Quantum Information Science Activities at NSF

Some History, Current Programs, and Future Directions

Presentation for HEPAP 11/29/2018

Alex Cronin,
Program Director
National Science Foundation
Physics Division

QIS @ NSF goes back a long time

Wootters & Zurek (1982) "**A single quantum cannot be cloned**". *Nature*, ***299***, 802
acknowledged NSF Award 7826592 [PI: John A. Wheeler, UT Austin]

No Cloning Theorem

C. Caves (1981) "**Quantum Mechanical noise in an interferometer**" *PRD*, **23**,1693
acknowledged NSF Award 7922012 [PI: Kip Thorne, Caltech]

Squeezing & Metrology

"Information Mechanics (Computer and Information Science)"
NSF Award 8618002; PI: Tommaso Toffoli, MIT; Start: 1987
led to one of the "basic building blocks for quantum computation"
- Blatt, PRL, 102, 040501 (2009), "*Realization of the Quantum Toffoli Gate with Trapped Ions*"

Toffoli Gate

"Research on Randomized Algorithms, Complexity Theory, and Quantum Computers"
NSF Award 9310214; PI: Umesh Vazirani, UC-Berkeley; Start: 1993
led to a quantum Fourier transform algorithm, later used by Shor

Q. Fourier Transform

QIS @ NSF goes back a long time

Quantum Statistics of Nonclassical, Pulsed Light Fields
Award: 9224779; PI: Michael Raymer, U. Oregon - Eugene; NSF Org:PHY

Quantum Tomography

Complexity Studies in Communications and Quantum Computations
Award: 9627819; PI: Andrew Yao, Princeton; NSF Org:CCF

QC Complexity; Cryptography

Quantum Logic, Quantum Information and Quantum Computation
Award: 9601997; PI: David MacCallum, Carleton College; NSF Org:SES

Quantum Logic

Physics of Quantum Computing
Award: 9802413; PI:Julio Gea-Banacloche, U Arkansas; NSF Org:PHY

Photonic Q. Computing

Quantum Foundations and Information Theory Using Consistent Histories
Award: 9900755; PI: Robert Griffiths, Carnegie-Mellon U; NSF Org:PHY

Foundations; Eavesdropping

QIS @ NSF goes back a long time

ITR: Institute for Quantum Information
Award: 0086038; PI: John Preskill; Co-PI:John Doyle, Leonard Schulman, Axel Scherer, Alexei Kitaev, CalTech; NSF Org: CCF
Start: 09/01/2000; Award Amount:$5,012,000.

Q. Error Correction; Topological QC

Quantum Information Theory
Award: 0074566; PI: Mary Beth Ruskai, U Mass Lowell; NSF Org: DMS

Quantum Entropy (subadditivity)

MRI: Acquisition of Equipment for Quantum Information Processing
Award:0079842; PI: Eli Yablonovitch, UCLA; NSF Org: CNS

Quantum Memory Hybrid Q. Systems

and many more…

See NSF Award Search for 2078 current and past Awards with “quantum information” or “quantum comput*” in Title or Abstract. These are by 1218 unique PIs.

Selected QIS Workshops & Reports

1999 NSF workshop on QIS
NSF Document 00101
https://www.nsf.gov/pubs/2000/nsf00101/nsf00101.htm

2009 NSF workshop on QIS (Award 0937601)
http://calyptus.caltech.edu/qis2009/

2015 NSF conference on Mathematical Sciences Challenges in QIS
https://sites.google.com/site/mathqinfo2015/home

2016 NSF workshop on CHE and QIS
https://arxiv.org/abs/1706.05413

2017 NSF workshop on Quantum Elements of Secure Communication
(Award 1745810)

2018 NSF workshop on Quantum Biology
https://sites.google.com/site/mathqinfo2015/home

2007 NRC NAS Decadal Survey:
"Controlling the Quantum World"

2009 US National Science and Technology Council (NSTC) Report:
“A Federal Vision for QIS”

2016 US NSTC Report:
"Advancing QIS: National Challenges and Opportunities"

2018 US NSTC Report:
“National Strategic Overview for QIS”

2018-2019 NAS Decadal Survey
is underway for AMO & QIS

Several NSF Programs Support QIS

MPS/PHY/ ITR → PIF → QISRC → QIS Program (38 Awards + CQuiC)
in FY 2018

MPS/PHY Atomic Molecular & Optical Physics Programs (55 + ITAMP)

MPS/PHY Physics Frontiers Centers Program (…+ CUA, JILA, IQIM, JQI)

MPS/PHY Computational Physics Program (…+ PFCQC ideas Lab)

MPS/DMR
MPS/CHE
MPS/DMS
MPS/AST

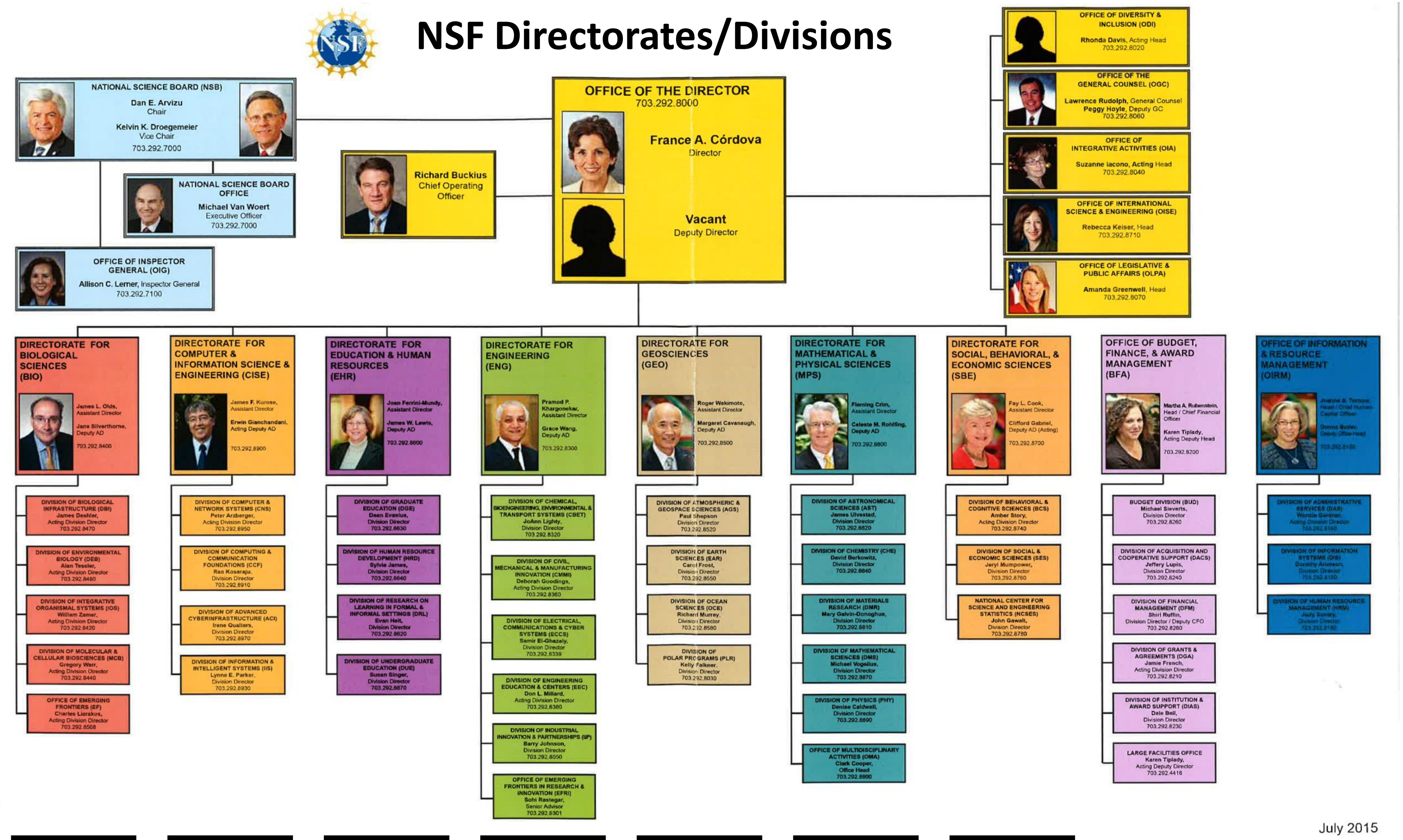
MPS/OMA

ENG/EFRI ACQUIRE
ENG/ECCS
ENG/IIP

See NSF org. chart to “locate” these **Directorates**/Divisions

CISE/CFF
CISE/AF
CISE/Expeditions

CISE/OAC



BIO

CISE

EHR

ENG

GEO

MPS

SBE

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- EFRI

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Clifford Gabriel, Deputy AD (Acting)
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Karen Tiplady, Acting Deputy Head
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- DGA
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Donna Butler, Deputy Office Head
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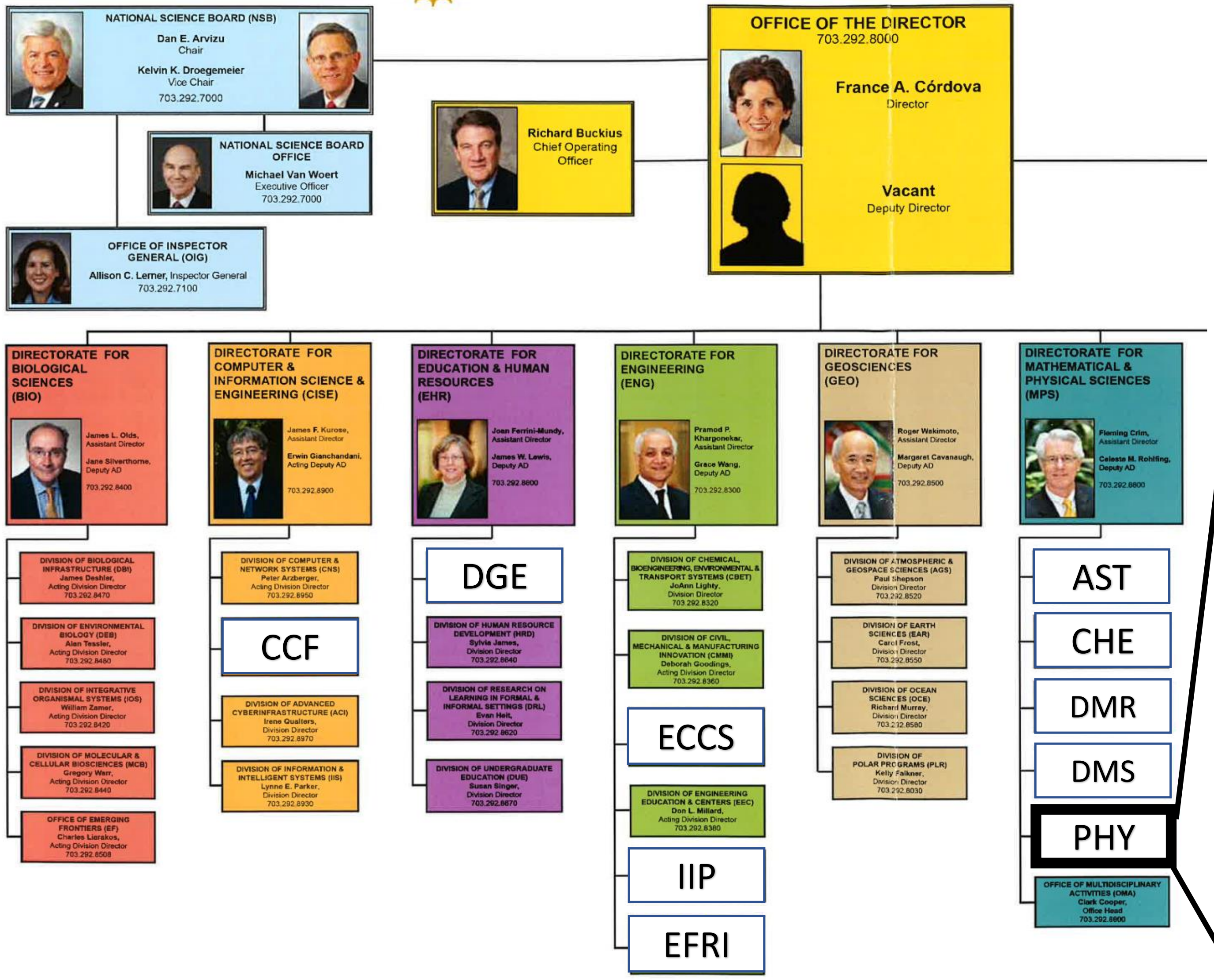
- DIVISION OF HUMAN RESOURCE MANAGEMENT (HRM) — Judy Sunley, Division Director, 703.292.8180

