THE UNIVERSITY OF ARIZONA
Wyant College of Optical Sciences

NATIONAL ACADEMY OF ENGINEERING®

REGIONAL MEETING
MARCH 30, 2022

Innovations in High Contrast, High Resolution Imaging Technologies

NATIONAL ACADEMY
OF ENGINEERING®

MEETING HOSTS

JOHN L. ANDERSON

President, National Academy of Engineering

John L. Anderson is president of the National Academy of Engineering since July 1, 2019. He was born in Wilmington, DE, and received his undergraduate degree from the University of Delaware (1967) and PhD from the University of Illinois at Urbana-Champaign (1971), both in chemical engineering. He was president of the Illinois Institute of Technology (IIT) and Distinguished Professor of Chemical Engineering (2007–15). Before that he was provost and executive vice president at Case Western Reserve University (2004–07), after 28 years at Carnegie Mellon University, including 8 years as dean of the College of Engineering and 11 years as head of the chemical engineering department. He began his career as assistant professor of chemical engineering at Cornell University (1971–76).

Dr. Anderson was elected to the NAE in 1992 for contributions to the understanding of colloidal hydrodynamics and membrane transport phenomena. He was elected an NAE councillor in 2015 and served on the Executive Compensation Committee and Temporary Nominating Committee on Member Diversity. He has also served on the Membership Policy Committee, Nominating Committee (chair), Chemical Engineering Section (chair, vice chair, section liaison), Chemical Engineering Peer Committee (chair), and Committee on Membership (chair, vice chair, peer committee chair). His NASEM service includes the Committee on Determining Basic Research Needs to Interrupt the Improvised Explosive Device Delivery Chain (chair); Committee on Review of Existing and Potential Standoff Explosives Detection Techniques (chair); Board on Chemical Sciences and Technology (cochair); and Ford Foundation Minority Postdoctoral Review Panel on Physical Sciences, Mathematics, and Engineering.

Dr. Anderson is a fellow of the American Academy of Arts and Sciences and American Association for the Advancement of Science, and was appointed to the National Science Board (2014–20). He received the Acrivos Professional Progress Award from the American Institute of Chemical Engineers (AIChE), an award from the Pittsburgh Section of AIChE for Outstanding Professional Accomplishments in the Field of Academics, and the National Engineering Award from the American Association of Engineering Societies. He has held visiting professorships at MIT, the University of Melbourne, and Landbouwuniversiteit Wageningen (the Netherlands), and holds honorary doctorates from IIT, Rensselaer Polytechnic Institute, and the University of Delaware.

THOMAS L. KOCH

Dean and Professor, Wyant College of Optical Sciences, University of Arizona

Thomas L. Koch is Dean of the College of Optical Sciences at the University of Arizona, where he is also Professor of Optical Sciences and Professor of Electrical and Computer Engineering. He received his BA in physics in 1977 from Princeton University and his Ph.D. in applied physics in 1982 from the California Institute of Technology. Dr. Koch joined UA from Lehigh University, where he was Director of the Center for Optical Technologies and Professor of Electrical Engineering and Physics.

Prior to his academic roles, Dr. Koch held Vice President positions at SDL, Lucent, and Agere Systems, where he was responsible for Research and Development of materials, device and subsystem technologies supporting optical, optoelectronic, and IC products. In his many years as a researcher at Bell Laboratories, his work focused on semiconductor lasers, photonic integrated circuits, and their implementation in optical communications systems. He has 37 issued patents, and has authored more than 350 journal, conference, and book publications.

Dr. Koch has received numerous recognitions for his work, including the IEEE's Eric E. Sumner Award, and the William Streifer and Distinguished Lecturer Awards from IEEE LEOS. He is a Fellow of Bell Labs, OSA, IEEE, SPIE, the National Academy of Inventors, and a member of the National Academy of Engineering where he previously Chaired the Electronics, Communication and Information Systems Engineering section.

