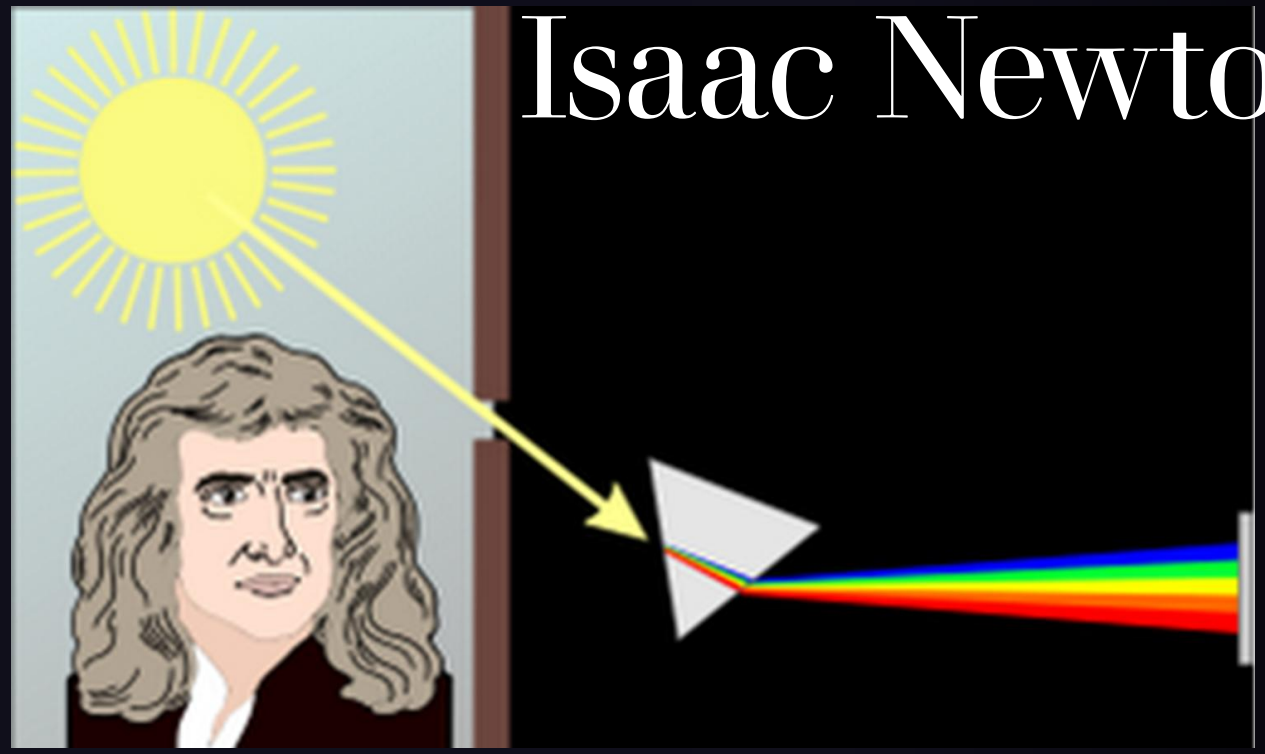
17 of the 29 attendees were or became Nobel Prize winners, including Marie Curie, who alone among them, had won two Nobel Prizes in physics and chemistry.



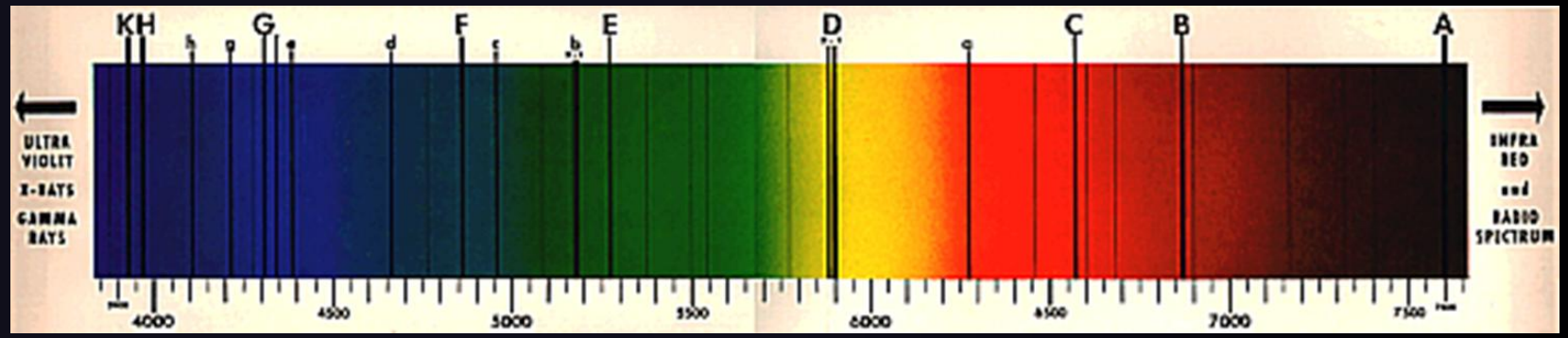
Map Videos - Domain of Science

The Map of Quantum Physics

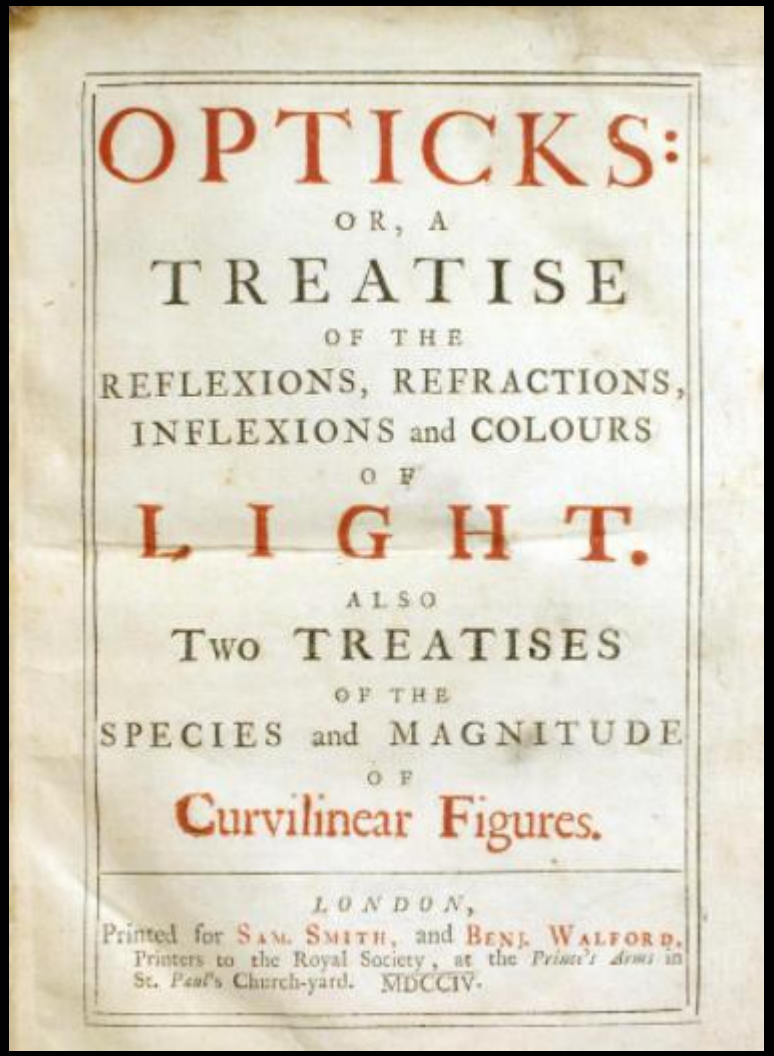
Isaac Newton & the Prism



The Solar Spectrum with Fraunhofer Lines



Discrete spectral lines correspond to the energy levels of various atoms that are burning in the Sun.



OPTICKS:
OR, A
TREATISE
OF THE
REFLEXIONS, REFRACTIONS,
INFLEXIONS and COLOURS
OF
LIGHT.
ALSO
Two TREATISES
OF THE
SPECIES and MAGNITUDE
OF
Curvilinear Figures.

LONDON,
Printed for Sam. Smith, and Benj. Walford,
Printers to the Royal Society, at the *Prince's Arms* in
St. *Paul's* Church-yard. MDCCIV.

The first, 1704, edition of *Opticks: or, a treatise of the reflexions, refractions, inflexions and colours of light.*

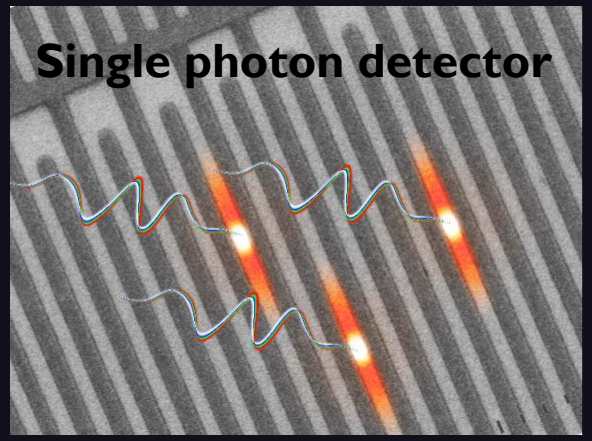
From Wikipedia: QUANTUM

In physics, a quantum is the minimum amount of any physical entity involved in an interaction. The fundamental notion that a physical property can be "quantized" is referred to as "the hypothesis of quantization".

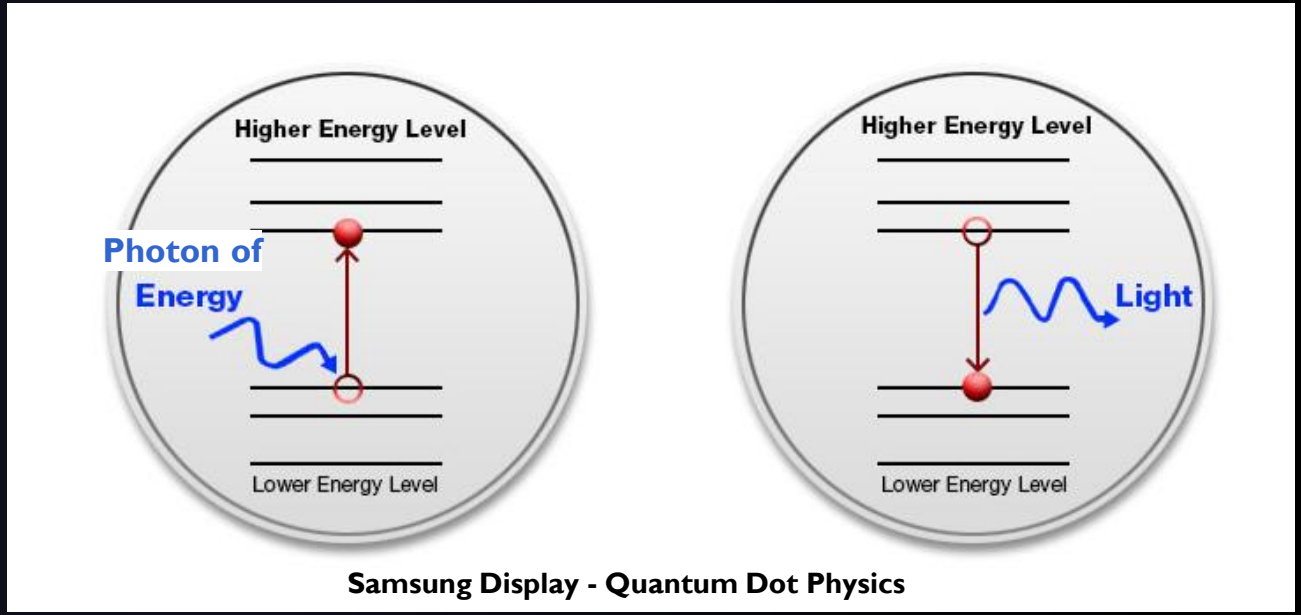
[1] This means that the magnitude of the physical property can take on only ***discrete values*** *consisting of integer multiples of one quantum.*

Can't have 1 ½ photons
Or ¾ of an electron

Graphic representation of an **electron (red O)** moving from one energy level to another, emitting or absorbing a **photon (Energy)** of light.

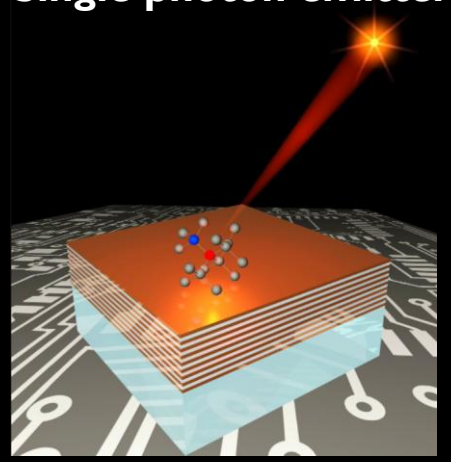


1-singlephoton.jpg (716×536) (b-cdn.net))



Samsung Display - Quantum Dot Physics

Single photon emitter



singlephoton.jpg (1000×1413) (b-cdn.net)

$E = h\nu$

frequency of radiation, sometimes written as f giving expression E = hf.

Quantum energy of a photon.

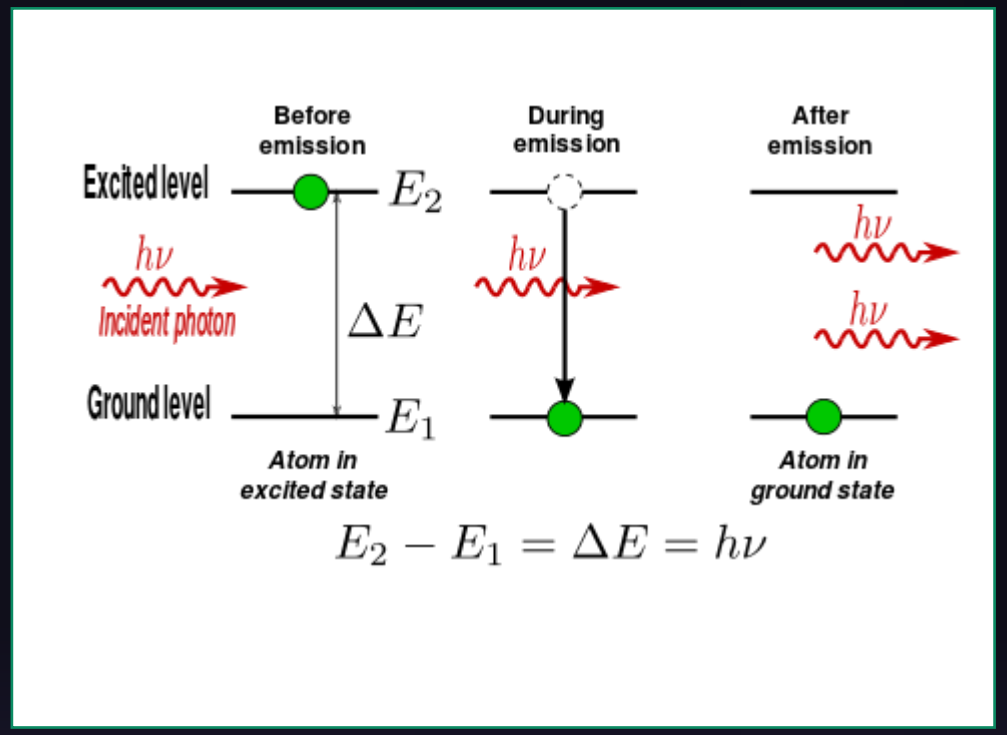
h = Planck's constant = 6.626×10^{-34} Joule·sec = 4.136×10^{-15} eV· s

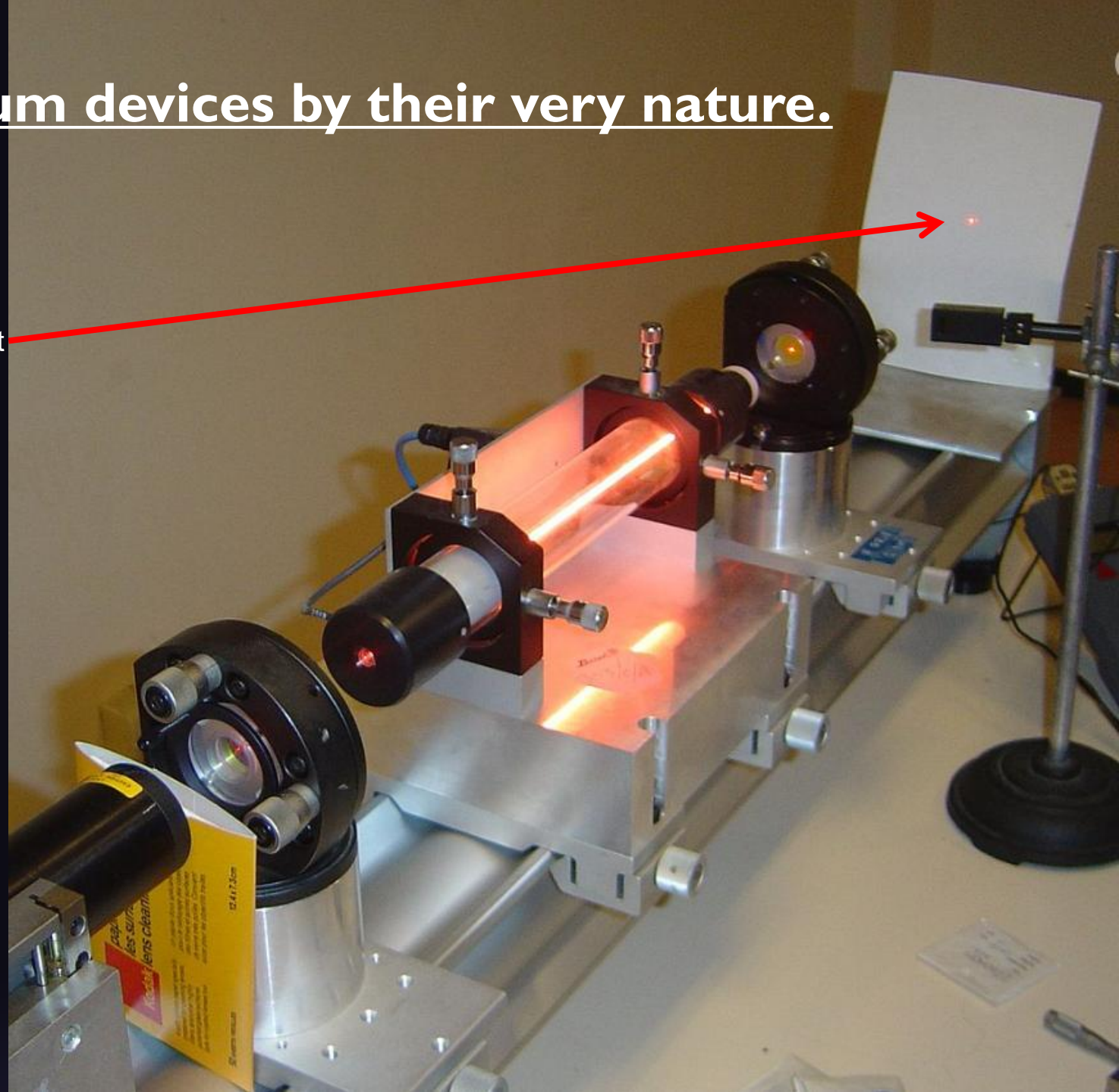
$E=mc^2$

Einstein's famous equation
Energy = mass x speed of light^2

Lasers are intrinsically quantum devices by their very nature.

