EXPANDING AMERICAN LEADERSHIP IN QUANTUM INFORMATION SCIENCE

Jake Taylor
Office of Science and Technology Policy

QUANTUM INFORMATION TECHNOLOGY

Promises

Quantum sensing

Measure beyond the limits of individual particles — use entanglement (Adv. LIGO, dual ion clock)

Quantum communication

Use fundamental quantum mechanics to ensure security (already commercial implementations)

Quantum simulation

Implement arbitrary Hamiltonians
(nonequilbrium, topological phases, quantum phase transitions)

Quantum computation

Shor's algorithm, Grover's algorithm
(breaking codes, searching databases)

The future

How do we operate in a post-quantum world?

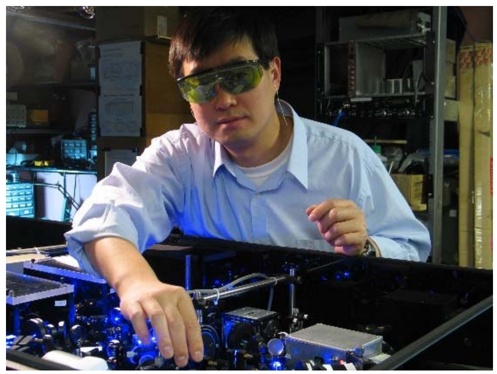
CURRENT QUANTUM TECHNOLOGY

Transistors

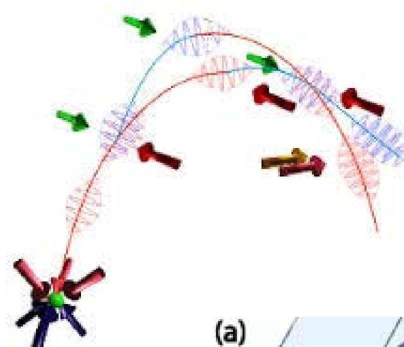
MRI (medicine)

Lasers

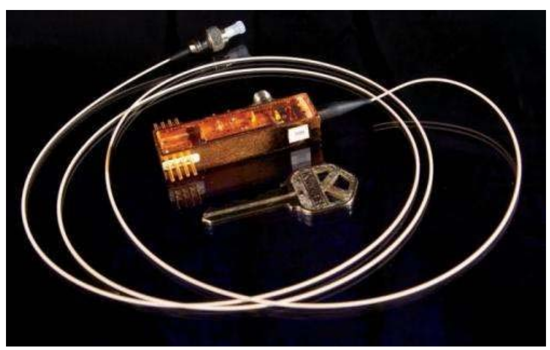
Atomic clocks (GPS!)

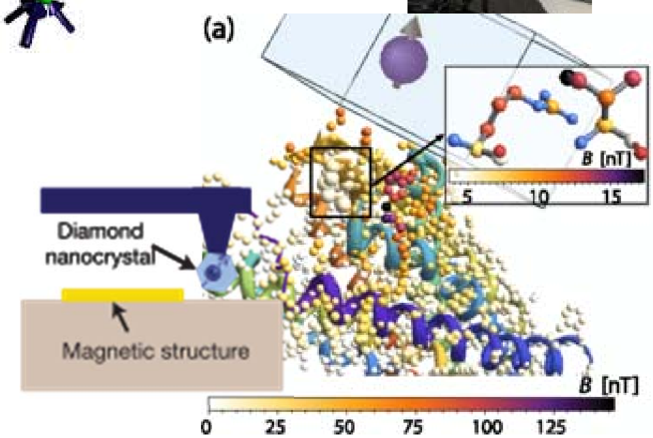


Quantum-limited sensors



Quantum key distribution





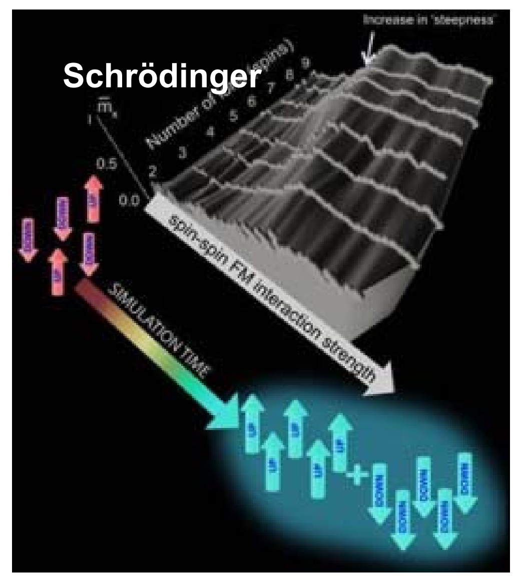
NEAR TERM: QUANTUM SIMULATION

Chemistry, biology, materials science all depend on solving quantum mechanics problems