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ABOUT NAE

NATIONAL ACADEMY OF ENGINEERING

Founded in 1964, the National Academy of Engineering (NAE) is a private, independent, nonprofit institution that provides engineering leadership in service to the nation. The mission of the National Academy of Engineering is to advance the well-being of the nation by promoting a vibrant engineering profession and by marshalling the expertise and insights of eminent engineers to provide independent advice to the federal government on matters involving engineering and technology.

The NAE has more than 2,000 peer-elected members and international members, senior professionals in business, academia, and government who are among the world's most accomplished engineers. They provide the leadership and expertise for numerous projects focused on the relationships between engineering, technology, and the quality of life.

The NAE is part of The National Academies of Sciences, Engineering, and Medicine. The NAE operates under the same congressional act of incorporation that established the National Academy of Sciences, signed in 1863 by President Lincoln. Under this charter the NAE is directed "whenever called upon by any department or agency of the government, to investigate, examine, experiment, and report upon any subject of science or art."

Engineering program activities cut across the many operational units of the National Academies of Sciences, Engineering, and Medicine.

The NAE's independent assets and operating funds are held in the National Academy of Engineering Fund (NAEF), a tax-exempt corporation under section 501 (c) (3) of the Internal Revenue Code. It was created to support the mission and goals of the NAE and its tax identification number is 23-7284092.

In addition to offices in Washington, DC, the Academy maintains meeting facilities in Irvine, Calif., and Woods Hole, Mass.

ABOUT OSC

WYANT COLLEGE OF OPTICAL SCIENCES

The mission of the University of Arizona, Wyant College of Optical Sciences is to provide the state of Arizona and the nation with an internationally pre-eminent program in education, research and outreach in all aspects of the science and application of light.

The Wyant College of Optical Sciences is the world's premier optical institute, with outstanding faculty members, an international student body, a challenging curriculum, pioneering research programs and close relationships with the optics industry.

Our research programs encompass exciting, rapidly changing areas ranging in size from the world's largest telescopes down to the mystical realm of quantum nanophotonics. Our technologies impact real-world applications ranging from new displays in smart phones to emerging 3-D systems; from engineering new imaging systems in consumer cameras to adaptive airborne or space systems for defense and scientific exploration; from biomedical imaging for disease diagnosis and treatment to the ultra-high capacity optical fiber communications technologies that will enable the future growth of the Internet. Recent developments in optical technology will help the blind to see, influence the future of quantum communications, impact clean and renewable energy, provide sensors and data for more accurate weather prediction, and realize solutions for more cost-effective manufacturing. At the Wyant College of Optical Sciences, the development of new research initiatives is as dynamic as the field of optics itself and is the foundation of our educational program.

Our renowned academic programs include bachelors, professional certificate, masters, and Ph.D. — and are also available to students worldwide through our distance learning program.

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NAE - MEMBER ONLY - MEETING

8:30 - 9:00 am	NAE Member Registration	Meinel Bldg - 3rd Floor Lobby
9:00 - 10:00 am	Special Tour for NAE Members & Executive Team	Private Lab Tour
10:15 - 11:45 am	NAE Member Business Meeting	Meinel Bldg - Conf. Rm 821
11:45 am - 12:30 pm	NAE Member & Speaker's Lunch	Meinel Bldg - Breakout Rm 829

