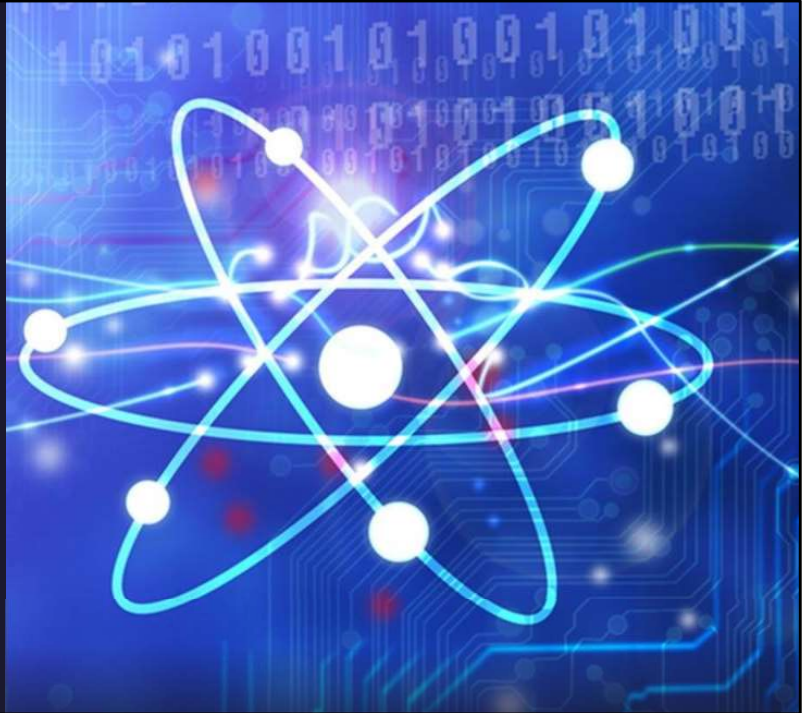


Quantum for High School & College Students

Education & Career Pathways

Donn Silberman

- Optics Institute of Southern California
- <http://oisc.net>



Hello welcome to quantum for high school & college students; education and career pathways.

My name is Donn Silberman and I'm the founder of the optics institute of Southern California .

Before we get started, I want you to know that all the slides and information in this presentation are available on my website with many links to follow deeper into the topics that I will be presenting.

So; while you can take notes, you can also just focus on the flow of the presentation.

The live version of this presentation may differ because questions may be taken and answered in real time; so, some of the details in the scripted notes may be skipped stay within the allotted time.

Introduction

Who am I?

And Why am I here talking to you?

- QuantumOpticsAge –
- <https://donn601.wixsite.com/opticsage>

Welcome to EdQuantum Project

HYBRID CURRICULUM IN ADVANCED OPTICS, SPECTROSCOPY, AND QUANTUM TECHNOLOGIES FOR TECHNICIANS



So, who am I and why am I here talking to you ? Well as I mentioned my name is Donn Silberman and I'm the founder of the Optics institute of Southern California; you can see the logo right under my photograph in this slide.

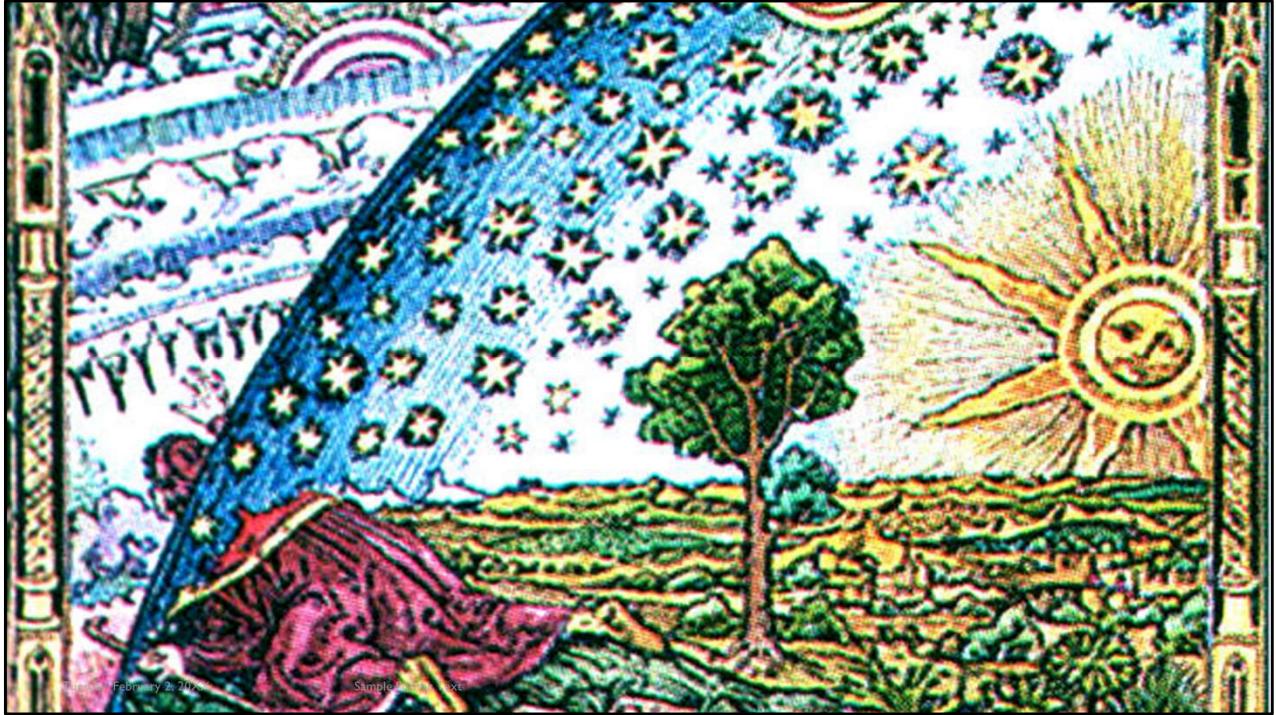
I also maintain an educational website about Experiencing Life in the Quantum OpticsAge. I am going to tell you a brief history of my educational career because many years ago, I was your age!!

I was fortunate to go to a high school that taught astronomy and then I went to the University of Arizona to study astronomy, physics, engineering and optics.

I've placed the logos of these entities including the one of the honors college, which I was nominated to join by one of my professors, not because I had a very high-grade point average, but because I was very enthusiastic about physics. He also asked me to teach freshman physics laboratory classes when I was a junior and senior in college. And I had a job as a student assistant in the College of Optical Sciences. I volunteered to be the president of the college chapter of the Society of Physics Students. This allowed me to set up meetings and presentations that I was interested in and even tours of various scientific and technological facilities around the university .

SPS was invited by Optical Society of America (now Optica) to host a presentation at their annual meeting in Tucson in 1982 and I invited my former professor, who was then the acting director of the very first multiple mirror telescope project. I still have a key fob from the very memorable event.

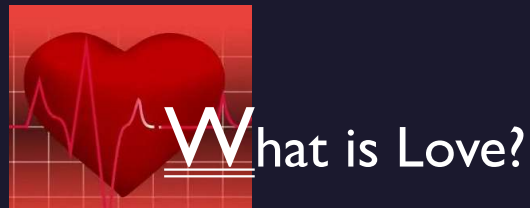
After graduating I became a counselor for the Society of physics students and then a member of the optical Society of America and eventually SPIE & OSSC ; and there are long stories associated with each of these organizations including doing education outreach and teaching laser technology to community colleges and optical engineering at UC Irvine and most recently the EdQuantum project .



Before we get into quantum for students, I want to show you this slide and asked if anyone will volunteer to tell me what they see?

It's a curious engraving from the Middle Ages of a man seeking to understand the workings of the universe beyond the stars, and we are still doing that today.

Critical Thinking



To understand a little about education and career opportunities in the quantum world, I want to guide you in the fine art of critical thinking. I have these questions I like to ask starting with “what is light?” It seems familiar enough, but when we think critically about light, it's a bit elusive; we'll get into that later in this presentation.

The question, “what is money?” has more to do with career than with science; but again, to think critically about money will be very important in your life.

When we talk about “Trust” & “Truth”, all I can say is that each person gets to decide who they trust and what they believe to be true. Quantum Mechanics has some very unusual experimental and theoretical ‘truths’ that I will introduce in this presentation.

This presentation will not have much to do with money, truth, trust or even love. It's just that words are a bit like light, in that they are not so easy to grasp when you really think critically about them.

Mentors



Frank Memmer



Ke Chiang Hsieh



William Bickel



Bob Fisher



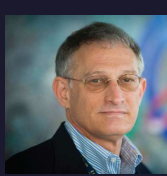
Al Hatheway



Brian Lula



Jim Trolinger



Steve Jacobs
Univ. of Rochester
Optics Suitcase



My wife, Mom & Dad

When we talk about love, I like to point to my mentors starting with Frank Memmer, he was my high school astronomy teacher and professors Hsieh & Bickel who were my physics advisors in college. Steve Jacobs was the creator of the Optics Suitcase, which I learned from, modified and used to do Optics Educational Outreach for many years. Now I am using some Quantum Optics concepts that grew from the Optics Suitcase.

These mentors and the others pictured here help me along my career path and showed me kind affection that helped me through many years of life .

And then of course there is the love I have for my wife and my parents.

So the main idea of this slide is to encourage you to find your mentors in life including those of your family friends and people who will help guide you in your career .

Agenda

1. **What is Quantum & why should you care?**
2. **Quantum Computers & Cybersecurity**
3. **Many More Quantum Applications**
4. **Pathways for High School & College Students**
5. **On-line and In-Person Resources**
6. **Questions & Answers**



The main topics of this presentation are divided into 6 sections starting with what is quantum and why should you care. Followed by quantum computers and cyber security, which are two main topics that are front and center in the world around us.

There are many more quantum applications that people are studying and working in right now. And there are pathways for students that I'll show you towards the end of this presentation. We have some online and in person resources to provide and then I can answer any questions you might have at the end.

What is Quantum

& why should you care?

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

So what is quantum and why should you care ?

In this presentation, I will show you that:

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

[Article Landing Page | opticsage \(donn601.wixsite.com\)](http://opticsage.donn601.wixsite.com)

This web page has the article below and links to all the references.

Quantum Theory with Computer & Cyber Security Applications

Donn M. Silberman, Fellow of the OSSC & SPIE



Here are the first two paragraphs of the article. Click on the link below to download the full article.

8

Recently I wrote a short article for a technical business group I belong to titled quantum theory with computer and cyber security applications . and it starts with this photograph and the following text .

“The transition from classical to modern physics (including quantum) has dramatically changed our civilization. The people in the above photo ushered in this change beginning over 100 years ago and the effects are still making exponential change with current and future applications including quantum computing, encryption, sensing, materials development, logistics, communications and much more.”

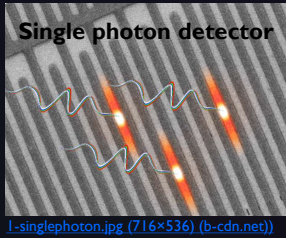
From Wikipedia: QUANTUM

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".

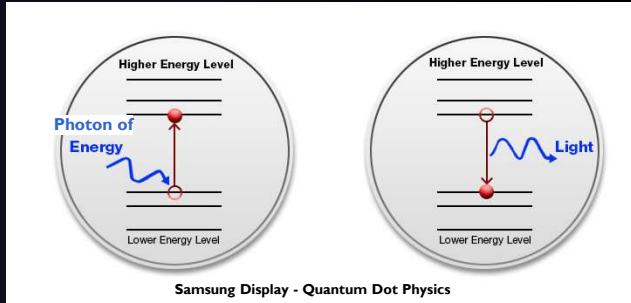
[1] This means that the magnitude of the physical property can take on only **discrete values** consisting of integer multiples of one quantum.

