International Symposium
of Quantum Science and Technology

Hosted by Purdue Quantum Science and Engineering Institute, Discovery Park, Purdue University

SPEAKERS

Paul C. Canfield

Distinguished Professor of Physics, Iowa State University and Senior Scientist, Ames Laboratory

Paul C. Canfield, Ph.D., graduated summa cum laude with a B.S. in physics from the University of Virginia (Charlottesville) in 1983. He received his Ph.D. in experimental condensed matter physics from the University of California, Los Angeles in 1990. From 1990 to 1993, Dr. Canfield was a postdoctoral researcher at the Los Alamos National Laboratory in New Mexico, working with Drs. Joe Thompson and Zachary Fisk. In 1993, Dr. Canfield joined the Ames Laboratory at Iowa State University (Ames). Since then, he has become a senior physicist at the laboratory, and a Distinguished Professor of Physics at the university, holding the Robert Allen Wright Professorship. Dr. Canfield's research is centered on the design, discovery, growth, and characterization of novel electronic and magnetic materials. He has made key contributions to the fields of superconductivity, heavy fermions, quantum criticality, quasicrystals, spin glasses, local-moment metamagnetism, and metal-to-insulator transitions. Dr. Canfield has helped to educate and train researchers in experimental, new-materials-physics throughout the world, emphasizing the need to tightly couple growth (often in single crystal form) and measurement of new materials. Dr. Canfield is a fellow of the American Physical Society (APS). He was awarded the 2011 Department of Energy Lawrence Award for Condensed Matter Physics. In 2014, Dr. Canfield was awarded the APS David Adler Lectureship Award in the Field of Materials Physics, and was named a Gordon and Betty Moore Materials Synthesis Investigator. In 2015, he received the Humboldt Research Award. In 2017, Dr. Canfield was awarded the APS James McGroddy for New Materials Research.

Discovery of spin-vortex-crystal magnetic order in Ni- and Co- doped $CaKFe_4As_4$

The discovery of $CaFe_2As_2$ in 2008 revealed the extreme member of the $AEFe_2As_2$ family AE = Ba, Sr, Ca. $CaFe_2As_2$ has the smallest c-lattice parameter, manifests a strongly coupled, first-order, structural/magnetic phase transition and can be coaxed into a collapsed tetragonal phase transition, associated with As-As bonding across the Ca-plane and an ~10% decrease in the c-lattice parameter, by very low pressures or strains. In 2016 $CaKFe_4As_4$ was found to form as an ordered quaternary compound, stabilized, to a large part, by the steric differences between $CaFe_2As_2$ and KFe_2As_2. Whereas $CaKFe_4As_4$ superconducts below 35 K and manifests no other phase transitions for $T < 300$ K, we find that by replacing some of the Fe with Co or Ni allows us to dope the system, suppressing Tc and inducing a new form of magnetic order: a spin vortex crystal (SVC) phase. The SVC phase remains in the tetragonal structure and as such represents a new combination of magnetic/structural ordering for Fe-based superconductors.

Jimmy Chen

Quantum Electronics Engineer, Google

Engineering a Superconducting Quantum Computer

Quantum computers are on the cusp of being able to perform computations that are intractable for classical computers - a milestone known as "quantum supremacy." Superconducting qubits have been at the forefront of building scalable quantum computers because they can leverage traditional integrated circuit technology to manufacture large numbers of qubits. Nevertheless, scaling up remains challenging in many areas ranging from fabrication and packaging to classical electronics and software. In this talk, I will discuss Google's efforts to tackle these challenges and engineer a large scale quantum processor. I will also show our latest results on achieving high fidelity single and two qubit operations on these devices, and discuss the prospects for achieving quantum supremacy.

