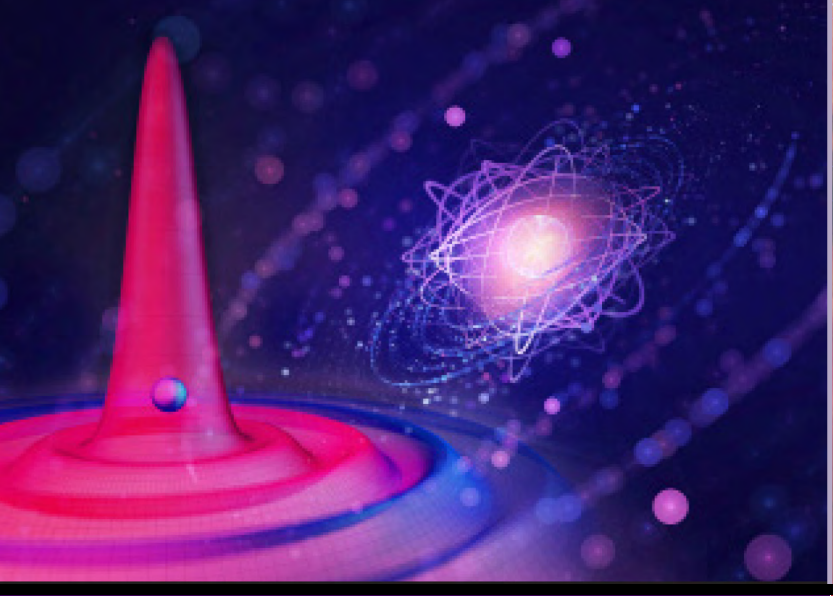
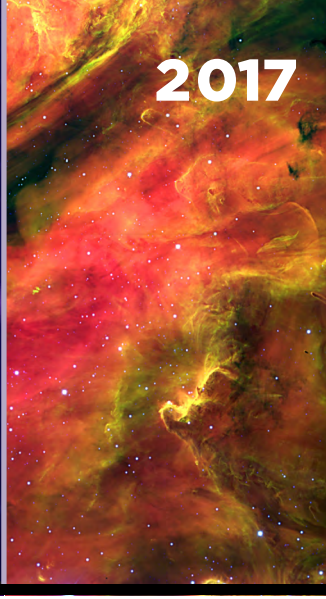




2017

DIRECTORATE FOR

MATHEMATICAL & PHYSICAL SCIENCES

National Science Foundation
WHERE DISCOVERIES BEGIN

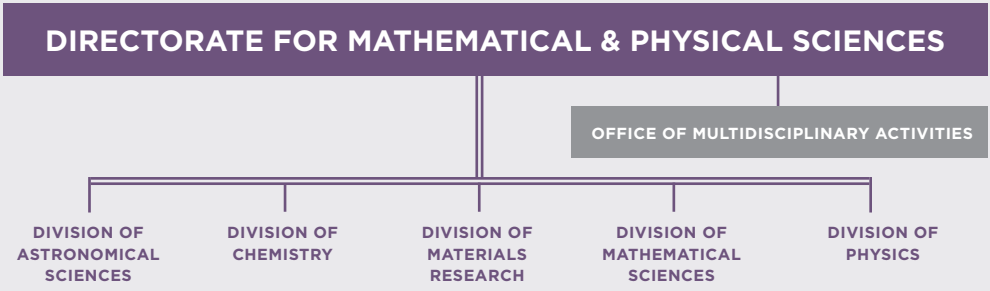
DIRECTORATE FOR

MATHEMATICAL & PHYSICAL SCIENCES (MPS)

The NSF Directorate for Mathematical and Physical Sciences consists of the Divisions of Astronomical Sciences, Chemistry, Materials Research, Mathematical Sciences, and Physics, as well as the Office of Multidisciplinary Activities. These organizations constitute the basic structure for MPS support of research and workforce development. The MPS divisions support both disciplinary and interdisciplinary activities and partner with each other and with other NSF directorates to promote basic research across the scientific disciplines.

MPS MISSION STATEMENT

The mission of MPS is to harness the collective efforts of the mathematical and physical sciences communities to address the most compelling scientific questions, educate the future advanced workforce, and promote discoveries to meet the needs of the Nation.



National Science Foundation
WHERE DISCOVERIES BEGIN

NSF MISSION

To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes.

NSF VISION

A Nation that creates and exploits new concepts in science and engineering and provides global leadership in research and education.

DEAR READER:

The Directorate for Mathematical and Physical Sciences (MPS) of the National Science Foundation (NSF) funds fundamental research in astronomy, chemistry, materials, mathematical sciences, and physics. This research excites our imaginations and changes our lives, expanding the frontiers of knowledge and providing a foundation that supports economic growth, public health, and national security. Fundamental discoveries in the mathematical and physical sciences are the bedrock of technological innovation. MPS investments rest on the long march of transformative ideas to societal benefits: some benefits occur in a few years and others take many decades to develop.

The MPS annual budget is more than a billion dollars, and it funds research that covers a large intellectual space. It supports projects ranging from exploration of the intersections of the life sciences, the physical sciences, and mathematics to discovery of the very nature of matter, space, time, and the physical laws governing the universe. The investigations funded by MPS encompass a vast range of topics, from research on the smallest particles to the largest galaxies, from number theory to quantum information science, and from biomaterials to chemical catalysis. The detection of gravitational waves at NSF's Laser Interferometer Gravitational-Wave Observatory (LIGO), confirming part of Einstein's theory of general relativity, illustrates the intellectual return on MPS-funded research. MPS investments, made over more than three decades, in fundamental research on sensors, lasers, materials, time domain astronomy, and control systems, contributed to the LIGO discovery.

MPS-funded research propels the nation's investments in a host of important areas. Just a few illustrations of the practical consequences of research in mathematical and physical sciences are the evolution of medical imaging technology, the development of ultrasensitive biological and chemical detectors, advances in alternate fuel technologies, and transformations in electronics, photonics, and optics. To continue reaping the benefits of discovery, invention, and innovation, NSF has defined ten "Big Ideas," cutting-edge research agendas and processes aimed at catalyzing interest and investment in fundamental research. Learn more about these "Big Ideas" at https://www.nsf.gov/news/special_reports/big_ideas.

This brochure provides an introduction to the research we support at universities and laboratories throughout the Nation, and we invite you to learn more about MPS on our web site at www.nsf.gov/MPS.

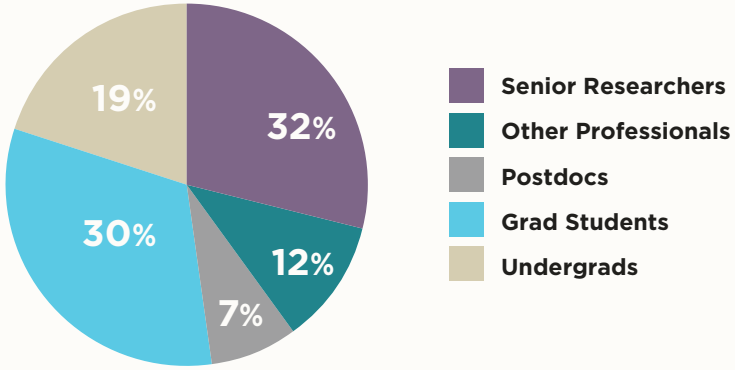
Best regards,

Anne L. Kinney

Assistant Director
National Science Foundation
Directorate for Mathematical and Physical Sciences

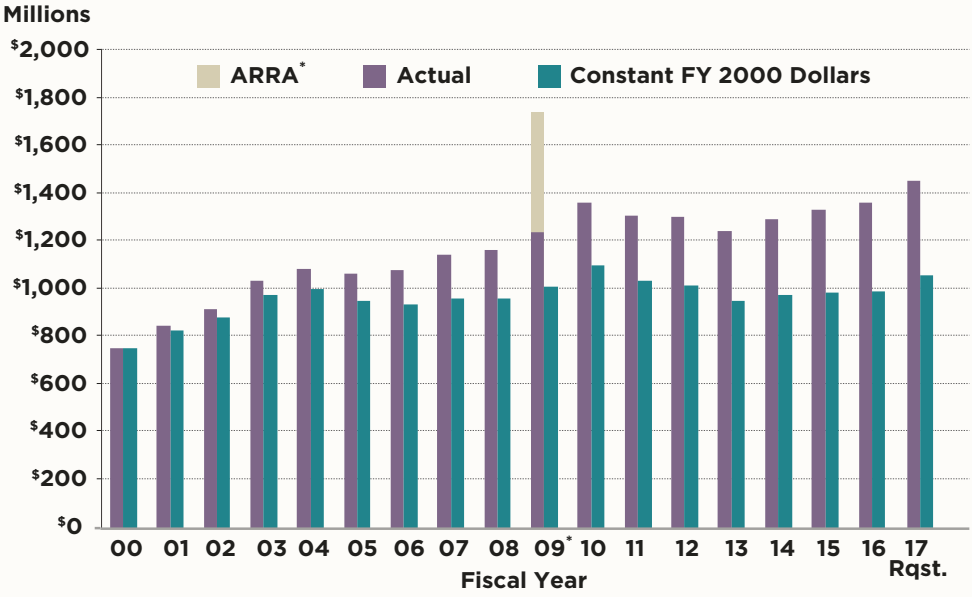
MPS Grant Personnel FY 2016

Distribution of people supported by MPS.