Can't have 1 1/2 photons
Or 3/4 of an electron

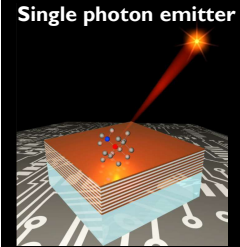
Graphic representation of an **electron (red O)** moving from one energy level to another, emitting or absorbing a **photon (Energy)** of light.



l-singlephoton.jpg (716x536) (b-cdn.net)



Samsung Display - Quantum Dot Physics



singlephoton.jpg (1000x1413) (b-cdn.net)

$E = h\nu$
frequency of radiation, sometimes written as f giving expression $E = hf$.
Quantum energy of a photon.
 $h = \text{Planck's constant} = 6.626 \times 10^{-34} \text{ Joule}\cdot\text{sec} = 4.136 \times 10^{-15} \text{ eV}\cdot\text{s}$

$E=mc^2$

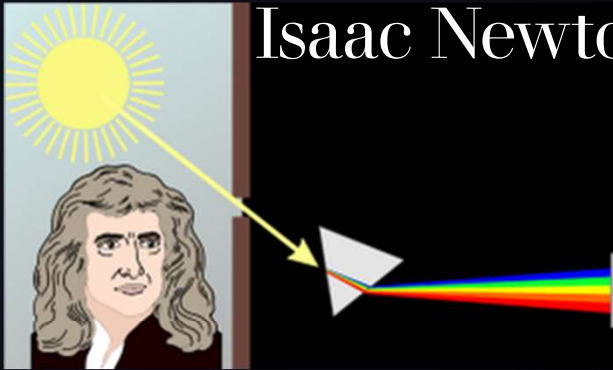
From Wikipedia we can learn that a quantum is the minimum amount of any physical entity involved in an interaction.

1. This means that the magnitude of the physical property can take on only discrete values consisting of integer multiples of 1 quantum .
2. So for example, a photon of energy is a single quantum of light. You cannot have 1 1/2 photons or 3/4 of an electron or a fraction of any other quantum entity.
3. Here, a photon of energy is graphically interacting with an atom, so that an electron's energy is raised by a discrete amount. On the left is a graphically enhanced photo showing a single photon detector. The reverse can happen as shown on the right with a graphic showing a single photon being emitted from the surface atom of a material.
4. Quantum mechanics does not tell us why this is the case but the theory including the energy of a photon $E = \text{Plank's constant } h \text{ times the frequency (or color) of the light photon.}$ matches the experimental evidence to such a high degree, that our entire modern civilization is based on QM and QM has been proven to be true using modern scientific methods .
5. This includes Einstein's famous energy equation $E=mc^2$, where m is the mass of any object and c is the speed of light.

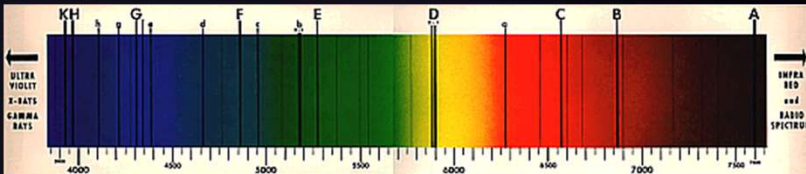
(Atoms and matter in general are stable because electrons can exist only at discrete energy levels within an atom.) Quantization is one of the foundations of the much broader physics of quantum mechanics. Quantization of energy and its influence on how energy and matter interact (quantum electrodynamics) is part of the fundamental framework for understanding and describing nature.

Wiener, N. (1966). Differential Space, Quantum Systems, and Prediction. Cambridge: The Massachusetts Institute of Technology Press

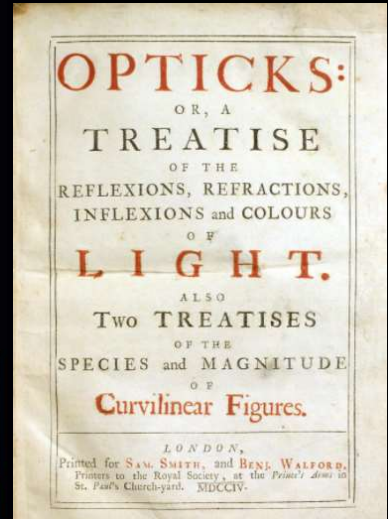
Isaac Newton & the Prism



The Solar Spectrum with Fraunhofer Lines



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

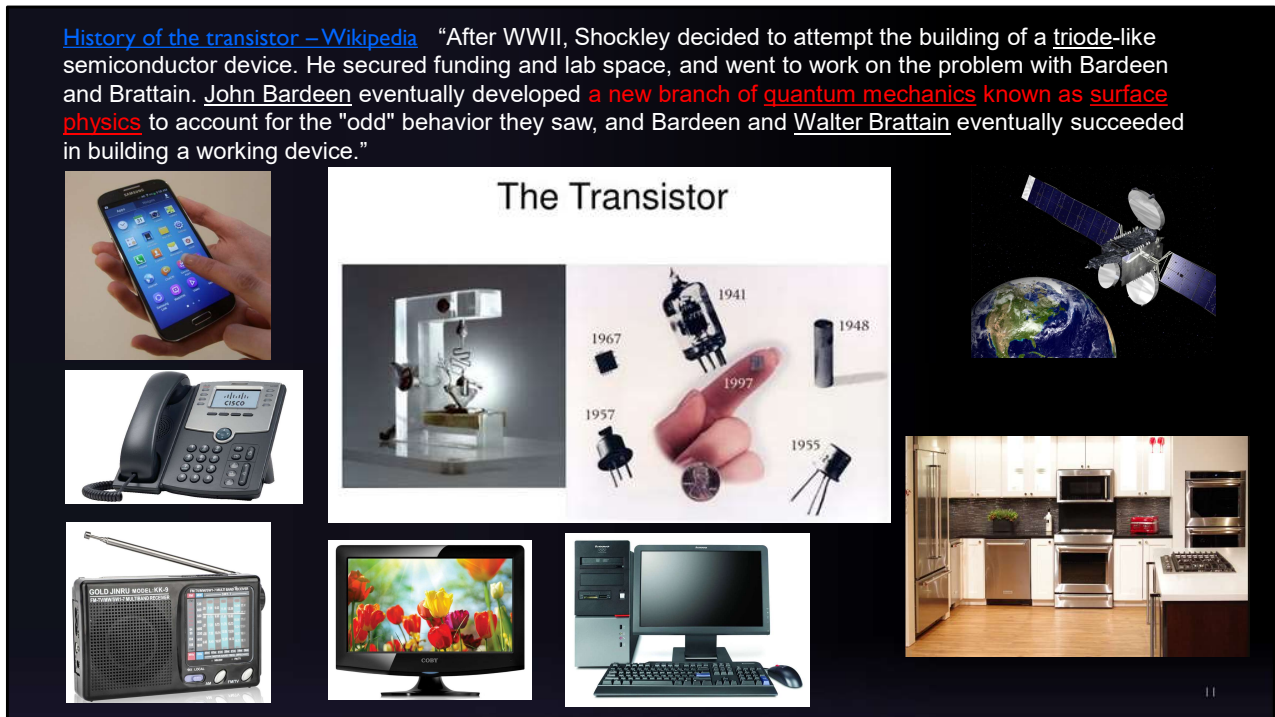


The first, 1704, edition of *Opticks: or, a treatise of the reflexions, refractions, inflexions and colours of light.* ¹⁰

Isaac Newton first published his book on optics in 1704 and included information on reflection, refractions, inflexions, colors, prisms, and spectroscopy.

The discrete Fraunhofer lines shown in this typical solar spectrum are a direct experimental result of the quantum nature of light and the frequencies shown on the x-axis related directly to frequency in Plank's energy equation in the last slide.

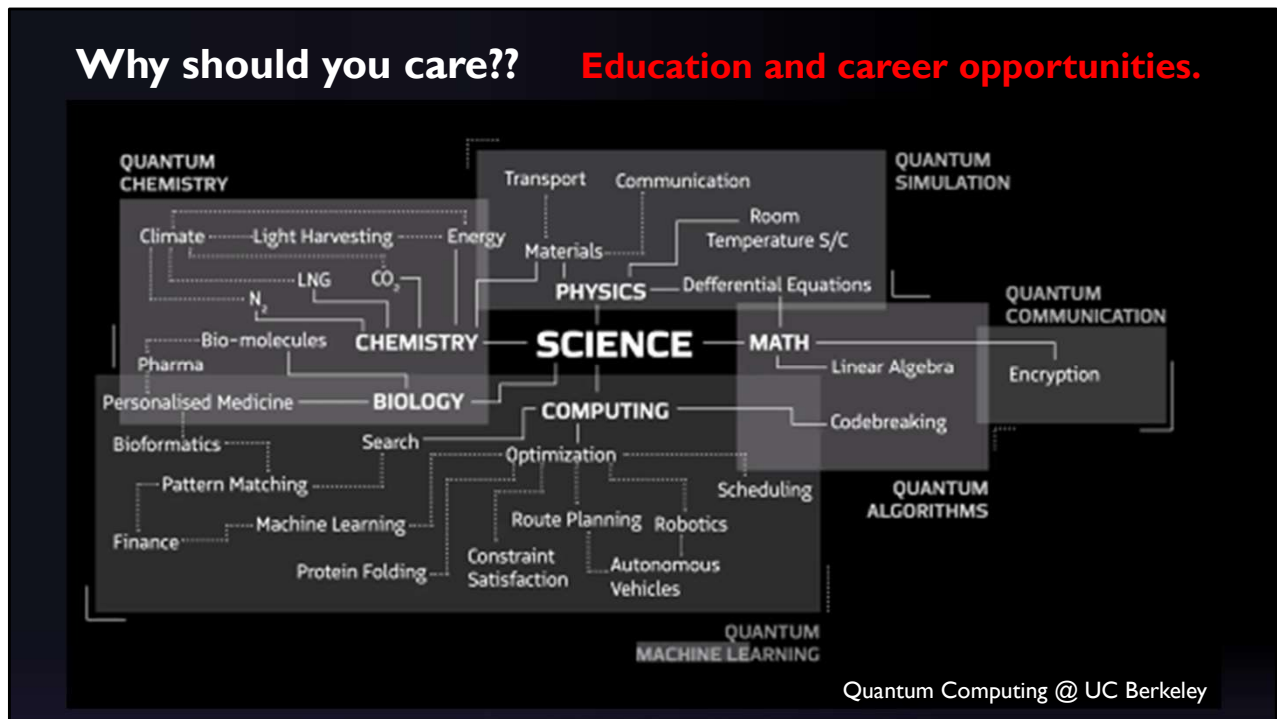
[History of the transistor – Wikipedia](#) “After WWII, Shockley decided to attempt the building of a triode-like semiconductor device. He secured funding and lab space, and went to work on the problem with Bardeen and Brattain. John Bardeen eventually developed a new branch of quantum mechanics known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



From Wikipedia “The History of the transistor,” we learn that it was not until “After WWII, when William Shockley decided to attempt to build 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.”

This is the foundation of modern electronics and computers which our entire modern civilization has been built. Every cell phone, telephone, radio, television, computer, satellite, and all the other modern electronic conveniences have their bases in the simple transistor which is a quantum mechanical device .

