Quantum Information Science and Engineering at NSF

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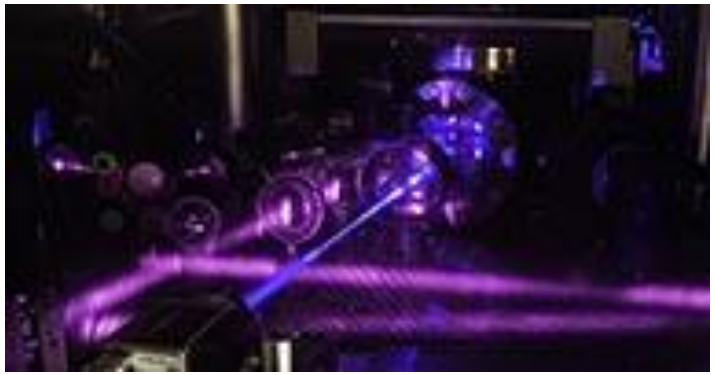
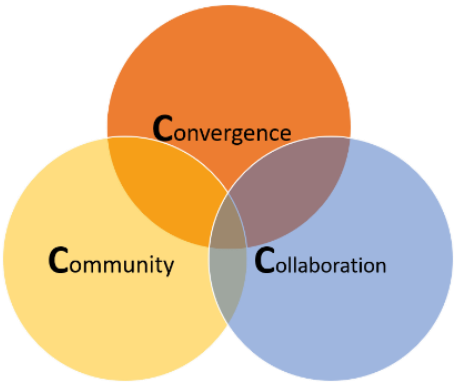
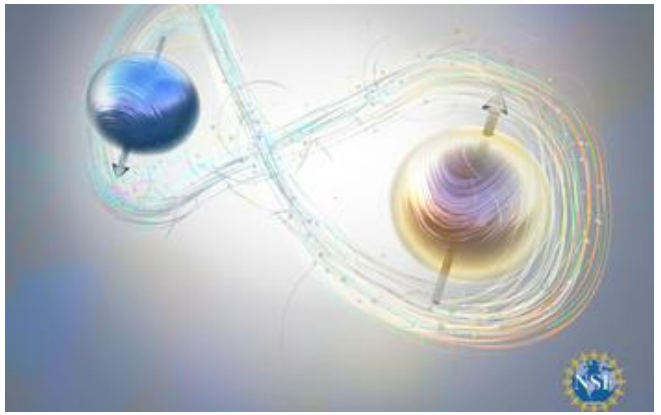
Co-Chair NSF Quantum Stewardship Steering Committee

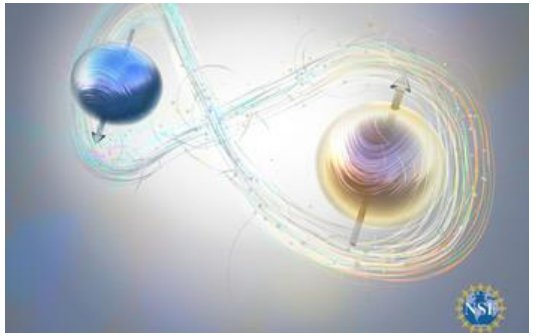
https://www.nsf.gov/mps/quantum/quantum_research_at_nsf.jsp





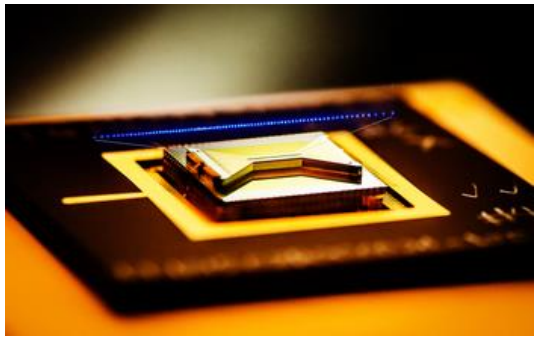


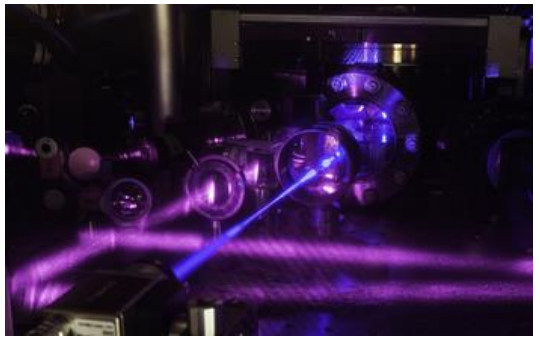
NSF and the NQI



Sec. 301: The Director of the National Science Foundation shall carry out a basic research and education program on quantum information science and engineering, including the competitive award of grants to institutions of higher education or eligible nonprofit organizations (or consortia thereof).

