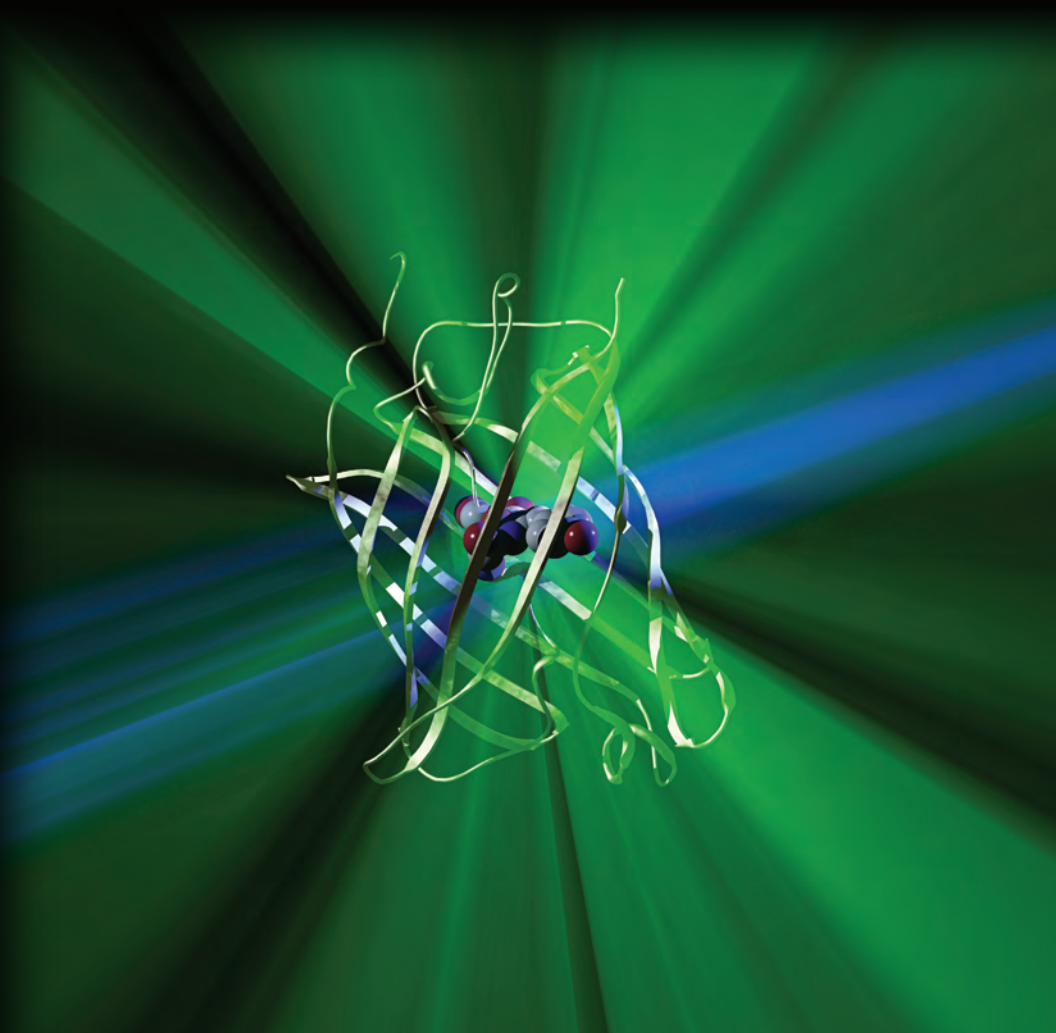
Fitzpatrick Institute for Photonics

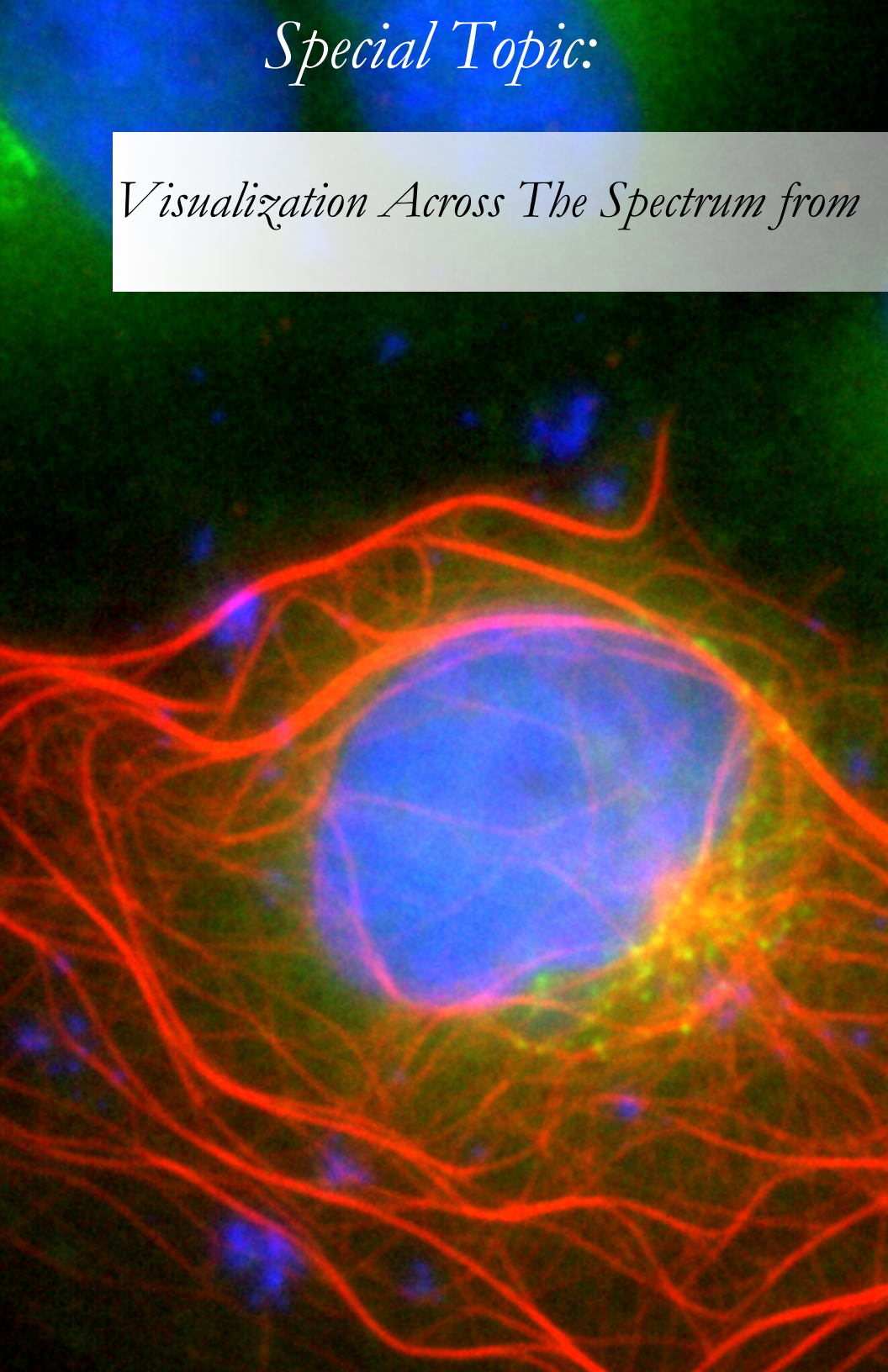
Pratt School of Engineering, Duke University

2014 FIP Symposium
Frontiers in Photonics Science and Technology
March 11-12, 2014

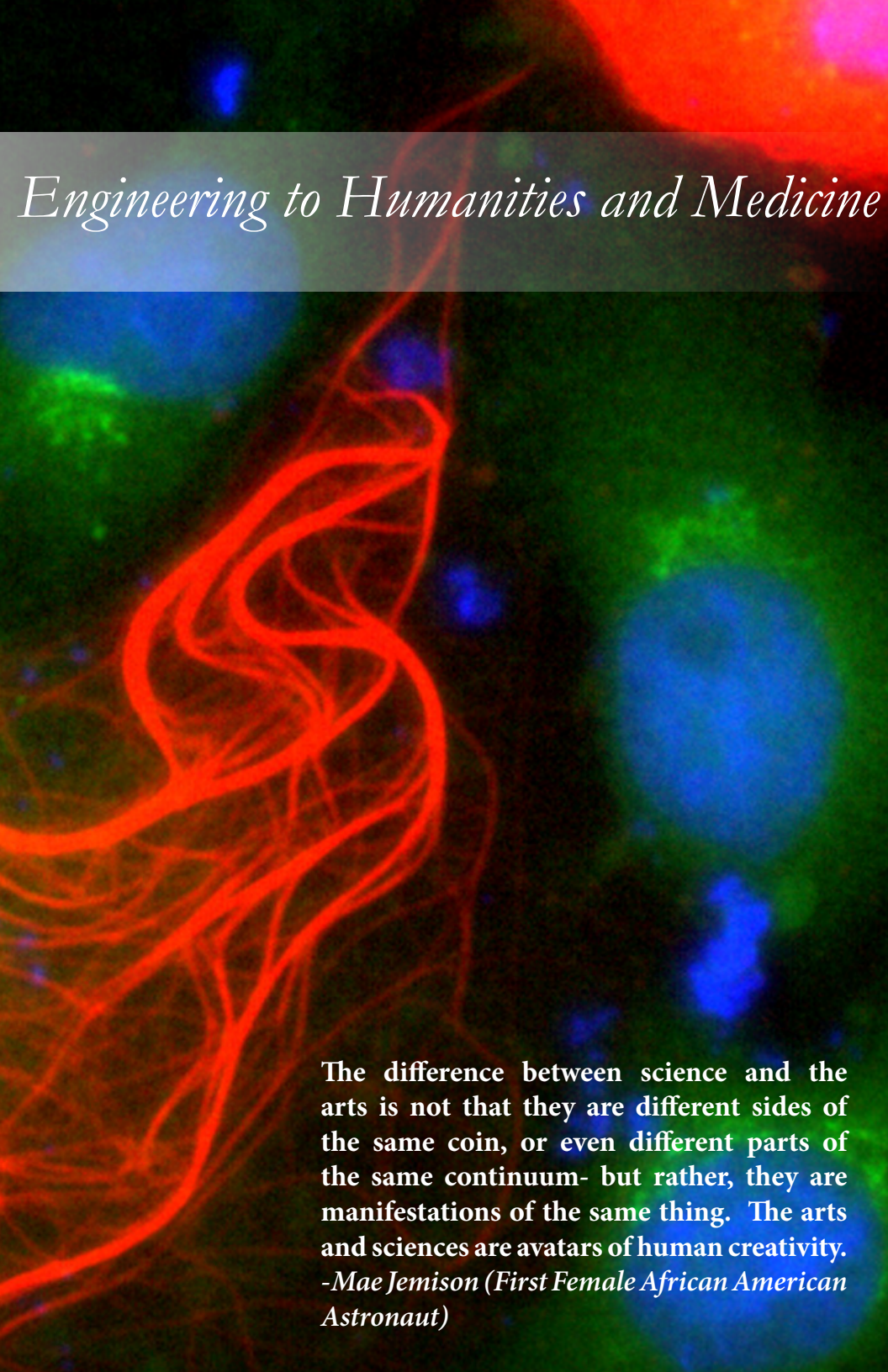


Special Topic:

Visualization Across The Spectrum from



Engineering to Humanities and Medicine



The difference between science and the arts is not that they are different sides of the same coin, or even different parts of the same continuum- but rather, they are manifestations of the same thing. The arts and sciences are avatars of human creativity.
-Mae Jemison (First Female African American Astronaut)

Welcome to the Fitzpatrick Institute for Photonics

Symposium on Photonics Science and Technology
2014 FIP Annual Meeting
March 11-12, 2014, Duke University

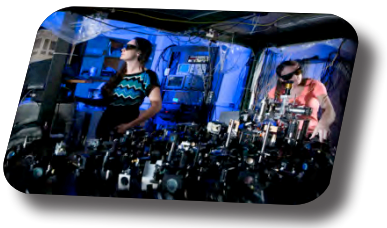
Symposium Chair – Tuan Vo-Dinh, Director, Fitzpatrick Institute for Photonics

Symposium Co-Chair - Andrew Janiak

Scientific Program Committee – David Beratan, Steven Cummer, Daniel Gauthier, Joseph Izatt, Nan Jokerst, Jungsang Kim, Kam Leong, Barry Myers, Michael Platt, William Reichert, Hans Van Miegroet, Warren Warren, Adam Wax, Weitao Yang

Symposium Administrative Manager – August Burns, Department Business Manager, Fitzpatrick Institute for Photonics

Assistant Coordinator – Janna Register, Lab Manager, Fitzpatrick Institute for Photonics



Tuesday, March 11, 2014

Fitzpatrick Building

8:00 am - 9:00 am Registration

9:00 am - 5:00 pm Meeting

5:00 pm - 7:00 pm Poster Session-Reception

Wednesday, March 12, 2014

Fitzpatrick Building

8:30 am - 9:00 am Registration

9:00 am - 11:45 am Meeting

Symposium on Photonics Science and Technology

2014 Fitzpatrick Institute for Photonics (FIP) Annual Meeting
March 11-12, 2014, Duke University

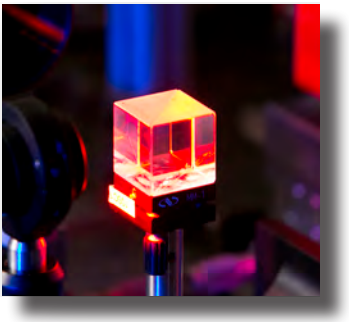
The Fitzpatrick Institute for Photonics is an extensively interdisciplinary Duke effort to advance photonics and optical sciences. The institute leverages Duke's faculty from the Pratt School of Engineering, Trinity Arts and Sciences, and the Duke Medical School to explore problems at the boundary nexus of nano-bio-info-opto convergence.

The Fitzpatrick Institute for Photonics (FIP) has 105 Faculty Members from 33 Participating Departments, Centers & Institutions at Duke University

Departments –

- Anesthesiology
- Biology
- Biomedical Engineering (BME)
- Cell Biology
- Chemical Biology
- Chemistry
- Civil & Environmental Engineering (CEE)
- Computer Science
- Dermatology
- Electrical and Computer Engineering (ECE)
- Gastroenterology
- Literature
- Mathematics
- Mechanical Engineering and Materials Science (MEMS)
- Molecular Genetics and Microbiology
- Neurobiology
- Neurosurgery
- Oncology
- Ophthalmology
- Orthopaedic Engineering
- Pathology
- Pediatrics
- Philosophy
- Physics
- Radiation Oncology
- Radiology
- Surgery

Center for Metamaterials & Integrated Plasmonics
Division of Infectious Diseases & International Health
Duke Comprehensive Cancer Center
Duke Human Vaccine Institute
Institute for Genome Science and Policy
Nicholas School of the Environment



FIP Research Programs and Program Directors

Biophotonics – Joseph Izatt
Nano/Micro Systems – Nan Jokerst
Quantum Optics and Information Photonics – Daniel Gauthier
Photonic Materials – Steven Cummer
Advanced Photonic Systems – William "Monty" Reichert
Nanophotonics – Kam Leong
Systems Modeling, Theory & Data Treatment – Weitao Yang
Novel Spectroscopies – Warren Warren

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ADVANCE PROGRAM

Tuesday, March 11 (Fitzpatrick Center) – Morning Session

8:00-9:00 am	**Registration** *Photonics Theme Lab Tours* (sign up at Registration Desk for participation and times)
9:00-9:05	**Introduction** **Tuan Vo-Dinh,** Director of the Fitzpatrick Institute for Photonics, R. Eugene and Susie E. Goodson Professor of Biomedical Engineering and Professor, Duke University
9:05-9:15	**Opening Welcome Address** **Peter Lange,** Provost and Thomas A. Langford University Professor, Duke University
9:15-9:30	**Tom Katsouleas,** Vinik Dean, Pratt School of Engineering, Duke University
9:30-10:10	**Symposium Keynote** **Roger Y. Tsien,** Nobel Laureate in Chemistry (2008), Professor, Department of Pharmacology, Department of Chemistry and Biochemistry, University of California, San Diego "Fun with Photons and Designed Molecules"
10:10-10:20	**FIP Award Presentation – *2014 Pioneer in Photonics Award***
10:20-10:40	**COFFEE BREAK**
10:40-11:10	**Plenary Lecture** **Steven M. Block,** S.W. Ascherman Professor of Sciences, Department of Biology, Department of Applied Physics, Stanford University, California *"Optical Tweezers: Gene Regulation, Studied One at a Time"*
11:10-11:55	**Session 1: Special Topic on Photonics for Medicine, Arts and the Humanities** **Co-Chair: Steven Cummer,** Bass Fellow, Professor of Electrical and Computer Engineering, Duke University **Co-Chair: Harold Erickson,** James B. Duke Professor of Medicine, Professor of Cell Biology and Biochemistry, Duke University

11:10-11:25 **Joseph A. Izatt,** Professor of Biomedical Engineering, Duke University *"Advances in Ophthalmic Imaging Technology for Real Time 3D Imaging and Surgical Guidance"*

11:25-11:40 **Adam P. Wax,** Theodore Kennedy, Professor of Biomedical Engineering, Duke University co-presenting with **Howard Levinson,** MD, FACS, Associate Professor, Departments of Surgery and Pathology, Duke University Medical Center *"Noncontact Optical Tissue Diagnostics for Assessing Burn Wound Depth"*