SCIENTIFIC MEETING - PUBLIC | KUIPER 308

1:00 - 1:10 pm	**Welcome** John L. Anderson, President, National Academy of Engineering
1:10 - 1:20 pm	**Program Introduction** Thomas L. Koch, Dean and Professor, Wyant College of Optical Sciences University of Arizona
	Session 1: Advances in Imaging for Life Sciences
1:20 - 2:00 pm	**Keynote: High-speed Optical Imaging of Biology at the Speed of Life** **Elizabeth M.C. Hillman** Herbert and Florence Irving Professor, Zuckerman Mind Brain Behavior Institute, Departments of Biomedical engineering and Radiology | Columbia University
2:00 - 2:20 pm	**Multiscale Optical and Acoustic Imaging Technologies to Characterize Disease States from the Single Cell to the Organ** **Barbara Smith** Associate Professor, Biomedical Engineering, School of Biological and Health Systems Engineering | Arizona State University
2:20 - 2:40 pm	**Advanced Endoscopic Imaging for Early Cancer Detection** **Jennifer Barton** Thomas R. Brown Distinguished Professor, Biomedical Engineering; Professor, Wyant College of Optical Sciences; Director, BIO5 Institute | University of Arizona
2:40 - 3:00 pm	**Development of Compact Ultrafast Fiber Lasers for Nonlinear Optical Imaging** **Khanh Kieu** Associate Professor, Wyant College of Optical Sciences | University of Arizona

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SCIENTIFIC MEETING - PUBLIC | KUIPER 308

3:00 - 3:20 pm	**Break & Refreshments - Kuiper Building Atrium**
	Session 2: Astronomy & Exoplanets
3:20 - 4:00 pm	**Keynote: A Challenge for 21st Century Telescopes: Finding and Characterizing Earth 2.0** **Charles A. Beichman** Executive Director, NASA Exoplanet Science Institute | California Institute of Technology
4:00 - 4:20 pm	**Adaptive Optics & the Exoplanet Imaging Challenge** **Olivier Guyon** Astronomer, Steward Observatory; Professor, Wyant College of Optical Sciences | University of Arizona
4:20 - 4:40 pm	**Technology Demonstrations for Exoplanet Imaging with Space Coronagraphy** **Ewan S. Douglas** Assistant Professor, Astronomy; Assistant Astronomer, Steward Observatory | University of Arizona
4:40 - 5:00 pm	**Searching for Life with Ground-based Telescopes** **Jared R. Males** Assistant Astronomer, Steward Observatory | University of Arizona
5:00 - 6:00 pm	**Reception - Kuiper Building, 3rd Floor Atrium**

For those unable to travel, we have established a non-interactive meeting webinar link:
https://arizona.zoom.us/j/83867757852

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SPEAKERS

ELIZABETH HILLMAN - KEYNOTE SESSION 1

Herbert and Florence Irving Professor, Zuckerman Mind Brain Behavior Institute,
Departments of Biomedical engineering and Radiology | Columbia University
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High-speed Optical Imaging of Biology at the Speed of Life

Abstract:

The microscopes of your childhood had an eyepiece or two, a light and some knobs to turn, and you used them to look at thinly sliced (yet fascinating) dead things. However, microscopy has been transformed in recent years thanks to incredible advances in all areas of optics, from lasers to high-speed cameras, as well as our ability to handle and analyze large and high-dimensional digital datasets. The way that we study living things has also changed dramatically thanks to new dyes and fluorescent proteins that enable exquisite, genetically precise labeling of not just the structure, but the function of living cells. My research program leverages these rich opportunities, and most recently recognized that an important frontier not reached by earlier microscopes was the ability to image 3D samples at very high speeds. To address this need, we devised a method called 'Swept confocally aligned planar excitation' (SCAPE) microscopy that is capable of generating cellular-level images in 3D that are so fast that we can watch the heart of a developing fish beat in real time, or track the firing patterns of neurons along the body of a fruit fly larva as it crawls along. A key feature of SCAPE is the system's use of oblique light sheet illumination, which yields much higher signals and lower photodamage compared to traditional point-scanning methods, while our single, stationary objective lens makes the system accessible for a wide range of applications. Our lab has continued to develop and extend this approach into a suite of different SCAPE configurations, while also working closely with a wide range of collaborators to support new studies of biological phenomena. To broadly disseminate this technology, in addition to licensing SCAPE to Leica Microsystems, we have assisted groups worldwide with building their own SCAPE systems. I will discuss this work along with ongoing projects to leverage optical methods to reveal fundamentally new aspects of dynamic, living systems.