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PURDUE UNIVERSITY

Yong Chen

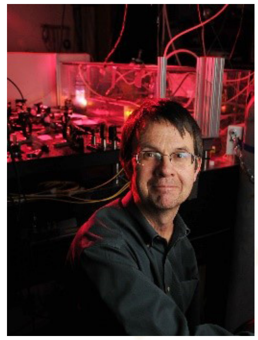
Director, Purdue Quantum Science and Engineering Institute; Associate Director of Research, Birck Nanotechnology Center; Professor of Physics and Astronomy; Professor of Electrical and Computer Engineering

Yong P. Chen leads the "Quantum Matter and Devices Laboratory" that makes, measures and manipulates diverse quantum matter ranging from 2D/topological/hybrid quantum materials to atomic quantum gases, with potential applications such as energy, sensing, and quantum technologies. He received a BS and MS in mathematics from Xi'an Jiaotong University and MIT, a Ph.D. in electrical engineering from Princeton University, and did a physics postdoc at Rice University. He joined Purdue faculty in 2007 and is currently Professor of Physics and Electrical and Computer Engineering as well as the Associate Director of Research for Birck Nanotechnology Center, and the Inaugural Director of Purdue Quantum Science and Engineering Institute (PQSEI). He is a recipient of (young) faculty awards from NSF, DOD, ACS, IBM, and Horiba Award, a Fellow of American Physical Society, a principal investigator in WPI-AIMR International Materials Research Center in Japan, and selected as a Villum Investigator in Denmark.

Spin-helical particles: an enabling platform for quantum matter and quantum technologies

Spin is one of the most fundamental quantum properties of particles. In this talk I will describe our experimental studies of "spin-helical" particles (analogous to neutrinos with spin locked to the momentum, but for electrons and atoms) as a powerful platform to realize novel quantum matter and enable new applications in quantum technologies — such quantum information, quantum energy, quantum chemistry and quantum simulation. For example, we have demonstrated spin-helical electrons [1,2] on the surface of "topological insulators" (TI) and discovered a "topological spin battery" [3], opening the possibility to electrically induce and readout a nuclear and electronic spin polarization with exceptionally long lifetime — which we present as a remarkable demonstration of the "topological protection" unique to TI. We further observe unusual behaviors in superconducting Josephson junctions and SQUIDs made out of our TIs [4,5], paving the way for using such spin-helical electrons to realize "topological superconductor" proposed to harbor "majorana fermions" that could enable scalable, topologically-protected quantum computing. Using light-matter interaction to engineer "synthetic" spin orbit coupling and gauge fields on laser-cooled 87Rb atoms, we realize spin-helical bosons in a Bose-Einstein condensate (BEC), where we can dynamically control the Hamiltonian and perform various quantum transport, interferometry, chemistry, and even "collider" experiments. We demonstrate a new "interferometric" approach for quantum control of chemical reactions by preparing reactants in spin superpositions [6]. The system could also be used as a quantum simulator to study phenomena ranging from spin decoherence in interacting systems [7] to novel quantum matter in extra "synthetic" dimensions or curved spaces not easily realized in electronic materials [8].

Refs: [1] J.Tian et al. "Electrical injection and detection of spin-polarized currents in topological insulator Bi_2Te_2Se", Sci. Rep. 5, 14293 (2015); [2] J. Tian et al., "On the understanding of current-induced spin polarization of three-dimensional topological insulators", Nature Comm. 10, 1461 (2019); [3] J.Tian et al., "Observation of current-induced, long-lived persistent spin polarization in a topological insulator: a rechargeable spin battery", Science Advances 3, e1602531 (2017); [4] M.Kayyalha et al., "Anomalous low-temperature enhancement of supercurrent in topological-insulator nanoribbon Josephson junctions: evidence for low-energy Andreev bound states", PRL 122, 047003 (2019); [5] M.Kayyalha et al., "Highly skewed current-phase relation in superconductor-topological insulator-superconductor Josephson junctions", arXiv:1812.00499; [6] D.Blasing et al. "Observation of Quantum Interference and Coherent Control in a Photo-Chemical Reaction", PRL 121, 073202 (2018) [7] C. Li et al."Spin Current Generation and Relaxation in a Quenched Spin-Orbit Coupled Bose-Einstein Condensate", Nature Comm. 10, 375 (2019); [8] C.Li et al., "A Bose-Einstein Condensate on a Synthetic Hall Cylinder", arXiv:1809.02122



Eric Cornell

Senior Scientist, National Institute of Standards and Technology, Fellow of JILA and Professor Adjoint, Department of Physics, University of Colorado

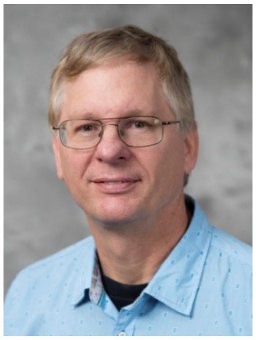
Eric Cornell received his B.S. from Stanford University in 1985, and his Ph.D. from MIT in 1990. His doctoral research, with Dave Pritchard, was on precision mass spectroscopy of single trapped molecular ions. Cornell went to JILA in Boulder, Colorado in 1990. Since 1992 he has been a senior scientist with the National Institute of Standards and Technology. He is a Fellow of JILA and Professor Adjoint in the Physics Department of the University of Colorado.

