

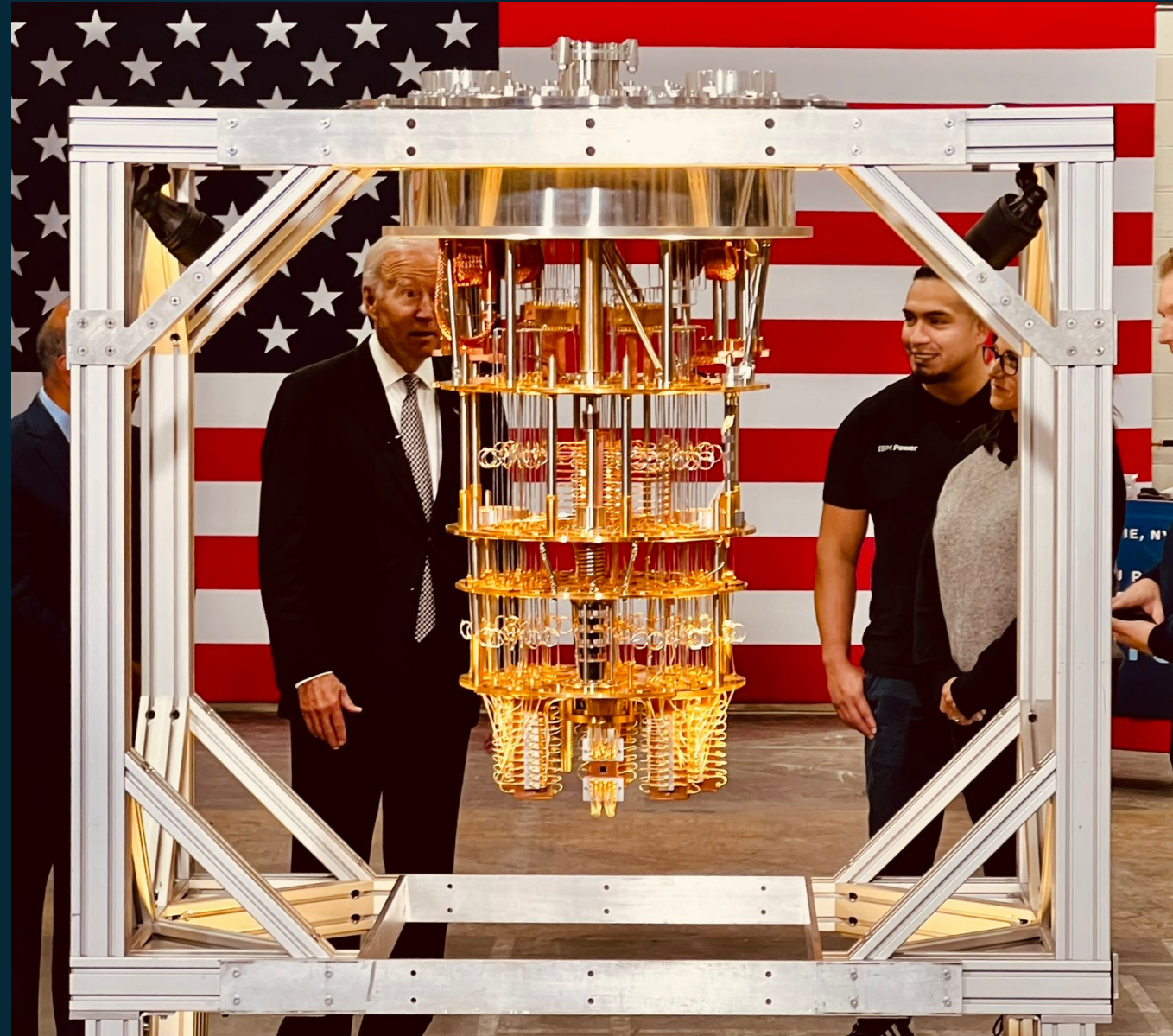
# Quantum Information Science

Charles Tahan

Assistant Director for QIS and Director of the National Quantum Coordination Office, Office of Science and Technology Policy

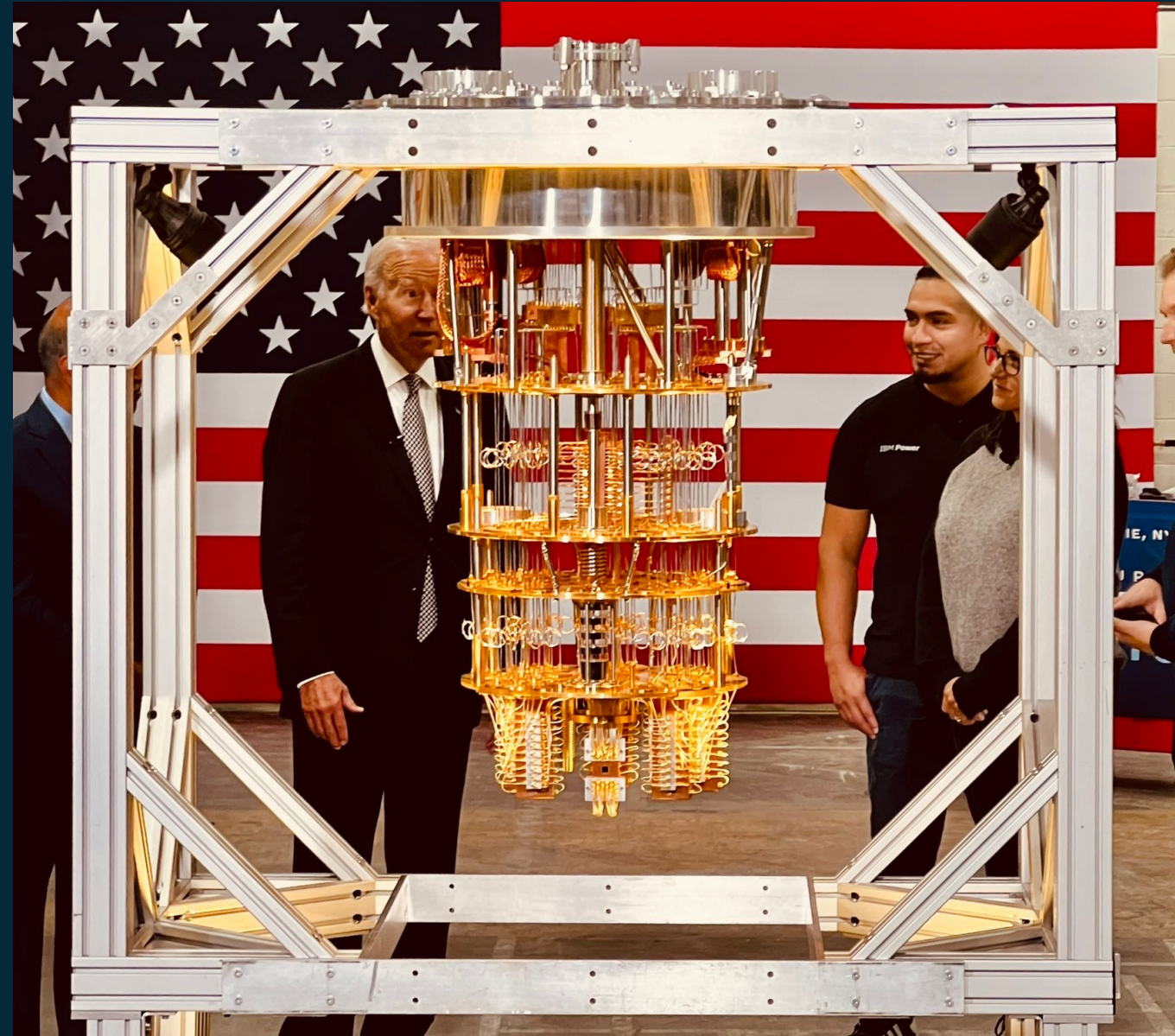
Chief Scientist & Chief of QIS, Laboratory for Physical Sciences

- Best picture of the year?