A helium–neon laser demonstration. The glow running through the center of the tube is an electric discharge. This glowing plasma is the gain medium for the laser. The laser produces a tiny, intense spot on the screen to the right. The center of the spot appears white because the image is overexposed there.





Laser Light Distribution Patterns

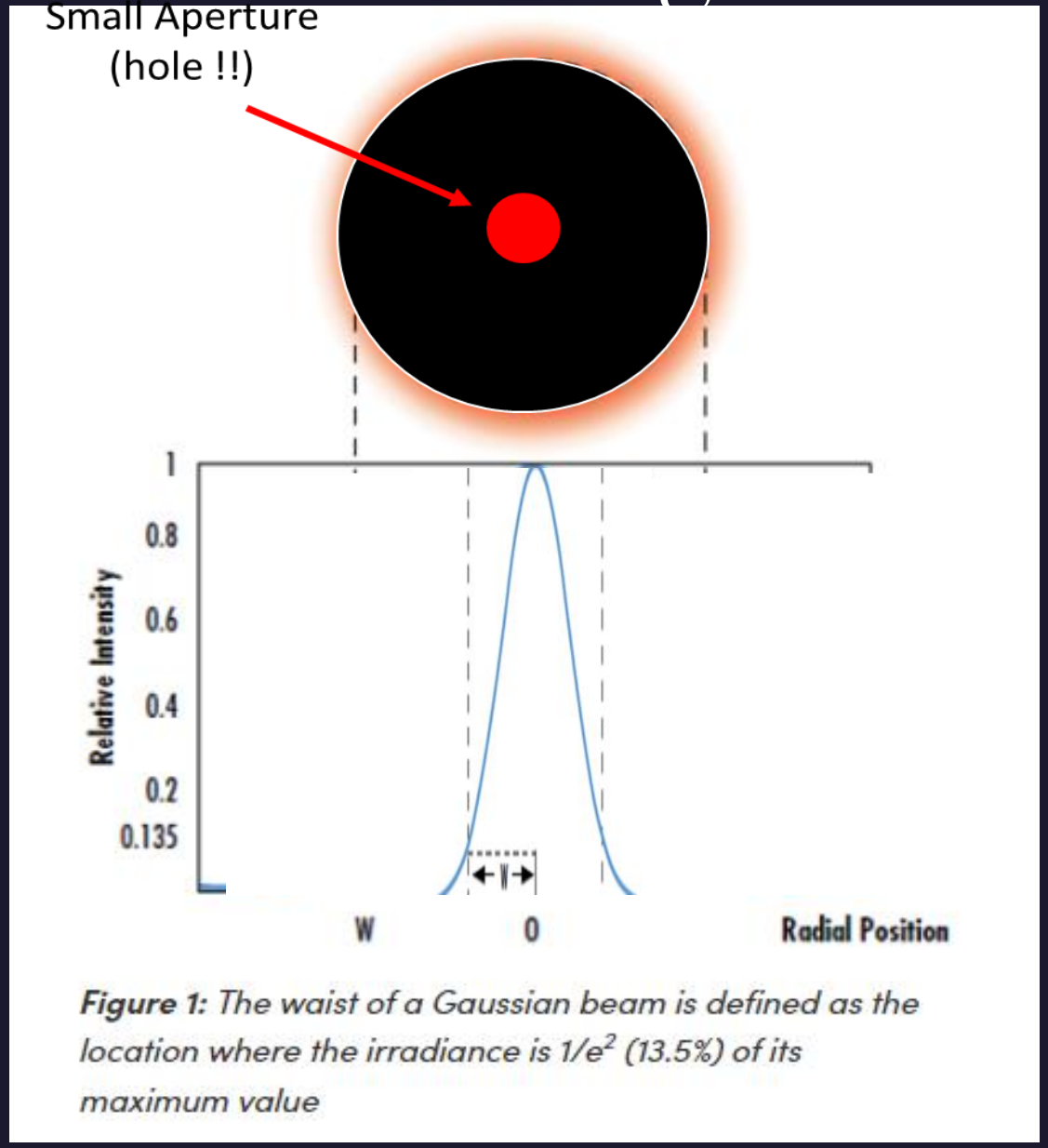
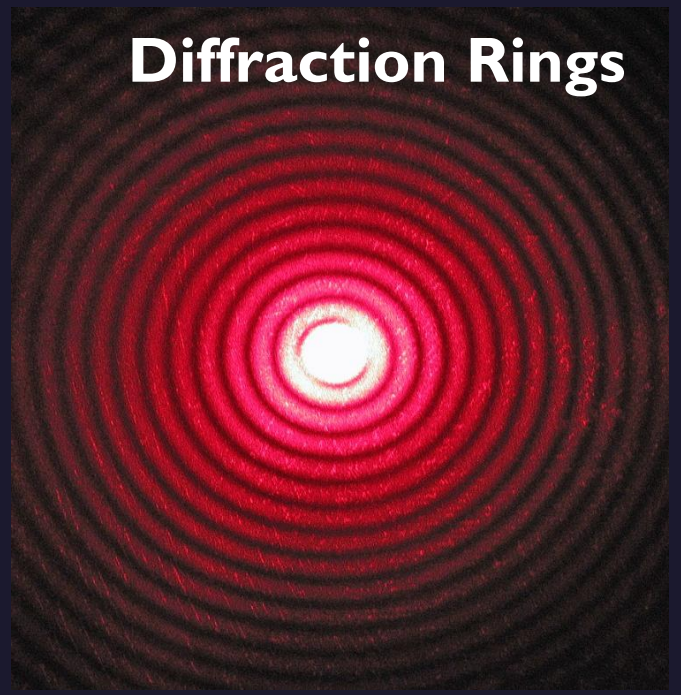


Figure 1: The waist of a Gaussian beam is defined as the location where the irradiance is $1/e^2$ (13.5%) of its maximum value

Gaussian Beam Propagation | Edmund Optics

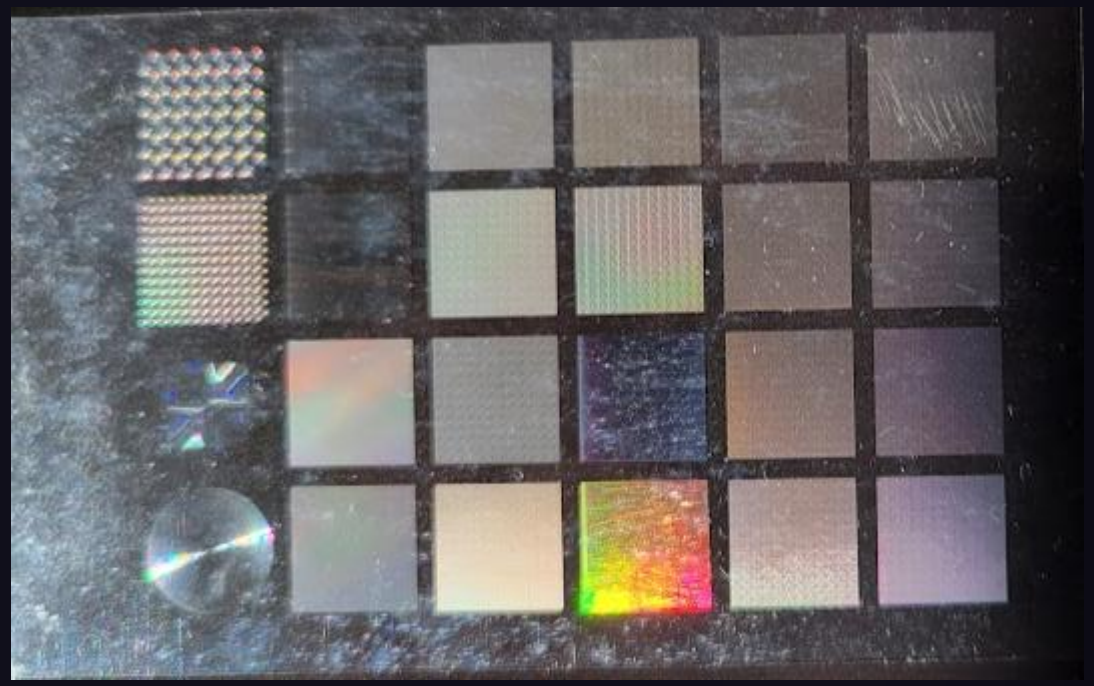


A diffraction pattern of a red laser beam projected onto a plate after passing through a small circular aperture in another plate

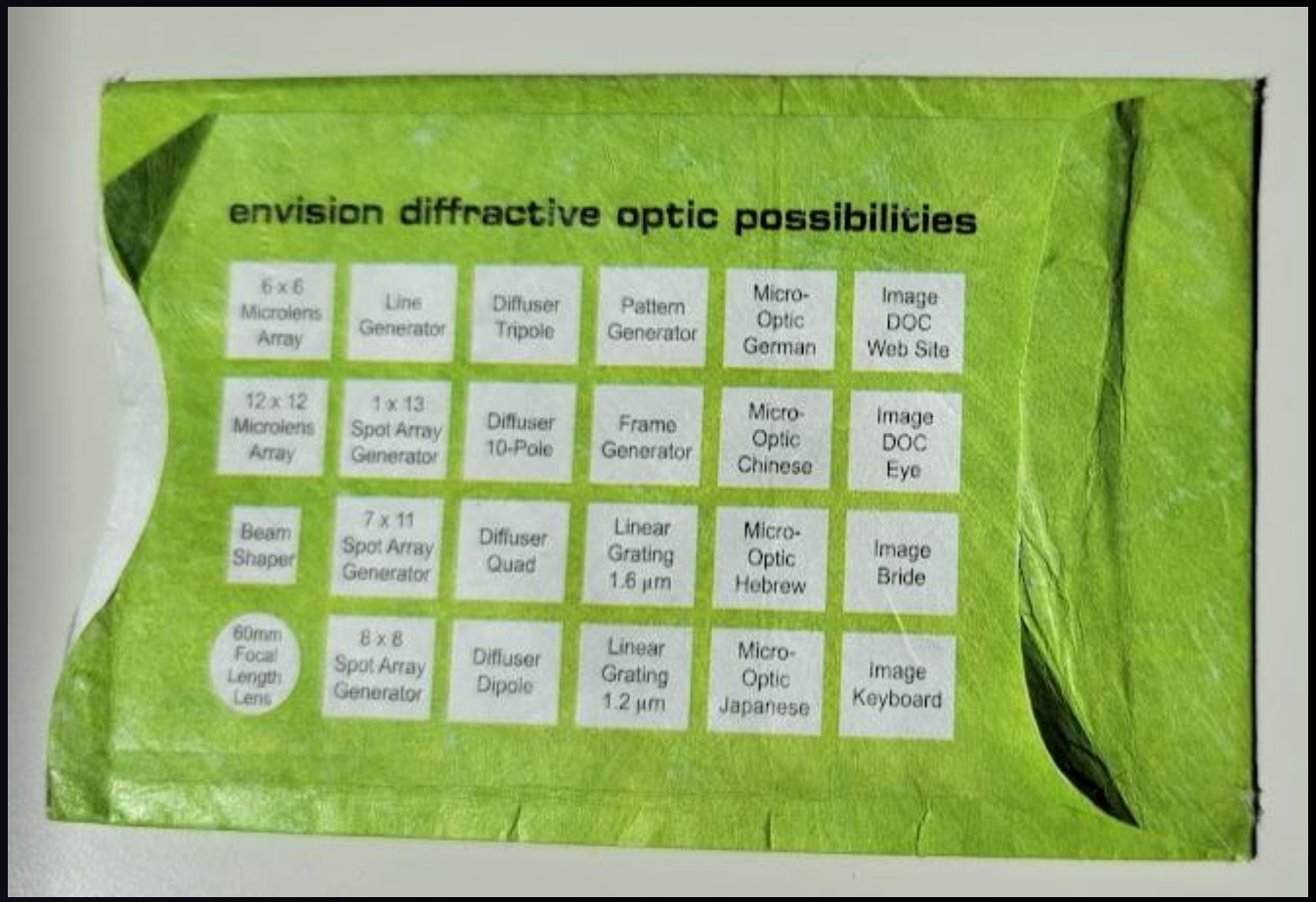
Laser Interference - Diffraction - Wikipedia



Computer Generated Diffractive Optical Elements

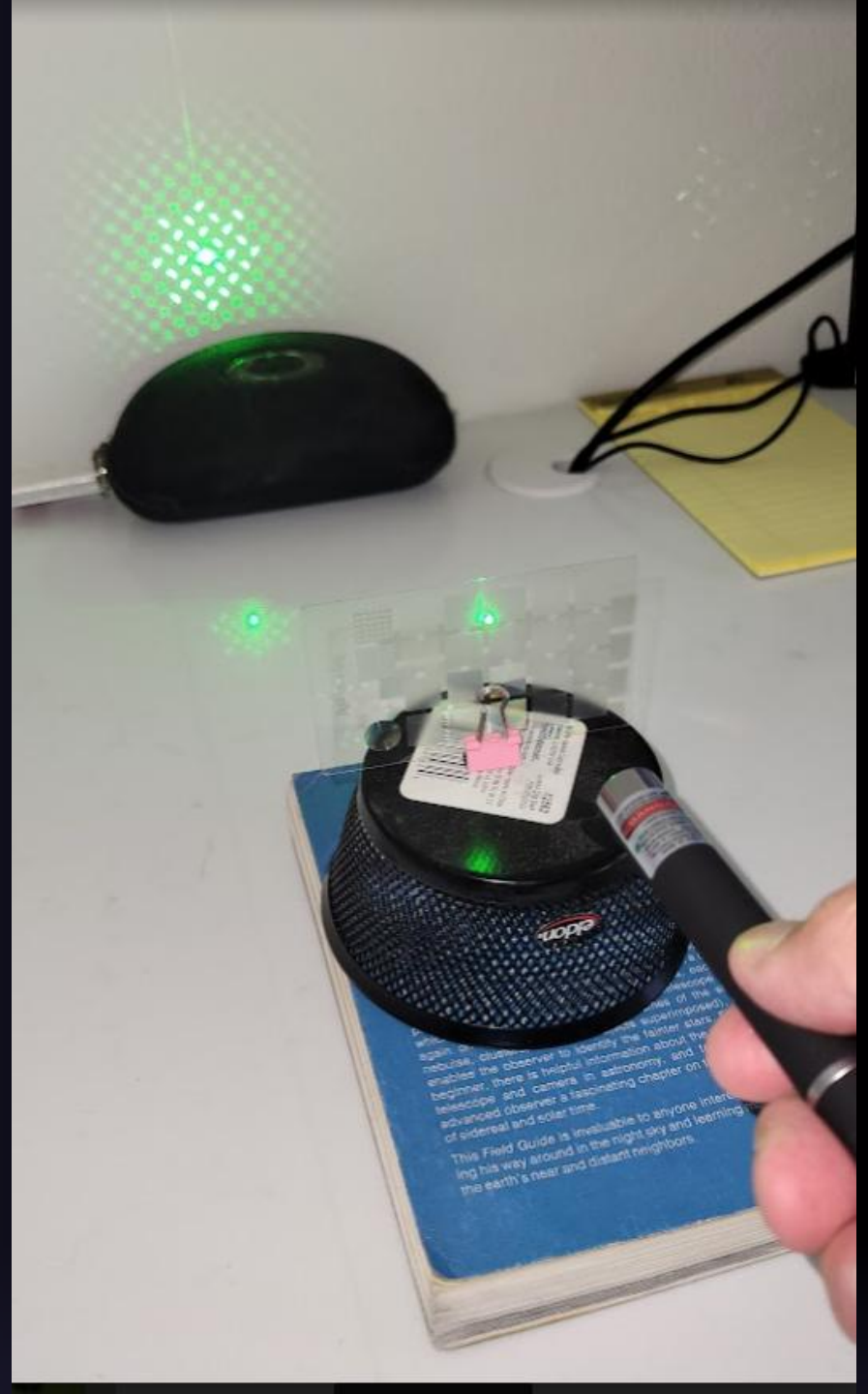


Not available anymore.

