

Identifying Opportunities at the Interface of Chemistry and Quantum Information Science

Committee

Theodore G. Goodson, III

Chair

Theodore G. Goodson, III is the Richard Barry Bernstein Collegiate Professor of Chemistry at the University of Michigan. He is also a Professor in the College of Engineering and Macromolecular Science as well as in Applied Physics at the University of Michigan. His research is in the area of physical chemistry of novel materials for optical and electronic applications. His lab investigates the properties of nanomaterials with time-resolved, nonlinear, and quantum optical methods. These studies have probed optical effects in organic chromophores and polymers as well as inorganic metal cluster systems. He has served on a previous National Research Council committee concerning laboratory safety in the Chemical Sciences. A native of Indianapolis, Indiana, Goodson studied Chemistry at Wabash College for his undergraduate degree and at the University of Nebraska-Lincoln for his Ph.D.

David D. Awschalom

Member

David D. Awschalom is the Liew Family Professor and Vice Dean of the Pritzker School for Molecular Engineering at the University of Chicago, a Senior Scientist at Argonne National Laboratory, and Director of the Chicago Quantum Exchange. He is also the inaugural director of Q-NEXT, one of the US Department of Energy Quantum Information Science Research Centers. Before arriving in Chicago, he was the Director of the California NanoSystems Institute and Professor of Physics, Electrical and Computer Engineering at the University of California – Santa Barbara. He served as a Research Staff and Manager at the IBM Watson Research Center. He works in spintronics and quantum information engineering, studying the quantum states of electrons, nuclei, and photons in semiconductors and molecules for quantum information processing. Awschalom received the American Physical Society Oliver Buckley Prize and Julius Edgar Lilienfeld Prize, the European Physical Society Europhysics Prize, the Materials Research Society David Turnbull Award and Outstanding Investigator Prize, the American Association for the Advancement of Science Newcomb Cleveland Prize, the International Magnetism Prize from the International Union of Pure and Applied Physics, and an IBM Outstanding Innovation Award. He is a member of the American Academy of Arts & Sciences, the National Academy of Science, the National Academy of Engineering, and the European Academy of Sciences. Professor Awschalom received his BSc in physics from the University of Illinois at Urbana-Champaign, and his Ph.D. in experimental physics from Cornell University.

Ryan J. Babbush

Member

Ryan J. Babbush is a researcher leading the quantum algorithms team at Google Quantum AI (Google's flagship quantum computing effort). He was the first intern of this group back in 2013 when it was four people, it has now grown to well over 100 scientists. He joined the effort full time in 2015 after finishing a Ph.D. focusing on quantum algorithms for chemistry. In 2021, he received the TR35 award from MIT Tech Review for his leading work in this area. Babbush received his Ph.D. in chemical physics from Harvard University.

Lawrence W. Cheuk

Member

Lawrence W. Cheuk is an assistant professor in the department of physics at Princeton University. His research expertise is in using atoms and laser-cooled molecules at ultracold temperatures for quantum simulation of many-body systems and quantum information processing. Cheuk is a member of the American Physics Society (APS). His relevant honors include being a finalist for the APS Division of Atomic and Molecular and Optical Physics thesis award and being awarded a Max-Planck-Harvard Quantum Optics Center post-doctoral fellowship. Cheuk obtained his Ph.D. in physics in 2017 from Massachusetts Institute of Technology, where he worked on ultracold fermionic atomic gases.

Scott K. Cushing

Member

Scott K. Cushing is an Assistant Professor at Caltech with a multidisciplinary background spanning Chemistry, Materials Science, and Physics. His research focuses on the creation of new scientific instrumentation that can translate quantum phenomena to practical devices and applications, including attosecond x-ray, ultrafast transmission electron microscopy/electron energy loss spectroscopy, and entangled photon studies. The Cushing lab is pioneering entangled photon microscopy and spectroscopy methods that can measure chemical systems without perturbation, while also obtaining new information about classical and quantum correlations. The Cushing lab has developed new entangled photon sources for chemical spectroscopy and are working towards completely on-chip, portable entangled photon spectroscopy to explore molecular systems as qubits, quantum optical components, and quantum sensors. Cushing is also exploring if excited state entanglement can lead to new reaction pathways. He has been awarded Department of Energy, Air Force Office of Scientific Research, Rose Hill, and American Chemical Society related Early Career awards amongst others. Cushing also leads a four institution, seven-person collaboration exploring nanographene-molecular qubit systems. Cushing received his Ph.D. in Physics from West Virginia University.