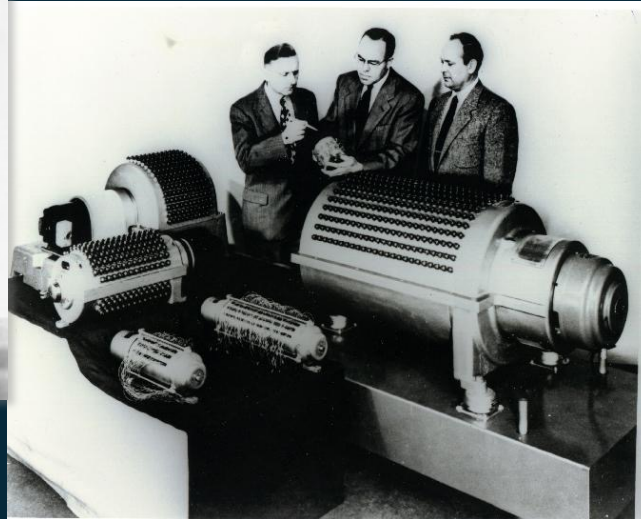
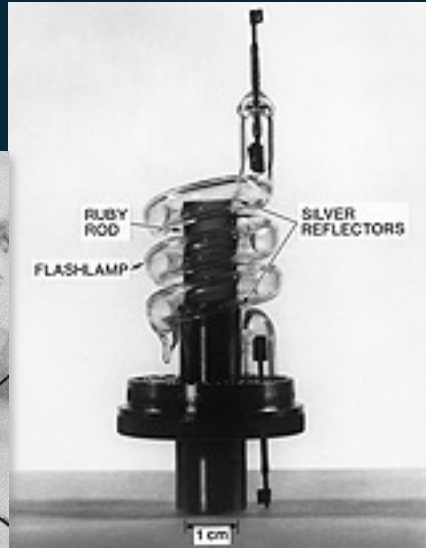
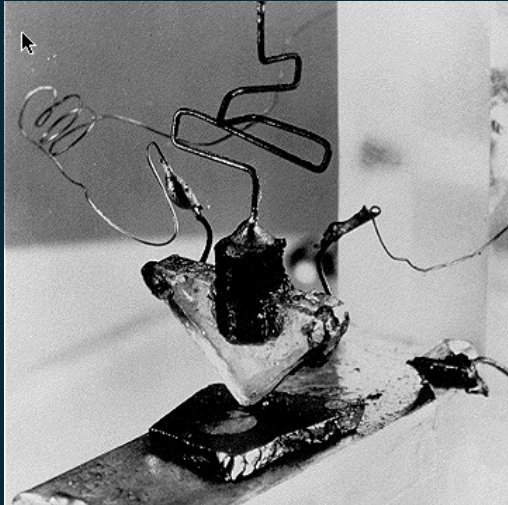


- Second best.





# Quantum mechanics enabled modern computing and communication



The TRANSISTOR, LASER, MAGNETIC STORAGE, and MRI could not have been developed without an understanding of quantum mechanics, primarily the “benign” parts of QM, such as energy levels.



# Physical devices allow us to manipulate information

- Quantum mechanics are the rules that describe how really small things behave.
- Discovered over 100 years ago, these curious facts about matter enabled humans to design the transistor, ultra-precise clocks, and brain imagers.
- With these physical devices in hand, we built abstractions. The most amazing of which are computers and the programming languages that control them.
- But while physical devices allow us to manipulate information, information is also physical. The 0's and 1's that humans came up with – what came to be called computer science or information theory – works great, except, that the universe works by the laws of quantum mechanics.

But quantum physics problems are really hard to solve on computers. So, what if you could build a computer based on the laws of the Universe – a “quantum computer”...?



1. No efficient computer simulations of quantum theory
2. Systems evolving according to quantum theory efficiently compute properties of the quantum system – Nature is quantum

“How can we simulate quantum mechanics?... Can we do it with a new kind of computer...a **quantum computer**? It’s not a Turing machine but a machine of a different kind” (1981)

*Naively, adding a single particle (or orbital) doubles the size of the matrix you need to diagonalize.*

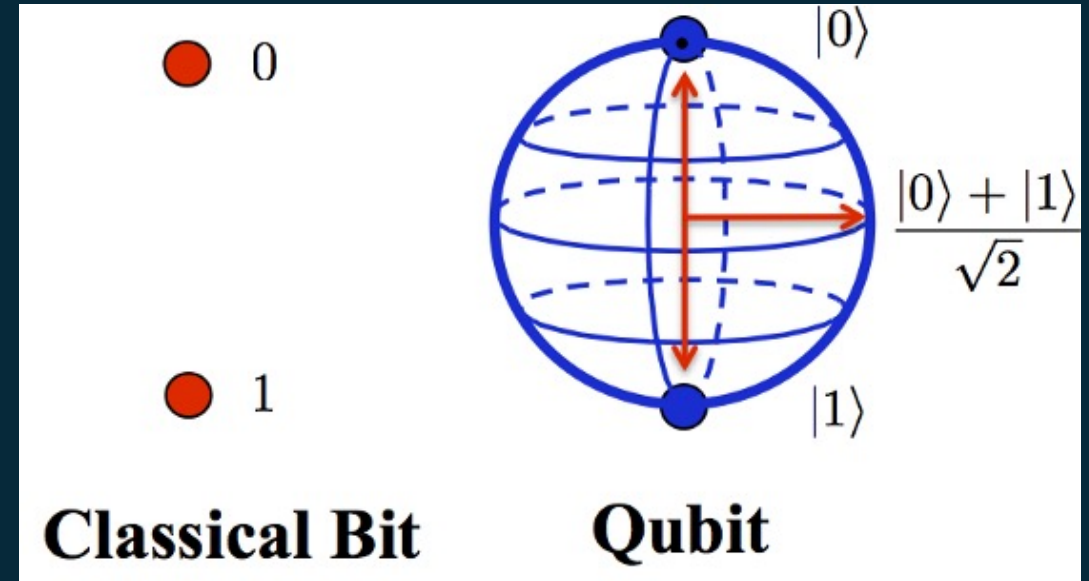
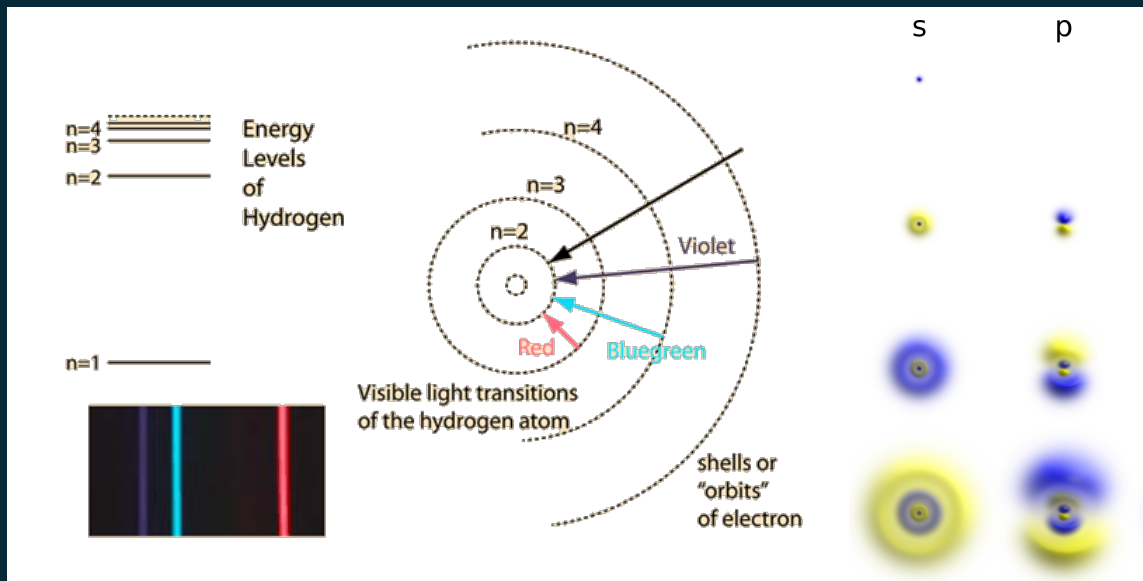


# Quantum to *Quantum Information*

- Quantum 1.0 – particles
  - *Quanta*: atoms, photons, electrons
  - Atoms have discrete energy levels and electron wave functions
  - Electronics, photonics, etc.