Research interests include various aspects of ultracold atoms — in particular, Bose-Einstein condensation, strongly interacting Bose gases, and chip-based atom traps. He is also working on using precision molecular spectroscopy to explore possible extensions to the Standard Model of particle physics. His most recent research includes a project to measure the electric dipole moment of the electron, a project designed to investigate the particle physics concept known as "supersymmetry."

Cornell received the Stratton Award from NIST in 1995, the Carl Zeiss Award in 1996, the Fritz London Prize in 1996, the Presidential Early Career Award for Scientists and Engineers in 1996, the 1997 I.I. Rabi Award, the 1997 King Faisal International Prize for Science, the 1995-96 AAAS Newcomb-Cleveland Prize, the 1997 Alan T. Waterman Award, the Lorentz Medal in 1998, in 1999 the R. W. Wood Prize and the Benjamin Franklin Medal in Physics, and in 2000 was elected as a Fellow of the Optical Society of America and a Member of the National Academy of Sciences. In 2005, he was elected Fellow of the American Academy of Arts and Sciences, and in 2012 he was awarded the Ioannes Marcus Marci Medal for Molecular Spectroscopy. He shares the 2001 Nobel Prize in Physics with Carl Wieman and Wolfgang Ketterle.

Looking for Fossils of the Big Bang in Molecular Spectra

How can you learn about the early moments of the universe? How can you discover evidence for new sub-atomic particles? We usually think of ever-more exotic telescopes, or of ever-larger particle accelerators. I will talk about the third leg of the stool: precision measurement. We will see that the humble two-atom molecule should be thought of as an ultrahigh electric-field laboratory.



Chris Greene

Albert Overhauser Distinguished Professor of Physics, Purdue University

- 1976 B.S., University of Nebraska-Lincoln
- 1980 Ph.D., Univesity of Chicago, Advisor: Ugo Fano
- 1981 - Postdoctoral Associate, Stanford University, Advisor: Richard Zare
- 1982-1988 - Assistant, then Associate, then Professor of Physics, Louisiana State University
- 1989-2012 - Professor, then Professor of Distinction, Physics Dept and JILA, University of Colorado at Boulder
- 2012 – present - Albert Overhauser Distinguished Professor of Physics, Purdue University

Recognitions:

1991 First I. I. Rabi Prize of the American Physical Society
2007 Alexander von Humboldt Award for Senior U.S. Scientists
2010 Davisson-Germer Prize of the American Physical Society
2013 Hamburg Prize for Theoretical Physics
2017 Gutzwiller Fellow, Max-Planck-Institute for the Physics of Complex Systems, Dresden

Peculiar Corners of Hilbert Space where Strange States Lie

Deeply quantum mechanical, counterintuitive states are lurking in unexpected areas of few-body Hilbert space, both in the bound state spectrum and in the scattering continuum. Such states are often connected with the physics of very large scattering length, and they produce surprises that challenge normal expectations, even for systems as simple as the 3- or 4-nucleon problem, or for diatomic Rydberg molecules. This talk will summarize some of the peculiar states that have been found, which relate in some cases to Efimov physics, and in other cases to ultra-long-range Rydberg molecules, sometimes referred to as 'trilobite' or 'butterfly' molecules and their ghosts.

Sabre Kais

Professor of Chemistry, Purdue University

Prof. Kais's research is in the field of quantum information and computation and quantum phase transitions. In particular, his research focuses on quantifying entanglement, quantum algorithms, teleportation using quantum dots, decoherence in spin systems and solid state implementations of qubits.

Prof. Kais received the National Science Foundation Career Award in 1997. He was also awarded the Purdue University Faculty Scholar Award (2004-2009), and the Guggenheim Fellowship Award (2005). In 2007, Prof. Kais was the Elected Fellow of the American Physical Society and the Elected Fellow of the American Association for the Advancement of Science.