July 2015

BIO | CISE | EHR | ENG | GEO | MPS | SBE

NSF Directorates/Divisions



MPS/PHY programs:

Elem. Particle Phys.
Particle Astrophys.
LIGO Research
Physics of living syst.
Accelerator Sci.
Nuclear Phys.
Phys. Frontiers Cntrs
Computational Phys.
Gravitational Ph.
Plasma Physics
Q. Info. Science
AMO-Theory
AMO-Experiment

BIO | CISE | EHR | ENG | GEO | MPS | SBE

PHY Solicitation: NSF 18-564

Theory: NSF MPS/PHY QIS Program Awards made in 2018 (pg 1)

1630114 Deutsch (CQuIC: Center for Quantum Information and Control)
1521560 Sadeghpour (ITAMP: Institute for Theoretical Atomic and Molecular Physics)
1820939 Pryadko (Quantum error correction; Quantum LDPC codes; statistical mechanics) Q. Error Correction
1820747 Whitfield (topological fermionic quantum simulation) Q. Algorithms
1816695 Wu (provable quantum advantages in optimization)
1819189 Zanardi (coherence power of quantum processes)
1820871 Chitambar (quantum resource theories) Q. Resource Theory
1820885 Rey (dynamics of entanglement in a trapped ion quantum magnet)
1820758 Deutsch (collaborative: quantum complexity, chaos, and quantum simulation) Ions + entanglement
1806372 Carr (complex networks on quantum states in AMO platforms) Q. Complexity
1804026 Robicheaux (many facets of laser-atom and dipole-dipole interactions) AMO for Rydberg QC
1802472 Franson (hybrid optical approach for quantum information applications)
1807485 Ozdemir (collaborative: efficient nonlinear light sources; quantum networks) Q. Optics theory
1820870 Byrd (system-environment correlations)
1752727 Laumann (Stat Mech; Algorithms; quantum optimization, glassiness and localization) SM → CMP & Algor.

Experiment:

1753021 Schleier-Smith (Atoms; cavity QED; quantum many-body physics) Cavity QED - squeezin
1752630 Barreiro Guerrero (Atoms; quantum simulations with fermionic Sr) Q.Sim w/ atoms
1753386 Endres (Atoms; quantum many-body control with alkaline-earth atom-arrays)
1820679 Jessen (Atoms; collaborative: quantum complexity, chaos, and quantum simulation) Atoms for Q.Sim.
1820849 Weiss (Atoms; quantum computing with Cs atom qubits)

Continued next page

NSF MPS/PHY QIS Program Awards in 2018 (pg 2)

Experiment (Continued)

1820938 Bleszynski Jayich (Defects; chiral quantum networks)
1820614 Fu (Defects; donor electron spins in direct bandgap semiconductors for quantum networks)
1820790 Faraon (Defects; coherent control of single neodymium ion qubits)
1820930 Akimov (Defects; new color centers in diamond; broadband quantum memories)
1820789 Raymer (Photons; photon temporal modes as a quantum information resource)
1820882 Pfister (Photons; Squeezed optical frequency comb; computing and measurement)
1806425 Ou (Photons; quantum state engineering with novel nonlinear interferometric techniques)
1752938 Marino (Photons; control of spatial quantum correlations for enhanced quantum networks)
1807552 El-Ganainy (Photons; collaborative: efficient nonlinear light sources; quantum networks)
1807785 Rimberg (Hybrid; single-quantum strong coupling regime)
1839153 Hemmerling (RAISE-TAQS: molecules; novel quantum phases)
1839164 Bhave (RAISE-TAQS hybrid quantum systems)
1839165 Wang (RAISE-TAQS: Defects; single-photon sources from organic color-centers)
1839176 Saffman (RAISE-TAQS: Atoms; integrated photonics control of atoms and molecules)
1839216 Raymer (RAISE-TAQS: Photons; entangled photon pairs; spectroscopy and metrology)

NV + Defects
Control & Q. Mem

Photons

Superconductors

Cold Molecules

Hybrid Q. Systems

Photonics for contro

Biphoton Spectrosc

Conferences:

SQUINT An annual conference is partly supported by 1630114 Deutsch (CQuIC)
ITAMP Workshops are partly supported by 1521560 Sadeghpour (ITAMP)
1828938 Houck (student travel grants to the Gordon conference on non-equilibrium matter & QIS)
1832394 Olmschenk (student travel grants to DAMOP)
NSF/DOE Quantum Science Summer School

SQUIINT

DAMOP

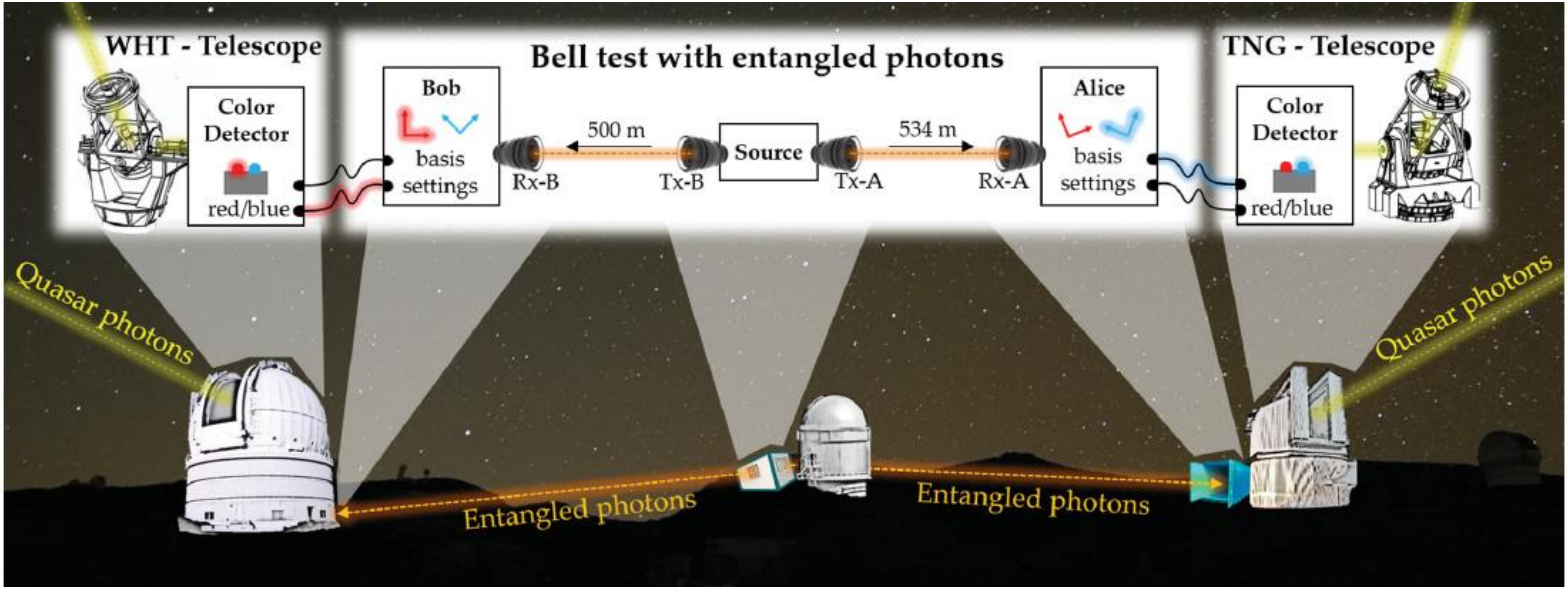
GRC

QS^3

A few QIS Highlights

Award 1541160 “**Testing Bell's Inequality with Astrophysical Observations**” **PI: David Kaiser, MIT**

"Cosmic bell test using random measurement settings from high-redshift quasars." *Physical Review Letters* 121.8 (2018): 080403.