- **Quantum 2.0 - qubits**

- Quantum superposition/entanglement
- Quantum measurement: collapse
- **Quantum sensors, networks, computers**



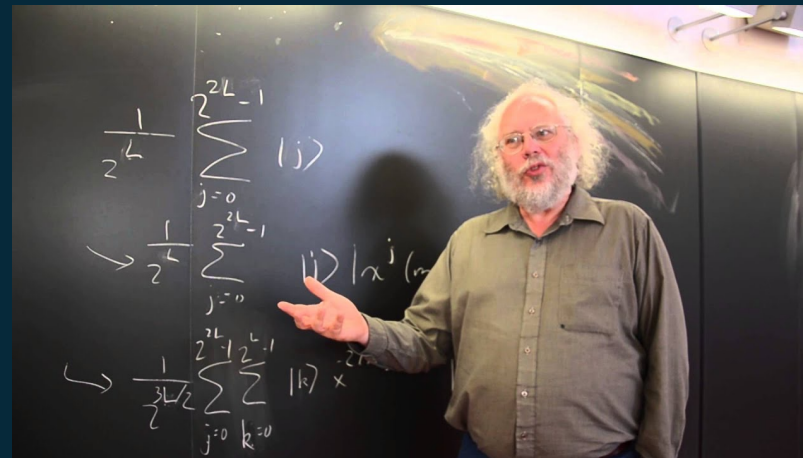
# Quantum Information Science is a foundational shift in Information Technology

- Consider large-scale quantum computers
- QCs offer dramatic speed up for *a few unique but important* problems



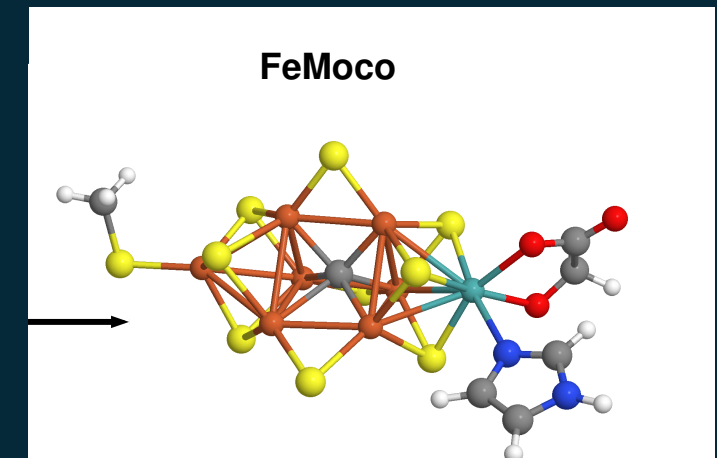
## Exploring quantum mechanics

[we can't simulate ~50 (perfect) qubits]



## Cryptanalysis

[10+million *physical* qubits breaks modern public key crypto]



## Utility?

[?100-1000 *logical* qubits does something economically useful in chemistry/materials science]



# National Quantum Initiative

Charles Tahan

Assistant Director for Quantum Information Science  
Director, National Quantum Coordination Office  
Office of Science and Technology Policy

[whitehouse.gov/ostp](https://whitehouse.gov/ostp)

[www.quantum.gov](https://www.quantum.gov)

@WHOSTP



*"As new technologies continue to evolve, we'll work together with our democratic partners to ensure that new advances in areas from biotechnology, to quantum computing, 5G, artificial intelligence, and more are used to lift people up, to solve problems, and advance human freedom." – President Biden*



# QIST is a National Priority

- ***Getting the science right*** by understanding the applications and timelines by which quantum information science and technology will benefit our society, and roadblocks we must overcome to get there;
- ***Enhancing American competitiveness*** by accelerating technology development toward useful economic and mission applications while also protecting our national security; and
- ***Enabling our people*** by building the necessary talent pipeline and ensuring that this field creates new opportunities for all Americans.



Oct 5, 2021: White House Summit on Quantum Industry and Society





# Presidential Actions

BRIEFING ROOM

## Executive Order on Enhancing the National Quantum Initiative Advisory Committee

MAY 04, 2022 • PRESIDENTIAL ACTIONS

“Quantum information science (QIS) can enable transformative advances in knowledge and technology for industry, academia, and government. Accordingly, the National Quantum Initiative (NQI), which aims to ensure the continued leadership of the United States in QIS and its technology applications, is a substantial and sustained national priority.”

“The NQI Program encompasses contributions from across the Federal Government, ... with membership on SCQIS or ESIX”

BRIEFING ROOM

## National Security Memorandum on Promoting United States Leadership in Quantum Computing While Mitigating Risks to Vulnerable Cryptographic Systems

MAY 04, 2022 • STATEMENTS AND RELEASES

**Policy:** Balance the competing opportunities and risks of quantum computers by (1) maintaining U.S. leadership in QIS; and (2) mitigating the threat of CRQCs through a timely and equitable transition to PQC.

**Promotion:** The United States must pursue a whole-of-government and whole-of-society strategy to harness the economic and scientific benefits of QIS.

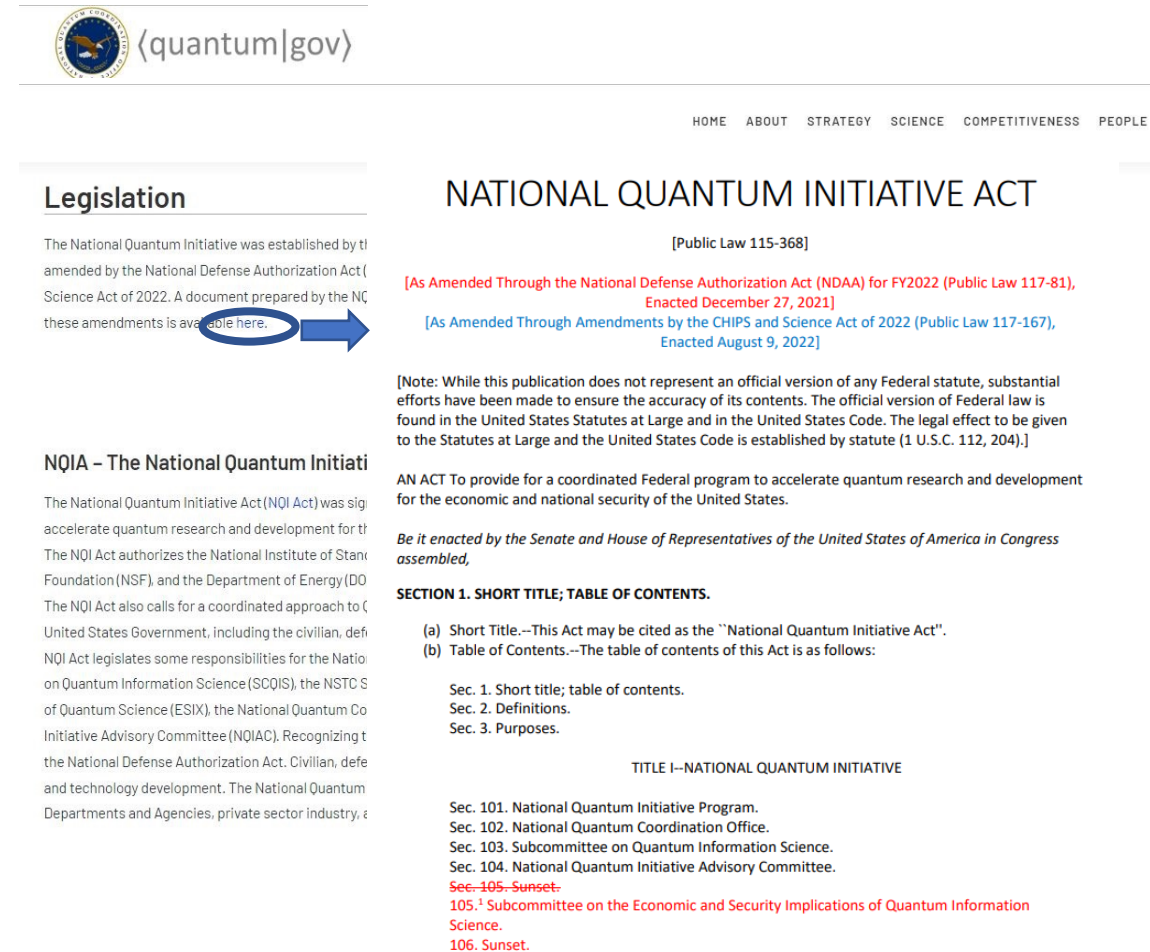
**Mitigating Risks:** The United States must prioritize the timely and equitable transition of cryptographic systems to QRC.

