EXPANDING AMERICAN LEADERSHIP IN QUANTUM INFORMATION SCIENCE

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Quantum Information Technology

Quantum simulation
  Implement arbitrary Hamiltonians (nonequilibrium, topological phases, quantum phase transitions)

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

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

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 key distribution
- Quantum-limited sensors
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

Schrödinger
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?
HHL
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 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
WHAT DOES QUANTUM INFORMATION SCIENCE POLICY COVER?

- Quantum computing
- Quantum networking
- Quantum sensing

Focus on basic research!
## OUR CHOICE

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<tr>
<th>Invest in our talent</th>
<th>Enhance workforce</th>
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<tbody>
<tr>
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<td>Drive market opportunities</td>
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<td>Enable new jobs in science, engineering, and beyond</td>
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<th>Develop public-private partnerships</th>
<th>Realize government multiplier for innovation economy</th>
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<td>Gain efficiency via division of responsibility</td>
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<td>Two-way knowledge transfer for improved R&amp;D</td>
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<th>Lead through smart policy</th>
<th>STEM effort for quantum engineering, masters</th>
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<td>Regular coordination across boundaries</td>
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<td>Continuous refactoring with improving knowledge</td>
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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