

Decadal Survey on Biological and Physical Sciences

Research in Space 2023-2032: Physical Sciences

Panel

Committee

Beverley J. McKeon

Co-Chair

Beverley J. McKeon is the Theodore von Karman Professor of Aeronautics at the Graduate Aerospace Laboratories at the California Institute of Technology and deputy chair of the Division of Engineering and Applied Science. McKeon is the chair of and the American Physical Society representative on the U.S. National Committee on Theoretical and Applied Mechanics. McKeon serves as co-lead editor of *Physical Review Fluids* and on the editorial board of the *Annual Review of Fluid Mechanics*. McKeon's research interests include interdisciplinary approaches to manipulation of boundary layer flows using morphing surfaces, fundamental experimental investigations of wall turbulence at high Reynolds number, the development of resolvent analysis for modeling turbulent flows, and assimilation of experimental data for efficient low-order flow modeling. McKeon was the recipient of a Vannevar Bush Faculty Fellowship from the Department of Defense in 2017, a Presidential Early Career Award in 2009, and an NSF CAREER Award in 2008. McKeon is a fellow of the American Physical Society and American Institute of Aeronautics and Astronautics. McKeon received a Ph.D. in mechanical and aerospace engineering from Princeton University.

Alexandra Navrotsky

Co-Chair

Alexandra Navrotsky, NAS is a professor at Arizona State University and the director of the Center for Materials of the Universe. Navrotsky's research interests have centered on relating microscopic features of structure and bonding to macroscopic thermodynamic behavior in minerals, ceramics, and other complex materials. Navrotsky has made contributions to mineral thermodynamics; mantle mineralogy and high-pressure phase transitions; silicate melt and glass thermodynamics; order-disorder in spinels; framework silicates; ceramic processing; oxide superconductors; nanophase oxides, zeolites, nitrides, and perovskites; and the general problem of structure-energy-property systematics. Navrotsky also conducts research in high-temperature reaction calorimetry. Navrotsky's honors include an Alfred P. Sloan Fellowship, Mineralogical Society of America Award, American Geophysical Union Fellow, Vice-President and President of the Mineralogical Society of America, and Geochemical Society Fellow. Navrotsky received a Ph.D. in physical chemistry from the University of Chicago.

Jamel Ali

Member

Jamel Ali is an assistant professor of chemical and biomedical engineering at Florida A&M University–Florida State University College of Engineering in Tallahassee, Florida. Ali also holds an affiliation in the Condensed Matter Science group at the National High Magnetic Field Laboratory. Previously, Ali served as the chief technology officer at Acrogenic Technologies. Research interests focus on microbial dynamics, nanobiomaterials for biomedical applications, and the development of self-assembled small-scale robots for sensing, actuation, and transport applications. Notable awards include the National Science Foundation Research Initiation Award, Air Force Office of Scientific Research Young Investigator Research Program Award, the Florida-California Early Stage Investigator Cancer Research Education and Engagement Program Award, and the Leading Emerging and Diverse Scientists to Success Fellowship in Translational Research. Ali received a Ph.D. in mechanical engineering and mechanics from Drexel University.

Debjyoti Banerjee

Member

Debjyoti Banerjee is a professor of mechanical engineering and a faculty fellow at the Mary Kay O'Connor Process Safety Center at Texas A&M University. Previously, Banerjee was the manager of the Fluidics and Device Engineering Group in the Advanced Research and Technology Division at Applied Biosystems Inc./Applera Corporation (currently called Life Technologies). Research interests involve thermal-fluids sciences with emphasis on multi-phase flows (boiling, condensation), microelectromechanical systems (MEMS, including radio-frequency-MEMS, optical-MEMS, and bio-MEMS), micro/nano-fluidics, bio-nanotechnology (Dip-Pen nanolithography, nanofabrication, nanosynthesis, explosives sensing for detection of improvised explosive devices using nano-calorimetry), and renewable energy technologies (using nanofluids for solar thermal energy storage and power conversion). Banerjee received a Ph.D. in mechanical engineering from the University of California, Los Angeles.