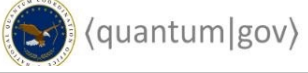
**Protecting US Tech:** The U.S. Gov must work to safeguard relevant quantum R&D and intellectual property (IP) and to protect relevant enabling technologies and materials.

# Congressional Actions

- NDAA FY22
  - Amended the NQI to formally establish ESIX Subcommittee
    - “review and assess any economic or security implications of such investments; assess the export of technology associated with quantum information science and recommend...”
- CHIPS (approp) and Science Act (auth)
  - Amended the NQI Act
    - QN-IWG to update QN Strategy
    - DOE Quantum Network Infrastructure R&D Program
    - DOE QUEST Program
    - Incorporating QISE into STEM Curriculum
    - NIST development and standardization of quantum and post-quantum cryptography
  - NSF to carry out program on Next Generation Quantum Leaders, leveraging the Q-12 Partnership.

<https://www.quantum.gov/wp-content/uploads/2022/08/NQIA2018-NDAA2022-CHIPS2022.pdf>





HOME ABOUT STRATEGY SCIENCE COMPETITIVENESS PEOPLE

## Legislation

The National Quantum Initiative was established by the National Quantum Initiative Act (NQIA), which was amended by the National Defense Authorization Act (NDAA) for FY2022 (Public Law 117-81), Science Act of 2022. A document prepared by the NQI team for these amendments is available [here](#).

## NATIONAL QUANTUM INITIATIVE ACT

[Public Law 115-368]

[As Amended Through the National Defense Authorization Act (NDAA) for FY2022 (Public Law 117-81), Enacted December 27, 2021]

[As Amended Through Amendments by the CHIPS and Science Act of 2022 (Public Law 117-167), Enacted August 9, 2022]

[Note: While this publication does not represent an official version of any Federal statute, substantial efforts have been made to ensure the accuracy of its contents. The official version of Federal law is found in the United States Statutes at Large and in the United States Code. The legal effect to be given to the Statutes at Large and the United States Code is established by statute (1 U.S.C. 112, 204).]

### NQIA – The National Quantum Initiative Act

The National Quantum Initiative Act (NQIA) was signed into law on August 9, 2022. The NQIA authorizes the National Institute of Standards and Technology (NIST), the Department of Energy (DOE), and the Department of Defense (DOD) to carry out a coordinated approach to quantum information science (QIS) research and development. The NQIA also calls for a coordinated approach to quantum information science (QIS) research and development, including the civilian, defense, and technology development. The National Quantum Initiative Act, Civilian, defense, and technology development. The National Quantum Initiative Act, Civilian, defense, and technology development. The National Quantum Initiative Act, Civilian, defense, and technology development.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,*

#### SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) Short Title.--This Act may be cited as the "National Quantum Initiative Act".

(b) Table of Contents.--The table of contents of this Act is as follows:

Sec. 1. Short title; table of contents.  
Sec. 2. Definitions.  
Sec. 3. Purposes.

#### TITLE I--NATIONAL QUANTUM INITIATIVE

Sec. 101. National Quantum Initiative Program.  
Sec. 102. National Quantum Coordination Office.  
Sec. 103. Subcommittee on Quantum Information Science.  
Sec. 104. National Quantum Initiative Advisory Committee.  
~~Sec. 105. Sunset.~~  
105.<sup>1</sup> Subcommittee on the Economic and Security Implications of Quantum Information Science.  
106. Sunset.





# National Quantum Initiative (NQI) Act Oversight/Coordination

## NQI COORDINATING BODIES

*NSTC Subcommittee on Quantum Information Science (SCQIS)\**

*NSTC Subcommittee on Economic and Security Implications of Quantum Science (ESIX)\*\**

*National Quantum Coordination Office (NQCO)\**

*NQI Advisory Committee\**

*Quantum Economic Development-Consortium (non-gov)*

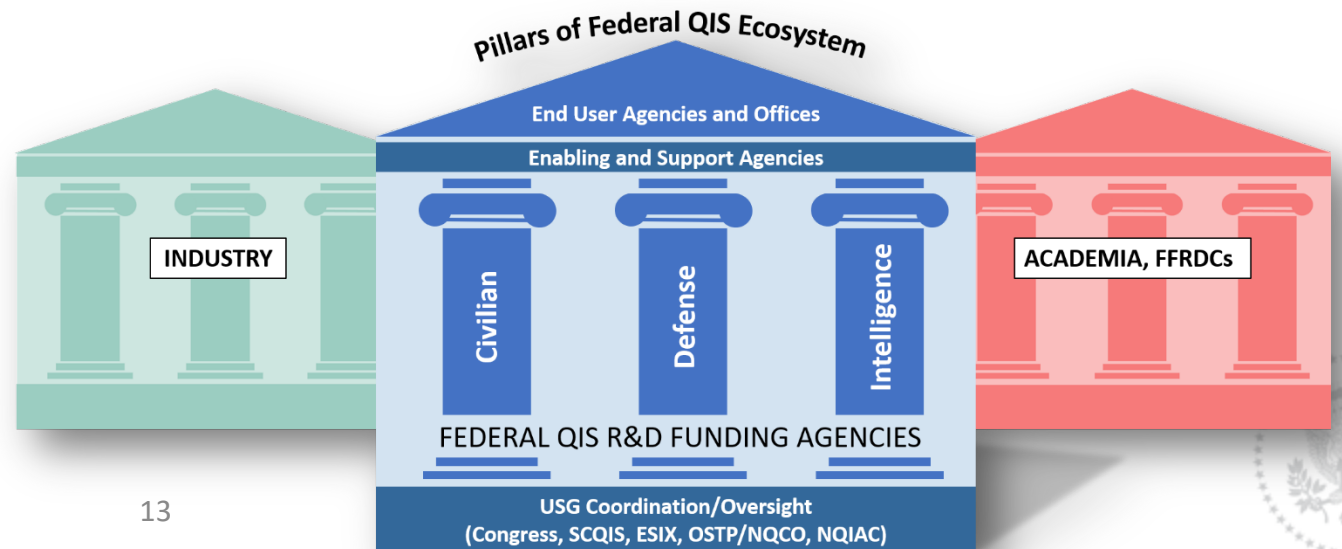
Co-Chairs from:



Co-Chairs from:



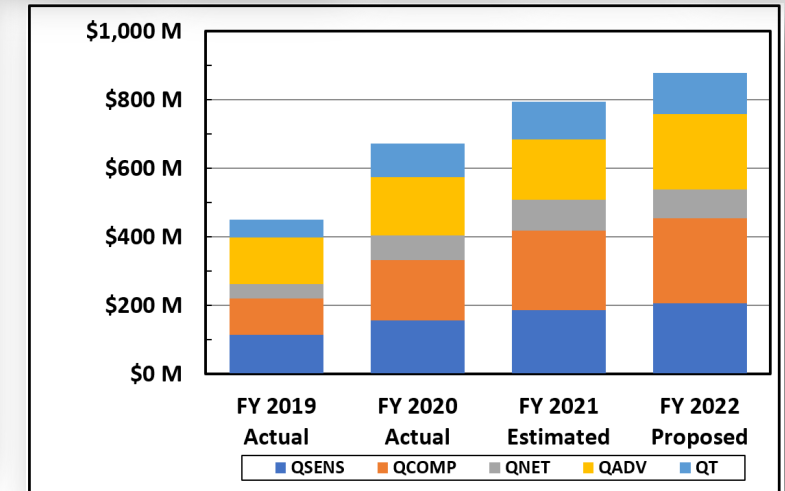
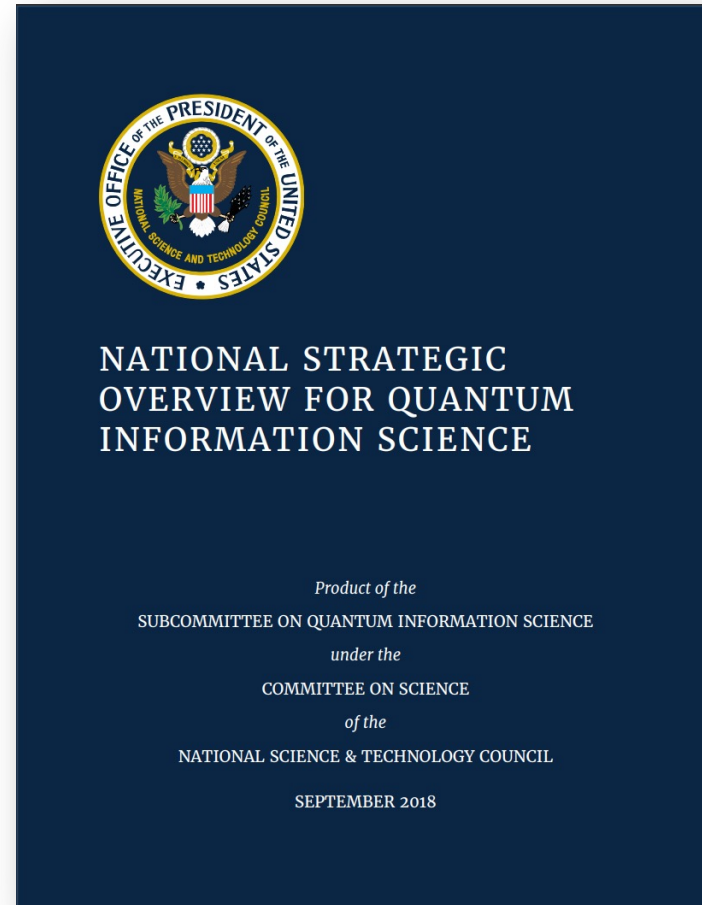
## Participating Agencies