MPS Research and Related Activities Funding

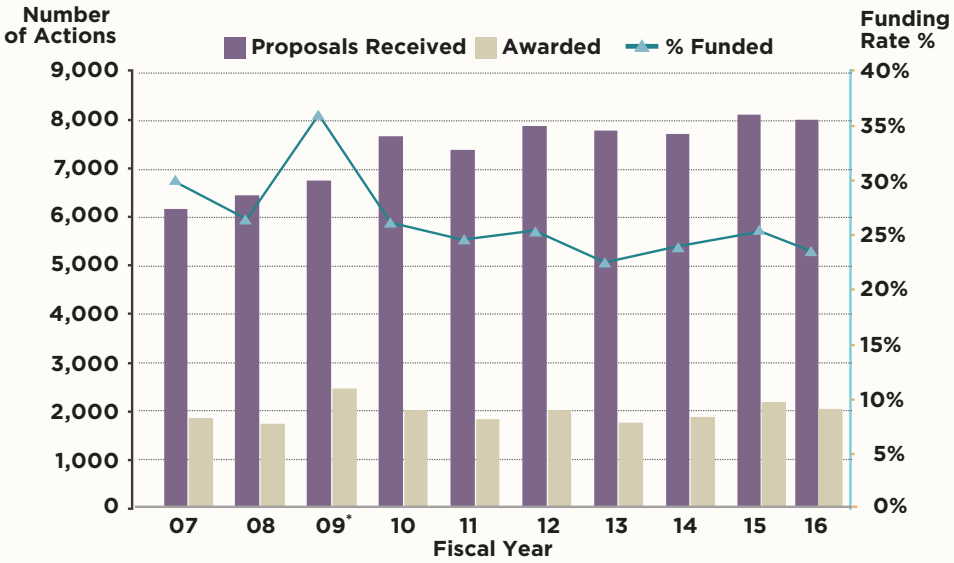
Constant dollars show the purchasing power of the MPS budget.



* ARRA – American Recovery and Reinvestment Act of FY 2009. Rqst. = Request.
Data provided from NSF Budget Requests to Congress, www.nsf.gov/about/budget

MPS Funding Rates and Number of Actions

Graph shows number of proposals submitted and awarded Research Grants (as defined by NSF) and resultant funding rates. Funding rate is defined as the percentage of new or renewal proposals awarded funding.



* FY 2009 funding rate includes awards made with ARRA funds.

Note: The funding reflects the average for the Directorate and may not represent funding rates in individual Divisions or programs

DIVISION OF ASTRONOMICAL SCIENCES (AST)

MISSION

The mission of the Division of Astronomical Sciences is to support forefront research in ground-based astronomy; to help ensure scientific excellence of the U.S. astronomical community; to provide access to world-class research facilities through merit review; to support the development of new instrumentation and next-generation facilities; and to encourage broad understanding of the astronomical sciences by a diverse population of scientists, policy makers, educators, and the public at large.

The Division supports research in all areas of astronomy and astrophysics as well as related multidisciplinary studies. Because of the scale of modern astronomical research, the Division engages in numerous interagency and international collaborations. Areas of emphasis and the priorities of specific programs are guided by community recommendations and federal advisory committees and developed by National Academies decadal surveys.

ASTRONOMICAL FACILITIES

Through NSF-funded national observatories and international partnerships, AST supports a system of multi-user telescopes that enabled transformational capabilities in radio and optical/infrared astronomy. In FY 2016, AST accomplishments included continued breakthrough science observations with the Atacama Large Millimeter/submillimeter Array (ALMA). Construction progress continues for NSF's Daniel K. Inouye Solar Telescope (DKIST), the largest solar telescope in the world, atop Haleakala peak on Maui, Hawaii, which will be operational in 2020. Construction of the Large Synoptic Survey Telescope (LSST) is also progressing, with survey observations scheduled to begin in 2022. The Division is proud of the unique capabilities and recent discoveries provided by all its observatories.

AST invested 61% of its FY 2016 research appropriation in the management and operation of national, ground-based astronomical facilities. The researchers using these facilities made a multitude of important discoveries, reported in scientific journals and the popular press.

Credit: Gemini Observatory/AURA image by Joy Pollard

This image features the Gemini North telescope during laser guide star operations (LGS): This time lapse image consists of roughly 40 images edited together to create a star trails image, with an attenuation on the earlier images, which makes the earlier images appear to fade out. Shot near the summit of Maunakea, the glow of nearby Waimea can clearly be seen reflected in the low cloud cover. Also prominently featured in the image are the new photovoltaic panels that have been installed at all of the Gemini Observatory facilities.

Contact Information

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PROGRAMS IN ASTRONOMICAL SCIENCES

INDIVIDUAL INVESTIGATOR PROGRAMS

- Astronomy and Astrophysics Research Grants (AAG)
- Solar and Planetary Research Grants (SPG)
- Faculty Early Career Development Program (CAREER)
- NSF Astronomy and Astrophysics Postdoctoral Fellowships (AAPF)
- Partnerships in Astronomy and Astrophysics Research and Education (PAARE)
- Research Experiences for Undergraduates Sites (REU)
- Advanced Technologies and Instrumentation (ATI)
- Major Research Instrumentation (MRI)

MID-SCALE INNOVATIONS PROGRAM (MSIP)

The Mid-Scale Innovations Program supports astronomical projects ranging from $4 million to $30 million. MSIP currently supports an optical survey which will generate over 300 all-sky images per year, an ultra-high-resolution radio telescope program for observing the black hole at the center of the Milky Way galaxy, projects that are exploring the cosmic microwave background, a new wide-field bolometer camera for millimeter-wave observations of distant galaxies, and a low frequency radio array with 350 telescopes to study very early times when the universe transitioned from darkness to being lit by the first stars and galaxies.

LARGE FACILITIES

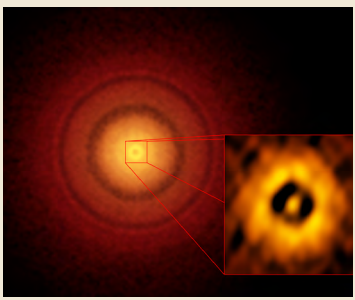
- Arecibo Observatory
- Atacama Large Millimeter/submillimeter Array
- Gemini Observatory
- Green Bank Observatory
- Long Baseline Observatory
- National Optical Astronomy Observatory
- National Radio Astronomy Observatory
- National Solar Observatory

LARGE FACILITIES UNDER CONSTRUCTION

- Daniel K. Inouye Solar Telescope
- Large Synoptic Survey Telescope

ELECTROMAGNETIC SPECTRUM MANAGEMENT (ESM)

AST represents the interests of NSF and the scientific community in protecting access to the electromagnetic spectrum for research purposes. The sensitivity of telescopes can be compromised by electromagnetic interference from ground, airborne, and satellite radio transmissions and light pollution. ESM personnel protect scientific capabilities by participating in the establishment of regulations, operating procedures, and technical standards related to government, private sector, and international uses of the spectrum.

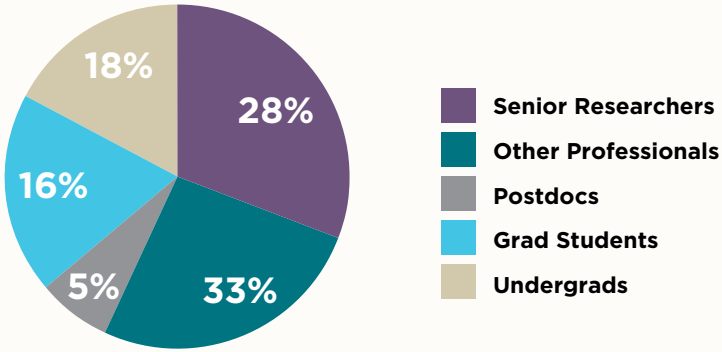


Credit: S. Andrews (Harvard-Smithsonian CfA), ALMA (ESO/NAOJ/NRAO)

Possible planet formation in Earth-like orbit around a young star: ALMA image of the planet-forming disk around the young, Sun-like star TW Hydrae. The inset image (lower right) zooms in on the gap nearest to the star, which is at the same distance as the Earth is from the Sun, suggesting an infant version of our home planet could be emerging from the dust and gas. The additional concentric light and dark features may represent other planet-forming regions farther out in the disk.

