Department of Physics and Astronomy

"Frontiers in Quantum Information Science"

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Wednesday, September 09, 2020

12:00p.m.

Zoom Link

Meeting URL: https://usc.zoom.us/j/98655183152?from=msft

Meeting ID: 986 5518 3152

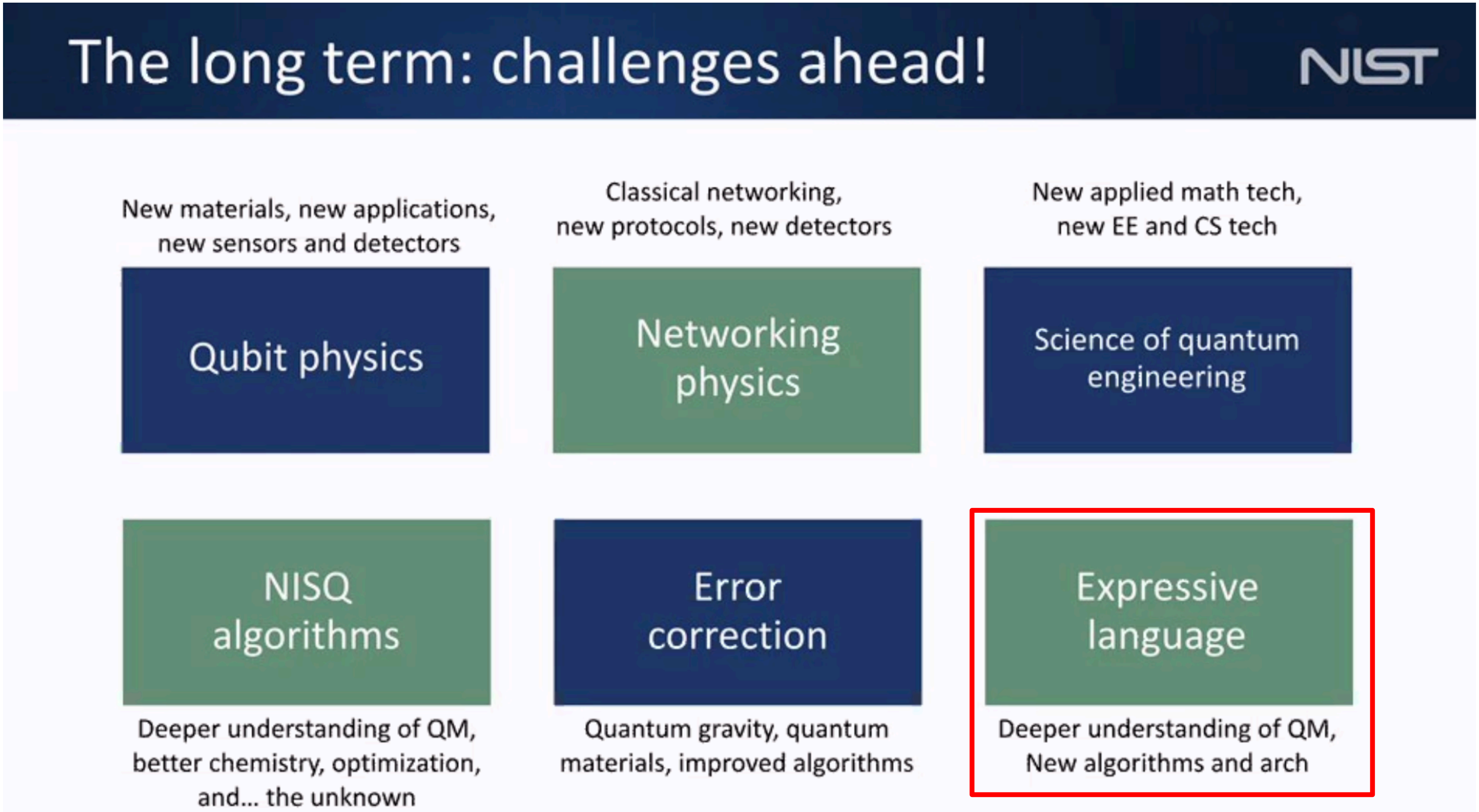
Quantum information science (QIS) promises dramatic improvements in our ability to understand the physical world and in our capabilities for communication and computation. Over the past five years, a worldwide expansion of Government-funded research and development has combined with an unprecedented investment from the private sector to dramatically accelerate progress in realizing the potential of quantum systems. In this talk I will discuss the re-envisioning of the U.S. research and development approach to QIS enacted over the past two years through the National Quantum Initiative and other efforts, and consider future opportunities and challenges for academia, industry, government, and the public. I will focus the latter half of the talk on specific research frontiers of personal interest in the space, specifically the interplay between quantum device development and physical understanding, where I will touch upon searches for dark matter using advanced quantum sensors and challenges in terrestrial tests of the quantum nature of gravity.