\* from National Quantum Initiative Act (PL 115-368) 2018  
 \*\* from National Defense Authorization Act for FY'22 (PL 117-81)

# National Strategy for QIST Continues to Evolve and Expand

1. Take a **science-first** approach
2. Provide the key **infrastructure**
3. Build a quantum-capable and diverse **workforce**
4. Nurture the nascent quantum **industry**
5. Balance **economic** and **national security**
6. Continue to develop **international collaboration** and cooperation



FY21 NQI Annual Report

Find all our strategy documents on [quantum.gov](https://www.quantum.gov)



# Augmenting the National Strategy



## THE ROLE OF INTERNATIONAL TALENT IN QUANTUM INFORMATION SCIENCE

*A Report by the*  
SUBCOMMITTEE ON ECONOMIC AND SECURITY  
IMPLICATIONS OF QUANTUM SCIENCE  
COMMITTEE ON HOMELAND AND NATIONAL  
SECURITY  
*of the*  
NATIONAL SCIENCE & TECHNOLOGY COUNCIL

October 2021



## 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



## BRINGING QUANTUM SENSORS TO FRUITION

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

MARCH 2022

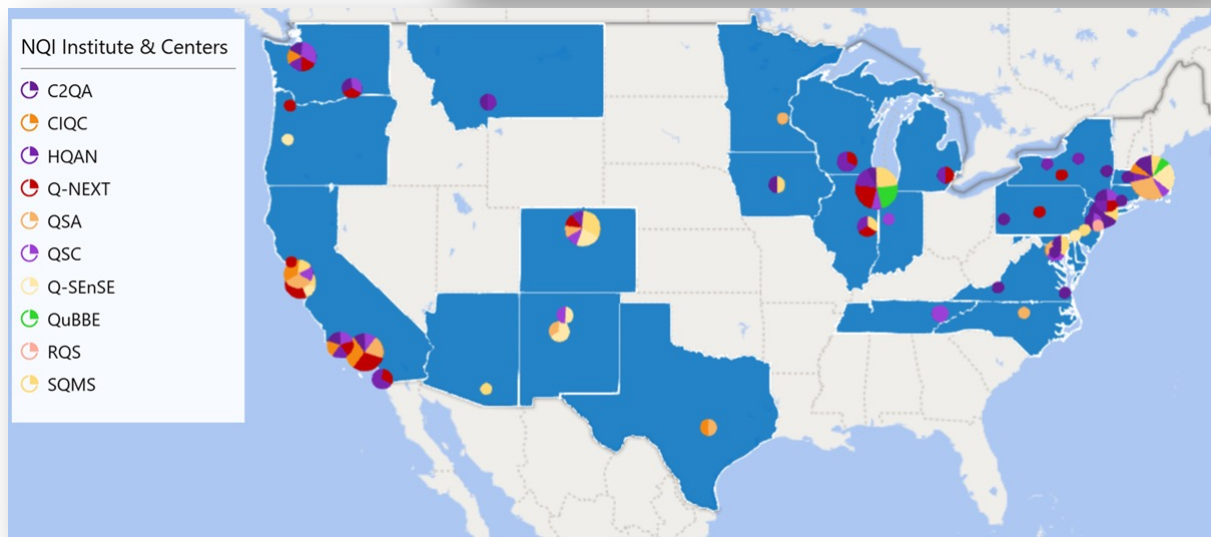


# Getting the Science Right

by understanding the applications and timelines by which QIST will benefit our society, and roadblocks we must overcome to get there.

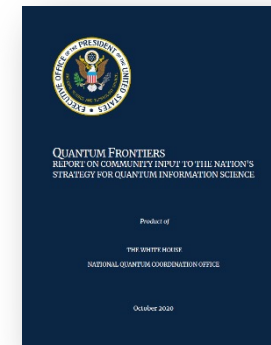
## Infrastructure

- 5 DOE National QIS Research Centers
- 5 NSF Quantum Leap Challenge Institutes (+2 FY21)
- 3 DOD/IC QIS Centers (+1 FY21)



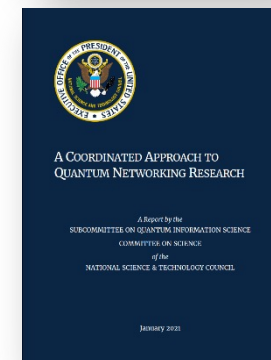
## Quantum Frontiers

1. QIST to Benefit Society
2. Building Quantum Engineering
3. Materials Science for QIST
4. Quantum Mechanics using Quantum Simulations
5. QIST for Precision Measurement
6. Quantum Entanglement for New Applications
7. Quantum Errors
8. The Universe through Quantum Information



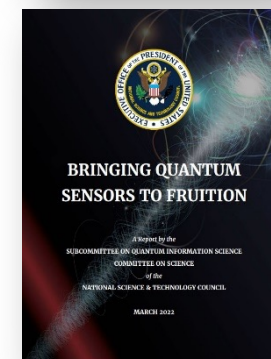
## Quantum Networking

- TR 1: Continue Research on Use Cases
- TR 2: Prioritize Cross-Beneficial Core Components
- TR 3: Improve Classical Capabilities
- TR 4: Leverage "Right-Sized" Quantum Testbeds
- PR 1: Increase Interagency Coordination
- PR 2: Establish Timetables for R&D Infrastructure
- PR 3: Facilitate International Cooperation




## Quantum Sensing

1. QIST R&D leaders should partner with end-users to raise the TRL of new quantum sensors
2. Agencies using sensors should jointly test quantum prototypes with QIST R&D leaders
3. Develop broadly applicable components and subsystems
4. Streamline tech transfer and acquisition practices



# New Programs and Solicitations Listed on Quantum.gov



**QUANTUM COMPUTING / R&D FUNDING OPPORTUNITIES**

## IARPA Launching New Program on Entangled Logical Qubits

(July 22, 2022) The Intelligence Advanced Research Projects Activity (IARPA) is launching a new program on Entangled Logical Qubits (ELQ). It is a four-year program scheduled to start in the ...

Colleague Letter: Enabling Quantum Computing Platforms for National Science Foundation Researchers with Amazon Web Services, IBM, and Microsoft Quantum

**NSF / QUANTUM COMPUTING / R&D FUNDING OPPORTUNITIES**

## NSF Funds Access to Cloud-based Quantum Computing Platforms

(June 3, 2022) The National Science Foundation, in conjunction with Amazon Web Services (AWS), IBM, and Microsoft, is promoting the availability of cloud-based access to quantum-computing platforms to advance research ...

**BIOLOGICAL AND ENVIRONMENTAL RESEARCH (BER)**



**QUANTUM-ENABLED BIOMAGING AND SENSING APPROACHES FOR BIOENERGY**

**QUANTUM SENSING / R&D FUNDING OPPORTUNITIES**

## DOE BER Releases FOA for Quantum-Enabled Imaging and Sensing for Bioenergy


The DOE SC program in Biological and Environmental Research (BER), through its Biomaging Research effort, announced its interest in receiving applications to advance fundamental research or use-inspired technologies of new ...