Natia L. Frank

Member

Natia L. Frank is an Associate Professor at University of Nevada, Reno. She began her independent career in 2000 as an Assistant Professor at the University of Washington-Seattle in the study of multifunctional magnetic materials for spintronics and biosensing. In 2005, she was recruited as a Canada Research Chair Tier II in Multifunctional Materials Chemistry at the University of Victoria where she developed optically switchable spin-based qubits for quantum science. Her primary expertise is at the interface of organic chemistry, inorganic chemistry, spin-based materials and photochemistry/electron transfer theory which allows her to be well-situated to address current challenges in molecular quantum information science: the design of molecular qubits with long decoherence times, multiqubit arrays, and qubits/qudits that can respond to external stimuli for quantum computing and sensing. Frank currently serves on two funded Department of Energy, Energy Frontiers Research Center advisory boards in quantum science, the American Chemical Society-Petroleum Research Fund Advisory Board, and has served on numerous National Science Foundation funding panels in quantum relevant areas. Frank received her Bachelor's degree with Honors from Bard College in Chemistry, Math, and Music; an M.Sc. in Inorganic Chemistry at the University of Wisconsin-Madison, and a Ph.D. at the University of California-San Diego in Organic Chemistry.

Danna E. Freedman

Member

Danna E. Freedman is the Keyes Professor of Chemistry at Massachusetts Institute of Technology (MIT). Freedman began her independent career as Assistant Professor at Northwestern, where she was promoted to Associate Professor with tenure, and subsequently to Full Professor. The Freedman Group applies the atomistic control inherent to synthetic chemistry to address fundamental questions in physics. Within this paradigm, the group is creating the next generation of materials for quantum information and harnessing high pressure to synthesize new emergent materials. Notable accomplishments include realizing millisecond coherence times in molecular qubits and developing molecular analogues of nitrogen vacancy centers – enabling optical read-out of spin information in molecules. Freedman's research has been recognized by a number of awards including the American Chemical Society award in Pure Chemistry, the Presidential Early Career Award for Scientists and Engineers, Camille Dreyfus Teacher-Scholar Award, and a National Science Foundation CAREER award. Freedman received her A.B. from Harvard University, and her Ph.D. from University of California, Berkeley where she studied magnetic anisotropy in molecules.

Sinéad M. Griffin

Member

Sinéad M. Griffin is a staff scientist in the Materials Sciences Division and Molecular Foundry at Lawrence Berkeley National Laboratory. Her work uses first principles calculations and phenomenological models to describe and predict novel and enhanced phenomena in quantum materials. Applications of her work range from next-generation quantum sensors for dark matter detection and coherence enhancement in materials for quantum information science, to predicting new forms of topological and multi-order quantum matter. Her awards include the Swiss Physical Society's Award in General Physics and the Material and Processes Awards of the ETH Zürich. Dr. Griffin obtained a B.A. (mod) hons in Theoretical Physics at Trinity College Dublin, followed by a M.Sc. D.I.C. in Quantum Field Theory from Imperial College London. Her doctorate work was carried out at U.C. Santa Barbara and E.T.H. Zürich where she received her Dr. Sc. in Materials Physics.

Stephen O. Hill

Member

Stephen O. Hill currently holds the title of Professor of Physics at Florida State University (FSU) whilst also serving as Director of the Electron Magnetic Resonance user program at the United States National High Magnetic Field Laboratory (NHMFL). He previously held postdoctoral positions at Boston University and at the NHMFL, then took up faculty positions at Montana State University and the University of Florida before moving back to FSU in 2008. Hill has 30 years of experience performing microwave and far-infrared magneto-optical spectroscopy of materials in high magnetic fields, using a wide array of compact radiation sources and measurement techniques. Through this work, he has gained an international reputation in the spectroscopy of low-dimensional conducting, superconducting and magnetic systems in high magnetic fields, including significant technique development. Hill's recent research has focused on fundamental studies of quantum phenomena in molecule-based magnets, as well as structure property relationships in a variety of inorganic coordination compounds. Hill was elected fellow of the American Physical Society (APS) in 2014, he won the Silver Medal for Instrumentation from the International EPR Society in the same year, and then served in Chair's line of the APS Topical Group on Magnetism from 2016 to 2020. Hill received both his Bachelors and Ph.D. degrees from the University of Oxford in the United Kingdom.

Hongbin Liu

Member

Hongbin Liu is a senior researcher at Microsoft Quantum. He currently leads Microsoft's effort to understand how quantum computer could benefit the computational chemistry applications. As a chemist by training, he is driving innovations with modern and future computer architectures to help address a wide variety of chemistry problems, from catalysis to photovoltaic. His research interests range from developing novel classical electronic structure methods, improving quantum algorithms for chemistry simulations, to building hybrid classical-quantum computational chemistry solutions. He has been the developer of multiple quantum chemistry packages, including Gaussian and Chronus Quantum. Liu obtained his Ph.D. from the University of Washington in 2019 focusing on developing electronic structure methods to understand excited states and relativistic effects of molecules and materials.