Daniel L. Dietrich

Member

Daniel L. Dietrich is a research scientist at the NASA Glenn Research Center and is the discipline science lead for the Microgravity Combustion Science Program. Dietrich has been a principal and/or co-investigator on numerous ground-based combustion experiments in the fundamental combustion science and spacecraft fire safety, including experiments on the Space Shuttle, Mir Orbiting Station, and the International Space Station. The space experiments included studying a candle burning in the absence of gravity and droplet combustion investigations that discovered for the first time cool-flame supported diffusion flames. Dietrich has also supported the human research program and extra-vehicular activity programs. The work in the human research program resulted in the patented Portable Unit for Metabolic Analysis (PUMA). Awards include the NASA Exceptional Service Medal, Steven R. Sabo Engineering Excellence Award, and the Abe Silverstein Medal. Dietrich received a Ph.D. in mechanical engineering from Drexel University.

Adrienne R. Dove

Member

Adrienne R. Dove is a planetary scientist and an associate professor in the department of physics at the University of Central Florida. Dove's main research interests are dust charging and dynamics on planetary surfaces and plasma interactions with planetary and spacecraft surfaces. Dove examines these processes through dust dynamics and dust charging experiments in the laboratory and on research flights (with parabolic aircraft, suborbital vehicles, the International Space Station, and CubeSats). Experiments study fundamental processes as well as technology development for future missions. Dove received a Ph.D. in astrophysical and planetary science from the University of Colorado, Boulder.

Tanvir Farouk

Member

Tanvir Farouk is an associate professor in the Department of Mechanical Engineering at the University of South Carolina, Columbia. Research interests include non-equilibrium plasmas, low-temperature combustion, emission kinetics, and multiphase systems. Farouk's Laboratory for Reacting Systems & Advanced Energy Research develops multi-physics models to understand combustion and plasma processes at near limit conditions, and design strategies for high-efficiency energy conversion processes with low emission signatures. Farouk received a Ph.D. in mechanical engineering from Drexel University.

Eden Figueroa

Member

Eden Figueroa is an associate professor in the department of physics and astronomy at Stony Brook University. Figueroa leads the Quantum Information Sciences and Technology group which focuses on novel quantum memories and processors that will enable future quantum information networks and computing. One of the main goals is to understand the quantum nature of information and to learn how to formulate, manipulate, and process it using physical systems that operate on quantum mechanical principles. Figueroa received a Ph.D. from the University of Calgary, Canada.

Amber Genau

Member

Amber Genau is an associate professor in the Department of Materials Science and Engineering at the University of Alabama at Birmingham. Genau's research focuses on the solidification behavior of metal alloys and the characterization of complex microstructures in two and three dimensions. The goal of this research is to better understand and predict the behavior of multi-phase, multi-component alloys during and after freezing. Previously, Genau was a guest scientist at the German Aerospace Center in Cologne, Germany, working in the Institute for Material Physics in Space. Genau has received a UAB President's Award for Excellent in Teaching, an National Science Foundation CAREER Award, an ASM International Bradley Stoughton Award for Young Teachers, and a Materials Processing and Manufacturing Division Young Leader Professional Development Award from the Minerals, Metals and Materials Society. Genau received a Ph.D. in materials science and engineering from Northwestern University.

Teja Guda

Member

Teja Guda is the Jacobson Distinguished Professor of Innovation and Entrepreneurship and associate professor in the Department of Biomedical Engineering and Chemical Engineering at the University of Texas at San Antonio and is associate dean of the graduate school. Guda's Laboratory for Regenerative Medicine and Medical Device Development is focused on leveraging matrix mechanics to drive biomaterials translation for tissue engineering applications, 3D architectures of porous materials and their manufacture using 3D printing, the use of biophysical stimulation using bioreactors, and the use of micro-computed tomography as a modeling tool. Applications of this research are primarily targeted at the preservation and/or restoration of musculoskeletal tissues and the upper airway after injury. Guda received a Ph.D. in biomedical engineering from the University of Texas at San Antonio.

John I. Hochstein

Member

John I. Hochstein is a professor of mechanical engineering at the University of Memphis. Research interests include computational modeling of flows with free surfaces; innovations in engineering education; spacecraft cryogenic propellant management; and flow in vascular aneurysms. Hochstein received a Ph.D. in mechanical engineering from the University of Akron.