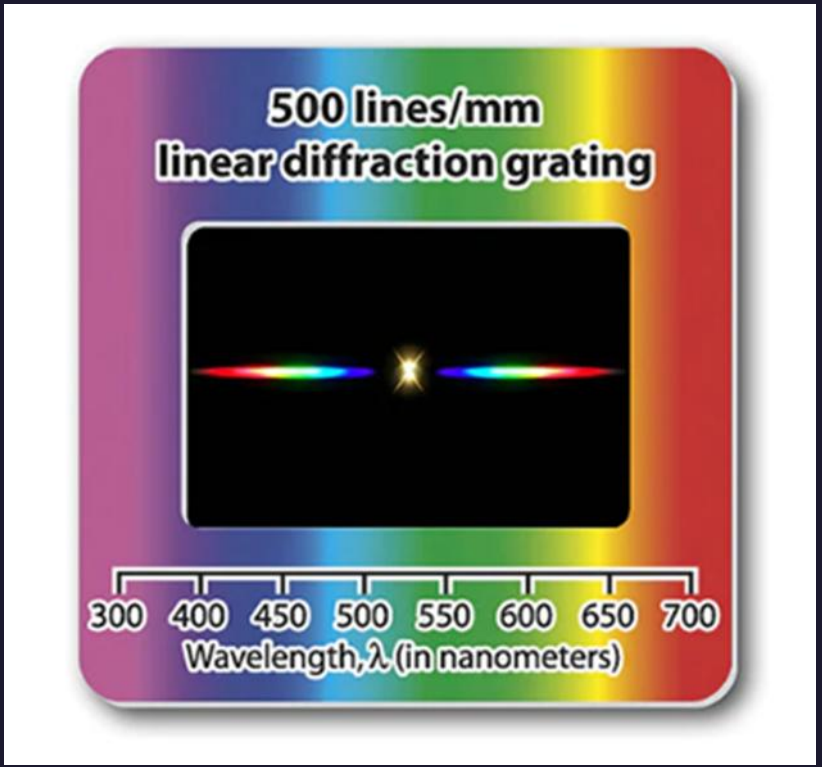


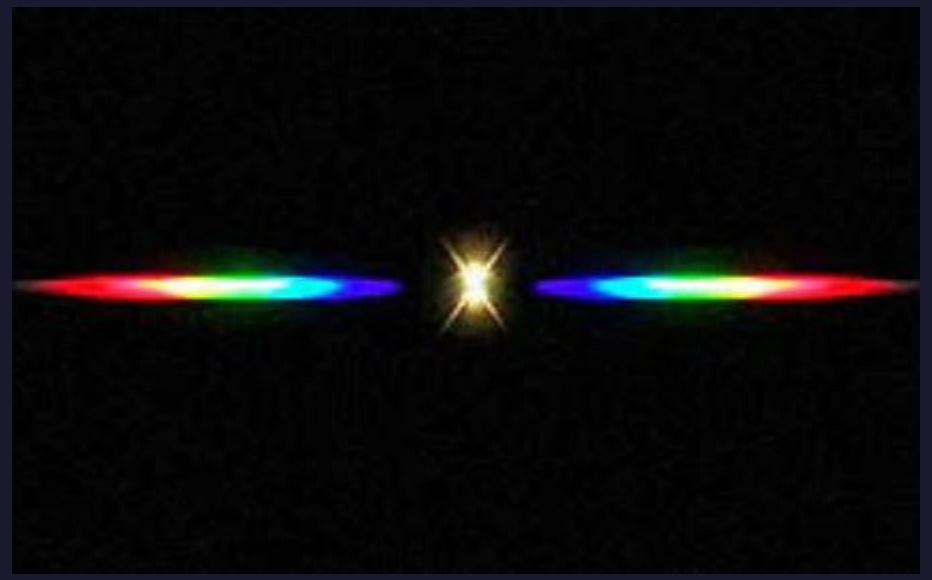


A 5.6 mm 'closed can' commercial laser diode, such as those used in a laser pointer.



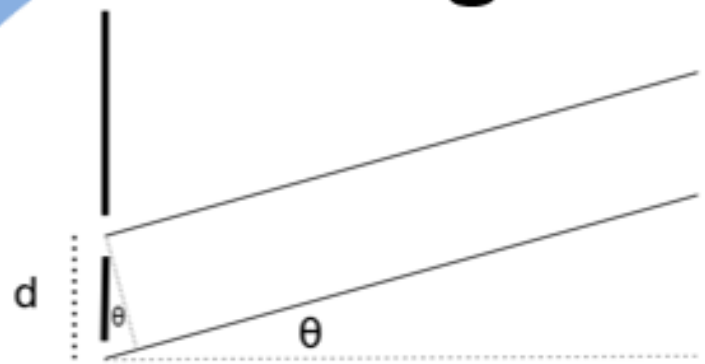
Diffraction Gratings





The grid of bumps in the plastic **diffract** the colors of the white light into the **visible spectrum**.

Young's Double-slit experiment



$$d \sin\theta \approx d\theta$$

$$d\theta_n = n\lambda, \; n = 0, 1, 2, \ldots$$

$$\theta_f \approx \lambda / d$$

$$w = z\theta_f = z\lambda / d$$

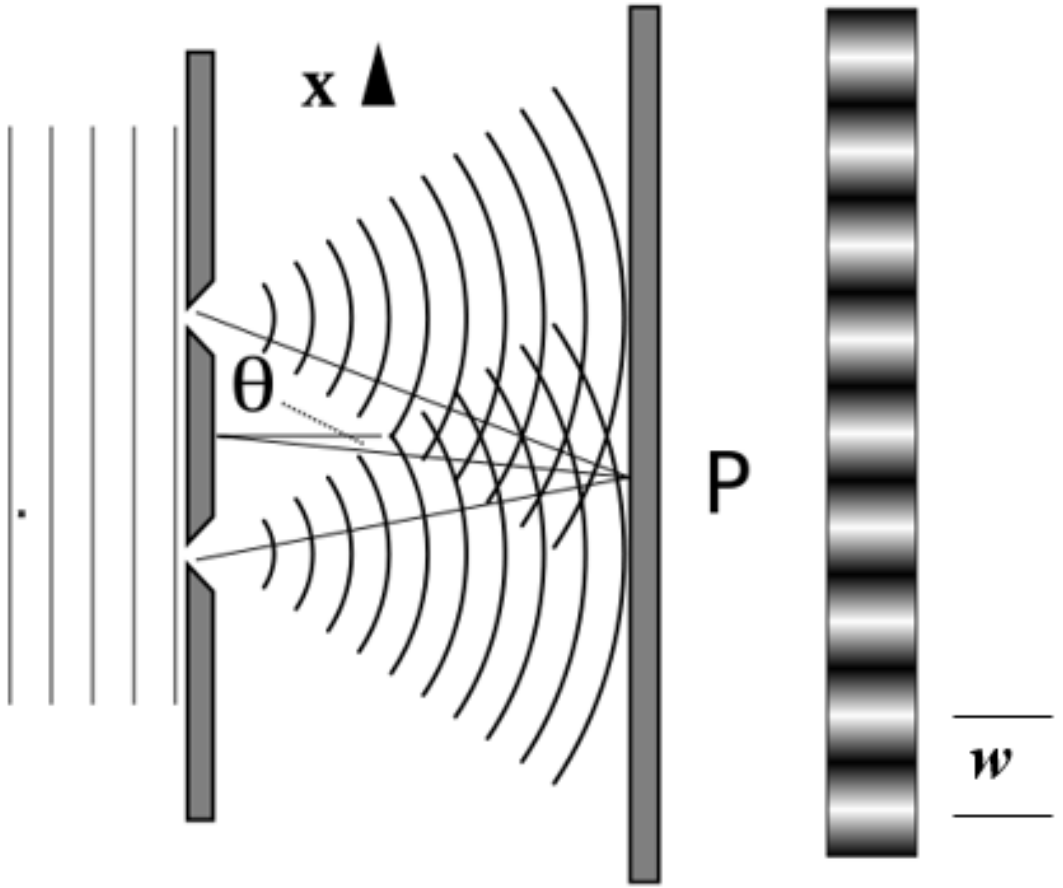
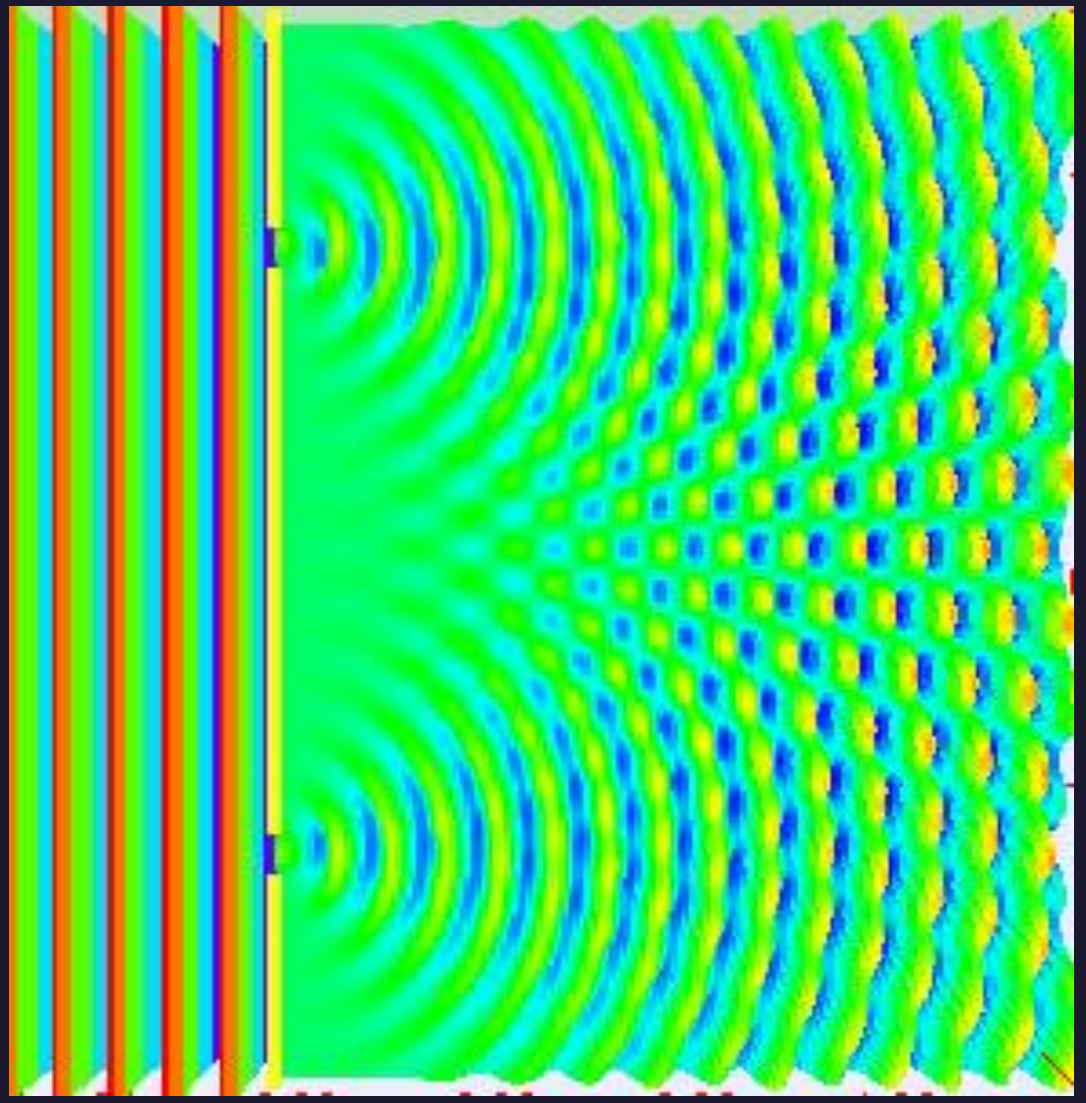
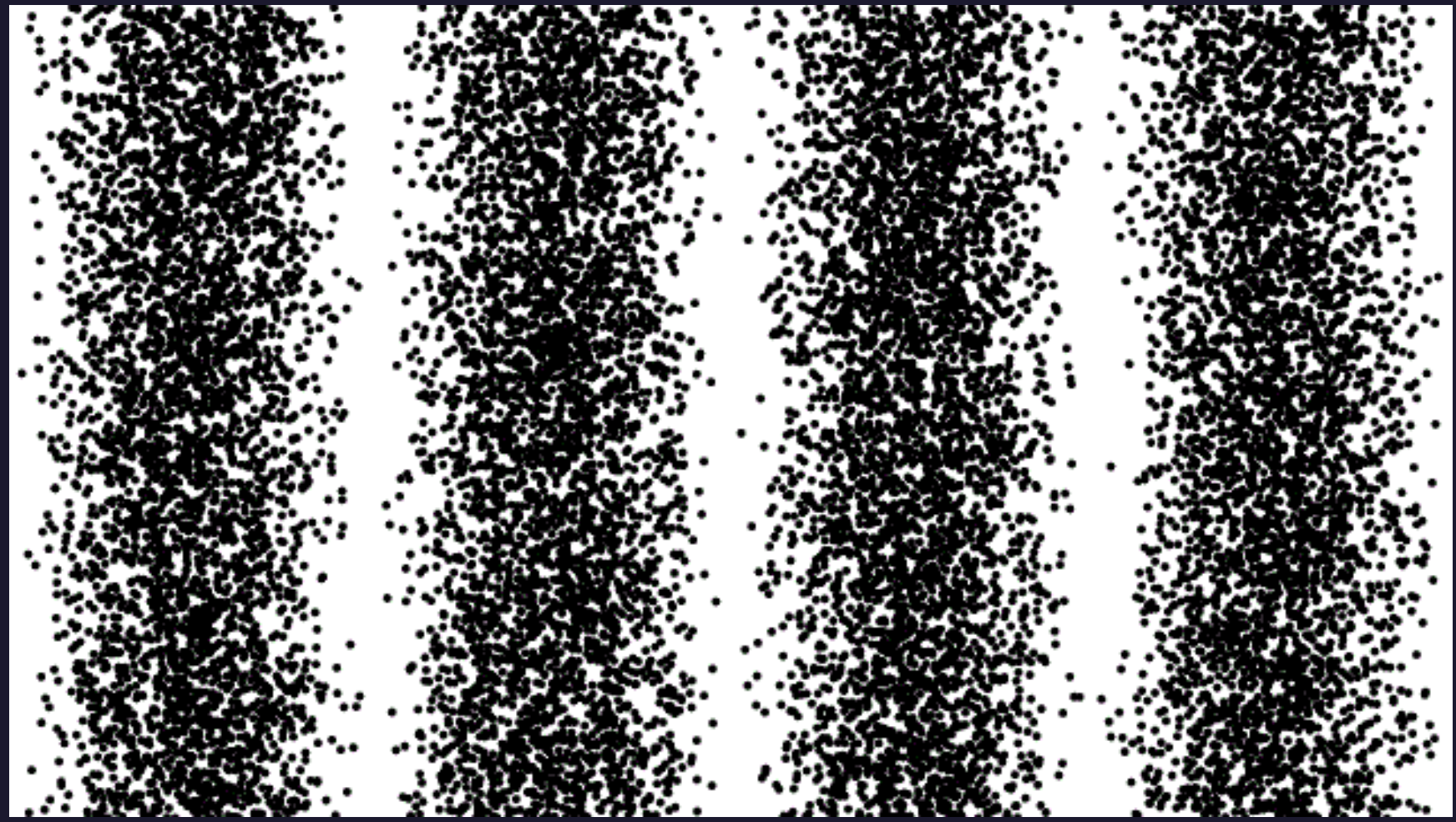


Diagram for the double-slit experiment

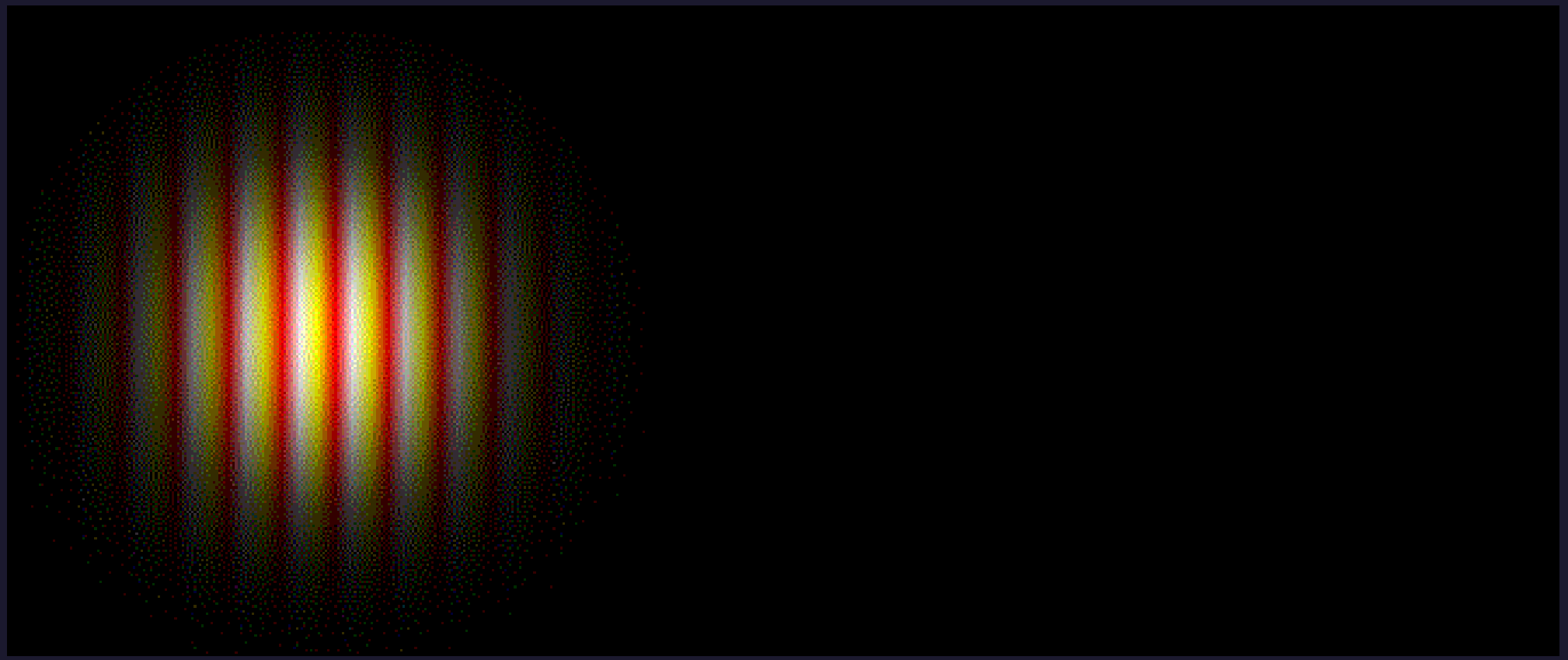
Two slits diffraction pattern by a plane wave