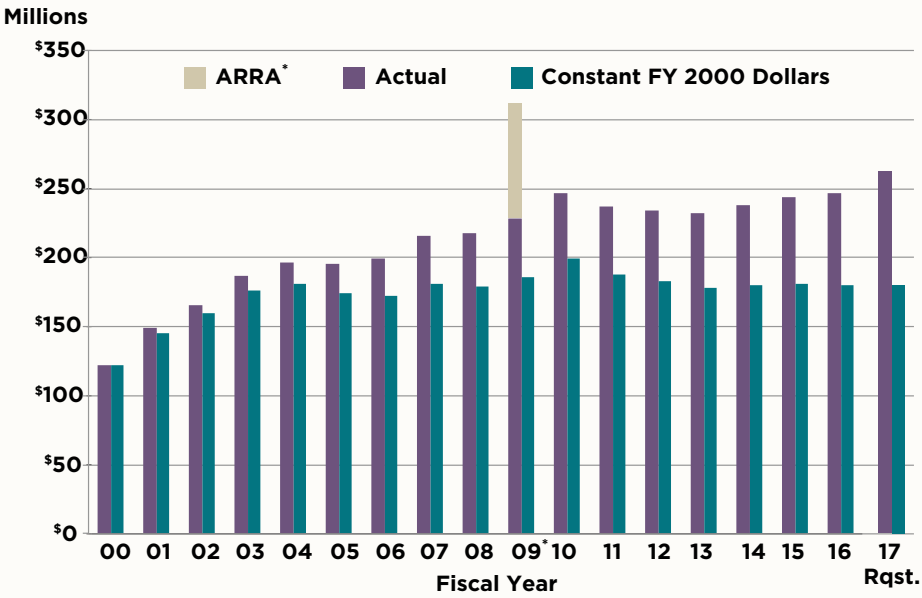
AST Grant Personnel FY 2016

Distribution of people supported by AST.



AST Research and Related Activities Funding

Constant dollars show the purchasing power of the AST budget.



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Data provided from NSF Budget Requests to Congress, www.nsf.gov/about/budget

AST Funding Rates and Number of Actions

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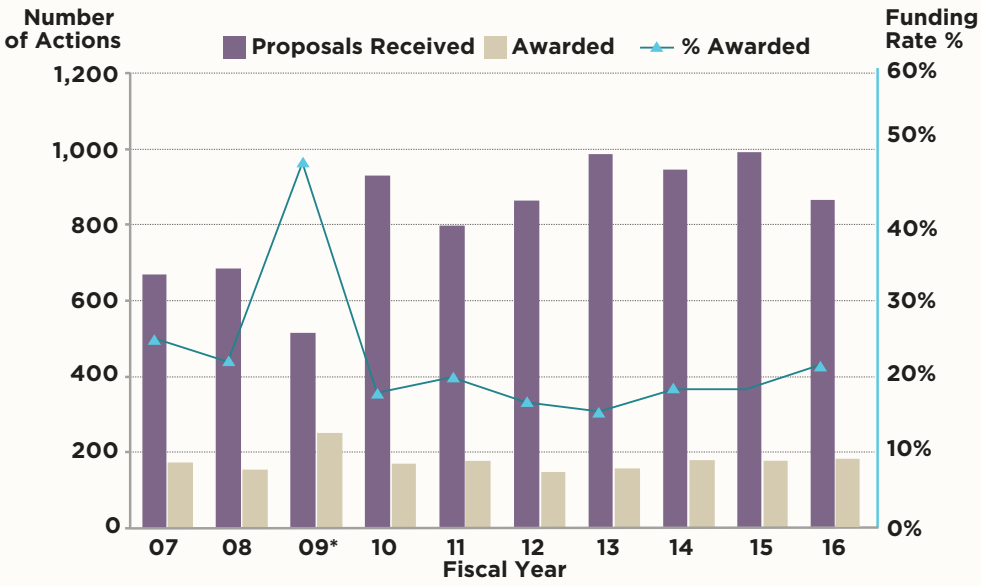

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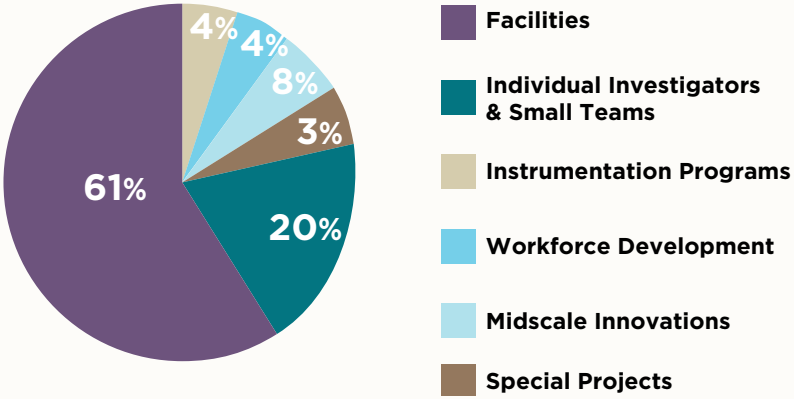
AST Modes of Support FY 2016



DIVISION OF CHEMISTRY (CHE)

MISSION

The mission of the NSF Division of Chemistry (CHE) is to support innovative research in chemical sciences, integrated with education, through strategic investment in developing a globally engaged U.S. chemistry workforce reflecting the diversity of America.

PROGRAMS IN CHEMISTRY

INDIVIDUAL INVESTIGATOR PROGRAMS

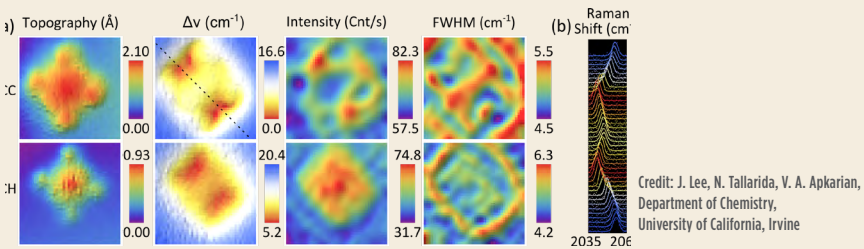
- Chemical Catalysis (CAT)
- Chemical Measurement and Imaging (CMI)
- Chemical Structure, Dynamics, and Mechanisms – A (CSDM-A)
- Chemical Structure, Dynamics, and Mechanisms – B (CSDM-B)
- Chemical Synthesis (SYN)
- Chemistry of Life Processes (CLP)
- Chemical Theory, Models and Computational Methods (CTMC)
- Environmental Chemical Sciences (ECS)
- Macromolecular, Supramolecular and Nanochemistry (MSN)

INTEGRATIVE CHEMISTRY ACTIVITIES

Centers for Chemical Innovation; Facilities and Research Infrastructure (National High Magnetic Field Lab and Chemistry and Materials Center for Advanced Radiation Sources (ChemMatCARS) at the Advanced Photon Source); Research Experiences for Undergraduates (NSF-wide); Major Research Instrumentation (NSF-wide)

CENTERS FOR CHEMICAL INNOVATION (CCIs)

The CCI Program supports research centers focused on major, long-term, fundamental chemical research challenges. CCIs produce transformative research, lead to innovation, and attract broad scientific and public interest. CCIs respond rapidly to emerging opportunities, enhance collaborations, and may partner with researchers from industry, government laboratories and international organizations. The CCI Program is a two-phase program. Phase I CCIs



Credit: J. Lee, N. Tallarida, V. A. Apkarian, Department of Chemistry, University of California, Irvine

Catching Chemistry in the Act, Imaging Molecules in Real Space and Time: To observe the making and breaking of bonds in real-space and real-time, individual atoms must be seen, requiring spatial resolution on the Å-scale, a factor of 10,000 improvement over the best optical microscope. Images must be recorded at a frame rate of 1/femtosecond (a thousand million million frames per second). The Center for Chemistry at the Space-Time Limit (CaSTL) combines ultrafast spectroscopy with scanning probe microscopy to achieve the resolution and records moving pictures of steps in bond making and breaking. This is a first step towards the manipulation of individual atoms and molecules towards molecular engineering and controlling chemistry.

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receive resources to develop the science, management and broader impacts of a major research center before requesting Phase II funding ($4 million/year for up to 10 years).

FACILITIES AND RESEARCH INFRASTRUCTURE

The Chemistry and Materials Center for Advanced Radiation Sources (ChemMatCARS) of the University of Chicago operates three experimental stations at the Advanced Photon Source (APS), an undulator-based synchrotron source of high-brilliance, high-energy X-rays at Argonne National Laboratory. The instrumentation at ChemMatCARS is used by a broad range chemistry and materials researchers, such as those employing small-molecule crystallography, liquid surface and interface scattering, and small to wide-angle scattering.