Recall: Simulating quantum mechanics is hard…

Solution: Use one system to simulate another

Navier-Stokes



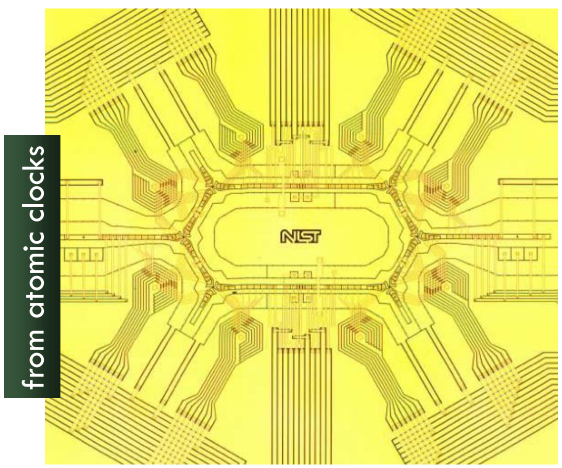
TOWARDS QUANTUM COMPUTATION

Ideal case: programmable quantum computer

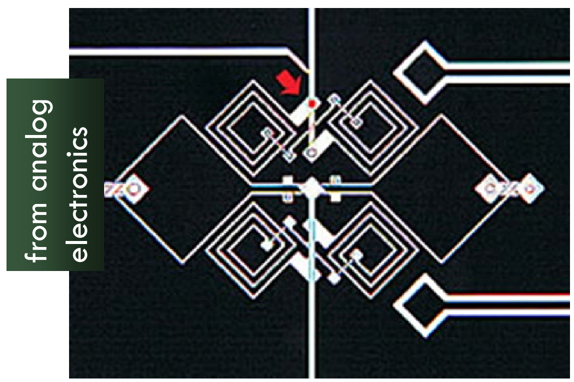
Moving from the lab to systems and engineering…