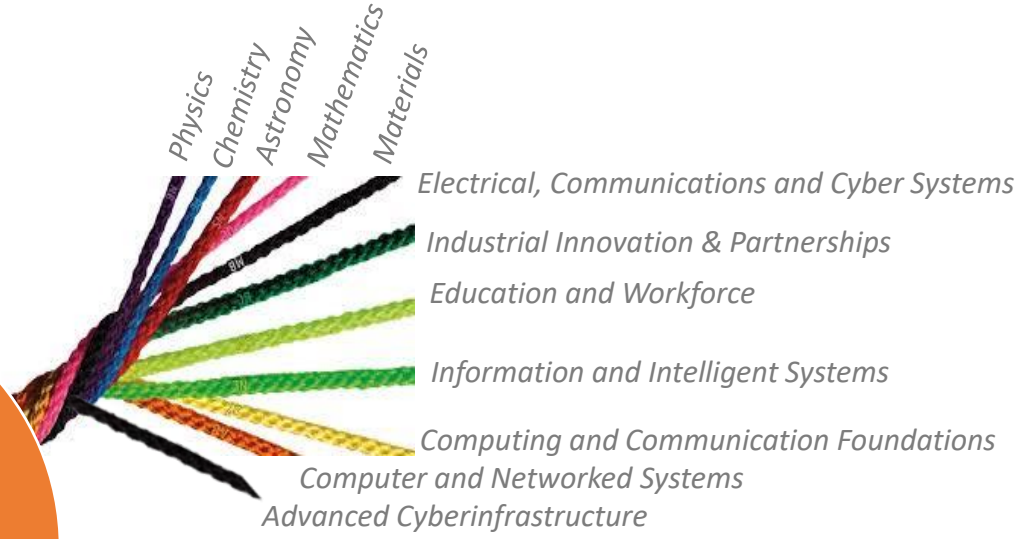
Sec. 302: The Director of the National Science Foundation, in consultation with other Federal departments and agencies, as appropriate, shall award grants to institutions of higher education or eligible nonprofit organizations (or consortia thereof) to establish at least 2, but not more than 5, Multidisciplinary Centers for Quantum Research and Education (referred to in this section as ‘‘Centers’’).