11:40-11:55 **Nimmi Ramanujam,** Professor of Biomedical Engineering, Director of the Center for Global Women's Health Technologies, Duke University *"Point of Care Optical Technologies for Women's Health"*

11:55-1:30 pm **LUNCH BREAK (Lunch Provided)**

Poster Session & Industry Booths
Posters and Industry Booths are exhibited in the Atrium area of the Fitzpatrick Center

Tuesday, March 11 – Afternoon Session

1:30-2:30 **Session 2: Special Topic on Photonics for Medicine, Arts and the Humanities**
Chair: Sally Kornbluth, James B. Duke Professor of Pharmacology and Cancer Biology, Vice Dean for Basic Science, Duke University School of Medicine

1:30-1:45 **Hans J. Van Miegroet,** Professor and Department Chair of Art, Art History and Visual Studies, Duke University *"Media Sciences at Duke from the Humanities Outward to the Science and the Social Sciences"*

1:45-2:00 **Geoffrey Ginsburg,** Professor of Medicine, Director of the IGSP Center for Genomic Medicine, Duke University *"Novel Platforms for the Diagnosis of Infectious Disease"*

2:00-2:15 **Warren Warren,** James B. Duke Professor of Chemistry and Radiology, Duke University *"Adapting Modern Biomolecular Imaging to Cultural Heritage Applications"*

2:15-2:30 **Andrew Janiak,** Creed C. Black Associate Professor of Philosophy; Chair, Faculty Advisory Council, Bass Connections, Duke University *"Newton's Disputes in Optics and Their Philosophical Implications"*

2:30-2:50 **COFFEE BREAK**

2:50-3:35 **Session 3: Panel Forum Session**
Convergence of Science, Engineering and the Humanities: Education and Social Impact for the New Era

Introduction: Tom Katsouleas, Co-Moderator, Vinik Dean, Pratt School of Engineering, Duke University
Arranged by: Hans J. Van Miegroet, Co-Moderator, Professor and Department Chair of Art, Art History and Visual Studies, Duke University
Tuan Vo-Dinh, Director of Fitzpatrick Institute for Photonics, R. Eugene and Susie E. Goodson Professor of Biomedical Engineering, Professor of Chemistry, Duke University

Panel Members
Steven M. Block, S.W. Ascherman Professor of Sciences, Department of Biology, Department of Applied Physics, Stanford University, California
Andrew Janiak, Creed C. Black Associate Professor of Philosophy; Chair, Faculty Advisory Council, Bass Connections, Duke University
Sally Kornbluth, James B. Duke Professor of Pharmacology and Cancer Biology, Vice Dean for Basic Science, Duke University School of Medicine
Robert Lieberman, Vice President, SPIE, The International Society of Optics and Photonics and President and CTO of Intelligent Optical Systems, Inc.
William Seaman, Professor Visual Studies, Department of Art, Art History & Visual Studies, Duke University
Hans J. Van Miegroet, Professor and Department Chair of Art, Art History and Visual Studies, Duke University

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3:35-4:05 **Plenary Lecture**
Daniel E. Morse, Wilcox Professor of Biotechnology, Biomolecular Science and Engineering, Founding Director, UCSB-MIT-Caltech Institute for Collaborative Biotechnologies, University of California, Santa Barbara
"Tunable Bio-Photonics: Nanoscale Protein Assembly Drives Changes in Iridescence and Enhanced Photosynthesis in Molluscs"

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4:05-5:00 **Session 4: Special Topic on Visualization Across the Spectrum: From Science and Engineering to Medicine and the Humanities**
Chair: Sönke Johnsen, Professor of Physics, Duke University

4:05-4:25 *Invited Lecture:* **Thomas W. Cronin,** Department of Biological Sciences, University of Maryland-Baltimore County *"Biological Optics and Mantis Shrimp: Evolutionary Inventiveness in Light Control"*

4:25-4:45 *Invited Lecture:* **Steven Haddock,** Scientist, Bioluminescence and Zooplankton, Monterey Bay Aquarium Research Institute *"Biologically Generated Light: Diversity and Functions of Natural Luminescence and Fluorescence in the Sea"*

4:45-5:00 **Sönke Johnsen,** Professor of Biology, Duke University *"Hidden in Plain Sight: The Optics of Organismal Transparency"*

5:00-5:30 **POSTER SESSION & INDUSTRY BOOTHS**

Posters and Industry Booths are exhibited in the Atrium area of the Fitzpatrick Center

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5:30-7:30 **COCKTAIL RECEPTION - Exhibit & Industry Booths**
(Heavy hors d'oeuvres will be served)

Symposium FEATURE EXHIBIT
"An Engine of Many Senses"

Arranged by
William Seaman, Professor of Visual Studies, Duke University

Additional Exhibits on Display during Reception: Mahato & FCIEMAS

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75 YEARS Celebrating DUKE ENGINEERING EST. 1939

Duke PRATT SCHOOL OF Engineering

The Fitzpatrick Institute for Photonics is proud to celebrate the 75th anniversary of Duke Engineering in 2014-2015. Learn more at pratt.duke.edu/75

Symposium on Photonics Science and Technology

2014 Fitzpatrick Institute for Photonics (FIP) Annual Meeting
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Wednesday, March 12 (Fitzpatrick Center) – Morning Session

8:30-9:00 am **Registration**

9:00-9:50 **Session 5: Special Topic on Visualization Across the Spectrum: From Science and Engineering to Medicine and the Humanities**
Chair: Christopher Dwyer, Associate Professor of Electrical and Computer Engineering, Duke University

9:00-9:20 *Invited Lecture:* **Dorothy A. Erie,** Professor of Chemistry and Curriculum in Applied Sciences and Engineering, University of North Carolina at Chapel Hill *"Combing Single-Molecule Methods to Study DNA Repair In Vitro and In Vivo"*

9:20-9:35 **G. Allan Johnson,** Charles E. Putnam University Professor of Radiology, Professor of Biomedical Engineering, Director of the Duke Center for In Vivo Microscopy, Duke University *"Magnetic Resonance Histology"*

9:35- 9:50 **Ute Hochgeschwender,** Associate Research Professor of Neurobiology, Director of the Duke Neurotransgenic Laboratory, Duke University *"Bioluminescence Activation of Light-Sensing Molecules"*

9:50-10:30 **COFFEE BREAK**

10:30-11:45 **Session 6: Advances in Photonics**
Chair: Fan Yuan, Professor of Biomedical Engineering, Duke University

10:30-10:45 **Poster Award Winners Announced**

10:45-11:00 **Charles Gersbach,** Assistant Professor, Biomedical Engineering, Duke University *"Spatiotemporal Control of Mammalian Gene Expression with Light-Inducible Transcription Factors and Recombinases"*

11:00-11:15 **Maiken H. Mikkelsen,** Assistant Professor of Electrical and Computer Engineering, Assistant Professor of Physics, Duke University *"Tunable Plasmonic Platform for Giant Fluorescence Enhancement"*

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11:15-11:30 **Gregory M. Palmer,** Associate Professor of Radiation Oncology, Duke University *"Characterization of Tumor Physiology and Vascular Function in Response to Therapy Using Optical Spectroscopy and Intravital Microscopy"*

11:30-11:45 **Regis Kopper,** Director of the Duke Immersive Virtual Environment (DiVE), Duke University *"Using Immersive Virtual Reality as a Medium for Applied Photonics"*

11:45am **SYMPOSIUM ADJOURNS**

Post-Symposium Workshop (Invitation Only & Lunch provided)
Wednesday, March 12, (Fitzpatrick Center)

12:15-1:15pm - Mumma Commons (3rd Floor) FCIEMAS – Luncheon
1:15-4:00pm - Mumma Commons (3rd Floor) FCIEMAS -Workshop

BUILDING BRIDGES FOR SCIENCE, TECHNOLOGY, ENGINEERING, ARTS AND MATHEMATICS (STEAM)

Arranged by
Keith Whitfield, Vice Provost for Academic Affairs, Duke University
Scott Lindroth, Vice Provost for the Arts, Duke University
Tuan Vo-Dinh, Director of Fitzpatrick Institute for Photonics, Duke University

CO-SPONSORED BY
OFFICE OF THE VICE PROVOST OF ACADEMIC AFFAIRS,
OFFICE OF THE VICE PROVOST OF ARTS,
AND PRATT SCHOOL OF ENGINEERING,
DUKE UNIVERSITY

Welcome and Opening Marks

Tuan Vo-Dinh, Ph.D.

Director of the Fitzpatrick Institute for Photonics
R. Eugene and Susie E. Goodson Professor of Biomedical Engineering
Professor of Chemistry
Duke University

Tuan Vo-Dinh's research activities and interests involve biophotonics, laser-excited luminescence spectroscopy, room temperature phosphorimetry, synchronous luminescence spectroscopy, surface-enhanced Raman spectroscopy, field environmental instrumentation, fiberoptics sensors, nanosensors, biosensors and biochips for the protection of the environment and the improvement of human health.

Peter Lange, Ph.D.

Provost, Thomas A. Langford University Professor
Duke University

Peter Lange joined the Department of Political Science at Duke University in 1981 after a previous teaching position at Harvard University. Since arriving at Duke, he has been Associate Professor (1982-1989), Full Professor (since 1989), and Chair of the Department of Political Science (1996 to 1999). He assumed his position as the Provost of Duke University in July of 1999.

Tom Katsouleas, Ph.D.

Vinik Dean, Pratt School of Engineering
Duke University

Thomas C. Katsouleas became dean of Duke University's Pratt School of Engineering, in July 2008, where he is also a Professor of Electrical and Computing Engineering. He earned a Ph.D. in physics and B.S. in physics, from UCLA in 1979 and 1984, respectively. He continued at UCLA where he served for seven years on the faculty. He joined the University of Southern California faculty as an associate professor of electrical engineering in 1991, becoming full professor in 1997. There he also served as an Associate Dean of Engineering and Vice Provost of Information Technology Services. He currently serves as associate editor of the IEEE Transactions on Plasma Science, co-chair of the ASEE Global Symposium on Engineering Education (Shanghai, 2011) and chair of the National Academy of Engineering Advisory Committee on Grand Challenges. Katsouleas' primary research interest is in the use of plasmas as novel particle accelerators and light sources.

Keynote Speaker

Roger Y. Tsien, Ph.D.

Professor, Department of Pharmacology, Department of Chemistry and Biochemistry
Howard Hughes Medical Institute
University of California, San Diego

"Fun with Photons and Designed Molecules"

Much recent progress in biomedical science has resulted from the invention of molecules that enable us to visualize or photostimulate biochemical pathways in living cells and tissues. Such molecules can be devised by a variety of strategies, ranging from pure chemical design and total synthesis to genome mining and high-throughput directed evolution. Examples of both successes and failures will be chosen mainly from my own experience. The key challenge is to match one's own neuroses and pleasures with research challenges that will have the widest possible impact.

Dr. Roger Y. Tsien, born in 1952, received his A.B. in Chemistry and Physics from Harvard College in 1972. He received his Ph.D. in Physiology in 1977 from the University of Cambridge and remained as a Research Fellow until 1981. He then became an Assistant, Associate, then full Professor at the University of California, Berkeley. In 1989 he moved to the University of California, San Diego, where he is an Investigator of the Howard Hughes Medical Institute and Professor in the Depts. of Pharmacology and of Chemistry & Biochemistry. His honors include Artois-Baillet-Latour Health Prize (1995), Gairdner Foundation International Award (1995), Award for Creative Invention from the American Chemical Society (2002), Heineken Prize in Biochemistry and Biophysics (2002), Wolf Prize in Medicine (shared with Robert Weinberg, 2004), Rosenstiel Award (2006), E.B. Wilson Medal of the American Society for Cell Biology (shared with M. Chalfie, 2008), and Nobel Prize in Chemistry (shared with O. Shimomura and M. Chalfie, 2008). He is a member of the National Academy of Sciences and the Royal Society. Dr. Tsien is best known for designing and building molecules that either report or perturb signal transduction inside living cells. These molecules, created by organic synthesis or by engineering naturally fluorescent proteins, have enabled many new insights into signaling. He is now developing new ways to target contrast agents and therapeutic agents to tumors and sites of inflammation based on their expression of extracellular proteases, and to highlight peripheral nerves to aid surgery.

Pleanary Speakers

Steven M. Block, Ph.D.

S. W. Ascherman Professor of Sciences
Department of Biology, Department of Applied Physics
Stanford University, California

"Optical Tweezers: Gene Regulation, Studied One at a Time"

Technical advances have led to the birth a new field, dubbed "single molecule biophysics." Single-molecule methods can record characteristics that are otherwise obscured by traditional, ensemble-based approaches, revealing rich new behaviors in biomolecules. An entire arsenal of techniques with single-molecule sensitivity has now been developed. Prominent among these technologies is the optical trap, or "optical tweezers," which is based upon radiation pressure. When combined with in vitro bioassays, optical trapping microscopes can measure molecular properties with unprecedented precision, down the atomic level—currently achieving a resolution of ~1 angstrom in a bandwidth of ~100 Hz—all while exerting exquisitely controlled forces in the piconewton (pN) range. Ultrasensitive systems for measuring force and displacement permit the nanomechanical properties of single molecules to be explored noninvasively. Among the notable successes for optical traps have been measurements of the fundamental steps generated by motor proteins and by processive nucleic acid enzymes, as well as the strengths of noncovalent bonds between proteins and the energetics and kinetics of folding in biopolymers, such as DNA and RNA. This talk will give special attention to our recent success in following the co-transcriptional folding of RNA in real time as it gets synthesized by RNA polymerase, and how that folding directly regulates genes.

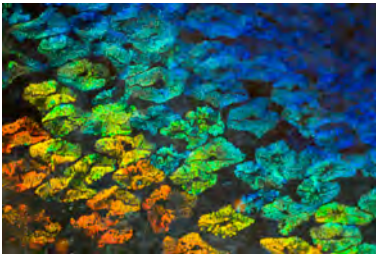
Dr. Steven M. Block is the S.W. Ascherman Chair of Sciences in the Departments of Applied Physics and Biology at Stanford University. He's best-known as a founder of the research field known as "single molecule biophysics." Block holds graduate degrees from Oxford University (B.A. 1974; M.A. 1978) and the California Institute of Technology (Ph.D. 1983). After completing postdoctoral research at Stanford (1983-87), where he was a Jane Coffin Childs Fellow, he served as a Staff Scientist at the Rowland Institute for Science and Lecturer at Harvard University (1987-1993), then Professor of Molecular Biology at Princeton University (1994-1999), prior to joining the Stanford faculty (1999). Block has been elected to the National Academy of Sciences and the American Academy of Arts & Sciences, and is a Fellow of the American Association for the Advancement of Science (AAAS), the American Physical Society (APS), and the Biophysical Society (BPS). He is a recipient of the Max Delbrück Prize in Biological Physics of the APS (2008), the Young Investigator (1994) and Outstanding Investigator in Single Molecule Biophysics Awards of the BPS (2008), and an NIH MERIT Award (2010, 2014). He has served as the Biophysical Society's President (2005-2006), National Program Chair (1999), and National Lecturer (2012). Block's scientific research lies at the interface of physics and biology, particularly in the study of biomolecular motors, such as kinesin and RNA polymerase, and the folding of nucleic acid-based structures. His group has pioneered the use of laser-based optical traps, also called 'optical tweezers,' to study the nanoscale motions of individual biomolecules. Today, this work forms a central part of the field known as 'single molecule biophysics.'

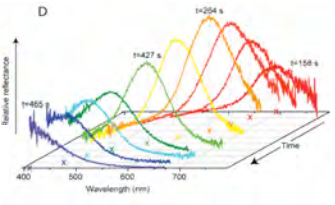
Daniel E. Morse, Ph.D.

Wilcox Professor of Biotechnology, Biomolecular Science and Engineering
Founding Director, UCSB-MIT-Caltech Institute for Collaborative Biotechnologies
University of California, Santa Barbara

"Tunable Bio-Photonics: Nanoscale Protein Assembly Drives Changes in Iridescence and Enhanced Photosynthesis in Molluscs"

Skin cells of octopi, squids and cuttlefish exhibit a remarkable ability to rapidly change color and reflectivity for camouflage and communication. Neurotransmitter signaling to the skin triggers synergistic changes in the refractive index, thickness and spacing of subcellular Bragg reflectors, producing dramatic changes in both the wavelength and intensity of iridescence. We discovered that iridescence (angle-dependent colored reflectance) is controlled by a neurotransmitter-activated signal transduction cascade culminating in catalytic changes in phosphorylation of unique reflectin proteins, the major constituents of the membrane-bound Bragg lamellae. These changes are a reversible molecular switch, triggering hierarchical assembly of the reflectin proteins; the resulting Gibbs-Donnan equilibration drives expulsion of water from the Bragg lamellae, shrinking the thickness and spacing of the Bragg lamellae. The result is a simultaneous increase in reflectance and a progressive change of color of the reflected light. The process is reversible and finely tunable, allowing selective reflection of any color. Related mechanisms of dynamically switchable, omnidirectional bright white reflectors in squid skin; omnidirectional, broad-band, metal-like reflectors surrounding the eyes of squid; and bifunctional, bidirectional reflectors enhancing the photosynthesis of symbiotic microalgae in giant clams will be discussed. Each of these photonic systems is governed by the reflectin proteins; these proteins are intrinsically transparent, producing the multitude of photonic behaviors observed by determining the formation of unique nanostructures that modulate the interaction with light. Translation of the lessons learned from these protein-based nanostructures governing photonic behavior in biology may open new approaches to dynamically tunable and transductive nanostructured photonic materials and devices.