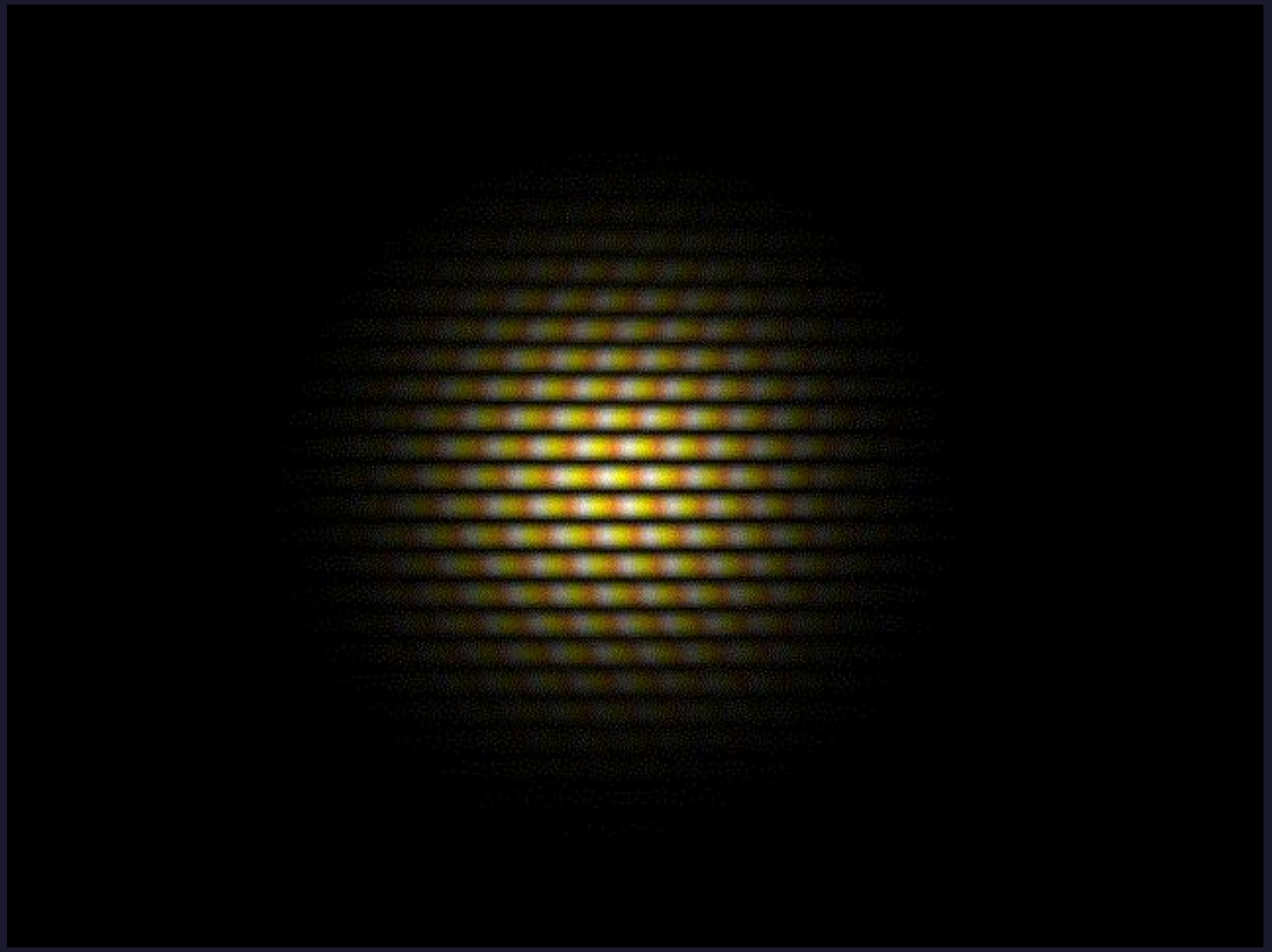
Particle impacts make visible the interference pattern of waves.



A quantum particle is represented by a wave packet.



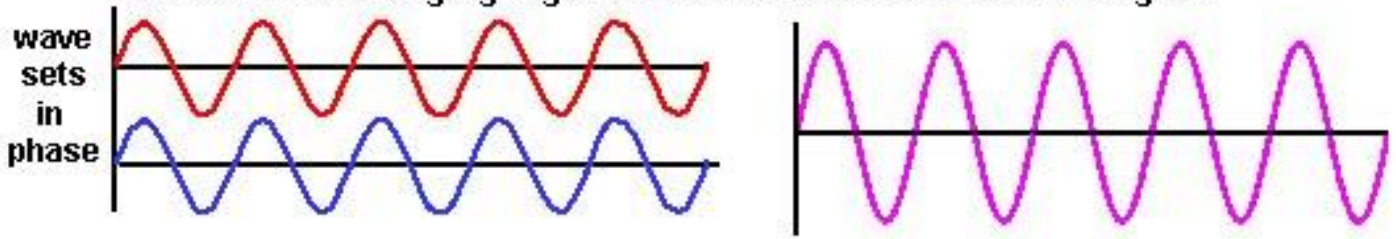
Interference of a quantum particle with itself



Superposition and Interference

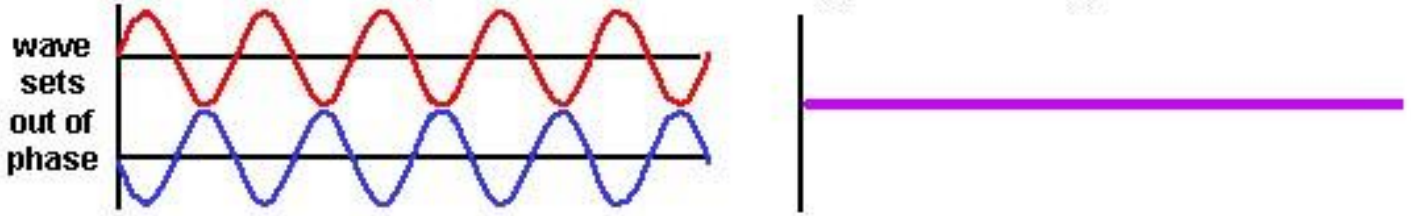
Constructive wave interference

Two wave sets merging together result in combined wave heights.



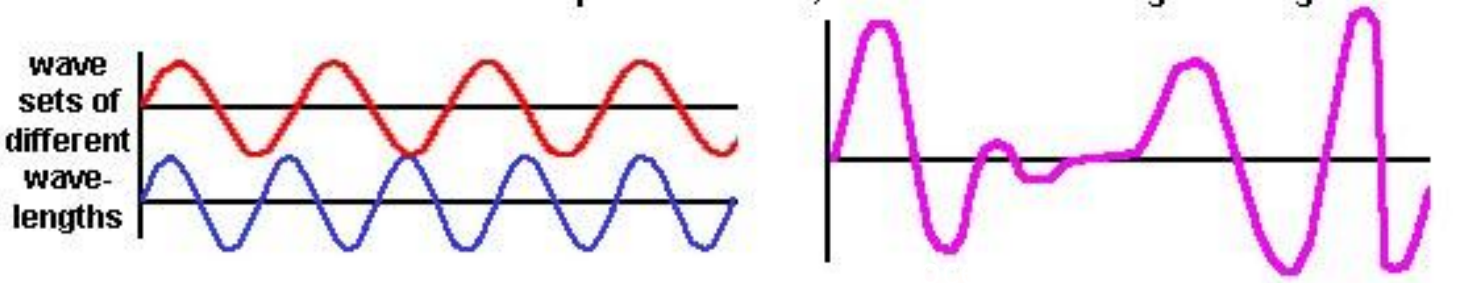
Destructive wave interference

Two wave sets off phase result in cancelling out wave heights.



Wave interference with wave set of different wavelengths

Wave sets of different wavelenths result in complex wave patterns:
both constructive and destructive patterns occur, sometimes resulting in “rouge waves”

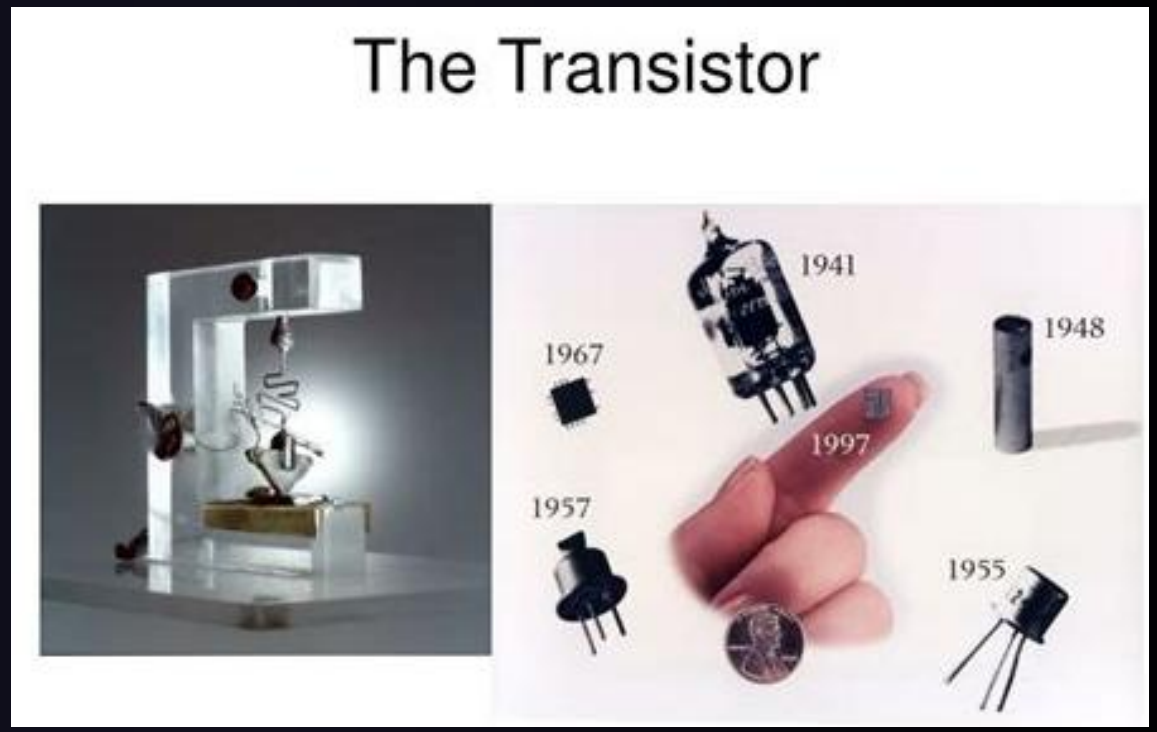


History of the transistor – Wikipedia "After WWII, Shockley decided to attempt the building of a triode-like semiconductor device. He secured funding and lab space, and went to work on the problem with Bardeen and Brattain. John Bardeen eventually developed a new branch of quantum mechanics known as surface physics to account for the "odd" behavior they saw, and Bardeen and Walter Brattain eventually succeeded in building a working device."











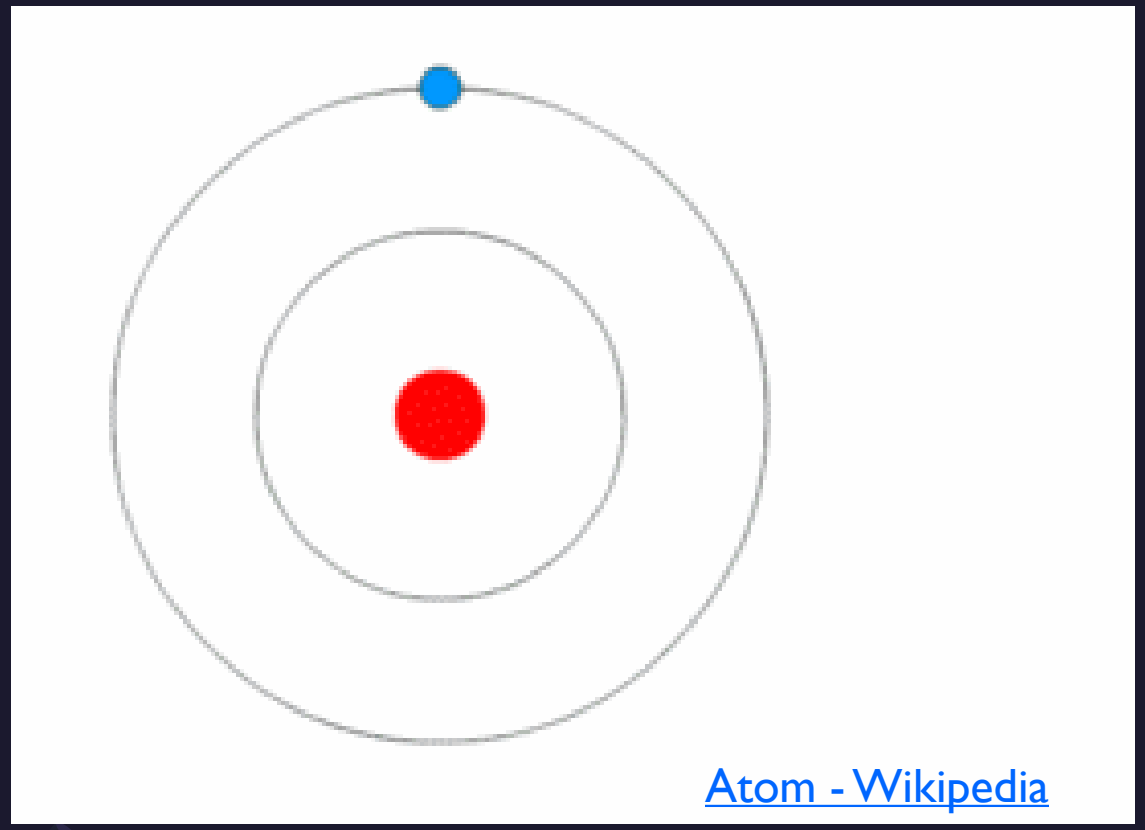






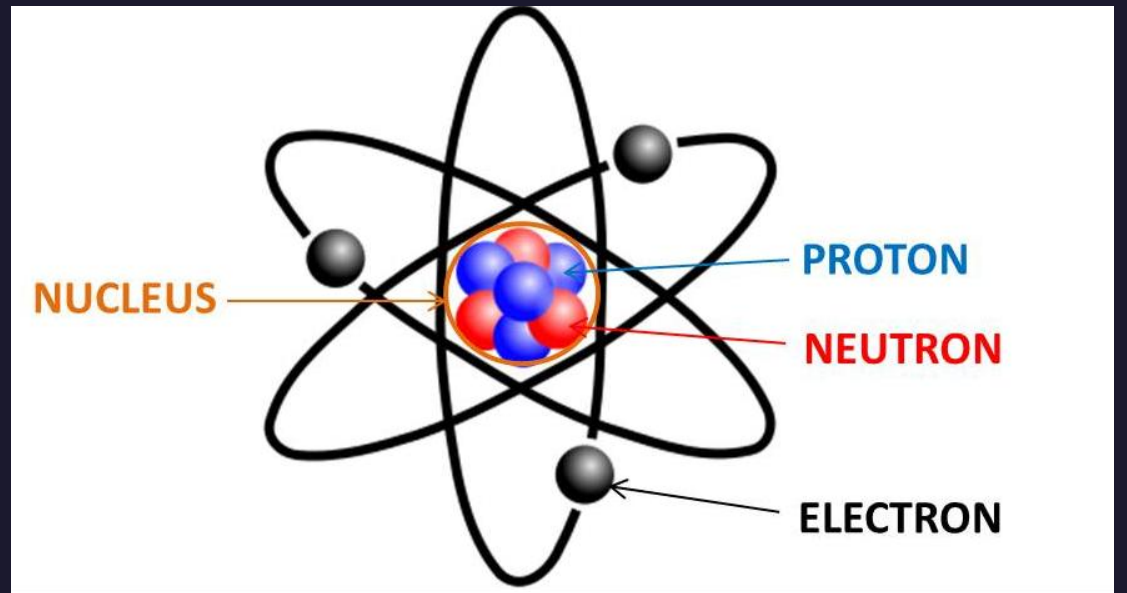
What are atoms & How do we know?