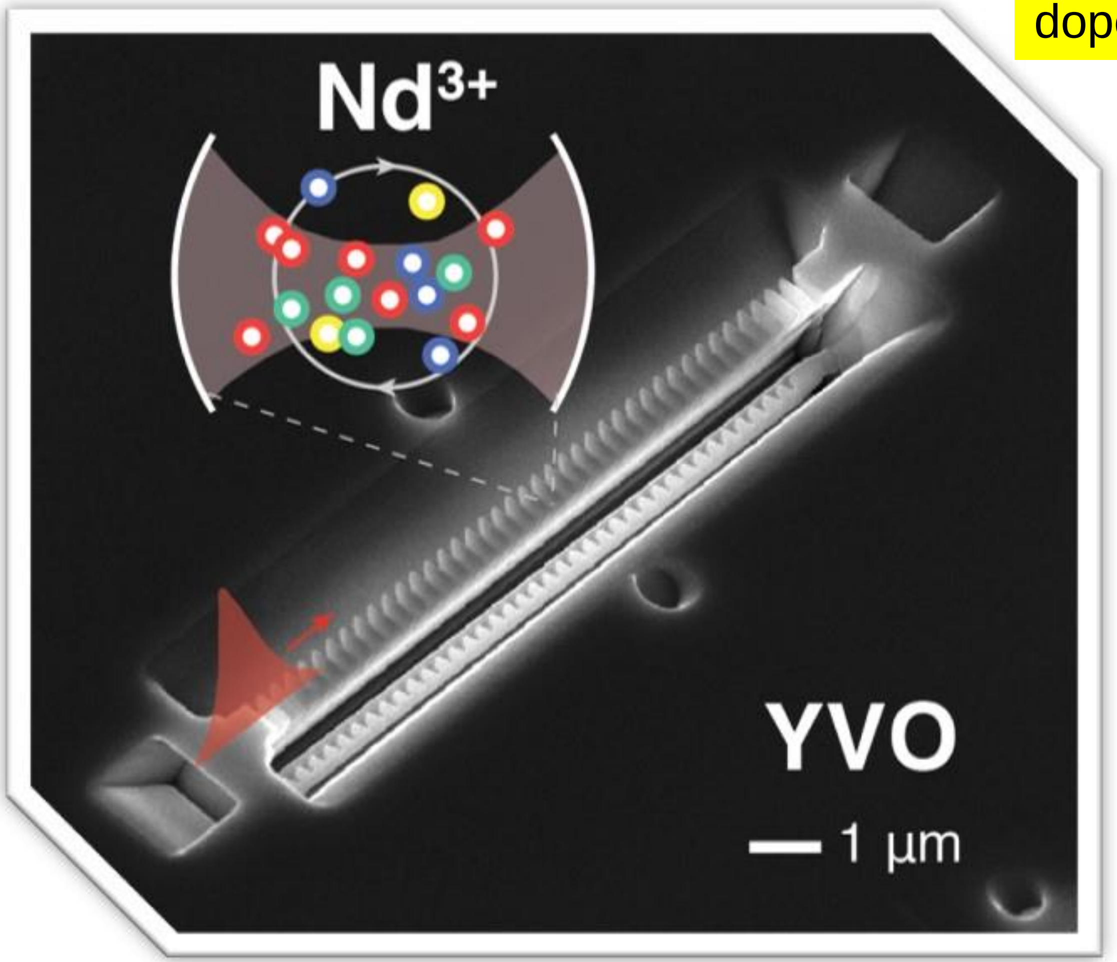


“This experiment pushes back to at least ~7.8 Gyr ago the most recent time by which any local-realist influences could have exploited the ‘freedom-of-choice’ loophole to engineer the observed Bell violation, excluding any such mechanism from 96% of the space-time volume of the past light cone of our experiment, extending from the big bang to today.”

A few QIS Highlights

“CAREER: Quantum Light-Matter Interfaces Based on Rare-Earth Ions and Nanophotonics”
Award ECCS – 1454607; PI: Andrei Faraon, CalTech

Optical Quantum Memory for
Secure Communications



Tian Zhong, Jonathan M. Kindem, Evan Miyazono, Andrei Faraon "Nanophotonic coherent light-matter interfaces based on rare-earth-doped crystals," *Nature Communications*, v.6, (2015), p. 8206.

ECCS CAREER PI Andrei Faraon first demonstrated storage of photonic quantum states for 75 nanoseconds in an on-chip nano-photonic device – a major breakthrough in optical quantum memory.

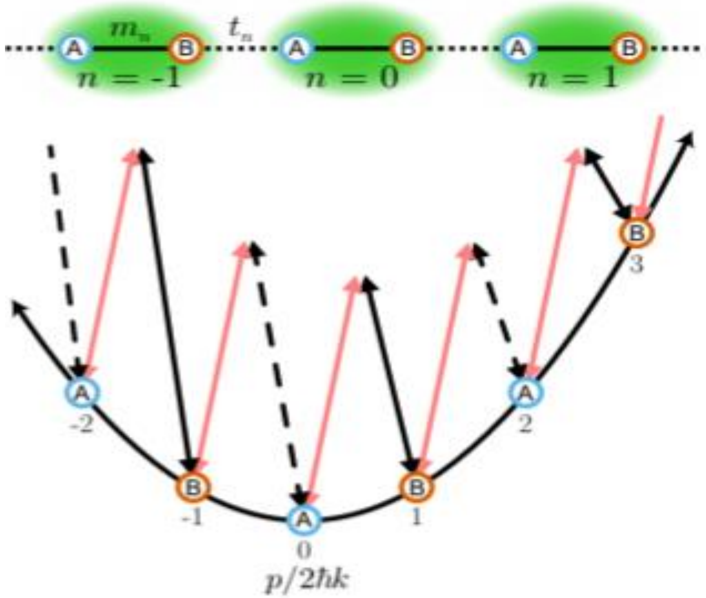
Its extremely small size – carefully engineered at the nanoscale level – allows for on-chip integration with traditional hardware components. Applications include increasing security of communication systems through development of quantum cryptographic mechanisms.

A few QIS Highlights

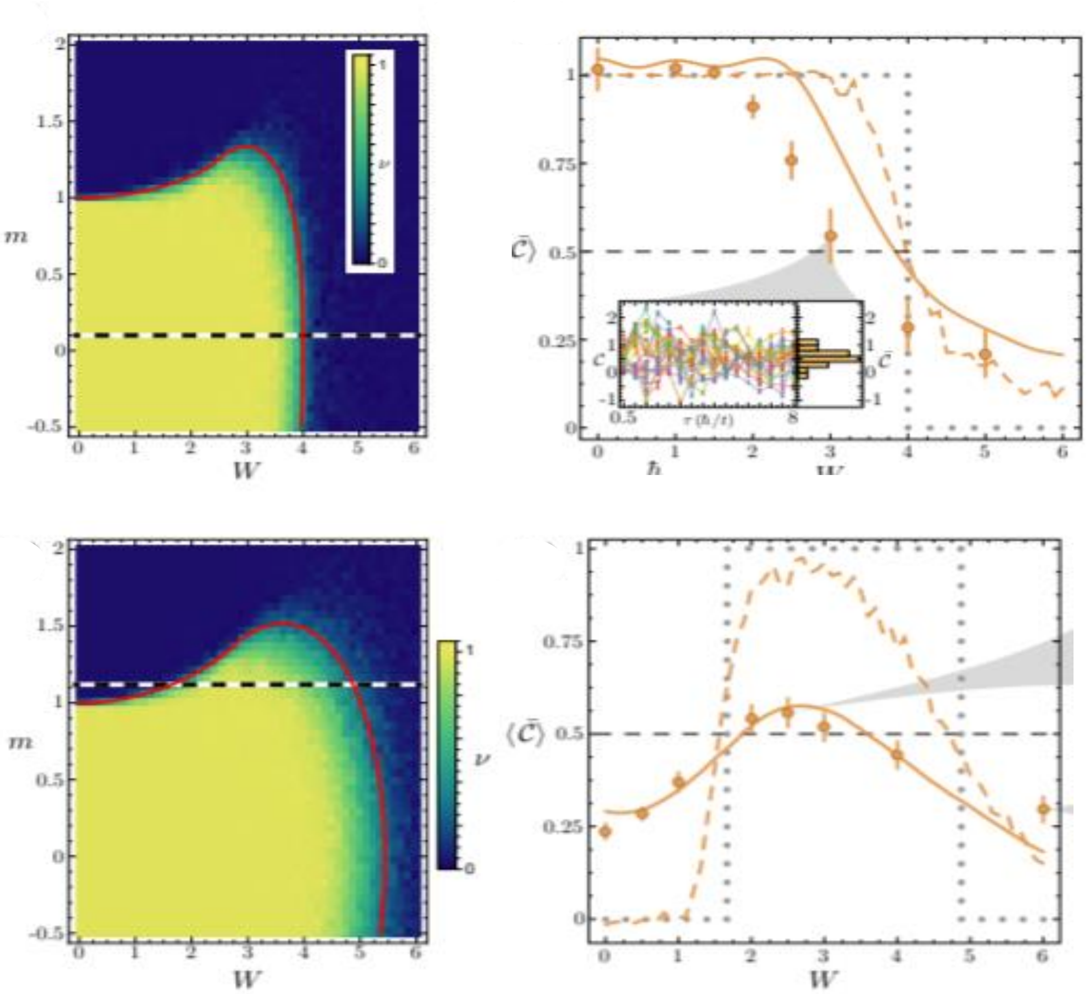
PHY - 1707731 “Exploring Interacting Topological Fluids in a Synthetic Lattice” PI: Bryce Gadway, U. Illinois

“Observation of the topological Anderson insulator in disordered atomic wires”

Science 11 Oct 2018: DOI: 10.1126/science.aat3406



Synthetic wires with chiral (sub-lattice) symmetry Engineered with atomic momentum states to simulate the Su-Schrieffer-Heeger model in condensed matter.



Winding number, or “mean chiral displacement” as a function of disorder (W) and lattice asymmetry (m).

- First observation of the “long-sought” Topological Anderson Insulator (TAI) Phase