Recently, Purdue University received $1.5 million in National Science Foundation (NSF) funding to establish a research center to study quantum information science. The Center for Quantum Information and Computation for Chemistry will investigate information techniques used to gain novel viewpoints on diverse chemical processes from photosynthesis to bond breaking.

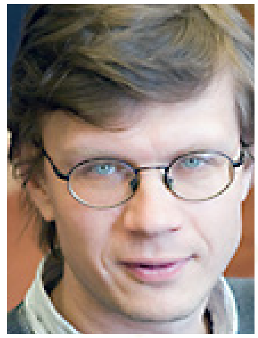
Daniel Lidar

Viterbi Professor of Engineering at USC and Professor of Electrical Engineering, Chemistry, and Physics

Daniel Lidar is the Viterbi Professor of Engineering at USC, and a professor of Electrical Engineering, Chemistry, and Physics. He holds a Ph.D. in physics from the Hebrew University of Jerusalem. He did his postdoctoral work at UC Berkeley. Prior to joining USC in 2005 he was a faculty member at the University of Toronto. His main research interest is quantum information processing, where he works on quantum control, quantum error correction, the theory of open quantum systems, quantum algorithms, and theoretical as well as experimental adiabatic quantum computation. He is the Director of the USC Center for Quantum Information Science and Technology, and is the co-Director (Scientific Director) of the USC-Lockheed Martin Center for Quantum Computing. Lidar is a recipient of a Sloan Research Fellowship, a Guggenheim Fellowship and is a Fellow of the AAAS, APS, and IEEE.

Quantum Algorithmic Breakeven: on scaling up with noisy qubits

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.



Mikhail D. Lukin

George Vasmer Leverett Professor of Physics

Mikhail Lukin's research is in the areas of quantum optics and atomic physics. The emphasis is on studies of quantum systems consisting of interacting photons, atoms, molecules and electrons coupled to realistic environments. We are developing new techniques for controlling the quantum dynamics of such systems, and studying fundamental physical phenomena associated with them. These techniques are used to explore new physics, as well as to facilitate implementation of potential applications in emerging areas such as quantum information science and in more traditional fields such as nonlinear optics. In the course of this work we are also exploring the emerging interfaces between quantum optics and atomic physics on the one hand, and condensed matter and mesoscopic physics on the other.

Exploring quantum dynamics and entanglement using programmable quantum simulator

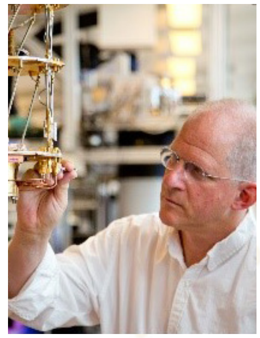
Michael Manfra

Bill and Dee O'Brien Chair Professor of Physics and Astronomy; Professor of Electrical and Computer Engineering; Professor of Materials Engineering

Michael Manfra is the Director of Microsoft Station Q Purdue and the Bill and Dee O'Brian Chair Professor of Physics and Astronomy at Purdue University. He is also a Professor of Electrical and Computer Engineering and Materials Engineering at Purdue. Prior to joining Purdue, Manfra worked for ten years at Bell Laboratories, Lucent Technologies in Murray Hill, New Jersey. Manfra earned a Ph.D. in Physics from Boston University and was an undergraduate at Harvard University.

Aharonov-Bohm interference of fractional quantum Hall edge modes

The braiding statistics of certain fractional quantum Hall states can be probed via interferometry of their edge states. Practical difficulties – including loss of phase coherence – make this a challenging task. We demonstrate the operation of a small Fabry-Perot interferometer in which highly coherent Aharonov-Bohm oscillations are observed in the integer and fractional quantum Hall regimes. Careful design of the heterostructure suppresses Coulomb effects and promotes strong phase coherence. We characterize the coherency of edge-mode interference by the energy scale for thermal damping and determine the velocities of the inner and outer edge modes independently via selective backscattering of edge modes originating in the N=0, 1, 2 Landau levels. We also observe clear Aharonov-Bohm oscillations at fractional filling factors $\nu=2/3$ and $\nu=1/3$, which indicates that our device architecture provides a platform for measurement of anyonic braiding statistics.