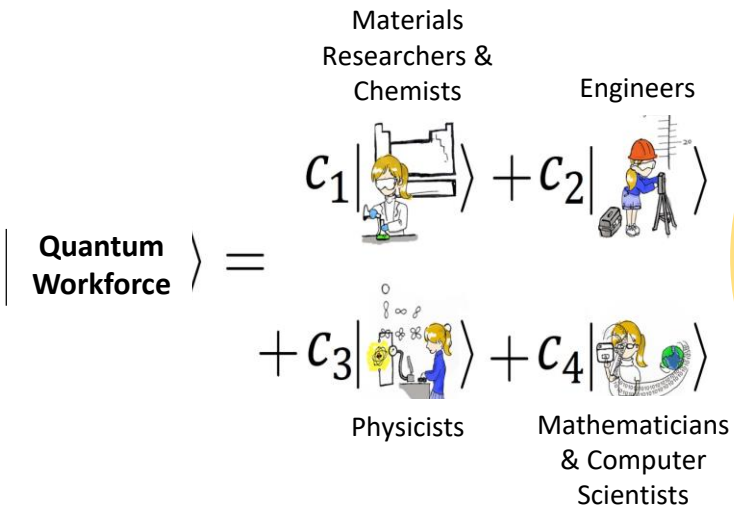


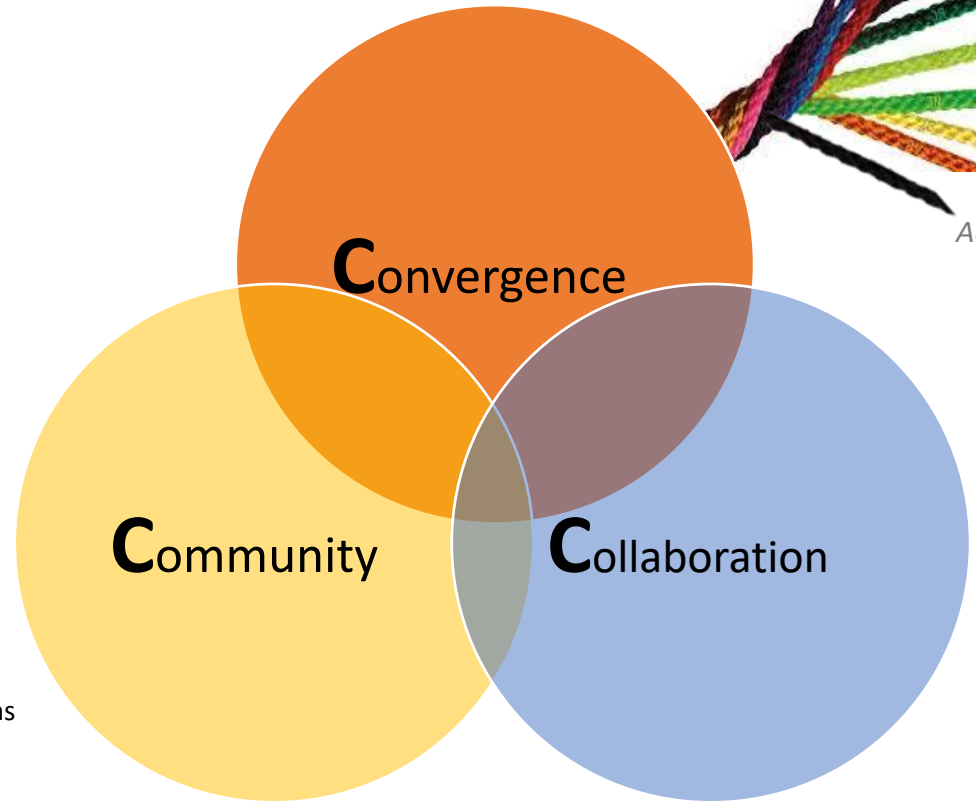


The NSF Approach

The 3 C's







Building a Convergent Quantum Community

★ **Convergent Quantum Centers**
Challenge Institutes & Foundries

Transformational Collaborative Research
TAQS Small Team Awards, 19 awards, totaling $35.5M

★ **Quantum Workforce Development**
Summer Schools, Triplets, Faculty Fellows, Q2Work

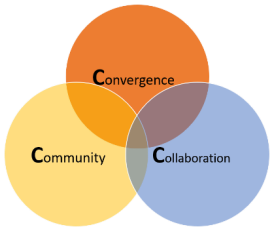
Capacity Building Across Disciplines
56 awards made in FY 2016-18, totaling over $35M

★ **Foundational Investments in QIS – 40 Years & Counting**
More than 2000 awards & 1200 unique PIs in multiple areas

Quantum Leap Challenge Institutes (QLCI)

- Support **large-scale projects** driven by a ***cross-disciplinary challenge research theme*** for the frontiers of quantum information science and engineering.
- Maintain a timely and bold research agenda aimed at making **breakthroughs** on compelling challenges in a 5-year period.
- Conceptualize, develop, and implement **revolutionary** new approaches and technologies for quantum information processing.
- Enable the development of a **well-trained workforce** with strong cross-disciplinary skill sets needed for quantum information science and engineering.

QLCI Phase One Awardees



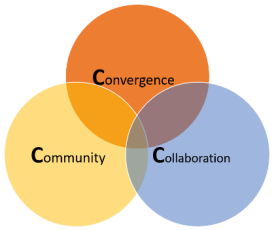
NSF Quantum Leap Challenge Institute for Hybrid Quantum Architectures and Networks (HQAN)

Lead PI: Brian DeMarco, University of Illinois, Urbana-Champaign

Major Participants: University of Illinois, Urbana-Champaign
University of Wisconsin, Madison
University of Chicago

HQAN will create hybrid quantum platforms that discover and refine designs for locally distributed quantum processors and networks by leveraging the strengths of multiple types of quantum hardware, including atomic and superconducting systems.

