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OSA Incubator

Emerging Connections: Quantum & Classical Optics

6-8 November 2016
Washington, DC USA

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Emerging Connections: Quantum & Classical Optics

6-8 November 2016

Washington, DC USA

HOSTED BY:

Joseph Eberly, Department of Physics & Astronomy, University of Rochester, United States

Elisabeth Giacobino, CNRS, Laboratoire Kastler Brossel, France

Gerd Leuchs, University of Erlangen & Max-Planck Institute for the Science of Light, Germany

Nick Vamivakas, Institute of Optics, University of Rochester, United States

AGENDA

Sunday, 6 November 2016

- Afternoon Arrival/Hotel Check-in
Washington Hilton, 1919 Connecticut Ave NW, Washington, DC
- 18:00 Welcome Dinner
Mourayo, 1732 Connecticut Ave NW, Washington, DC

Monday, 7 November 2016

- 8:00 Breakfast
AGU, 2000 Florida Ave NW, Washington, DC
- 8:30 **Welcome**
Elizabeth Rogan, CEO, OSA
- 8:45 **Program Overview and Goals**
Hosts

Session 1 Chair: Ari Tapio Friberg, Itä-Suomen Yliopisto, Finland

- 9:00 **The Quantum-Classical Interplay: Three Lessons Drawn from Classical Light Beams**
Francisco De Zela, Pontificia Universidad Católica del Perú, Peru
- 9:30 **Emerging Connections between Classical & Quantum Optics**
Wolfgang Peter Schleich, Universität Ulm, Germany
- 10:00 Coffee Break

Monday, 7 November 2016, continued

10:30 **Entanglement & Hilbert Space Partitions – from Theory to Experiments**
Andrea Aiello, Max-Planck Institute for the Science of Light, Germany

11:00 **Facilitated Discussion**
Moderator: Ari Friberg

12:00 Lunch, provided

Session 2 Chair: Luis Sanchez-Soto, Universidad Complutense de Madrid, Spain

13:00 **Quantum Information Analogies in Classical Optics**
Antonio Khoury, Universidade Federal Fluminense, Brazil

13:30 **Non-Quantum Complementarity - Triality Rather than Duality**
Xiao-Feng Qian, University of Rochester, United States

14:00 **Exploring the Quantum/Classical Boundary with Massive Particles**
Kenneth Baldwin, Australian National University, Australia

14:30 **Facilitated Discussion**
Moderator: Luis Sanchez-Soto

15:30 Coffee Break

Session 3 Chair: Ralf Menzel, Universität Potsdam, Germany

16:00 **Classical Optical Entanglement in Space & Time:
From Diffraction-Free Beams to Omni-Resonant Optics**
Ayman Abouraddy, CREOL, University of Central Florida, United States

16:30 **Quantum Physics Inspired Optics: Partial Coherence & Bell Measurements**
Girish Agarwal, Texas A&M University, United States

17:00 **Coherence, Entanglement & Bell's Inequalities**
Juan Torres, ICFO -The Institute of Photonic Sciences, Spain

17:30 **Facilitated Discussion**
Moderator: Ralf Menzel

18:45 Dinner
Bistro Bistro, 1727 Connecticut Ave NW, Washington, DC

8:00 Breakfast
AGU, 2000 Florida Ave NW, Washington, DC

Session 4 Chair: Kenneth Baldwin, Australian National University, Australia

8:30 **Vector Light Field Coherences**
Ari Tapio Friberg, Itä-Suomen Yliopisto, Finland

9:00 **Quantum Strategies in Classical Coherence Theory**
Luis Sanchez-Soto, Universidad Complutense de Madrid, Spain

9:30 **Complementarity, Modes & Vacuum Fields**
Ralf Menzel, Universität Potsdam, Germany

10:00 **Facilitated Discussion**
Moderator: Kenneth Baldwin

11:00 Coffee Break

Session 5 Chair: Antonio Khoury, Universidade Federal Fluminense, Brazil

11:30 **Non-universal Correlations in Complex Electromagnetic Fields**
Aristide Dogariu, CREOL, University of Central Florida, United States

12:00 **Interference, Correlation & Entanglement by Path Identity**
Mayukh Lahiri, IQOQI, University of Vienna, Austria