Charles Marcus

Director of the Center for Quantum Devices, sponsored by the Danish National Research Foundation, and Director of Microsoft Quantum Lab–Copenhagen

Charles Marcus was raised in Sonoma, California, USA, and was an undergraduate at Stanford University (1980-84). He received his Ph.D. in Physics from Harvard in 1990 and was an IBM postdoctoral fellow at Harvard from 1990-92. He then served on the Physics faculty at Stanford (1992-2000) and Harvard (2000-2011) where he also was director of the Center for Nanoscale Systems (2006-2011). Marcus joined the Niels Bohr Institute (NBI), University of Copenhagen in Denmark in 2012 as Villum Kann Rasmussen Professor. In 2016, he joined Microsoft as Principal. He is currently Director of the Center for Quantum Devices, sponsored by the Danish National Research Foundation, and Director of Microsoft Quantum Lab–Copenhagen.

Marcus's research interests focus on quantum mechanically coherent electronics, quantum bits, and topology in condensed matter systems. The long-term research goal is to build and explore large-scale interconnected quantum coherent systems with applications in quantum information processing.

Routes to Topological Qubits

This talk summarizes a number of approaches to generating topological states in solid state systems that can be used for quantum information processing, and the relationship between them. Examples include one-dimensional and two-dimensional hybrid superconductor-semiconductor materials, recently realized in epitaxial form. Research is supported by the Microsoft and the Danish National Research Foundation.

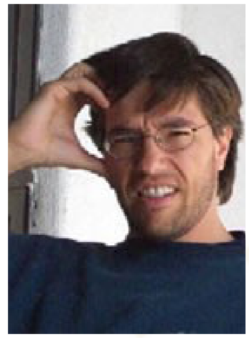
Joel Moore

Chern-Simons Professor of Physics at the University of California, Berkeley, and Senior Faculty Scientist at Lawrence Berkeley National Laboratory

Joel Moore is Chern-Simons Professor of Physics at the University of California, Berkeley, and Senior Faculty Scientist at Lawrence Berkeley National Laboratory. His research is in quantum condensed matter physics with connections to statistical physics and quantum information. Specific areas of research are topological phases of matter, including the prediction of three-dimensional topological insulators with L. Balents, and non-equilibrium quantum dynamics ranging from many-body localization to integrability. He completed his bachelor's degree in physics from Princeton in 1995, held a Fulbright visiting position at TIFR in 1996, and received his Ph.D. from MIT in 2001 with support from a Hertz Fellowship. After a year at Bell Labs he moved to Berkeley as an assistant professor and received tenure in 2007. Moore is currently a Simons Investigator (since 2013) and an elected Fellow and Member-at-Large of the American Physical Society. He is an elected General Member of the Aspen Center for Physics and chair of the science advisory board for the Kavli Institute for Theoretical Physics at UCSB, and became founding director of the DOE-supported Center for Novel Pathways to Quantum Coherence in Materials in 2018.

Topological materials as platforms for new particles and electromagnetic responses

This talk starts by reviewing the remarkable theoretical and experimental progress in topological materials over the past decade. Three-dimensional topological insulators realize a particular electromagnetic coupling known as "axion electrodynamics," and understanding this leads to an improved understanding of magnetoelectricity in all materials. We then turn to how topological Weyl and Dirac semimetals can show unique electromagnetic responses; we argue that in linear response the main observable effect solves an old problem via the orbital moment of Bloch electrons, and how in nonlinear optics there should be a new quantized effect, which may just have been seen experimentally.



Gerardo Ortiz

Professor, Department of Physics, Indiana University

M.S. - Instituto Balseiro (Bariloche) 1987
Ph.D. - Swiss Federal Institute of Technology 1992
Postdoctoral Positions: University of Illinois at Urbana-Champaign; Oppenheimer fellow at LANL
Other Affiliations: Theoretical Division, Los Alamos National Laboratory; Institute for Quantum Computing (Waterloo)

A great challenge of theoretical physics is understanding and modeling interacting quantum many-body systems or quantum fields, and accurately predicting properties and functionalities of matter from the fundamental laws of quantum mechanics. My research work is in condensed matter physics and quantum information science.