Daniel E. Morse is the Wilcox Professor Emeritus of Biotechnology, Biomolecular Science and Engineering at the University of California, Santa Barbara (UCSB), and was the Founding Director of the UCSB-MIT-Caltech Institute for Collaborative Biotechnologies, a unique University-Industry-Government collaborative R&D enterprise. He received his B.A. in Biochemistry from Harvard, his Ph.D. in Molecular Biology from Albert Einstein College of Medicine, and conducted postdoctoral research in molecular genetics at Stanford University. He was the Silas Arnold Houghton Associate Professor of Microbiology and Molecular Genetics at Harvard Medical School before joining the faculty at Santa Barbara. Professor Morse's research is focused at the interface between biotechnology, chemical physics and materials science. He was honored by Scientific American as one of the top 50 technology innovators of 2006 for his development of biologically inspired, kinetically controlled catalytic routes to semiconductor thin films and nanoparticles. He was the 7th Kelly Lecturer in Materials and Chemistry at the University of Cambridge and a 3M Lecturer in Chemistry and Materials at the University of Vancouver. Elected a Fellow of the Materials Research Society, AAAS and the Smithsonian Institution, he's received Research Career awards from the NIH, American Cancer Society and recognition as Visiting Professor of Bio-Nano-Electronics in Japan, Visiting Professor at the University of Paris and universities in Singapore and the UK. His students also have won international recognition for their research.

Invited Speakers

Thomas W. Cronin, Ph.D.

Professor, Department of Biological Sciences
University of Maryland-Baltimore County

"Biological Optics and Mantis Shrimp: Evolutionary Inventiveness in Light Control"

Stomatopod crustaceans (mantis shrimps) exhibit a range of diverse and unusual optical adaptations in their eyes and on their body surfaces, including polarization-handling features and structural optics at the microscale and nanoscale. They are the only animals known to produce polarization signals using dichroic molecules or to detect circularly polarized light with the aid of an achromatic retarder, formed by a microvillar array. Other optical specializations extend to 1D chiral reflectors and 3D photonic crystal structures. Some reflectors, including those in the eyes of larval stages and certain polarization-inducing structures on appendages, fall into the category of amorphous photonic devices. Such structures have local correlations between scatterers ("short-range order"), producing optical responses via coherent interference. Of particular interest are certain polarization reflectors that are shape-anisotropic and relatively large in size; these apparently operate due to spatial correlations between the planes of the structures themselves and the electric vectors of incident light. Mantis shrimps thus have been extraordinarily inventive in their ability to control light's spectrum and polarization.

Thomas W. Cronin received his PhD degree from Duke University in 1979. He then spent three years as a postdoctoral fellow in the laboratory of Timothy Goldsmith at Yale University before moving to his current position at the University of Maryland Baltimore County. Dr. Cronin's research concerns the adaptations of biological visual systems for biologically relevant tasks in particular environments. He has published research on animals ranging from sponges to humans, but he works primarily on marine invertebrate animals. He has been a AAAS Fellow since 2002, and he recently co-authored a book on his research area, entitled Visual Ecology.

Dorothy Erie, Ph.D.

Professor of Chemistry and Curriculum in Applied Sciences and Engineering
University of North Carolina at Chapel Hill

"Combing Single-Molecule Methods to Study DNA Repair In Vitro and In Vivo

DNA polymerases that are responsible for replication make approximately one error for every 107¬ bases copied, but the human results in ~600 errors per round of replication. The DNA mismatch repair (MMR) system corrects these DNA synthesis errors that occur during replication. MMR is initiated by the highly conserved MutS and MutL homologs, which are both dimers and contain DNA binding and ATPase activities that are essential for MMR in vivo. MutS homologs initiate repair by binding to a mismatch and undergoing an ATP-dependent conformational change that promotes its interaction with MutL homologs. This complex signals the initiation of excision and resynthesis of the newly synthesized DNA strand containing the incorrect nucleotide. We have been using a combination of atomic force microscopy (AFM) and single molecule fluorescence to characterize the stoichiometries and the conformational and dynamic properties of MutS and MutL homologs and their assembly on DNA containing a mismatch. We have also developed a new dual resonance frequency enhanced electrostatic force

microscopy (DREEM), in which we simultaneously collect the AFM topographic image and an image of the electrostatic potential of the surface. The DREEM images reveal the path of DNA inside individual protein-DNA complexes, yielding unprecedented details about DNA conformations within simple and complicated complexes. Finally, to follow assembly of MutS and MutL in vivo, we have been developing methods to obtain single molecule detection of eGFP-tagged MMR proteins in yeast. I will discuss our studies on the assembly of MutS and MutL homologs on mismatches, with a focus on how AFM, DREEM, and single-molecule fluorescence can be powerful tools to study the stoichiometries, conformations, and dynamic assembly of multi-component complexes.

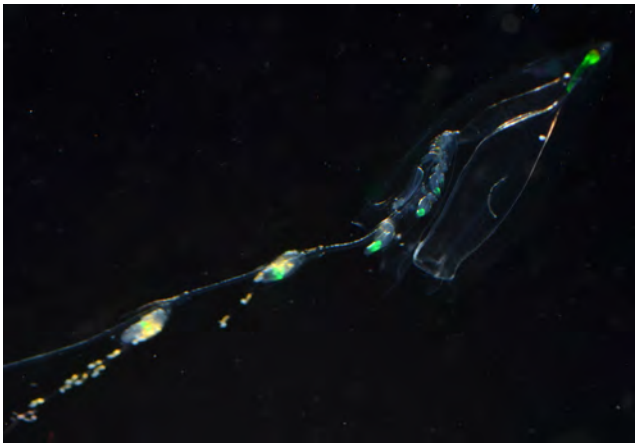
Dr. Dorothy Erie is Professor of Chemistry and Curriculum in Applied Sciences and Engineering at the University of North Carolina at Chapel Hill. She received her Ph.D. in Physical Chemistry from Rutgers- The State University of New Jersey in 1989. Afterward, she was awarded an NIH postdoctoral fellowship and worked as a research associate at the University of Oregon until 1994. She then spent one year at the University of Carlifornia- Berkeley working as a research associate under Professor Michael Chamberlin before arriving at the University of North Carolina. In her first year at UNC, she received a Junior Faculty Development Award and went on to serve as Vice Chair of the Division of Natural Sciences at UNC from 2007-2010. Her research spans the biochemical, biophysical, and analytical regimes- using AFM and fluorescence to study protein-protein and protein-nucleic acid interactions as well as investigating mechanistic studies of transcription elongation.

Steven Haddock, Ph.D.

Scientist Bioluminescence and Zooplankton
Monterey Bay Aquarium Research Institute

"Biologically Generated Light: Diversity and Functions of Natural Luminescence and Fluorescence in the Sea"

Using light is one of the most popular and effective means of communicating in the sea, and a wide array of organisms have evolved ways to generate their own light (bioluminescence) or modify the color of available light (fluorescence). These two mechanisms occur across the tree of life, including in many animals without visual systems. Technology like deep-diving submersibles and transcriptome sequencing and analysis can help us understand how these capabilities have evolved. Bio-optical signals carry out many ecological roles, including unexpected ones that are being discovered through exploration of the diversity of marine organisms from the surface into the deep sea. I will present a survey of new discoveries in the realms of bioluminescence and fluorescence, as well as some of the additional questions which merit further study.



Dr. Steven Haddock studies marine diversity, bioluminescence, and other optical properties of marine organisms at the Monterey Bay Aquarium Research Institute and UC Santa Cruz. In addition to conducting deep-sea expeditions, he uses genetic methods to reveal the relationships between organisms and the proteins that they use to make light. He also runs the Bioluminescence Web Page (http://biolum.eemb.ucsb.edu/), the citizen-science project jellywatch.org, and teaches computing to scientists at practicalcomputing.org

Duke Speakers

Charles Gersbach, Ph.D.

Assistant Professor of Biomedical Engineering
Duke University

"Spatiotemporal Control of Mammalian Gene Expression with Light-Inducible Transcription Factors and Recombinases "

Advanced gene regulatory systems are necessary for scientific research, synthetic biology, and gene-based medicine. An ideal system would allow facile spatiotemporal manipulation of gene expression within a cell population that is tunable, reversible, repeatable, and can be targeted to diverse DNA sequences. To meet these criteria, we engineered a gene regulation system that uses two light-inducible dimerizing proteins from plants to control synthetic zinc finger transcription factors targeted to diverse sequences in mammalian cells. Activation of gene expression in engineered human cells was reversible and repeatable by modulating the duration of illumination. The level of gene expression could also be controlled by modulating light intensity. Finally, gene expression could be activated in a spatially defined pattern by illuminating the cell culture through a photomask. More recently, we have also used light-inducible recombinases to achieve irreversible changes in gene activation in response to blue light. We are using this system to direct cell lineage specification and tissue formation. Collectively, these technologies enable new approaches for precisely regulating gene expression in biotechnology and medicine, as well as studying gene function, cell-cell interactions, and tissue morphogenesis.

Charles A. Gersbach received his B.S. in Chemical Engineering from Georgia Tech and a Ph.D. in Biomedical Engineering from Georgia Tech and Emory University, where he worked on incorporating gene therapy strategies into tissue engineering and regenerative medicine. He then completed a postdoctoral fellowship at The Scripps Research Institute focused on engineering synthetic enzymes for precise and robust genome engineering. Dr. Gersbach's laboratory at Duke is focused on applying molecular and cellular engineering to applications in gene therapy, regenerative medicine, and basic science. In particular, his research aims to develop new methods to genetically modify genome sequences and cellular gene networks in a precise and targeted manner. These new methods are then applied to directing stem cell differentiation, tissue regeneration, correction of genetic diseases, or answering fundamental biological questions regarding gene regulation and genome structure and function. Examples of technologies used in his research include genome editing, protein engineering, directed evolution, genetic reprogramming, and optogenetics. He has received several awards for this work, including the NIH Director's New Innovator Award, the NSF CAREER Award, and the American Society of Gene and Cell Therapy Outstanding New Investigator Award.

Geoffrey S. Ginsburg, M.D., Ph.D.

Professor of Medicine and Professor of Pathology
Director of IGSP Center for Genomic Medicine
Duke University

"Novel Platforms for the Diagnosis of Infectious Disease"

Early detection of infection could have profound implications on patient management and prognosis by allowing prompt initiation of appropriate therapy. This strategy is not possible with current culture-based diagnostic platforms owing to their low sensitivities and the time required to obtain results. Compelling evidence now exists that the host response to pathogens, in the form of pathogen-specific host gene and protein expression signatures, can serve as a potential early and rapid diagnostic strategy. Therefore we have identified host gene expression profiles as a strategy for the diagnosis of infection. Using unbiased sparse latent factor regression analysis, we generated gene signatures (or factors) from peripheral blood RNA analysis that distinguish individuals with symptomatic acute respiratory infection from individuals with bacterial infection or from uninfected individuals with ~ 90% accuracy. Signatures specific

for bacterial infection based on the host response have also been derived. Moreover, with collaborators in the Fitzpatrick Institute of Photonics we have developed prototype novel sensing technologies for mRNA that can elevate this approach from a research-based endeavor to a clinically useful point of care diagnostic tool. Combining host-based diagnostics with novel sensor technologies will result in a paradigm shift in the early detection and diagnosis of disease causing pathogens.

Geoffrey S. Ginsburg is the founding director for Genomic Medicine in the Duke Institute for Genome Sciences & Policy and the founding executive director of the Center for Personalized Medicine in the Duke University Health System. He is a professor of Medicine, Pathology, and Biomedical Engineering at Duke University. He is an internationally recognized expert in genomics and personalized medicine with funding from NIH, DOD, Air Force, DARPA, the Gates Foundation, and industry. Prior to Duke he was at Millennium Pharmaceuticals Inc where he was vice president of Molecular and Personalized Medicine and responsible for developing pharmacogenomic and biomarker strategies for therapeutics. He serves as an expert panel member for Genome Canada, as a member of the Board of External Experts for the NHLBI, as Co-Chair of the Institute of Medicine[1]s Roundtable on Genome-Based Research to Human Health, as a member of the advisory council for the National Center for Accelerating Translational Science, as co-Chair of the Cures Acceleration Network, as an Expert Advisor to the Pharmacogenetics Research Network, and as a member of the World Economics Forum[1]s Global Agenda Council on Personalized and Precision Health Care.

Ute Hochgeschwender, M.D.

Associate Research Professor of Neurobiology
Director of the Duke Neurotransgenic Laboratory
Duke University

"Bioluminescence Activation of Light-Sensing Molecules"

In optogenetic manipulations of neurons genetically addressable opsins are activated by physical light sources (laser, LED), resulting in stimulation or silencing of neuronal activity. We set out to use a biological light source to activate opsins by combining a light-generating protein (luciferase) with a light-transducing protein (opsin). Our strategy was to fuse the blue light-generating luciferase from the marine copepod Gaussia princeps to a blue light-sensitive ion channel or proton pump, yielding a bioluminescent opsin, or luminopsin. This allows the opsin moiety to be activated by light produced by the luciferase moiety upon application of its substrate, coelenterazine (CTZ). In proof-of-concept experiments we show that responses to CTZ are detected in neurons expressing luminopsins in culture, in brain slices, and in behaving animals. The concept of genetically encoding both light production and light sensing is applicable not only to opsins, but to a broader and rapidly expanding arsenal of tools for light-based cellular manipulations. Further developments of this technology may allow translation of such non-invasive optogenetics into clinical settings.

Ute Hochgeschwender received her degrees in medicine and philosophy from the Free University of Berlin, Germany. She is an Associate Research Professor of Neurobiology at Duke University Medical Center and the Director of the Duke Neurotransgenic Laboratory. Her long-standing research efforts have been in developing genetic animal models of neurological and psychiatric dysfunction. More recently, she has focused her interests on combining genetic approaches of light emission and light sensing for neuronal manipulation.

Joseph A. Izatt, Ph.D.

Professor of Biomedical Engineering
Duke University

"Advances in Ophthalmic Imaging Technology for Real Time 3D Imaging and Surgical Guidance"

Optical coherence tomography (OCT) and its extensions employ combinations of spatial and spectral encoding techniques to obtain micron-scale measurements of structure and function in living tissues and organisms. OCT has become a standard of care in clinical ophthalmology and has shown significant potential for applications in cardiology, endoscopy, surgery, and developmental biology. We are developing next-generation OCT technologies customized for new applications in refraction correction, pediatric imaging, and retinal microsurgery. These technology advances allow for real time volumetric microstructural

imaging in living patients, which we are deploying for hand-held and intrasurgical applications. Compact multi-modal combinations of OCT with confocal microscopy allow for imaging of individual retinal receptor cells without adaptive optics. Functional extensions of OCT for Doppler and speckle-variance based blood flow imaging provide imaging of capillary-level blood flow without contrast agents in living eyes. The lecture will review the current state of these technologies and provide an overview of selected applications.

Dr. Joseph A. Izatt is Professor of Biomedical Engineering and Ophthalmology, and Program Director for Biophotonics at the Fitzpatrick Institute for Photonics at Duke University in Durham, North Carolina. He is also Chairman and Chief Science Officer at Bioptigen, Inc., a North Carolina startup company commercializing optical coherence tomography technology. Dr. Izatt is a Fellow of the American Institute for Medical and Biological Engineering (AIMBE), Society of Photo-Instrumentation Engineers (SPIE), and Optical Society of America (OSA). He serves as editor-in-chief of Biomedical Optics Express.

Andrew Janiak, Ph.D.

Creed C. Black Associate Professor of Philosophy
Chair, Faculty Advisory Council, Bass Connections
Duke University

"Newton's Disputes in Optics and Their Philosophical Implications"

When Isaac Newton first published the results of his experiments with prisms in the 1670s, they immediately generated a controversy amongst wave and particle theorists. In these early days of experimental optics, basic agreements concerning the proper methodology for experimentation and data collection had not been forged. As a result, leading experimentalists such as Newton were forced into protracted philosophical disputes that are illuminating when viewed from a historical perspective.

Andrew Janiak is Creed C. Black Associate Professor of Philosophy at Duke University, where he directs the PhD program in History and Philosophy of Science, Technology and Medicine. He came to Duke in 2002 after holding a Dibner postdoctoral fellowship at MIT. He is the author, editor and co-editor of five books concerning the history and philosophy of science in the 17th and 18th centuries, along with numerous refereed articles in these areas.

Sönke Johnsen, Ph.D.

Professor of Biology
Duke University

"Hidden in Plain Sight: The Optics of Organismal Transparency"

The open ocean, which comprises over 99.5% of the earth's biosphere, is an exceptionally difficult place to hide. The background is nearly featureless, predation is intense, and there is nothing to swim behind. Because most oceanic animals approach any object, complete invisibility is usually the only successful strategy. Therefore animals in the open ocean have evolved a number of strategies that are absent or rare in other environments, including mirrors, bioluminescence, and whole-body transparency. This talk explores the last strategy – transparency – and briefly discusses the potential optical mechanisms underlying this fascinating trait.

