Free Online Quantum Engineering Workshop 2022

Wed, May 25, 2022 8:30 AM – 6:30 PM PDT

Sponsored by the American Society of Mechanical Engineers
(Journal of Autonomous Vehicles and Systems)

About this event: Workshop brings classical engineering and quantum mechanics together to explore the opportunities at the interface.

This is the second workshop in quantum engineering. The quantum engineering workshop aims to bring the engineering and physics experts together and promote and explore the interface of classical engineering (such as mechatronics, instrumentation and robotics) and quantum mechanics (such as the applications of quantum entanglement, cryptography, and teleportation).

Online event - the webinar link will be emailed to the participants closer to the event

The information about the past event, the 2021 workshop, is available here:
https://www.cpp.edu/faculty/fkhoshnoud/quantumengineeringworkshopflyer2021

May 25, 2022 (Online event - the webinar link will be emailed to the participants closer to the event)

Agenda & Speaker Bios

Agenda

Wednesday May 25th (Pacific Time Zone)

8:20 am - 8:30 am - Opening

8:30 am - 9:00 am; TBA

9:00 am - 9:30 am; Dr. Marco Quadrelli, Jet Propulsion Laboratory

9:30 am - 10:00 am; Prof. Prem Kumar, ECE and Physics, Northwestern University

10:00 am - 10:30 am; Break

10:30 am - 11:30 am; Prof. Steven M. Girvin, Yale University

11:30 am - 12:00 pm; Prof. Edoardo Charbon, Advanced Quantum Architecture Lab (AQUA), EPFL

12:00 pm - 12:30 pm; Break

12:30 am - 1:00 pm; Dr. Kathy-Anne Brickman Soderberg, Air Force Research Laboratory (AFRL) Information Directorate

1:00 pm - 1:30 pm; Prof. Tryphon Georgiou, UC Irvine

1:30 pm - 2:00 pm; Dr. Clarice D. Aiello, UCLA

2:00 pm - 2:30 pm; Break

2:30 pm - 3:00 pm; Prof. Britton Plourde, Syracuse University

3:00pm - 3:30 pm; Dr. Alexey Gorshkov, University of Maryland

3:30 pm - 4:00 pm; Dr. Alan L. Migdall; National Institute of Standards and Technology (NIST)

4:00 pm - 4:30 pm; Break

4:30 pm - 5:00 pm; Dr. Joshua C. Bienfang; NIST

5:00 pm - 5:30 pm; Dr. Aditya N. Sharma; NIST

5:30 pm - 6:00 pm; Discussions

Speaker Bios and Abstracts

Professor Steven M. Girvin

Eugene Higgins Professor of Physics and Professor of Applied Physics, Yale University
Websites:
https://girvin.sites.yale.edu/ https://quantuminstitute.yale.edu/ https://www.bnl.gov/quantumcenter/

After graduating in a high school class of 5 students in the small village of Brant Lake, NY and completing his undergraduate degree in physics from Bates College, Dr. Girvin earned his Ph.D. in theoretical physics from Princeton University in 1977.

Dr. Girvin joined the Yale faculty in 2001, where he is Eugene Higgins Professor of Physics and Professor of Applied Physics. From 2007 to 2017 he served as Yale's Deputy Provost for Research, overseeing strategic planning for research across Yale. From 2019 to 2021, he served as founding director of the Co-Design Center for Quantum Advantage, one of five national quantum information science research centers funded by the Department of Energy.

Along with his experimenter colleagues Michel Devoret and Robert Schoelkopf, Professor Girvin co-developed 'circuit QED,' the leading architecture for construction of quantum computers based on superconducting microwave circuits.

Dr. Girvin is a Foreign Member of the Royal Swedish Academy of Sciences and Member of the US National Academy of Sciences. In 2007, he and his collaborators, Allan H. MacDonald and James P. Eisenstein were awarded the Oliver E. Buckley Prize of the American Physical Society for their work on the fractional quantum Hall effect. In 2019, he and coauthor Kun Yang published the textbook "Modern Condensed Matter Physics" with Cambridge University Press.