Biography:

Elizabeth Hillman is a Herbert and Florence Irving Professor at the Mortimer B. Zuckerman Mind Brain Behavior Institute, and the Departments of Biomedical Engineering and Radiology at Columbia University. Hillman received her undergraduate degree in Physics and Ph.D. in Medical Physics and Bioengineering at University College London and completed post-doctoral training at Massachusetts General Hospital/Harvard Medical School. In 2006, Hillman moved to Columbia University, founding the Laboratory for Functional Optical Imaging.

Hillman's research program focuses on the development and use of novel optical imaging and microscopy technologies to capture functional dynamics of living systems. Most recently, she developed swept confocally aligned planar excitation (SCAPE) microscopy, a technique capable of very high speed volumetric imaging of neural activity in behaving organisms such as adult and larval Drosophila, zebrafish, C. elegans and the rodent brain. Hillman's research program also includes exploring the physiological mechanisms linking neural activity and the modulation of blood flow in the brain, as the basis for signals detected by functional magnetic resonance imaging (fMRI), as well as studying the dynamical properties of real-time brain activity across species.

Hillman is a fellow of the Optical Society of America (OSA), the society of photo-optical instrumentation (SPIE) and the American Institute for Medical and Biological Engineering (AIMBE). She received the 2011 OSA Adolf Lomb Medal for contributions to optics at a young age, the 2018 SPIE Biophotonics Technology Innovator Award, the 2020 Royal Microscopical Society Mid-Career Scientific Achievement Award and early career awards from the Wallace Coulter Foundation, National Science Foundation and Human Frontier Science Program.

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CHARLES A. BEICHMAN - KEYNOTE SESSION 2

Executive Director, NASA Exoplanet Science Institute | California Institute of Technology
Charles.A.Beichman@jpl.nasa.gov; chas@ipac.caltech.edu

A Challenge for 21st Century Telescopes: Finding and Characterizing Earth 2.0

Abstract:

The search for other worlds and life beyond the Earth has challenged humanity for over 2,000 years. It is only in the past 25 years, however, that we have been able to address this question with the tools of modern science and technology. I will discuss our progress to date which includes the 2019 Nobel Prize in Physics for the discovery of the first exoplanet in 1995, the identification of over 5,000 exoplanets, and our dramatic ambitions for future observatories on the ground and in space.

Launched on Christmas Day, 2021, the James Webb Space Telescope (JWST) will use direct imaging to search for planets smaller than Jupiter on distant orbits around young stars and the transit technique to provide a detailed characterization of the atmospheres of planets ranging in size from Jupiters to super-Earths.

A subsequent generation of telescopes will be needed to search for signs of life on Earth analog planets. From the ground, direct imaging with Extremely Large Telescopes (ELTs) will detect and characterize rocky planets in the habitable zones of nearby cool M stars while diffraction-limited, single-mode-fiber spectrometers (R~150,000) will probe elemental and molecular abundances, atmospheric structure and even weather patterns on other worlds. The National Academy's Astro2020 decadal report endorsed the development of a space-based ~6 m telescope equipped with coronagraphs and/or external occulters (starshades) as NASA next flagship observatory to find for signs of life on other Earths orbiting in the habitable zones of stars like our own sun.

Some of this research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

Biography:

Dr. Charles Beichman is the Executive Director of the NASA Exoplanet Science Institute (NExScI) at Caltech, NASA's Center for exo-planet research. In addition to overseeing the development of the science operations center for Space Interferometer Mission (SIM; now on hold) at the NExScI, he leads a SIM Key Project to find planets orbiting young stars. Dr. Beichman has been deeply involved in the search for evidence of planetary systems using first IRAS and now Spitzer. Most recently he and his collaborators have published numerous papers on Kuiper Belt and asteroid analogs surrounding nearby solar type stars based on Spitzer results. One spectacular system, HD 69830, shows emission due to sub-micron sized particles some 1,400 times brighter than our own zodiacal cloud and which appears to be closely associated with a triple planetary system discovered via RV measurements. With Mark Swain and collaborators, he adapted analysis tools used to identify weak debris disks with the Spitzer spectrometer to extract the spectrum of the planet HD209458b during a secondary transit.