The Bohr model of the atom



Atom - Wikipedia

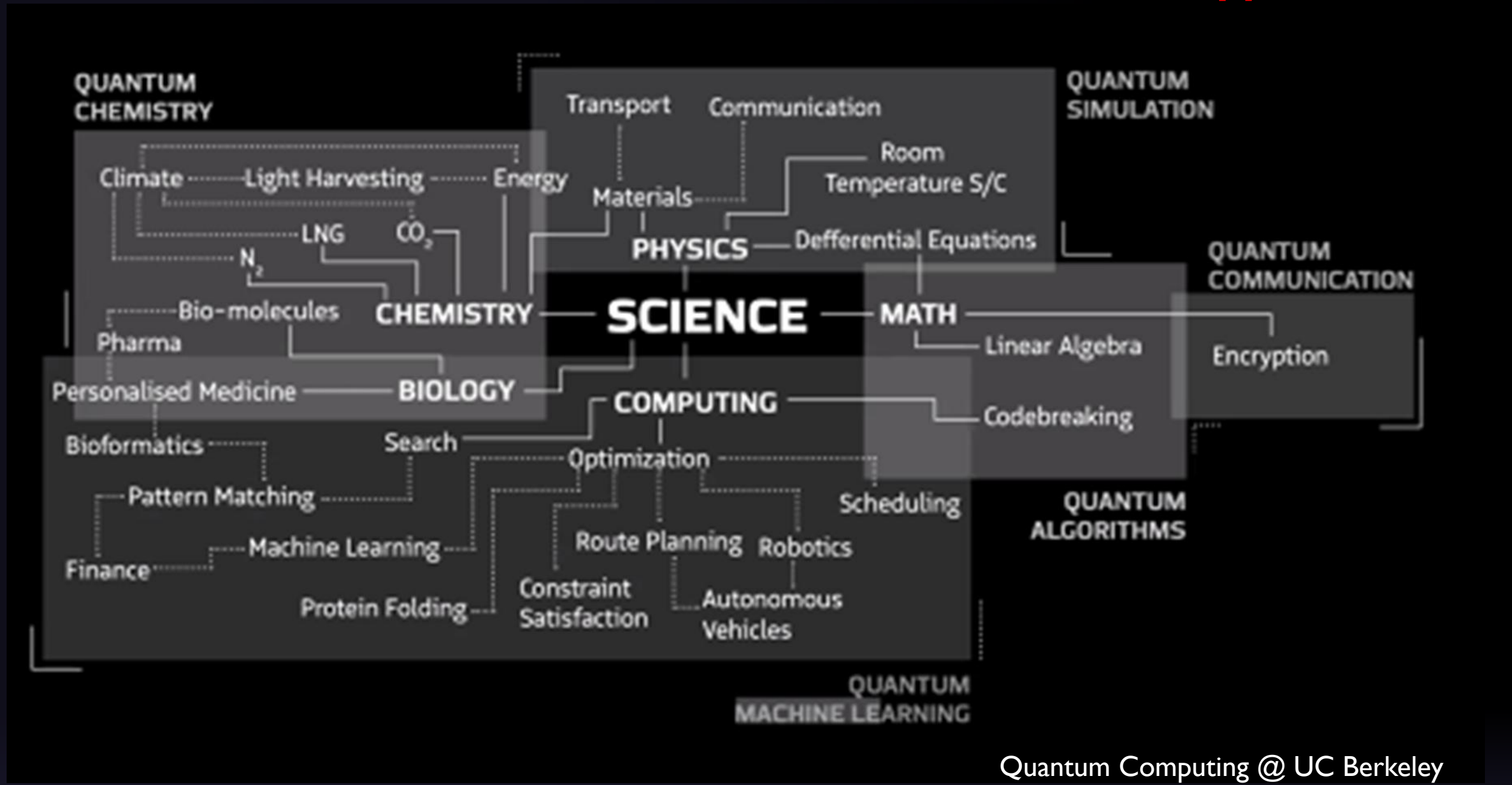
The Bohr model of the atom, with an electron making instantaneous "quantum leaps" from one orbit to another with gain or loss of energy. This model of electrons in orbits is obsolete.



Atoms – EWT (energywavetheory.com)

Why should you care??

Education and career opportunities.




THE QUANTUM OPPORTUNITY
Building Southern California's Future
INNOVATION
EDUCATION
WORKFORCE
COLLABORATION
SECURE COMMUNICATIONS
QUANTUM NETWORK
QUANTUM COMPUTER
QUANTUM NETWORK
QUANTUM SENSOR
PHOTONICS • FIBER OPTICS • QUANTUM COMMUNICATIONS • QUANTUM COMPUTING • QUANTUM SENSING • CYBERSECURITY

THE TWO QUANTUM REVOLUTIONS

From Exploiting Quantum Phenomena to Engineering Quantum Systems for a Better World

THE FIRST QUANTUM REVOLUTION

Exploiting Quantum Phenomena

1900s – 2000s

1927 Solvay Conference
Quantum theory emerges

1947 The Transistor
Birth of modern electronics

1960 The Laser
"A solution looking for a problem"

1965 Integrated Circuits
Miniaturization revolution begins

1970s–1980s Fiber Optics
Enabling global communications

1990s–2000s The Internet & Photonics
Connecting the world and driving the digital age

Classical technologies that harness the byproducts of quantum mechanics

THE SECOND QUANTUM REVOLUTION

Engineering Quantum Systems

2010s – 2030s and Beyond

2010s Quantum Computing
Processing information with qubits

2010s Quantum Communications
Secure links using quantum phenomena

2020s Quantum Networking
Connecting quantum devices at scale

2020s Quantum Sensing
Unprecedented precision measurement

2020s+ Quantum Cybersecurity
Protecting data in the post-quantum era

2030s+ Quantum Technologies in Society
Transforming industries and improving lives

Technologies that control and manipulate quantum systems

ENABLING FOUNDATIONS THROUGHOUT BOTH REVOLUTIONS

- Fundamental Science
- Engineering Innovation
- Computing Power
- Materials Advances
- Education & Workforce
- Collaboration & Partnerships
- Government Investment
- Entrepreneurship & Industry

TWO REVOLUTIONS. ONE CONTINUUM OF INNOVATION. LIMITLESS POSSIBILITIES.

SOUTHERN CALIFORNIA'S QUANTUM ECOSYSTEM

Collaboration • Education • Innovation • Workforce • Economic Growth

UNIVERSITIES & RESEARCH INSTITUTIONS

- Quantum Information Science
- Photonics & Optics
- Materials & Nanotechnology
- Computer Science & AI
- Engineering & Applied Physics
- Interdisciplinary Research



Knowledge Creation & Talent Development

WORKFORCE DEVELOPMENT & EDUCATION PIPELINE

K-12 Outreach → Community Colleges → Universities → Continuing Education → Industry Training

INDUSTRY PARTNERS

- Aerospace & Defense
- Semiconductors
- Photonics & Optics
- Telecommunications
- Quantum Computing
- Cybersecurity
- Advanced Manufacturing
- Healthcare & Biotech



Technology Innovation & Commercialization

COMMUNITY COLLEGES

- Accessible Education
- Technical Training
- Associate Degrees
- Hands-on Laboratories
- Transfer Pathways
- Workforce Preparation



Workforce Pipeline & Skills Development

QUANTUM INNOVATION ECOSYSTEM

Connecting People, Ideas and Technology Across Southern California



SOUTHERN CALIFORNIA

Diverse Talent • World-Class Institutions
Advanced Infrastructure • Entrepreneurial Spirit

STARTUPS & ENTREPRENEURS

- Quantum Software
- Quantum Hardware
- Sensing & Imaging
- Secure Communications
- Applications & Services
- Commercialization



Innovation, Agility & New Solutions

GOVERNMENT & NATIONAL LABORATORIES

- Research Funding
- National Labs
- Policy & Strategy
- Infrastructure Support
- Standards & Security
- Economic Development



Investment, Policy & Strategic Support

PROFESSIONAL SOCIETIES & ASSOCIATIONS

- Networking & Collaboration
- Conferences & Workshops
- Publications & Knowledge Sharing
- Standards & Best Practices
- Outreach & Advocacy
- Mentorship & Community



Community, Connections & Knowledge Exchange

ENABLING INFRASTRUCTURE

Fiber Optic Networks | Semiconductor Manufacturing | Cryogenics & Precision Fab | High Performance Computing & Cloud | Cybersecurity & Data Security | Testbeds & Shared Research Facilities | Investment & Venture Capital

TOGETHER WE BUILD →

- **A STRONGER WORKFORCE** — Skilled talent for tomorrow's quantum economy
- **BREAKTHROUGH INNOVATIONS** — Solving real-world problems with quantum technologies
- **ECONOMIC GROWTH** — New companies, jobs and investment
- **GLOBAL LEADERSHIP** — Positioning Southern California as a quantum hub

→ A BETTER FUTURE FOR ALL

TOGETHER, WE ACCELERATE THE SECOND QUANTUM REVOLUTION



One Ecosystem. Many Partners. Limitless Possibilities.

PREPARING THE QUANTUM WORKFORCE

A Pathway from Education to Careers in the Quantum Economy

A CONTINUOUS PATH OF LEARNING, EXPERIENCE, AND GROWTH

1. K–12 STEM

Inspire • Engage • Explore

- STEM Education & Hands-on Activities
- Science Fairs & Competitions
- Robotics, Coding, and Maker Programs
- Early Exposure to Quantum Concepts

2. COMMUNITY COLLEGES

Build Skills • Gain Experience

- Associate Degrees & Certificates
- Photonics, Optics, Electronics, IT
- Hands-on Laboratories & Internships
- Affordable Pathways to High-Tech Careers

3. UNIVERSITIES

Deepen Knowledge • Innovate

- Bachelor's, Master's, and Ph.D. Programs
- Quantum Information Science, Engineering, Physics, CS
- Research & Innovation
- Industry Partnerships & Co-op Programs

4. CONTINUING EDUCATION

Advance • Adapt • Lead

- Professional Certifications
- Short Courses & Bootcamps
- Online & Hybrid Programs
- Upskilling for Career Advancement
- Lifelong Learning for a Rapidly Evolving Field

5. CAREERS IN THE QUANTUM ECONOMY

Build the Future

- Quantum Computing Engineer
- Quantum Software Developer
- Photonics & Quantum Hardware Engineer
- Quantum Network Architect
- Quantum Sensing Specialist
- Quantum Cybersecurity Expert
- Research Scientist
- Technical Sales & Applications
- Entrepreneurship & Startups

CORE COMPETENCIES DEVELOPED AT EVERY STAGE

- Critical Thinking & Problem Solving
- Math & Physics Foundations
- Programming & Data Skills
- Laboratory & Experimental Skills
- Communication Teamwork
- Innovation & Entrepreneurship
- Ethics, Security & Responsibility

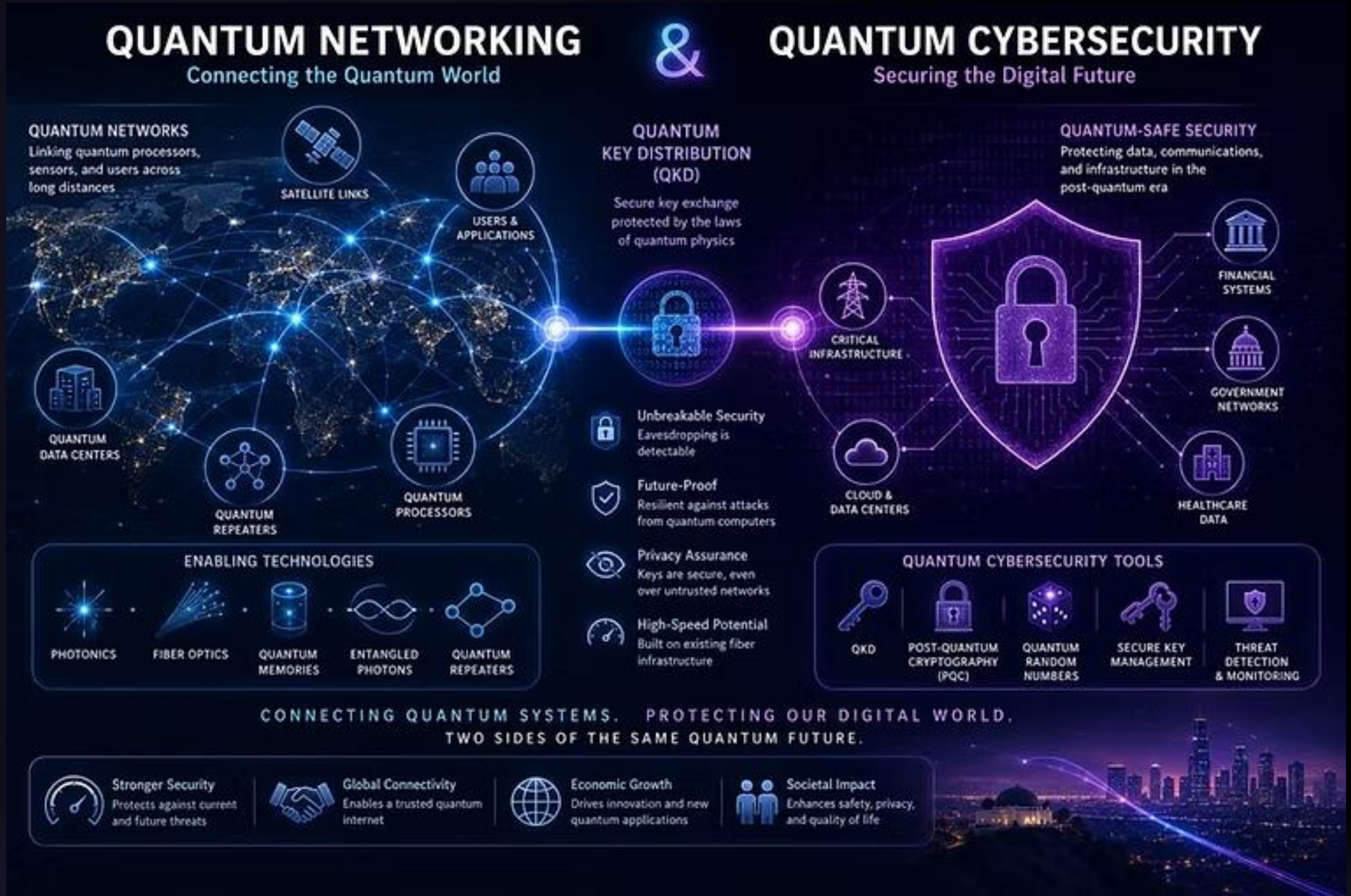
ENABLING FOUNDATIONS

- PHOTONICS & OPTICS
- FIBER OPTICS & COMMUNICATIONS
- ELECTRONICS & SEMICONDUCTORS
- QUANTUM COMPUTING & SIMULATION
- QUANTUM NETWORKING & COMMUNICATIONS
- QUANTUM SENSING & METROLOGY
- CYBERSECURITY & DATA PROTECTION
- ARTIFICIAL INTELLIGENCE & DATA SCIENCE

IMPACT

- STRONGER ECONOMY & JOB GROWTH
- NATIONAL SECURITY & RESILIENCE
- BETTER HEALTHCARE & QUALITY OF LIFE
- SCIENTIFIC DISCOVERY & INNOVATION
- A SUSTAINABLE FUTURE FOR ALL

EDUCATE · EMPOWER · INNOVATE · COLLABORATE · LEAD | TOGETHER, WE BUILD THE QUANTUM FUTURE.


QUANTUM NETWORKING
Connecting the Quantum World
&
QUANTUM CYBERSECURITY
Securing the Digital Future
QUANTUM NETWORKS
Linking quantum processors, sensors, and users across long distances
SATELLITE LINKS
USERS & APPLICATIONS
QUANTUM DATA CENTERS
QUANTUM REPEATERS
QUANTUM PROCESSORS
QUANTUM KEY DISTRIBUTION (QKD)
Secure key exchange protected by the laws of quantum physics
Unbreakable Security
Eavesdropping is detectable
Future-Proof
Resilient against attacks from quantum computers
Privacy Assurance
Keys are secure, even over untrusted networks
High-Speed Potential
Built on existing fiber infrastructure
CRITICAL INFRASTRUCTURE
CLOUD & DATA CENTERS
QUANTUM-SAFE SECURITY
Protecting data, communications, and infrastructure in the post-quantum era
FINANCIAL SYSTEMS
GOVERNMENT NETWORKS
HEALTHCARE DATA
ENABLING TECHNOLOGIES
PHOTONICS
FIBER OPTICS
QUANTUM MEMORIES
ENTANGLED PHOTONS
QUANTUM REPEATERS
QUANTUM CYBERSECURITY TOOLS
QKD
POST-QUANTUM CRYPTOGRAPHY (PQC)
QUANTUM RANDOM NUMBERS
SECURE KEY MANAGEMENT
THREAT DETECTION & MONITORING
CONNECTING QUANTUM SYSTEMS. PROTECTING OUR DIGITAL WORLD.
TWO SIDES OF THE SAME QUANTUM FUTURE.
Stronger Security
Protects against current and future threats
Global Connectivity
Enables a trusted quantum internet
Economic Growth
Drives innovation and new quantum applications
Societal Impact
Enhances safety, privacy, and quality of life

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Spark's Offerings

K–14 Classrooms

Bridging classrooms and careers in photonics and advanced manufacturing.

1. SparkAlpha Explore
   - Introduction to photonics & adv manufacturing
   - QIS EXTENSION
2. SparkBeta
   - Introduction to photonic chip design
3. SparkGamma
   - Hands-on photonic chip design

Educators

SparkEd

- Expert guidance on the future of semiconductors & photonics
- Practical classroom strategies ready to implement right away
- Career-connected learning activities that link instruction to real-world STEM pathways
- Activities that link directly to student career exploration
- Ongoing connection to Spark's educator and industry network
- Inspiration to spark student curiosity in STEM

SPARK COMMUNITY OF PRACTICE

"CoP"

Training

Materials

Community

- *Educators*
- *Foundation Employees*
- *Industry & Academia*

Life in the QuantumOptics Age

The QOISC is a focal point for Donn Silberman's Quantum Optics Education Adventures



OSSC Optical Society of Southern California

Visit the OSSC website for monthly meeting & outreach events info.



UC Irvine Division of Continuing Education

Follow the Digital White Rabbit

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Submit





Things at the Atomic Scale are very different than at the human scale.