12:30 **Classical Polarization Clarifies Quantum Entanglement**
Miguel Alonso, University of Rochester, United States

13:00 Lunch, provided

14:00 **Facilitated Discussion**
Antonio Khoury

15:00 **Final Discuss/Closing**
Hosts

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PARTICIPANT BIOGRAPHIES

Ayman Abouraddy



Ayman F. Abouraddy received the B.S. and M.S. degrees from Alexandria University, Alexandria, Egypt, in 1994 and 1997, respectively, and the Ph.D. degree from Boston University, Boston, MA, in 2003, all in electrical engineering. In 2003 he joined the Massachusetts Institute of Technology (MIT), Cambridge, as a postdoctoral fellow working with Prof. Yoel Fink and Prof. John D. Joannopoulos, and then became a Research Scientist at the Research Laboratory of Electronics in 2005. At MIT he pursued research on novel multi-material optical fiber structures, photonic bandgap fibers, nanophotonics, fiber-based optoelectronic devices, and mid-infrared nonlinear fiber optics. He has also been engaged in investigating techniques that lead to sub-diffraction-limited resolution in optical microscopy and lithography. He is the coauthor of more than 70 journal publications, 160 conference presentations, and 65 invited talks; he holds seven patents, and has three patents pending. His research also encompasses quantum optics and quantum information processing. He joined CREOL, The College of Optics & Photonics, at the University of Central Florida as an assistant professor in September 2008. He continues to pursue research testing the foundations of quantum mechanics and implementing optical realizations of quantum computation. He is particularly interested in the foundations of classical and quantum optics. He was awarded tenure and promoted to associate professor in August 2014.

Girish Agarwal

He is best known for his pioneering contributions to quantum optics, quantum statistics and coherent control of quantum systems. He has also made major contributions to the fields of nonlinear optics, nano photonics and plasmonics. With more than 650 reviewed papers Girish S. Agarwal has contributed to a wide range of topics in the fields of optics and quantum optics. In 2013 he published a textbook Quantum Optics (Cambridge University Press), covering a wide variety of recent developments in the field, which has been well received by the community.

Andrea Aiello



Is a researcher at the Max Planck Institute for the Science of Light in Erlangen (Germany). After getting the Ph.D. in physics at the University of Rome "La Sapienza", he moved to Leiden (The Netherlands). From 2008 he has worked in Erlangen, doing research in the fields of classical and quantum optics.

Miguel A. Alonso



Miguel A. Alonso received the degree of Engineer in Physics in 1990 from the Universidad Autonoma Metropolitana in Mexico City and received the Ph.D. degree in Optics in 1996 from The Institute of Optics, University of Rochester. In 2003, he joined the faculty of the Institute of Optics. He was first Associate Editor and then Deputy Editor for Optics Express from 2002 to 2013. He is now Associate Editor for Optica, Chair of Spotlight on Optics, and a Fellow of the Optical Society.

Brian Anderson, University of Rochester, United States

Photo and bio unavailable

Ravindra Anant Athale



Dr. Athale received his B.S. (1972) from the University of Bombay and M.S. (1974) from the Indian Institute of Technology, Kanpur, both in physics. He received his Ph.D. (1980) in Electrical Engineering from the University of California, San Diego. From 1981 to 1985 he worked as a Research Physicist in the Optical Signal Processing section of Naval Research Laboratory. From 1985 to 1990 he was a Senior Principal Staff Member at BDM Corporation in McLean, VA, where he headed a group in Optical Computing and supported DARPA program in Strategic Computing. From 1990 to 2001 he was a faculty member in the Electrical and Computer Engineering Department at George Mason University, in Fairfax, VA. From 2001-2005 he was on assignment to Defense Advanced Research Projects Agency as a Program Manager in Photonics. At DARPA, he initiated programs in Chip-to-chip optical interconnects, computational imaging systems and university centers in nanophotonics. From 2005 to 2012 he was Principal Scientist in the Emerging Technology Office at MITRE Corp. where he managed an IR&D portfolio in Emerging Technologies and led a group in computational imaging. He is currently a Program Officer at Office of Naval Research managing research in imaging sensors, optical computing and nanophotonics. Dr. Athale was elected Fellow of the Optical Society in 1989. He has published over 50 journal papers including two invited papers in Proceedings of IEEE and holds several patents in the area of optical processing. Dr. Athale received Optical Society's Leadership Award - New Focus/Bookham Prize for 2005 and was awarded Secretary of Defense Medal for Exceptional Public Service.