For the past 10 years Dr. Beichman has been closely associated with and helped to formulate NASA's program to search for planets around other stars, serving as Chair of the Science Working Group for the Terrestrial Planet Finder (TPF) and authoring numerous articles and reports on TPF and the search for terrestrial and ultimately habitable planets. Before taking up his role at the MSC he was as Chief Scientist for JPL's Astrophysics Directorate. Dr. Beichman also was Director of the Infrared Processing and Analysis Center (IPAC) for almost a decade. At IPAC he worked on the Infrared Satellite Astronomy Satellite (IRAS) as Deputy and later Project Scientist. After IRAS he led the initial software development for the 2 Micron All Sky Survey (2MASS) and was involved as a science team member in all aspects of the project, oversaw NASA's science center support for the Infrared Space Observatory in collaboration with ESA, and initiated the development of the Spitzer Science Center.

He has served on numerous advisory groups, most recently NASA's SSAC and the Astronomy/Origins Subcommittee. In 1988-1990 he was member and executive secretary of the NRC Astronomy and Astrophysics Survey Committee (the Bahcall Report).

JENNIFER BARTON

Thomas R. Brown Distinguished Professor, Biomedical Engineering; Professor, Wyant College of Optical Sciences; Director, BIO5 Institute | University of Arizona
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Advanced Endoscopic Imaging for Early Cancer Detection

Abstract:

Optical methods of investigating tissue have the advantages of high sensitivity, high resolution, relatively low cost, and ability to sense both structural and biochemical characteristics of tissue. Their limited penetration depth can be mitigated by endoscopic delivery using small-diameter optics. Optical techniques hold the promise of directing, minimizing, or perhaps even eliminating traditional destructive biopsy by providing diagnostic information in a harmless manner.

Two complimentary optical modalities hold excellent promise for early cancer detection: optical coherence tomography (OCT) and fluorescence spectroscopy (FS). OCT provides micron-scale cross-sectional imaging up about 1 mm deep in scattering tissue, whereas FS provides information about the concentration and distribution of fluorescent biomolecules. When packaged into endoscopes ranging from 0.3 – 4 mm in diameter, the colon, ovary and fallopian tubes (among other organs) can be accessed. Intriguing images of early stage cancer have been obtained with OCT, while FS has provided information both on the metabolic activity of the tissue and has resolved possible confounders in OCT.

Biography:

Jennifer Barton received the BS and MS degrees in electrical engineering from the University of Texas at Austin and University of California Irvine, respectively. She worked for McDonnell Douglas (now Boeing) on the Space Station program before returning to The University of Texas at Austin to obtain the Ph.D. in Biomedical Engineering in 1998. She is currently Professor of Biomedical Engineering and Optical Sciences. She has served as department head of Biomedical Engineering, Associate and Interim Vice President for Research, and is currently Director of the BIO5 Institute, a collaborative research institute dedicated to solving complex biology-based problems affecting humanity.

Barton develops miniature endoscopes that combine multiple optical imaging techniques, particularly optical coherence tomography and fluorescence spectroscopy. She evaluates the suitability of these endoscopic techniques for detecting early cancer development in patients and pre-clinical models. She has a particular interest in the early detection of ovarian cancer, the most deadly gynecological malignancy. Additionally, her research into light-tissue interaction and dynamic optical properties of blood laid the groundwork for a novel therapeutic laser to treat disorders of the skin's blood vessels. She has published over 120 peer-reviewed journal papers in these research areas. She is a fellow of SPIE- the International Optics Society, and a fellow of the American Institute for Medical and Biological Engineering.