Excerpt: Quantum Field of Dreams

Quantum scientific computing — right field home run!

cf. CSCI 596

Excerpt: Quantum Challenges



Expressive quantum programming languages: Breakthrough will come from the confluence of calculus & algorithm

Quantum Programming Languages

- **Schrödinger (unitary time propagator ~ partial differential equation solver) *vs.* Feynman (path integral) languages**

  "A flexible high-performance simulator for verifying and benchmarking quantum circuits implemented on real hardware," B. Villalonga *et al.*, *npj Quantum Info.* **5**, 86 (2019)

  http://cacs.usc.edu/education/cs596/Villalonga-qFlex-npjQI19.pdf

- **Used in pre-exaflop/s (classical) supercomputer simulation of quantum circuits**

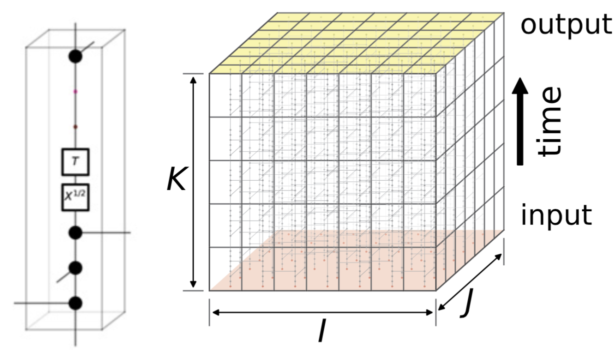
  "Establishing the quantum supremacy frontier with a 281 Pflop/s simulation," B. Villalonga *et al.*, *Quantum Sci. Tech*. **5**, 034003 (2020)

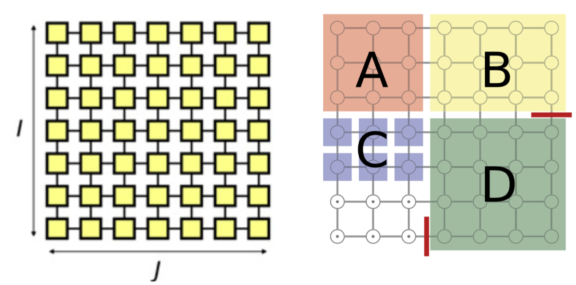
  http://cacs.usc.edu/education/cs596/Villalonga-PreexaQuantumCircuitSim-QST20.pdf

- **Potential final project?**

  Hard by yourself, but CS-EE-physics team?

  Discussion board thread?





Excerpt: Quantum IoT

Quantum ~~Communication~~ Networking

Quantum communication
Quantum key distribution, and tons of enabling technology:
Sources, detectors, fibers, transducers, low-loss elements, improved engineering, new networking protocols and procedures

Quantum repeaters drive small-scale (5 qubit-ish) device growth, enable modular architectures.

Quantum internet of things
Internetworked sensors enable new measurement modalities and capabilities.

Many technological steps such as optical phase synchronization between distant clocks are goals in their own right.

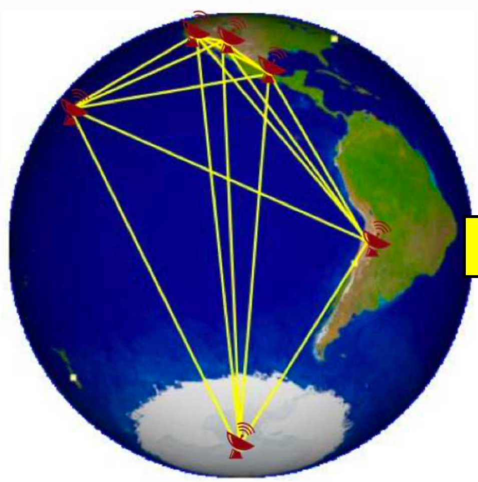
Space-based systems can play critical roles in both comms and sensing.

