Quantum Science and Technology Mini-Symposium
Room 123 - Session QS-WeM

Quantum Technologies: From Networks and Education to Sensors and User Facilities

Moderators: Vijaya Begum-Hudde, University of Illinois at Urbana-Champaign, **Sean Jones**, Argonne National Laboratory

8:00am **QS-WeM-1 The New York Quantum Network: An Advanced Platform for Experiments in Real-Life Conditions***, **Gabriella Carini**,* Brookhaven National Laboratory **INVITED**

The BNL – SBU (Brookhaven National Laboratory – Stony Brook University) team has built one of the longest and most advanced quantum networks now covering more than 161 miles with five distinct nodes on Long Island. The network uses commercial optical fibers and operates at standard telecommunication wavelengths. It includes quantum memories and remote-control capabilities. Research to expand the use of different quantum platforms and network links including free space link for a truly heterogeneous quantum network is ongoing. The team is focused on developing quantum network key technologies as well as novel applications of entanglement distribution network. An overview of the activities will be presented at the conference.

8:30am **QS-WeM-3 Building Quantum Information Science Capabilities at HBCUs: Insights and Recommendation***, K. Lee,* IBM*; M. Lowe,* IBM HBCU Quantum Center, Howard University*; **Thomas A. Searles**,* University of Illinois - Chicago

The IBM HBCU Quantum Center is at the forefront of revolutionizing Quantum Information Science and Engineering (QISE) education and research through a one-of-a-kind industry academic partnership. In this presentation, we delve into various strategies for building Quantum Information Science and Engineering (QISE) capabilities at Historically Black Colleges and Universities (HBCUs), drawing insights from initiatives such as the IBM HBCU Quantum Center while considering the broader context. Our discussion encompasses the current status of QISE initiatives at HBCUs, including curriculum development, research capabilities, and faculty demographics across physics, computer science, and engineering departments.

We explore the interdisciplinary nature of quantum education and research, emphasizing collaborative efforts aimed at equipping students with the skills necessary for success in advanced computing technologies of the future. Drawing upon the experiences and achievements of HBCUs involved in quantum initiatives, we offer actionable recommendations for enhancing capacity-building efforts. These recommendations encompass curriculum enhancement, faculty recruitment and retention strategies, research collaboration frameworks, and initiatives to promote diversity and inclusion across disciplines.

In conclusion, this presentation provides a comprehensive overview of the ongoing efforts to build QISE capabilities at HBCUs, informed by both specific initiatives such as the IBM HBCU Quantum Center and broader trends within the HBCU community. Through collaboration and strategic investment, we can further advance quantum education and research, ensuring that HBCUs play a pivotal role in shaping the future of quantum information science.

8:45am **QS-WeM-4 The UCSB NSF Quantum Foundry***, **John Harter**,* UC Santa Barbara **INVITED**

Founded through the NSF's Q-AMASE-i initiative, the Quantum Foundry at UC Santa Barbara is a next generation materials foundry that develops materials and interfaces hosting the coherent quantum states needed to power the coming age of quantum-based electronics. The mission of the Foundry is to develop materials hosting unprecedented quantum coherence, train the next generation quantum workforce, and to partner with industry to accelerate the development of quantum technologies. In this talk, I will present a broad overview of the activities and services of the UCSB NSF Quantum Foundry over the last several years.

9:15am **QS-WeM-6 Recent Progress in Quantum Applications via the Q-One Single Ion Implantation System***, G. Aresta, K. Stockbrodge,* Unit B6, UK*; **Kate McHardy**, P. Blenkinsopp,* Ionoptika Ltd., UK

Quantum computing has the potential to revolutionize many aspects of modern technology, including digital communications, “quantum-safe” cryptography, and incredibly accurate time measurements. The development of this technology represents the next great frontier of science and engineering.

Devices based on single impurity atoms in semiconductors are receiving attention as potential quantum technologies and shown to be promising proof-of-concept.

However, such devices are incredibly challenging to manufacture, as single atoms must be placed within nanometric precision in isotopically pure host matrix such as ^{28}Si.

All working devices thus far have been fabricated using hydrogen lithography with an STM followed by atomic layer deposition. This is labor-intensive and requires several days of meticulous preparation to create just a single quantum bit (qubit).