but many questions about a processor await

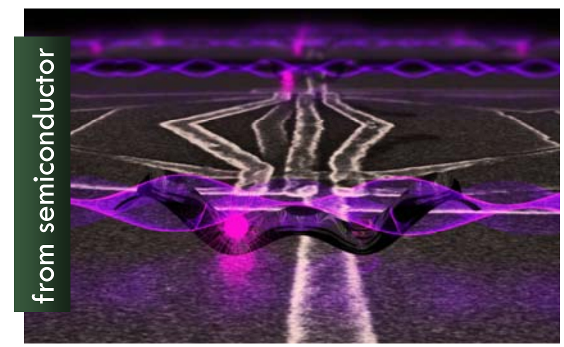
Atomic qubits

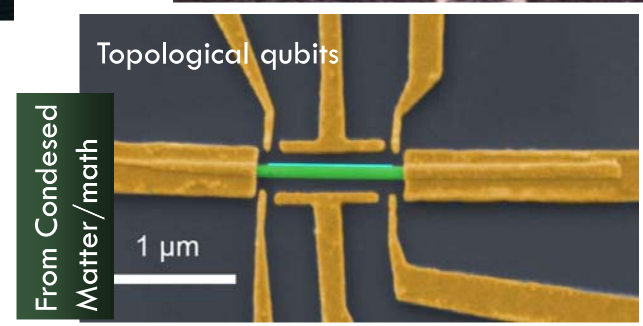


Superconducting qubits



Semiconductor spins

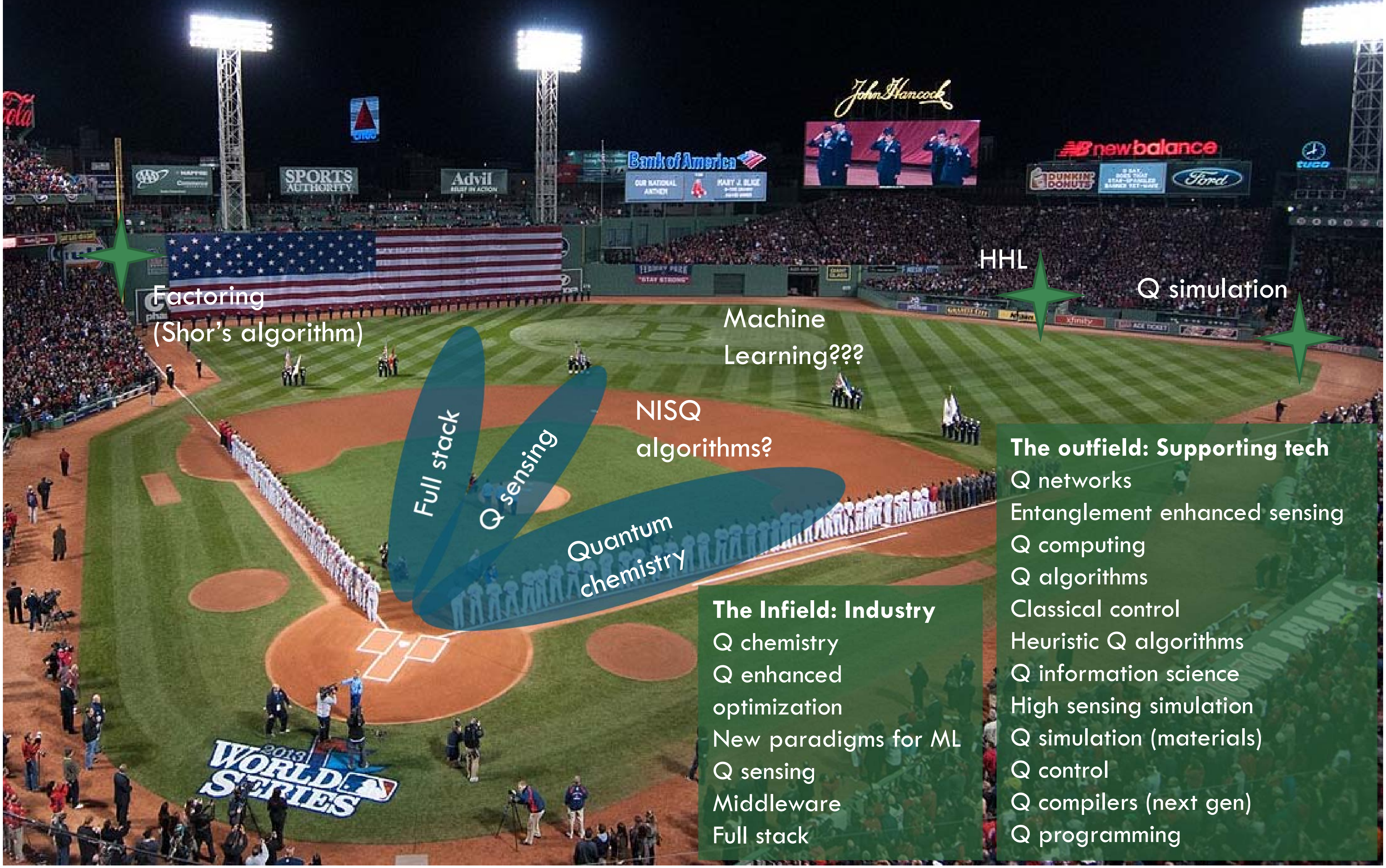




And more (photonic, impurity, …)

WHAT DO WE KNOW? WHERE CAN WE GO?

THE FIELD OF DREAMS



The Infield: Industry

Q chemistry
Q enhanced optimization
New paradigms for ML
Q sensing
Middleware
Full stack

The outfield: Supporting tech

Q networks
Entanglement enhanced sensing
Q computing
Q algorithms
Classical control
Heuristic Q algorithms
Q information science
High sensing simulation
Q simulation (materials)
Q control
Q compilers (next gen)
Q programming

QUANTUM INDUSTRY: AN OPPORTUNITY

Current quantum technology: atomic clocks, nuclear magnetic resonance, modern telecom detectors and sources, LIGO, optical sensors, …

Next generation quantum?

