Where: Online/Virtual
When: 26 May, 2021
Space availability is limited
Register here

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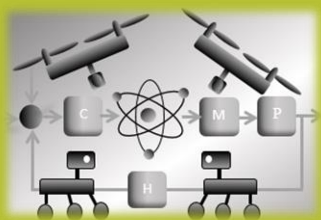

Quantum Engineering Workshop

Theory & Practice

26 May, 2021

A 1-day free online workshop

Pushing the engineering boundaries beyond existing techniques

Quantum Engineering Workshop - 26 May 2021

8:30am–8:40am - Opening

Keynote talks:

8:40–9:00
Prof. Morteza Gharib, CAST, *Caltech*
"Introduction to CAST"

9:00–9:30
Prof. Daniel Lidar, *USC*
"Demonstrating Algorithmic Breakeven in Quantum Annealing"

9:30–10:00
Prof. Prem Kumar, *Northwestern University,*
***"*Quantum Communications and Networking"**

10:00–10:30
Prof. Paul Kwiat, *University of Illinois, Urbana-Champaign*

10:30–11:00
Dr. Sanjay Padhi, *University of California, San Diego*

11:00–11:30
Dr. Marco Quadrelli, *Jet Propulsion Laboratory*
"JPL Robotics and related applications"

11:30-12:00
Prof. Alexander Lvovsky, *Oxford University*
"Optics and machine learning as symbionts"

Invited talks:

12:30-13:00
Dr. Clarice D. Aiello, *UCLA*
"Quantum Sensing/Communications"

13:00–14:00
Prof. Enrique (Kiko) Galvez, *Colgate University*
"Photon quantum mechanics and education"

14:00–15:00
Dr. Alan L. Migdall, National Institute of Standards and Technology
"multiplexed single photon sources, metrology using photon statistics"

15:00–15:30
Colonel Dr. Timothy Lawrence, US Air Force, tentative

15:30–16:30
Doug Finke, *Quantum Computing Report*
"A Tour Through the Quantum Ecosystem"

16:30–17:30
Remote hands-on quantum entanglement and cryptography experiments

Professor Daniel Lidar

Daniel Lidar is the holder of the Viterbi Professorship of Engineering at the University of Southern California, and researches quantum information processing. He holds join appointments in the departments of Chemistry and Physics, is the Director of the USC Center for Quantum Information Science and Technology, and is the co-Director of the USC-Lockheed Martin Center for Quantum Computing. He did his postdoctoral work at UC Berkeley after receiving his Ph.D. in Physics from the Hebrew University of Jerusalem in 1997. Prior to joining USC in 2005 he was a faculty member at the University of Toronto for five years. Lidar is a recipient of a Sloan Research Fellowship, a Guggenheim Foundation Fellowship, is an elected Fellow of the American Association for the Advancement of Science (AAAS), the American Physical Society (APS), and the Institute of Electrical and Electronics Engineers (IEEE), and was a Moore Distinguished Scholar in Physics at Caltech.

Talk:
As quantum computing proceeds from perfecting physical qubits towards testing logical qubits and small scale algorithms, an urgent question being confronted is how to decide that critical milestones and thresholds have been reached. Typical criteria are gates exceeding the accuracy threshold for fault tolerance, logical qubits with higher coherence than the constituent physical qubits, and logical gates with higher fidelity than the constituent physical gates. In this talk I will argue in favor of a different criterion I call "quantum algorithmic breakeven", which focuses on demonstrating an algorithmic scaling improvement in an error-corrected setting over the uncorrected setting. I will present evidence that current experiments with commercial quantum annealers have already crossed this threshold. I will also discuss our latest evidence for a “limited quantum speedup” with such devices. The lessons we have learned from experimenting with commercial devices with many noisy qubits will hopefully inform other approaches to quantum computing.

Professor Paul G. Kwiat

Paul G. Kwiat is the Bardeen Chair in Physics, at the University of Illinois, in Urbana-Champaign, and is the inaugural Director of the Illinois Quantum Information Science and Technology Center (IQUIST). A Fellow of the American Physical Society and the Optical Society of America, he has given invited talks at numerous national and international conferences, and has authored over 160 articles on various topics in quantum optics and quantum information, including several review articles. His research focuses on optical implementations of quantum information protocols, particularly using entangled—and hyperentangled—photons from parametric down-conversion. He received the Optical Society of America 2009 R. W. Wood Prize, as the primary inventor of the world’s first sources of polarization-entangled photons from down-conversion, which have been used for quantum cryptography, dense-coding, quantum teleportation, quantum metrology, and realizing optical quantum gates. He has also done pioneering work on high-efficiency single-photon detectors, frequency-upconversion-based detection, and high-speed quantum random number generation.