Ken Baldwin



Professor Ken Baldwin is Deputy Director of the Research School of Physics and Engineering at the Australian National University, where he is also the Director of the Energy Change Institute. His research interests lie in two main fields: • Precision measurement, in particular the use of laser techniques (especially the generation of vacuum ultraviolet radiation <200nm) for high resolution spectroscopy of atoms and molecules; and • Quantum-atom optics, in particular laser cooling and trapping to manipulate metastable helium (He*) atoms to investigate the behaviour of ultracold quantum gases (including correlation measurements and fundamental studies in quantum mechanics), as well as precision measurement in helium. In 2007, Professor Baldwin was awarded the W.H. Beattie Steele Medal, the highest honour of the Australian Optical

Society. In 2010 he was awarded the Barry Inglis Medal by the National Measurement Institute for excellence in precision measurement. Professor Baldwin is a Fellow of the American Physical Society, the Institute of Physics (UK), the Optical Society of America and the Australian Institute of Physics. Professor Baldwin is an inaugural ANU Public Policy Fellow, and winner of the 2004 Australian Government Eureka Prize for Promoting Understanding of Science, for his role in initiating and championing “Science meets Parliament”.

Stefan Berg-Johansen



Stefan Berg-Johansen is an experimentalist with an interest in quantum optics, continuous-variable quantum information and nonseparable beams of light in both the classical and quantum pictures. He holds an MSci with first-class honours from Imperial College, London with a thesis completed at INP Grenoble, France. Presently he is a Ph.D. student with Gerd Leuchs and Christoph Marquardt at the Max Planck Institute for the Science of Light in Erlangen, Germany.

Yusui Chen



Dr. Yusui Chen is the post-doctoral fellow in Prof. Ting Yu group. His research interests are open quantum system, quantum dynamics, quantum information and quantum measurement theory. He received Physics Ph.D. degree from Stevens Institute of Technology in 2015.

Francisco De Zela



Francisco De Zela began his academic studies at Pontificia Universidad Católica del Perú (PUCP) before getting his Diplom-Physiker degree from Bonn University, Germany. After completing research stays at Rome and Vienna he returned to PUCP where he currently holds a professorship. He works as the coordinator for the double-degree program in Material Sciences, Cybernetics, Mechatronics, and Mechanical Engineering with the Technical University of Ilmenau, Germany.

Francisco is an Elected Member of the Peruvian National Academy of Sciences and an Associated Member of the International Centre of Theoretical Physics, regional center (ICTP-SAIFR). He also serves as a reviewer for the following journals: Journal of Physics B: Atomic, Molecular and Optical Physics; Journal of Physics A: Mathematical and Theoretical; New Journal of Physics; Physical Review Letters; Physics Letters A; Physica A; JOSA A; JOSA B; Optics Express; and the Canadian Journal of Physics.

Aristide Dogariu

Aristide Dogariu received his Ph.D. from Hokkaido University and he is the Florida Photonics Center of Excellence Professor of Optics. His research interests include optical physics, waves propagation and scattering, electromagnetism, and random media characterization. Professor Dogariu is a Fellow of the Optical Society, the Physical Society of America, and currently serves as the division editor of Applied Optics - Optical Technology.

Joseph Eberly



Joseph Eberly earned B.S. and Ph.D. degrees from Penn State and Stanford. He is currently the Andrew Carnegie Professor of Physics and also Professor of Optics, and teaches graduate and undergraduate classes at the University of Rochester. His research interests in quantum optics and radiation physics have led to discoveries and innovations, including predictions prompting the first observations of spontaneous collapse and revivals in cavity QED, solitonic pulse trains in resonant media, quantum non-spreading Trojan states of atomic electrons, and the sudden death effect in quantum entanglement, as well as the first laboratory production of a Bessel beam. He received the Townes Award and the Frederick Ives Medal from OSA and the Goergen Award for Creative Undergraduate Teaching from the University of Rochester. He was awarded the Smoluchowski Medal by the Polish Physical Society. Eberly has mentored more than 35 PhD graduates, and published more than 400 research papers, as well as three texts: *Optical Resonance and Two-Level Atoms* with L. Allen, and both *Lasers* and *Laser Physics* with P.W. Milonni. He was the designer and founding editor of Optics Express and has served as President of OSA and Chair of the APS Division of Laser Physics, on the APS Council and the AIP Board of Governors, and as a member of the Advisory Boards of the Santa Barbara Kavli Institute, ITAMP at Harvard-Smithsonian, and the Investment Advisory Committee of AIP. He is a Fellow of OSA and APS, and is a Foreign Member of the Polish Academy of Science.