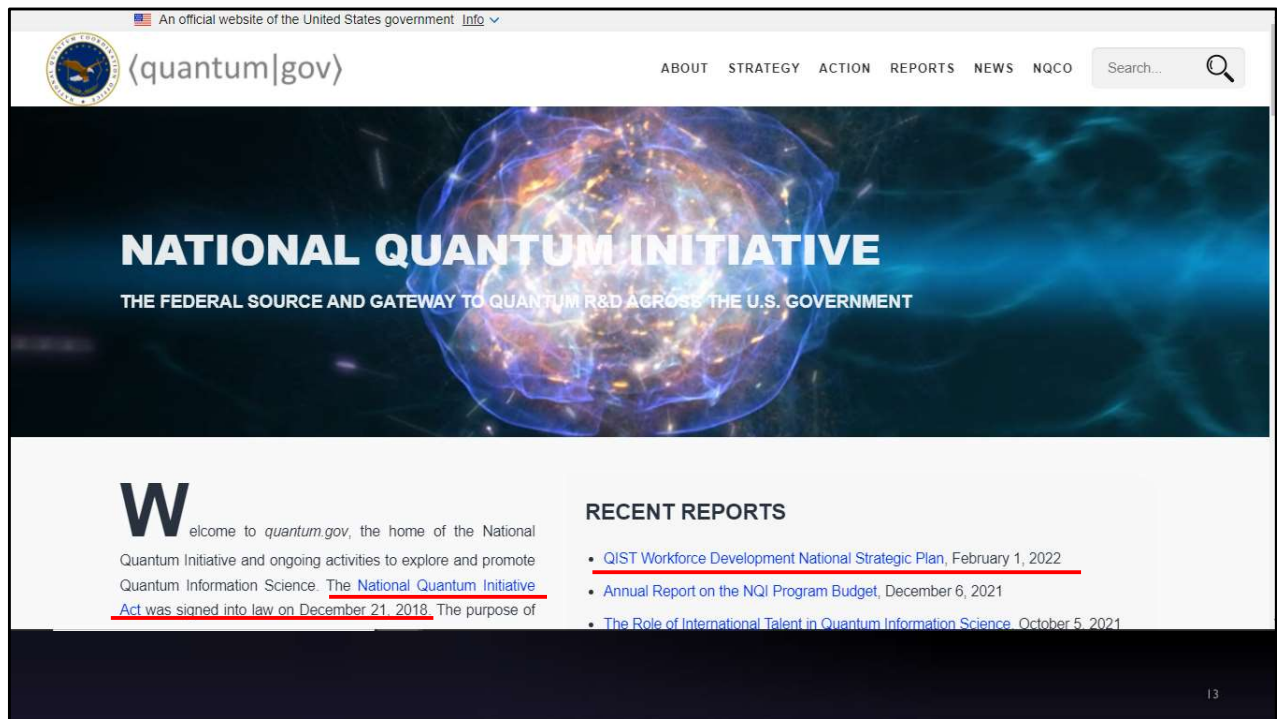
Why should you care?? Education and career opportunities.



So why should you care ? Because there are education and career opportunities throughout the sciences that can now use fundamental quantum mechanical principles and devices to help create the next generation of our modern civilization.

And for each one of you to become knowledgeable and valuable to prospective educators and employers, learning about quantum science and technologies at this phase of your educational career will further set you apart from other students vying for those same educational and career opportunities .

And you still get to choose from many different fields of study in careers that are shown diagrammatically on this chart from our friends at the UC Berkeley quantum computing club . I'll talk more about some of these in a few minutes but just to list a few of the broad categories they include quantum chemistry, physics, biology, math, quantum algorithms, quantum simulations, quantum computing, and quantum communications .



In December 2018, the US Federal Government passed the National Quantum Initiative that recognized and funded some of the current efforts in developing the quantum industry in the United States. Other countries have done this both before and after the US, making this a global race to capitalize on the significant progress that has been made in past decades.

On their website 'quantum.gov' they have links to the original act and recent reports. I'll talk about the QIST Workforce Development National Strategic Plan in just a few minutes.

QED-C About Membership News & events Blog Contact us Quantum jobs Quantum Marketplace For members

Quantum jobs

Check out available listings of employment opportunities at [QED-C members companies](#). Members include corporations, academic institutions, national laboratories and government agencies working in quantum.

QED-C thanks [Quantum Computing Report](#) and [Harrisburg University of Science and Technology](#) for contributing to this list.

CORPORATE ACADEMIC GOV'T/NAT'L LABS/OTHER

Welcome to EdQuantum Project

HYBRID CURRICULUM IN ADVANCED OPTICS, SPECTROSCOPY, AND QUANTUM TECHNOLOGIES FOR TECHNICIANS

This project is supported by the National Science Foundation under Grant No. EEC-2004561. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Alliro	Senior/Principal Software Developer (Quantum Network Controller)	USA; Massachusetts; Boston	2022-04-16
Alliro	Senior/Principal Software Developer (Quantum Network Protocols)	USA; Massachusetts; Boston	2022-04-16
Amazon	2022 Fall Applied Science Internship - Automated Reasoning, Computer Vision,	Canada; Ontario;	2022-05-

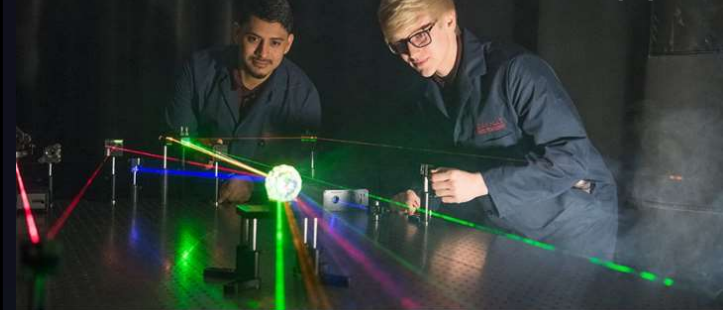
Quantum Technician Skills and Competencies for the Emerging Quantum 2.0 Industry (SPIE Optical Engineering)
 Authors: Mo Hasanovic, Chrys Panayiotou, Donn Silberman, Paul Stimers, and Celia Merzbacher
 Available on-line Apr. 9, 2022 - Open Access at the link above. To be published in hardcopy form August 2022

14

The Quantum Economic Development Consortium (QED-E) has been established to enable and grow a robust commercial quantum-based industry and associated supply chain in the United States.

1. In the past few years, the amount of attention that has been focused on many advances has left companies, national laboratories, colleges, and universities with many open positions for people skilled with knowledge and experience in quantum technologies. Some very excellent work has been done assessing the needs of the quantum industry. Most of this work has been for people with undergraduate and graduate degrees in physics, chemistry, math, engineering, computer science, material science and related technologies.
2. In line with some of my past educational endeavors, I have been consulting with EdQuantum to develop a hybrid curriculum in advanced optics, spectroscopy, and quantum technologies for technicians to fill the workforce gap between those with undergraduate and high school degrees.
3. My colleagues and I at Ed quantum recently published a paper through SPIE regarding the EdQuantum program. This paper is available free of charge from my website .

**We are educating and training tomorrow's workforce now.
Quantum education can be added to laser and physics.**



Credit: Indian Hills Community College



Administration

BRIEFING ROOM

FACT SHEET: President Biden Announces Two Presidential Directives Advancing Quantum Technologies

MAY 04, 2022 • STATEMENTS AND RELEASES

QIST WORKFORCE DEVELOPMENT



QUANTUM INFORMATION SCIENCE AND TECHNOLOGY WORKFORCE DEVELOPMENT NATIONAL STRATEGIC PLAN

A Report by the
SUBCOMMITTEE ON QUANTUM INFORMATION SCIENCE
COMMITTEE ON SCIENCE
of the
NATIONAL SCIENCE & TECHNOLOGY COUNCIL

February 2022

In February of this year the executive office of the president of the United states subcommittee on quantum information science published the quantum information science and technology workforce development national strategic plan which includes the national Q through 12 education partnership . This strategic plan is also available to download from my website.

Here it says we are educating and training tomorrow's workforce now.
That means you !!

And on May 4th, the White House announced that the president signed two new directives advancing quantum technologies.



The national Q through 12 education partnership has a dedicated website at q12education.org and has many corporate and institutional sponsors.

Their aim is to support and grow a quantum workforce that is diverse and equitable, invent new technologies and drive societal change and to increase opportunities for students from all backgrounds.



Pasadena City College

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

 **Jet Propulsion Laboratory**
California Institute of Technology

PCC LASERTECH

Are you seeking a career with cutting-edge technology that pays well? With the in-demand skills of laser technology, you can work in aerospace, medicine, robotics, manufacturing, entertainment, forensics, or defense!

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

44
Partner Colleges

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 career by mastering more technically demanding skills

naturalsciences@pasadena.edu

A National Science Foundation Center
LASER-TEC – Center for Laser & Fiber Optics Education

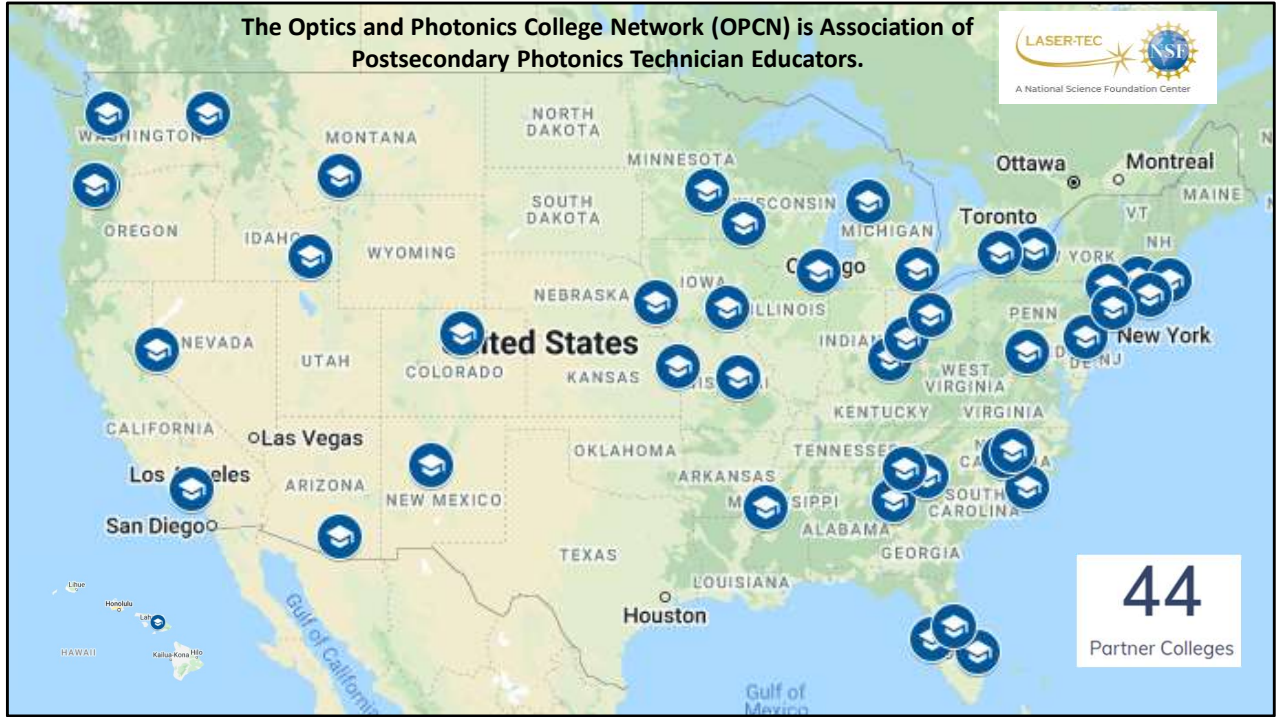
My good friend Dr. Brian Monicelli wanted me to share this with you now in case you might like to take a course in this program beginning in the fall.