Dr. Sönke Johnsen originally trained in mathematics and art, has studied camouflage, signaling, and non-human visual modalities for the last 20 years. He is particularly interested in vision and camouflage in the open ocean, but has also worked on coastal and terrestrial species, magnetoreception, nocturnal illumination, and human cataracts. His research combines mathematical analyses with behavioral and morphological studies and in situ measurements and observations. His field work primarily involves open-ocean research cruises that use SCUBA and deep-sea submersibles. In addition to exploring the evolution and diversity of the optical and visual tricks that animals perform, Dr. Johnsen is interested in improving communication between theoretical and experimental scientists and between scientists and artists. Outreach is a strong focus and his research has been presented in numerous magazines, newspapers and television shows. In his spare time, he is an avid nature photographer.

G. Allan Johnson, Ph.D.

Charles E. Putnam Professor of Radiology
Professor of Physics and Professor of Biomedical Engineering
Director of the Duke Center for In Vivo Microscopy
Duke University

"Magnetic Resonance Histology"

The closing sentence of Paul Lauterbur's seminal article describing magnetic resonance imaging is " Zeugmatigraphic (imaging) techniques should find many useful applications in studies of the internal structures, states, and compositions of microscopic objects" [1] – an obvious understatement about the impact MRI has had on modern medicine and science. MRI continues to deliver exciting new opportunities for discovery in science and medicine. Magnetic resonance histology, the topic of this presentation is an area in which we have seen dramatic advances over the last few years. Magnetic resonance histology (MRH), the study of tissue structure- through the use of magnetic resonance imaging was first suggested in 1993 [2]. MRH provides several unique compliments to more traditional optical methods: MRH is nondestructive, is inherently digital and 3 dimensional, and provides particularly fascinating tissue contrast dependent proton sources and their environments in the tissue. This talk will describe the technology that has allowed us to acquire MR images at spatial resolution more than 1 million times that seen in clinical scanners, some of the unique sources of contrast, and some recent applications in genetics and neuroscience.

1. Lauterbur, P.C., Image formation by induced local interactions - examples employing nuclear magnetic resonance. Nature, 1973. 242: p. 190-1.
2. Johnson, G.A., et al., Histology by magnetic resonance microscopy. Magnetic Resonance Quarterly, 1993. 9(1): p. 1-30.

Dr. G. Allan Johnson performed his Ph.D. research in (electron spin) magnetic resonance under Professor Walter Gordy from 1969-1974. He joined the Duke Department of Radiology in 1974 where he was responsible for installing the first CT system at Duke (the second CT system in the US). From 1979-2009 he served as the Director of Diagnostic Physics for Duke Medical Center where he was intimately engaged with translating CT technology into clinical application. From 1982-1989, he worked closely with colleagues at General Electric in the installation of the world's first clinical high-field (1.5 T) MR system at Duke. During that time, a desire to limit research on large animals (dogs) stimulated his interest in the technical challenges of translating imaging methodologies to small animals. He founded the Center for In Vivo Microscopy in 1986, now one of the oldest dedicated imaging resources in the country. His interest remains in developing novel technologies for small animal imaging and translation of those technologies to important biomedical questions. While he has been interested in a wide range of imaging methods, his most recent personal interest has been in MR histology of the rodent brain, the topic of this presentation.

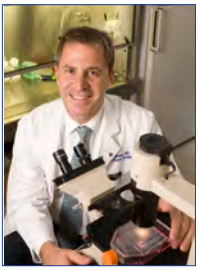
Regis Kopper, Ph.D.

Director of the Duke Immersive Virtual Environment (DiVE)
Duke University

"Using Immersive Virtual Reality as a Medium for Applied Photonics"

Virtual reality technology has been shown to improve user performance in tasks such as spatial understanding, memorization and training. Immersive virtual environments allow users to experience three dimensional computer graphics applications from a first person perspective and interact using natural motions. In this talk, I will provide an overview of the research I have conducted on the benefits of immersive virtual reality on different application areas, ranging from spatial judgments to procedure memorization. I will present a recent project in which neutrino interaction events from a detector are displayed to scale in immersive virtual reality, where it is possible to see the progression of a neutrino interaction as a user-controlled time playback. I will conclude by presenting the Duke immersive Virtual Environment (DiVE), an advanced interactive virtual reality infrastructure at Duke University where users are completely surrounded by the computer graphics. I will discuss how the Duke and external scientific communities can get involved with virtual reality research.

Dr. Regis Kopper is the director of the Duke immersive Virtual Environment (DiVE). Previously, Regis was a Post-Doctoral Associate in the Virtual Experiences Research Group at the University of Florida, where he researched the value of virtual humans in interpersonal skills training. At Duke, Regis does multidisciplinary research using virtual reality for domains such as archeology, health care and engineering. His research interests include 3D user interfaces, novel interaction techniques and immersive virtual reality. Regis is a recipient of the best paper award in the IEEE Symposium in 3D User Interfaces and was a member of the first team to be awarded the 3D User Interfaces Grand Prize. His research has been funded by the DoD, NSF and NIH. Regis received his B.A and M.S. from the Pontifical Catholic University in Porto Alegre, Brazil and his Ph.D. from Virginia Tech.



Howard Levinson, M.D., FACS *(co-presenting with Professor Adam Wax)*

Director of Plastic Surgery Research
Associate Professor Plastic and Reconstructive Surgery
Associate Professor Division of Surgical Services
Associate Professor Pathology
Departments of Surgery and Pathology
Duke University Medical Center

"Noncontact Optical Tissue Diagnostics for Assessing Burn Wound Depth"

We present a new method for assessing tissue health based on coherent detection of multiply scattered light. Multispectral measurements of scattering signals image tissue components with millimeter resolution at depths of up to 1 cm. New applications to assessing burns in animal and human tissues are presented.

Howard Levinson, MD is an Associate Professor in the Divisions of Plastic and Reconstructive Surgery and Surgical Sciences, Departments of Surgery and Pathology at Duke University Medical Center (DUMC). He is a double-board certified General Surgeon and Plastic and Reconstructive Surgeon and cares for patients both at DUMC and the Veterans Administration Hospital in Durham, North Carolina. As the Director of the Wound Healing and Fibrosis Research Laboratory, he leads a translational research team, which includes graduate students, multiple research fellows and medical students. His primary focus is to develop innovative therapies in the peri-operative space including technologies to prevent skin scar contracture and promote skin wound healing. He holds multiple patents. His laboratory is funded by multiple intramural, as well as extramural grants. He has consulted for GlaxoSmithKline, Johnson and Johnson, Cardinal Health, Heraeus Pharmaceuticals, Exoxemis, and Allergan in their anti-scarring drug development efforts. He has more than 30 publications and has served on multiple study sections for the Department of Defense and the Plastic Surgery Foundation grant review committees.

Maiken Mikkelsen, Ph.D.

Assistant Professor of Electrical and Computer Engineering
Assistant Professor of Physics
Duke University

"Tunable Plasmonic Platform for Giant Fluorescence Enhancement"

Plasmonic cavities and nanoantennas have proven to be particularly attractive candidates for modifying the excitation and decay rates of nearby emitters. Here, we demonstrate giant enhancement of fluorescence in planar nanoparticles electromagnetically coupled to a metallic film, resembling nanopatch antennas. The antennas consist of colloidally synthesized silver nanocubes deposited over a 50 nm silver film. The cubes and film are separated by a ~5 nm selfassembled polyelectrolyte spacer layer, coated with a dilute layer of fluorophores (sulfo-cy5 carboxylic acid). By varying the size of the nanocubes, we tune the plasmonic resonance throughout the excitation and emission spectra of the embedded fluorophores, demonstrating a seamless transition between fluorescence enhancement and quenching. The experimentally observed behavior agrees well with performed finite-element simulations. Using this tunable platform, design rules for optimal enhancement are revealed, allowing us to

demonstrate giant fluorescence enhancements and a significantly increased spontaneous emission rate.

Dr. Maiken H. Mikkelsen is an Assistant Professor of Electrical and Computer Engineering and Physics at Duke University. She received her B.S. in Physics from the University of Copenhagen, Denmark in 2004 and her M.A. and Ph.D. degrees in Physics from the University of California, Santa Barbara in 2007 and 2009, respectively. She did her PhD in the group of Prof. David Awschalom on experimental studies of single electron spins in semiconductor quantum dots. Before joining Duke, she was a postdoctoral fellow in the group of Prof. Xiang Zhang at the University of California, Berkeley doing research in the area of nanophotonics. In 2011 she received the European Physical Society's Ph.D. Thesis prize from the Quantum Electronics and Optics Division. Her research interests include experimental studies of spin dynamics in solid state systems, light-matter interactions in nanostructures, nanophotonics, metamaterials, and quantum information science.

Gregory M. Palmer, Ph.D.

Associate Professor of Radiation Oncology
Duke University

"Characterization of Tumor Physiology and Vascular Function in Response to Therapy Using Optical Spectroscopy and Intravital Microscopy"

Optical methods enable non-destructive, quantitative, longitudinal monitoring of tissue, in vivo. This enables dynamic imaging of a variety of physiologic and molecular sources of contrast. I will describe techniques applicable to two different settings. First, optical spectroscopy combined with Monte Carlo models of light propagation in tissue allows for quantitative assessment of tissue absorption, scattering, and fluorescence contrast. We have applied this technique to quantify tissue blood volume, oxygenation, and drug delivery in response to a range of therapies, including antiangiogenic therapy, and hyperthermia. Key advantages of this technique are that it is clinically translatable and relatively inexpensive, and so can be used to monitor pharmacokinetics and pharmacodynamics in vivo at multiple time points. Secondly, intravital imaging using window chamber models allows the wide range of available optical microscopy techniques to be applied to living tissues. The acquisition and analysis of three types of functional information will be discusses: 1) hemodynamic parameters, including oxygen saturation and blood flow, 2) oxygen sensing nanoparticles for assessment of tissue hypoxia, and 3) fluorescent reporters for cell tracking and gene expression. These enable quantitative assessment of oxygen supply and consumption, including fluctuating hypoxia in tumors. The combination of these tools facilitates a more complete characterization of tumor physiology and molecular responses, and how these interplay to influence tumor response to therapy.

Dr. Gregory M. Palmer completed his PhD at the University of Wisconsin, Madison in 2005 under Dr. Nimmi Ramanujam. His project was to develop quantitative Monte Carlo based algorithms to extract tissue optical properties from fluorescence and diffuse reflectance spectra, particularly applied to the diagnosis of breast cancer. He then studied as a postdoc under Dr. Mark Dewhirst at Duke University, where he worked to apply optical techniques to evaluate therapeutic response in preclinical and clinical settings. He has been an Assistant Professor at Duke since 2009, and Associate Professor since 2014. His lab currently specializes in developing quantitative optical imaging techniques, and in particular window chamber and intravital microscopy techniques for characterizing tumor growth, physiology, and therapeutic response. Notable achievements include the development of hypoxia sensing techniques through use of oxygen sensing nanoparticles as well as the development of quantitative optical techniques to monitor drug delivery and pharmacodynamics.

Nimmi Ramanujam, Ph.D.

Professor of Biomedical Engineering
Director for the Center for Global Women's Health Technologies
Duke University

"Point of Care Optical Technologies for Women's Health"

Optical technologies have been exploited widely in the analytical chemical analysis

of biological samples. While the benefits of optical spectroscopy and microscopy have long been known in the laboratory, over the past quarter century there has been increasing interest in the application of these techniques to intact human tissues. One of the distinct attributes of light is that is provides exquisite chemical specificity by interacting with a number of molecules that are already present in the tissue and thus has the capability to provide insight into functional, morphological and molecular contrast. Our objective is to exploit the wealth of physiological, metabolic, morphological and molecular sources of optical contrast to develop novel strategies that focus on cervical cancer screening and breast cancer diagnostics.

Dr. Nimmi Ramanujam, since coming to Duke University in 2005, has established the Tissue Optical Spectroscopy laboratory. Prof. Ramanujam's group is innovating on optical strategies to peer into the biological landscape of thick tissues. Technologies being developed in her lab leverage principles of optical spectroscopy, optical sectioning microscopy, and molecular imaging. Her research group is developing and applying these optically based tools for three problems in cancer: cancer screening in resource-limited settings, intra-operative margin assessment to detect residual disease during cancer surgery, and visualizing tumor hypoxia and metabolism in the context of cancer therapy and drug discovery. Prof. Ramanujam is leading a multi-disciplinary effort to translate these technologies to clinical applications in the breast, cervix and head and neck. In addition to her academic efforts, Prof. Ramanujam has spun out a company, Zenalux, to commercialize several of the technologies developed in her lab. In October of 2013, Dr. Nimmi Ramanujam founded the Global Women's Health Technologies Center. The Global Women's Health Technologies Center reflects a partnership between the Pratt School of Engineering and the Duke Global Health Institute The center's mission is to increase research, training and education in women's diseases, with a focus on breast cancer, cervical cancer, and maternal-fetal health; and to increase retention of women and underrepresented minorities in Science, Technology, Engineering, and Mathematics (STEM) educational disciplines locally and globally. Dr. Ramanujam earned her Ph.D. in Biomedical Engineering from the University of Texas, Austin in 1995 and then trained as an NIH postdoctoral fellow at the University of Pennsylvania from 1996-2000.

Hans J. Van Miegroet, Ph.D.

Professor and Chair of Art, Art History and Visual Studies
Duke University

"Media Arts + Sciences at Duke From the Humanities Outward to the Sciences and the Social Sciences"

The new program in Media Arts + Sciences at Duke is shaped by a conviction that the conditions for knowledge production in today's global world have been fundamentally altered by the computational revolution. From experimental practices in the sciences to research methodologies in the humanities, knowledge has come increasingly to depend on the gathering and analysis of large aggregates of data that in some crucial ways cannot be "understood" or "manipulated" without the assistance of sophisticated computational methodologies, new forms of visualization and media technologies. Media Arts + Sciences aims to address this new cultural condition for knowledge pro¬duction by integrating humanities-based research with theoretical inquiry in the natural sciences and social sciences as well as media pro¬duc¬tion and practice.

Dr. Hans J. Van Miegroet is professor and Chair of the Department of Art, Art History & Visual Studies at Duke University. He also heads the Duke University Visual Studies Initiative (VSI), which received a major institutional grant from the Andrew W. Mellon Foundation and is Director of the Duke Art, Law and Markets Initiative (DALMI).

He was trained at the Higher Institute for Art History and Archaeology of the University of Ghent (Belgium) and received his Ph.D. at the University of California, Santa Barbara. He is engaged in exploring Art History and Visual Studies at the interface of the humanities, social sciences, law and the sciences. He has adopted a scientific collaborative model to conducting research on emerging Art Markets, legal questions related to copyright and cultural heritage and visual culture as a commercial pursuit. This approach has made it possible to create, and sustain, a variety of new research strategies and modes of interpretation, attractive to museum professionals as well as to scholars and students from the humanities, law and the social sciences.

Warren S. Warren, Ph.D.

Professor of Chemistry
Duke University

"Adapting Modern Biomolecular Imaging to Cultural Heritage Applications"

Many of the same challenges faced in tissue imaging (scatter, lack of contrast) are found in cultural heritage applications, such as three-dimensional imaging of Renaissance painting, pottery, or scrolls. Remarkably, laser systems optimized for one application do a great job in the others. We will discuss our recently published work (PNAS 2014), and the lessons it provides for improving imaging in both artwork and biomedical applications.

Dr. Warren S. Warren received his A.B degree summa cum laude in Chemistry and Physics from Harvard in 1977; his M. S. in 1979 and Ph. D. in 1980 from U. C. Berkeley, working with Alexander Pines; and his postdoctoral training in 1981-1982 at Caltech, working with Ahmed Zewail. From 1982 to 2005 he was on the faculty at Princeton, ultimately as the Ralph W. Dornte Professor of Chemistry, with appointments in Physics, EE, and Molecular Biology; he was also Adjunct Professor of Radiology at the University of Pennsylvania from 2001-2006. Since 2005 he has been at Duke, where he is the James B. Duke Professor of Chemistry, Physics, Radiology, and Biomedical Engineering; and Director of the Center for Molecular and Biomolecular Imaging. Warren's research interests are in molecular imaging and molecular spectroscopy, primarily focusing on magnetic resonance and nonlinear optics. Warren is a fellow of APS, OSA, SPIE, AAAS and ISMAR; 2011 American Physical Society Herbert Broida Prize and 1982 American Chemical Society Nobel Laureate Signature Award recipient; and a former Sloan, NSF Graduate, and NSF postdoctoral fellow. He is also the author of an award winning honors chemistry textbook, The Physical Basis of Chemistry.

Adam P. Wax, Ph.D. *(co-presenting with Dr. Howard Levinson)*

Theodore Kennedy Professor of Biomedical Engineering
Duke University

"Noncontact Optical Tissue Diagnostics for Assessing Burn Wound Depth"

We present a new method for assessing tissue health based on coherent detection of multiply scattered light. Multispectral measurements of scattering signals image tissue components with millimeter resolution at depths of up to 1 cm. New applications to assessing burns in animal and human tissues are presented.