Michael Fiddy



Michael Fiddy received his Ph.D. from the University of London in 1977, and was a physics faculty member at London University (Kings College). He moved to the University of Massachusetts Lowell in 1987 where he was ECE Department Head from 1994 until 2001. In January 2002 he was appointed the founding director of the Center for Optoelectronics and Optical Communications at UNC Charlotte. He stepped down from this position in 2010 and to launch the NSF Industry/University Collaborative Research Center for Metamaterials in 2011. He is currently on leave from UNC Charlotte, serving as a program manager at DARPA (DSO). He was editor-in-chief of the journal *Waves in Random and Complex Media* from 1996 to 2015 and is a fellow of the OSA, IOP and SPIE.

Ari Tapio Friberg



Holds Ph.D. (Rochester, 1979) and DSc Tech (Helsinki, 1993). Professor of physics at the University of Eastern Finland (UEF) since 2013, Finland Distinguished Professor (Aalto University and UEF) 2007-2012, professor of optics at KTH Stockholm 1997-2007. Visiting appointments at University of Rochester, Imperial College London, TU Berlin, and University of Neuchâtel. Main research areas are optical physics, electromagnetic optics, and nanophotonics, with long-time interest in optical coherence. Authored some 300 refereed journal articles. Fellow of OSA and SPIE, Senior member of IEEE. On editorial boards of many journals, e.g. *Progress in Optics*, and in scientific advisory committee for *European Physical Journal*. Past President of International Commission for Optics, served on the boards of many optical and physical societies.

Carla Hermann



Carla is an experimental physicist currently working as a postdoctoral research assistant at the Joint Quantum Institute, University of Maryland. Her research involves nonlinear optics, currently focusing on the generation of squeezed light from Four Wave mixing. Based on this technique we are able to generate two-mode squeezed beams whose quantum correlations are very useful for the exploration of fields such as metrology or quantum imaging.

Antonio Zelaquett Khoury



Antonio Zelaquett Khoury obtained his bachelor degree at Universidade Federal do Rio de Janeiro in 1987 and the doctor degree at Pontifícia Universidade Católica do Rio de Janeiro in 1994, working in Subpoissonian Lasers and Masers under supervision of Prof. Luiz Davidovich. From 1994 until 1996 he held a postdoc position at Universidade Federal de Pernambuco working on chaotic lasers with Prof. José Roberto Rios Leite. Then, he moved to Paris to work on squeezing with cold atoms and diode lasers at Laboratoire Kastler Brossel with Prof. Elisabeth Giacobino until 1998, when he went back to Brazil and was hired at Universidade Federal Fluminense in Niterói, nearby Rio de Janeiro. He is currently a full professor at UFF, working on experimental and theoretical problems in quantum and classical optics. His main interests include geometric and topological phases, optical beams carrying orbital angular momentum and quantum information analogies in classical optics.

Mayukh Lahiri, IQOQI, University of Vienna, Austria

Photo and bio unavailable

Alejandra Maldonado-Trapp, Joint Quantum Institute, UMD, United States

Photo and bio unavailable

Tanya Malhotra

Tanya is a Physics Ph.D. candidate at the University of Rochester and is working in Nick Vamivakas' Quantum Optoelectronics and Optical Metrology group at the Institute of Optics. The focus of her Ph.D. research is on understanding and manipulating the spatial degree of freedom of the electromagnetic fields for nanophotonics, enhanced spatial scene recognition and optical communication.