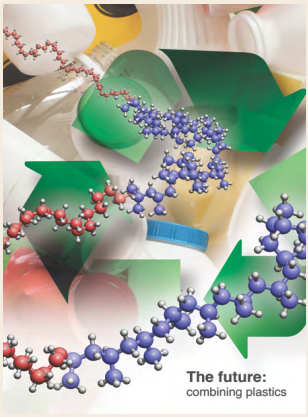
CHE also supports the development of Fourier transform ion cyclotron mass spectrometry (FTICR-MS) at the National High Magnetic Field Laboratory (NHMFL) at Florida State University (FSU). FTICR-MS is an ultra-high performance type of mass spectrometry capable of high resolution and large sample masses. FTICR-MS is highly advantageous for complex mixtures of large molecules, such as those found in biological or petroleum research. The NHMFL Ion Cyclotron Resonance facility now houses the highest magnetic field FTICR-MS instrument, which offers unprecedented resolution and speed of data acquisition.

DATA-DRIVEN DISCOVERY SCIENCE IN CHEMISTRY (D3SC)

The need to extract useful insight from the amount and variety of data generated in the chemical sciences creates an opportunity to enable the chemistry community to effectively share, mine, and repurpose rapidly-growing chemical datasets and to apply state-of-the-art data analytics tools to expand chemical understanding in a broad range of areas including the acceleration of predictive design of chemical species or reactions, real-time data collection and analysis, and new routes to provide novel chemical insight.

WORKFORCE DEVELOPMENT AND BROADENING PARTICIPATION

CHE supports opportunities for workforce development throughout one's career. Examples include the 70 Research Experiences for Undergraduates (REU) sites which facilitate research in a diversity of settings (universities, government laboratories, and international institutions) and Improving Graduate Student Preparedness for the Chemistry Workforce to enable internships or similar experiences in industry, government laboratories, policy organizations, and non-profit foundations. Also included are professional development courses on topics including business and entrepreneurship training and communicating science to the public. Activities that include an international component are also encouraged. CHE also participates in the Career-Life Balance Program which provides supplemental funding for graduate students, postdocs, and faculty facing dependent-care issues to sustain research activities while the researcher is on family leave.

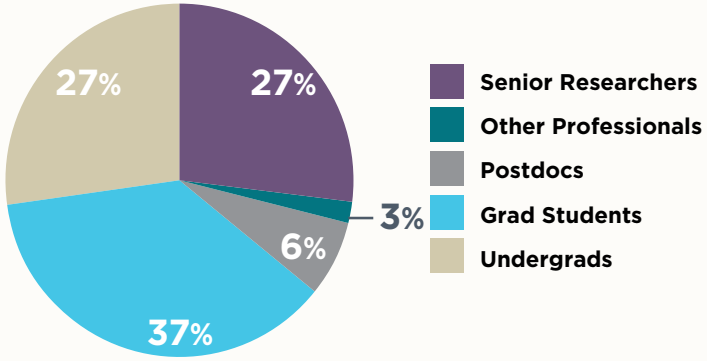


Credit: Marc Hillmyer and Laura Siefert, Center for Sustainable Polymers at the University of Minnesota

Mixing and Recycling Plastics: Just 2% of the 78 million tons of plastic used annually for packaging is recycled and reused. The one-time use of plastic packaging results in an $80-120 billion loss of materials. The team at CHE's Center for Sustainable Polymers is exploring new catalysts and additives, with the long term goal of making plastics recycling both effective and economical. They have developed a new class of mechanically tough polymer blends from recycled polyethylene and polypropylene. On their own, these two polymers would not mix, but an additive developed by CSP researchers helps these two different materials work together.

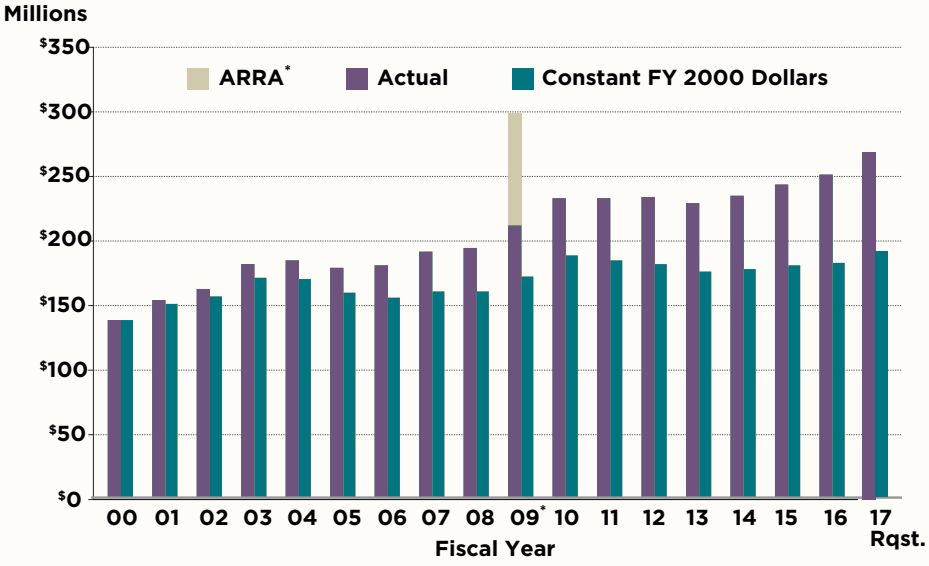
CHE Grant Personnel FY 2016

Distribution of people supported by CHE.



CHE Research and Related Activities Funding

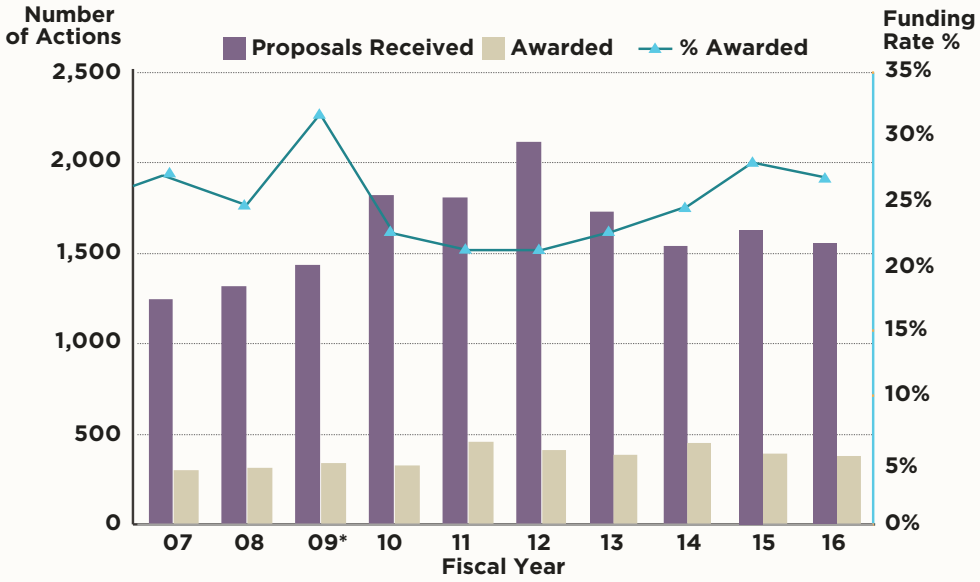
Constant dollars show the purchasing power of the CHE budget.



* ARRA – American Recovery and Reinvestment Act of FY 2009. Rqst. = Request.
Data provided from NSF Budget Requests to Congress, www.nsf.gov/about/budget

CHE Funding Rates and Number of Actions

Graph shows number of proposals submitted and awarded Research Grants (as defined by NSF) and resultant funding rates. Funding rate is defined as the percentage of new or renewal proposals awarded funding.



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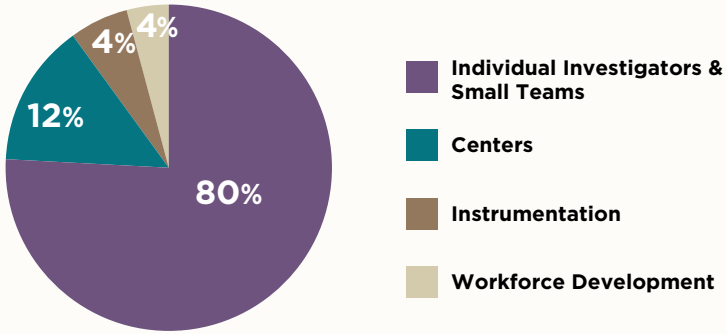
Note: The funding reflects the average for CHE and may not represent funding rates in individual programs

CHE Modes of Support FY 2016



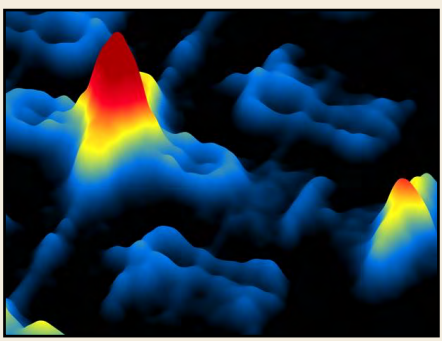
MISSION

The mission of the Division of Materials Research is to discover new knowledge about the behavior of matter and materials phenomena, to address fundamental materials questions that often transcend traditional scientific and engineering disciplines and may lead to new technologies, to prepare the next generation of materials researchers, to develop and support the instruments and facilities that are crucial to advance the field, and to share the excitement and significance of materials science with the general public.