Summary

- The Quantum World underlies our modern civilization.
- And Quantum is about take humanity to the next level.
- **You can help make it happen.**

Thank You

Donn Silberman

Quantum Optics Institute of Southern California

http://qoisc.org Donn@qoisc.org

The remaining slides are for backup
And can be used during Q&A
as time permits



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Pasadena City College

http://pasadena.edu/academics/degrees-and-certificates/certificates-of-achievement/laser-technology.php

NASA Jet Propulsion Laboratory
California Institute of Technology

Be Laser-Focused

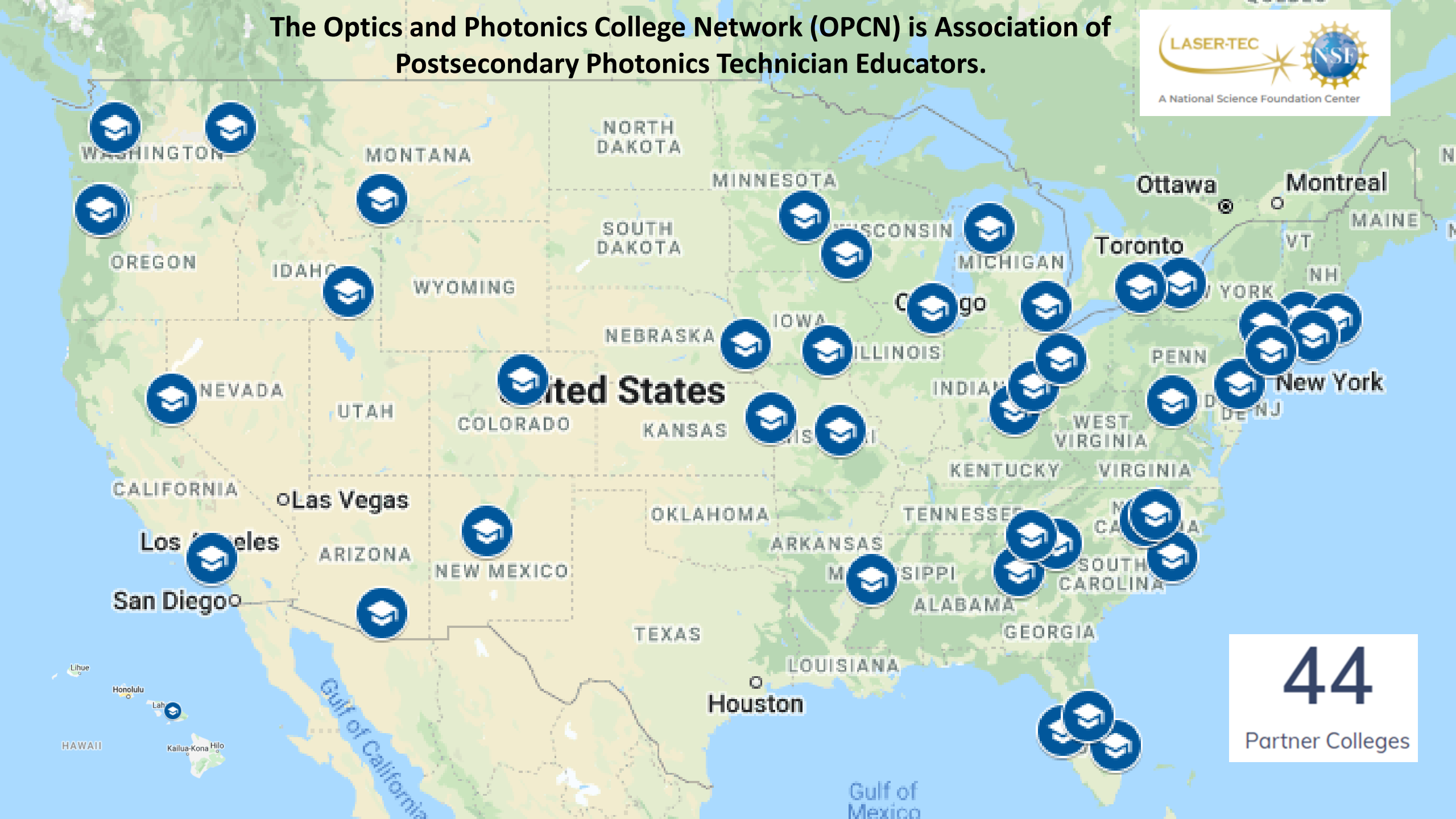
LaserTech is the use of lasers, cameras, lenses, mirrors, sensors, displays, fiber optics, and other technical devices that interact with light.



- ✓Earn skills to be immediately hired as a technician
- ✓Be prepared for success in a university engineering program
- ✓Advance your careeer by mastering more technically demanding skills

naturalsciences@pasadena.edu

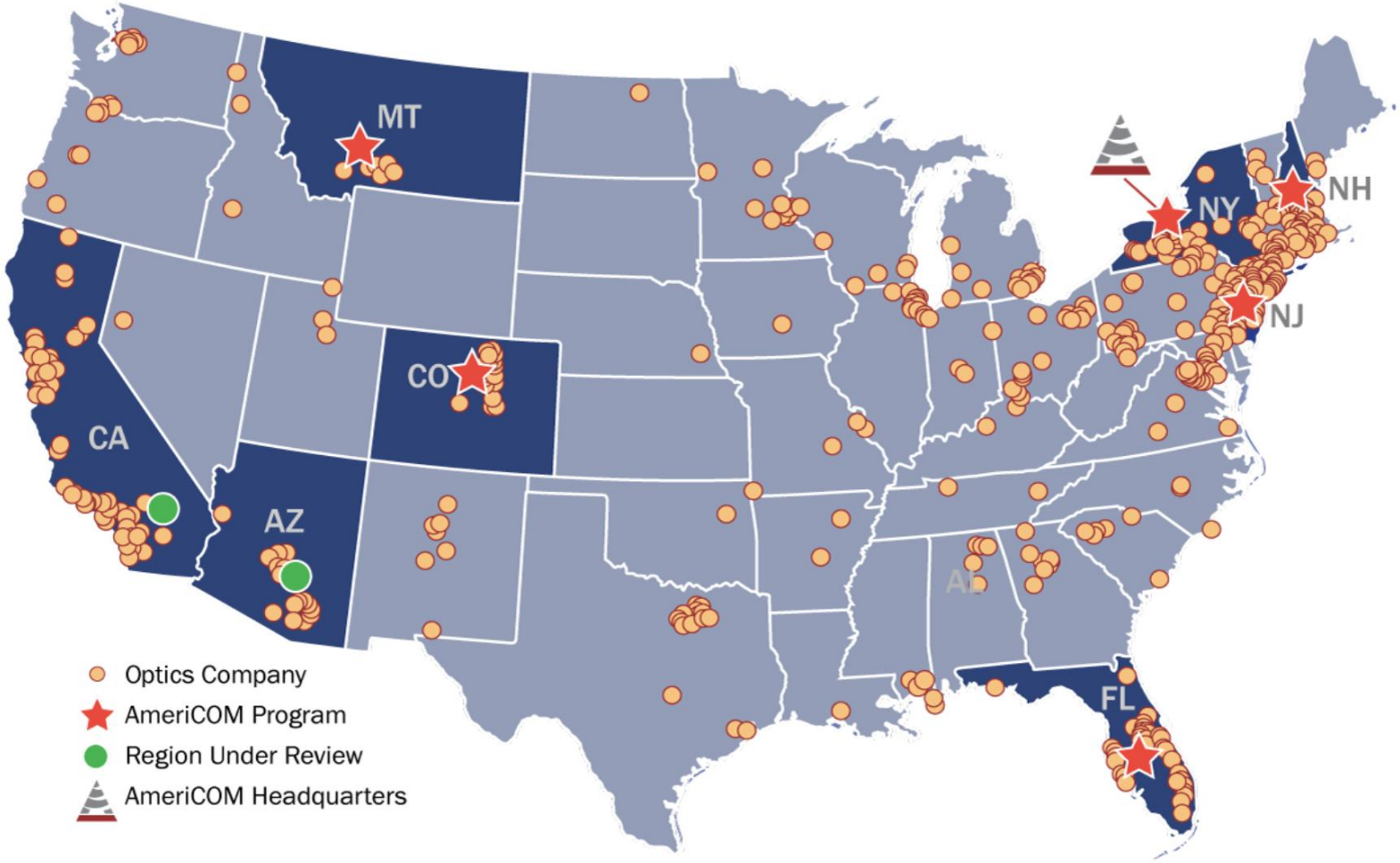
The Optics and Photonics College Network (OPCN) is Association of Postsecondary Photonics Technician Educators.



44

Partner Colleges

Recognizing a critical shortage in skilled technicians across the nation's advanced manufacturing industries, the U.S. Department of Defense (DoD) established the National Imperative for Industrial Skills (NIIS) program and selected AmeriCOM to significantly build and sustain the country's precision optics manufacturing base. Utilizing a training program model, AmeriCOM works in concert with industrial, academic, nonprofit, and government partners in regions where there is a significant cluster of optics manufacturing companies to leverage American ingenuity and forge new paths of prosperity for our workforce.



Quantum Computers & Cybersecurity

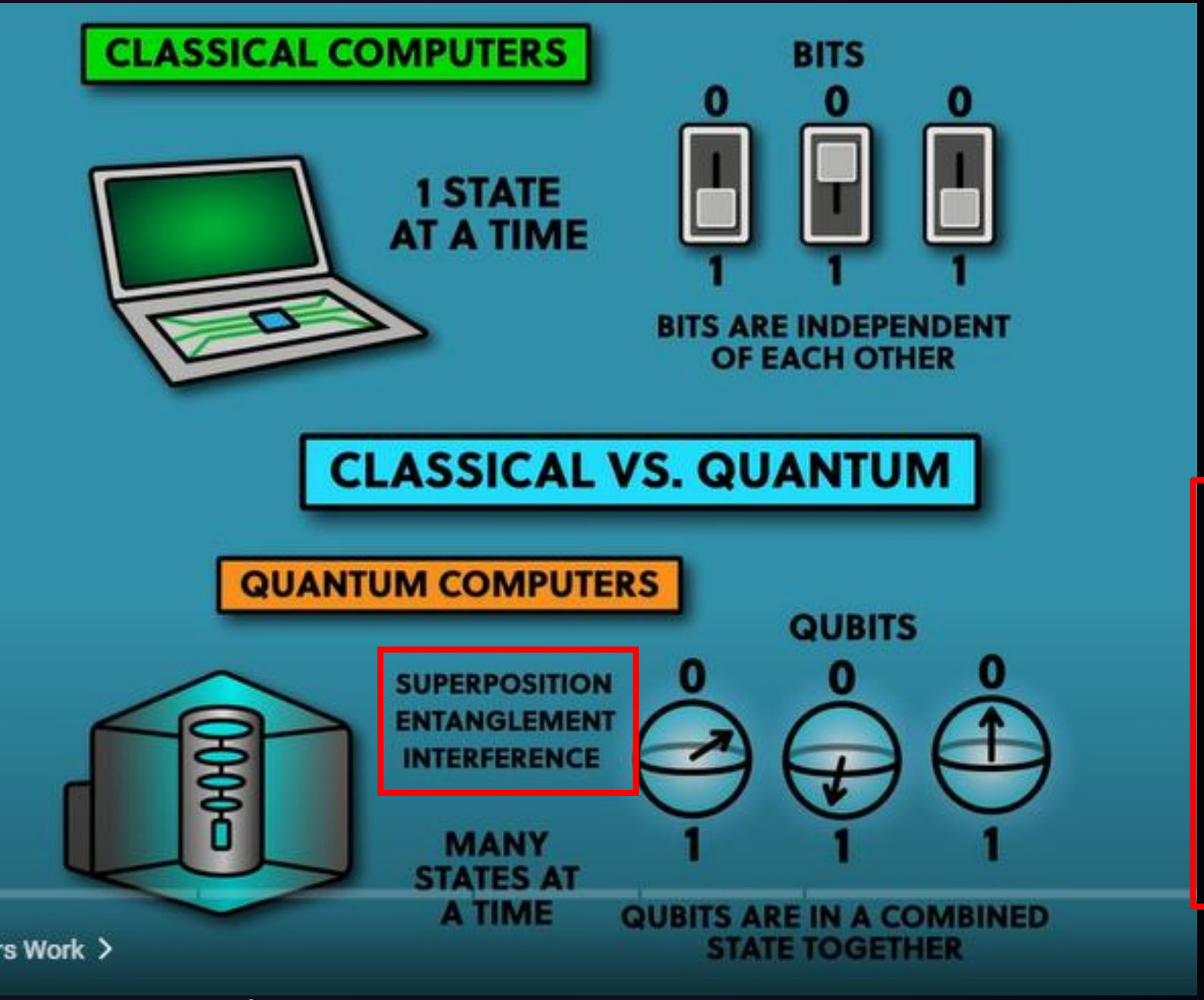
Including cryptocurrencies and blockchain technologies

Risks & Opportunities

The global race to develop practical quantum computers that can 'hack' all current encryption technologies
Against the implementation of quantum resistant encryption technologies.

Intellectual property (IP) -

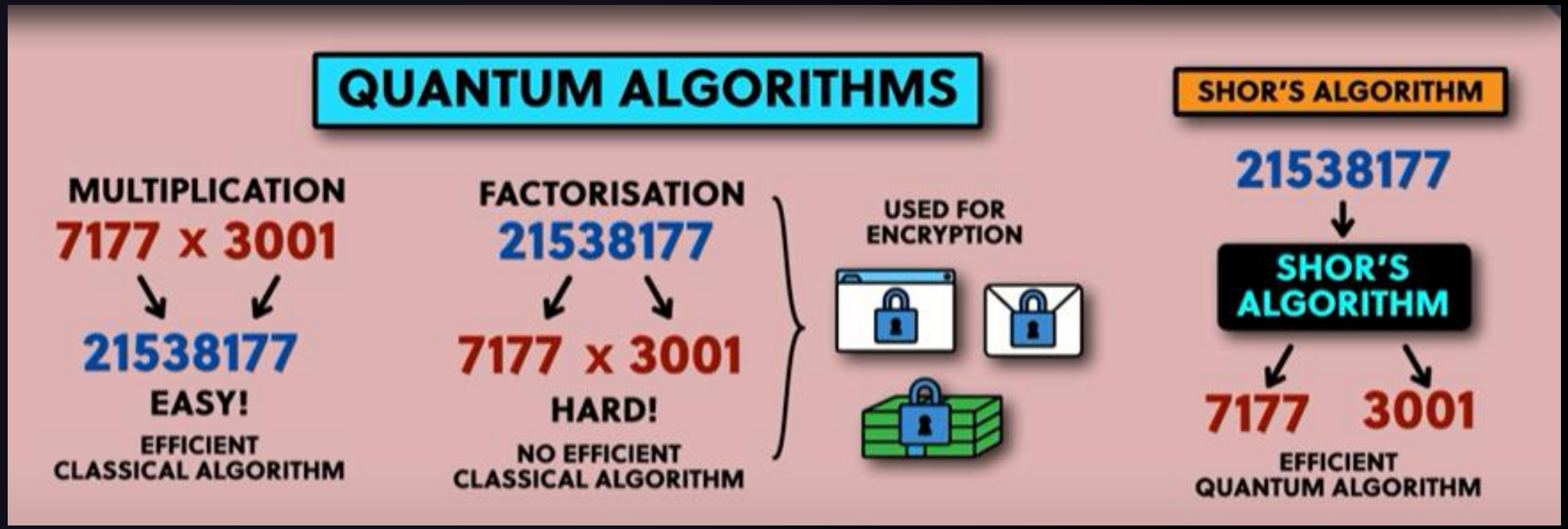
- **in the public domain via patents and published papers**
- **Trade Secrets – held 'close to the vest'**



Superposition
Entanglement
Interference

Einstein's
"Spooky Action at a Distance"

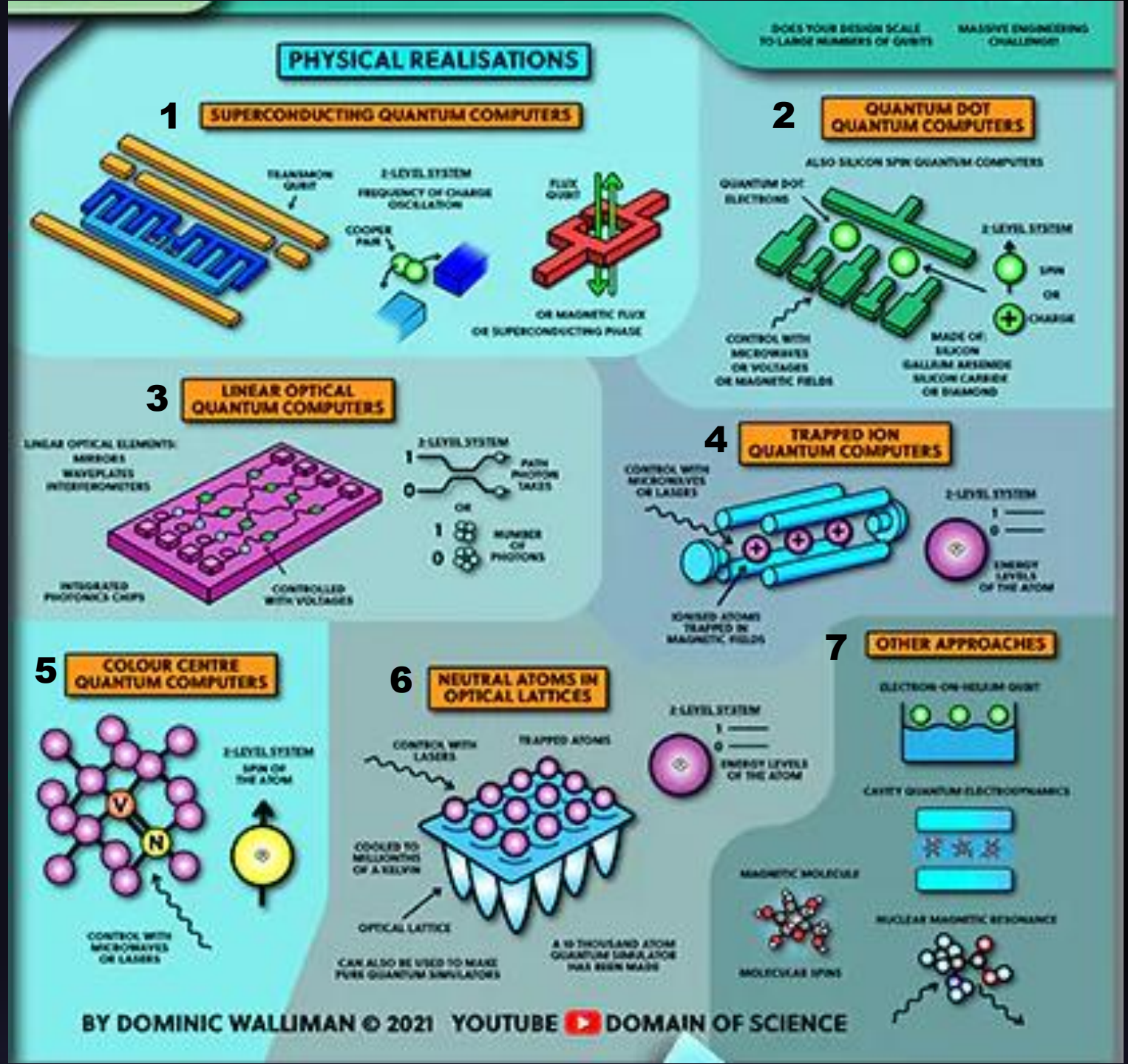
The Map of Quantum Computing | Quantum Computers Explained
DoS - Domain of Science – YouTube