Certified Quantum Measurement of Majorana Fermions and New Entangled Quantum Probes

Mordechai (Moti) Segev

Robert J. Shillman Distinguished Professor of Physics, at the Technion, Israel

Moti Segev received his B.Sc. and Ph.D. from the Technion in 1985 and 1990. After postdoc at Caltech, he joined Princeton as Assistant Professor (1994), becoming Associate Professor in 1997, and Professor in 1999. Subsequently, Moti went back to Israel, and in 2009 was appointed as Distinguished Professor.

Moti's interests are mainly in nonlinear optics, photonics, solitons, sub-wavelength imaging, lasers, quantum simulators, and quantum electronics, although he finds entertainment in more demanding fields such as basketball and hiking. He has won numerous international awards, among them the 2007 Quantum Electronics Prize of the European Physics Society, the 2009 Max Born Award of the Optical Society of America, and the 2014 Arthur Schawlow Prize of the American Physical Society, which are the highest professional awards of the three scientific societies. In 2011, he was elected to the Israel Academy of Sciences and Humanities, and in 2015 he was elected to the National Academy of Science (NAS) of the United States of America. In 2014 Moti Segev won the Israel Prize in Physics and Chemistry (highest honor in Israel). However, above all his personal achievements, he takes pride in the success of his graduate students and postdocs, among them are currently 21 professors in the USA, Germany, Taiwan, Croatia, Italy, India, and Israel, and many holding senior R&D positions in the industry.

Topological Photonics

Topological phases of matter enable protected transport along the edges of materials, offering immunity against scattering from disorder and imperfections. In the past decade, topological phases were demonstrated to occur in many wave systems beyond electronic, ranging from microwaves and photonics to cold atoms and acoustics. This talk will review the fundamentals of Topological Photonics, present exciting applications such as topological insulator lasers, and discuss challenges and open questions.

Vladimir M. Shalaev

Scientific Director for Nanophotonics at Birck Nanotechnology Center and Distinguished Professor of Electrical and Computer Engineering at Purdue University

Vladimir M. Shalaev specializes in nanophotonics, plasmonics, optical metamaterials, and quantum photonics. Vladimir M. Shalaev has received several awards for his research in the field of nanophotonics and metamaterials, including the Max Born Award of the Optical Society of America for his pioneering contributions to the field of optical metamaterials, the Willis E. Lamb Award for Laser Science and Quantum Optics, IEEE Photonics Society William Streifer Scientific Achievement Award, Rolf Landauer medal of the ETOPIM (Electrical, Transport and Optical Properties of Inhomogeneous Media) International Association, the UNESCO Medal for the development of nanosciences and nanotechnologies, and the OSA and SPIE Goodman Book Writing Award. He is a Fellow of the IEEE, APS, SPIE, MRS and OSA.

Can plasmonics help outpace quantum decoherence?

We discuss an unorthodox way to overcome quantum decoherence by using plasmonics that can speed up quantum processes to the extent that they outpace and thus become immune to decoherence.

Photons are the primary candidates for implementing quantum networks, which are essential for both secure communication and transmission of quantum information. In order to produce single photons or make them interact, one needs to couple light with matter. The issue of low bitrates is central to most photonic quantum technologies and requires a targeted and strong enhancement of light-matter interaction. The interaction enhancement approach based on plasmonic nanostructures has a potential to transform the way quantum photonic systems operate. It strongly contrasts with the conventional pursuit of longer matter coherence time, relying instead on speeding up processes beyond the rates of dephasing. We discuss our recent and planned work aimed at outpacing decoherence in quantum optical devices using nanoscale photonic components.

Andrew M. Weiner

Scifres Family Distinguished Professor of Electrical and Computer Engineering at Purdue University

Andrew Weiner is best known for pioneering work on programmable femtosecond pulse shaping and ultrafast signal processing. Weiner is a member of the National Academy of Engineering and National Academy of Inventors, was selected as a Department of Defense National Security Science and Engineering Faculty Fellow, and has received the OSA Wood Prize and the IEEE Photonics Society Quantum Electronics Award, among others. He is author of the textbook *Ultrafast Optics* and recently concluded a six year term as Editor-in-Chief of *Optics Express*.

Frequency Domain Quantum Photonics

Entanglement and encoding in discrete frequency bins – essentially a quantum analogue of wavelength-division multiplexing – represents a relatively new degree of freedom for quantum information with photons. In this talk I describe experiments demonstrating manipulation and measurement of qubit and qudit states encoded and entangled in photonic frequency degree of freedom.