Professor Alexander Lvovsky

Alexander Lvovsky is an experimental physicist. He was born and raised in Moscow and did his undergraduate in Physics at the Moscow Institute of Physics and Technology. In 1993, he became a graduate student in Physics at Columbia University in New York City. His thesis research, conducted under the supervision of Dr. Sven R. Hartmann, was in the field of coherent optical transients in atomic gases. After completing his Ph. D. in 1998, he spent a year at the University of California, Berkeley as a postdoctoral fellow in the Department of Physics, and then five years at Universität Konstanz in Germany, first as an Alexander von Humboldt postdoctoral fellow, then as a research group leader in quantum-optical information technology. In 2004 he became Professor in the Department of Physics and Astronomy at the University of Calgary, and from autumn 2018, a professor at the University of Oxford. Alexander has also been a part of the team that created the Russian Quantum Center, and, since 2013, he has been working there as a part-time research group leader. Alexander is a past Canada Research Chair, a lifetime member of the American Physical Society, a Fellow of the Optical Society and a winner of many awards – most notably the International Quantum Communications award, commendation letter from the Prime Minister of Canada and the Emmy Noether research award of the German Science Foundation. His research has been featured by CBC, NBC, Wired, New Scientist, MIT Technology Review, TASS, Daily Mail, and other media.

Talk:
Optics and machine learning are natural symbionts. I will present three examples of how these fields can benefit each other based on our recent experimental work:

- optical neural networks and their all-optical training;
- robotic alignment of optical experiments;
- application of machine learning in linear-optical far-field superresolution imaging.

Dr. Clarice D. Aiello
Dr. 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.

Talk: **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 Enrique J. Galvez -- Short Professional Bio

He obtained a Ph.D. in physics from the University of Notre Dame, Indiana, in 1986. He has been member of the faculty at Colgate University since 1988—currently the Charles A. Dana Professor of Physics and Astronomy. His research interests include atomic and optical physics and physics education. Recent research projects include studies of light in complex scalar and vector modes, and photon entanglement. Educational projects include modernizing the introductory physics curriculum and the development new laboratories to teach about light and quantum mechanics. He is a Fellow of OSA and has received two APS awards.

Talk: **Photon Quantum Mechanics and Education**

Technological advances in the production and detection of single photons has opened new opportunities for teaching the fundamentals of quantum mechanics via hands-on laboratories. The rise of quantum information has only underscored the need for students to confront the counter intuitive aspects of quantum physics and their contrast with classical physics. The future workforce needs to understand these concepts deeply along with the quantum formalism and statistics. Photon laboratories provide a platform for understanding both the fundamental concepts and their application to physical systems.

Dr. Alan Migdall
Dr. Migdall's current interests broadly cover quantum optics with research related to single-photon sources, detectors, processors, and quantum memory for quantum cryptography and quantum computation. Specific efforts involve **correlated two-photon light** (https://www.youtube.com/watch?v=1MaOqvnkBxk), nonlinear optics, parametric downconversion, Raman scattering, microstructure fibers, multi-particle entanglement, **randomness generation** (http://www.nist.gov/itl/csd/ct/nist_beacon.cfm), and classical and quantum metrology.

Migdall leads the Quantum Optics Group of the Quantum Measurement Division at NIST. He is a fellow of the Joint Quantum Institute at the University of Maryland and a fellow of the American Physical Society. He has organized a number of conferences and workshops on single photon detector and source technologies, as well as the applications and metrology of that technology. He founded the Single Photon Workshop, which debuted at NIST in Gaithersburg in 2003 and has continued biannually at metrology and national labs in the US and around the world. He was editor of a book entitled Single Photon Generation and Detection.

Migdall has been part of a number of science outreach efforts including the OSA Eastman/Presidential Speaker program, giving lectures at numerous universities and colleges, as well as local high schools, middle schools, and elementary schools. He has provided research opportunities for graduate, undergraduate, and high school students. In addition, he was the science advisor for a National Academy of Sciences middle school optics curriculum program.

Migdall began his career at NIST with an NRC postdoctoral fellowship in laser cooling and trapping of neutral atoms, was made a fellow of the American Physical Society in 2007, awarded a NIST Bronze medal in 2009 for his efforts in single photon technology, in 2013 and 2015 awarded patents related to single photon technology, and in 2016 was part of the team that was awarded a Commerce Dept. Gold medal for the long-sought goal of achieving a very strong test rejecting local realistic models as possible alternatives to quantum mechanics.

Talk - Part I:

The Quantum Age-
Measurements: For all time, For all people

A. L. Migdall
Joint Quantum Institute, University of Maryland &
National Institute of Standards and Technology, Gaithersburg, MD, USA

Measurement is arguably the basis of all civilization. We are born into this world measuring our environment and trying to understand it and we continue measuring for the rest of our lives. All of our measurements should rely on standards that ideally are accurate, unchanging, and universally defined. While such a solid foundation for our measurement systems has been dream since before the time of the French Revolution, it is only with the dawn of the quantum age that it could be realized. As a result, humankind just recently achieved an advance that goes beyond the level of a once-in-a-lifetime event, it achieved an advance that, hopefully, is just a once-on-a-planet event. I hope to convey the momentousness of what just occurred.