QLCI Phase One Awardees



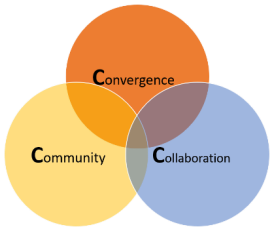
NSF Quantum Leap Challenge Institute for Present and Future Quantum Computation

Lead PI: Daniel Stamper-Kurn, University of California, Berkeley

Major Participants: UC Berkeley, UCLA, UC Santa Barbara University of Southern California, California Institute of Technology, University of Texas at Austin, Massachusetts Institute of Technology; University of Washington, Seattle

One of the institute's first challenges is to identify the applications for which current quantum computers are most suited, in order to make full use of today's first generation computers. The institute will also address the long-term challenge of developing algorithms for the next generation of quantum computers that will enable critical scientific, economic and societal advances, as well as navigate the boundary between quantum and classical computational capabilities.

QLCI Phase One Awardees



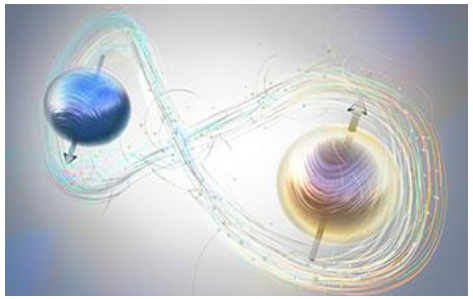
NSF Quantum Leap Challenge Institute Quantum Systems through Entangled Science and Engineering (Q-SEnSE)

Lead PI: Jun Ye, University of Colorado

Major Participants: JILA at CU Boulder; Harvard University; MIT; Stanford University; University of Delaware; University of Oregon; University of New Mexico; University of Innsbruck in Austria; National Institute of Standards and Technology (NIST); Los Alamos National Laboratory; MIT Lincoln Laboratory; Sandia National Laboratory

Q-SEnSE will explore how exotic quantum phenomena, such as quantum entanglement, will advance new frontiers in measurement science; how quantum sensing can help researchers to discover new fundamental physics; and how researchers can turn those advancements into real-world technologies.

Quantum Information Science and Engineering
An Industry of the Future



Strong disciplinary programs in MPS/CHE,DMR,DMS,PHY; CISE/CCF; ENG/ECCS + **Centers**

Quantum Leap Challenge Institutes: 3 now**;** Second phase of competition underway

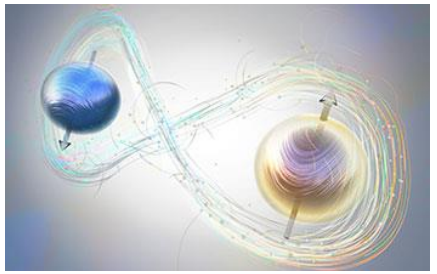
Foundry: "Enabling Quantum Leap: Q-AMASE-i: Quantum Foundry at UCSB"; A. Bleszynski-Jayich; $25M over 6 years. (Led by MPS/DMR)

Computer: "PFCQC: STAQ: Software-Tailored Architecture for Quantum Co-Design", K. Brown, Duke U; $15M over 5 years (Led by MPS/PHY)

Computer: "Collaborative Research: EPiQC: Enabling Practical-scale Quantum Computing", F. Chong, U Chicago; $10M over 5 years (Led by *Expeditions in Computing* program in CISE)

Network: "NSF Engineering Research Center for Quantum Networks (CQN)", S. Guha, U of Arizona; $26M over 5 years (Led by EEC in ENG)

Investment Focus



Budget: $226.36 in FY 2021 Request

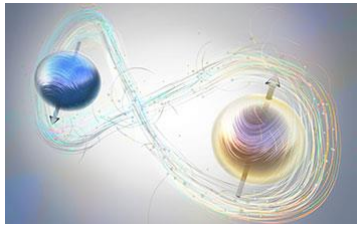
Expand Capacity:

Increase diversity of types of awardee institutions involved (e.g. RUI, HBCU)
Increase geographical distribution of awardee institutions (e.g. not just East Coast, West Coast)
Further broaden disciplinary focus of participants (e.g. add more engineers, computer scientists)
Identify more potential partners (e.g. other agencies, industry)
Bring in more end-user communities (e.g. biologists)

Grow Workforce:

New Quantum Workforce Development Working Group has taken on the challenge: Develop a roadmap to address near-term and long-term diverse workforce needed to retain US leadership in QISE – New announcements in clearance

Workforce

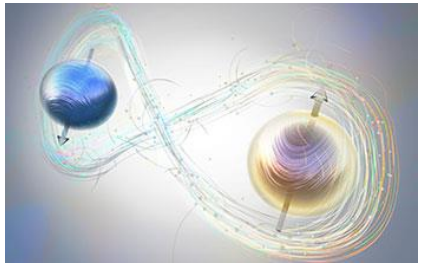


TRIPLETS: “Convergence QL: Workshop Series: Cross-Sector Connections in Quantum Leap”; “Quantum Information Science and Engineering Network” of “triplets” of students, faculty, industry partners to work on Quantum Leap challenges, U. Chicago, https://qisenet.uchicago.edu/

NSF Quantum Computing and Information Science Faculty Fellows (QCIS-FF) to encourage departments and schools in U.S. universities to hire new, full-time faculty in either tenure-track or tenured roles in quantum computing and/or communication; 13 awards to date.

National Q12 Education Partnership An NSF and OSTP co-sponsored workshop connecting the communities of university and industry researchers, secondary school and college educators, and representatives from educational and professional organizations produced a list of "Key Concepts for Future Quantum Information Science Learners“. These form the basis of the new Q2Work partnership https://q12education.org led by Emily Edwards, UIUC, and Diana Franklin, UoC, that has been assembled to enable the recommendations.

Expanding Outward



Dear Colleague Letter: Enabling Quantum Computing Platform Access for NSF Researchers with Amazon Web Services, IBM, and Microsoft Quantum

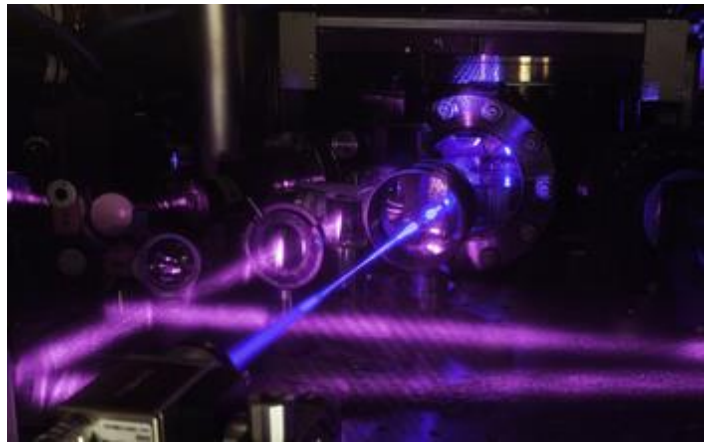
Support for students to implement quantum computing calculations on cloud-based platforms

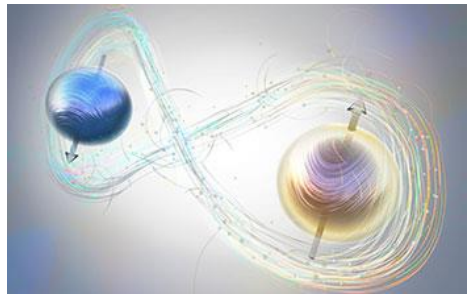
Dear Colleague Letter: International Collaboration Supplements in Quantum Information Science and Engineering Research

Support to add a new - or strengthen an existing - international dimension to an award

NSF Convergence Accelerator Phase I and II — Quantum Technology (Track C)

Support for projects that bridge the gap between state-of-the-art fundamental research generating lab proof of concept architectures, devices, and theories and current industry efforts to build a universal quantum computer.





Discussion