EXPANDING AMERICAN LEADERSHIP IN QUANTUM INFORMATION SCIENCE

Jake Taylor
Office of Science and Technology Policy
QUANTUM INFORMATION TECHNOLOGY

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 (nonequilibrium, 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
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

Factoring (Shor’s algorithm)

Q simulation

Machine Learning???

NISQ algorithms?

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

The infield: Industry
- Q chemistry
- Q enhanced optimization
- New paradigms for ML
- Q sensing
- Middleware
- Full stack

Quantum chemistry

Q sensing

Full stack

The World Series

John Hancock

New balance

Coca Cola

Sports Authority

Bank of America

Aviva
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!

- Quantum computing
- Quantum networking
- Quantum sensing

Technological base

QIS-inspired science and tech
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
POLICY RECOMMENDATIONS

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.