Dr. Adam Wax received dual B.S. degrees in 1993, one in electrical engineering from Rensselaer Polytechnic Institute, Troy, NY and one in physics from the State University of New York at Albany, and the Ph.D. degree in physics from Duke University, Durham, NC in 1999. He joined the George R. Harrison Spectroscopy Laboratory at the Massachusetts Institute of Technology, as a postdoctoral fellow of the National Institutes of Health immediately after his doctorate. Dr. Wax joined the faculty of the Department of Biomedical Engineering at Duke University in the fall of 2002. In 2006, Dr. Wax founded Oncoscope, Inc. to commercialize early cancer detection technology developed in his laboratory. In 2010, he was named as Fellow of the Optical Society of America and SPIE, the international society for optics and photonics. He is currently the Theodore Kennedy professor of biomedical engineering at Duke University and Chairman of Oncoscope, Inc. His research interests are in the use of light scattering and interferometry to probe the biophysical properties of cells for both diagnosis of disease and fundamental cell biology studies.

Panel Members

Steven M. Block, Ph.D.

S. W. Ascherman Professor of Sciences
Department of Biology, Department of Applied Physics
Stanford University, California

Dr. Steven M. Block is the S.W. Ascherman Chair of Sciences in the Departments of Applied Physics and Biology at Stanford University. He's best-known as a founder of the research field known as "single molecule biophysics." Block holds graduate degrees from Oxford University (B.A. 1974; M.A. 1978) and the California Institute of Technology (Ph.D. 1983). After completing postdoctoral research at Stanford (1983-87), where he was a Jane Coffin Childs Fellow, he served as a Staff Scientist at the Rowland Institute for Science and Lecturer at Harvard University (1987-1993), then Professor of Molecular Biology at Princeton University (1994-1999), prior to joining the Stanford faculty (1999). Block has been elected to the National Academy of Sciences and the American Academy of Arts & Sciences, and is a Fellow of the American Association for the Advancement of Science (AAAS), the American Physical Society (APS), and the Biophysical Society (BPS). He is a recipient of the Max Delbrück Prize in Biological Physics of the APS (2008), the Young Investigator (1994) and Outstanding Investigator in Single Molecule Biophysics Awards of the BPS (2008), and an NIH MERIT Award (2010, 2014). He has served as the Biophysical Society's President (2005-2006), National Program Chair (1999), and National Lecturer (2012). Block's scientific research lies at the interface of physics and biology, particularly in the study of biomolecular motors, such as kinesin and RNA polymerase, and the folding of nucleic acid-based structures. His group has pioneered the use of laser-based optical traps, also called 'optical tweezers,' to study the nanoscale motions of individual biomolecules. Today, this work forms a central part of the field known as 'single molecule biophysics.'

Andrew Janiak, Ph.D.

Creed C. Black Associate Professor of Philosophy
Chair, Faculty Advisory Council, Bass Connections
Duke University

Dr. Andrew Janiak is Creed C. Black Associate Professor of Philosophy at Duke University, where he directs the PhD program in History and Philosophy of Science, Technology and Medicine. He came to Duke in 2002 after holding a Dibner postdoctoral fellowship at MIT. He is the author, editor and co-editor of five books concerning the history and philosophy of science in the 17th and 18th centuries, along with numerous refereed articles in these areas.

Sally Kornbluth, Ph.D.

James B. Duke Professor of Pharmacology and Cancer Biology, Vice Dean for Basic Science
Duke University School of Medicine

Dr. Sally Kornbluth received a B.A. in Political Science from Williams College in 1982 and a B.S. in Genetics from Cambridge University, England in 1984 where she was a Herchel Smith Scholar at Emmanuel College. She received her Ph.D. from The Rockefeller University in 1989 in Molecular Oncology and went on to postdoctoral training at the University of California, San Diego. She joined the Duke faculty in 1994 and is currently a Professor in the Department of Pharmacology and Cancer Biology and appointed the Vice Dean for Basic Science at Duke University School of Medicine in 2006. Dr. Kornbluth's research interests include the study of cell proliferation and programmed cell death, areas of central importance for understanding both carcinogenesis and degenerative disorders. She has published extensively in these areas, studying these problems in a variety of model organisms.

Robert A. Lieberman, Ph.D.

Vice President of SPIE, The International Society of Optics and Photonics
President and CTO of Intelligent Optical Systems, Inc.

Dr. Robert A. Lieberman, President, Intelligent Optical Systems (IOS), received his Ph.D. in Physics with an emphasis on solid-state physics and biophysics from the University of Michigan in 1981. Dr. Lieberman then joined AT&T Bell Laboratories where he was a Member of the Technical Staff for ten years. Before founding IOS he moved to Physical Optics Corporation, where he served as Vice President and General Manager for Research and Development. He has holds 34 U.S. patents, has chaired more than 25 conferences and symposia on fiber optic sensors, biosensors, and chemical sensors, and has published extensively in the field of optical sensing. Dr. Lieberman is a Fellow of SPIE, a Senior Member of IEEE, has served on the editorial boards of Optical Engineering and the Journal of Measurement Science and Technology, and on the boards of directors of SPIE, IOS, OpTech Ventures, Optinetrics, Sensorware Systems, Optical Security Sensing LLC, and the South Bay Science Center. He is the 2008 winner of the SPIE President's Award, three NASA Tech Briefs awards, and three Bell Labs Exceptional Contribution Awards. Dr. Lieberman is the 2014 Vice President of SPIE, the international society for optics and photonics; in addition to his ongoing work in optical sensing, his current interests include national and international science policy and translational research.

William Seaman

Professor Visual Studies
Department of Art, Art History and Visual Studies
Duke University

Dr. William Seaman, Professor focusing on Visual and Media Studies, Art & Science Relationalities, Digital Arts, Experimental forms of Computation Bill Seaman, An internationally known media artist, scholar, and media researcher, has had over thirty major installation works and commissions around the world, a dozen solo exhibitions, and numerous performance collaborations, video screenings, and articles/essays/reviews in books and catalogues. His work often explores an expanded media-oriented poetics through various technological means. More recently he has been exploring notions surrounding "Recombinant Informatics" — a multi-perspective approach to inventive knowledge production. He has been commissioned on a number of occasions. He is currently working on a series of art/science collaborations — poetic installations and scientific research papers. The book Neosentience | The Benevolence Engine with Otto Rössler has recently come out on Intellect Press. This research explores new approaches to AI and Robotics. He is also collaborating with artist/computer scientist Daniel Howe on multiple works exploring AI and creative writing/multi-media and completing an album of experimental music with Howe entitled Minor Distance. He is developing a new VR work and undertaking interface research with Todd Berreth; is exploring the creation of a transdisciplinary research tool entitled "The Insight Engine"; is collaborating with John Supko on a new generative audio work; and is working with Gideon May and Rachel Brady on re-articulating "The World Generator / The Engine of Desire" a virtual world building system.

Hans J. Van Miegroet, Ph.D.

Professor and Department Chair of Art, Art History and Visual Studies
Duke University

Dr. Hans J. Van Miegroet is professor and Chair of the Department of Art, Art History & Visual Studies at Duke University. He also heads the Duke University Visual Studies Initiative (VSI), which received a major institutional grant from the Andrew W. Mellon Foundation and is Director of the Duke Art, Law and Markets Initiative (DALMI).

He was trained at the Higher Institute for Art History and Archaeology of the University of Ghent (Belgium) and received his Ph.D. at the University of California, Santa Barbara. He is engaged in exploring Art History and Visual Studies at the interface of the humanities, social sciences, law and the sciences. He has adopted a scientific collaborative model to conducting research on emerging Art Markets, legal questions related to copyright and cultural heritage and visual culture as a commercial pursuit. This approach has made it possible to create, and sustain, a variety of new research strategies and modes of interpretation, attractive to museum professionals as well as to scholars and students from the humanities, law and the social sciences.

Session Chairs

Steven Cummer, Ph.D.

Bass Fellow, Professor of Electrical and Computer Engineering
Duke University

"Session 1: Special Topic on Photonics for Medicine, Arts and Humanities"
March 11, 11:10-11:55am

Dr. Steven Cummer received his Ph.D. in Electrical Engineering from Stanford University in 1997 and prior to joining Duke University in 1999 he spent two years at NASA Goddard Space Flight Center as an NRC postdoctoral research associate. Awards he has received include a National Science Foundation CAREER award and a Presidential Early Career Award for Scientists and Engineers (PECASE) in 2001. His current work is in a variety of theoretical and experimental electromagnetic problems related to geophysical remote sensing and engineered electromagnetic materials.

Chris Dwyer, Ph.D.

Associate Professor of Electrical and Computer Engineering
Duke University

"Session 5: Special Topic on Visualization Across the Spectrum: From Science and Engineering to Medicine and the Humanities"
March 12, 9:00-9:50am

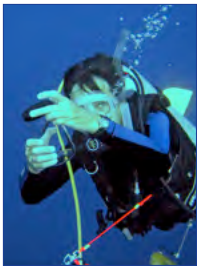
Dr. Chris Dwyer received his B.S. in computer engineering from the Pennsylvania State University in 1998, and his M.S. and Ph.D. in computer science from the University of North Carolina at Chapel Hill in 2000 and 2003, respectively.

Harold Erickson, Ph.D.

James B. Duke Professor of Medicine
Professor of Cell Biology and Biochemistry
Duke University

"Session 1: Special Topic on Photonics for Medicine, Arts and Humanities"
March 11, 11:10-11:55am

Dr. Harold Erickson group's most important discovery was the reconstitution of FtsZ rings inside liposomes, achieved by Asst Res Prof Masaki Osawa and published in Science in 2008. This reconstitution showed that the Z ring could be assembled from purified FtsZ, and did not need any of the dozen other cell division proteins found in bacteria. Of equal importance, we demonstrated that these reconstituted Z rings generated a constriction force on the liposomes, again without any other proteins. Subsequent work supported a model that the constriction force is generated by bending protofilaments.



Sönke Johnsen, Ph.D.

Professor of Biology
Duke University

"Session 4: Special Topic on Visualization Across the Spectrum: From Science and Engineering to Medicine and the Humanities"
March 11 4:05-5:00pm

Dr. Sönke Johnsen originally trained in mathematics and art, has studied camouflage, signaling, and non-human visual modalities for the last 20 years. He is particularly interested in vision and camouflage in the open ocean, but has also worked on coastal and terrestrial species, magnetoreception, nocturnal illumination, and human cataracts. His research combines mathematical analyses with behavioral and morphological studies and in situ measurements and observations. His field work primarily involves open-ocean research cruises that use SCUBA and deep-sea submersibles. In addition to exploring the evolution and diversity of the optical and visual tricks that animals perform, Dr. Johnsen is interested in improving communication between theoretical and experimental scientists and between scientists and artists. Outreach is a strong focus and his research has been presented in numerous magazines, newspapers and television shows. In his spare time, he is an avid nature photographer.

Sally Kornbluth, Ph.D.

James B. Duke Professor of Pharmacology and Cancer Biology, Vice Dean for Basic Science
Duke University School of Medicine

"Session 2: Special Topic on Photonics for Medicine, Arts and Humanities"
March 11 1:30-2:30pm

Dr. Sally Kornbluth received a B.A. in Political Science from Williams College in 1982 and a B.S. in Genetics from Cambridge University, England in 1984 where she was a Herchel Smith Scholar at Emmanuel College. She received her Ph.D. from The Rockefeller University in 1989 in Molecular Oncology and went on to postdoctoral training at the University of California, San Diego. She joined the Duke faculty in 1994 and is currently a Professor in the Department of Pharmacology and Cancer Biology and appointed the Vice Dean for Basic Science at Duke University School of Medicine in 2006. Dr. Kornbluth's research interests include the study of cell proliferation and programmed cell death, areas of central importance for understanding both carcinogenesis and degenerative disorders. She has published extensively in these areas, studying these problems in a variety of model organisms.

Fan Yuan, Ph.D.

Professor of Biomedical Engineering
Duke University

"Session 6: Advances in Photonics
March 12 10:30-11:45am

Dr. Fan Yuan's research interests include drug and gene delivery, mechanisms of molecular transport in cells and tissues, and tumor pathophysiology. Cure of cancer through chemotherapy requires drug molecules to reach all tumor cells at an adequately high concentration. At present, such a requirement cannot be satisfied in most patients. This is because (a) amount of drugs that can be administered into patients is limited by normal tissue tolerance and (b) drug distribution and cellular response to drugs in tumors are heterogeneous. Therefore, cells in regions with drug concentration below the therapeutic level will cause tumor recurrence and they may also develop resistance to future treatment.

Symposium on Photonics Science and Technology

2014 Fitzpatrick Institute for Photonics (FIP) Annual Meeting
October 10-11, 2011, Duke University

Poster Session Exhibit

Poster # 1 **A Self-Consistent Model for Optical Pattern Formation in Cold Atoms**
Bonnie L. Schmittberger and Daniel J. Gauthier
Duke University Physics Department and Fitzpatrick Institute for Photonics

The study of pattern formation in atomic systems is of great interest for nonlinear optics, quantum information science, and condensed matter physics. Transverse optical pattern formation has been well studied in samples of warm atoms, but the use of cold atoms gives rise to additional nonlinear effects that have useful consequences. In particular, the nonlinearity that arises due to the spatial bunching of cold atoms is quite strong, which leads to strong light-atom interactions and low thresholds for optical pattern formation. The effects of this bunching-induced nonlinearity are theoretically described using two different formalisms, each of which is only valid in certain atomic temperature limits. We present a model that accurately describes the effects of atomic bunching in all temperature limits. Our model provides new insights into light-matter interactions in cold atoms and the importance of high-order nonlinear effects when there is strong atomic bunching.

Poster #2 **The Restoration of a Roman Urn with the Erbium: YAG Laser. Science in the the Service of Art.**
Adele DeCruz (Duke University) and Alessia Androtti (University of Pisa)

The cleaning of a Roman funerary urn, 67-100 CE. Acquired by the St. Louis Art Museum in 1922, and never exhibited because of the intractable encrustation on the surface of the marble was sent to the conservation laboratory at Duke University for cleaning with the Erbium:YAG laser at 2.94mm. During the testing it was discovered that the encrustation was a combination of organic materials, which over the millennia had transformed to oxalates.

- *The Roman Cinerary urn was incrusted with an intractable layer of calcite that covered the decorative area of the body of the marble surface.) None of the traditional conservation methods for cleaning the surface was effective in removing the dark crystal structure .*
- *In a number of areas located over the surface of the urn, round or oval black fungi nests have eaten in to the marble. Laser ablation was able to remove these nests and follow into the stone to remove the embedded fungi. A bright white flash of black-body light occurred during the ablation process that is a reaction to Er:YAG laser ablation of the thick cell wall of the fungi, which are comprised of long chain polysaccharides that are made up of many C–OH bonds*
- *A literature review of Roman burial customs gave an indication that the encrustation on the marble surface was caused by the oxidation of organic materials that were applied to the surface of the urn on the anniversary of the death of the person whose ashes were interned in the urn. The intent of these rituals was to assure abundance in the afterlife.*

Raman, Scanning Electron Microscope, Gas Chromatographic Mass Spectrometric, Emission Spectroscopy are analytic techniques used to identify the degraded materials as well as marble structure.

Poster# 3 **DSP lock-in for in vivo nonlinear optical microscopy**
Jesse W. Wilson1, Martin C. Fischer1, and Warren S. Warren1,2,3
Duke University, departments of Chemistry1, Radiology2, and Biomedical Engineering3

The number of imaging contrast mechanisms available in a multiphoton microscope can be greatly extended by employing lock-in detection to sense weak nonlinear interactions that couple two or more incident light fields. We have been using such 'pump-probe' interactions to perform in vivo virtual histology in mouse models of melanoma. In these models, we are searching for hallmarks of malignancy by imaging the distribution and chemical variations of melanin. Usually, the signal is detected with a commercial lock-in amplifier, which is designed to achieve high sensitivity with long integration times. This limits imaging speed and severely restricts the area that can be imaged while the mouse is under anesthesia. To increase acquisition speed, we have designed and implemented an all-digital lock-in detector on the coprocessor field-programmable gate array (FPGA) of a high-speed data acquisition board. The flexibility of the FPGA architecture allows for operations that would be difficult or costly to implement with traditional electronics, such as simultaneous demodulation of an arbitrary number of separate channels.

Poster# 4 **X-ray Coherent Scatter Imaging for Visualizing Cancer in Resected Tissue: A Monte Carlo Study using a Digital Anthropomorphic Phantom**

Manu N. Lakshmanan a, Anuj Kapadia a, Brian P. Harrawood a, David Brady b, and Ehsan Sameia,b
aRavin Advanced Imaging Labs, Duke University Medical Center, Durham, NC, USA
bDept. of Electrical & Computer Engineering, Duke University, Durham, NC, USA

Instead of having the entire breast removed (a mastectomy), breast cancer patients often receive a breast conserving surgery (BCS) for removal of only the breast tumor. If post-surgery analysis reveals a missed margin around the tumor tissue excised through the BCS procedure, the physician must often call the patient back for another surgery, which is both difficult and risky for the patient. If this "margin detection" could be performed during the BCS procedure itself, the surgical team could use the analysis to ensure that all tumor tissue was removed in a single surgery, thereby potentially reducing the number of call backs from breast cancer surgery. We describe here a potential technique to detect surgical tumor margins in breast cancer using x-ray coherent scatter imaging. In this study, we demonstrate the ability of this technique using Monte Carlo simulations of coherent scatter imaging of a digital anthropomorphic phantom.