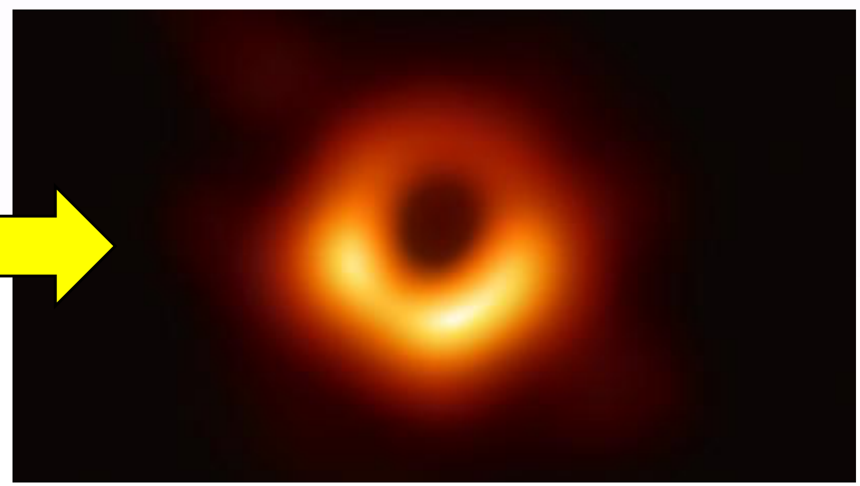
Quantum² cloud computing
Distributed quantum computing:
• quantum error correction (inside data center)

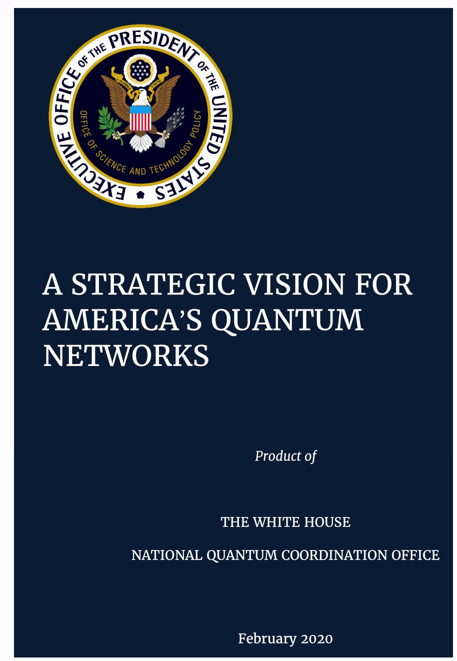
• interactive proofs (MIP*=RE ☺)

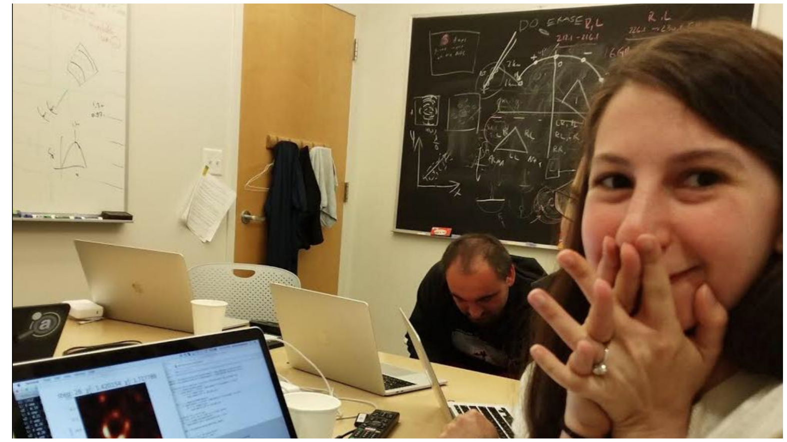
• homomorphic computing

And more???









Katherine Bouman

Caltech

"Capturing the First Image of a Black Hole & Designing the Future of Black Hole Imaging"

Abstract:

This talk will present the methods and procedures used to produce the first image of a black hole from the Event Horizon Telescope, as well as discuss future developments for black hole imaging. It had been theorized for decades that a black hole would leave a "shadow" on a background of hot gas. Taking a picture of this black hole shadow would help to address a number of important scientific questions, both on the nature of black holes and the validity of general relativity. Unfortunately, due to its small size, traditional imaging approaches require an Earth-sized radio telescope. In this talk, I discuss techniques the Event Horizon Telescope Collaboration has developed to photograph a black hole using the Event Horizon Telescope, a network of telescopes scattered across the globe. Imaging a black hole’s structure with this computational telescope required us to reconstruct images from sparse measurements, heavily corrupted by atmospheric error. The talk will also discuss future developments, including new imaging techniques and how we are developing machine learning methods to help design future telescope arrays.

FRIDAY, September 11, 2020
3:30 PM Pacific Time (US and Canada)