Jun Ye

Fellow of JILA, Fellow of National Institute of Standards and Technology and Professor Adjoint, Department of Physics, University of Colorado

Jun Ye is a Fellow of JILA and a Fellow of NIST. He is a member of the National Academy of Sciences, a Fellow of the American Physical Society, and a Fellow of the Optical Society of America. His research focuses on the frontiers of light-matter interactions and includes precision measurement, quantum physics and ultracold matter, optical frequency metrology, and ultrafast science. He has co-authored more than 300 scientific papers and has delivered more than 500 invited talks. Recent awards and honors include N.F. Ramsey Prize (APS) and Rabi Award (IEEE). Group web page, http://jila.colorado.edu/YeLabs/.

Quantum matter and atomic clocks

Relentless pursuit of spectroscopy resolution has been a key driving force for important scientific and technological breakthroughs, including the invention of laser and the creation of cold atomic matter. The most stable lasers now maintain optical phase coherence over tens of seconds. Meanwhile, precise quantum state engineering of individual atoms in both internal and external degrees of freedom has led to the unprecedented measurement performance for time and frequency. The use of many atoms not only enhances counting statistics, but also provides a powerful tool to protect against systematic uncertainties. At the core of the new three-dimensional optical lattice clock is a quantum gas of fermionic atoms spatially configured to guard against motional and collisional effects. This precise control of light-matter interactions is fostering new capabilities for probing fundamental and emerging phenomena.

Peter Zoller

Center for Quantum Physics, University of Innsbruck, and Institute for Quantum Optics and Quantum Information, Austrian Academy of Sciences, Innsbruck, Austria

Peter Zoller has written major works on the interaction of laser light and atoms. In addition to fundamental developments in quantum optics he has made major contributions in the field of quantum information. The model of a quantum computer, suggested by him and Ignacio Cirac in 1995, is based on the interaction of lasers with cold ions confined in an electromagnetic trap. The principles of this idea have been implemented in experiments over recent years and it is considered one of the most promising concepts for the development of a scalable quantum computer. Zoller and his researcher colleagues have also managed to link quantum physics with solid state physics. One of his suggestions has been to build a quantum simulator with cold atoms.

Programmable Quantum Simulators with Atoms and Ions

Programmable analog quantum simulators have recently emerged as a new paradigm in quantum information processing. In contrast to the universal quantum computer, programmable quantum simulators are non-universal quantum devices with restricted sets of quantum operations, which however can be naturally scaled to a large number of qubits. In this talk we will focus on programmable analog quantum simulators with trapped ions and Rydberg tweezer arrays, and discuss various scenarios and applications of programming these quantum machines. We show results from a theory-experiment collaboration at Innsbruck demonstrating hybrid classical-quantum algorithms where a 20 quit ion analog simulator computes the energy of the ground state of a lattice Schwinger model representing 1D QED. Remarkably, in this experiment we can not only compute the energy on the quantum machine but also the algorithmic error (error bar of the energy) by measuring the energy variance. Further examples include theoretical studies where variational algorithms are applied to generate optimal spin squeezed states for given (restricted) quantum resources provided by Rydberg tweezer arrays, which has potential applications in quantum sensing. We conclude with a discussion of the generic question of cross platform verification of quantum computers and quantum simulators, where the goal is to compare quantum devices on the level of many-quit wavefunctions with protocols requiring only classical communication, which can be implemented in present day experiments.

International Symposium of Quantum Science and Technology

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Tomás Díaz de la Rubia

Vice President for Discovery Park

Tomás Díaz de la Rubia is Purdue University's vice president for Discovery Park. In this position, his responsibilities include building upon Discovery Park's foundation of excellence which has enabled high-impact research that crosses traditional academic boundaries. He works closely with the faculty and deans to help catalyze Purdue's many strengths and build on its legacy of interdisciplinary research with global impact. He is also a professor of Materials Science, and of Strategic Management (by Courtesy) in the Krannert School of Management.

Before coming to Purdue, Díaz de la Rubia served as innovation leader and a director in Deloitte's energy and resources industry practice in Washington, D.C., working with Fortune 500 energy and manufacturing companies to identify and capitalize on business opportunities arising from potentially disruptive, innovative new technologies.