**R&D FUNDING OPPORTUNITIES / WORKFORCE**

## AFOSR Funding Opportunities in STEM Education, Quantum Welcomed

(March 21, 2022) The Air Force Office of Scientific Research (AFOSR) has two funding opportunities involving STEM education, which could include quantum information science: STEM F0A: This announcement explicitly encourages ...




**R&D FUNDING OPPORTUNITIES / WORKFORCE**

## LPS Supports Young Investigator Program in QIS

(March 17, 2022) The Laboratory for Physical Sciences (LPS), which hosts a National Quantum Information Science Research Center called the LPS Qubit Collaboratory (LQC), is partnering with the Air Force ...



**RENEW Program for Quantum Networking Events**




NASA's Space Communications and Navigation (SCaN) program office seeks to enhance faculty professional knowledge and leadership experience by offering two 10-week summer fellowship opportunities for educators who are interested in ...

**INTERNATIONAL / NSF / R&D FUNDING OPPORTUNITIES**

## NSF Funding for International Collaboration in Quantum

(August 18, 2022) The National Science Foundation (NSF) released a Dear Colleague Letter on July 21, 2022 on International Collaboration Supplements in Quantum Information Science and Engineering Research. With this ...

**BROAD AGENCY ANNOUNCEMENT FOR QUANTUM COMPUTING IN THE SOLID STATE WITH SPIN AND SUPERCONDUCTING SYSTEMS (QC-S)**



**QUANTUM COMPUTING / R&D FUNDING OPPORTUNITIES**

## ARL and LPS release BAA on Quantum Computing in the Solid State

(January, 18 2022) A new Broad Agency Announcement (BAA) for the QC-S5 program, BAA # W911NF-22-S-0006 has been released. The U.S. Army Research Office (ARO), in collaboration with the Laboratory ...

**EXPANDING CAPACITY IN QUANTUM INFORMATION SCIENCE AND ENGINEERING (ExpandQISE)**

**PROGRAM SOLICITATION SF 22-561**

**National Science Foundation**

- Directorate for Mathematical and Physical Sciences
- Directorate for Education and Human Resources
- Directorate for Computer and Information Science and Engineering

**INFRASTRUCTURE / R&D FUNDING OPPORTUNITIES / WORKFORCE**

## ExpandQISE Solicitation: Invitation to a Connections-Building Workshop

(Feb. 27, 2022) ExpandQISE Solicitation: Invitation to a connections-building workshop. The recently issued program solicitation NSF 22-561 "Expanding Capacity in Quantum Information Science and Engineering (ExpandQISE)" aims to increase research ...





# Stakeholder Engagement

## WH Summit on Quantum Industry and Society



## Factsheets and more on quantum.gov

(quantum|gov)

### FEDERAL WORKFORCE ACTIVITIES IN QUANTUM INFORMATION SCIENCE

ACTIVE

merican economy. agnetic Resonance ps, and lasers for mise for another uting, networking, ment approach to

OVERVIEW

The 2018 [National Strategic Overview for Quantum Information Science \(QIS\)](#) identifies creating a quantum-smart workforce for tomorrow as a key policy area. The strategy for creating this workforce is detailed in the 2022 report, [Quantum Information Science and Technology \(QIST\) Workforce Development National Strategic Plan](#), and it includes four critical actions:

1. Develop and maintain an understanding of the workforce needs in the QIST ecosystem, with both short-term and long-term perspectives.
2. Introduce broader audiences to QIST through public outreach and educational materials.
3. Address QIST-specific gaps in professional education and training opportunities.
4. Make careers in QIST and related fields more accessible and equitable.

One of the primary mechanisms for coordinating Federal workforce activities in QIST is through the National Science and Technology Council (NSTC) Subcommittee on Quantum Information Science (SQIS) Interagency Working Group on Workforce (IWG-WF).

This factsheet gives some examples of activities that Federal agencies have engaged in or funded in order to create a quantum-smart workforce for tomorrow. At the K-12 level, the activities include identifying QIST concepts and integrating them into existing K-12 courses, developing and curating approachable quantum lessons and activities, providing professional development for teachers, and engaging in public outreach about QIST and QIST careers. For undergraduate and graduate students, the activities increasingly involve scholarships, fellowships, and research opportunities, while providing additional on-ramps to QIST through summer schools. For postdoctoral scholars and professionals, activities include fellowships, summer schools, research opportunities, and funding for institutions traditionally underrepresented in the Federal research portfolio.

See [quantum.gov](https://www.quantum.gov) for more information

Acts (NDAAs), are over 20 Federal , is creating new ; for prosperity and

QIS R&D, with an and international

timelines by which get there.

ent toward useful, rational partners,

ensuring that QIS

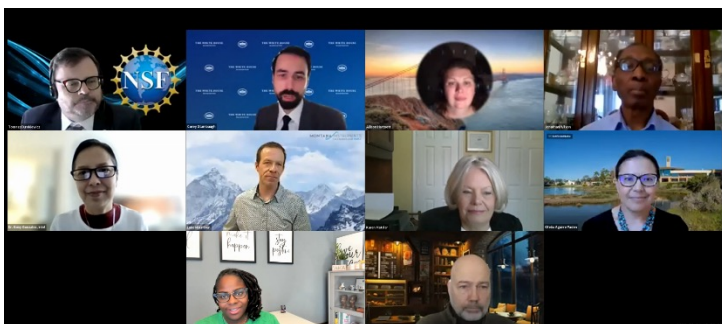
tum physics that y in solar cells. In  $15 \times 10^{14}$  J-s (or ant.

## OSTP-NSF Quantum Computer Cybersecurity Workshop 9/22

## NQI Centers Meeting @ WH 12/22



## WH Meeting on Quantum Workforce: Q-12 Actions for Community Growth



## NQI Advisory Committee (Federal Registry Notice Dec 16)

Learn More [www.quantum.gov](https://www.quantum.gov)





# International engagement

## New Bilateral Quantum Statements



INTERNATIONAL

### The United States and Finland Move to Strengthen Cooperation in Quantum

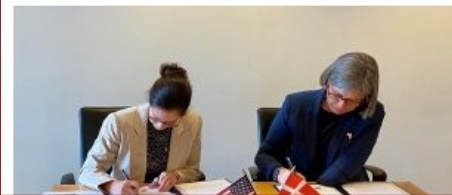
On April 5, the United States and Finland signed a Joint Statement on



INTERNATIONAL

### The United States and Sweden Sign Quantum Cooperation Statement

Photo by Ulrika Westerberg at the Government Offices of Sweden. On



INTERNATIONAL

### The United States and Denmark Take Steps to Strengthen Quantum Cooperation

(June 8, 2022) Following the June 3 meeting between the United



INTERNATIONAL

### The United States and Switzerland Sign Joint Statement to Strengthen Collaboration on Quantum

(October 19, 2022) Today, the United States and Switzerland signed a Joint Statement on Cooperation in Quantum Information Science and Technology (QIST) at the Embassy of Switzerland in Washington, DC. ...

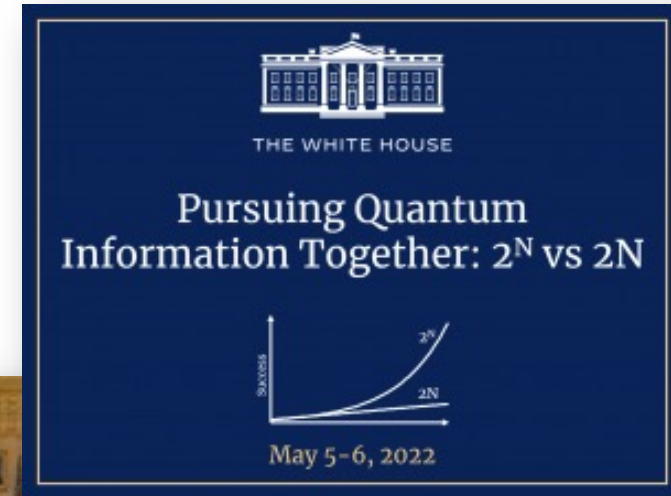
## Multilateral quantum dialogues

May 2022

Nov 2022

AUKUS  
QUAD  
NATO (DIANA)

....