Real-world devices will require arrays of hundreds or thousands of impurity atoms, highlighting the requirement for a scalable method of positioning single atoms with nanometer precision.

In 2019, Ionoptika launched a new commercial focused ion beam (FIB) instrument specifically made for the fabrication of quantum materials and devices via single ion implantation, the Q-One.

With a continuously expanding range of available ion species, a high-resolution mass-filter system, high-precision stage and proven capability of single ion deterministic implantation with isotopic resolution, Q-One is, nowadays, the instrument of choice for Universities and Research Institutes.

During last year’s AVS Conference we reported on the overall Q-One performances and Liquid Metal Alloy Ion source development carried out at Ionoptika, since the instrument launch.

This year we will report on the results achieved with the Q-One instrument by different research groups. Due to the fact that the ion dose delivered to the sample can be adjusted across a wide range, providing many nanoscale material engineering capabilities in a single tool, examples of the Q-One use as a photolithographic tool, to achieve a ^{28}Si matrix, and single ion implantation will be reported and discussed.

9:30am **QS-WeM-7 Laying the Foundation for a Global Quantum EconomyThrough Sensors and Standards***, **Barbara Goldstein**,* NIST **INVITED**

Bringing quantum technologies out of the lab and into the market requires a new foundation of metrology and standards. Quantum 2.0, which exploits properties like superposition and entanglement, presents a new suite of parameters to measure, requires the characterization of components in new environments such as at cyrogenic temperatures, and challenges us to come up with benchmarks that work across multiple and rapidly changing hardware platforms, such as for quantum computing and networking. This talk will explore the role of standards in critical and emerging technologies, how the broader quantum community is working together to develop pre-standards (NMI-Q) and standards (IEC/ISO JTC-3), and will provide an overview of the NIST on a Chip program which is developing a suite of intrinsically accurate, fit-for-function quantum-based sensors and standards.

11:00am **QS-WeM-13 PARADIM: An NSF-Supported National User Facility that can help YOU Discover and Perfect Quantum Materials***, **Darrell Schlom**,* Cornell University **INVITED**

Creating quantum materials with unprecedented properties, by design rather than by serendipity, is accomplished in PARADIM through a synergistic set of user facilities dedicated to theory, synthesis, and characterization. Each of these world-class user facilities is equipped with the latest tools, techniques, and expertise to help users like you realize this materials-by-design dream. Users from throughout the nation are using PARADIM to discover and create quantum materials.*

PARADIM’s vision is to democratize materials discovery in the U.S.A. and to enable a more effective way of pursuing materials research, one that accelerates materials discovery by establishing a materials discovery ecosystem—a national community of practitioners—and equipping them with theoretical and experimental methods that enable them to reduce to practice the inorganic materials of which they dream. Among the tools that PARADIM provides it users are:

• A fully automated MBE system in which users can select among 62 elements of the periodic table and grow at substrate temperatures as high as 2000 °C—the most elements and the hottest growth temperatures of any MBE system in the world—to make the inorganic materials desired. Any 11 of these elements may be loaded into the MBE system at one time.

• An *in situ* UHV connection between PARADIM's 62-element MBE system and a spin-resolved ARPES system enabling users to determine the electronic structure of the new materials and interfaces they create.

• A scanning transmission electron microscope that has achieved the highest resolution ever reported (0.16 Å). This is made possible by a new electron microscope pixel array detector (EMPAD), developed at Cornell, and made available first in PARADIM's electron microscopy user facility.

Use of PARADIM facilities and associated user facilities at Cornell and Johns Hopkins is free to users from academia and national labs from the U.S.A. provided their 2-page proposal is highly ranked by PARADIM's User Proposal Review Committee. All data from PARADIM facilities is recorded and stored for future use. After a period of inactivity or completion of scientific publications by the primary users, all data associated with user projects is made publicly available. PARADIM is also open to users from industry, who pay for access to PARADIM user facilities, but whose data are never made public.

*The capabilities and success stories described in this talk made use of the facilities of the *Platform for the Accelerated Realization, Analysis, and Discovery of Interface Materials* (PARADIM), which are supported by the National Science Foundation under Cooperative Agreement No. DMR-2039380.

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