"Progress and Prospects for the Second Quantum Revolution"
Department of Physics & Yale Quantum Institute Yale University and Co-Design Center for Quantum Advantage Brookhaven National Laboratory

The first quantum revolution brought us the great technological advances of the 20th century—the transistor, the laser, the atomic clock and GPS, the global positioning system. A 'second quantum revolution' is now underway based on our relatively new understanding of how information can be stored, manipulated and communicated using strange quantum hardware that is neither fully digital nor fully analog. We now realize that 20th century hardware does not take advantage of the full power of quantum machines. This talk will give a gentle introduction to the basic concepts that underlie this quantum information revolution and describe recent remarkable experimental progress in the race to build quantum machines for computing, sensing and communication.

Professor Edoardo Charbon

Edoardo Charbon (SM'00 F'17) received the Diploma from ETH Zurich, the M.S. from the University of California at San Diego, and the Ph.D. from the University of California at Berkeley in 1988, 1991, and 1995, respectively, all in electrical engineering and EECS. He has consulted with numerous organizations, including Bosch, X-Fab, Texas Instruments, Maxim, Sony, Agilent, and the Carlyle Group. He was with Cadence Design Systems from 1995 to 2000, where he was the Architect of the company's initiative on information hiding for intellectual property protection. In 2000, he joined Canesta Inc., as the Chief Architect, where he led the development of wireless 3-D CMOS image sensors. Since 2002 he has been a member of the faculty of EPFL. From 2008 to 2016 he was with Delft University of Technology's as full professor and Chair of VLSI design. He has been the driving force behind the creation of deep-submicron CMOS SPAD technology, which is mass-produced since 2015 and is present in telemeters, proximity sensors, and medical diagnostics tools. His interests span from 3-D vision, LiDAR, FLIM, FCS, NIROT to super-resolution microscopy, time-resolved Raman spectroscopy, and cryo-CMOS circuits and systems for quantum computing. He has authored or co-authored over 400 papers and two books, and he holds 23 patents. Dr. Charbon is a distinguished visiting scholar of the W. M. Keck Institute for Space at Caltech, a fellow of the Kavli Institute of Nanoscience Delft, a distinguished lecturer of the IEEE Photonics Society, and a fellow of the IEEE.

"On Cryo-CMOS Qubit Control: from a Wild Idea to Working Silicon"

Abstract—The core of a quantum processor is generally an array of qubits that need to be controlled and read out by a classical processor. This processor operates on the qubits with nanosecond latency, several millions of times per second, with tight constraints on noise and power. This is due to the extremely weak signals involved in the process that require highly sensitive circuits and systems, along with very precise timing capability. We advocate the use of CMOS technologies to achieve these goals, whereas the circuits will be operated at deep-cryogenic temperatures. We believe that these circuits, collectively known as cryo-CMOS control, will make future qubit arrays scalable, enabling a faster growth in qubit count. In the lecture, the challenges of designing and operating complex circuits and systems at 4K and below will be outlined, along with preliminary results achieved in the control and read-out of qubits by ad hoc integrated circuits that were optimized to operate at low power in these conditions. The talk will conclude with a perspective on the field and its trends

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Dr. Clarice D. Aiello

Prof. Clarice D. Aiello is a quantum engineer interested in how quantum physics informs biology at the nanoscale. She is an expert on nanosensors harnessing room-temperature quantum effects in noisy environments. Aiello received her Ph.D. from MIT in Electrical Engineering and held postdoctoral appointments in Bioengineering at Stanford, and in Chemistry at Berkeley. She joined UCLA in 2019, where she leads the Quantum Biology Tech (QuBiT) Lab.