Classical Computing

Quantum Computing

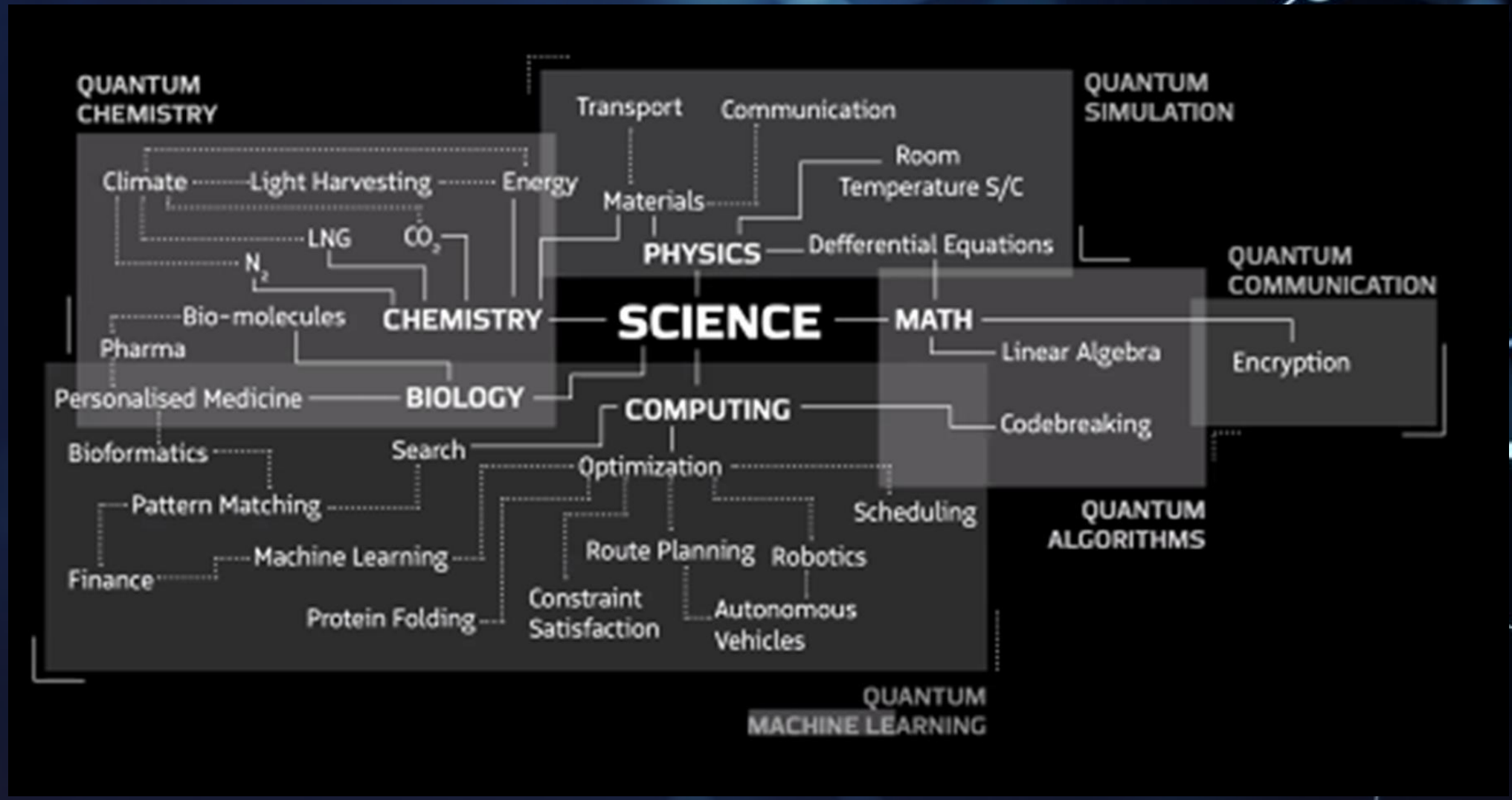
The Map of Quantum Computing | Quantum Computers Explained
DoS - Domain of Science – YouTube



Fundamental Quantum Computer Technologies

1. Super Conducting
2. Quantum Dots
3. Linear Optical (Photonic)
4. Trapped Ions
5. Color Centers
6. Neutral Atoms in Optical Lattices
7. Other Approaches
   - ✓ Electron-on-Helium Qubit
   - ✓ Magnetic Molecule - Spin
   - ✓ Cavity Quantum Electrodynamics
   - ✓ Nuclear Magnetic Resonance

Many More Quantum Applications



Quantum Computing Applications

https://www.qoisc.org/high-school-quantum

The Daily Qubit

1. Quantum computing use cases for financial services | IBM
2. The Future of Quantum Drug Discovery - Cambridge Quantum
3. Quantum computer models a chemical reaction (scitation.org)
4. Quantum Computing: Accelerating the Digitization of Chemistry • EFMaterials Blog
5. Quantum Computing in Oil and Gas | Accenture
6. Inside Google's Quantum Computing Data Center
7. Quantum ML - Quantum: Machine Learning & Analytics
8. Exploring quantum computing use cases for manufacturing | IBM
9. University of Arizona Awarded $26M to Architect the Quantum Internet

Quantum Educational Resources
Big Tech Quantum Websites ←
Quantum Computing Companies
Quantum On-Line Resources
Quantum Biology Papers
And much more ……

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https://quantumconsortium.org/

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Global Quantum Intelligence publishes market & business intelligences available for a fee to investors, governments, providers, and users to help them navigate through the complex landscape of the quantum industry. For details visit www.global-qi.com.

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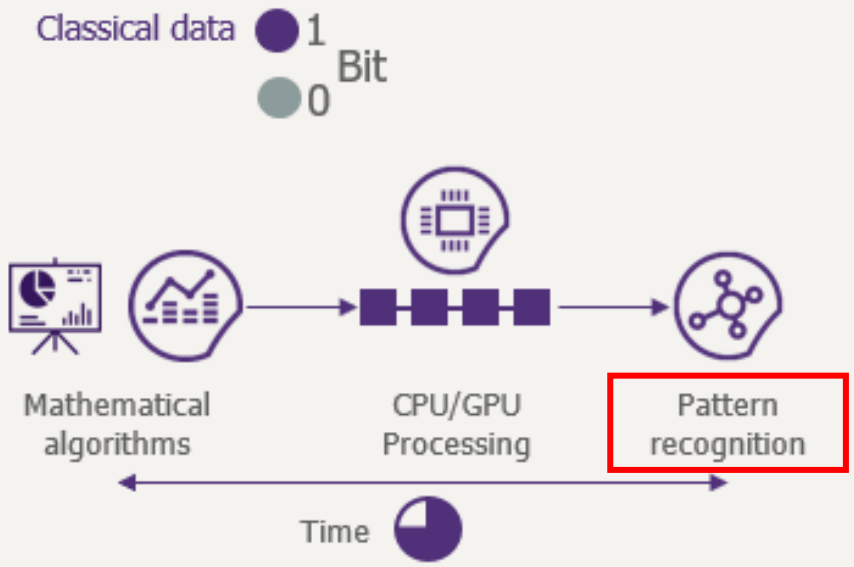
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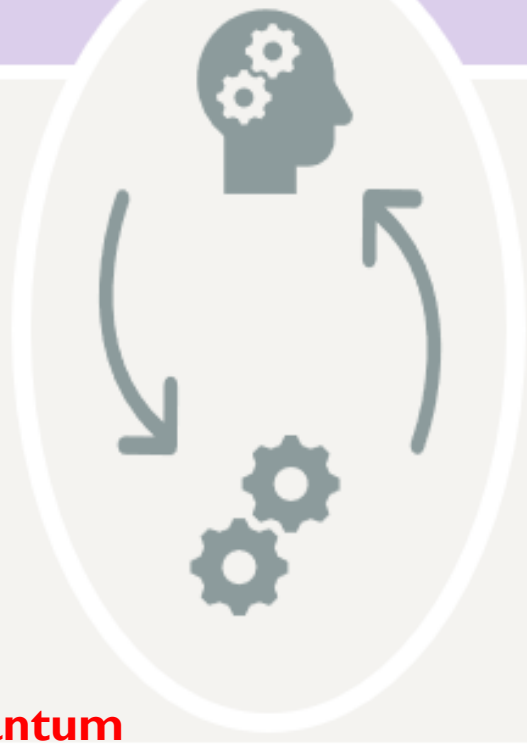
- Dodd-Walls Centre Researchers Demonstrate Coherent Control of Magnon–Polaritons with Exceptional Points
- Morgan Stanley Discloses 7% Ownership Stake in IonQ via SEC Filing
- University of Sydney Researchers Demonstrate GKP Logical Gate Set on a Single Trapped Ion
- U.S. Space Force to Test Quantum Inertial Sensor for Autonomous Navigation on X-37B Space Plane Mission
- UChicago PME Researchers

Machine Learning

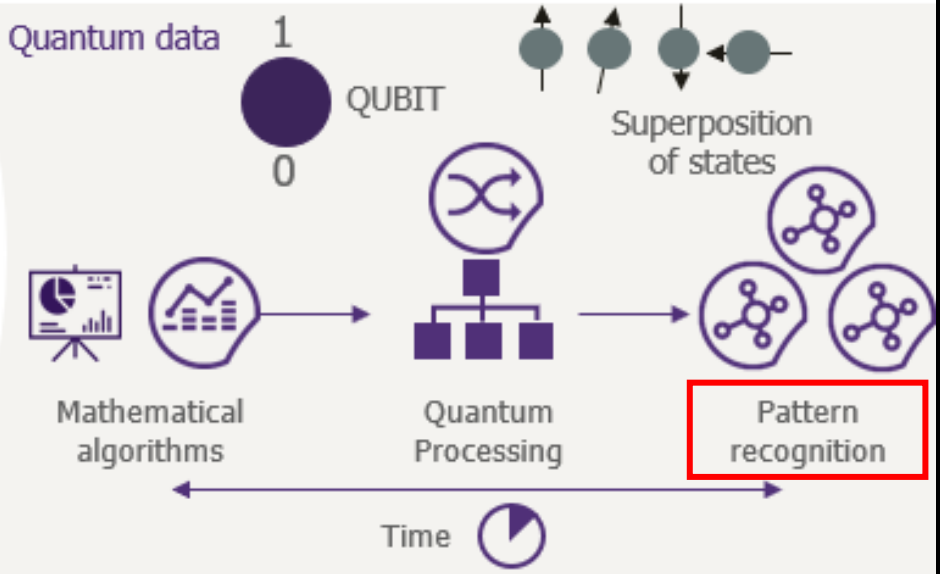
Quantum ML - Quantum: Machine Learning & Analytics (ml2quantum.com)

Classical Machine Learning - CML

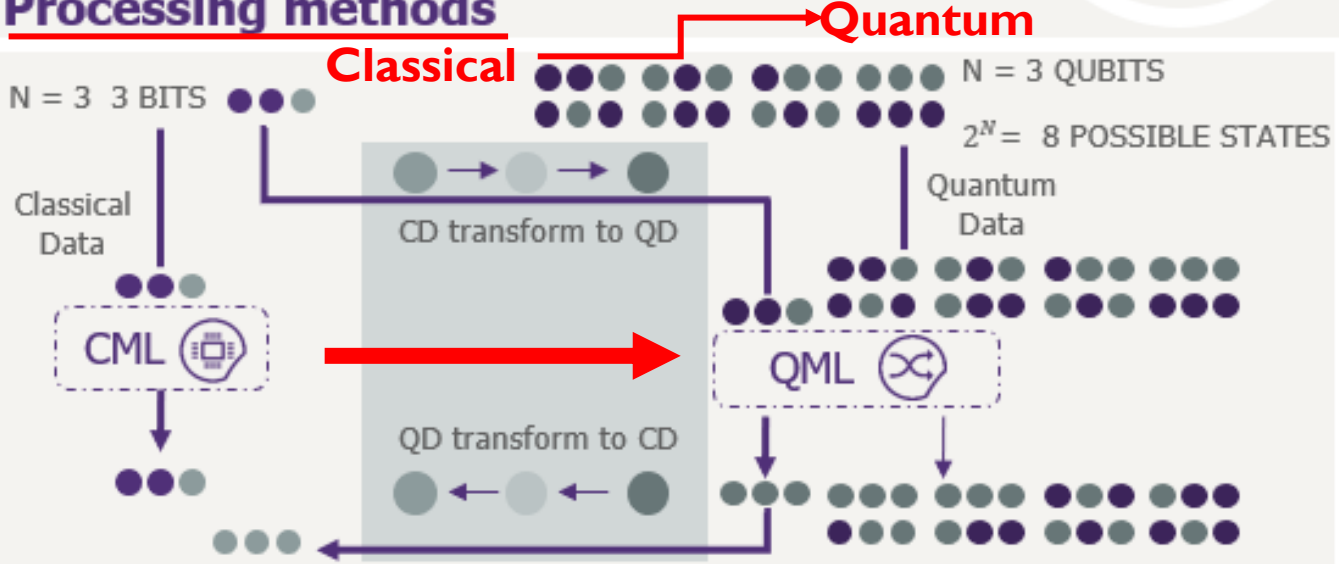




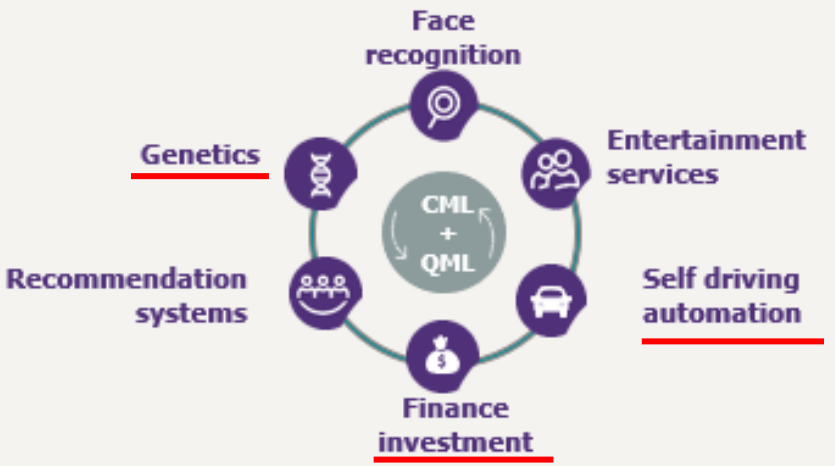
Quantum Machine Learning - QML



Processing methods



Applications



Microsoft, Google, Honeywell, and Amazon

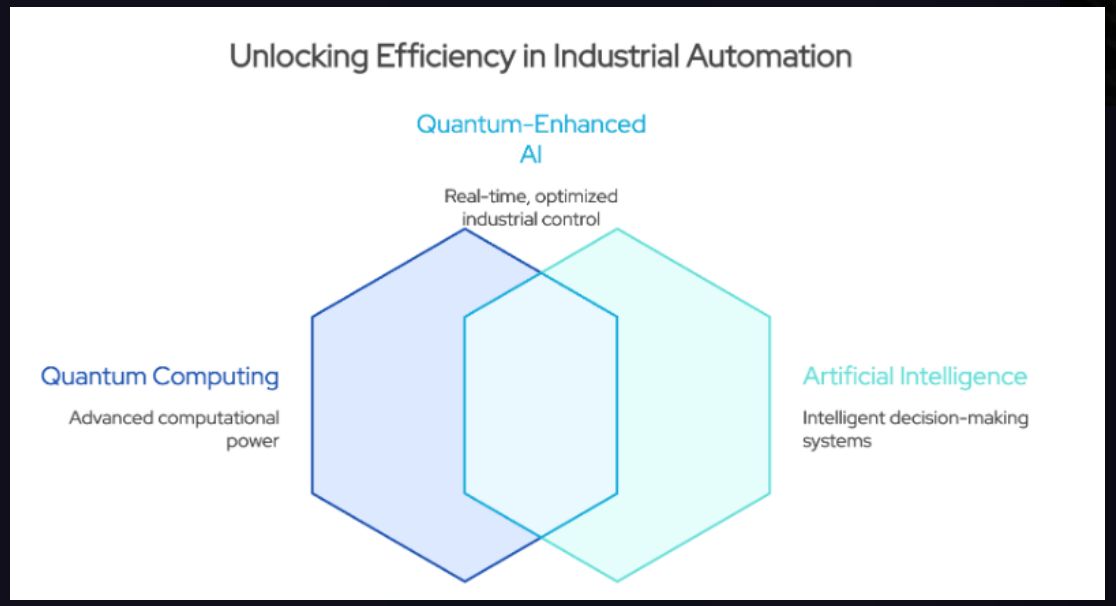
IQM

Quantum AI Applications in Manufacturing

30 Jul 2025

6 min read

Quantum AI in the future



https://meetiqm.com/blog/quantum-ai-applications-manufacturing/

Optimizing performance, improving safety, and driving efficiency in manufacturing with Quantum AI applications