Ralf Menzel



Ralf Menzel received the diploma degree in physics in 1972 from the Technical University, Dresden. Then he worked at the Institute of Optics and Spectroscopy of the Academy of Sciences in Berlin with Prof. J. Hertz. In 1978 he received the Ph. D. degree in experimental physics. His thesis concerned nonlinear spectroscopy of electronic transitions. In 1980 he joined the chemistry department of the Technical University, Berlin (TUB). 1989 he finished his "Habilitation" in physical chemistry in the field of laser spectroscopy. Subsequently, he moved to the Optical Institute of the TUB and managed the research project "Phase conjugating SBS-mirrors for beam quality improvement of

high power solid state lasers". In 1994 he became a Full Professor for photonics, and in 1996 he was elected as vice president at the newly founded Universität Potsdam for 4 years. As a member of the QEOD-board of the EPS he arranged together with D. Hall, G. Huber, S. de Silvestri and H. Walther the start of the World of Photonics Conference in Munich. He is now working in nonlinear spectroscopy, new lasers and quantum optics.

Andreas Norrman

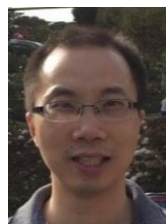


Andreas Norrman received an MSc degree from the University of Helsinki in 2011 on electromagnetic coherence and polarization of surface-plasmon polaritons. He is expected to receive his Ph.D. degree in 2016 from the University of Eastern Finland, with the thesis concerning theoretical research on plasmonics, electromagnetic coherence, and quantum complementarity. Three main topics are covered: novel surface-plasmon polariton modes at planar single-interface and metal-slab geometries, partially coherent optical surface fields, and complementarity in genuine vector-light photon interference involving polarization modulation.

Andrew Pipino

Dr. Pipino received his Ph.D. in chemical physics at Northwestern University, working with George C. Schatz and Richard P. van Duyne in the area of nonlinear plasmonics. As an NRC postdoctoral associate and staff scientist at NIST/Gaithersburg, he conceived, demonstrated, and developed evanescent wave cavity ring-down spectroscopy to enable ultra-sensitive spectroscopic studies of monolayers, thin films, and nano-materials. Dr. Pipino was a Visiting Scholar at the TU-Eindhoven in the Netherlands, a Senior Scientist at Tanner Research, Inc., and is presently supporting the EO-IR technologies program at ONR.

Xiaofeng Qian



Dr. Xiaofeng Qian received his Ph.D. degree in April 2014 from the Department of Physics and Astronomy, University of Rochester, under the supervision of Professor Joseph H. Eberly. He then became a Visiting Scientist and subsequently an Instructor/Fellow at the same institute. Since July 2015 he was employed as a Research Associate by the Institute of Optics, University of Rochester. His research focuses on both theoretical and experimental issues in quantum physics and coherence optics.

Dennis Rätzel



Dennis Rätzel studied physics at the University of Potsdam. He finished his Ph.D. about "Tensorial spacetime geometries and background-independent quantum field theory" at the Albert Einstein Institute and the University of Potsdam in 2013. Recently, he did some work about the gravitational field of laser pulses and the effect of entanglement in photon photon scattering. He holds a Feodor Lynen Fellowship by the Humboldt Foundation and is part of the Quantum Group at the University of Vienna.

Luis Sanchez Soto

Luis Sanchez Soto is a Full Professor at the Universidad Complutense in Madrid, where he is the leader of the Quantum Optics group.

Wolfgang Peter Schleich

Wolfgang P. Schleich is engaged at Universität Ulm in research on quantum optics ranging from the foundations of quantum physics via general relativity to number theory. He was educated at the Ludwig Maximilians-Universität (LMU) in Munich and studied with Marlan O. Scully at the University of New Mexico, Albuquerque, and the Max-Planck Institute for Quantum Optics, Garching. Moreover, he was also a post-doctoral fellow with John Archibald Wheeler at the University of Texas at Austin. Professor Schleich is a member of several national and international academies and has received numerous prizes and honors for his scientific work such as the Gottfried Wilhelm Leibniz Prize, the Max Planck Research Award, and the Willis E. Lamb Award for Laser Science and Quantum Optics. He is also a Fellow of the Optical Society of America, a Distinguished Adjunct Professor at the University of North Texas and a Faculty Fellow at the Texas A&M University Institute for Advanced Study. His textbook, Quantum Optics in Phase Space, has been translated into Russian and a Chinese edition was published in 2010

