Schedule for WKS15 –Industrial and Academic Engineering Challenges for Quantum Systems

Silicon Spin Qubit Session (Chair: Ryoichi Ishihara):

10:00 AM-10:45 **Bill Coish (McGill)**
"Scaling quantum computers based on spins in silicon: Interconnects and readout"

10:45-11:30 **Nathan Bishop (Intel)**
"Intel Qubits for Research Partners"

Superconducting Qubit Session (Chair: Tom Watson):

1:00-1:45 **Andrei Vrajitoarea (NYU)**
"Challenges and Opportunities in Controlling Photonic Quantum Matter with Superconducting Qubits"

1:45-2:30 **Alex Opremcak (Google)**
"Resisting high-energy impact events through gap engineering in superconducting qubit arrays"

Government Session (Chair: Anthony Sigillito):

3:00-3:30 **Chris Richardson (LPS)**
The Laboratory for Physical Sciences Qubit Collaboratory, a different research center model

3:30-4:00 **Nicolas Doiron-Leyraud (MEIE)**
Building a collaborative quantum technologies ecosystem in Québec: a governmental perspective

4:00-4:30 **Roundtable Discussion (All invited speakers)**

Detailed Schedule:

Session I – Semiconducting Qubits

10:00 AM-10:45 AM

Scaling quantum computers based on spins in silicon: Interconnects and readout

Bill Coish
Associate Professor
Department of Physics
McGill University

Abstract:
There are intrinsic advantages to a quantum computing platform based on the spins of electrons or holes in silicon. These include their small size, the possibility to leverage existing industrial fabrication methods, and the fact that the two-qubit interactions mediated by exchange are highly local, potentially minimizing crosstalk and improving scalability. Disadvantages include unwanted charge/spin noise leading to decoherence, the problem of integrating sufficiently many gates for control/readout in a small form factor, and potential difficulties in engineering a readout that is sufficiently fast and high-quality to perform quantum error correction. In this talk, I will briefly review how the community has met these challenges, with an emphasis on strategies for integrating long-range interconnects and for improving readout. I will then briefly highlight 2-3 recent examples from my own research group, where we have used physics-informed design principles to suggest novel strategies that could significantly improve long-range interconnects and readout in these systems with minimal technological requirements.

10:45 AM-11:30 AM

Intel Qubits for Research Partners

Nathan Bishop (Intel)

Abstract: TBD

Session II – Superconducting Qubits

1:00 PM – 1:45 PM

Challenges and Opportunities in Controlling Photonic Quantum Matter with Superconducting Qubits

Author: Andrei Vrajitoarea
Assistant Professor
New York University

Abstract:

A central challenge of modern quantum science is learning how to create and control highly-entangled quantum states in a synthetic many-body system. This has promising applications across various research fields, from quantum computing to many-body physics and quantum-enhanced metrology. Analog quantum simulators provide a rich playground for investigating the collective phenomena that emerge in these synthetic quantum systems, and for identifying novel ways to leverage these few-body effects for future quantum technologies.

In this talk, I will describe various techniques for assembling and probing quantum matter from strongly interacting microwave photons using superconducting circuits. We showcase these techniques on an array of capacitively coupled transmon qubits acting as a Hubbard model for photons. Capitalizing on the precise time- and space-resolved control of the lattice potential landscape has played a pivotal role in our platform for adiabatically preparing quantum fluids of light and investigating many-body quantum dynamics. While these techniques have thus far relied entirely on the classical control of the lattice, harnessing the intrinsic quantum nature of our sites unlocks a new capability to evolve our photonic material under a quantum superposition of different lattice configurations. We demonstrate this concept with a quantum-controlled photonic transistor by employing ancilla-conditioned many-body transport, whereby the orchestrated interference and freezing of the dynamics produces highly entangled cat states useful for quantum information and metrology.

1:45 PM-2:30 PM

Resisting high-energy impact events through gap engineering in superconducting qubit arrays

Author: Alex Opremcak
Google Quantum AI

Abstract:

Quantum error correction (QEC) provides a practical path to fault-tolerant quantum computing through scaling to large qubit numbers, assuming that physical errors are sufficiently uncorrelated in time and space. In superconducting qubit arrays, high-energy impact events produce correlated errors, violating this key assumption. Following such an event, phonons with energy above the superconducting gap propagate throughout the device substrate, which in turn generate a temporary surge in quasiparticle (QP) density throughout the array. When these QPs tunnel across the qubits' Josephson junctions, they induce correlated errors. Engineering different

superconducting gaps across the qubit's Josephson junctions provides a method to resist this form of QP tunneling. By fabricating all-aluminum transmon qubits with both strong and weak gap engineering on the same substrate, we observe starkly different responses during high-energy impact events. Strongly gap engineered qubits do not show any degradation in T1 during impact events, while weakly gap engineered qubits show events of correlated degradation in T1. We also show that strongly gap engineered qubits are robust to QP poisoning from increasing optical illumination intensity, whereas weakly gap engineered qubits display rapid degradation in coherence. Based on these results, gap engineering mitigates the threat of high-energy impacts to QEC in superconducting qubit arrays.

Session III – Government Session

3:00 PM-3:30 PM

The Laboratory for Physical Sciences Qubit Collaboratory, a different research center model

Chris Richardson
Laboratory for Physical Sciences, College Park, MD 20740

Abstract:

This workshop presentation will provide an overview of the Laboratory for Physical Sciences (LPS) Qubit Collaboratory (LQC), one of 13 Quantum Information Science Research Centers supporting the National Quantum Initiative. The LQC mission is to pursue research in disruptive qubit devices, contribute to the development of a quantum information science workforce, and develop deep partnerships in the QIS community. The LQC Qubits for Computing Foundry will also be highlighted. This program creates partnerships between research groups and state-of-the-art foundry services to ease the device fabrication burden necessary to conduct quantum computing hardware focused research.

3:30 PM-4:00 PM

Building a collaborative quantum technologies ecosystem in Québec: a governmental perspective

Nicolas Doiron-Leyraud PhD
Conseiller émérite en technologies quantiques
Direction de la recherche collaborative

4:00-4:30

Roundtable Discussion (All invited speakers)