I was involved with a program like this at Irvine Valley College for about 25 years and in 2008 Dr. Monicelli took over the program and two years ago we moved it to Pasadena City College where it's close to the Jet Propulsion Laboratories where he works and California Institute of Technology which has many great science and technology programs including some in quantum mechanics. They also have a joint quantum program with Amazon Web Services.

The quantum science and technology curriculum will be added to programs like this one as soon as we are done developing the course content and hands-on experiments.

The EdQuantum program is adding quantum education to the Laser-Tec programs that have established at 44 colleges across the country including Pasadena City College .

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



Institute for Quantum Information and Matter, a National Science Foundation Physics Frontiers Center

California Institute of Technology

The screenshot shows the website for the Institute for Quantum Information and Matter at Caltech. At the top, it identifies the institute as a National Science Foundation Physics Frontiers Center. Below this is a navigation bar with links for PEOPLE, NEWS, SCIENCE, SEMINARS, OUTREACH, BLOG, ABOUT, and a search icon. The main visual is a large, colorful graphic with a dark purple background. It features glowing yellow and orange ribbons, a central orange cylindrical structure, and various scientific symbols like atoms and circuit patterns. Two figures are shown: one in a wheelchair and another standing, both interacting with the central structure. A black cat is perched on a ledge to the right. The text 'Caltech Science Exchange' is prominently displayed in white, with the tagline 'brings insight and expertise to critical topics in science and engineering.' below it. A 'LEARN MORE' button is positioned at the bottom right of the graphic, with the text 'about Quantum Science and Technology' next to it.

Many colleges and universities have dedicated institutes for quantum science and technologies. This example from Cal Tech has a nice graphic. You can find one near your home so you can get involved locally.

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'

20

While there will be many aspects of modern life that will continue to be affected by the push to integrate quantum technologies into many products and services, I will now focus on quantum computing, encryption, and the internet, as they pose the greatest risks and opportunities to people's everyday economic life.

Cryptocurrencies have been developed on Blockchain technologies and is a fast-growing sector of the modern financial landscape. Blockchain technologies are also being applied to many other industrial sectors; but quantum computer technologies pose a threat to all these currently secure applications. Quantum computers also may be used to hack all other encryption technologies currently in use.

A global race is currently being run by private and public entities, some individually and some in consortium to develop both practical quantum computers and quantum resistant technologies. Much of the work is being published in the public domain that can be tracked; and some must be held 'close to the vest' and their progress is unknown to the public. Herein lies the greatest risk, if an unknown entity develops a quantum computer with the capability to hack current encryption technology and does it without anyone knowing; losses could be substantial.

CLASSICAL COMPUTERS

1 STATE AT A TIME

BITS

0 0 0

1 1 1

BITS ARE INDEPENDENT OF EACH OTHER

CLASSICAL VS. QUANTUM

QUANTUM COMPUTERS

SUPERPOSITION
ENTANGLEMENT
INTERFERENCE

QUBITS

0 0 0

1 1 1

MANY STATES AT A TIME

QUBITS ARE IN A COMBINED STATE TOGETHER

**Superposition
Entanglement
Interference**

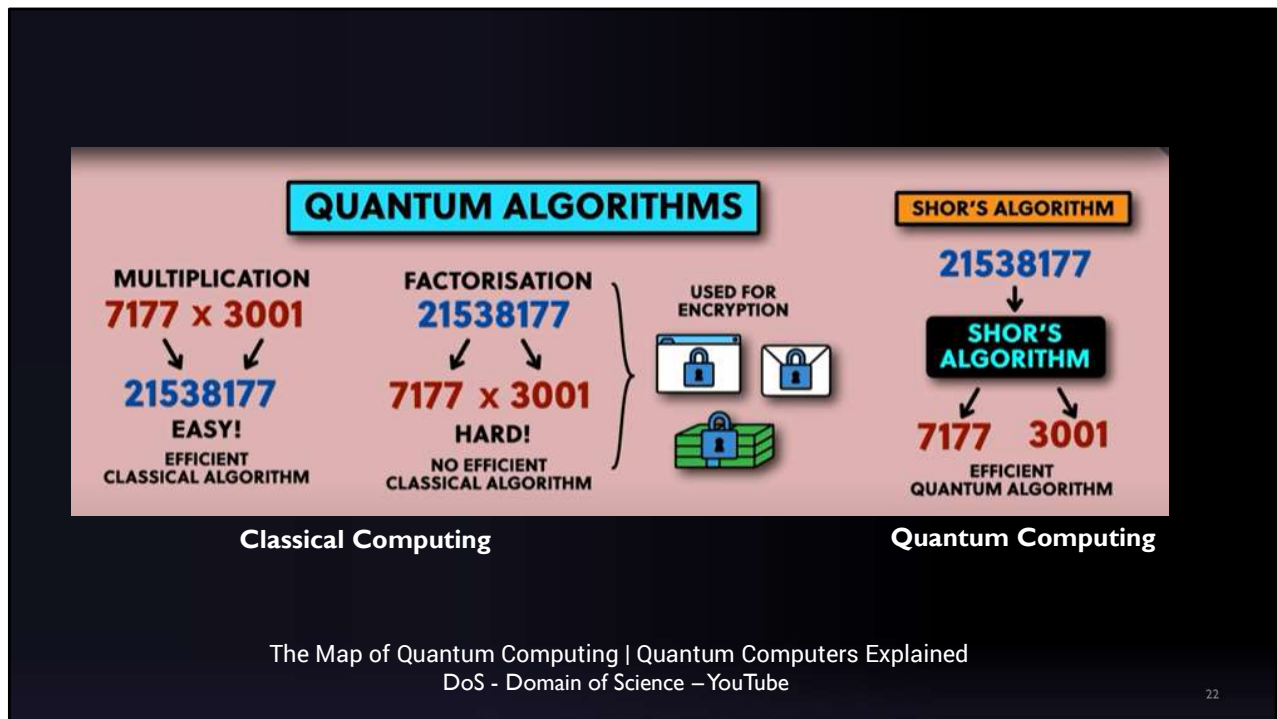
**Einstein's
"Spooky Action at a Distance"**

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

So what is the difference between a classical computer like we have on our desktops today and a quantum computer that may exist in the labs at a university or modern corporate entity? Fundamentally you might know better classical computer has bits that are independent of each other and can only be in one state at a time either zero or one.

In a quantum computer, as we can learn from our friends at the domain of science, a qubit (or quantum bit) can be at many states at the same time and that is the confusing part of quantum mechanics that we need to begin educating many people on how this works.

The most important concepts in quantum mechanics that relate to these states are superposition, entanglement, and interference. Quantum entanglement is what Albert Einstein described as "spooky action at a distance" and we can discuss that a little bit later in this presentation.



A clear example of the differences between a classical computer and a quantum computer is the process of factorization. In a classical computer we can see that multiplication is easy and quick $7177 * 3001$ equals 21,538,177.

But to factor 21 million 538,177 into $7177 * 3001$ is very hard and not efficient in a classical computer, it takes a very long time.

However, using the famous Shor's algorithm and a quantum computer the same factorization problem can be accomplished very quickly. And factorizations is used in standard encryption technology all across the Internet all over the globe.

So, a practical quantum computer with sufficient qubits and error correction can be used to break current encryption technologies using Shor's algorithms and other mathematical constructions.

Preventing "hack now, decrypt later" attacks with quantum safe VPNs

Quantum.Tech

Preventing "hack now, decrypt later" attacks with quantum safe VPNs (quantumtechcongress.com)

Video

Preventing "hack now, decrypt later" attacks with quantum safe VPNs

04/11/2022

f t in e p +

Almost all the data we transmit today is protected by quantum-vulnerable algorithms, such as RSA. Attackers can record this encrypted data, knowing they can decrypt it in the future on a quantum computer.

This talk from September 2021, we discussed a case study in which we defend against this threat, using virtual private networks (VPNs) combined with quantum-safe algorithms and key generation methods with Nick Van Duyn, Senior Solutions Architect - Cybersecurity, Cambridge Quantum.

23

There is also the concept that encrypted information could be collected secretly, from the current internet and stored until the quantum computer is available to crack the code and read the information later.

There are two paths that need to be tracked;

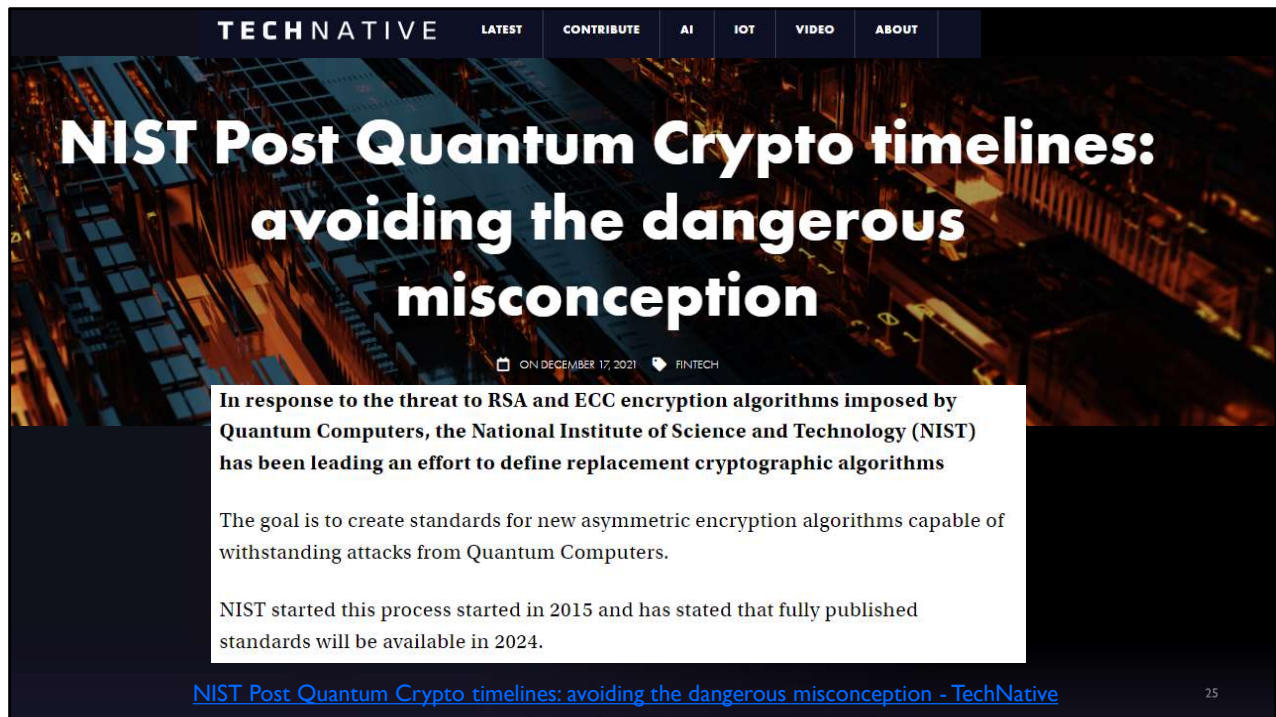
1. the development of quantum computers and their ability to hack secure encrypted information and
2. the development of quantum resistant encryption.

One parallel technology being developed is quantum secure communications over the internet.

Millions and even billions of dollars are being spent on quantum technologies globally and China is clearly the leader in dollars spent.

It is possible that they are also acquiring intellectual property in this domain faster than all other countries combined.

So, the actual ability to successfully implement effective quantum technologies through trade secrets will likely be the deciding factor winning this global race.