DMR supports experimental and theoretical research, and their interplay with each other and with data, over a broad range of materials research domains. These include condensed matter and materials physics, solid state and materials chemistry, electronic and photonic materials, metals and metallic nano-structures, polymers, ceramics, and biomaterials. Funding modes range from awards to individual investigators, small groups, and centers to support for instrumentation and major facilities.

WORKFORCE DEVELOPMENT AND BROADENING PARTICIPATION

DMR strives to broaden the participation of women and underrepresented minority groups in science and engineering at all academic levels. One outcome of this vision is the Partnerships for Research and Education in Materials (PREM) program, which develops and supports long-term partnerships between academic institutions serving underrepresented groups and DMR centers and facilities, such as Materials Science and Engineering Centers (MRSECs). PREM was started in 2004 and currently supports 12 awards.



Credit: H. Inoue, A. Gyenis, Z. Wang, J. Li, S. Oh, S. Jiang, N. Ni, A. Bernevig & A. Yazdani, Princeton University

Quasiparticle interference of the Fermi arcs and surface-bulk connectivity of a Weyl semimetal: This is a three-dimensional image using scanning tunneling electron microscopy (STM) of electrons on the surface of a Weyl semimetal, a kind of crystal with unusual conducting and insulating properties. Weyl semimetals are newly discovered topological electronic materials in which surface electrons (Fermi arcs) are topologically connected with those of the bulk. In a clean Weyl semimetal, electrons can transverse the bulk through the special momentum states, called Weyl points, moving between opposing surfaces. Yazdani and Bernevig have found experimental evidence for this exotic behavior of Weyl semimetals by studying the interference of electrons on the surface of the Weyl semimetal TaAs. They find that the interference patterns measured with STM can only be understood if they take into account the surface-bulk connectivity through the Weyl nodes.

Contact Information

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PROGRAMS IN MATERIALS RESEARCH

PROGRAMS FOR INDIVIDUAL INVESTIGATORS AND GROUPS

- Biomaterials
- Ceramics
- Condensed Matter and Materials Theory
- Condensed Matter Physics
- Electronic and Photonic Materials
- Metallic Materials and Nanostructures
- Polymers
- Solid State and Materials Chemistry

CROSSCUTTING DMR PROGRAMS

Material Research Science and Engineering Centers (MRSECs)

MRSECs address fundamental materials research whose scope and complexity require the scale and interdisciplinarity provided by a center. In addition, MRSECs promote active collaboration between universities and other sectors, such as industry, and through the Materials Research Facilities Network (MRFN) support materials research infrastructure across the United States. The MRSEC program currently supports approximately 20 centers. For more information, visit www.mrsec.org.

NATIONAL FACILITIES

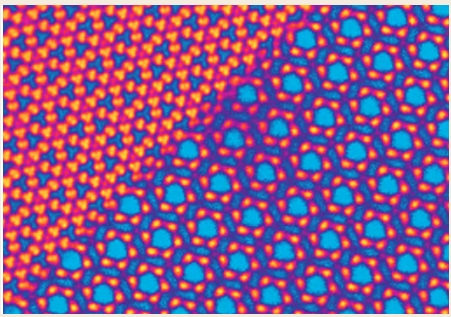
DMR is the steward of the Cornell High Energy Synchrotron Source (CHESS) and the National High Magnetic Field Laboratory (NHMFL). In addition, DMR supports the Center for High Resolution Neutron Scattering (CHRNS) at NIST and the National Nanotechnology Infrastructure Network (NNIN). New to DMR are the Materials Innovation Platforms (MIPs), user facilities dedicated to providing access to synthesis capabilities.

DESIGNING MATERIALS TO REVOLUTIONIZE AND ENGINEER OUR FUTURE (DMREF)

DMR leads in the DMREF initiative, which is the primary program by which NSF participates in the Materials Genome Initiative (MGI) for Global Competitiveness. DMREF encourages proposals that involve a collaborative and iterative process integrating experimental, theoretical, and data-driven efforts to achieve more rapid materials discovery, development, and deployment.

RESEARCH EXPERIENCE FOR UNDERGRADUATES (REU) AND TEACHERS (RET)

DMR supports REU sites that focus on research in materials science and related areas, including condensed matter physics, materials chemistry and physics, and materials engineering. REU projects involve students in meaningful ways in ongoing research or in projects specifically designed for the REU program. Most DMR-supported MRSECs and National Facilities offer REU and RET opportunities each summer.

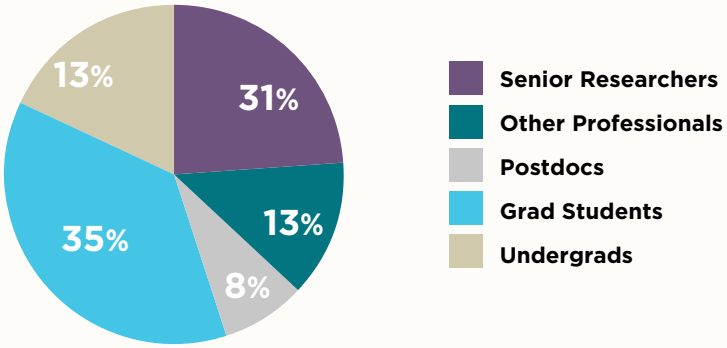


Credit: James M. LeBeau, North Carolina State University

Atomic resolution electron microscopy as art: "Phases of Silicon Nitride:" This piece highlights the importance of controlling processing conditions to determine structure and properties. In this example, the silicon nitride whose pattern is shown in the upper left is much harder than the silicon nitride whose pattern is shown in the lower right.

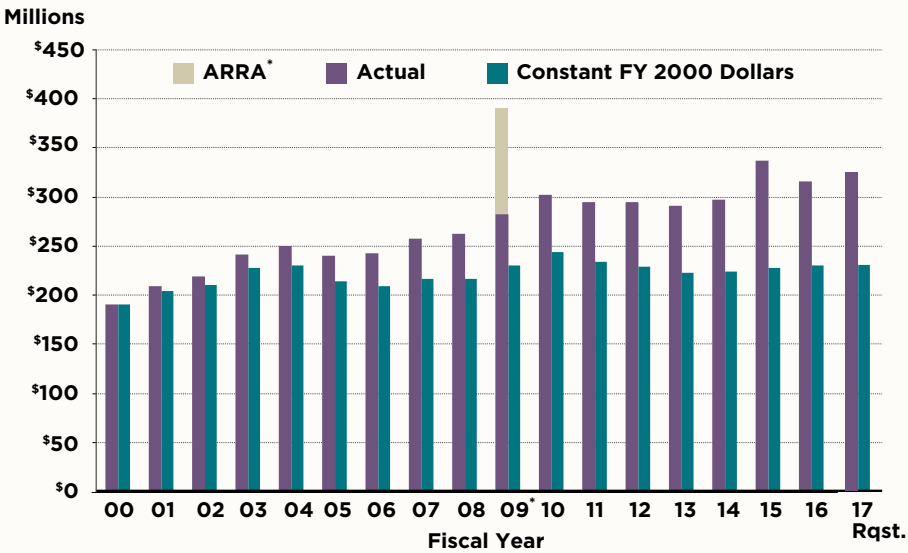
DMR Grant Personnel FY 2016

Distribution of people supported by DMR.



DMR Research and Related Activities Funding

Constant dollars show the purchasing power of the DMR budget.



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DMR Funding Rates and Number of Actions

