Quantum Information Science Focus Topic
Room 302 - Session QS+EM+MN+NS-ThA

The Quantum Metrology Revolution
Moderator: Dave Pappas, Rigetti Computing

2:20pm **QS+EM+MN+NS-ThA-1 Magnetic Textures in Quantum Materials Revealed by SQUID-on-tip Microscopy**, ***Ella Lachman,*** Rigetti Computing **INVITED**

Quantum materials are rapidly emerging as the basis for possible novel computation devices. However, fully understanding the interplay between magnetic and electronic excitations prevents us from realizing their full potential. In my talk, I will present the nano-SQUID-on-tip device and the scanning microscope built around it. Originally built to study superconducting vortex dynamics, this microscope has unprecedented magnetic sensitivity and spatial resolution.

I will show how expanding the microscope's range and realizing the microscopic magnetic textures in quantum materials is crucial to the understanding of transport phenomena on the macro scale. This will be demonstrated with two examples from two different types of materials. First, I will show how scanning nanoSQUID-on-tip magnetic imaging of magnetically doped topological insulators reveals the underlying fragility of the Quantum Anomalous Hall effect at elevated temperatures. Then, I will show how with a combination of transport, magnetization, and magnetic imaging of the Weyl semimetal $Co_3Sn_2S_2$, we find that the dynamics of domain walls are responsible for the anomalous transport behavior in the material.

These examples show that better understanding of the microscopic magnetism in these systems reveal new phenomena and deepen our understanding of the interplay between magnetic textures and electronic properties.

3:00pm **QS+EM+MN+NS-ThA-3 Quantum-Based Measurements for Pressure and Vacuum and the NIST on a Chip Program**, ***Jay Hendricks,*** *B. Goldstein,* NIST

The world of pressure and vacuum measurements and standards is currently undergoing a revolution in both measurement traceability, "the fundamental philosophy behind a measurement chain back to primary units", and measurement technology, the "how a measurement is made".This keynote presentation covers a bit of metrology history of how we got to where we are today and gives a forward-looking vision for the future.The role of NIST as a National Metrology institute is described along with an explanation of how and why our world-wide standards changed on May 20th, 2019.The NIST on a Chip program (NOAC) is introduced which seeks to utilize fundamental physics and laws of nature to develop quantum-based sensors and standards that one day may be miniatured to the chip scale.The technical core of the lecture will be a deeper dive into new research on measurement methods for pressure, the Fixed Length Optical Cavity (FLOC) and for vacuum, the Cold Atom Vacuum Standard (CAVS).What is exciting about these new measurement approaches is that they are both primary (relying on fundamental physics), are quantum-based and use photons for the measurement readout which is key for taking advantage of the fast-growing field of photonics. The FLOC will enable the elimination of mercury barometers pressure standards worldwide and the CAVS will be first primary standard for making vacuum measurements below 1.3x10-5 Pa.

3:20pm **QS+EM+MN+NS-ThA-4 Materials and Devices for Efficient Quantum Memories and Sensors**, ***Lee Bassett,*** University of Pennsylvania **INVITED**

Certain point defects in semiconductors exhibit quantum-mechanical features comparable to isolated atoms or molecules, in a solid-state materials platform amenable to nanofabrication, heterointegration with other materials and classical devices, and large-scale system engineering. Well-known quantum point defects such as the diamond nitrogen-vacancy center are leading candidates as robust quantum memories, versatile quantum sensors, and efficient light-matter interfaces. Meanwhile it is increasingly clear that alternative materials and defect systems offer potential advantages and new capabilities for quantum science [1]. However, millions of potential defects exist, and their identification is often tedious and challenging. This talk will introduce the opportunities and challenges of identifying point defects, including several new approaches to efficiently predict, characterize, and engineer their properties for quantum science and technology.

[1] L. C. Bassett, A. Alkauskas, A. L. Exarhos, and K.-M. C. Fu, "Quantum defects by design" Nanophotonics 8, 1867 (2019).

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Author Index

Bold page numbers indicate presenter