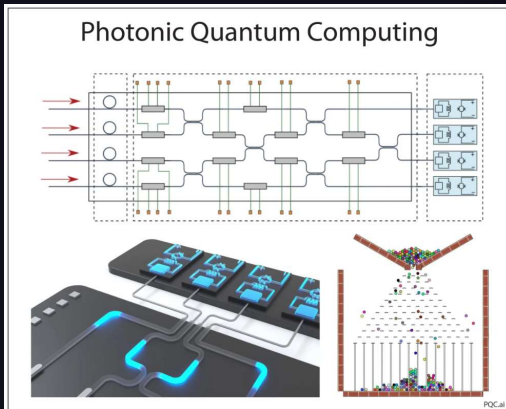
In an article on TechNative in December 2021, Alan Grau, the Vice President of Business Development for PQShield, a post quantum crypto solutions company with both hardware and software implementations. He writes about the threat encryption algorithms will face by Quantum Computers.

NIST and partners have been working to define quantum resistant cryptographic algorithms with a goal to have them fully published standards will be available in 2024.

But companies are already implementing the Post Quantum Crypto solutions based on standardized algorithms. Implementations of these algorithms are available, so companies don't have to wait until 2024 to begin migration from classical crypto solutions to the new Post Quantum Crypto (PQC) algorithms.

Twenty Years at Light Speed: The Future of Photonic Quantum Computing

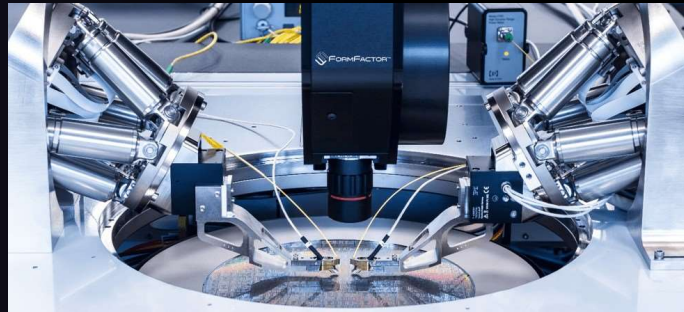
DECEMBER 20, 2021 BY DAVID D. NOLTE



[Twenty Years at Light Speed: The Future of Photonic Quantum Computing | Galileo Unbound \(galileo-unbound.blog\)](#)

The Quantum Era Emerges - How PI Fast Automated Alignment Enables Practical Manufacturing

PI PI (Physik Instrumente) L.P.



Silicon photonics wafer testers require much higher precision and alignment algorithm complexity compared to classical semiconductor wafer probes. The image shows PI's [double-aided alignment system](#) for fast NXM alignment of SiP devices Cascade Microtech's CM300xi photonic-enabled wafer probe station. (Image: Cascade Microtech, a FormFactor company)

[Quantum Technology, Alignment & Nanopositioning | PI \(pi-usa.us\)](#)

26

My belief that the 2030 DHS time prediction is too long, is based on my years of industry and academic experience with physics, optics, lasers, fiber optics, and Silicon (Photonic) Integrated Circuits (SICs). Part of that work experience was with PI (Physik Instrumente) where I helped with applications of Fast automated alignment systems for test and measurement of advanced silicon photonic integrated circuits.

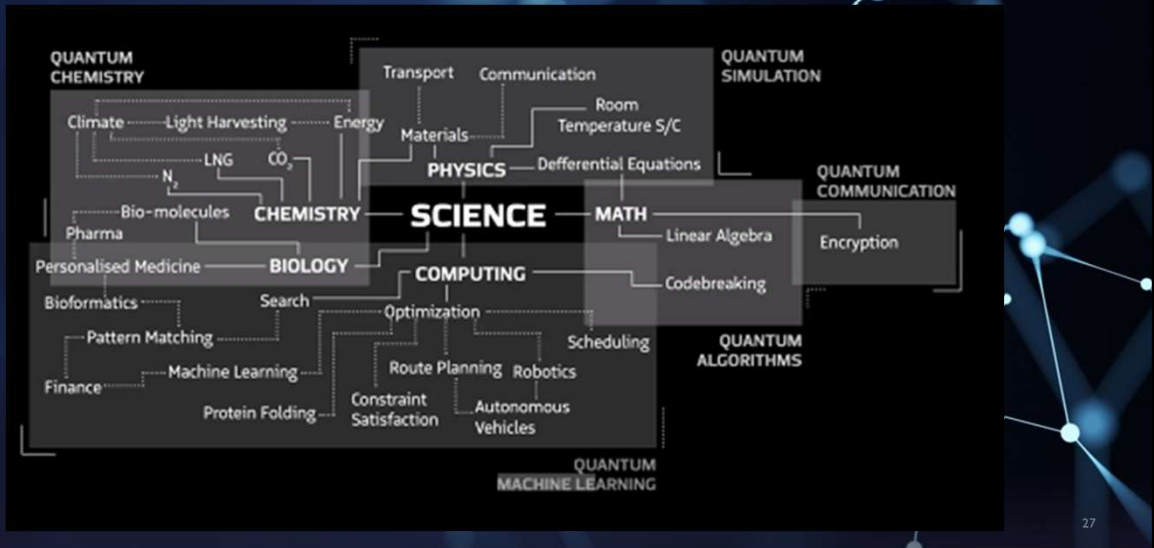
These are one type of hands-on instruments technicians need to get experience with to help companies bring the next generation quantum computers to the marketplace.

In one of the articles in my references, the authors review over a dozen different quantum computing hardware technologies and companies that are all in this race to build and implement a practical quantum computer.

The details and technical references are all provided for readers interested in exploring them further.

My perspective is that Quantum Photonic Integrated Circuits (QPICs) will be the winning technology for multiple reasons that are reviewed in a recent blog article that reviews 20 years at light speed – the future of photonic quantum computing.

Many More Quantum Applications



OK that was an introduction to quantum computing and quantum encryption technologies. So, we'll leave that behind for the rest of this presentation and talk about many other quantum computing applications in some of the fields and industries seen on this chart from earlier in this presentation.

Quantum Computing Applications

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](#)

[*High School Quantum | opticsage \(donn601.wixsite.com\)*](#)

1. Better Batteries
2. Cleaner Fertilization
3. Traffic Optimization
4. Weather Forecasting and Climate Change
5. Improving Solar Panels
6. Quantum Systems Simulations
7. Quantum Sensors
8. The Quantum Internet

28

In the next set of slides I'll review these nine quantum computing applications in a little more detail so you can see some companies that are already working in areas very important to modern civilization . These include financial services, drug discovery, chemical reaction modeling, the oil and gas industry, data center management, machine learning and analytics, general manufacturing, and telecommunication infrastructure. In addition, you can find more information to each of these case studies in direct links to company websites on my webpage 'High School Quantum' and you can search for more links to information on the industries and fields listed below .

IBM Quantum solutions

Exploring quantum computing use cases for financial services

Benefits of the Quantum Era

Quantum computing's business value for financial services institutions result from four main scenarios:

- Enhancing investment gains
- Reducing capital requirements
- Opening new investment opportunities
- Improving the identification and management of risk and compliance

IBM is one of the oldest and biggest computer companies in the world and of course they are at the forefront of quantum computing and applications. One of the most important quantum computing applications is actually in the finance industry. In this composite chart we can see that IBM has highlighted four benefits of using quantum computing:

1. enhancing investment gains,
2. reducing capital requirements,
3. opening new investment opportunities, and
4. improving the identification and management of risk and compliance .

Now one might ask how does quantum computing benefit these four areas of the financial services industry?

IBM Quantum solutions

Exploring quantum computing use cases for financial services



Benefits of the Quantum Era

Quantum computing's business value for financial services institutions result from four main scenarios:

- Enhancing investment gains
- Reducing capital requirements
- Opening new investment opportunities
- Improving the identification and management of risk and compliance

Using the speed and parallel type processing power of quantum computing on financial problems—particularly those dealing with

- ✓ trading optimization,
- ✓ targeting and predicting financial movements and
- ✓ profiling many different risks

should prove hugely advantageous for those companies that adopt using quantum computers first.

Beyond that, greater compliance, employing behavioral data to enhance customer engagement, and faster reaction to market volatility are some of the specific benefits people expect quantum computing to deliver.

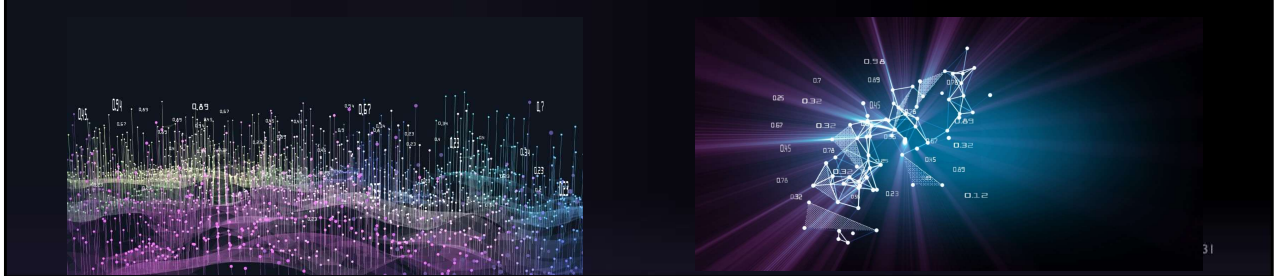
Quantum Computing: Accelerating the Digitization of Chemistry

August 25, 2020 | In Solution | By Ryan Esner

- Companies creating semiconductors, magnets, and superconductors will now be able to more precisely predict and optimize the structure of their solid-state materials.
- Tech companies creating OLED displays will now move away from endless trial-and-error methods to achieve desired brightness and hue of colors: thanks to simulation techniques, materials are simulated accurately before the first stage of production even begins.
- Catalyst design will be made more accurate, reducing research costs and, more importantly, making catalyzed processes less energy intensive. In other words, catalysis will advance exponentially.
- Drug discovery depends heavily on biochemical interactions; by optimizing the simulation process of pharmaceuticals and helping labs accelerate the research process, better drugs will be synthesized in less time.
- The in-depth study of molecular structure allowed by quantum computers will enable researchers to take the investigation of proteins and biomaterials to the next level and will allow for the creation of next-generation optical materials.

Quantum chemistry – the last frontier of materials science

[Quantum Computing: Accelerating the Digitization of Chemistry](#) • [EFMaterials Blog](#)



Because chemistry is quantum mechanical at its very nature there are many applications where using a quantum computer will help the process of discovering and engineering new materials in many fields. The ability to more precisely predict and optimize the structure of solid state materials in semiconductors, magnets, and superconductors will help companies bring advanced new products to markets where their customers will be able to implement them in many different end user products .

High tech companies making specialty display monitors based on quantum dot and organic LED technologies will move away from the endless trial and error methods to achieve desired brightness and colors by using quantum computer simulation.

Pharmaceutical companies using current advanced computing systems to optimize drug discovery will be able to synthesize better drugs faster with quantum computers.

And the next generation of optical materials using the molecular structure of proteins and other biomaterials will be enhanced by the use of quantum computers .

Finding the holy grail with quantum computing in oil and gas

JULY 18, 2018



Ely Colón
SENIOR PRINCIPAL – SUPPLY CHAIN AND OPERATIONS, DATA SCIENCE

Ely is an executive focused on Integrated Planning and Fulfillment Analytics.



Six key questions can guide you to apply quantum computing strategically to enable the holy grail for oil and gas organizations—the driverless supply chain:

1. What **processes** (such as extraction or transportation) should be optimized from reservoir-to-end-customer?
2. What are the current **optimization limits** for each supply chain silo'ed process?
3. What is the likely **untapped value** for each separate, locally optimized process?
4. What **enterprise objectives** are you trying to achieve? (identify best and worst case scenarios to align with corporate strategy).
5. What would your ideal **end-to-end supply chain** system look like, including enterprise constraints and decision variables?
6. What should your **roadmap** look like and where should you start to experiment?