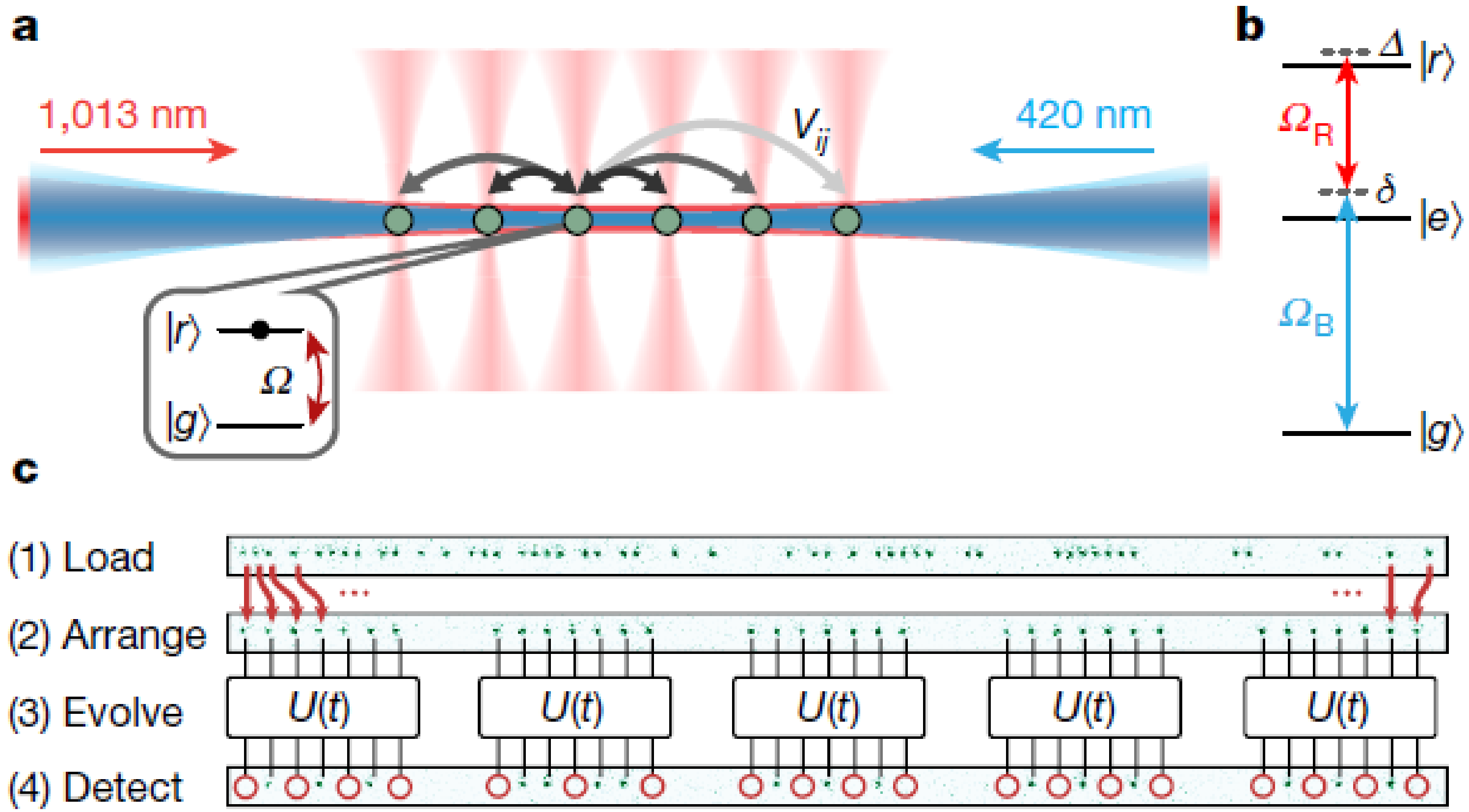
A few QIS Highlights

“Probing many-body dynamics on a 51-atom quantum simulator”,
Bernien et al, *Nature*, ***551***(7682), p.579. [November 30, 2017]

NSF Award 1506284

Principal Investigators:
Greiner, Lukin, and Vuletic
(Harvard and MIT)

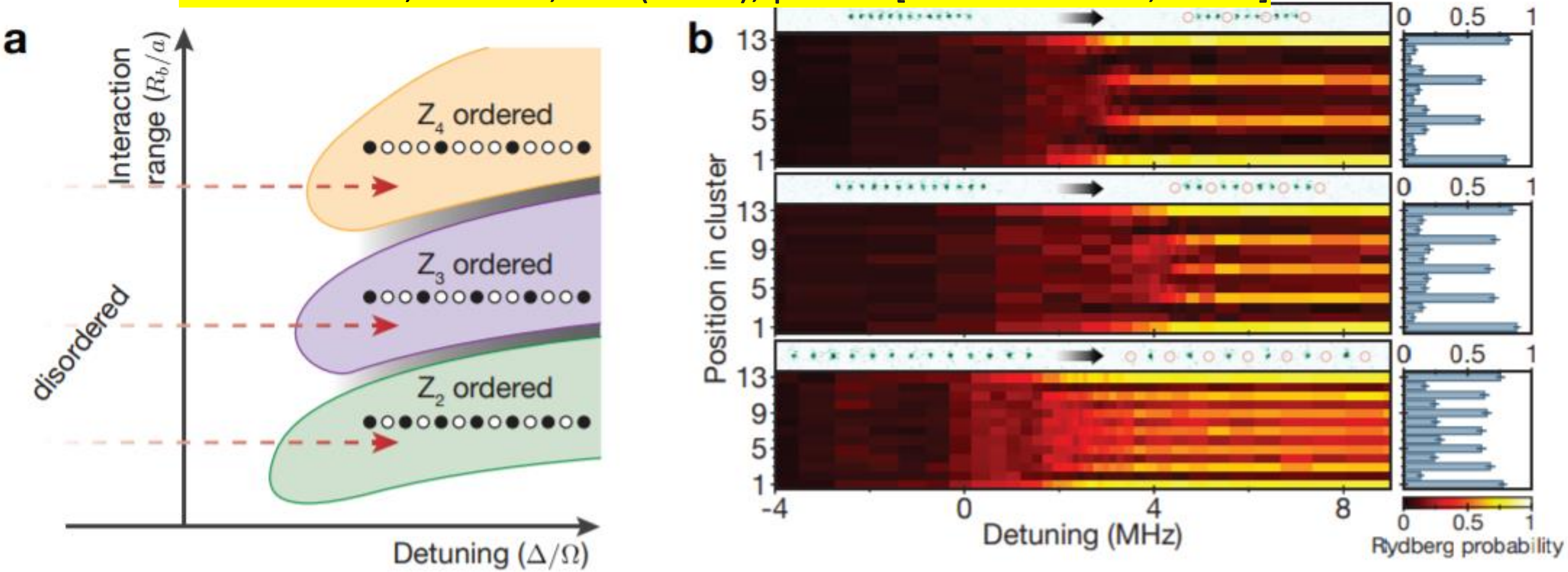
Entanglement via
Rydberg Blockade



From Abstract: “Controllable, coherent many-body systems can provide insights into the fundamental properties of quantum matter, enable the realization of new quantum phases and could ultimately lead to computational systems that outperform existing computers based on classical approaches. Here we demonstrate a method for creating controlled many-body quantum matter that combines deterministically prepared, reconfigurable arrays of individually trapped cold atoms with strong, coherent interactions enabled by excitation to Rydberg states.”

A few QIS Highlights

"Probing many-body dynamics on a 51-atom quantum simulator",
Bernien et al, *Nature*, ***551***(7682), p.579. [November 30, 2017]



- Observed new quantum many-body phases, and phase transitions.
- Pushing the limits of classical calculation techniques.

"For higher-order correlation functions, such as the variance of the domain wall number, the fully coherent simulation and the experiment agree only qualitatively (Fig. S7). The quantitative difference is likely due to either limitations of the MPS simulations or various incoherent processes present in the experiment."

A few QIS Highlights

SCALABLE QUANTUM SIMULATION OF MOLECULAR ENERGIES PHYS. REV. X **6,** 031007 (2016)

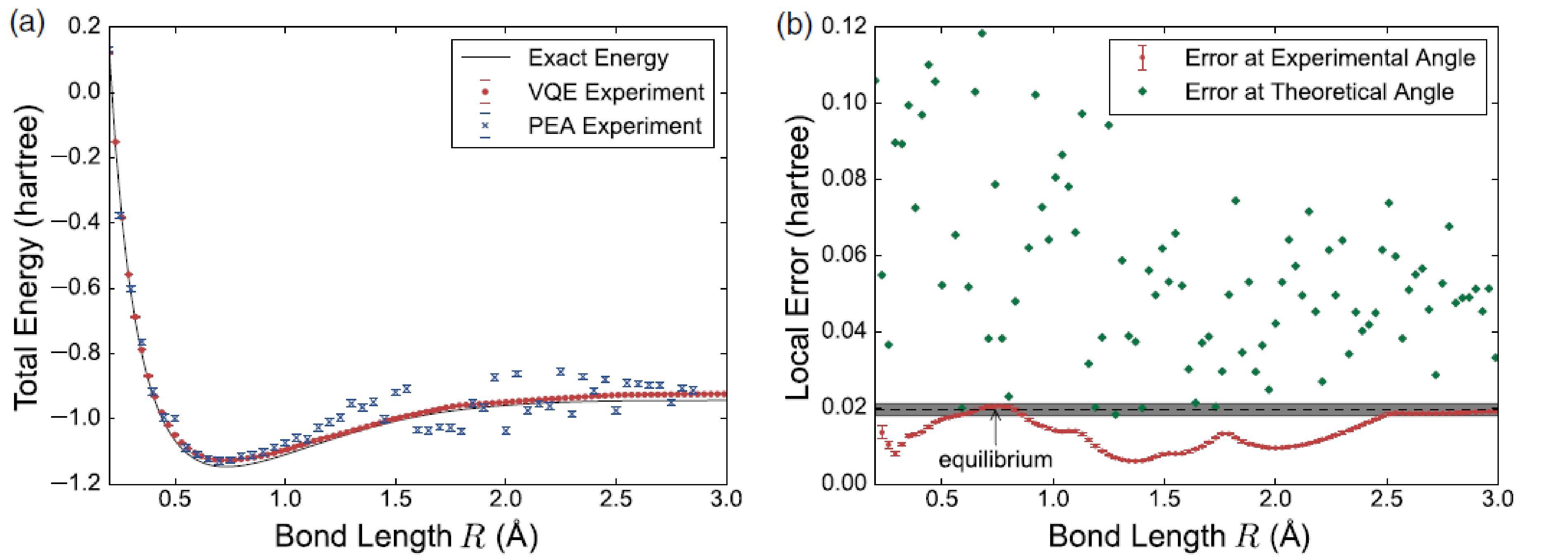


FIG. 3. Computed H_2 energy curve and errors. (a) Energy surface of molecular hydrogen as determined by both VQE and PEA. VQE

“This finding inspires hope that VQE may provide solutions to classically intractable problems even without error correction.”

NSF 0955518 PI: Peter Love, Tufts
“CAREER: A Roadmap for Quantum Simulation”,

O’Malley et al, PRX 6, 031007 (2016)