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EWAN S. DOUGLAS

Assistant Professor, Astronomy; Asisstant Astronomer, Steward Observatory | University of Arizona
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Technology Demonstrations for Exoplanet Imaging with Space Coronagraphy

Abstract:

High-contrast imaging above the turbulent atmosphere is expected to directly allow observation of Earthlike exoplanets in reflected light but first must overcome many technical hurdles. This talk will summarize the needed technological advances, the history of technology development for exoplanet imaging, the technologies that will be demonstrated by the NASA Nancy Grace Roman Space Telescope's Coronagraph expected to launch in the coming decade, and the remaining technologies needed to enable direct spectroscopy of Earthlike planets in the future.

Biography:

Ewan Douglas is an Assistant Professor of Astronomy at the University of Arizona Steward Observatory. Dr. Douglas' research focuses on space telescopes and instrumentation, wavefront sensing and control, and high-contrast imaging of extrasolar planets and debris disks. Ewan completed a postdoctoral appointment at the Massachusetts Institute of Technology, received master's and doctoral degrees in astronomy from Boston University, and a bachelor's degree in physics from Tufts University.

OLIVIER GUYON

Astronomer, Steward Observatory; Professor, Wyant College of Optical Sciences | University of Arizona
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Adaptive Optics & the Exoplanet Imaging Challenge

Abstract:

Planets outnumber stars, and many are potentially habitable. Directly catching light from these other worlds is key to probing for life outside our solar system - yet, it remains a formidable challenge. While the upcoming generation of large ground and space telescopes will offer the collecting necessary for spectroscopic analysis of nearby Earth-like planets, the much brighter starlight must first be finely controlled and suppressed. The level of starlight suppression required for these observations will be achievable with future large telescopes thanks to recent advances in optics and related technologies. These include high precision optics fabrication for components that cancel starlight, low-noise fast detectors for measuring optical aberrations in real-time, then compensated with deformable mirrors, and high performance computing. These components are integrated together in an adaptive optics system optimized for high contrast imaging.

Biography:

Dr. Olivier Guyon is an Astronomer and Professor in Optical Sciences at the University of Arizona, and is the principal investigator of the Subaru Coronagraphic Extreme Adaptive Optics instrument for the Subaru Telescope operated by the National Astronomical Observatory of Japan. His research focuses on exoplanet imaging techniques, including coronagraphy, adaptive optics, and image processing.

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SPEAKERS

KHANH KIEU

Associate Professor, Wyant College of Optical Sciences | University of Arizona
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Development of Compact Ultrafast Fiber Lasers for Nonlinear Optical Imaging

Abstract:

Mode-locked lasers which generate femtosecond or picosecond pulses are important tools in modern scientific research and technological applications. These lasers are notorious for their high cost, bulkiness, and complexity in day-to-day operation. I will review the most interesting compact mode-locked fiber laser systems that we have developed. In addition, I will discuss the application of these lasers in multiphoton imaging that has enabled label free determination of the stages of dysplasia in Barrett's esophagus and pancreatic cancer margin detection.

Biography:

Dr. Khanh Kieu is an associate professor at the Wyant College of Optical Sciences, The University of Arizona. He went to college in Saint Petersburg, Russia. He received a PhD degree from the College of Optical Sciences (UA) in 2007. Dr. Kieu then did a postdoctoral study at Cornell University for a couple of years before returning to UA as a faculty member. His main research interests are in laser physics, nonlinear optics, multiphoton microscopy, and precision measurements.

JARED MALES

Assistant Astronomer, Steward Observatory | University of Arizona
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Searching for Life with Ground-based Telescopes

Abstract:

The coming era of 25 to 40 meter ground-based telescopes promises many breakthroughs in our knowledge of the Universe. One of the most exciting will come from the characterization of nearby terrestrial planets, and the search for signs of life on them. To accomplish this, some technical challenges need to be solved in the area of high contrast imaging and precision wavefront control. Several current generation high contrast imagers are engaged in developing and testing solutions to these challenges. We will discuss one of them, MagAO-X, an "extreme" adaptive optics (ExAO) system for the 6.5 m Magellan Clay telescope in Chile. When not on the telescope, MagAO-X returns to the lab in Steward Observatory at the University of Arizona, to support development and testing. We will describe some of the key areas of research for MagAO-X. This includes initial testing of phasing strategies for the under construction 25 m Giant Magellan Telescope (GMT). Finally, we will discuss plans for a follow-on ExAO instrument for the GMT. The primary goal of this instrument will be to search for and characterize life on the nearest terrestrial worlds.