Poster#5 **Robust Quantum Information Processing with Trapped Ions in a Surface Trap**

Emily Mount, Stephen Crain*, So-Young Baek*, Daniel Gaultney*, Peter Maunz**, Jungsang Kim**
**Duke University, Department of Electrical and Computer Engineering*
***Sandia National Laboratories*

Microfabricated surface ion traps provide a scalable platform for building a trapped ion quantum information processor. These multi-segmented traps are fabricated using existing silicon processing technology and can provide the capability to store a chain of ions and shuttle parts of the chain to various locations within the trap structure. Utilizing micro-mirrors fabricated using microelectromechanical systems (MEMS) technology, we focus and shift Raman laser beams to individual ions in the chain to perform quantum logic gates on them. Using a microfabricated surface trap made by Sandia National Laboratories we demonstrate individually addressed single qubit gates on a chain of ions driven by a repetition-rate-stabilized frequency comb. Compensating pulse sequences were utilized to mitigate the effect of the intensity and frequency fluctuations of the Raman beams. Here we present results on un-compensated and compensated single qubit gates and progress towards entangling gates and their characterization.

Poster# 6 **Coherence Revival Multiplexed Swept Source Optical Coherence Tomography**

Derek Nankivil1, Al-Hafeez Dhalla1, Niklas Gahm1, Kevin Shia1, Sina Farsiu2,1 and Joseph A. Izatt1,2
*1Department of Biomedical Engineering, Duke University, Durham, NC 2Department of Ophthalmology, Duke University Medical Center, Durham, NC *Corresponding author: derek.nankivil@duke.edu*

Efficient sweep buffering along with coherence revival and spatial multiplexing multiplexing were used to quadruple the effective speed of a swept source optical coherence tomography (SSOCT) imaging system. A polarizing beam splitter and fold mirror assembly were employed to create a dual spot sample arm with a common objective designed for near-diffraction-limited human retinal imaging. The optical pathlength of each sample path was carefully controlled using a variable optical delay line, which, when combined with coherence revival, allowed for simultaneous imaging and frequency encoding of separate locations within a sample. With this method, the imaging speed of any SSOCT system employing a low duty cycle laser that exhibits coherence revival can be efficiently quadrupled. The system was used to image the retina of healthy human volunteers.

Poster#7 **Integrated System Technologies for Trapped Ion Quantum Information Processing**

Stephen Crain, Emily Mount*, Soyoung Baek*, Daniel Gaultney*, Caleb Knoernschild***, Peter Maunz**, and Jungsang Kim**
** Department of Electrical and Computer Engineering, Duke University, Durham, North Carolina*
*** Sandia National Laboratories, Albuquerque, New Mexico*
*Present Address: ***Raytheon, McKinney, Texas,*

Scalability is one of the main challenges of trapped ion based quantum computation, mainly limited by the lack of enabling technologies needed to trap, manipulate and process the increasing number of qubits. Microfabricated surface ion traps provide a scalable solution for trapping and shuttling chains of ions, utilizing existing silicon processing technologies. For individual addressing, microelectromechanical systems (MEMS) technology allows one to design movable micromirrors to focus laser beams on individual ions and steer the focal point in two dimensions. This system provides low optical loss across a broad wavelength range and can scale to multiple beams. In order to read the state of the ion chain we image the ion chain with a high numerical aperture lens (0.6 NA) onto a 32-channel PMT with a custom read-out electronics operating near the thermal noise limit of the amplifier.
Using a microfabricated surface trap from Sandia National Laboratories we trap chains of 171Yb+ ions. Using the MEMS mirrors, we perform single qubit gates on individual 171Yb+ ions in a chain with Raman transitions driven by stabilized frequency combs. Using this setup, we sequentially perform single qubit gates on multiple qubits and

characterize the gate performance using quantum state tomography.

Poster#8 **Scalable GPU Image Formation for Multiscale Gigapixel Cameras**
Qian Gong, Esteban Vera, Michael Gehm
Department of Electrical and Computer Engineering
Duke University

We present a highly-parallelizable image formation pipeline developed for the AWARE multiscale gigapixel cameras and its implementation on GPU hardware. The AWARE cameras consist of a single spherical objective shared by an array of microcameras which generate a collection of images that need to be combined together in order to synthesize wide-angle, high-resolution, and high dynamic range images and video. To address this challenge, we developed a highly-parallelizable, model-based image formation strategy based on MapReduce framework. The approach is general and scalable—able to produce images ranging from megapixels views at video-rate to full resolution gigapixel panoramas that are able to reveal every detail in the scene.

Poster#9 **Compressed Wavefront Sensing for Ophthalmic Aberrometry**
James Polans (1), Ryan McNabb (2,1), Joseph Izatt (1,2), and Sina Farsiu (2,1)
(1) Duke Department of Biomedical Engineering (2) Duke Department of Ophthalmology

We report on an algorithm for fast wavefront sensing that incorporates sparse representation for the first time in practice. The partial derivatives of optical wavefronts were sampled sparsely with a Shack-Hartman wavefront sensor (SHWFS) by randomly subsampling the original SHWFS data to as little as 3% (15 total lenslets). Reconstruction was performed by a sparse representation algorithm that utilized the Zernike basis. We name this method SPARZER. Experiments on real and simulated data attest to the accuracy of the proposed techniques as compared to traditional sampling and reconstruction methods. In one particular example, we tailor this algorithm towards the reconstruction of ophthalmic wavefronts originating from the human eye. Compressed wavefront sensing offers the potential to increase the speed of wavefront acquisition, and it could potentially lead to faster and/or wider field adaptive optic systems.

Poster#10 **Decoupling the Surface and Bulk Effects of Nitrogen Doping on ALD TiO2 Films for Photoelectrochemical Water Oxidation**
I.A. Cordova a, Q. Peng a, J.A. Fischer b, I.L.. Ferrall b, S.M. Ubnoske b, B.R. Stoner c, J.T. Glass a.
a) Electrical & Computer Engineering, b) Mechanical Engineering & Materials Science, c) RTI International, Durham, NC 27709

Atomic layer deposition (ALD) offers the ability to uniformly deposit conformal films over high aspect ratio (HAR) nanoscale scaffolds. This makes ALD particularly well-suited for photoelectrochemical (PEC) applications, where thin photoactive film coatings can maximize the effective absorption length and also minimize the charge carriers path length to the interface with an electrolyte. Although the deposition of TiO2 films over such scaffolds has been shown to vastly improve PEC performance, the large bandgap intrinsic to TiO2 still prevents such devices from harvesting most of the solar spectrum. To overcome this problem, doping TiO2 with nitrogen has been shown to narrow its bandgap, therefore increasing its photocatalytic activity under just visible light. However, the overall effect of such doping on performance varies substantially and the nature of this phenomenon is still not well understood, especially for thin ALD films. In this research, we investigated N-doping via various heat treatments in ammonia (NH3) and air for planar films less than 50 nm in thickness. In this report, we analyze the surface versus bulk thickness-dependent effects on performance by characterizing our films through XPS, XRD, and electrochemical impedance spectroscopy (EIS). We show that films with thicknesses less than 10 nm show an improvement in performance under certain doping conditions, while thicker films do not. Furthermore, we find that our ALD-grown TiO2 films undergo nitridation very differently than commercially-available TiO2 nanoparticles (Degussa P25). This indicates that the N concentrations near the surface and doping mechanisms are heavily dependent on the synthesis method of the original TiO2 material. The combination of these tools provides insight into the consequences of nitridation and enables the development of optimal thickness and treatment conditions for planar N:TiO2 films. The fundamental understanding of these N-doping effects enables engineering of semiconductor films that can be integrated onto nanostructured scaffold for superior PEC performance.

Poster#11 **Measuring the Diffusion of Gold Nanorods in Pulmonary Mucus Using Polarization-Sensitive, Spectral-Domain OCT**
Richard Blackmon,1 Raghav K. Chhetri,1 David B. Hill,1,2 Brian Button,2 Joseph B. Tracy,3 Wei-Chen Wu,3 Amy L. Oldenburg1,4
1Department of Physics and Astronomy, University of North Carolina at Chapel Hill, NC 27599
2Cystic Fibrosis Research and Treatment Center, University of North Carolina at Chapel Hill, NC 27599
3Department of Material Science & Engineering, North Carolina State University, Raleigh, NC 27695
4Biomedical Research Imaging Center, University of North Carolina at Chapel Hill, NC 27599

Mucociliary clearance is necessary in maintaining a healthy respiratory system. Diseases like Cystic Fibrosis and

COPD exhibit lower clearance rates and higher mucin concentration; measuring these in situ could aid in monitoring disease progression and drug efficacy. We demonstrate sensing changes in mucin concentration by introducing PEG-coated gold nanorods into mucus and monitoring the resulting dynamic light scattering using polarization-sensitive, spectral-domain OCT. We show that gold nanorods accurately track changes in mucin concentration, even in actively transporting mucus. We also demonstrate delivery of gold nanorods via nebulization that will be favorable for future in vivo studies.

Poster#12 **Efficient Collection of Single Photons Emitted from a Trapped Ion into a Single Mode Fiber for Scalable Quantum Information Processing**

Andre Van Rynbach, Geert Vrijsen, Dan Gaultney, Jungsang Kim
Fitzpatrick Institute for Photonics, Department of Electrical and Computer Engineering, Duke University

Atomic ions trapped in microfabricated traps can provide a useful resource for quantum information processing. Traditional approaches to qubit state detection using state dependent fluorescence utilize refractive lenses or reflective optics to direct scattered photons to the detector. Here we show progress towards a new method which can drastically enhance the fidelity and speed of qubit state detection by using the interaction between a trapped ion and an optical field in a cavity. Our experiment uses a concentric cavity geometry with a surface trap fabricated on a mirror which is highly reflective at UV wavelengths for 171 Yb+ ions. Using this system, we show that it is feasible to reduce the qubit measurement time to that comparable to single qubit gate times (~1μs), and the measurement errors down to the 10−5 range. Furthermore, this system can be used for enhanced photon collection and remote ion entanglement. We describe the design and fabrication of the traps used in the cavity system, and report the experimental progress towards the cavity realization.

Poster#13 **Dramatic Tumor Effect of Polymersome-Encapsulated Myoglobin as Imaged In vivo and Ex vivo**

Christina L. Hofmann (1), Jivan Yewle (2), Kathleen Ashcraft (3), P. Peter Ghoroghchian (2), Michael Therien (4), Mark W. Dewhirst (1,3), Gregory Palmer (3)
1 Department of Biomedical Engineering
2 Vindico NanoBioTechnology
3 Radiation Oncology Department, Duke University
4 Department of Chemistry

Polymersomes, nanoscale polymeric vesicles, were formulated to contain myoglobin (Mb), an oxygen-carrying protein found in muscle cells, for the purpose of delivering oxygen to hypoxic tumors. The Mb polymersomes (PEMs) were loaded with a near-infrared (NIR) emissive fluorophore to enable in vivo imaging of vesicle biodistribution. Upon tail vein injection in breast tumor-bearing mice, the PEMs accumulated within tumors due to the enhanced permeability and retention effect of solid tumors. Within 3-6h, all mice treated with PEMs displayed a dramatic tumor effect, with the tumors turning a dark red color consistent with hemorrhage. Immunohistochemistry and H&E revealed necrosis within the center of tumors 24h following treatment, as well as decreased perfusion and a rim of hypoxia surrounding the necrotic tissue. These results suggest a never-before-seen rapid and significant tumor effect of PEMs that will be studied more thoroughly using window chambers.

Poster#14 **Multi-functional Optical Imaging of Tumor Dynamics**

Hansford C. Hendargo, Li Li, and Gregory M. Palmer
Department of Radiation Oncology, Duke University Medical Center

Dynamic, in vivo imaging capabilities enable observation and quantification of cellular interactions and tissue properties that may lead to or are prognostic indicators for therapy-resistant tumorigenesis. Combining high resolution imaging methods with surgically implanted optical windows in mice allows for in vivo visualization and characterization of tumor development. Optical imaging techniques can yield high spatial and temporal resolution to allow detection of cellular interactions, vascular flow and remodeling, and hemoglobin saturation. By using fluorescent, hyperspectral, and optical coherence tomography techniques, we demonstrate the ability to perform multi-functional imaging in mouse dorsal window chambers to monitor tumor development and detect potential markers for therapy resistance.

Poster#15 **Measurement Scheme with 171Yb+ Chains in a Microfabricated Ion Trap**

Daniel Gaultney, Geert Vrijsen, Rachel Noek, Emily Mount, Soyoung Baek, Stephen Crain, and Jungsang Kim
Fitzpatrick Institute for Photonics, Duke University

Trapped ions are promising candidates for implementing a scalable quantum computing system. We consider a quantum information processor implemented in an ion chain, where a multi-qubit gate between ions is executed using the transverse modes of ion motion. Quantum error correction requires that the states of data qubits be maintained during the initialization and readout of ancilla qubits. Such procedures require the ability to collect light from individual fluorescing ions without resonantly exciting other ions in the system. We describe an ion measurement protocol that uses shuttling to separate the ions being detected from the rest of the chain in order to decrease the resonant crosstalk between measured and unmeasured qubits. We will discuss experimental progress towards

the implementation of this scheme in a microfabricated surface trap where scattered photons are collected using a high numerical aperture lens, and characterize the impact of resonant scattering from the measured qubits on the remaining qubits in the ion chain. A similar isolation scheme is required for the generation of heralded entanglement between two ion chains.

Poster#16 **Development of MEMS-based Cathodes for Miniature Mass Spectrometers**

E.J. Radauscher a, J. R. Piascik b, K.H. Gilchrist b, J. J. Amsden a, R.M. Danell c, S.M. Ubnoske a, C. B. Parker a, J.T. Glass a, and B. R. Stoner b
a) Duke University, Electrical & Computer Engineering, Durham, NC 27708
b) RTI International, Durham, NC 27709
c) Danell Consulting, Inc., Greenville, NC 27858

This project involves the development of MEMS-based cathodes for use in miniature mass spectrometers. The cathodes employ a carbon nanotube (CNT)-based field-emission source which consumes at least an order of magnitude less power than conventional thermionic sources. The CNT emitter arrays are used as impact ionization sources and have demonstrated electron currents (Ie) in excess of 150 μA. Field emission sources also tend to be more robust then their conventional counterparts and the arrays of CNTs enable a "self-healing" effect whereby neighbouring CNTs replace those damaged during operation. Incorporating the CNT field emitters into a MEMS-based electron source brings about certain advantages in size, power, and cost without significant loss in sensitivity. Figure 1 shows a) an SEM of the MEMS-based cathode with CNT array, accompanied by; b) Current lifetime data with continuous performance in excess of 130 hrs; and c) a device operated in pulse-mode operation, simulating a 20% operational duty-cycle. With continued advances in the unique polysilicon microfabrication process [1-3] it is conceivable that the fully integrated device could be fabricated and even packaged at the wafer-scale, leading to significantly lower development and manufacturing costs. This will allow for development of cost-effective, ergonomic, hand-held sampling tools offering increased capability in responding to emerging threats. The goal of this work is to optimize the novel on-chip micromachined cathodes for use in a miniaturized magnetic sector mass spectrometer [4].
Current development efforts are focused on improving the lifetime of the CNT-based field emission cathodes, as well as optimization for continuous and rapid on/off applications. Improving adhesion properties between the CNTs and the MEMS platform through the use of multi-layer metal catalysts are being explored to improve device lifetime. Capitalizing on a versatile MEMS platform, we are also investigating geometrical designs that integrate electron and ion optics to minimize energy and angular dispersion while also enhancing current density and cathode lifetime. The charged particle simulation program SIMION is employed to demonstrate and optimize new system designs as well as to establish appropriate working conditions for the different cathode designs.

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Acknowledgment: Work was partially supported by Department of Homeland Security, Science and Technology Directorate

Poster#17 **An Electrowetting on Dielectric Lab on Chip for Multiplex Automated Genome Engineering**

Andrew C Madison, Matthew W Royal, and Richard B Fair
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We present an electroporation (EP) device integrated into an electrowetting on dielectric (EWD) platform and results regarding fully automated on-chip cell transformation experiments. Multiplex automated genomic engineering (MAGE) involves the simultaneous insertion of many synthetic DNA fragments, typically ~100 bp oligos, into multiple sites of a bacterial genome [1]. Exposure of cells and oligos to a high strength (~2 kV/mm) electric field pulse generates pores in the cell membrane and drives the negatively charged DNA into the cell. After DNA uptake, the stressed cells will incorporate the foreign oligos into their genome and begin expressing gene products encoded in the oligo DNA. EWD digital microfluidics is nicely suited to MAGE because of its ease of automation, scalable reagent volumes, and parallelizability [2]. The fundamental challenge overcome by our work involves the co-design of EP and EWD devices. We utilized a serpentine electrode geometry patterned in copper over a polyimide electrowetting dielectric as the positive EP terminal and a common EP/EWD ground plane to electroporate E. coli cells lacking ampicillin resistance in the presence a 90 bp oligo encoding ampicillin resistance. Survival and transformation rates were found to be 1.7 ± 1.1% and 6.5 ± 3.4 %, respectively, which are comparable to macroscale transformations

done on-bench.