A few QIS Highlights

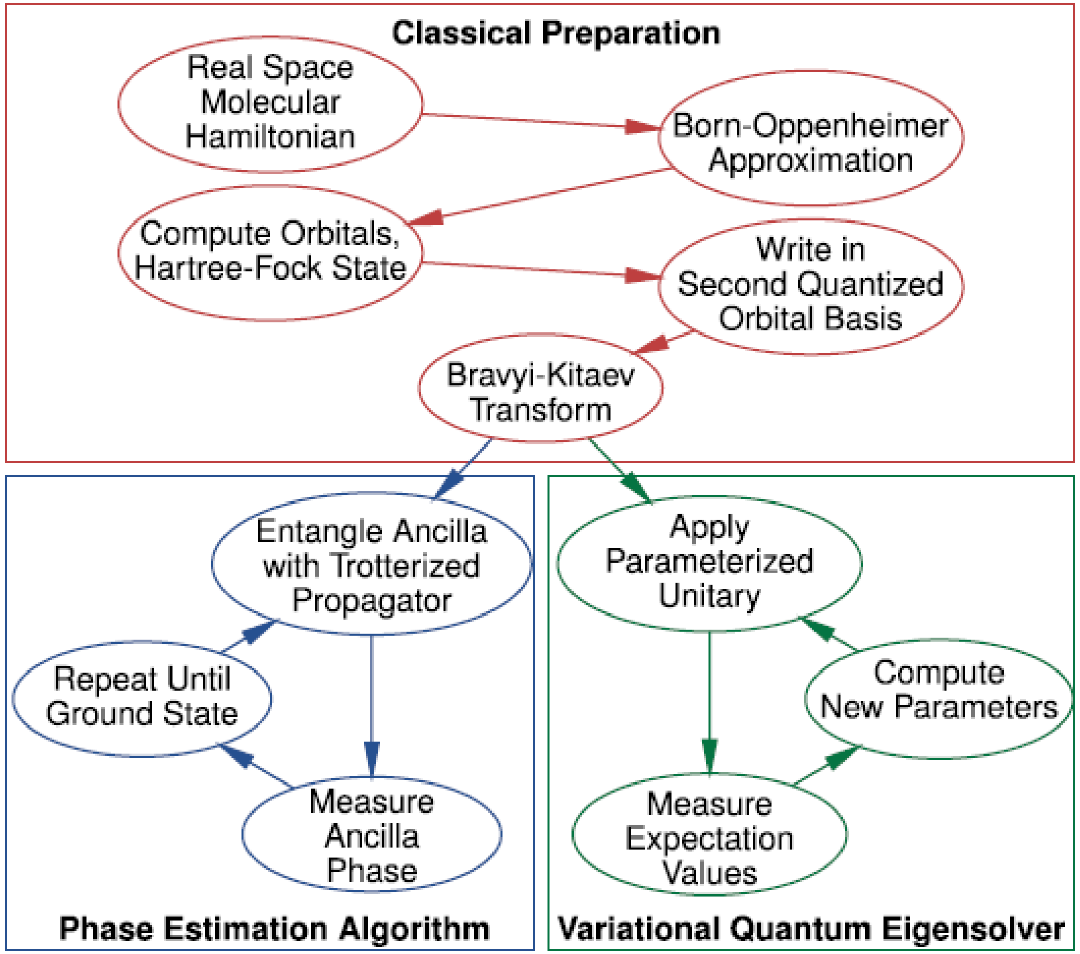


FIG. 5. A flow chart describing steps required to quantum compute molecular energies using both PEA and VQE.

- Hybrid quantum + classical computation technique.
- Quantum co-processor.

ACKNOWLEDGMENTS

The authors thank Cornelius Hempel for discussions regarding VQE. J. R. M. is supported by the Luis W. Alvarez fellowship in Computing Sciences at Lawrence Berkeley National Laboratory. J. R. acknowledges the Air Force Office of Scientific Research for support under Award No. FA9550-12-1-0046. A. A.-G. acknowledges the Army Research Office under Award No. W911NF-15-1-0256 and the Defense Security Science Engineering Fellowship managed by the Office of Naval Research under Award No. 00014-16-1-2008. P. J. L. acknowledges the support of the National Science Foundation under Grant No. PHY-0955518. Devices were made at the UCSB Nanofabrication Facility, a part of the NSF-funded National Nanotechnology Infrastructure Network, and at the NanoStructures Cleanroom Facility. R. Babbush,

NSF 0955518 **PI: Peter Love, Tufts**
“CAREER: A Roadmap for Quantum Simulation”,

O’Malley et al, PRX 6, 031007 (2016)

Latest NSF Investments in Quantum

Convergence
Community
Collaboration

Quantum Workforce

Convergence Quantum Research

Robust Research Community

Quantum Leap
The Next Quantum Revolution
Convergence Overarching Research

ENG	CISE	MPS	RAISE TAQS
FY2018: $26.8M	FY2018: $10.0M	FY2018: $31.65M	FY2018: $25.0M
FY2017: $33.2M	FY2017: $3.0M	FY2017: $21.9M	FY2017: $0.0M

Looking Ahead: Ten Big Ideas

RESEARCH IDEAS

Navigating the New Arctic

Harnessing Data for 21st Century Science and Engineering

Work at the Human-Technology Frontier: Shaping the Future

Understanding the Rules of Life: Predicting Phenotype

The Quantum Leap: Leading the Next Quantum Revolution

Windows on the Universe: The Era of Multi-messenger Astrophysics

PROCESS IDEAS

Growing Convergent Research at NSF

NSF-Includes: Enhancing Science and Engineering through Diversity

Mid-scale Research Infrastructure

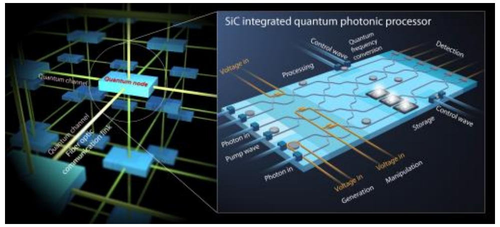
NSF 2050: Seeding Innovation

Recent NSF Activities Enabling the Quantum Leap

- **NSF 16-502 EFRI ACQUIRE. Quantum Communication and Networking; $18M; 9 Awds.**
- **NSF DMR-1743059 NSF/DOE Quantum Science Summer School (QS^3)**
- **NSF DMR-1747426 “Triplets” QISE-Net Workshop Series: Cross-Sector Connections; $2.5M**
- **NSF 17-548 Ideas Lab: Practical Fully-Connected Quantum Computer; $15M / 5yrs**
- **NSF CCF-1730449 “EPiQC: Enabling Practical-scale Quantum Computing”; $10M / 5 yrs *Expeditions in Computing* program in CISE/CCF; See NSF news release 18-011**
- **NSF 17-053 “Braiding” DCL: EAGER Awards for Demonstrating Topological QC;**
- **NSF 18-035 TAQS DCL: Transformational Advances in Quantum Systems; $25M; 25 Awds.**
- **NSF 18-051 DCL: Enabling Quantum Leap in Chemistry; $6.4M in FY 2018**
- **NSF 18-062 EQuIP DCL: Engineering Q. Integrated Platforms for Q. Comm.; $6M; 8 Awds.**
- **NSF 18-046 DCL: Room-Temperature Q. Logic through Improved Low-D Materials;**
- **NSF 18-578 Q-AMASE-I Foundries for Q. Materials Science, Engineering, and Info.**
- **NSF 19-507 QCIS Faculty Fellows; Preliminary proposals due Dec. 17, 2018**
- **NSF 19-532 QII-TAQS Transformational Advances in Quantum Systems; $26M / 2 yrs**

Quantum Leap:
Leading the next Quantum Revolution

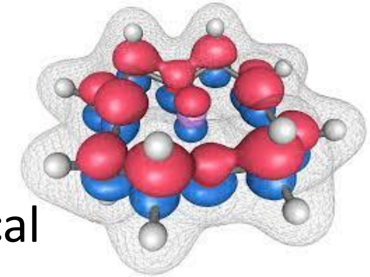
Next generation quantum devices and technologies



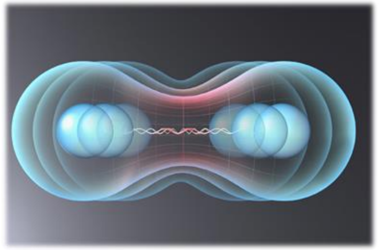
Materials, metrology, sensing,
secure communications,
information processing, computing

Breakthrough discoveries in natural and engineered quantum systems

Complexity, simulation,
emergent behavior,
theory, quantum/classical



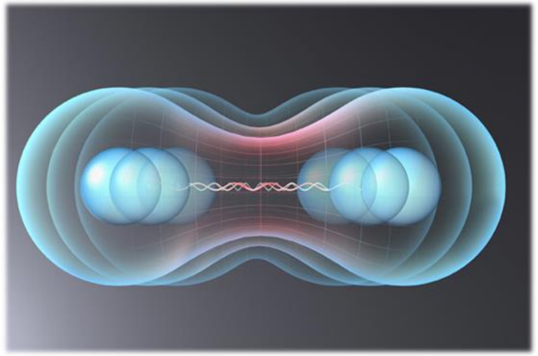
Fundamental science

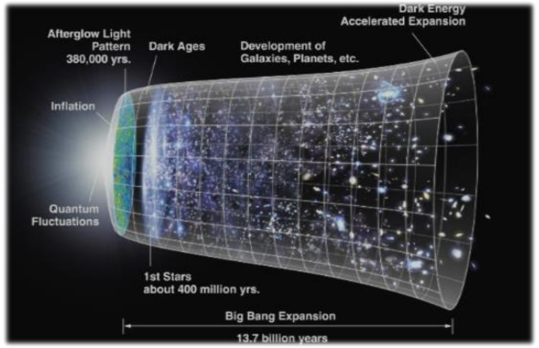


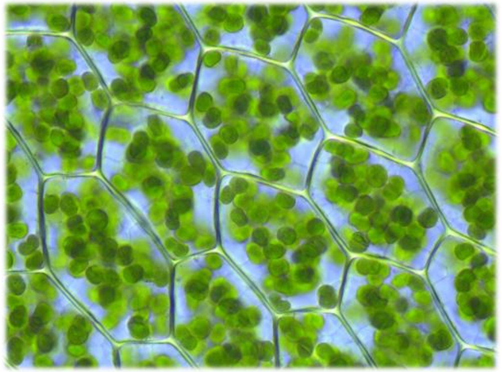
Understanding basic quantum properties
of entanglement, superposition,
coherence, interference, and squeezing

Quantum Leap : Asking Ambitious Questions

Q1: Are there fundamental limits to how far we can push the **entanglement and coherence** frontiers for quantum states? Are there limits in time, distance, or scale?

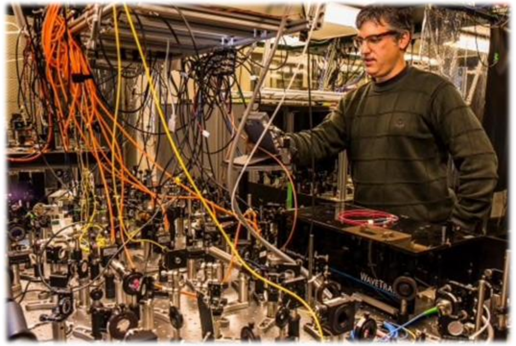






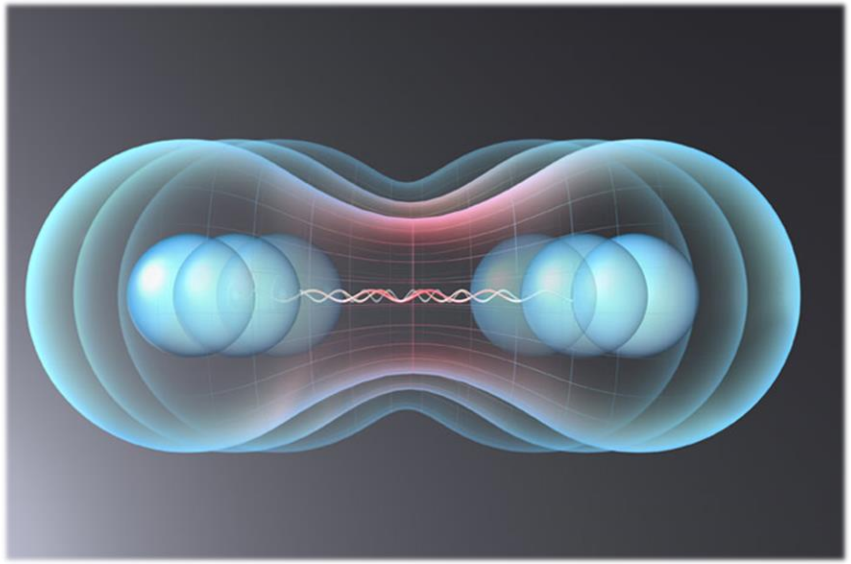
Q2: What can we learn from quantum phenomena in **naturally-occurring and engineered quantum systems**, including emergent behavior, complexity, quantum-classical boundaries, and their theoretical foundations?