Biography:

Dr. Jared Males is an Assistant Astronomer in the University of Arizona's Steward Observatory. He received his PhD in Astronomy from the University of Arizona in 2013, and was a NASA Sagan Fellow there from 2013-2016, after which he joined the faculty of Steward Observatory. His research is focused on searching for life on exoplanets, both from the ground and in space. He is the principal investigator of the NSF/MRI funded MagAO-X extreme adaptive optics system, a high contrast, coronagraphic exoplanet imaging instrument for the 6.5 m Magellan Clay Telescope in Chile.

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BARBARA SMITH

Associate Professor, Biomedical Engineering, School of Biological and Health Systems Engineering | Arizona State University
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Multiscale Optical and Acoustic Imaging Technologies to Characterize Disease States from the Single Cell to the Organ

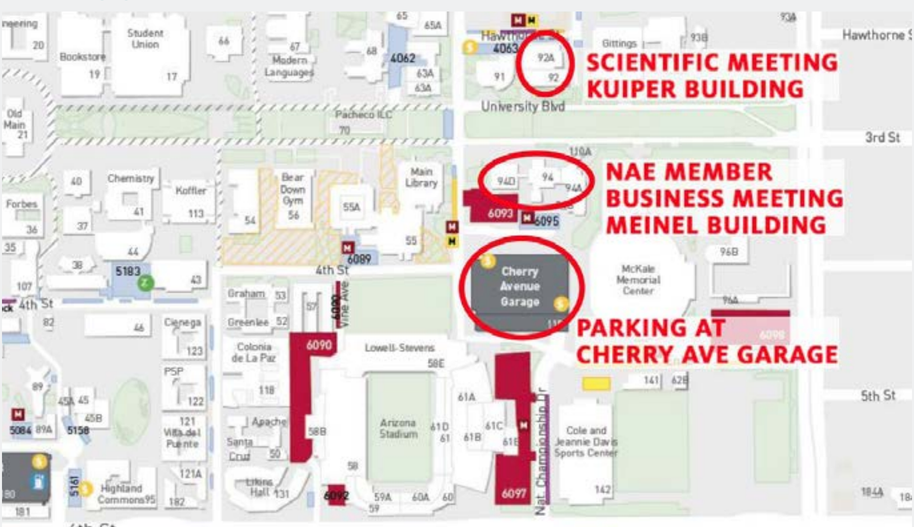
Abstract:

The ability to image at depth in biological tissue is critically important to diagnose and characterize disease states. Despite recent advancements, current optical techniques are restricted to an imaging depth of ~1mm due to the scattering of light in tissues. Photoacoustic systems can use both light and acoustic feedback to image cells of interest and disease processes deeper in biological tissues than traditional optical methods. This talk will highlight a series of photoacoustic imaging tools that have been developed in Dr. Smith's lab to address the urgent need for non- invasive cancer detection and the characterization of neurological disorders. Furthermore, this will allow investigators to better characterize, understand, and detect disease across a wide range of disorders, beyond current capabilities.

Biography:

Barbara Smith is an Associate Professor in the School of Biological and Health Systems Engineering at Arizona State University. Her laboratory focuses on developing novel imaging technologies and applying systems biology approaches for disease detection and patient stratification. Recent work in her lab has led to the publication of a Featured Article in Applied Physics Letters and the submission of 20 patent applications. Since joining ASU, Smith has led multiple Federal (NSF CAREER), State, Foundation, and University funded grants. In addition, she has received teaching awards including the Centennial Professorship Award, honoring her deep commitment to excellence in education.

CAMPUS MAP



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