32

As you can see by this slide from 4 years ago, the author wrote about using quantum computers in the oil and gas industry. He posed six key questions to guide users in the oil and gas organizations toward their 'holy grail – the driverless supply chain' or how to get the oil & gas to the customers without tanker trucks.

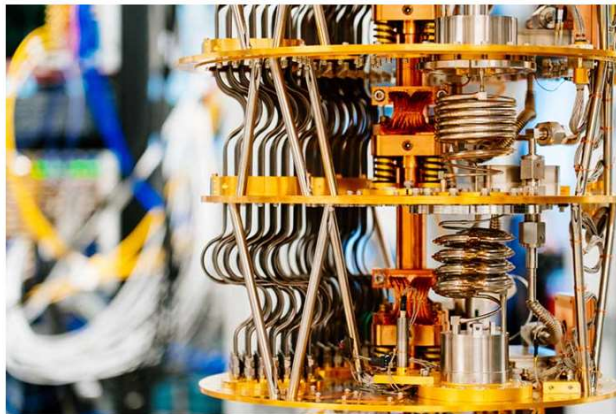
These questions ask about:

1. Optimizing the process from the reservoir to the end user
2. Optimization limits of silo'ed supply chain processes
3. Finding the untapped value for separate locally optimized processes
4. Achieving global enterprise objectives aligned with corporate strategies.
5. Identifying ideal end-to-end supply chain systems.
6. Creating a roadmap for using quantum computers and figuring out where to start.

While this author has written about using quantum computers in the oil and gas industries, these key topics could also be applied to other industries.

Inside Google's Quantum Computing Data Center

BY RICH MILLER - NOVEMBER 22, 2021 — LEAVE A COMMENT



One of the cryostats at the Google Quantum AI Lab in Santa Barbara, Calif. (Image: Google)



Source: Interior of one of Google's Data Center, www.google.com/about/datacenters/

The Quantum Consortium QED-C

Quantum Technician Skills and Competencies for the Emerging Quantum 2.0 Industry (SPIE Optical Engineering)
Authors: Mo Hasanovic, Chrys Panayiotou, Donn Silberman, Paul Stimers, and Celia Merzbacher
Available on-line Apr. 9, 2022 - Open Access at the link above. To be published in hardcopy form August 2022

[Inside Google's Quantum Computing Data Center \(datacenterfrontier.com\)](https://datacenterfrontier.com)

Welcome to EdQuantum Project

HYBRID CURRICULUM IN ADVANCED OPTICS, SPECTROSCOPY, AND QUANTUM TECHNOLOGIES FOR TECHNICIANS

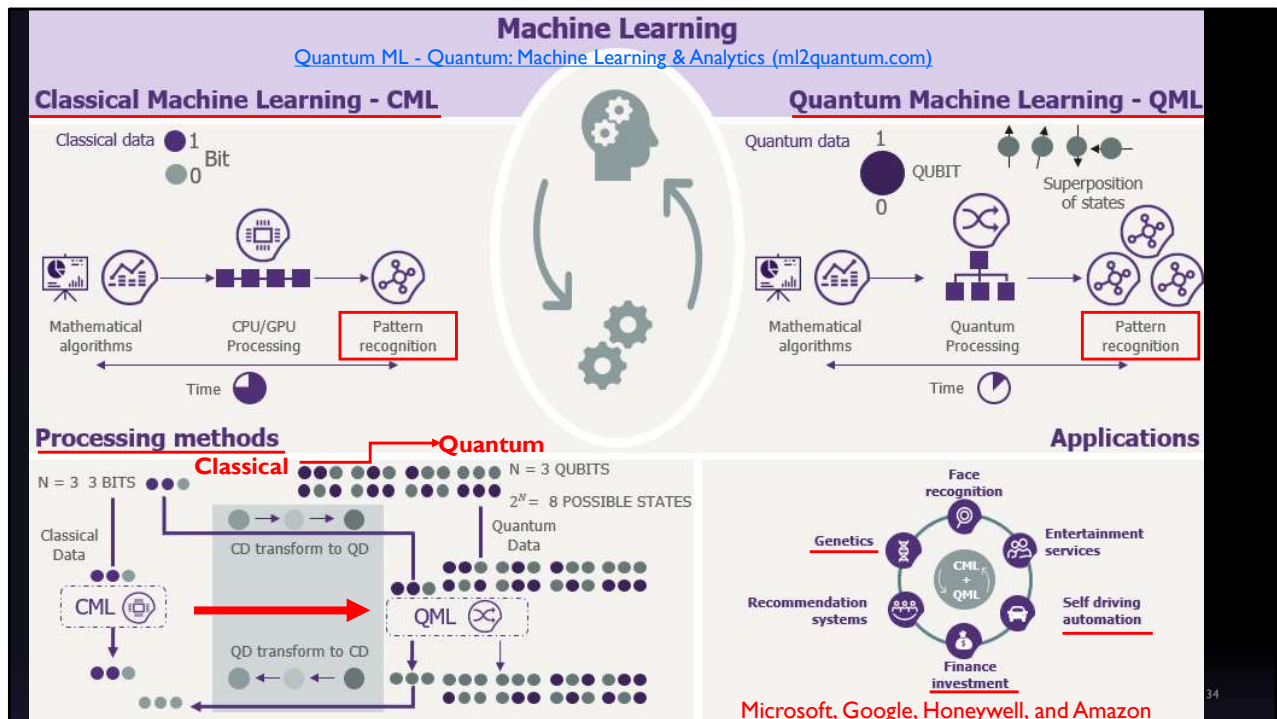
33

In November 2021 Rich Miller wrote an article for Data Center Frontier discussing Google's artificial intelligence lab efforts on creating a quantum computing data center. In the article Rich discusses the differences between classical and quantum computing and the challenges and pathways to create a quantum computer and then scale that up to a quantum data center. These are envisioned to be very different than today's generation of cloud and high-performance data centers due to the significant differences between classical and quantum computing.

One main difference pictured here is the cryostat needed for some implementations of a quantum computer. In the article, there is a 3-minute video tour of the Google AI labs where Erik Lucero, a Google Research Scientist, walks the viewer through their facility and talks through their vision of the future Google AI Quantum Computing Data Center.

Rich ends his article by noting that other key players in the quantum computing race are using different technical approaches to build quantum computers and these may have dramatic effects on the facilities required to make their versions of quantum data centers; especially if the quantum computers can operate at room temperature, as Celia Merzbacher, Director of the Quantum Economic Development Consortium (QED-C) described in her keynote talk at Data Center World in the summer of 2021.

This year I had the honor of co-authoring a journal paper with Celia and others associated with the EdQuantum project titled "Quantum Technician Skills and Competencies for the Emerging Quantum 2.0 industry in SPIE's Optical Engineering Journal. This is available to download from my website too.



On the Quantum Machine Learning website, you can learn more about the differences between classical and quantum computers and their respective applications using machine learning and data analytics. The advances in:

1. fundamental processing methods gained using quantum computing, shown here in this diagram, can lead to extreme advances in
2. pattern recognition which can be applied to end user applications such as
3. genetics, self driving cars, financial investments, logistics and many more, some of which we have already discussed and others that we listed.

This website also has some information about the Machine Learning efforts from larger key companies such as

4. Microsoft, Google, Honeywell, and Amazon.

IBM Institute for Business Value

Our insights C-suite Study COVID-19 Virtual Enterprise Benchmarking About the IBV

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

Exploring quantum computing use cases for manufacturing

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- Chemistry
- Materials science
- Condensed matter physics

Design

- Finite difference analysis
- Structural analysis
- Hydro/aerodynamics

Manufacturing

Control

- Optimization
- Machine learning
- Classification

Supply

- Supply chain optimization
- Risk modeling

[Exploring quantum computing use cases for manufacturing | IBM](#)

35

Once again, we look to IBM to help us understand the business use cases in some manufacturing industries to gain a sense of how and why quantum computing seems like such a worthwhile technology to explore and invest time, money and resources.

There is a complete report you can download from this website that highlight (and I quote) “the enormous potential that quantum computing is expected to help develop breakthrough products and services that will disrupt and redefine manufacturing”

There will be business advantages in these areas shown here on this diagram with substantial opportunities for early adopters to lock in that followers will have a difficult time overcoming.

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

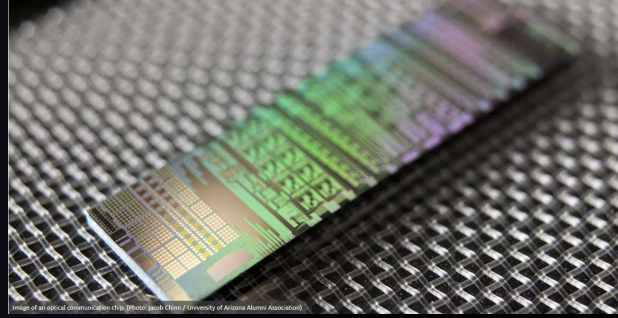


Image of an optical communication chip. (Photo: Jacob Chinn / University of Arizona Alumni Association)

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](#)

36

The last and possibly most important application of quantum computing is when these are networked together in the world's first quantum internet. The Univ of AZ is leading the National Science Foundation's Center for Quantum Networks, with core partners Harvard, MIT and Yale.

The team at the University of Arizona is led by the James C. Wyant College of Optical Sciences and includes the College of Engineering the James E. Rogers College of Law and the College of Social and Behavioral Sciences. This is due to the significant impact the quantum internet will have on society, workforce development, community outreach and the legal implications of inclusion.

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

So, if any of this sounds interesting for you, and you want find out how to get involved in the quantum world, I'll give you these three main points:

- 1 be interested.
- 2 find a mentor and
- 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

Hybrid curriculum for upskilling photonics technicians in advanced optics, spectroscopy and quantum research enabled technologies

Donn Silberman
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EdQuantum
SPIE Fellow
OPTICA

This project is supported by National Science Foundation grant DUE2055061

The Optics Institute of Southern California
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PASADENA CITY COLLEGE
Laser Technology Program

COLLEGE OF OPTICAL SCIENCES
COLLEGE OF ENGINEERING UC
THE UNIVERSITY OF ARIZONA
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Optical Engineering & Optical Instrument Design

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donn@oisc.net 949-636-6170

To learn more about Donn's related endeavors scan the QR code.

This is my business card – you can have one - FREE

38

To find a good mentor, you might start with your physics teacher or whoever brought this presentation to your school or group.

Then, “take action”, by visiting my website and click on links and read the articles that seem to interest you most. There is far too much information for anyone person to digest and use it all effectively, so you will need to focus on what interests you the most and find your own path.

You can watch YouTube videos, some are good, others – not so much.

Maybe you can find some hands-on workshops that you can attend in person, or even on-line.

There are colleges and universities that offer courses in quantum sciences; but not too many that have specific applications like those described in the previous slides.

Look for an internship in the field that interests you most.

Join or start a club at your school and engage with like minded fellow students.



On-line and In-Person Resources

To help you with the 'Take Action' steps, I have assembled a list of on-line and in-person resources where you can start your journey.

Quantum for Students

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.