## Agency actions

# 22-198  
Dear Colleague Letter: International Collaboration Supplements in Quantum Information Science and Engineering Research  
July 21, 2022  
Dear Colleagues

The National Science Foundation (NSF) has long supported research to advance quantum information science and engineering (QISE) from laboratory theory into practical reality and on the foundations for the next century quantum technology. Building on the core investment in QISE, NSF intends to catalyze discovery by fostering intelligent, interdisciplinary collaboration. This multipronged effort is aimed at advancing the fundamental understanding of quantum phenomena, materials, and systems toward revolutionary advances in quantum information science. As the science and engineering enterprise continues to expand, global engagement is critical to address the most complex research challenges, including those being explored through NSF work in quantum information science and engineering.

INTERNATIONAL / NSF / R&D FUNDING OPPORTUNITIES

### NSF Funding for International Collaboration in Quantum

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Entanglement  
Exchange

The development of the next generation of scientists and engineers benefits humanity and is necessary to expand the field of quantum information science and technology. The Entanglement Exchange represents a commitment to facilitate this exchange of students, researchers, and professionals in the field.

Quantum is a global endeavor. International cooperation and collaboration through people exchanges are key to combine the expertise, ingenuity, and creativity of all people to expand humanity's fundamental understanding of quantum information and thereby accelerate the realization of new technologies for the benefit of society.

These partnerships begin with personal experiences. The Entanglement Exchange represents a beginning step in creating more opportunities to work alongside each other from joint graduate fellowships to postdoctoral opportunities to visits and sabbaticals.

This website links to Entanglement Exchange pages hosted by several countries. Each page will be maintained to help individuals looking for international research experiences, both inward and outward, to or from the respective quantum ecosystems.


 [Australia](#)


 [Japan](#)


 [Canada](#)

 [Netherlands](#)


 [Denmark](#)


 [Sweden](#)

 [Finland](#)

 [Switzerland](#)

 [France](#)

 [United Kingdom](#)

 [Germany](#)

 [United States](#)

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## NEWS

11/30/2022 - [Entanglement Exchange Links Quantum Researchers Across Twelve Nations](#)

# Entanglement Exchange Links Quantum Researchers Across Twelve Nations

*New website is a portal for international exchange opportunities in quantum information science*

November 30, 2022

Australia, Canada, Denmark, Finland, France, Germany, Japan, the Netherlands, Sweden, Switzerland, the United Kingdom, and the United States are proud to launch the Entanglement Exchange, a portal for highlighting international exchange opportunities for students, postdocs, and researchers in quantum information science (QIS).

QIS is an emerging field that harnesses quantum physics for information processing, and it promises technological breakthroughs such as quantum computers, quantum networks, and quantum sensors, each of which offer capabilities beyond traditional devices. The field has been developing for decades, but in recent years, the pace of discovery has accelerated through programs and initiatives to invest in QIS research and development.

In May 2022, a [roundtable meeting](#) on Pursuing Quantum Information Together was held in Washington between the twelve countries. This meeting highlighted the importance of international cooperation in QIS to accelerate discovery, share resources, and jointly address global challenges. Recognizing the benefits of international partnerships and the global nature of science, the idea for the Entanglement Exchange was proposed as a follow-up action.

Working together, the countries identified exchange opportunities in QIS and developed the Entanglement Exchange to help distribute information about those opportunities. In November 2022, the countries





#WORLDQUANTUMDAY

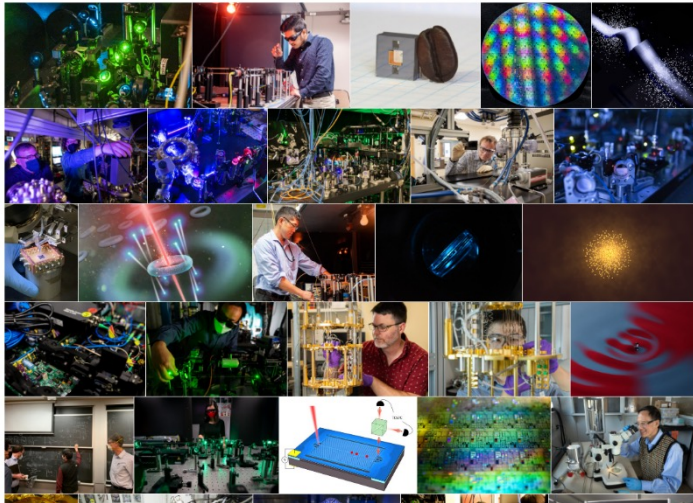
This is Quantum

100k Views  
Search: *This is quantum q12*

FRANCIS COLLINS  
MOHL VIDEOS | Jan - geneticist, Acting Science Advisor to the President

that let us see what we're made of.

1:25 / 2:52



**(quantum|gov)**

**FAST FACTS**

**23** Federal agencies involved in the National Quantum Initiative

**2018** Year the National Quantum Initiative Act became law and the National Strategic Overview for Quantum Information Science was released

**\$2.6B** Total U.S. Government investment in the National Quantum Initiative

**13** Major National Quantum Initiative Research Centers and Institutes

**~2000** Number of QIS R&D grants since the NQI, which engage over 1000 scientists and engineers from over 250 different institutions in 47 states

**>130** Number of companies currently participating in the Quantum Economic Development Consortium

**41** Number of U.S. Government-supported Nobel Laureates honored for quantum studies

**1994** First U.S. Government workshop on quantum computing

**Learn More**  
www.quantum.gov

**NATIONAL QUANTUM INITIATIVE**

**OVERVIEW**  
Quantum-based technologies have already transformed society and the American economy. Examples include the Global Positioning System (GPS) for navigation, Magnetic Resonance Imaging (MRI) for medical imaging, semiconductors for computer chips, and lasers for telecommunications. Quantum information science (QIS), holds promise for another revolution in technology, with new, more powerful approaches to computing, networking, and sensing. **The National Quantum Initiative (NQI) is a whole-of-government approach to ensuring American leadership in QIS.**

The 2018 NQI Act, along with recent National Defense Authorization Acts (NDAA), are accelerating U.S. research in QIS. A coordinated approach engaging over 20 Federal departments and agencies in QIS research and development (R&D), is creating new knowledge, broadening industrial capabilities and enhancing opportunities for prosperity and security.

**THE STRATEGY**  
The National Strategic Overview for QIS outlines the U.S. strategy for QIS R&D, with an emphasis on the science, workforce, industry, infrastructure, security, and international cooperation. The strategy focuses on:

- Getting the science right by understanding the applications and timelines by which QIS will benefit society, and the roadblocks we must overcome to get there.
- Enhancing competitiveness by accelerating technology development toward useful economic and mission applications of QIS and working with international partners, while also protecting national security.
- Enabling people by building the necessary talent pathways and ensuring that QIS creates new opportunities for all Americans.

**DID YOU KNOW?** Planck's constant is a fundamental constant in quantum physics that plays a role in numerous phenomena, such as converting light into energy in solar cells. In 2019, the value of Planck's constant was defined to be  $6.62607015 \times 10^{-34}$  J·s (or  $4.1356679 \times 10^{-15}$  eV·s), and now the kilogram is based on Planck's constant.

# What is the Planck Constant?

Quantum mechanics shows us that energy is exchanged in specific amounts, known as quanta. The Planck constant defines how much energy is in those quanta.

**One way to understand the Planck constant is with coffee and sugar.**

**Classical physics**  
If energy is the sugar you pour into coffee, it appears as if you can pour any amount, large or small. This is the familiar world of classical physics, at the scale of coffee cups and people and cars.

**Quantum physics**  
But if you look at the sugar closely, you see that it's made up of individual crystals. Each quantum (the singular of quanta) is like a single sugar crystal. You can't add anything smaller than it to the coffee. And the Planck constant determines the size of the crystal.

**Why is the Planck constant important?**  
The Planck constant provides the foundation of quantum physics and continues to bring about revolutionary breakthroughs in technology. It has played a central role in:

- Designing the computer chips in smartphones, tablets, laptops and desktops
- Bringing about GPS, which depends on atomic clocks to pinpoint your location on Earth
- Making possible the lasers and LEDs used in everything from television displays to lightbulbs
- Enabling photodetectors used in smoke detectors and garage doors
- Generating electricity from sunlight in solar cells
- Defining the kilogram, the international unit of mass

**So what is the value of the Planck constant?**  
The short answer is that it's a very small value.

**6.62607015 · 10<sup>-34</sup> Joule seconds**  
We can express it two ways:

**4.1356679 · 10<sup>-15</sup> eV seconds**

The two values are **equivalent**. It's kind of like how you can state the temperature in both degrees Fahrenheit and Celsius.