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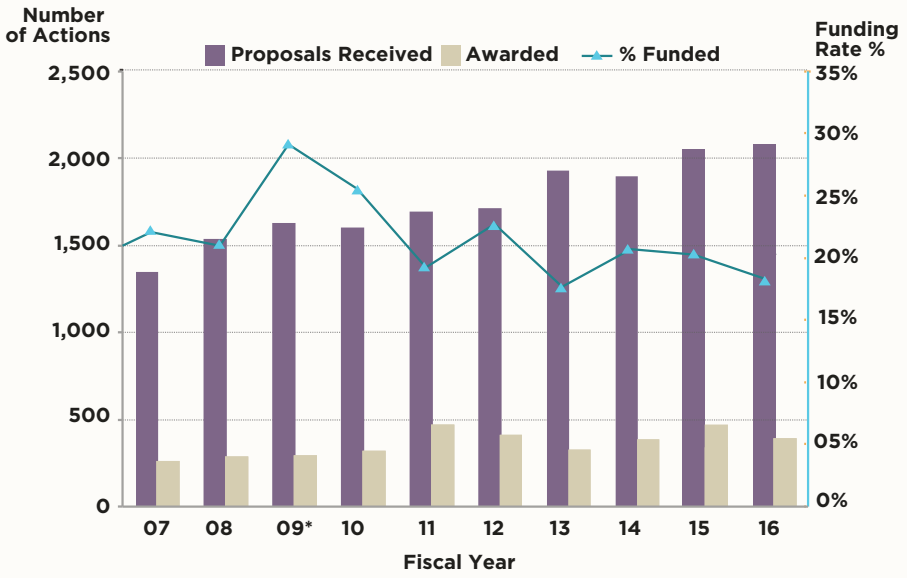
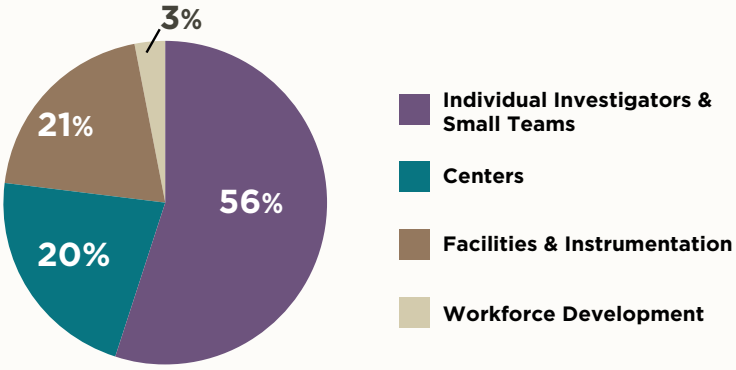


* FY 2009 funding rate includes awards made with ARRA funds.
Note: The funding reflects the average for DMR and may not represent funding rates in individual programs

DMR Modes of Support FY 2016



DIVISION OF MATHEMATICAL SCIENCES (DMS)

MISSION

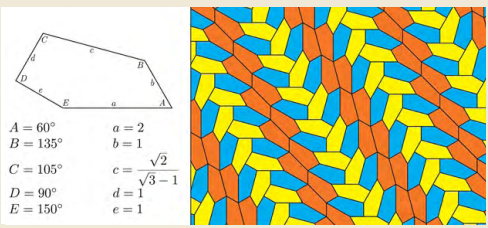
The mission of the Division of Mathematical Sciences is to support research at the frontiers of discovery in mathematical sciences and to support training of the next generation of mathematical sciences researchers. DMS is responsible for programs with a total annual budget of over $230 million in Fiscal Year 2016. These programs support research and training that expand the knowledge base of the mathematical sciences through awards to individual investigators and small groups, workforce training grants, and a portfolio of national mathematical sciences research institutes.

DISCOVERY, CONNECTIONS, COMMUNITY

The influence of mathematical sciences on our daily lives is fundamental and pervasive. For example, every secure commercial transaction on the internet is an application of research in number theory and algebraic geometry. Additionally, improvements in weather prediction, search engines, and industrial design processes rest on advances in algorithms and computational mathematics. DMS invests in discovery in mathematics and statistics; promotes interdisciplinary connections across fields of science, engineering, and technology; and cultivates a diverse and capable community of researchers, students, and professionals. The division's top investment priorities – discovery, connections, and community – are essential components of the innovation engine that drives the Nation's economy in the 21st century.

NEW INITIATIVES

DMS continues to develop interdisciplinary activities that reflect national priorities. Successful multi-agency programs such as the Joint DMS & National Institute of General Medical Sciences Activity in Mathematical Biology and Algorithms for Threat Detection are continuing, and newer activities such as the Transdisciplinary Research in Principles of Data Science and the Joint NSF/NIH Initiative on Quantitative Approaches to Biomedical Big Data are attracting broad interest from the mathematical sciences community. The DMS Workforce Program in the Mathematical Sciences offers funding opportunities, including the Research Training Groups in the Mathematical Sciences and the Mathematical Sciences Graduate Internship programs, that support efforts to increase the number of well-prepared students who pursue careers in the mathematical sciences and in other disciplines. NSF-wide programs in Critical Techniques, Technologies and Methodologies for Advancing Foundations and Applications of Big Data Sciences and Engineering; Secure and Trustworthy Cyberspace; and Materials Genome Initiative are also providing opportunities for engagement of the mathematical sciences community.



Credit: Casey Mann, Jennifer McLoud-Mann, and David Von Derau, Division of Engineering and Mathematics, University of Washington Bothell

Tiling a plane by pentagons: The mathematical theory of tiling has applications in crystallography, self-assembly, art and design, materials science, biology, and computer graphics. Classifying the convex pentagons that admit tilings of the plane is a long-standing unsolved problem. Supported by a REU Site award, Casey Mann, Jennifer McLoud-Mann, and David Von Derau, an undergraduate student at the University of Washington Bothell, recently discovered a new type of pentagon that can be used to tile a plane.

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PROGRAMS IN MATHEMATICAL SCIENCES

CORE PROGRAMS

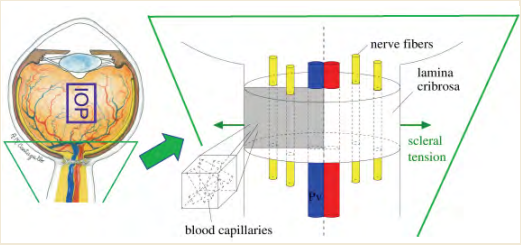
- Algebra and Number Theory
- Analysis
- Applied Mathematics
- Combinatorics
- Computational Mathematics
- Foundations
- Geometric Analysis
- Mathematical Biology
- Probability
- Statistics
- Topology

SPECIAL DMS PROGRAMS

- Mathematical Sciences Innovation Incubator
- Computational and Data-Enabled Science and Engineering in Mathematical and Statistical Sciences
- Focused Research Groups in the Mathematical Sciences
- Mathematical Sciences Infrastructure Program
- Joint DMS/NIGMS Initiative in Mathematical Biology
- Joint NSF/NIH Initiative on Quantitative Approaches to Biomedical Big Data
- Algorithms for Threat Detection
- Algorithms for Modern Power Systems
- Workforce Program in the Mathematical Sciences

The Mathematical Sciences Research Institutes program supports a portfolio of projects that advances research in the mathematical sciences, increases the impact of the mathematical sciences in other disciplines, enables the mathematical sciences to respond to national needs, and expands the talent base engaged in mathematical and statistical research in the United States.

The Mathematical Sciences Graduate Internship program, managed by the Oak Ridge Institute for Science and Education (ORISE) and supported by DMS, aims to provide opportunities to enrich the training of graduate doctoral students in the mathematical sciences by introducing them to interesting applications of mathematical or statistical theories outside of academia. The internships are aimed at students who are interested in understanding the application of advanced mathematical and statistical techniques to “real world” problems, regardless of whether they plan to pursue an academic or nonacademic career.

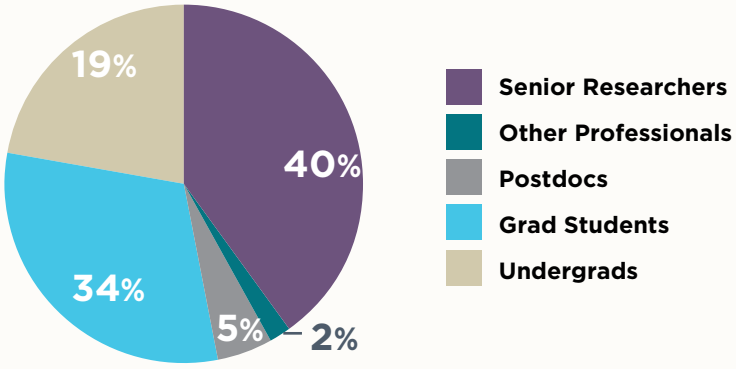


Credit: Daniele Prada, Istituto di Matematica Applicata e Tecnologie Informatiche “Enrico Magenes,” Consiglio Nazionale delle Ricerche, Pavia, Italy (right) and Alessandra Maria Cantagallo, Milano, Italy (left)

Control and sensitivity analysis for fluid-elasticity interactions and fluid-solid mixtures: In a project supported by a CAREER award, Lorena Bociu (North Carolina State University) and her international collaborators model the biomechanics in the lamina cribrosa, a structure in the eye, by a system of partial differential equations. This allows them to better understand the cause and progression of glaucoma and to find new ways to prevent or treat the disease. Elevated intraocular pressure (IOP) is the main modifiable risk factor in glaucoma patients.