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 \(illinois.edu\)](#)

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

(for the Schrödinger's Class materials, contact Donn directly)

[Quantum for Students | opticsage \(donn601.wixsite.com\)](#)

40

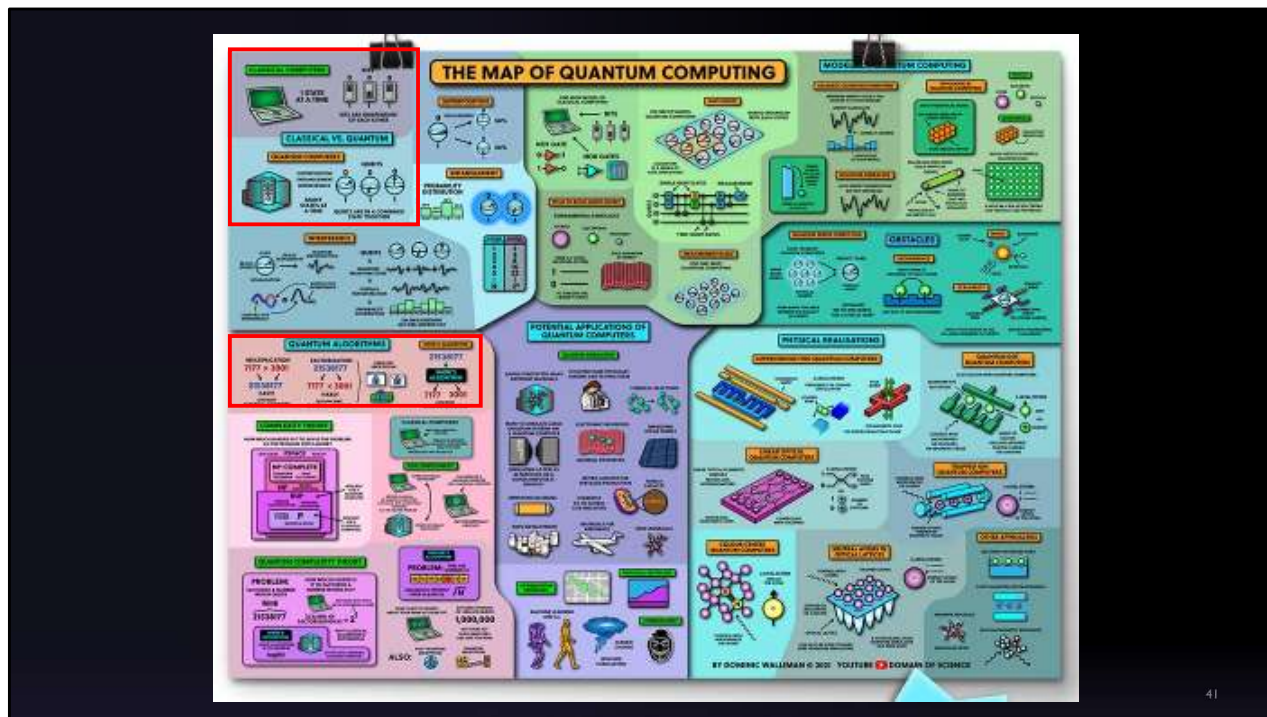
This slide shows a modified screen shot from my webpage Quantum for Students.

This is where you can download a pdf version of the slides and notes, and an audio / video version of the presentation. There are also URL links to all the websites I have referenced already and more that I will review in the time remaining.

These include:

1. [Map of Quantum Computing Poster – DFTBA](#)
2. [Qiskit - IBM's Open Source Quantum Computing Resource](#)
3. [Quantumapalooza 2020 Harrisburg University](#)
4. [QuVis \(st-andrews.ac.uk\)](#)
5. [Schrödinger's Class | Institute for Quantum Computing | University of Waterloo \(uwaterloo.ca\)](#)

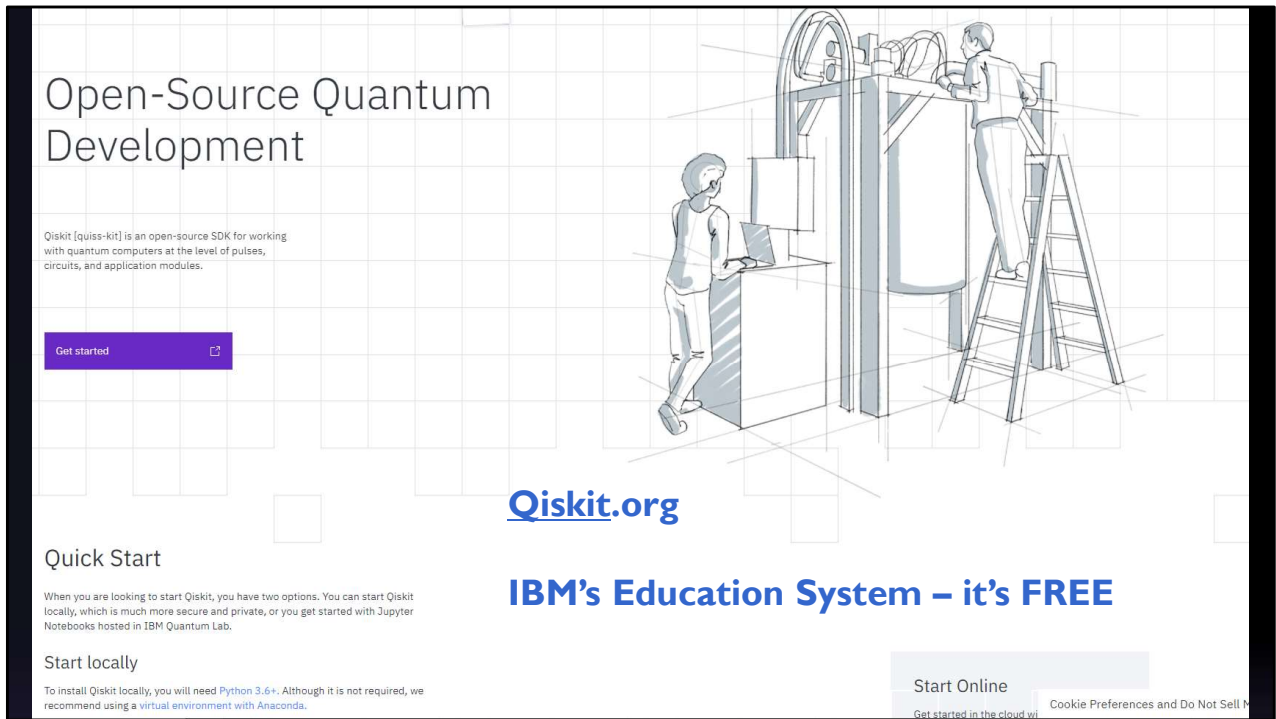
(for the Schrödinger's Class materials, contact Donn directly)



The Domain of Science YouTube channel and associated posters and books has been Made and hosted by Dr. Dominic Walliman, an experimental quantum physicist and author. Out of all the authors and publishers trying to communicate about science topics and particularly quantum science and computing; I have found these to be the most informative, educational and easiest to digest.

A couple of the slides and concepts I have used earlier in this presentation have come directly from this 'Map of Quantum Computing'. You can see the graphics in the two red squares, the first one showing the differences between classical and quantum computing and the second one showing how a quantum computer can factor large numbers much faster than a classical computer.

Clearly, I have only scratched the surface of this map and all the topics on quantum computing. But this map and the associated website and YouTube videos are a great place to start.

The image shows a screenshot of the Qiskit.org website. The page has a white background with a light gray grid pattern. At the top left, the text "Open-Source Quantum Development" is displayed in a large, black, sans-serif font. Below this, a smaller line of text describes Qiskit as an open-source SDK for working with quantum computers. A purple button with the text "Get started" and a small icon is positioned below the text. To the right of the text, there is a line-art illustration of two people interacting with a large, complex quantum device. One person is standing at a desk with a laptop, while the other is on a ladder, working on the top of the device. In the center of the page, the "Qiskit.org" logo is prominently displayed in blue. Below the logo, the text "IBM's Education System – it's FREE" is written in a bold, blue, sans-serif font. At the bottom left, there is a "Quick Start" section with sub-sections for "Start locally" and "Start Online". The "Start Online" section includes a button that says "Start Online" and a link "Get started in the cloud with". At the bottom right, there is a "Cookie Preferences and Do Not Sell My Info" link.

If this has really captured your attention and you want to take the next step to start learning about actually programming on a quantum computer; then IBM has this great open-source education system that is free. They call it Qiskit. I am not going to go into any details about this development tool; but if you are already programming on classical computers, then this could be a great place for you to explore.

* *Definition:* Suffix: apalooza. Forms the name of a promotional event such as a presentation. Emphasizes or exaggerates the element of a situation.

[Data powered by Harrisburg Quantum™. Contact: quantum@HarrisburgU.edu]
 Display time zone: US/Eastern | [Show Past Events](#)

Endless list of FREE online learning opportunities for the Quantum Computing community! (10 upcoming events listed below.)

Workforce Skills-Readiness Classifications (Quantum Computing):

(This is a work-in-progress, draft comments welcome!)

Level	Name	Type of question(s) an individual is presently asking
000	Quantum Curious	What is Quantum Computing?
100	Quantum Explorer	What is a Ket?
200	Quantum Climber	How to do a Controlled-Z 90-degree Rotation?
300	Quantum Enabled	Why does Shor's Algorithm utilize Modular Arithmetic?
400	Quantum Ready	How to make my Algorithm Robust to all that Error?
500	Quantum Professional	How can I Monetize my Skills?

This table is a WIP, send your improvement ideas to quantum@HarrisburgU.edu

note: The past 0 events (since May 18, 2020) are placed at the far bottom of this page)

Wed, May 04

Quantum Computing and Machine Learning

Wed., May. 04, 2022, 8:00am-9:00am (EDT/GMT-0400) [\[Start time local timezone conversion\]](#)

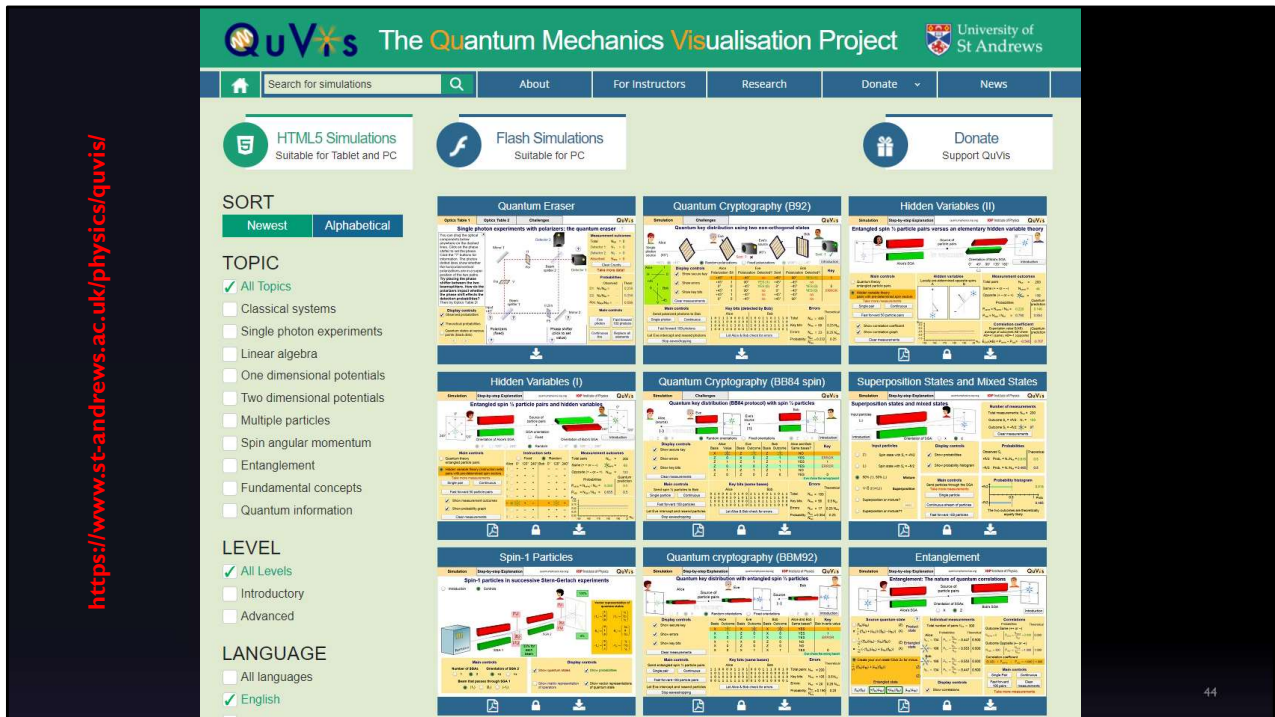
[add to calendar](#) | Contact Level: 300 (For Quantum Enabled)