Q3: How do we galvanize the science and engineering **community** to enable quantum devices, systems, and technologies that **surpass classical** capabilities?



Answering the Big Questions

Q1: Are there fundamental limits to how far we can push the **entanglement and coherence frontiers** for quantum states? Are there limits in time? distance? number?

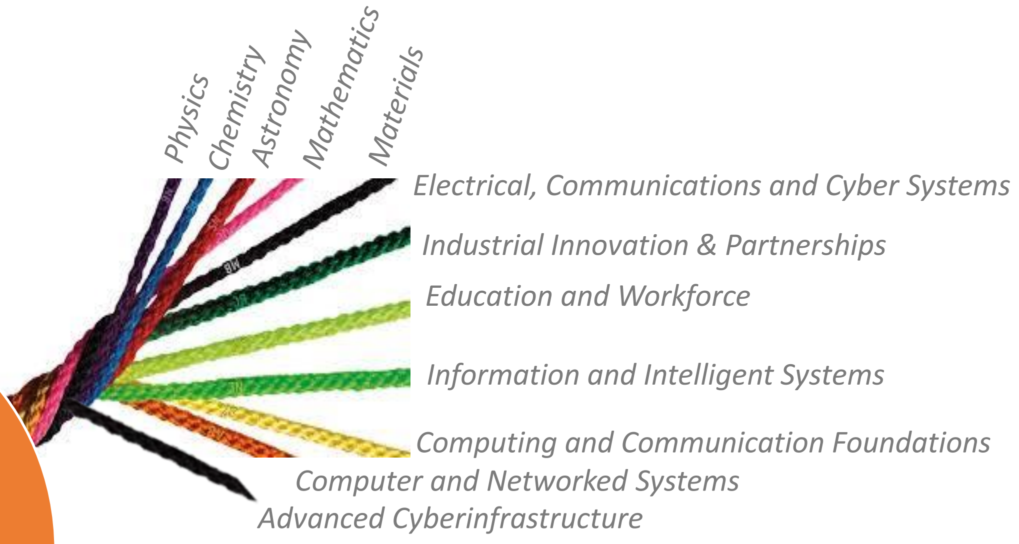


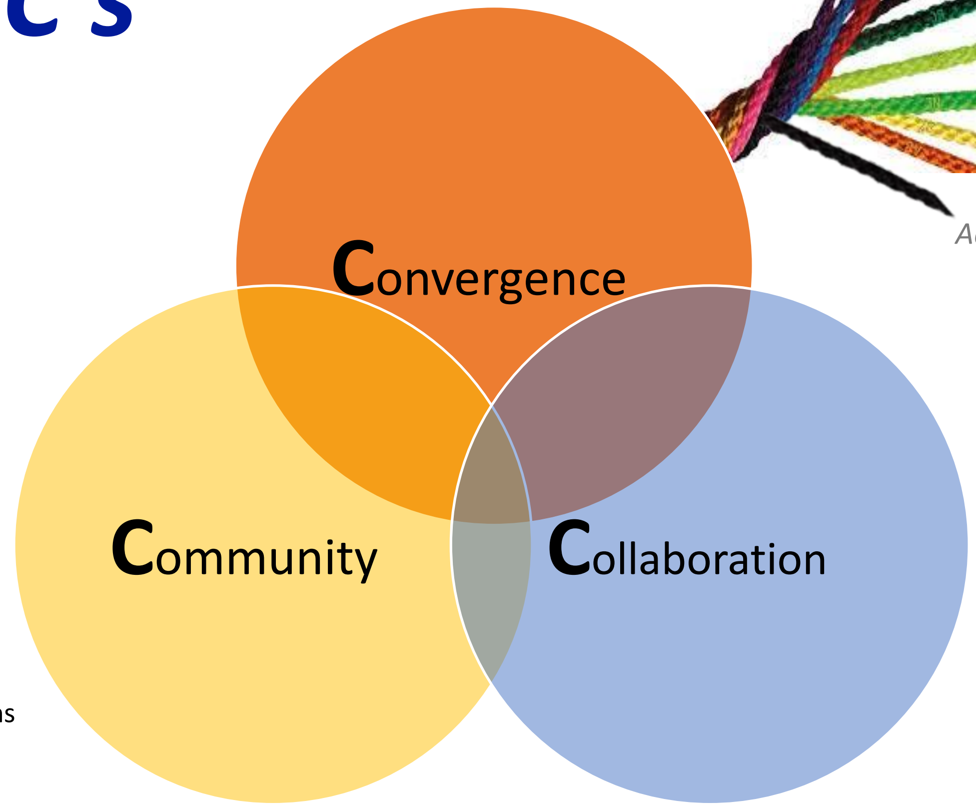
Expected advances:

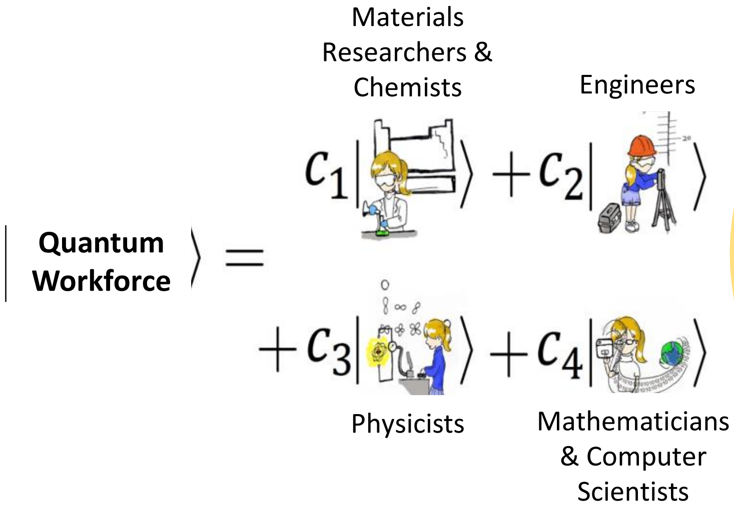
- Determine the origins and limits on the control of **decoherence**
- Elucidate the **quantum to classical transition**
- Push forward **tests of physical laws** using prototype quantum technology
- **Beat the standard quantum limit** for useful measurements using entanglement, interference, and squeezing
- Determine whether **topology** will revolutionize quantum technologies and materials science.
- Learn whether the **quantum volume** (qubit count/error rate) can be enlarged another 10,000 times.
- Discover new **metrics for quantum advantages** in communication, computation, and measurement.
- Advance **quantum thermodynamics**
- Discover ways to make **quantum error correction** efficient and scalable
- Devise **new algorithms** and applications (speedups) for quantum simulators, quantum co-processors
- Determine how much information can be encoded in a **single photon**.

The NSF Approach

The 3 C's







Completing the Foundation for the Leap

RAISE-EQuIP: Engineering Quantum Integrated Platforms for Quantum Communication

RAISE-TAQS: Transformational Advances in Quantum Systems

Ideas Lab: Practical Fully-Connected Quantum Computer Challenge (PFCQC)

Enabling Practical-scale Quantum Computing: *Expeditions in Computing*

DCL: Quantum Leap in Chemistry: molecular approaches

QISE-Net: Quantum Information Science and Engineering Network – "TRIPLETS"

NSF/DOE/AFOSR: Quantum Science Summer School; 2017-2020

EFRI-ACQUIRE (2016); *Advancing Communication Quantum Information Research in Engineering*

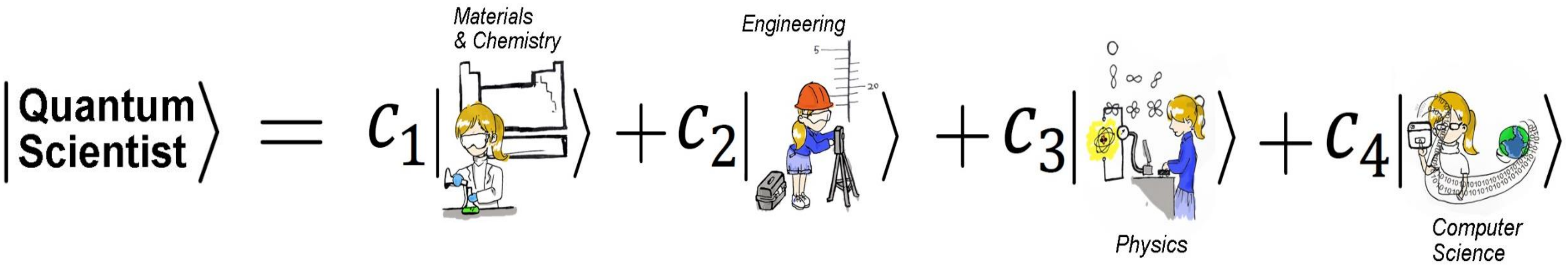
Taking the Leap (FY 19 and Beyond)

Pending NQI legislation may promote quantum research centers that will address Grand Challenges in sub-fields such as quantum communications, computing, simulation, sensing and metrology.

QII-TAQS Incubators: Transformational Advances in Quantum Systems; Follow-on to successful FY 2018 TAQS awards; $26 M over two years; NSF 19-532 released Nov. 20, 2018.

NSF Quantum Computing & Information Science Faculty Fellows (QCIS-FF); NSF 19-507; Preliminary proposals due Dec. 17, 2018

Q-AMASE-i: Quantum materials and devices (research, growth, characterization, and fabrication); $20 M from QL over five years; NSF 18-578; Full proposal deadline: Nov. 5, 2018.

