AVS Quantum Science Workshop
Room 208 W - Session AQS-SuA

AVS Quantum Science Workshop Oral Session (ALL-INVITED SESSION)

Moderators: Ekta Bhatia, NY CREATES, **Charles R. Eddy, Jr.**, Office of Naval Research Global - London, **David Pappas**, Rigetti Computing, **Andre Schleife**, University of Illinois at Urbana-Champaign

3:00pm **AQS-SuA-1 Experimental Discovery of Anyons: Realizing the Power of Quantum Statistics*, Michael Manfra,*** Purdue University

3:30pm **AQS-SuA-3 Fault Tolerant Quantum Computation using Majorana-Based Topological Qubits*, Roman Lutchyn,*** Microsoft Quantum **INVITED**

Research in quantum computing has provided numerous new physical insights and the potential to exponentially increase computational power for solving significant problems in science and technology. The primary obstacle to building a scalable quantum computer is errors caused by decoherence. Topological quantum computing addresses this challenge by utilizing topological materials that inherently limit errors.

In this talk, I will discuss the engineering of topological superconductors that support Majorana zero-energy modes at the interface between a conventional superconductor (Aluminum) and a semiconductor with spin-orbit interaction (Indium Arsenide). I will present recent findings from the Microsoft Quantum team that indicate the emergence of topological superconductivity in proximitized semiconductor nanowires. Additionally, I will cover recent measurements of fermion parity, which represent a step towards the fusion of Majorana zero modes. Finally, I will outline a proposal for scalable quantum computing that involves topological qubits composed of superconducting islands in a Coulomb blockade regime, hosting aggregates of four or more Majorana zero modes.

4:00pm **AQS-SuA-5 Enabling the Scaling of Superconducting Quantum Devices in a 300 mm Wafer Fab**, *Ekta Bhatia, Zhihao Xiao, Chung Kow, Stephen Olson, Jakub Nalaskowski, John Mucci, Nicholas Pieniazek, Daniel Romero, Hyuncher Chong, Bryan Egan, Geevanie Telhu, Wenli Collison, Sandra Schujman, Kevin Musick, Thomas Murray, Aleksandra Biedron,* ***Satyavolu Papa Rao,*** NY CREATES **INVITED**

Progress in superconducting qubit performance over the past three decades has led researchers to focus on scalable quantum computing. To achieve scalability, the following are among the desiderata: system stability, easy input/output, high component yields, low energy use, and predictable component performance with tight distributions. These demands are even more challenging for quantum computing.

The NY CREATES team, along with our partners, has taken on the scalability challenge by seeking to implement superconducting qubits at 300 mm wafer scale, leveraging state of the art tools and processes to support the development of a Superconducting Quantum Process Design Kit (PDK). A PDK will enable democratization of qubit design and fabrication for start-ups, academia and national labs - but a PDK is only as good as the fidelity with which fabricated devices meet the designer's intent. Hence it is critical to develop fabrication processes that are controlled and repeatable, in tools that are equipped with *in situ* monitors for process control.

This talk will describe our efforts to develop tantalum (Ta)-based qubits at 300 mm scale. We use α-Ta as the wiring material, and atomic layer deposited tantalum nitride in the tunnel barrier of the Josephson junction. The advantages provided by state-of-the-art 300 mm tools to enable *in situ* process monitoring and control will be described using a few examples from various stages of the process flow. This talk will discuss the impact of two-level systems in material surfaces and interfaces. We have addressed them in many ways - by burying some in a crystalline silicon matrix to eliminate air exposure, and by replacing native oxides with surface treatments providing improved physical characteristics. Implementation of integrated air bridges and lumped element resonators that use high kinetic inductance elements and capacitors that use crystalline silicon as the dielectric will be discussed. The talk will conclude with a description of the circuit elements that are being developed for the PDK cell library, both as ‘fixed geometry’ cells, and as parameterized cells.

We thank our many partners, including Brookhaven National Lab, Pacific Northwest National Lab, AFRL-Rome, SEEQC, QCI, Tokyo Electron Ltd, Applied Materials, Cadence, Cornell University, Princeton University, Syracuse University, and Auburn University. The various projects underlying this talk are funded in part by the US Department of Defense (ME Commons), the US Department of Energy (C2QA), and NY CREATES.

4:45pm **AQS-SuA-8 Laboratory-based Experiential Learning for Quantum Information Science*, Richard S. Ross,*** UCLA **INVITED**

UCLA's Master of Quantum Science and Technology program has developed innovative instructional laboratory curricula that provide students with a solid foundation in quantum science. This presentation will showcase several case studies, including "Decohering Michelson" and "Chloroforming Deutsch & Jozsa," which demonstrate how theoretical quantum concepts can be effectively translated into practical laboratory implementations. These laboratory experiences cultivate critical skills—quantum state characterization, gate calibration and compilation, tomography, noise analysis, and signal processing—bridging the gap between abstract quantum theory and technical proficiencies demanded by the quantum workforce. The approach effectively complements traditional educational programs at both advanced undergraduate and early graduate levels, providing students with a unique foundation whether they enter industry or pursue further graduate studies in the field.

5:15pm **AQS-SuA-10 Invited Paper*, Kasra Sardashti,*** Laboratory for Physical Sciences **INVITED**

5:45pm **AQS-SuA-12 Quantum Information Science at Brookhaven Lab and the Role of DOE Laboratories in National Research Priorities*, Charles Black,*** Brookhaven National Laboratory **INVITED**

The DOE National Laboratories are a network of mission-driven research organizations that address national-scale challenges through transformative science and technology. Comprising 17 locations and over 20,000 scientists and engineers, the Labs operate major scientific facility infrastructure and lead long-term, coordinated efforts that require deep and broad scientific expertise. The DOE Labs are central to the national strategy for quantum information science (QIS). Through the National Quantum Information Science Research Centers and the broader DOE science portfolio, the Labs are strengthening the QIS ecosystem to support U.S. science leadership, economic competitiveness, and national security.

Brookhaven Lab is the lead institution for the Co-Design Center for Quantum Advantage (C2QA), a multi-institutional partnership among national labs, universities, and industry. C2QA’s five-year goal is to overcome foundational limitations in quantum systems and deliver sufficient coherence and connectivity to enable scientific applications of national importance.

In this presentation, I will highlight Brookhaven Lab’s contributions to C2QA, including highly productive partnerships with university groups on coherence-driven materials design, unique materials characterization using synchrotron X-rays at the National Synchrotron Light Source II, and the application of domain expertise in nuclear and high energy physics to demonstrate the potential of near-term quantum systems for solving DOE mission priority problems

6:15pm **AQS-SuA-14 Panel Discussion*,***

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