Bonnie Schmittberger

Bonnie L. Schmittberger is currently a postdoctoral researcher at the Joint Quantum Institute in College Park, MD working under the supervision of Dr. Paul Lett. She is studying applications of using quantum light generated by four-wave-mixing, including precision phase measurements, noiseless amplification, and photodiode calibration. She did her graduate work at Duke University in Durham, NC under the supervision of Dr. Daniel Gauthier. She received her Ph.D. in February 2016 for the experimental observation and study of coupled optical-atomic pattern formation in a multimode system and the theoretical characterization of pattern formation in sub-Doppler-cooled atoms. She received her undergraduate degree from Bryn Mawr College in Bryn Mawr, PA in May 2010. There, she did her thesis work with Dr. Michael Noel building a new pulsed diode laser system for exciting atoms to Rydberg states.

Hector Sosa, University of Maryland, United States

Photo and bio unavailable

Zuleykhan Tomova

Zuleykhan is a Ph.D. student at University of Maryland College Park in the John Fourkas Lab studying multiphoton absorption polymerization. She is currently developing a nanoscale photolithography technique using multistep absorption process in photoresist using visible light. Prior to starting Graduate School at UMD, she studied at Lomonosov Moscow State University, where she graduate

with a Bachelor degree in Physics. Zuleykhan has been actively involved in OSA through the university Student Chapter management and participant in on several OSA committees, including International Council and Centennial Advisory Panel.

Juan Torres



Juan P. Torres is professor at the Universitat Politècnica de Catalunya since 1994. In 2000 he moved towards the realm of Quantum Optics and Quantum Information, at the same time that began collaborating with ICFO-Institute of Photonic Sciences as UPC professor. During all these years he has taught different courses in his university, or invited by other universities, about Quantum Theory, Optics, Electromagnetic Theory and Telecommunications. He keeps collaborations with many research groups all around the world, which have helped him to write more than 150 papers in scientific journals. My research combines theoretical and experimental work for distilling the meaning behind quantum concepts, such as entanglement, exploring what the concepts mean and represent in experiments. Light is the main tool of our research, that encompass a fuzzy area between nonlinear and quantum optics. Nonlinear optics provides most of the experimental tools that we use in the lab, and Quantum theory provides the framework to describe the results. We generate, tailor and detect streams of photons, under different conditions, what can be generally called as quantum engineering. Our research is a mix of fundamental physics and photonics engineering, where we answer fundamental questions about Nature, and devote efforts to looking for new or simply better solutions to important problems.

Nickolas Vamivakas



Associate Professor Nick Vamivakas received his B.S. and Ph.D. from Boston University where he developed high resolution microscopy and spectroscopy techniques to study the electro-optic properties of individual nanostructures. Following his Ph.D., he was a post-doctoral scholar during 2007-2011 in the Cavendish Laboratory at the University of Cambridge, where he was a Fellow and College Lecturer, King's College. Since his arrival at the University of Rochester in 2011, he has engaged Ph.D. students in a wide range of research topics in the area of light-matter interactions and the control of light. He is particularly interested in using optics to interrogate and control both artificial and naturally occurring solid-state systems. Hybrid nanostructures consisting of solid-state quantum emitters, active and passive nanophotonic cavities and nanomechanical resonators provide the platform for his innovative studies of quantum systems, and his publications appear in physics, optics, and photonics journals. He has received the NSF *Faculty Early Career Development Award* and in 2013 he received the *Young Scientist Prize in Quantum Electronics* from the International Union for Pure and Applied Physics. In 2015 the University of Rochester presented him with the *Curtis Award for Teaching Excellence*.

Ting Yu



Prof. Ting Yu established Quantum Information and Quantum Technology Group at Stevens Institute of Technology in 2008. His current research interests span many areas of quantum information science, quantum optics and quantum open systems, including quantum foundation, quantum entanglement dynamics, quantum trajectories, the theory of non-Markovian quantum dynamics, quantum feedback control, as well as numerical simulations of many-body quantum open systems coupled to a noisy environment. Dr. Yu received his Ph.D. in Physics from Imperial College, London, UK in 1998. Since then he has worked as a postdoctoral researcher in University of Geneva and University of Rochester.

Miaochan Zhi, National Institute of Standards & Technology, United States

Photo and bio unavailable