"From nanotech to living sensors: unraveling the spin physics of biosensing at the nanoscale"

Substantial in vitro and physiological experimental results suggest that similar coherent spin physics might underlie phenomena as varied as the biosensing of magnetic fields in animal navigation and the magnetosensitivity of metabolic reactions related to oxidative stress in cells. If this is correct, organisms might behave, for a short time, as "living quantum sensors" and might be studied and controlled using quantum sensing techniques developed for technological sensors. I will outline our approach towards performing coherent quantum measurements and control on proteins, cells and organisms in order to understand how they interact with their environment, and how physiology is regulated by such interactions. Can coherent spin physics be established – or refuted! – to account for physiologically relevant biosensing phenomena, and be manipulated to technological and therapeutic advantage?

Professor Britton Plourde

Britton Plourde is a Professor of Physics at Syracuse University where he runs a low-temperature research lab focused on the design, fabrication, and measurement of superconducting circuits for quantum information processing. He received his Ph.D. in Physics from the University of Illinois at Urbana-Champaign in 2000, then worked on superconducting flux qubit experiments as a postdoc with John Clarke at UC Berkeley until 2005, at which time he joined the faculty at Syracuse. Some of his many contributions to the field include investigations of decoherence mechanisms related to trapped vortices and quasiparticles, parametric driving schemes for coupling qubits and resonant modes, and digital coherent control and readout of superconducting qubits. He received an NSF CAREER Award and the IBM Faculty Award. From 2013-2019 he was the Editor-in-Chief of the IEEE Transactions on Applied Superconductivity, and from 2021-2022 he was the Editor-in-Chief of the IEEE Transactions on Quantum Engineering.

"Protecting Superconducting Qubits from Environmental Poisoning"

Superconducting circuits are an attractive system for forming qubits in a quantum computer because of the natural energy gap to excitations in the superconductor. However, experimentally it is observed that superconducting qubits have excitations above the superconducting ground state, known as quasiparticles, at a density that is many orders of magnitude above the expected equilibrium level. These quasiparticles are dissipative and can directly impact qubit coherence; in some cases, quasiparticle poisoning bursts can lead to correlated errors between qubits across an array, a process that is fatal to quantum error correction schemes. Quasiparticles can be generated by a range of energy-deposition sources, including photons from the qubit environment with energy above the superconducting gap, or the impact of high-energy particles from background radioactivity or cosmic ray muons. I will give an overview of these various quasiparticle poisoning mechanisms and describe some recent experiments in my lab to study correlated quasiparticle poisoning in multiqubit chips. In this case, the correlations are due to energetic phonons traveling through the device substrate. We have implemented a technique for using thick normal-metal reservoirs on the back-side of the qubit chip for downconverting these phonons to energies below the superconducting gap. We demonstrate a decrease in the flux of poisoning phonons by more than a factor of 20 and a two order-of-magnitude reduction in correlated poisoning due to ambient radiation. This approach reduces correlated errors due to background radiation below the level necessary for fault-tolerant operation of a multiqubit array.

Dr. Alexey Gorshkov

Alexey Gorshkov received his A.B. and Ph.D. degrees from Harvard in 2004 and 2010, respectively. In 2013, after three years as a Lee A. DuBridge Postdoctoral Scholar at Caltech, he became a staff physicist at NIST. At the same time, he started his own research group at the University of Maryland, where he is a fellow of the Joint Quantum Institute and of the Joint Center for Quantum Information and Computer Science. His theoretical research is at the interface of quantum optics, atomic physics, condensed matter physics, and quantum information science. Applications of his research include quantum computing, quantum communication, and quantum sensing. He is a recipient of the 2020 Arthur S. Flemming Award, the 2020 APS Fellowship, the 2019 PECASE, and the 2018 IUPAP Young Scientist Prize in AMO Physics.

"Quantum Sensor Networks"

Entangling quantum sensors, such as magnetometers or interferometers, can dramatically increase their sensitivity. In this talk, we will discuss how entanglement in a network of quantum sensors can be used to accurately measure one or more properties of spatially varying fields and how to do such measurements with a minimal use of entanglement.