NOTE: THIS IS AN EARLY TIME SLOT SESSION - repeated on Thu May 5 at 3:30-4:30 pm ET. Quantum computing is poised to potentially have an impact on machine learning methods. In this seminar, we will cover the current state and future prospects of machine learning with quantum computers. This includes algorithms and models such as quantum kernel estimation, variational quantum classifiers, quantum neural networks, and quantum generative-adversarial networks (QGANS). We will also demonstrate the capabilities of the Qiskit Machine Learning open source software project. Note that this is part 3 of a 6-session series on Quantum Computing on Apr 13-14, Apr 20-21, May 4-5, May 18-19, Jun 1-2, and Jun 15-16. The sessions are not prerequisites for each other, and are not recorded. We will provide reference links and do quick recaps of previous content as required, so if you miss an earlier session, you can still get value from subsequent sessions. Presenter: Sean Wagner Sean is a Research Scientist and a Quantum Technical Ambassador at IBM. When he's not programming and experimenting with Qiskit, Sean spends his time working with researchers at academic institutions and industry partners in Canada on projects involving high-performance computing, hardware acceleration, quantum computing, and data science and AI. Dr. Wagner holds a B.A.Sc. degree in Computer Engineering from the University of Waterloo, and M.A.Sc. and Ph.D. degrees in Electrical and Computer Engineering from the University of Toronto. It is recommended that you register at this Webex link ahead of time to receive a calendar invite and reminder. <https://ibm.webex.com/ibm/j.php?RGID=468ab05838f651bb6f4b46282f8444>

<http://2020.quantumapalooza.com/>

Harrisburg University of Science and Technology, Quantum Computing Academy (QCA) in Harrisburg, Pennsylvania, maintains this quantumapalooza website.

They continuously update this Endless list of FREE online learning opportunities for the Quantum Computing community! They have 10 upcoming events listed on this webpage like the one that just happened on May 4th - Quantum Computing and Machine Learning.



The Quantum Mechanics Visualization Project, developed and maintained by the University of St. Andrews School of Physics & Astronomy in the United Kingdom, offers students the ability to use very good graphical simulations to learn more about the fundamentals of quantum mechanics which can help them understand some of the non-intuitive outcomes of various physical experiments and the mathematics that describe them.

There are many different introductory and advanced topics to choose from including a few applications such as quantum cryptography that I mentioned earlier.

QuVis

Simulation
Challenges

Quantum key distribution using two non-orthogonal states

Alice and Bob need to share a secret perfectly random sequence of zeros and ones (a so-called secure key), but cannot meet in person. Classically this is impossible, as they can never be certain that the key was not intercepted during transmission. Quantum mechanics makes secure key generation possible!

In this simulation, you can help Alice and Bob generate a secure key with polarized photons using the so-called B92 protocol. Alice randomly prepares each photon with either 0° (horizontal) or $+45^\circ$ polarization. The horizontal polarization is assigned a bit value of 0, the $+45^\circ$ polarization a bit value of 1.

Alice sends the polarized photon to Bob, who is equipped with a polarization analyzer and a single photon detector. For each measurement Bob randomly sets his analyzer to one of two directions orthogonal to Alice's directions, so either 90° or -45° . Alice informs Bob whenever she sends a photon. If Bob detects the photon, he knows with certainty the polarization and hence the bit value (0 or 1) sent by Alice. For example, if Bob detects a photon when measuring along 90° ,

he knows that Alice sent a photon with $+45^\circ$ polarization (it cannot have been the 0° polarization) and thus with bit value 1. Bob can therefore assign detections with 90° a bit value of 1, and detections with -45° a bit value of 0.

If Bob does not detect the photon, he cannot be certain which state Alice sent. Thus, Alice and Bob keep only those measurements where Bob detected a photon – this sequence of 0 and 1 bit values forms the key. Alice and Bob publicly communicate to determine which photons were detected. They then exchange a small number of their bit values (which they then discard as they are not anymore secure) to check for errors.

Your goal is to help Alice and Bob decide whether or not they have generated a secure key. How can they tell that an eavesdropper Eve has infiltrated their experiment? Click on the virtual reality goggles that allow you to “see” the photons to start sending photons from Alice to Bob and to eavesdrop by intercepting and resending photons.

https://www.st-andrews.ac.uk/physics/quvis/

In this Quantum key distribution simulation & challenge, the student is provided a detailed description of the physics experiment, in this case using familiar polarization filters and a single photon source as the quantum object.

The student's goal is to help Alice and Bob determine if they have a secure quantum key that has been distributed without Eve eavesdropping.

QuVIs

Quantum key distribution using two non-orthogonal states

H(0°) +45° Random polarizations Fixed polarizations V(90°) -45°

Alice

Single photon source |H>

Bob

0 0 Alice | Bob 0 0

Let Alice & Bob compare 20 bits for errors

More measurements needed for error checking

Introduction

Display controls		Alice		Eve		Bob		Key	
		Polarization	Bit	Polarization	Detected?	Sent	Polarization		Detected?
<input checked="" type="checkbox"/>	Show key generation	0°	0				-45°	YES (0)	0
<input checked="" type="checkbox"/>	Show key bits	0°	0				90°	no	
<input checked="" type="checkbox"/>	Show total errors	0°	0				90°	no	0
<input type="button" value="Clear measurements"/>		0°	0				-45°	YES (0)	
		0°	0				90°	no	

Main controls

Send polarized photons to Bob

Let Eve intercept and resend photons

Most recent key bits (detected by Bob)

Alice: 0 0 Bob: 0 0

Let Alice & Bob compare 20 bits for errors

More measurements needed for error checking


Errors (all measurements)

		Theoretical
Total:	$N_{tot} = 8$	
Key bits:	$N_{key} = 2$	$0.25 N_{tot}$
Errors:	$N_{err} = 0$	0
Probability:	$\frac{N_{err}}{N_{key}} = 0.000$	0

The student can watch a simulation of the experiment using several polarization settings, display and main controls. Here I used the continuous setting with all the display controls shown.


QuVis

Quantum key distribution using two non-orthogonal states



Alice

Single photon source



Bob

H(0°) +45°

V(90°) -45°

Your score: 15/100

Assuming no eavesdropper has intervened, what sequence of detections and non-detections could Bob have measured? Choose one or more.

no , YES, YES, YES, no , YES

YES, no , no , no , YES, no

YES, YES, YES, no , YES, no

no , no , no , YES, no , YES

Alice Polarization Bit	Eve Polarization Detected?	Eve Sent	Bob Polarization Detected?	Key
0°	0		-45°	?
0°	0		90°	?
0°	0		90°	?
0°	0		-45°	?
0°	0		-45°	?
+45°	1		90°	?

Correct, congratulations! Bob does not detect the photon if his polarizer is orthogonal to Alice's polarizer. If Bob chooses a polarization 45° from Alice's polarization, 50% of the times he detects the photon.

1

2

3

4

5

6

<https://www.st-andrews.ac.uk/physics/quvis/>

In this slide I show my results of the challenge where I choose the correct sequence of detections assuming there was no eavesdropping. There are many more variations in this simulation and challenge that students can go through to further their understanding of this experiment. This can lead to a deeper understand of quantum science in general and quantum cryptography in particular.

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Schrödinger's Class

Applications for Schrödinger's Class 2021 are now closed.

Quantum for high school teachers

Learn how to teach quantum in your high-school class, and gain the tools to do it.

A free online workshop series for 2021

Schrödinger's Class 2021 will be held as a series of online micro-workshops this fall, geared toward lessons that can be implemented both in-person and virtually.

Registration is free and open to all interested teachers, but space is limited.

Online workshop schedule 2021

Schrödinger's Class will be offered in two identical sessions. Successful applicants will be asked to sign up for **either** Session 1 (evenings) **or** Session 2 (weekend).

EXPAND ALL COLLAPSE ALL

SESSION 1: TUESDAY, NOVEMBER 30-THURSDAY, DECEMBER 2

SESSION 2: SATURDAY, DECEMBER 4-SUNDAY, DECEMBER 5

What is Schrodinger's Class?

It is a professional development workshop for secondary school science teachers that takes

Interested in attending a local Quantum Education Workshop ??

48

Last summer I attended a two-day on-line workshop where I learned how to provide a short course on quantum science to high school students. This was offered by the University of Waterloo in Canada and was called Schrodinger's Class, after the famous quantum scientist Erwin Schrodinger and his conceptual cat.

I have the complete set of all the course materials (for students and teachers) and can work with your teachers to help bring this unique educational opportunity to your school. Some of the concepts are similar to the simulation and challenge I just described from the Univ. of St. Andrews.



We are now at the end of this presentation. If you think this is something you want to learn more about, then follow the white rabbit into the new quantum world of superposition, entanglement, and interference... or as Albert Einstein named it...."Spooky Action at a Distance"

It has always been a goal of mine to better understand the quantum world and now I have finally jumped down the rabbit hole and am hoping to guide many students.

Experience Life in the QuantumOptics Age

OpticsAge is a focal point for Donn Silberman's past Optics Education Adventures
Donn has retired from most of his educational outreach activities and his fulltime job at Starrett.
This website will be periodically maintained as an educational resource.

Donn is now focused on his Quantum Explorations and is consulting on EdQuantum.



Contact Us

First Name

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50

If you have any questions you would like to ask, you can contact me from my website.

Just follow the Digital White rabbit.



Summary

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

51

We are living in the Quantum World where the smallest subatomic particles and energy fields make up everything in our Marco world.

These new quantum technologies built on quantum science is taking humanity to the next level of our modern civilization and likely to many worlds beyond.

And you can be a part of making this all happen.

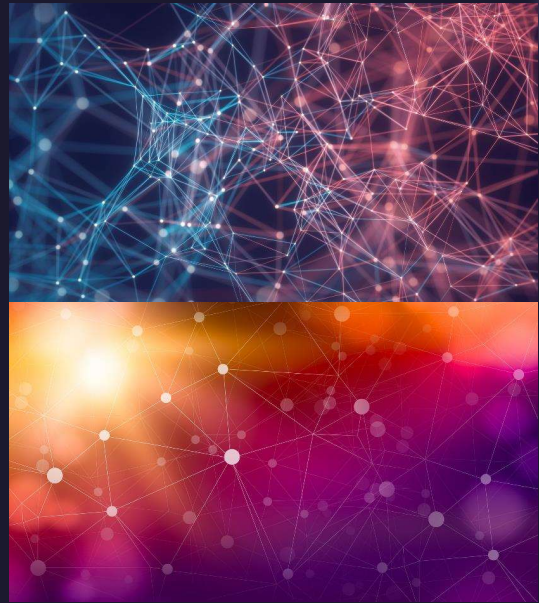
If we have time, there is a 3 minute video we can watch from the Q-12 education website.



Thank You

Donn Silberman

- Optics Institute of Southern California
- <http://oisc.net>



Questions & Answers

Tuesday, February 2, 20XX

Sample Footer Text

54