- Improved computational approach to materials, chemistry
- Fundamental advances in condensed matter, high energy theory
- New understanding of optimization, machine learning
- Spin-offs: Quantum random number generators, new sensing modalities, better PNT, new qubit technologies, new analog microwave and optical technologies

The 10 year outlook?

- The beginnings of a sea change for corporations and government – the need to incorporate quantum computing and technologies into their business model

HIGH-ENERGY PHYSICS AND QIS?

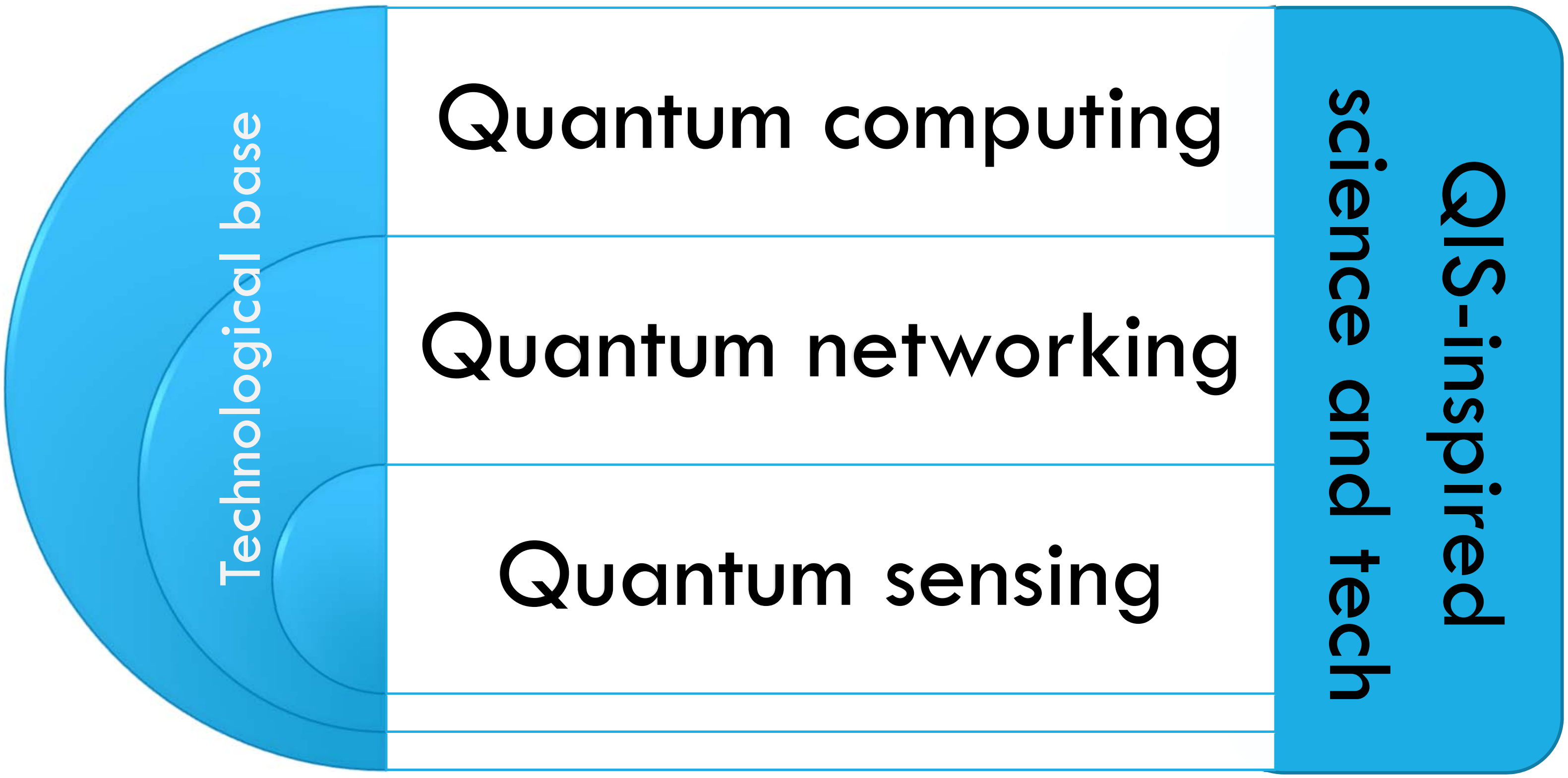
New approaches for high-energy (and other field theories) both computational and abstract

Fundamental understanding of spacetime structure through the lens of entanglement

New approaches to detecting particles, dark matter with precision measurement and at the quantum limit

A potential conflict between communities – how to grow together?