Marilu Perez Garcia

Member

Marilu Perez Garcia is a scientist at Ames Laboratory, a national laboratory operated by Iowa State University. She has helped organize conferences such as the Graduate Minority Assistantship Program Research Conference and was in the inaugural class of the Critical Materials Institute (CMI) Emerging Leaders Academy. She currently leads a project within CMI studying rare earth element chemistry using a combination of computational methods: molecular mechanics, quantum mechanics, and machine learning. She also leads a study on understanding quantum properties of organolanthanide molecules in a combined synthesis, magnetic analysis, and theoretical chemistry collaboration. Perez Garcia graduated from Idaho State University as an American Chemical Society Scholar and was a George Washington Carver Fellow at Iowa State University. She graduated with research and teaching excellence awards, and as a postdoc, served on the American Chemical Society Graduate Education Advisory Board. Perez Garcia received her Ph.D. from Iowa State University where she used solid-state Nuclear Magnetic Resonance and isotopically labeled plant cell walls to characterize the molecular interactions between intact plant cell wall molecules and computational methods to characterize highly concentrated particles of volatile organic molecules as they exist in the atmosphere.

Brenda M. Rubenstein

Member

Brenda Rubenstein is currently the Joukowsky Family Assistant Professor of Chemistry at Brown University. Her research focuses on developing new electronic structure methods and alternative computing paradigms. Prior to arriving at Brown, she was a Lawrence Distinguished Postdoctoral Fellow at Lawrence Livermore National Laboratory. She is the recipient of a Camille and Henry Dreyfus Teacher-Scholar Award, the Cottrell Teacher-Scholar Award, a Sloan Research Fellowship, and the Department of Energy Computational Science Graduate Fellowship. She received her Sc.B.s in Chemical Physics and Applied Mathematics at Brown University, her M.Phil. in Computational Chemistry while a Churchill Scholar at the University of Cambridge, and her Ph.D. in Chemical Physics at Columbia University.

Eric J. Schelter

Member

Eric J. Schelter is a Professor of Chemistry at the University of Pennsylvania and the Director of the NSF Center for Sustainable Separations of Metals. Schelter's research group studies synthetic inorganic chemistry, especially of the lanthanide and actinide elements, to address problems in chemical separations, electronic structure and bonding, photophysics and photocatalysis, bioinorganic chemistry, magnetism, and quantum materials. Schelter has been awarded a Department of Energy Early Career Research Program Award, the Research Corporation for Science Advancement Cottrell Scholar, an American Chemical Society Harry Gray Award for Creative Work in Inorganic Chemistry by a Young Investigator, a United States Environmental Protection Agency Green Chemistry Challenge Award, and the American Chemical Society Inorganic Chemistry Lectureship. He received his Ph.D. in Inorganic Chemistry from Texas A&M University and was a postdoc at Los Alamos National Laboratory.

Michael R. Wasielewski

Member

Michael R. Wasielewski is currently the Clare Hamilton Hall Professor of Chemistry at Northwestern University, Executive Director of the Institute for Sustainability and Energy at Northwestern, and Director of the Center for Molecular Quantum Transduction, a United States Department of Energy Energy Frontier Research Center. His research has resulted in over 730 publications and focuses on light-driven processes in molecules and materials, artificial photosynthesis, molecular electronics, quantum information science, ultrafast optical spectroscopy, and time-resolved electron paramagnetic resonance spectroscopy. His honors and awards include membership in the National Academy of Sciences and the American Academy of Arts and Sciences; the Bruker Prize in Electron Paramagnetic Spectroscopy (EPR); the Josef Michl American Chemical Society Award in Photochemistry; the International EPR Society Silver Medal in Chemistry; the Royal Society of Chemistry Physical Organic Chemistry Award; the Chemical Pioneer Award of the American Institute of Chemists; the Royal Society of Chemistry Environment Prize; the Humboldt Research Award; the Arthur C. Cope Scholar Award of the American Chemical Society; the Porter Medal for Photochemistry; and the James Flack Norris Award in Physical Organic Chemistry of the American Chemical Society. He received his B.S., M.S., and Ph.D. degrees from the University of Chicago.

Damian Watkins

Member

Damian Watkins is currently Chief of Research and Innovation for Aperio Global. He is a recognized expert in network protocol processing and analytic development for Department of Defense (DOD) agencies. His software development background includes over 15 year experience in Java and C++ development of data driven analytics. He also provides consulting to the development of requirements of analytics and provides analysis of network protocols. He has written custom algorithms on live data to analyze network protocol behavior. He has also written Hadoop Map-Reduce based analytics to support customer questions. He possesses a Cyber Security Analysis (CySA+) Certification as well as hands on experience with Malware analysis, Signals Intelligence (SIGINT) and Cyber Metadata generation and processing. He is currently developing Artificial intelligence applications on SIGINT data using TensorFlow for Intelligence/DOD customers. Watkins was awarded Patent No. 11037073, "Data Analysis System Using Artificial Intelligence." He was also a finalist for the National Aeronautics and Space Administration Science Mission Directorate Entrepreneurs Challenge in the area of Quantum Sensing for Dark Energy. Watkins received his doctorate in Electrical and Computer Engineering from Morgan State University.