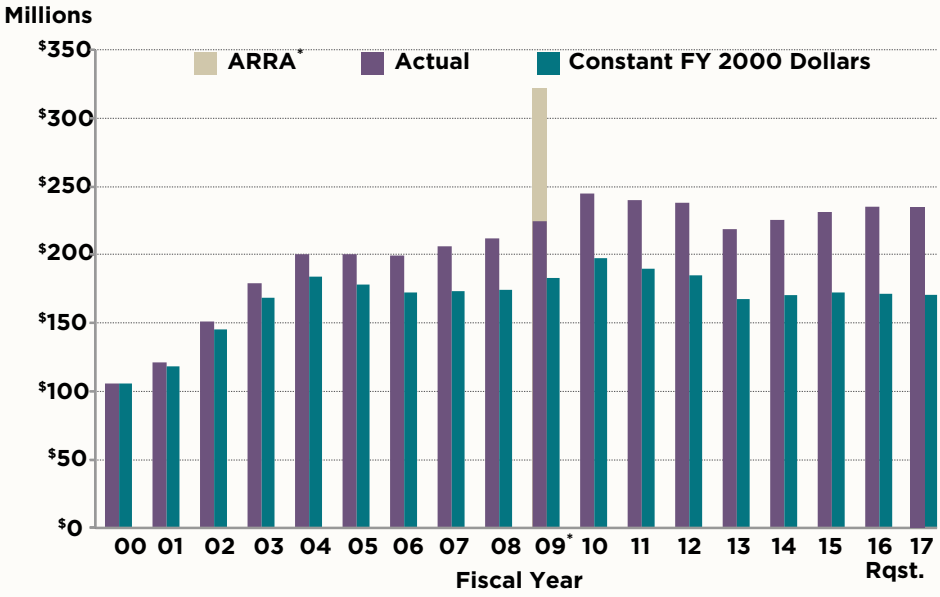
DMS Grant Personnel FY 2016

Distribution of people supported by DMS.



DMS Research and Related Activities Funding

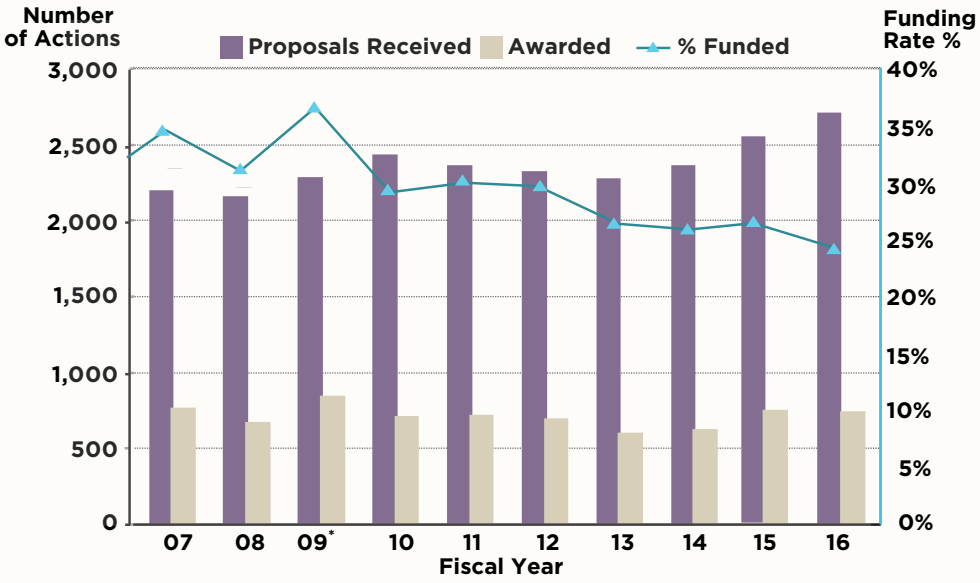
Constant dollars show the purchasing power of the DMS budget.



* ARRA – American Recovery and Reinvestment Act of FY 2009. Rqst. = Request.
Data provided from NSF Budget Requests to Congress, www.nsf.gov/about/budget

DMS Funding Rates and Number of Actions

Graph shows number of proposals submitted and awarded Research Grants (as defined by NSF) and resultant funding rates. Funding rate is defined as the percentage of new or renewal proposals awarded funding.



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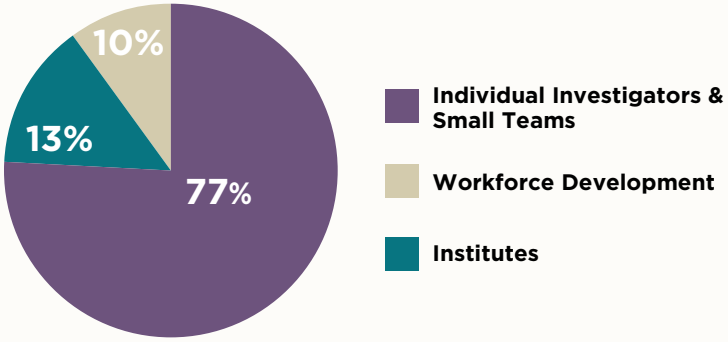
Note: The funding reflects the average for DMS and may not represent funding rates in individual programs

DMS Modes of Support FY 2016



DIVISION OF PHYSICS (PHY)

MISSION

The mission of the Division of Physics is to support fundamental research across the intellectual frontiers of physics; to support research that has broader impacts on other fields of science and on the health, economic strength, and defense of society; to share the excitement of science with the public through integration of research and education; and to maintain the intellectual capital essential for future advances in physics.

Physics research probes the properties of matter at its most fundamental level, the individual and collective interactions between particles, and the organization of constituents and symmetry principles that lead to the rich structure and phenomena that we observe in the world around us. Physics seeks a deep understanding of processes that led to the formation of the cosmos, to the structure of matter at the very shortest distance scales where quantum effects dominate, and to the structure and dynamics of atomic and molecular systems that shape and control the everyday world of chemistry and biological systems.

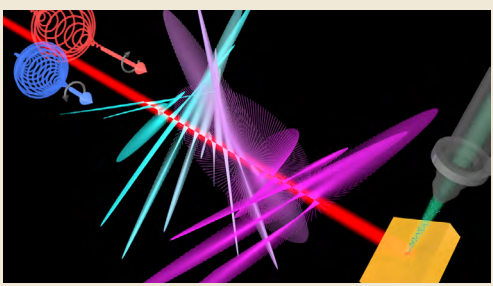
WORKFORCE DEVELOPMENT AND BROADENING PARTICIPATION

PHY strongly supports workforce development and broadening participation at all levels. This includes outreach efforts in large facilities and centers, a variety of opportunities for undergraduates through the Research Experiences for Undergraduates (REU) program, and individual investigator awards. Students of all backgrounds involved in these projects gain skills and knowledge to become members of the nationally critical, technology-centered workforce.

PROGRAMS IN PHYSICS

PROGRAMS FOR INDIVIDUAL INVESTIGATORS AND GROUPS

- Accelerator Science
- Atomic, Molecular and Optical Physics
- Plasma Physics
- Elementary Particle Physics, Astrophysics, and Cosmology



Credit: Cong Chen from the Kapteyn-Murnane group and Steve Burrows, JILA

Reconstructing a light field: By simultaneously illuminating a copper surface with circularly polarized extreme ultraviolet (EUV) light and an infrared laser beam that is perfectly synchronized with the EUV light, the Kapteyn-Murnane group was able to reconstruct the most complex light field to date. In these circularly polarized EUV bursts, the electric field oscillates and the polarization changes on attosecond timescales.

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- Gravitational Physics
- Nuclear Physics and Nuclear Astrophysics
- Particle Astrophysics
- Physics of Living Systems
- Quantum Information Science

CROSSCUTTING PHYSICS PROGRAMS

- Physics Frontiers Centers
- National Facilities
  - › National Supercomputing Cyclotron Laboratory (NSCL)
  - › Laser Interferometer Gravitational Wave Observatory (LIGO)
  - › Large Hadron Collider (LHC), a joint NSF-DOE-CERN project
  - › IceCube Neutrino Observatory
- Midscale Instrumentation
- Integrative Activities in Physics
- Computational Physics
- Research Experience for Undergraduates (REU) and Teachers (RET)

THE PHYSICS FRONTIERS CENTERS

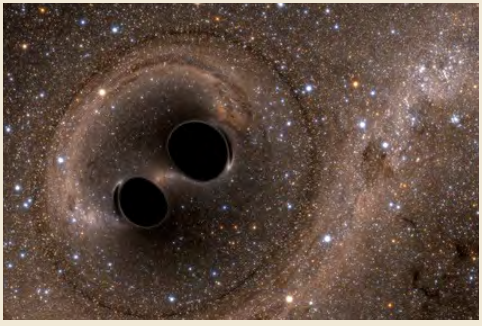
The Physics Frontiers Centers (PFC) program advances the intellectual frontiers of physics by supporting university-based centers and institutes where the collective efforts of a larger group can enable transformational research. Each PFC has a strong emphasis on educating students and postdoctoral researchers and outreach to both the scientific community and general population.

The PFC program currently supports activities in many subfields of physics; these include theoretical and experimental research in: Atomic, Molecular, and Optics Physics; Nuclear Astrophysics, Cosmology, Biophysics, Gravitational Physics, Particle Astrophysics, Particle Physics and Quantum Information Science. Partnerships with other NSF divisions allow for support of interdisciplinary activities in related and emerging areas.

PHYSICS AND THE GLOBAL COMMUNITY

PHY participates in numerous international efforts, including large scale facilities such as the LIGO, LHC, and IceCube facilities, and large astrophysics experiments such as HAWC and the Pierre Auger Observatory.