Michele V. Manuel

Member

Michele V. Manuel is the Rolf E. Hummel Professor of Electronic Materials and chair of the Department of Materials Science and Engineering at the University of Florida. Manuel's research lies in the basic understanding of the relationship between processing, structure, properties, and performance. Manuel uses a systems-based materials design approach that couples experimental research with theory and mechanistic modeling for the accelerated development of materials. Manuel's current research is focused on using systems-level design methods to advance the development of new materials through microstructure optimization. Specific interests include lightweight and functional materials, advanced manufacturing, and materials and systems under extreme environments – specifically at high magnetic fields or under irradiation. Manuel is the recipient of Presidential Early Career Award for Scientists and Engineers, a National Science Foundation CAREER Award, a NASA Early Career Faculty Award, an ASM Bradley Stoughton Award for Young Teachers, an American Vacuum Society Recognition for Excellence in Leadership, an Early Career Faculty Fellow Award from The Minerals, Metals and Materials Society (TMS), a TMS Brimacombe Medalist, a TMS/Japan Institute of Metals International Scholar Awards, and an ASM Fellow. Manuel received a Ph.D. in materials science and engineering at Northwestern University.

Robert J. McLean

Member

Robert J.C. McLean is regents' professor in the Department of Biology at Texas State University. McLean's laboratory studies the biology of bacteria as they naturally grow in surface-adherent communities (biofilms). These studies are conducted in pure single-species and mixed polymicrobial cultures. McLean has co-authored a textbook on microbial ecology. Previously, McLean was an assistant professor at Queen's University. McLean received a Ph.D. in microbiology from the University of Calgary.

John B. McQuillen

Member

John B. McQuillen is a project scientist in the areas of fluid physics and complex fluids in the Low Gravity Exploration Technology Branch at NASA's Glenn Research Center. McQuillen's research interests include the cooling, storage, and transfer of cryogenic rocket fuels (hydrogen, oxygen, and methane) on Earth and in space. McQuillen has been involved in a wide array of fluid physics research experiments on the International Space Station. McQuillen received an M.S. in chemical engineering from the University of Toledo.

Jeffrey F. Morris

Member

Jeffrey F. Morris is professor and chair of the Department of Chemical Engineering and the director of the Levich Institute at the CUNY City College of New York (CCNY). Previously, Morris worked at Halliburton as a senior academic advisor. Research interests include developing constitutive and bulk fluid mechanical descriptions appropriate for suspensions, from submicron colloids to sand slurries. Unifying features of the work are an emphasis on understanding the influence of nonequilibrium microstructure on rheology and bulk flow. Morris has recently focused on frictional interactions between particles in viscous liquids, toward the understanding of shear thickening. Elected a fellow of the American Physical Society (APS) and the Society of Rheology, Morris has received the J. Rheology Publication Award twice, the AIChE/Shell Thomas Baron Award for Fluid-Particle Systems, and the Stanley Corrsin Award of the APS. Currently the secretary-treasurer of the APS Division of Fluid Dynamics, and an associate editor of the Journal of Fluid Mechanics. Morris received a Ph.D. from the California Institute of Technology.

Issam Mudawar

Member

Issam Mudawar is the Betty Ruth and Milton B. Hollander Family Professor of Mechanical Engineering at Purdue University and director of the Purdue University Boiling and Two-Phase Flow Laboratory and International Electronic Cooling Alliance. Mudawar's research interests include boiling, condensation, two-phase flow, high heat flux, thermal management systems, cryogenic systems, space vehicles, lunar and Martian environments, microgravity, experiments on International Space Station, and electronic cooling. Mudawar is a Thomson Reuters Highly Cited Researcher. Mudawar is the recipient of the American Society for Gravitational and Space Research Founder's Award, American Society of Mechanical Engineers (ASME) Heat Transfer Memorial Award, 75th Anniversary Medal from the ASME Heat Transfer Division, American Institute of Aeronautics and Astronautics Space Processing Award, and ASME Allan Kraus Thermal Management Medal. Mudawar received his Ph.D. in mechanical engineering from the Massachusetts Institute of Technology.