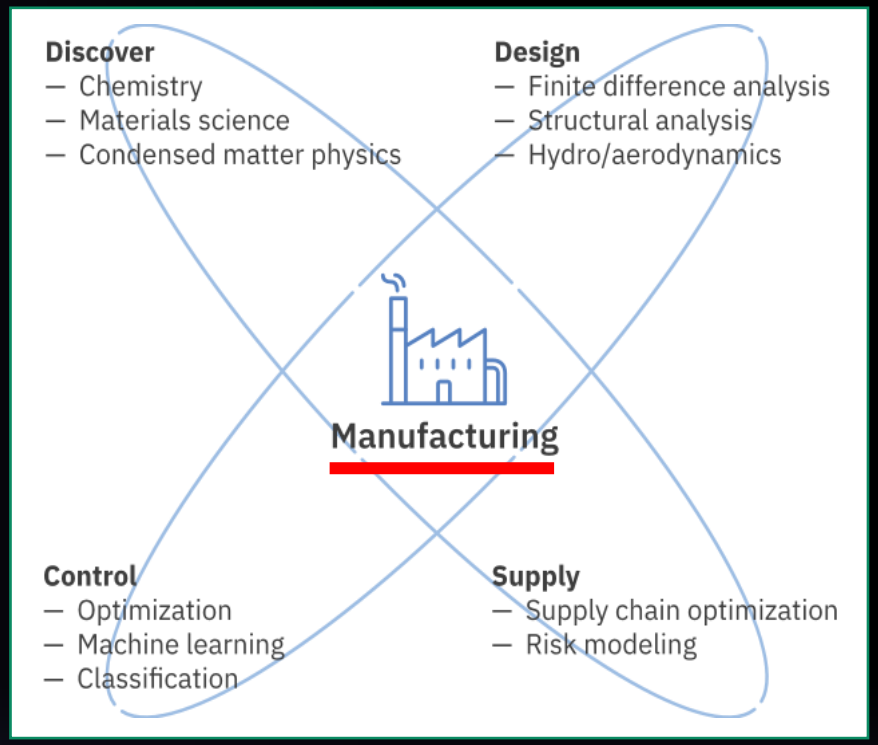
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Home | Quantum computing | Exploring quantum computing use cases for manufacturing

Exploring quantum computing use cases for manufacturing

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Exploring quantum computing use cases for manufacturing | IBM

Telecommunications



Quantum computing is just one of the many functions towards the development of a quantum network that will deliver the quantum Internet

The Quantum Internet

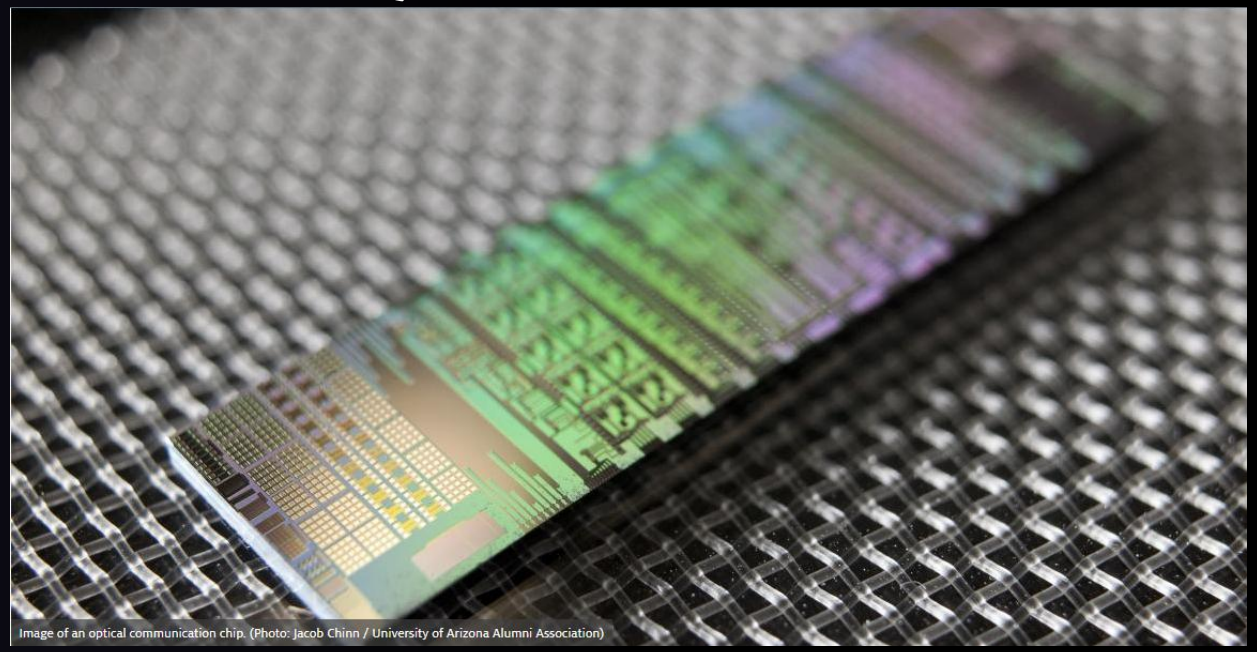


Image of an optical communication chip. (Photo: Jacob Chinn / University of Arizona Alumni Association)

University of Arizona Awarded $26M to Architect the Quantum Internet | News | College of Engineering | The University of Arizona

Pathways for High School & College Students

What can you do to get involved with the Quantum World?

1. Be interested
2. Find a Mentor
3. Take Action

Get involved with the Quantum World.

1. **Find good mentors**
    1. Start with your Physics Teacher
2. **Take Action:**
    1. Go to my website, click on links and read articles
    2. Watch YouTube videos on Quantum
    3. Find hands-on workshops close to home
    4. Take on-line courses
    5. Got to a college that offers quantum courses
    6. Take an internship that works in the field
    7. Join a club or start one your self

On-line and In-Person Resources

Quantum for Students

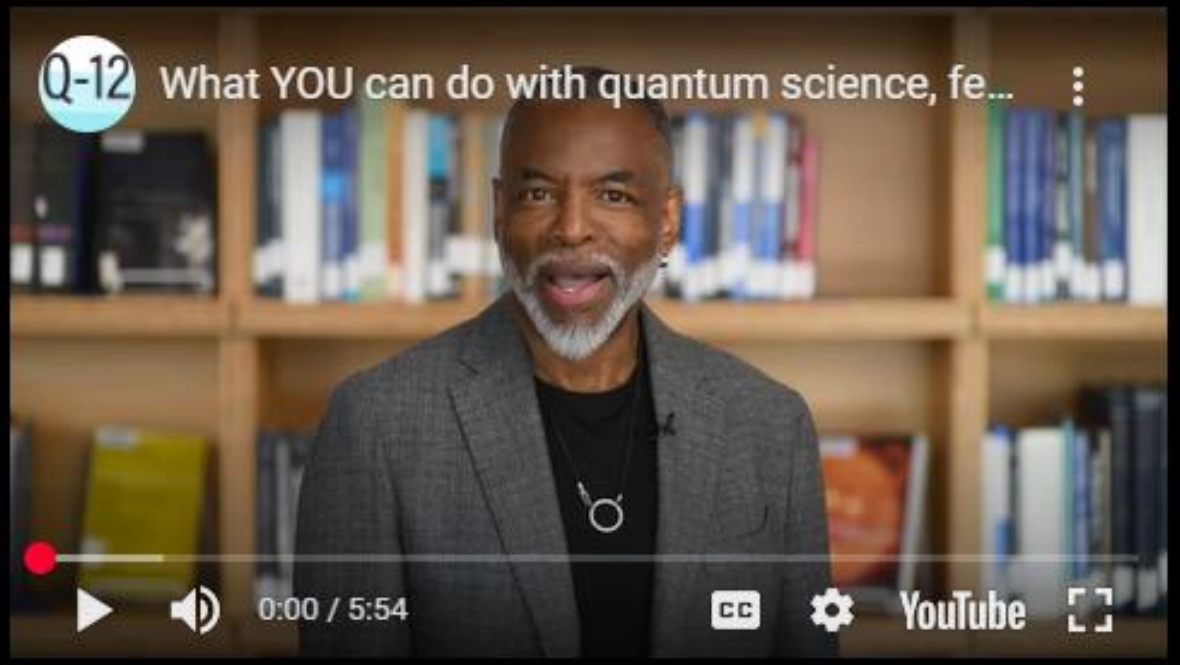
https://www.qoisc.org/high-school-quantum

This web page is a resource for students who may have seen my presentation.

Click here to download a pdf version of the slides. If you would like to give a version of this presentation, contact Donn directly.

These links will be updated periodically.

Video from National Q-12 Education (q12education.org)



Quantum Educational Resources

Available Courses | qBraid

DoS - Domain of Science - YouTube

Map of Quantum Computing Poster – DFTBA

Qiskit - IBM's Open Source Quantum Computing Resource

Quantumapalooza 2020 Harrisburg University

QuVis (st-andrews.ac.uk)

Key Concepts for Future QIS Learners (illinois.edu)

Stanford University - High School Quantum Course

A Beginner's Guide to Quantum Programming (scitechdaily.com)

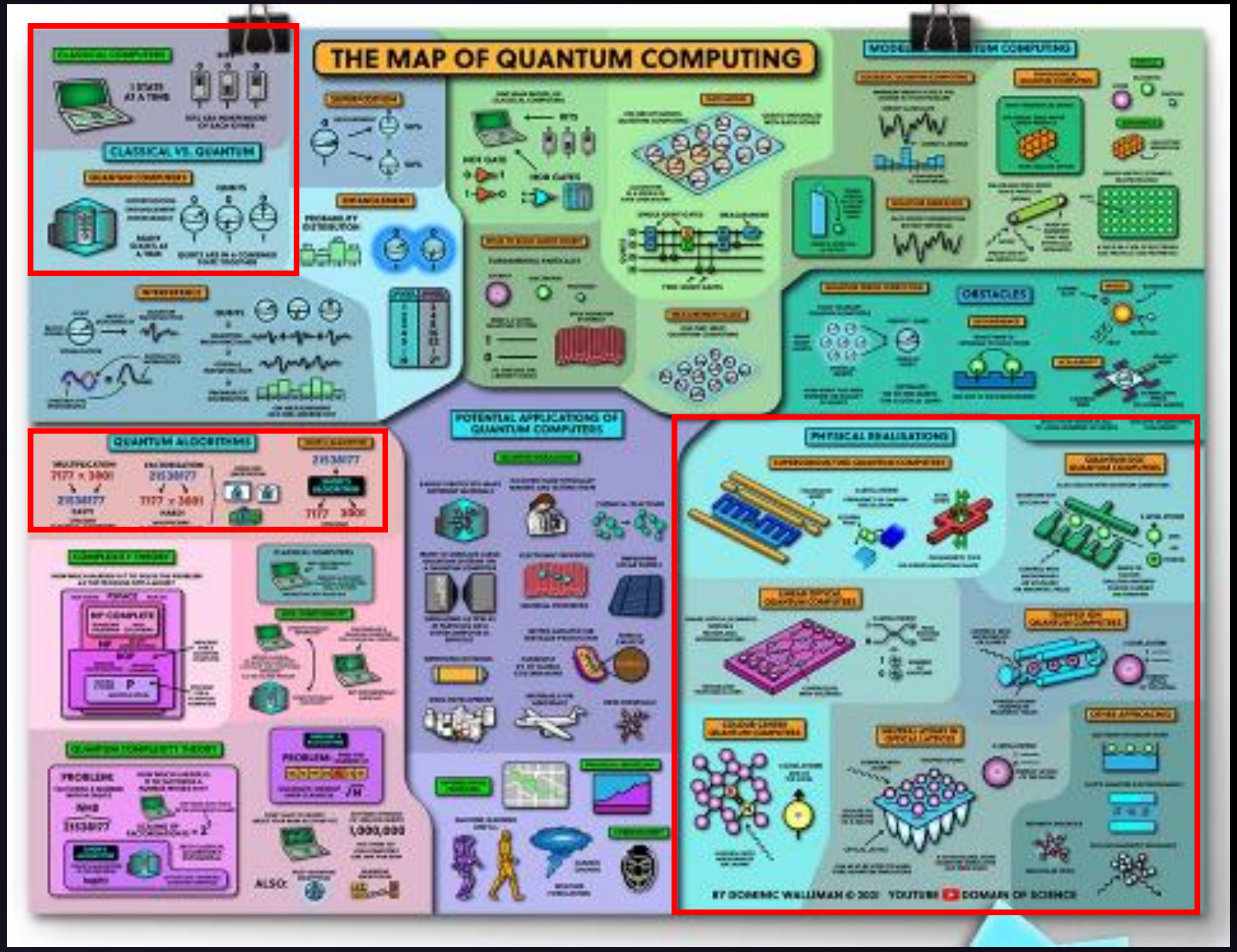
Quantum Algorithm Implementations for Beginners

Schrödinger's Class | Institute for Quantum Computing | University of Waterloo (uwaterloo.ca)

(for the Schrödinger's Class materials, contact Donn directly or go to.....)

Teacher resources | Institute for Quantum Computing | University of Waterloo (uwaterloo.ca)

Quantum Computing for High School Students - text book by Yuly Billing


THE MAP OF QUANTUM COMPUTING
CLASSICAL VS. QUANTUM
QUANTUM ALGORITHMS
POTENTIAL APPLICATIONS OF QUANTUM COMPUTERS
OBSTACLES
PHYSICAL REALISATIONS
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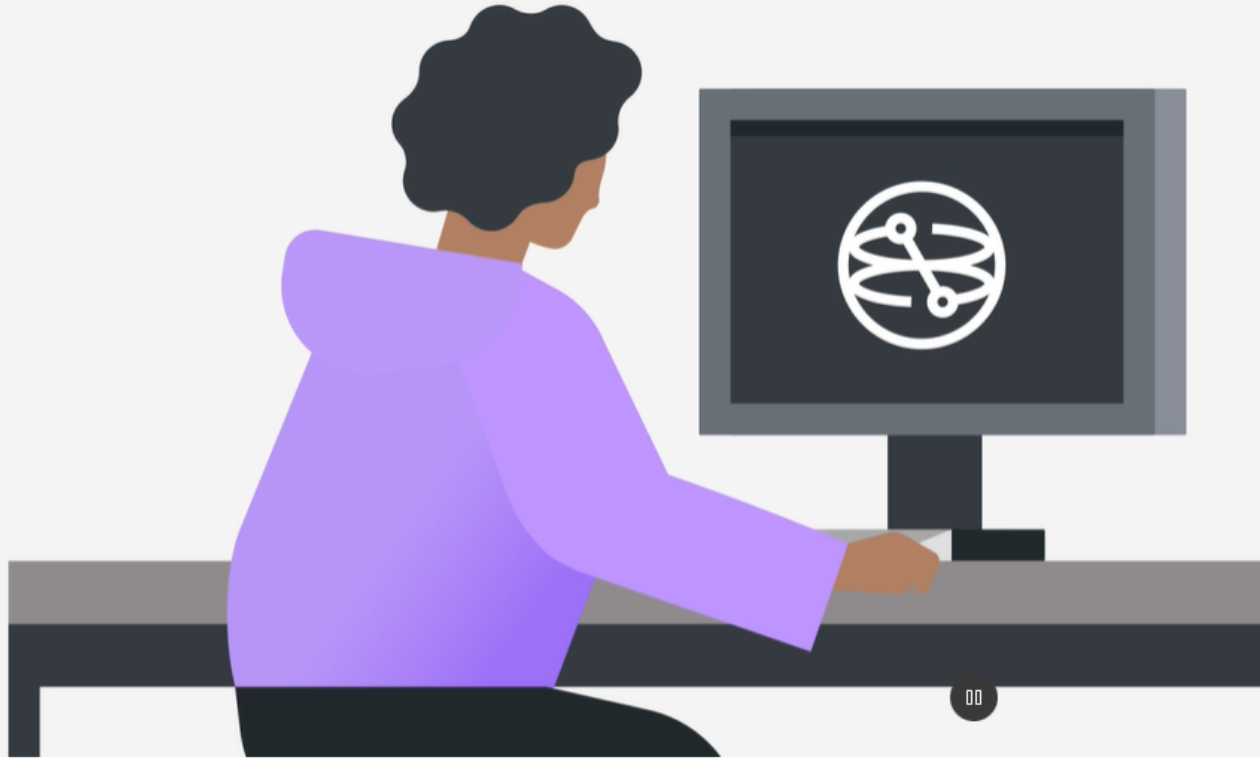
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What's new at IBM Quantum? Check out the latest tools, performance improvements, and updates delivered so far this year. Read the blog →

Qiskit SDK v2.1 is here
See what's new →

Qiskit

Qiskit is the world's most popular software stack for quantum computing. Build circuits, leverage Qiskit functions, transpile with AI tools, and execute workloads in an optimized runtime environment.



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Qiskit.org

IBM's Education System – it's FREE

Google Quantum AI

Discover Our Work About Careers

Our mission is to build quantum computing for otherwise unsolvable problems.

https://quantumai.google/

FEATURED

Introducing Willow, the next generation of quantum chips

Willow, Google Quantum AI's latest state-of-the-art quantum chip, is a big step towards developing a large-scale, error-corrected quantum computer. Read the blog and watch the video to learn more about Willow and its breakthrough achievements.

Blog post | Paper | Video | Spec Sheet