**NIST National Inst...** @NIST · Follow  
Time for another video? NIST researcher Ladan Arissian explains the reason we use quantum mechanics to keep track of time consistency. #WorldQuantumDay

**DOE Office of S...** @doescien... · Follow  
Keeping qubits - the heart of quantum computers - cold and connected to other electronics is a challenge. But Farah Fahim @Fermilab is up for it. Hear her talk about her research on the electronics that control qubits. #WorldQuantumDay quantum.fnal.gov

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4:53 PM · Apr 14, 2022

3:43 PM · Apr 14, 2022

4:01 PM · Apr 14, 2022

Thanks to all that contributed to make this a success!!!





# Quantum in CHIPS & CHIPS for Quantum



## Quantum in the CHIPS and Science Act of 2022

(8/9/2022)

*NQIA, QIS Budget*

(August 9, 2022) Ensuring science right, enhancing created by this new field

Quantum-specific programs authorized by the CHIPS and Science Act	Lead Agencies	Annual Authorization of Appropriations	Timeframe
Quantum Science Network	DOE	\$100,000,000	2023-2027
Quantum User Expansion for Science and Technology Program	DOE	\$30,000,000*	2023-2027
Quantum Networking and Communications Research and Standardization	NIST	\$15,000,000	2023-2027
Next Generation Quantum Leaders Pilot Program	NSF	\$8,000,000	2023-2026
Annual Authorized Investment		\$153,000,000	

**+ authorizations for \$++ for NSF, DOE, ...**

## DoD Funding for Prototyping Quantum Technologies

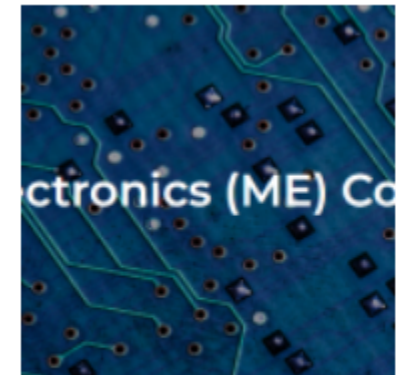
(9/19/2022)

*Infrastructure, R&D Funding Opportunities*

(September 19, 2022) The Office of the Undersecretary of Defense, Research & Engineering (OUSD(R&E))s

Microelectronics program will soon be supporting domestic prototyping capability in six application areas, including quantum technology. The end-state goal to develop a national network of regional innovation...

**Considering opportunities for QIST in the implementation of the CHIPS Act**



# Report from the National Quantum Initiative Advisory Committee

- *Renewing the National Quantum Initiative: Recommendations for Sustaining American Leadership in Quantum Information Science*
  - Available at <https://www.quantum.gov/about/nqiadc/>
1. Reauthorize and appropriate the NQI Act
  2. Expand research
  3. Fund industry-led partnerships
  4. Invest in equipment and infrastructure
  5. Promote international cooperation
  6. Promote and protect U.S. QIST R&D
  7. Strengthen supply chains
  8. Develop domestic talent
  9. Attract and retain foreign talent




NQIAC & NQCO



# House Science Committee Hearing on the NQI

- On June 7, 2023, the House Committee on Science, Space, and Technology (HSST) held a full hearing on *Advancing American Leadership in Quantum Technology*.
1. **Reauthorize the NSF and DOE quantum information science research and education centers**
  2. **Expand and broaden participation in quantum information science**
  3. **Expand the authorized core agencies: STATE, NIH, NASA, DHS, DOD/IC**
  4. **Begin translating discoveries in quantum information science to commercial utility and agency missions.**
  5. **Prioritize funding to upgrade the aging infrastructure of laboratory facilities.**

<https://science.house.gov/2023/6/full-committee-hearing><sup>24</sup>



COMMITTEE ON  
**SCIENCE, SPACE  
AND TECHNOLOGY**  
CHAIRMAN FRANK LUCAS

FULL COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY  
HEARING CHARTER

*“Advancing American Leadership in Quantum Technology”*

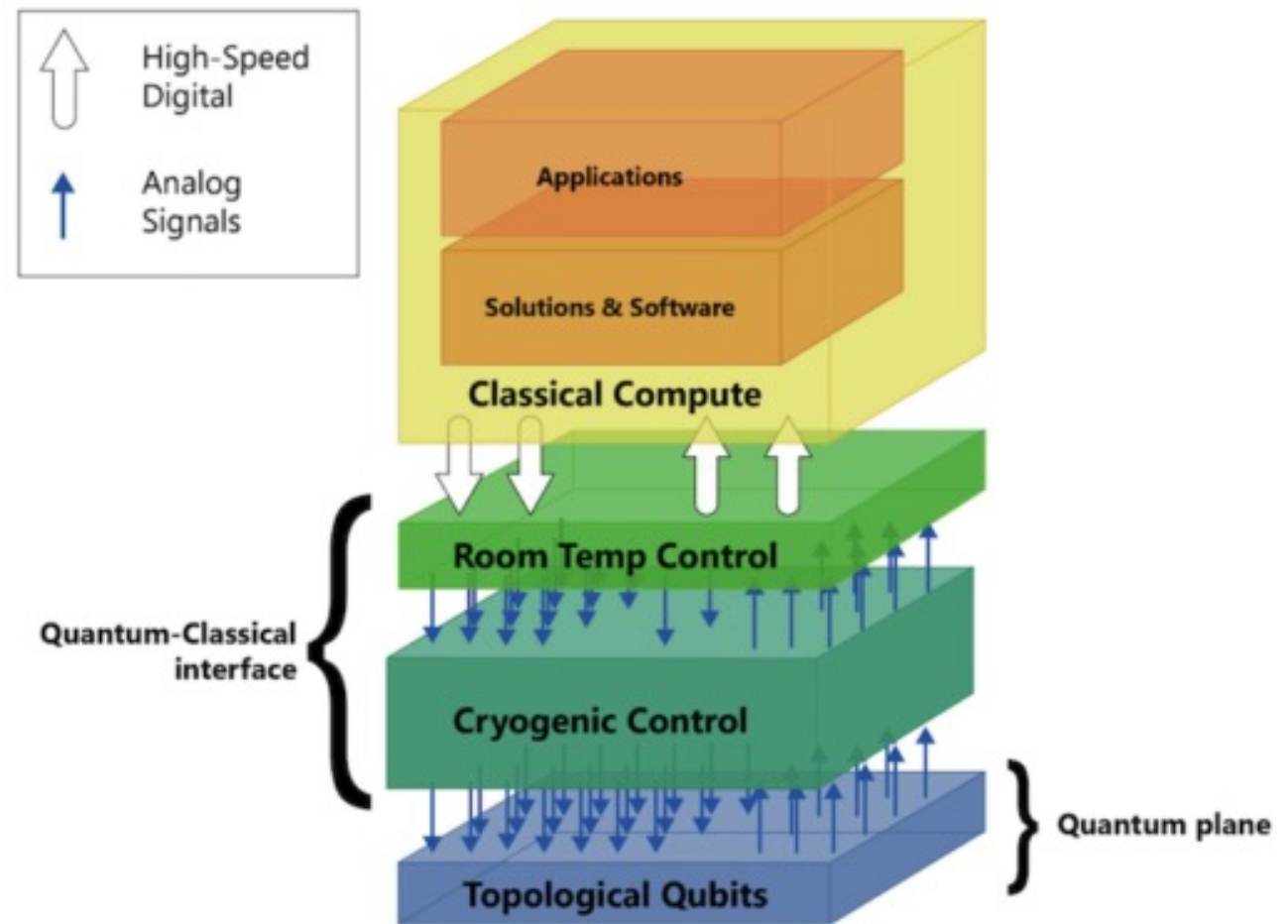
Wednesday, June 7, 2023  
10:00 a.m.  
2318 Rayburn House Office Building





# Quantum is more than Quantum Physics

- The future of information processing is *different*
- QC's are one example
- And representative of others (AI accelerators, beyond-Moore, etc.)
- Exotic materials, packaging, operating regimes, ...
- **The skillsets needed are applicable broadly to other industries of the future**





[Quantum.gov](https://www.quantum.gov)