WHAT DOES QUANTUM INFORMATION SCIENCE POLICY COVER?



Focus on basic research!

NEXT STEPS: NSTC SUBCOMMITTEE ON QUANTUM INFORMATION SCIENCE

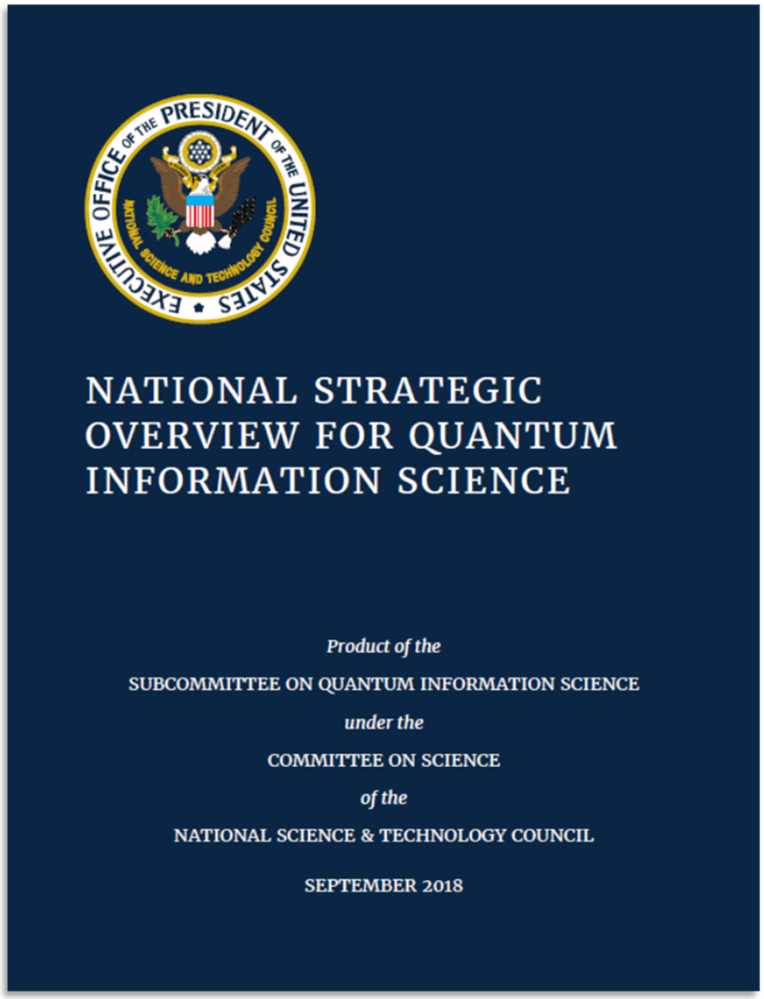
Create and maintain
a national strategy for
Quantum information science

Coordinate current and future
efforts across the agencies

Co-chairs: DoE, NSF, NIST


ADVANCING AMERICAN LEADERSHIP
in QUANTUM INFORMATION SCIENCE
#WHQISSummit

POLICY RECOMMENDATIONS



NATIONAL STRATEGIC OVERVIEW FOR QUANTUM INFORMATION SCIENCE

Product of the

SUBCOMMITTEE ON QUANTUM INFORMATION SCIENCE

under the

COMMITTEE ON SCIENCE

of the

NATIONAL SCIENCE & TECHNOLOGY COUNCIL

SEPTEMBER 2018

☐ Focus on a science-first approach that aims to identify and solve Grand Challenges: problems whose solutions enable transformative scientific and industrial progress;

☐ Build a quantum-smart and diverse workforce to meet the needs of a growing field;

☐ Encourage industry engagement, providing appropriate mechanisms for public-private partnerships;

☐ Provide the key infrastructure and support needed to realize the scientific and technological opportunities;

☐ Drive economic growth;

☐ Maintain national security; and

☐ Continue to develop international collaboration and cooperation.