Prior to joining Deloitte, Tomás was the chief research officer and deputy laboratory director for science and technology at the Lawrence Livermore National Laboratory (LLNL) in California, where he was responsible for the long-term health of the science and technology foundations of the laboratory's $1.6 billion research program. In this capacity, he oversaw a $300M program of basic and applied research, and was responsible for the Laboratory's industrial partnerships and technology commercialization. From 2002-2009, he was an associate director at LLNL, leading its chemistry, materials science, life sciences, and energy and environmental sciences organizations, as well as its $60 million basic materials science, chemistry and biology programs with the Department of Energy's Office of Science.

Tomás is a member of the National Academies of Sciences, Engineering and Medicine Intelligence Community Studies Board, which discusses science and technology issues of importance to the nations' intelligence community. Tomás also serves as a member of the Board of Directors of the Civilian Research and Development Foundation (CRDF Global), a non-profit organization dedicated to promoting peace and prosperity through international scientific collaboration, and as a member of the Editorial Board of Applied Physics Reviews. Among his hobbies, he is a member of the Confrerie des Chevaliers du Tastevin, a worldwide group dedicated to promoting the virtues of the wines and foods of Burgundy.

Díaz de la Rubia has published more than 150 peer-reviewed articles and has co-edited several books and conference proceedings. He is a fellow of the American Physical Society and of the American Association for the Advancement of Science and served as an elected member of the board of directors of the Materials Research Society, and vice-chair of the division of computational physics of the American Physical Society. He holds a bachelor's degree (summa cum laude) and a doctorate in physics from The State University of New York, Albany.

Alexandra Boltasseva

Professor, Electrical and Computer Engineering, Purdue University, inaugural Discovery Park Fellow

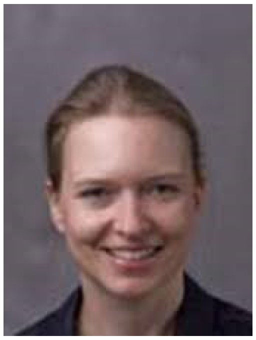
Degrees:

- BS, Moscow Institute of Physics and Technology, 1999
- MS, Moscow Institute of Physics and Technology, 2000
- PhD, Technical University of Denmark, 2004

Research:
Nanophotonics, nanofabrication, plasmonics, metamaterials, integrated optics, sensing

Areas of Interest:

- Microelectronics and Nanotechnology
- Fields and Optics (Area Chair)



Birgit Kaufmann
Professor, Department of Mathematics and Physics and Astronomy, Purdue University

Research Area - Mathematical Physics

- Non-equilibrium systems
- Quantum wire networks from triply-periodic minimal surfaces
- Finite-size scaling in atomic models

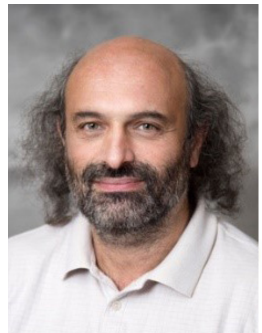
Ralph Kaufmann
Professor, Department of Mathematics, Purdue University

Research Areas - Algebraic Topology, Algebraic Geometry, Mathematical Physics, Higher Stuctures

- Feynman Categories
- String Topology and Related Operations such as Deligne Conjectures
- Hopf Algebras
- Quantum Cohomology and Mirror Symmetry
- Stringy Phenomena for Stacks/Orbifolds
- Geometry of Moduli and Teichmueller Spaces
- Noncommutative Geometry
- Nano Wire Networks and Topological Insulators
- 2+1 dim TQFT and its Extensions

Michael F. Shlesinger
Program Officer, Nonlinear Physics, Office of Naval Research (ONR)

- Bachelor of Science (B.S.), Mathematics and Physics, SUNY Stony Brook: 1970
- Doctor of Philosophy (Ph.D.), Physics: 1975



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Research Areas:

- Electron transport in mesoscopic systems
- Spintronics and spin interactions
- Magnetic materials and devices
- Quantum information processing
- Topologically non-trivial states of matter
- Nanofabrication
- Novel materials and devices

Awards and Honors:

- NSF CAREER Award, 2004

Jason Turner
Chairman, Entanglement Institute

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