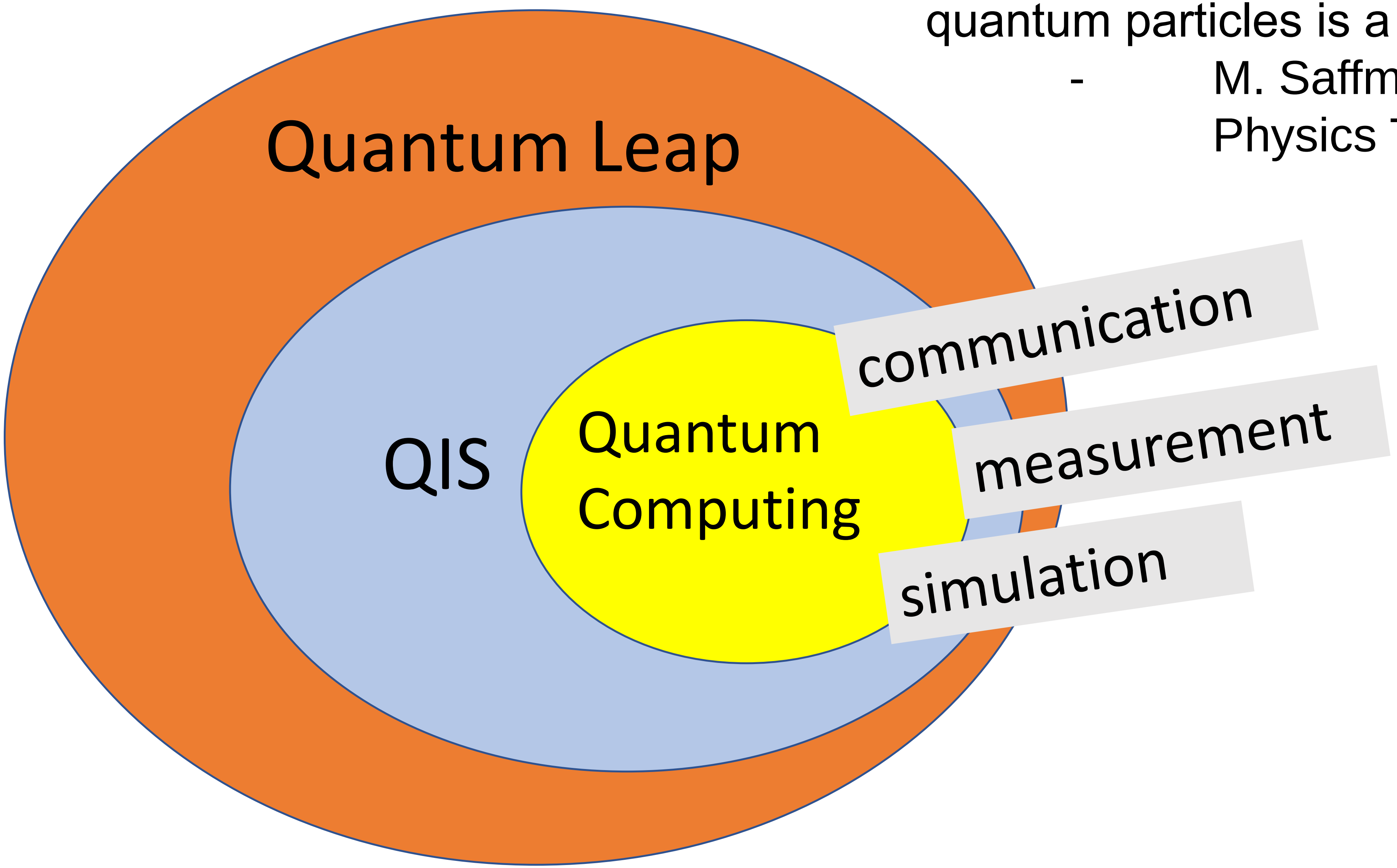

Quantum Scientist
$= c_1 | \ \rangle + c_2 | \ \rangle + c_3 | \ \rangle + c_4 | \ \rangle$
Materials & Chemistry
Engineering
Physics
Computer Science

Questions?

Extra slides

“From the view of an experimental physicist, the task of exerting precise control over a large number of individual quantum particles is a grand challenge.”

- M. Saffman and D. Weiss, Physics Today JULY 2017

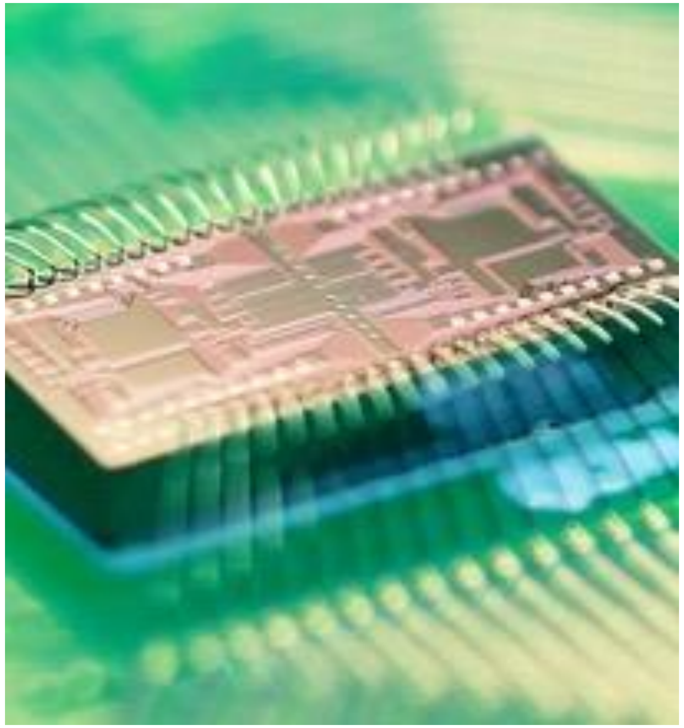


(Not to scale)

EFRI-ACQUIRE Topic (2016-2017)

Advancing Communication
Quantum Information Research in Engineering

$18M
9 Awards



- Engineering of deployable quantum communication systems
- A New Workforce, through training in quantum technology

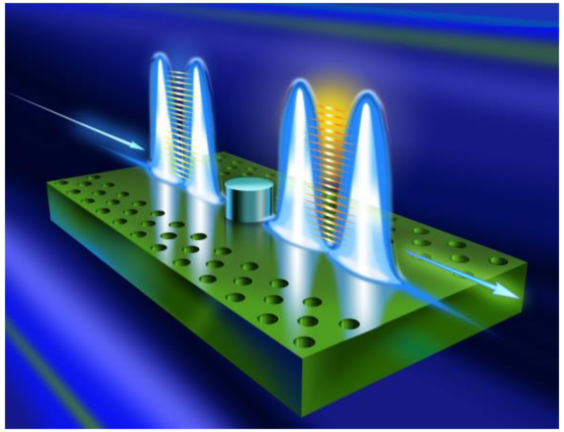
QUANTUM ENGINEERS

EXPECTED OUTCOMES

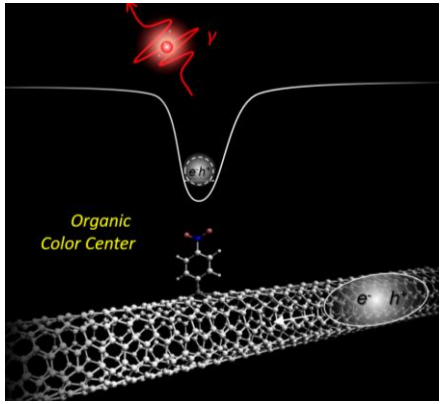
- Address challenges of quantum communication network engineering
- **Target: Operation at/near room temperature with low energy in a secure communication network.**

NSF News Release 16-091

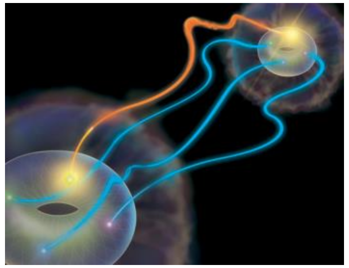
Transformational Advances in Quantum Systems (RAISE-TAQS) NSF 18-035

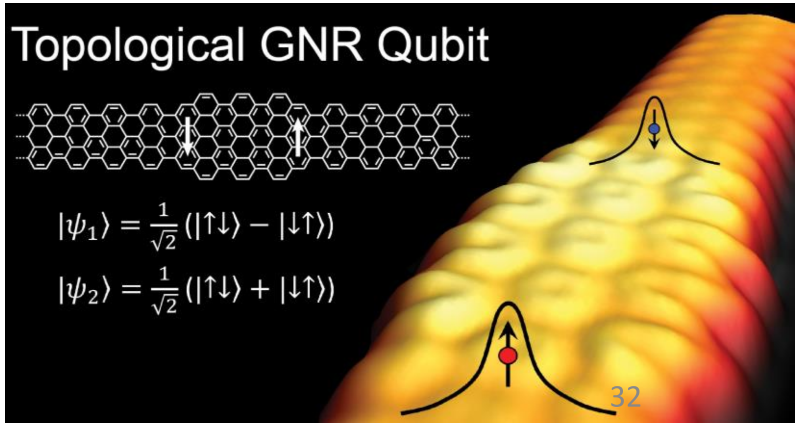


- *Interdisciplinary Research Idea*
  - Include at least **3 topics from 3 different technical disciplines**
  - **Team effort:** 3 PIs (at least) with complementary expertise in the respective disciplines
  - Submission to at least 3 PDs aligned with their program focus



- *Research Focus: The innovative proposals must:*
  - **Focus on quantum functionality** by addressing aspects <u>relevant to both fundamental and applications concepts</u>
  - **Result in experimental demonstration** of transformative advances towards quantum systems and/or proof-of-concept validations
- *Result*
  - 25 meritorious awards totaling $25M



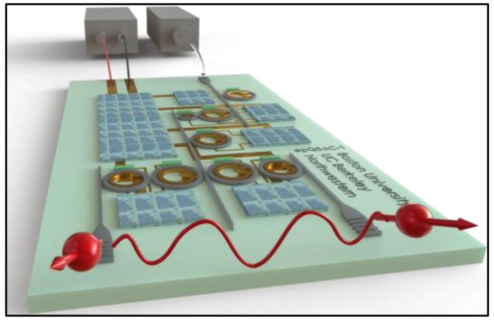


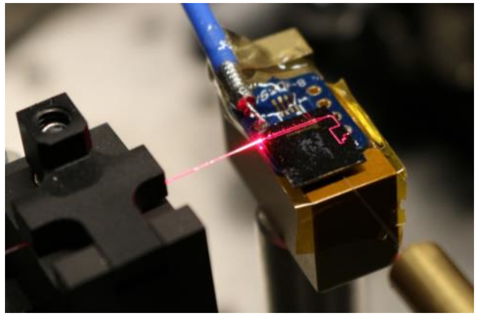
https://www.nsf.gov/news/news_summ.jsp?cntn_id=296699

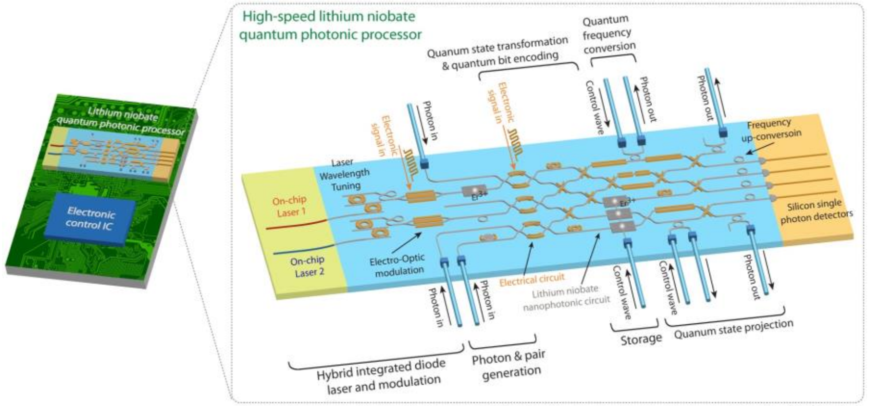
Engineering Quantum Integrated Platforms for Quantum Communication (RAISE-EQuIP)