References:
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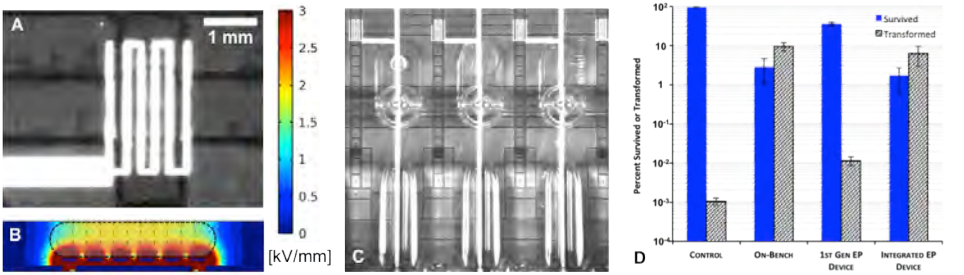

Poster#18 **Seeing Historic Artwork in "Laser-Sharp" 3D**
Tana E. Villafana, William Brown, John K. Delaney, Michael Palmer, Warren S. Warren, and Martin C. Fischer
Fitzpatrick Institute for Photonics, Duke University

The stratigraphy of a painting contains a wealth of information about the artist's choice of materials and working methods. The study of such layered structure can lead to greater understanding of long lost cultures as well as enhance the ability of the conservators to conserve, preserve, and restore those cultures in our vast cultural heritage. Unfortunately, this three dimensional (3d) information is often studied by the physical removal of a cross-section sample, which can then be analyzed by a multitude of analytical techniques. There are a plethora of nondestructive macro- and microscopic analytical techniques that are useful for the study of materials and working methods, unfortunately, no current traditional method contains quantitative depth-resolved material information. Femtosecond pump-probe optical microscopy is a novel nonlinear imaging technique that allows for the noninvasive 3d imaging of pigments with molecular and structural contrast. Achieving pump-probe contrast in fine art objects can be difficult because of the wide range of colors in the artist palette from organic dyes to inorganic minerals; pigments that span the entire visible spectrum. A greater understanding of pigment response to pump-probe wavelength and time delay will allow our approach to be applied to a wide variety of cultural heritage objects, providing information extremely relevant to current areas of interest in conservation science. First, we demonstrate the different multi-spectral pump-probe responses for various pigments, even when those pigments have broad and relatively featureless linear absorption spectra. Then we apply these pigment specific contrast to the study of several Italian paintings, The Crucifixion by Puccio Capanna, The Body of Christ Supported by Angels and The Martyrdom of St. Alexander by Lorenzo Lotto, and Madonna and Child with St. John the Evangelist, a Donor, and St. Anthony Abbot by the Pavian School.

Poster#19 **Development of Hybrid Silver-Coated Gold Nanostars for Nonaggregated Surface-Enhanced Raman Scattering**
Andrew M. Fales, Hsiangkuo Yuan, and Tuan Vo-Dinh
Fitzpatrick Institute for Photonics, Duke University

In the ongoing search for ever-brighter surface-enhanced Raman scattering (SERS) nanoprobes, gold nanostars (AuNSs) have emerged as one of the best geometries for producing SERS in a nonaggregated state. Despite their high enhancement factor, optical extinction from plasmon-matched nanoparticles can greatly attenuate the overall SERS intensity. Herein, we report the development of a new hybrid bimetallic NS-based platform that exhibits superior resonant SERS (SERRS) properties. In this new nanoplatform, coating AuNSs with a subtotal layer of silver (AuNS@Ag) can further increase their SERRS brightness by an order of magnitude when being interrogated by an off-resonant excitation source. Silica-encapsulated AuNS@Ag nanoprobes were injected intradermally into a rat pelt, where SERRS was readily detected with higher signal-to-noise than nanoprobes prepared from AuNS. Moreover, these off-resonance AuNS@Ag nanoprobes did not cause any gross photothermal damage to tissue, which was observed with the plasmon-matched AuNSs. This novel SERRS-active hybrid nanoprobe exhibits high SERRS brightness and offers promising properties for future applications in sensing and molecular imaging.

Poster#20 **Using Pump-Probe Imaging to Monitor Melanoma Tumor Cell Populations In Vivo**
Christina S. Gainey1, Jesse W. Wilson1, Simone Degan1, Jennifer Zhang, Christopher Dall1, Yasmine Tamaze2, Warren S. Warren1

1Department of Chemistry, Duke University, 2Department of Dermatology, Duke Medical Center

Pump-probe is a multiphoton imaging technique that gives us molecular contrast of two key biomarkers of melanoma: melanin and hemoglobin. Our work uses pump-probe to study the chemical and morphological changes that occur during the growth and progression of melanomas, and we are currently conducting in vivo studies in a genetically engineered mouse model (BrafV600E/PtenNull). In addition to probing the genetic mechanisms, we are also exploring the effects of a combination drug therapy (BRAF-inhibitor vemurafenib and dopamine antagonist thioridazine) to better understand the pathways for regression and chemoresistance. Our studies have revealed various, distinct tumor cell subpopulations that we can correlate with malignancy based on their pigment chemistry as well as morphology.

Poster#21 **Quantitative High-Resolution Fluorescence Imaging for In Vivo Detection of Residual Disease During Cancer Surgery**

Jenna Mueller1, Henry Fu1, Jeff Mito1, Melodi Javid1, Zachary Harmany2, Leslie Dodd3, Rebecca Willett2, David Kirsch1, Quincy Brown4, Nimmi Ramanujam1
1Duke University, Durham NC 27708
2Univeristy of Wisconsin, Madison WI 53706
3University of North Carolina School of Medicine, Chapel Hill NC 27514
4Tulane University, New Orleans LA 70118

Fluorescent contrast agents combined with microscopy is a powerful technique to obtain images of tissue histology at the point-of-care, without the need for fixing, sectioning, and staining. The potential of these technologies lies in the identification of robust methods for image segmentation and quantitation, particularly in heterogeneous tissues. To address this important need, sparse decomposition (SD) is applied to images of fluorescently-stained microanatomy to segment and quantify distinct tissue types. The clinical utility of our approach is demonstrated by imaging tumor beds in vivo in a cohort of mice after surgical resection of a sarcoma.

Poster#22 **Molecular Imaging Using Coded, Energy-Sensitive Detection**

Joel Greenberg, Kalyani Krishnamurthy, Mehadi Hassan and David Brady
Electrical and Computer Engineering, Fitzpatrick Institute for Photonics, Duke University

We demonstrate a technique for measuring the range-resolved coherent scatter form factors of different objects from a single snapshot. By illuminating the object with an x-ray pencil beam and placing a coded aperture in front of a linear array of energy-sensitive detector elements, we record the coherently scattered x-rays. This approach yields lateral, range, and momentum transfer resolutions of 1 mm, 5 mm, and 0.2 nm^-1 , respectively, which is sufficient for the distinguishing a variety of solids and liquids. These results indicate a path toward real-time volumetric molecular imaging for non-destructive examination in a variety of applications, including medical diagnostics, quality inspection, and security detection.

Poster#23 **Design and Characterization of a Swept-Source, Anatomical Optical Coherence Tomography System for upper airway endoscopy**

Kushal Wijesundara,1 Carlton Zdanski,2 Julia Kimbell,2 Hillel Price,1 Nicusor Iftimia,3 and Amy L. Oldenburg1,4,5
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2Department of Otolaryngology/Head and Neck Surgery, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-7070, USA
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5Joint Department of Biomedical Engineering, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599-7575, USA

Pediatric upper airway abnormalities such as Subglottic stenosis and Pierre Robin syndrome lead to insufficient respiration and morbidity. Imaging with CT or MRI is limited by either ionizing radiation or motion artifacts. To overcome such issues, we developed a swept-source anatomical optical coherence tomography (aOCT) system for real-time imaging of human airways.
This instrument pushes the boundaries of long-range imaging, under the limitations prevalent to working within the small bore (1.2mm) of a pediatric bronchoscope. Helical scans were obtained from a fiber-optic catheter with a ball lens tip and an internally-reflective polished flat surface designed for sideways-directed proximal-scans by rotating and translating the optical fiber. A large imaging range is enabled by the use of a long coherence length swept-source laser and a relatively long focal length (>2.0 mm) from the fiber catheter, providing a working distance (12.0 mm) comparable to the maximum size of the upper airway in children less than 10 years of age. Measurements of the signal-to-noise ratio (SNR) roll-off as a function of distance from the catheter revealed the relative contributions of beam focusing, coherence length, and k-space nonlinearity. With digital dispersion compensation, the k-space non-

linearity and interferometer imbalance effects are removed to obtain improved operational SNR of 90.2 dB. 3-D visualization of known plastic tubes and lung phantoms are obtained through helical data scans and image processing to locate the air-tissue interface. The ability to accurately measure airway luminal geometry is crucial for informing predictive models such as those based on computational fluid dynamics (CFD), which can be highly sensitive to small differences. Here we chose to quantify cross-sectional areas (CSA) because it is the primary factor affecting airflow resistance. Operating at 10 rotations/s, the average accuracy of segmented CSA was found to be −1.4 ± 1.0%.

For validation in tissue, helical scans of ex vivo porcine airways were also performed in the bronchi, carina, and trachea for a total duration less than 35 seconds. Importantly, the high accuracy of the upper airway luminal geometries obtained by aOCT can provide more accurate models for CFD of airflow. Thus, aOCT can provide unprecedented dynamic airway imaging that, in conjunction with CFD, gives new insight into obstructive breathing disorders. These high resolution aOCT-derived geometries can also lead to methods for predictive modeling of airway disorders that may aid in medical and surgical decision-making.

Poster#24 **Synthesis, Characterization, and Pre-Clinical Evaluation of Hyaluronan Based Nanoparticles for Image-Guided Surgery**

Tanner Hill1,2, Sneha Kelkar1,2, Frank C. Marini2,3, Edward A. Levine4, Aaron M. Mohs1-3
1Wake Forest – Virginia Tech School of Biomedical Engineering and Sciences, 2Wake Forest Institute for Regenerative Medicine, and Departments of 3Cancer Biology and 4Surgery; Wake Forest University Health Sciences, Winston-Salem, NC 27157

Surgery plays a critical role in cancer diagnosis, treatment, and prevention. Complete surgical resection of malignant tissue, including removal of the primary tumor, draining lymph nodes, and adjacent local nodules, is the single most important predictor of patient survival for almostall solid tumors. Unfortunately, incomplete removal of malignant tissue can result in recurrent disease, potential changes in treatment regimen, and ultimately poor patient prognosis. It is crucial that technologies be developed that allow for tumor margins to be effectively established for surgeons in the operating room. We have previously developed an intraoperative imaging system that detects near infrared fluorophores, namely indocyanine green (ICG), as well as SERS nanoparticles [1]. These imaging agents rely solely on nonspecific accumulation in tumor or other inflamed tissue. To improve specificity of the image-guided intervention, we have applied an overall approach to develop a nanoparticle-based system that can entrap and specifically deliver ICG to tumors. To that end we have modified hyaluronic acid to self assemble into nanoparticles and effectively load and deliver ICG to tumors. A series of hydrophobic ligands, 5β-cholanamide, 1-pyrenebutanamide, and octadecylamine, were first synthesized and then conjugated to hyaluronic acid, based on methods in the literature [2], to drive self-assembly into nanoparticles. The resulting nanoparticle image agents had a hydrodynamic diameter of 90-150 nm with 10 wt% ICG loading and were stable in a variety of conditions. HLA is a ligand for CD44, a receptor that is overexpressed in many tumors. Nanoparticle entrapment of ICG resulted in specific uptake of ICG due to CD44-HLA interaction in CD44-expressing MDA-MB-231 breast cancer cells. Administration of the nanoparticles to mice bearing MDA-MB-231 tumor xenografts showed a large increase in contrast between tumor and surrounding tissue compared to ICG alone. The strong contrast was readily detected using image-guided surgery instrumentation and demonstrated the potential of the nanoparticles to guide tumor removal in a simulated surgical procedure. Further investigations are underway to minimize nonspecific release of ICG from the nanoparticles and to quantitatively assess surgical margin detection. References:

[1] Mohs AM, et al. Anal Chem 2010, 82, 9058-9065.
[2] Choi KY, et al. Biomaterials 2010, 31, 106-114.

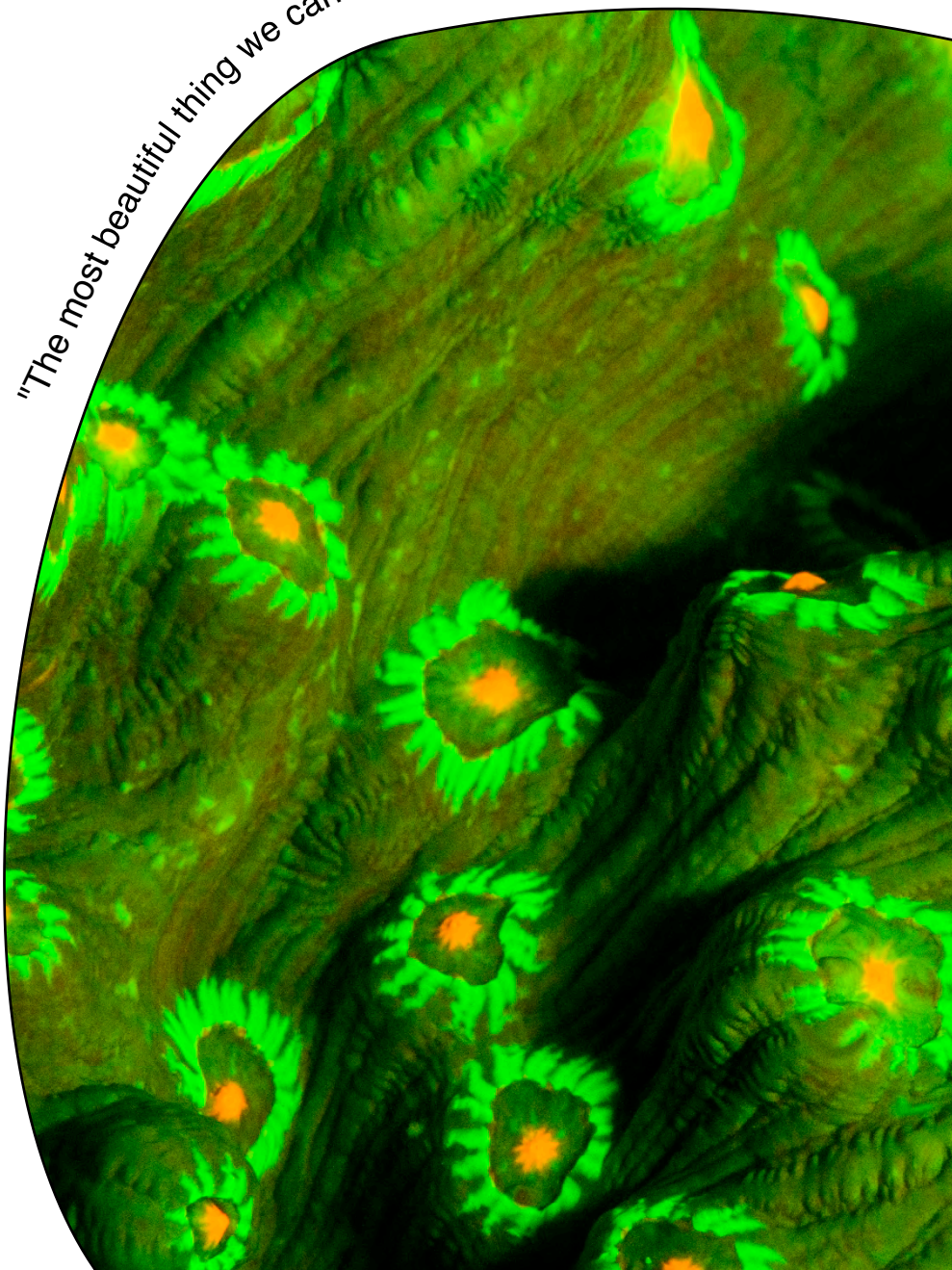
Acknowledgements:
This research was funded in part by the NIH (R00 CA153916 to AMM), Wake Forest – Virginia Tech School of Biomedical Engineering and Sciences, and the Wake Forest Institute for Regenerative Medicine.