Talk - Part II:

Multiplexing: A path to an ideal single-photon source

A. L. Migdall
Joint Quantum Institute, University of Maryland &
National Institute of Standards and Technology, Gaithersburg, MD, USA

Single-photon sources, inherently nonclassical in their nature, are quite distinct from the light sources of a century ago. And since the first efforts at nonclassical sources of light a half century ago, significant progress has been made. Now, sources that produce photons in pairs, allowing for the heralding of a single photon, are the workhorse of a wide array of applications, from tests of fundamental physics to metrology, and even to biological microscopy. Single-photon sources built from processes that generate photons in pairs rely on either spontaneous parametric down-conversion or spontaneous four-wave mixing and can now achieve production rates of millions of heralded single photons per second in controlled states, with tailored spectral properties and near-perfect spatial modes. However, because these nonlinear optical processes are inherently probabilistic, they cannot simultaneously achieve a high probability of producing a photon and a high single-photon fidelity. This inherent tradeoff can be a severe constraint in many applications.

The multiplexing of many of these probabilistic single-photon sources offers a path to overcoming this tradeoff. By having many low-probability-of-generation, but high-fidelity heralded single-photon sources, it is possible to create a system that boosts the probability of successfully generating an output, while retaining high single-photon fidelity. Multiplexing of such sources is achieved through the use of time, space, and/or frequency to parallelize the spontaneous photon creation, then actively switch the photons into a single mode or actively switch the pumping laser based on feedback from heralding detection events.

We review some of the history and recent exponential progress in this exciting field. From a few theoretical proposals around the beginning of this millennia, the field has sharply grown: numerous distinct multiplexing schemes have been proposed, with many experiments realized in just the past few years, a rate which is strongly increasing. It seems likely that through the use of source multiplexing, one can expect that ten-photon states at rates of $\approx 10^3$ /s are within immediate reach, and 50 photons, enough for a conclusive quantum advantage over classical computers, are no longer a pipe dream.

Doug Finke
Doug Finke is Managing Editor of the Quantum Computing Report which he founded in 2015 so he could apply his wide breadth of experience to help accelerate the proliferation of quantum computing to the general marketplace. He started his career as a mainframe computer design engineer at IBM and subsequently served in a variety of executive roles in marketing, engineering, and operations at Intel, Western Digital, Corning, and several startup companies. Doug holds degrees in computer engineering and management from the University of Illinois and MIT respectively.

Talk: **A Tour Through the Quantum Ecosystem**
The presentation would show all the different industry players and how they can work together to provide a complete solution to an end user. It shows a model for the complete solution stack from User Community down to the chip of what is needed to make quantum computing a reality.

Organizer: Dr. Farbod Khoshnoud
Contact: farbodk@caltech.edu

Farbod Khoshnoud, PhD, PGCE, CEng, M.IMechE, M.ASME, HEA Fellow, is a faculty member in Electromechanical Engineering at California State Polytechnic University, Pomona. His current research areas include Self-powered Dynamic Systems, Nature/Biologically Inspired Dynamic Systems, and Quantum Entanglement and Quantum Cryptography for Multibody Dynamics, Robotics, Controls, and Autonomy applications. He is a visiting associate in the Center for Autonomous Systems and Technologies in the Department of Aerospace Engineering at California Institute of Technology.

He was a research affiliate in the Mobility and Robotic Systems section at NASA Jet Propulsion Laboratory, Caltech in 2019; an Associate Professor of Mechanical Engineering at California State University, USA; a visiting Associate Professor in the Department of Mechanical Engineering at the University of British Columbia (UBC), Vancouver, Canada, in 2017; a Lecturer in the Department of Mechanical Engineering at Brunel University London, UK, 2014-16; a senior lecturer at the University of Hertfordshire, 2011-2014; a visiting scientist and postdoctoral researcher in the Industrial Automation Laboratory, Department of Mechanical Engineering, at UBC, Vancouver, 2007-2012; a visiting researcher at California Institute of Technology, USA, 2009-2011; and a Postdoctoral Research Fellow in the Department of Civil Engineering at UBC, 2005-2007. He received his Ph.D. in Mechanical Engineering from Brunel University in 2005. He has worked in industry as a mechanical engineer for over six years. He is an associate editor of the Journal of Mechatronic Systems and Control (formerly Control and Intelligent Systems); and the editor of the Quantum Engineering special issue of the Journal of Mechatronic Systems and Control.