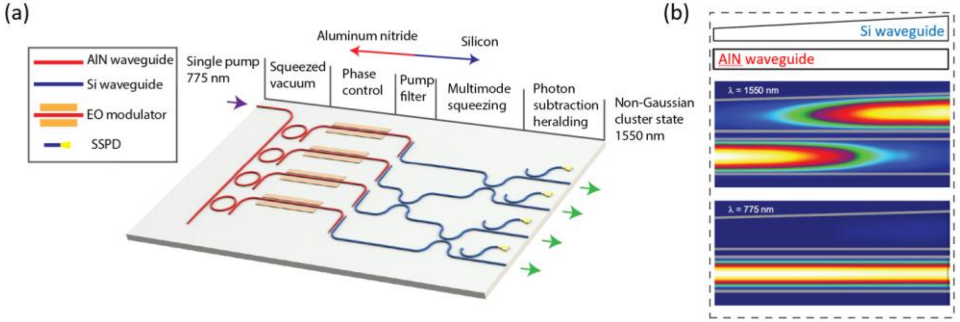
- Engineering-led interdisciplinary research for advancing quantum communication
- Innovations in at least two of the three key components:
  - Transmitter or emitter of quantum information
  - Channel for propagation or storage of quantum information
  - Receiver or detector of quantum information
- Address problems from two perspectives:
  - Device level challenges
  - Signal processing and communication protocol challenges
- Lead to a prototype system for:
  - Proof-of-concept demonstration
  - Experimental platform for future research
  - Identification of relevant performance metrics
- 8 meritorious awards, totaling $6M

https://www.nsf.gov/news/news_summ.jsp?cntn_id=296699

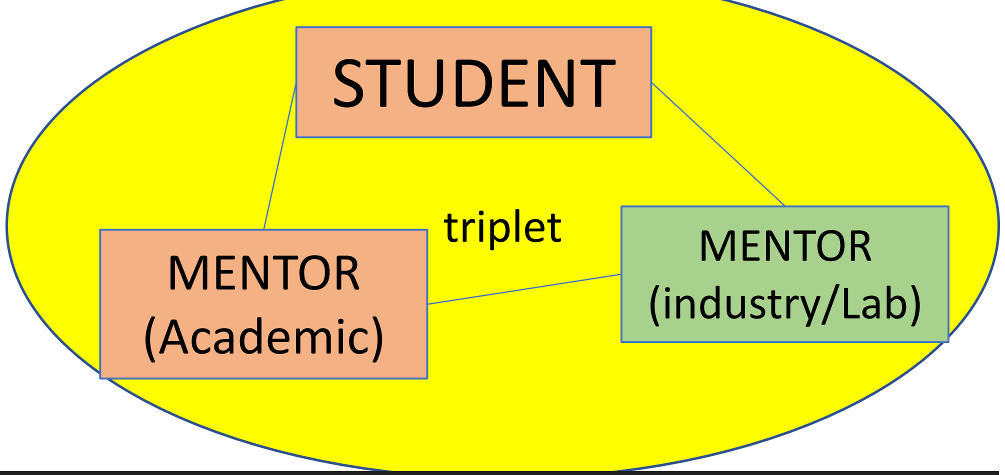








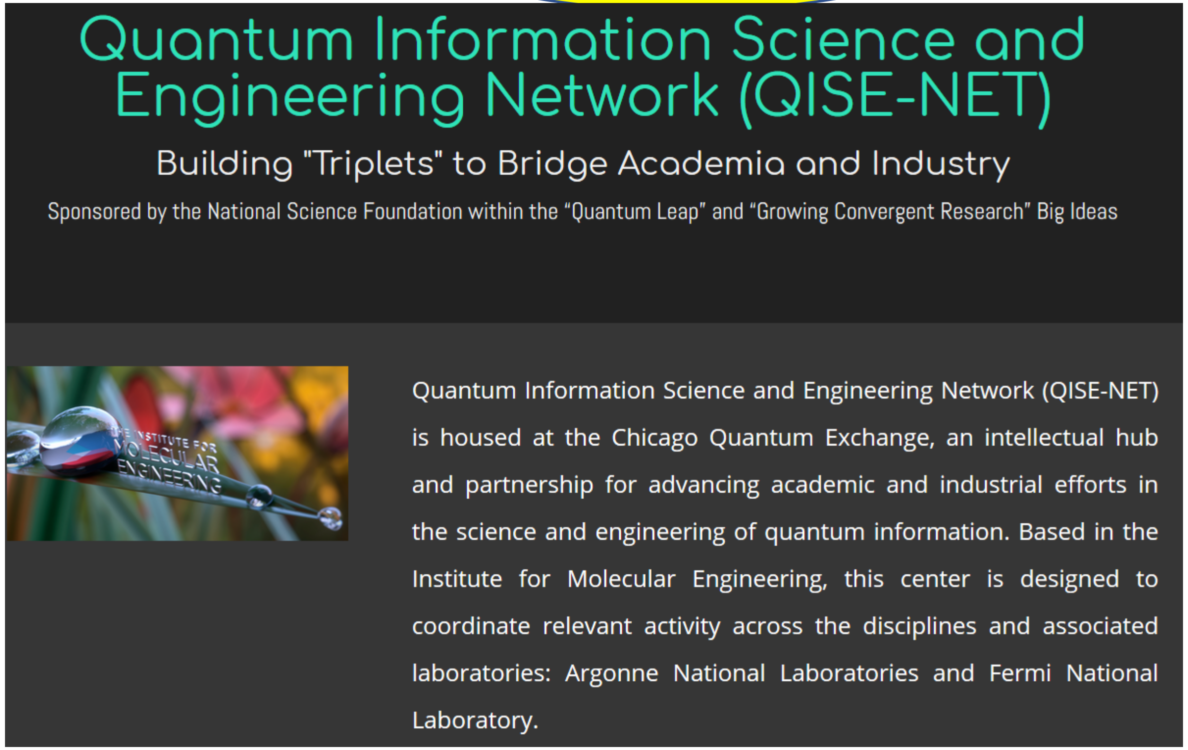
Quantum Leap: Triplets



Quantum Information Science and Engineering Network” of “triplets” of students, faculty, industry partners to work on Quantum Leap challenges (nine NSF Divisions participating)

University	*Partner*
Columbia U	Raytheon BBN
Georgia Tech	IBM Watson
MIT	Sandia Labs
U. Maryland	IonQ Inc.
MIT	Google
U. Maryland	IBM Watson
UW-Madison	Google
Georgetown	IBM Almaden
Georgia Tech	IBM
Dartmouth	Google

University	*Partner*
U. Chicago	IBM
UCSC	Argonne
UT Austin	NIST
Caltech	IBM
Caltech	Google
U. Pitt.	IBM
U. Illinois	NIST
Vanderbilt	ORNL
Sony Brook U.	BNL
UW Madison	Adamas Nano.
MT State	MT Instruments


Quantum Information Science and Engineering Network (QISE-NET)

Building "Triplets" to Bridge Academia and Industry

Sponsored by the National Science Foundation within the “Quantum Leap” and “Growing Convergent Research” Big Ideas

Quantum Information Science and Engineering Network (QISE-NET) is housed at the Chicago Quantum Exchange, an intellectual hub and partnership for advancing academic and industrial efforts in the science and engineering of quantum information. Based in the Institute for Molecular Engineering, this center is designed to coordinate relevant activity across the disciplines and associated laboratories: Argonne National Laboratories and Fermi National Laboratory.

http://news.uchicago.edu/article/2018/05/08/nationwide-program-launches-train-new-generation-quantum-engineers24

Quantum Leap: Working Quantum Computer

Solicitation NSF 17-548 “**Ideas Lab**: Practical Fully-Connected Quantum Computer Challenge (PFCQC)” A co-design approach to integrating hardware, software and quantum algorithms”

NSF Award 1818914

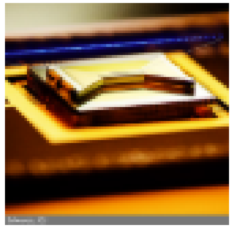
STAQ: “Software-Tailored Architecture for Quantum co-design”

- Develop a fully-connected quantum computer with enough qubits to solve a relevant problem
- “Full stack”: software, algorithms, devices, systems integration

White House OSTP
@WHOSTP

Following

Fresh from the @NSF Ideas Lab: $15 million towards building the world's first practical quantum computer!



National Science Foundation @NSF
Quantum computers will change the world, but they remain largely proofs of concept. NSF's STAQ project, with $15 million of NSF funding awarded today, hopes to change that: bit.ly/2vo85VX

August 8, 2018

Q-AMASE-i

- NSF 18-578: Enabling Quantum Leap: Convergent Accelerated Discovery Foundries for Quantum Materials Science, Engineering and Information (Q-AMASE-i)- DMR + DMS + ECCS +OAC/CISE
- https://www.nsf.gov/pubs/2018/nsf18578/nsf18578.htm
- Full Proposal deadline: November 05, 2018.
- The program will support between 1 and 5 Foundries, depending on available budget.
- Anticipated funding level is between $20,000,000.- to $25,000,000.- per Foundry over a six-year period.

National Science Foundation's Mission:

"To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense..."

National Science Foundation

GOLD STANDARD IN MERIT REVIEW

Research proposals submitted to NSF are subjected to a rigorous merit review system – impartial, competitive, and transparent – ensuring that each proposal meets the highest standards of intellectual merit and broader impact on society. NSF's merit review process is widely regarded as the gold standard of scientific review and has been emulated in numerous countries around the world.

$7.3 billion NSF FY 2015 Budget Request

94% Funds research, education and related activities

INPUT

50,000
Proposals evaluated through competitive review process

38,000
Reviewers, including external experts and program staff

233,000
Total number of reviews, each proposal evaluated multiple times

OUTPUT

10,800
Competitive awards funded

1,922
U.S. colleges, universities, and other institutions receiving NSF funding

299,000
Estimated number of researchers, postdoctoral fellows, trainees, teachers and students NSF supports directly

IMPACT

47,800
Students supported by NSF Graduate Research Fellowships since 1952

210+
Number of Nobel Laureates supported by NSF

NSF-Supported Research
has spurred economic activity and improved the quality of life for all Americans

STEM Workforce Development
supports students, teachers and tools to enable the development of a diverse and highly qualified science and technology workforce

Figures other than Budget Request represent FY 2013 actuals

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