Poster#25 **Coded Aperture 4D Tomographic Molecular X-ray Imaging**

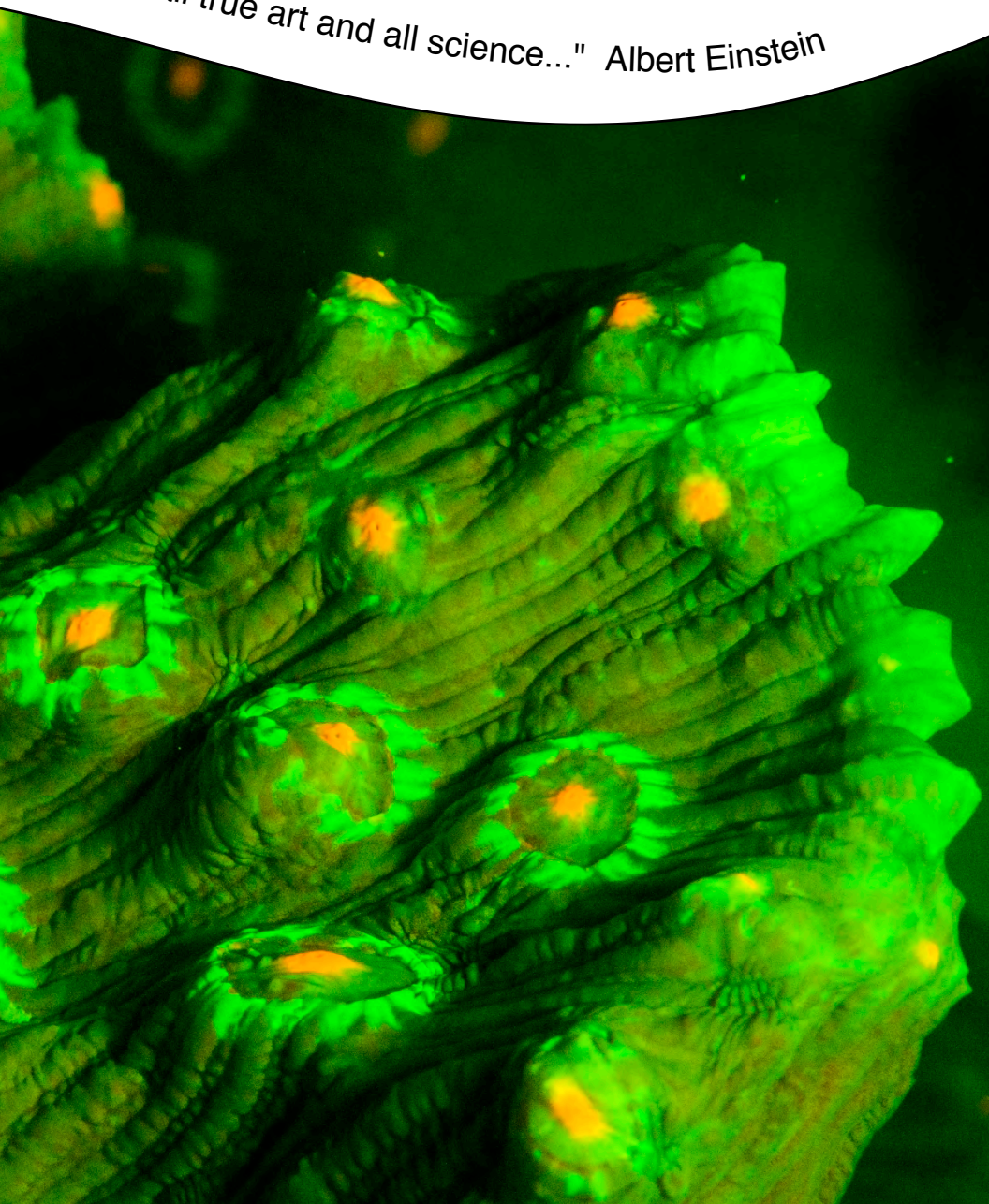
Shuo Pang, Joel Greenberg, Mehadi Hassan, Andrew Holmgren, Ken Maccabe, Kalyani Krishnamurthy, David Brady
Electrical and Computer Engineering, Fitzpatrick Institute for Photonics, Duke University

X-ray scattering has played a key role in non-destructive materials characterization due to the material-specific scattering signatures. Selected volume tomography (SVT) is the current coherent scatter imaging method, which is based on x-ray diffraction (XRD) experiments. In XRD setup each object voxel is measured at single scattering angle at specific energy, which suffers from extended acquisition time. In our proposed 4 dimensional x-ray scattering imaging system, a coded aperture introduces parallelism of structured multiplexing on an energy-sensitive detector array, which provide three dimension spatial information and reveals molecular signature in momentum transfer space. The elimination of the detector side collimation can greatly improve the scattered x-ray photon detection efficiency and thus increase the throughput, making this technology promising for real time imaging and material identification.

"The most beautiful thing we can experience is the mysterious. It is the



source of all true art and all science..." Albert Einstein



An Engine of Many Senses

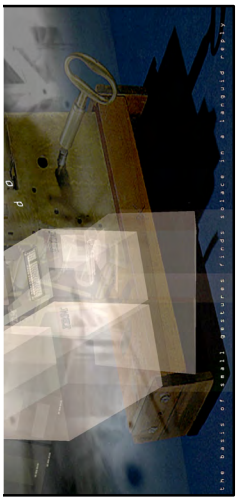
2014 FIP Annual Symposium
FEATURE EXHIBIT

Bill Seaman, Principle Investigator and Artist (concept and initial design), Todd Berreth (programming and additional design).

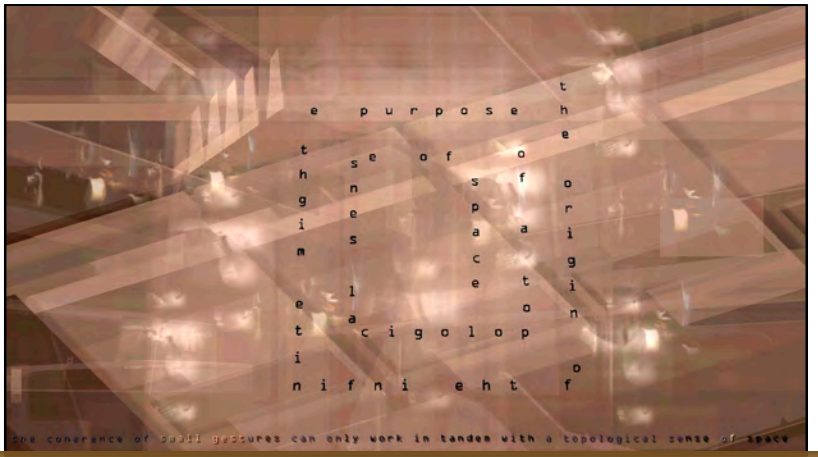
generative installation | sample video/audio output from real-time engine

(32:9 aspect ratio for two screens)

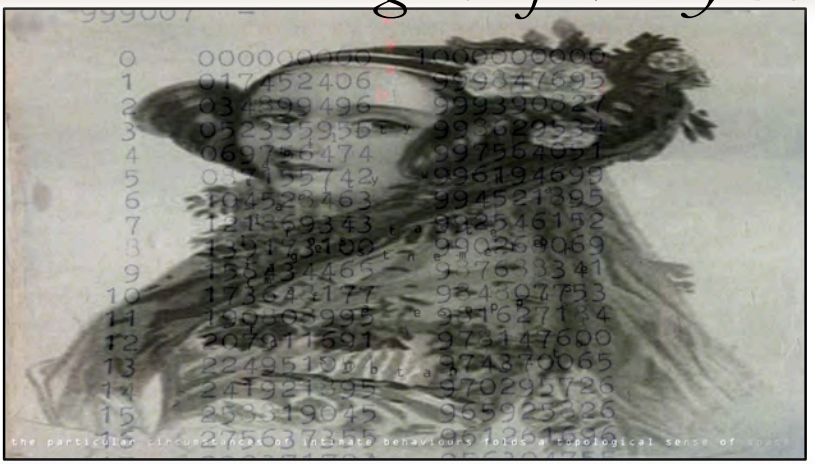
custom software written in C++/OpenGL, digital video/audio source material



An Engine of Many Senses is a generative computational work exploring the history and potential future of the computer. It includes a series of media elements that combine and recombine over time -- 3d images, 2d stills, generative audio, generative media "landscapes", generative text and video components. The work has a series of internal rules that play out different combinatoric strategies, as drawn from an extensive database of architectural typologies and processes. In particular the work includes a series of allegorical time-based images of computers as well as collaged images from the history of the computer and computational history in general. It also includes diagrams of systems that have never been built. The text in the work is combinatoric and is displayed across a series of moving glyphs. The work is always different in that it never plays out the same media elements and/or processes. It is an example of computational creativity. The work is emergent in nature. It can be shown on a series of high-definition screens, or via projections in architectural settings.



An Engine of Many Senses



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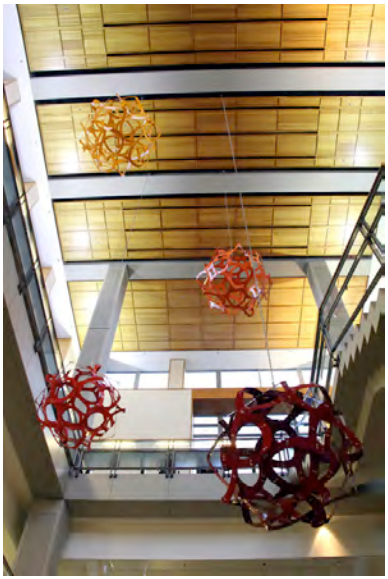
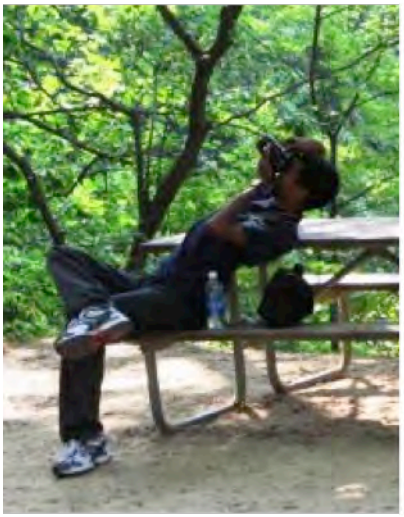


FCIEMAS
Sculptures

The Duke community came together to create art in the Fitzpatrick Center for Interdisciplinary Engineering, Medicine, and Applied Science (FCIEMAS). Under the direction of designer George Hart, four orbs were assembled and raised high in the atrium of FCIEMAS. The sculpture, commissioned by math and ECE professor Ingrid Daubechies, will be a permanent exhibit in the building. - Pratt School of Engineering Press Release October 25, 2013.

Permanent Art Exhibit in FCIEMAS



Envisioning the Invisible

Abhijit Mahato Memorial/Pratt School of Engineering

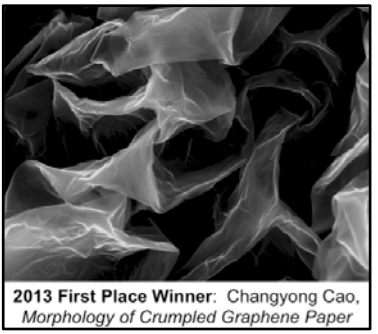
ABHIJIT MAHATO EXHIBIT

on display at 2014 FIP Annual Symposium

The Mahato Memorial exhibit honors Abhijit Mahato, a former engineering graduate student who was tragically murdered on Friday, January 18, 2008. He valued activities that bridged the gaps between the science/engineering and social sciences/humanities disciplines, including sports, chess and photography. By holding this multi-disciplinary image contest, we hope to celebrate Abhijit's life by bringing together the graduate and professional community at Duke in a wonderful display of our talents and some friendly competition.

The Envisioning the Invisible image contest is a way to explore and explain our world. Though the skills honed across disciplines at Duke University are as diverse as the students who employ them, every field of study values students who have mastered the art of explaining dense research through visuals such as pictures and images. Images can stimulate interest in a novel concept or provide further insight into an established theory. – Source: mahato.pratt.duke.edu

Abhijit Mahato



2013 First Place Winner: Changyong Cao, *Morphology of Crumpled Graphene Paper*

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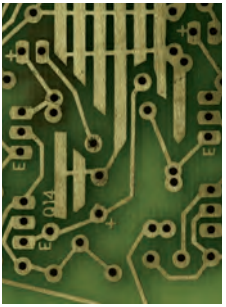

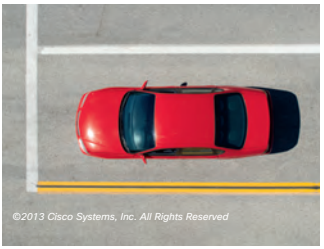

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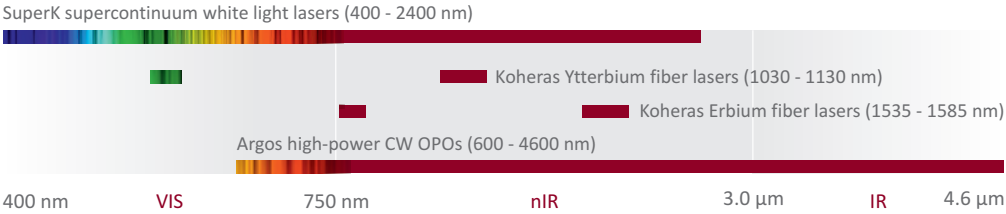

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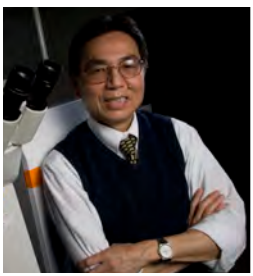

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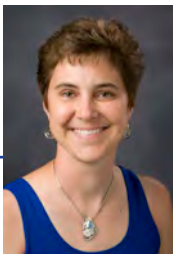
Department Business Manager
The Fitzpatrick Institute for Photonics



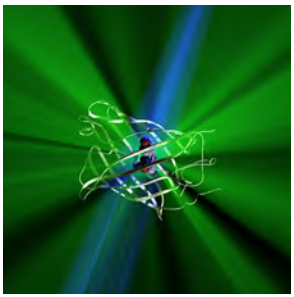
2013 FIP Fellow & Scholar Winners
John Chambers Fellows & Scholars

From Left to Right: Tana Villafana (Scholar), Brian Crouch (Fellow), Dalton Sycks (Fellow), William Eldridge (Fellow), Jenna Mueller (Scholar), Yuan Fang (Fellow), Derek Ho (Fellow), Lindsay McTague (Fellow), and Jong Kang Park (Scholar)

The Fitzpatrick Institute for Photonics (FIP) was able to award several graduate student fellowships through the continued support and generosity of the Fitzpatrick Foundation and John Chambers. Each candidate was nominated by a FIP Professor and judged on the criteria of research accomplishments, research potential, personal qualities and collaborative potential.

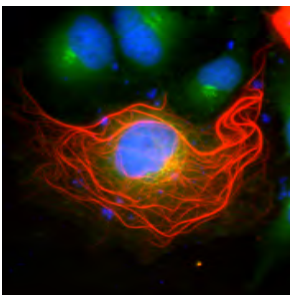
Photo Captions

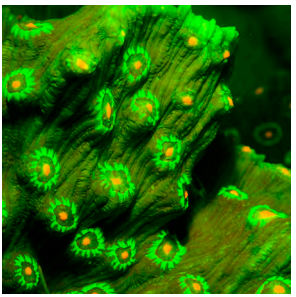
Find below the captions that describe the research of the artistic images throughout the program. The Source for the images and captions is Sciencephoto.com



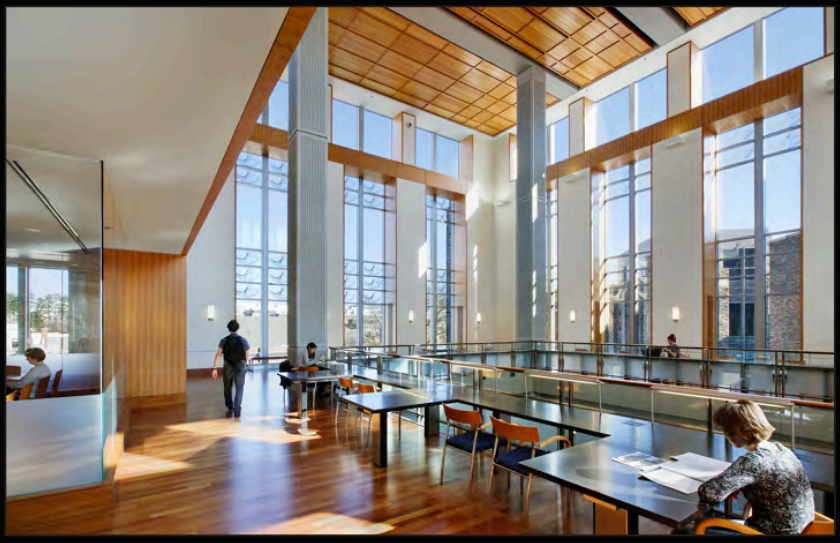
Cover Photo Research Caption:
Green fluorescent protein. Computer artwork of the molecular structure of green fluorescent protein (GFP). Some central atoms are represented as spheres. The molecule has a cylindrical structure formed from beta sheets (ribbons). GFP is found in the Pacific jellyfish (Aequorea victoria). It fluoresces green when blue light is shone on it (as depicted here). GFP is widely used as a research tool in biology and medicine. The gene coding for it can be tagged to the genes of other proteins or viruses to study their movements within cells. They can also be used to tagged cancer cells to track their spread through the body.

Inside Cover Caption:
Cell structure. Fluorescent light micrograph of cultured cells from a cell line derived from African green monkey kidney cells. Nuclei, which contain the cells' DNA (deoxyribonucleic acid), are blue. Microtubules, part of the cells' cytoskeleton, are red. The cytoskeleton is responsible for intracellular transport, structure and motility of the cell, as well as segregating the chromosomes during nuclear division. Golgi bodies, which modify and package proteins, are green.





Caption:
Mycedium coral fluorescing. Blue light excites pigments within some underwater organisms causing them to emit a fluorescent glow. It is thought the coral's glow attracts symbiotic algae which in turn allows the coral to grow in deeper water. Fluorescence may also offer protection against harmful ultraviolet light from the sun in shallower water. Photographed in the Red Sea, Egypt.



www.fitzpatrick.duke.edu

The Fitzpatrick Institute for Photonics business office has achieved the **Duke Green Workplace Certification**.

Duke Green Workplace Certification is a program created by Sustainable Duke to help staff reduce the environmental footprint of their workplace. The program helps to train and foster staff sustainability leaders within a department and provides resources to guide the process of greening your workplace.

The Fitzpatrick Institute for Photonics supports and promotes Duke Sustainability.
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