Holger Müller

Member

Holger Mueller, an associate professor at the University of California, Berkeley, has been pushing the forefront of quantum sensing and precision measurement in many areas, including in atom interferometry. Recent highlights include making the most accurate measurement of the fine-structure constant, searching for dark energy, testing forces arising from blackbody radiation, or exploring whether gravity is a quantum force in an atom interferometer with an unprecedented coherence time. He is a Fellow of the American Physical Society, has received the Francis M. Pipkin Award of the American Physical Society, the NSF Career Award, the DARPA Young Investigator Award, a Packard Fellowship in Science and Engineering, and a Sloan Fellowship. He is currently a Miller Professor at Berkeley, a honorary position that allows him to focus fully on research.

Aleksandar G. Ostrogorsky

Member

Aleksandar G. Ostrogorsky is a professor of materials and aerospace engineering at the Illinois Institute of Technology. Ostrogorsky's research focuses on heat and mass transfer phenomena occurring in materials processing and directional solidification/single crystal growth in semiconductor alloys. Recent work examines the effects of magnetic fields on the physiology of living organisms at the molecular cellular, tissue, and whole-body level. Ostrogorsky was director of the Center for Microgravity and Materials Research (CMMR) in Huntsville. Ostrogorsky has been the principal investigator of several experiments conducted at the International Space Station. Ostrogorsky is a fellow of American Society of Mechanical Engineers and an associate fellow of the American Institute of Aeronautics and Astronautics. Ostrogorsky received an Sc.D. in mechanical engineering from the Massachusetts Institute of Technology.

Amy Peterson

Member

Amy M. Peterson is an associate professor of plastics engineering at University of Massachusetts Lowell with expertise in interfacial phenomena and additive manufacturing. Peterson's research group studies processing-structure-property relationships in polymers and polymer composites, with a focus on interfacial phenomena in multilayered systems. This research involves investigation of how reinforcement phases affect processing, structure, properties, and formulation/printing of novel materials. Peterson received a Ph.D. in chemical engineering from Drexel University.

William D. Phillips

Member

William D. Phillips, NAS, is a NIST fellow of the National Institute of Standards and Technology (NIST), a fellow of the Joint Quantum Institute, and a College Park Professor and Distinguished University Professor of the University of Maryland, College Park. Phillips is the founder and emeritus leader of NIST's Laser Cooling and Trapping Group. That group has been responsible for developing some of the main techniques now used for laser-cooling and cold-atom experiments in laboratories around the world. The group's achievements include the first electromagnetic trapping of neutral atoms; reaching unexpectedly low laser-cooling temperatures, within a millionth of a degree of absolute zero; the confinement of atoms in optical lattices; and coherent atom-optical manipulation of atomic-gas Bose-Einstein condensates. Atomic fountain clocks, based on the work of this group, are now the primary standards for world timekeeping. Among the group's current research directions is the use of ultra-cold atoms for quantum information processing and quantum simulation of important physical problems. Phillips received a Ph.D. in physics from the Massachusetts Institute of Technology.

Marianna Safronova

Member

Marianna S. Safronova is a professor of physics at the University of Delaware. Research interests include applications of quantum technologies to search for physics beyond the standard model of elementary particles and fields, development of atomic and nuclear clocks and their applications, ultra-cold atoms and quantum information, studies of fundamental symmetries, dark matter searches, quantum many-body theory, and development of high-precision relativistic atomic codes, development of the online atomic data portal, highly-charged ions, superheavy atoms, and other topics. Safronova is a fellow of the American Physical Society, prior chair of the American Physical Society Division of the Atomic, Molecular, and Optical Physics, and a member of the Quantum Science and Technology Journal editorial board. Safronova received a Ph.D. in physics from the University of Notre Dame.

Peter B. Sunderland

Member

Peter B. Sunderland is a professor and director of undergraduate studies in the Department of Fire Protection Engineering (with affiliations to the Department of Aerospace Engineering and the Department of Mechanical Engineering) and a Keystone Professor in the College of Engineering at the University of Maryland, College Park (UMD). Before joining UMD, Sunderland was a staff scientist at NASA Glenn Research Center. Sunderland's research interests are in combustion and fire protection, including soot formation and oxidation, hydrogen flames, laminar diffusion flames, vehicle fires, microgravity combustion, and diagnostics development. Sunderland has received a National Science Foundation CAREER Award, the Kent Teaching Award for Junior Faculty, the SAE Ralph H. Isbrandt Automotive Safety Engineering Award, and the Best-Paper Award from the Combustion Institute Central States Section. Sunderland received a Ph.D. in aerospace engineering from the University of Michigan.