Additionally, PHY participates directly in distributed shared cyberinfrastructure, both nationally and internationally, which provides opportunistic computing and storage resources for large NSF-supported international projects.

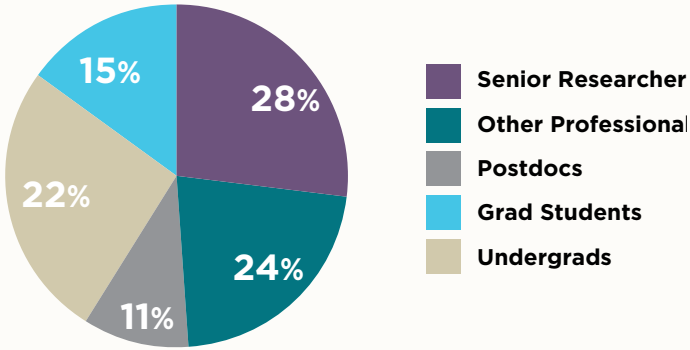


Credit: Geoffrey Lovelace, the Simulating eXtreme Spacetimes (SXS) Collaboration

The merger of two black holes: Solutions of equations from Albert Einstein's general theory of relativity illustrating the merger of two black holes, each roughly 30 times the mass of the sun, with one slightly larger than the other. LIGO observed such a merger, which took place 1.3 billion years ago, on September 14, 2015.

PHY Grant Personnel FY 2016

Distribution of people supported by PHY.



PHY Research and Related Activities Funding

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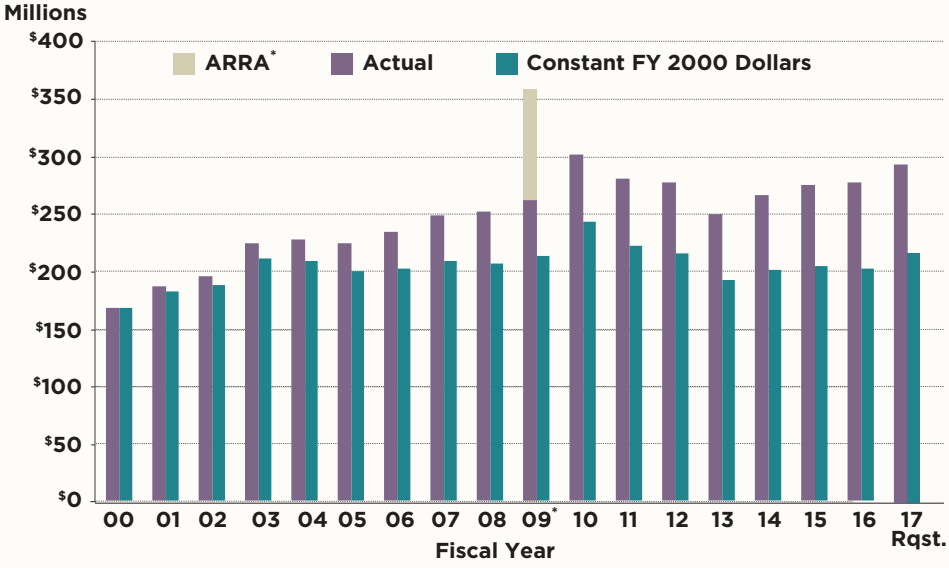

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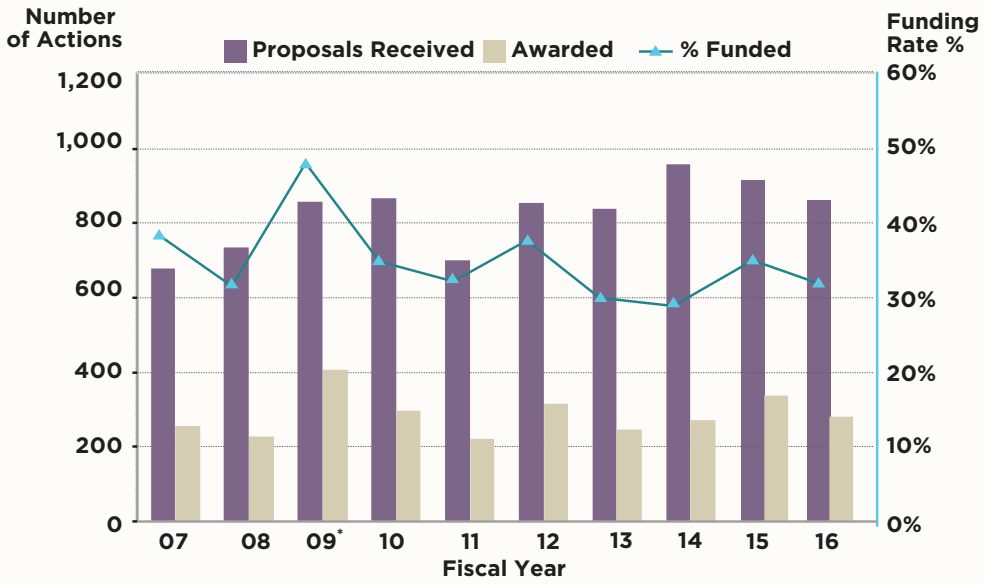

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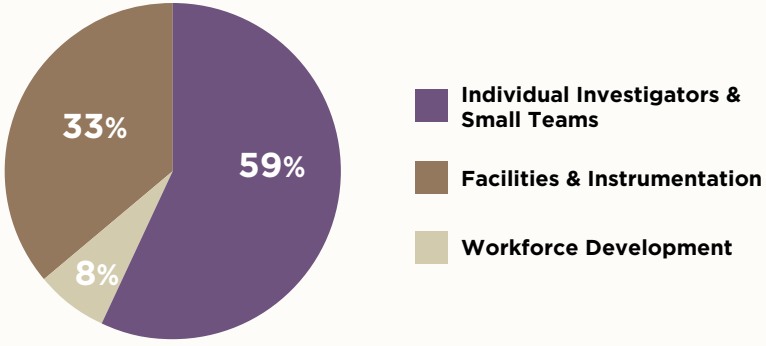
PHY Modes of Support FY 2016



DIRECTORATE FOR MATHEMATICAL & PHYSICAL SCIENCES

Proposal Review: MPS maximizes the quality of the proposals it supports through a competitive, merit-based review process. In FY 2016, more than 90 percent of research funds supported externally reviewed projects.

Committee of Visitors (COV): MPS convenes Committees of Visitors, composed of qualified external evaluators, to review each division periodically. These experts assess the integrity and efficiency of the processes for proposal review. COV reports and relevant directorate responses are available at http://www.nsf.gov/od/iia/activities/cov/covs.jsp.

MPS Advisory Committee (MPSAC): The Mathematical and Physical Sciences Advisory Committee advises MPS on issues such as the mission, programs, and goals that can best serve the scientific community; priority investment areas in MPS-supported research; and promoting workforce development in the mathematical and physical sciences. Minutes from MPSAC meetings are available at http://www.nsf.gov/mps/advisory.jsp.

Office of Multidisciplinary Activities (OMA)

OMA seeds crosscutting research in areas of current or potential future strategic emphasis for MPS as well as areas that might develop into strategic importance; facilities; partnerships with other agencies, national laboratories, industries, state and local governments, and international organizations; and supports innovative experiments in developing the workforce and broadening participation.

OMA does not accept external proposals; rather it encourages submission from MPS divisions of initiatives and projects that are multi-investigator, multi-disciplinary, and strategic to MPS, as well as innovative projects that contribute to a diverse, technical workforce.

The purpose of OMA investments is to initiate, but not sustain indefinitely, these activities.

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Ms. Tamara Savage
Science Assistant

Ms. Vanessa Simon
Program and Management Analyst

Mr. Christopher Coox
Program Analyst

Ms. Denise Zelaya
Program Assistant (Pathways Student)

Mr. Ryan Bael
IT Specialist

Ms. Kim Elliot
IT Specialist

Mr. Paul Spyropoulos
IT Specialist

MPSAC Membership List

TERM EXPIRES 9/30/2018

Susanne Brenner
Louisiana State University

Robert Bryant
Duke University

Lynne Hillenbrand
California Institute of Technology

Melanie Sanford
University of Michigan

William Zajc
Columbia University

TERM EXPIRES 9/30/2019

David Awschalom
University of Chicago

Philip Bucksbaum
Stanford University

Miguel Garcia-Garibay
University of California, Los Angeles

Catherine Hunt
University of Virginia

Jennifer Lewis
Harvard University

Andrew Millis
Columbia University/Simons Foundation

Catherine Pilachowski (Chair)
Indiana University

DIRECTORATE FOR

MATHEMATICAL & PHYSICAL SCIENCES

DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES
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DIVISION OF CHEMISTRY (CHE)
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DIVISION OF MATERIALS RESEARCH (DMR)
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DIVISION OF MATHEMATICAL SCIENCES (DMS)
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DIVISION OF PHYSICS (PHY)
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