MATHEMATICAL AND PHYSICAL SCIENCES $1,402,670,000

The FY 2009 Budget Request for the Mathematical and Physical Sciences (MPS) Directorate is $1.40 billion, an increase of $235.36 million, or 20.2 percent, over the FY 2008 Estimate of $1.17 billion.

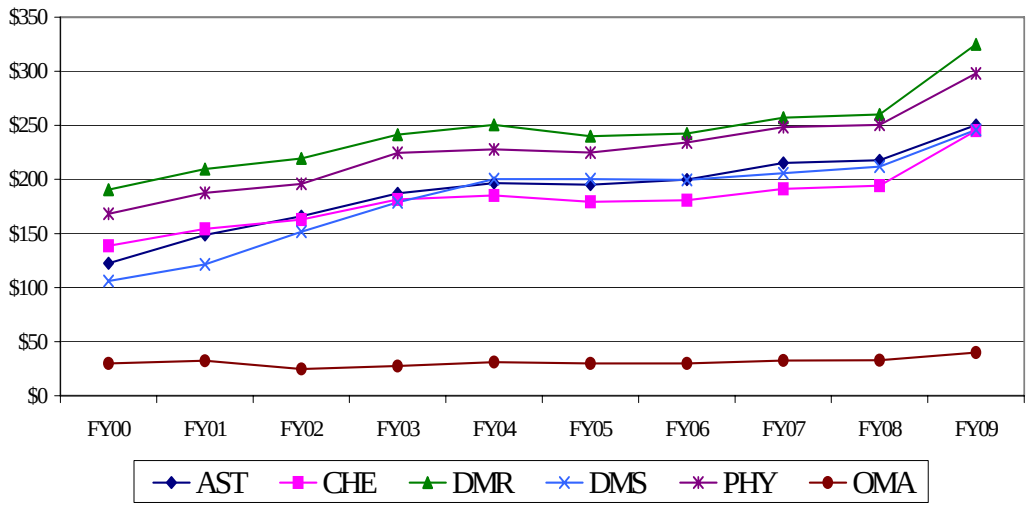
Mathematical and Physical Sciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Astronomical Sciences	$215.39	$217.86	$250.01	$32.15	14.8%
Chemistry	191.22	194.22	244.67	50.45	26.0%
Materials Research	257.27	260.22	324.59	64.37	24.7%
Mathematical Sciences	205.74	211.79	245.70	33.91	16.0%
Physics	248.47	250.52	297.70	47.18	18.8%
Multidisciplinary Activities	32.64	32.70	40.00	7.30	22.3%
Total, MPS	$1,150.73	$1,167.31	$1,402.67	$235.36	20.2%

Totals may not add due to rounding.

The Mathematical and Physical Sciences Directorate (MPS) supports a broad portfolio of investments in fundamental research, facilities, and instruments that enable discovery and development, and through integrated education and research activities that contribute to the development of the science and engineering workforce. The portfolio includes MPS participation in NSF-wide and interagency research and education, and emphasizes discovery, innovation, and learning aligned with the overall goals of the American Competitiveness Initiative (ACI), the America COMPETES Act (ACA), and NSF's mission and vision.

MPS Subactivity Funding
(Dollars in Millions)



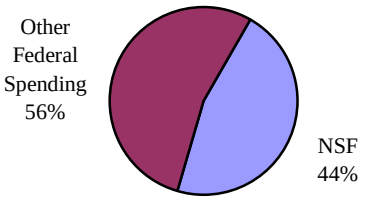
RELEVANCE

Mathematical and physical sciences play a major role in America's overall competitiveness. MPS scientists and mathematicians provide the basic knowledge required for advances in engineering and health-related disciplines, and supply a broad basis for technological innovation in industry, defense, homeland security and national security. They investigate the fundamental properties of matter, determine the complex laws governing chemical reactivity, and develop the mathematical and statistical tools needed to formulate and solve such problems. America's economic strength depends on her ability to generate and harness the latest in scientific and technological developments and to apply these developments to real-world applications. MPS-supported research sparks the innovation crucial to maintaining U.S. competitiveness and generating new industries, focusing on fundamental discoveries to produce valuable and marketable technologies.

MPS-supported research also advances the frontiers of knowledge, excites the imagination, and can lead to new basic concepts. It involves cutting-edge basic research ranging from the structure and evolution of the universe to the fundamental particles and processes of matter; from the behavior and control of molecules at the nanoscale to the complexity of their chemical interactions in materials and life processes; from developing new mathematical structures and theories to transforming them into models of natural systems that connect to computation, experimentation, and observation. It spans the spatial scales from quarks to the cosmos and time scales from the incredibly short to the unimaginably long. It brings the perspective and methodologies of the mathematical and physical sciences to exploring complex biological systems, to human and social dynamics, and to sustainability of energy and the environment.

The development of new ideas and new tools in the mathematical and physical sciences depends strongly on the support provided by the MPS Directorate. MPS provides about 44 percent of federal funding for basic research at academic institutions in the mathematical and physical sciences (with percentages ranging from 34 percent for physics to about 60 percent for mathematical sciences). Much of the Nation's progress at the cutting edge of astronomical sciences, physics, and materials research relies on MPS-supported facilities, including ground-based telescopes, particle accelerators and colliders, and materials laboratories. In addition, MPS collaborates with other disciplines within NSF and partners with other agencies, the private sector, and other nations.

Federal Support of Basic Research in Math and Physical Sciences at Academic Institutions



Both the ACI and ACA place high priority on enhancing the strength of the U.S. technical and instructional workforce. MPS integrates its investments in research and infrastructure with investments aiming to improve the quality and diversity of the U.S. science and engineering workforce and to enhance the public's knowledge of MPS fields by linking both formal and informal education and training programs to forefront research activities in the U.S. and other countries.

A diverse, internationally competitive, and globally-engaged workforce of scientists, engineers, and well-prepared citizens is required for global competitiveness. Through both direct support and its many centers and institutes, MPS continues to make investments in all phases of education – from K-12 through undergraduate, graduate, postgraduate, and continuing education, as well as outreach activities. In FY 2009, MPS will include a concentrated effort, the American Competitiveness Initiative Fellowships, to link undergraduate and graduate education, postdoctoral research, and early faculty experience in areas of particular relevance to ACI and ACA. MPS will continue to emphasize activities connecting

undergraduate education with research, taking advantage of the larger numbers and greater diversity in this pool. MPS will also support partnerships aimed at enhanced teacher preparation, broadened graduate and postdoctoral opportunities, and more informed teaching and learning strategies. The MPS strategy uses the excitement of research at the frontier to attract the next generation of scientists and engineers.

In FY 2009, Division allocations reflect the strong emphasis MPS is placing on investments and activities that most directly tie to ACI and ACA.

Summary of Major Changes by Division ***(Dollars in Millions)***

FY 2008 Estimate, MPS…….....……..…….....$1,167.31

Astronomical Sciences Division (AST) +$32.15

Increased funding for research grants and instrumentation, with emphasis on addressing scientific priorities articulated in the National Research Council's "Astronomy and Astrophysics for the New Millennium"; cyberscience and cyberinfrastructure, including implementation of a national virtual observatory in partnership with NASA and the development of tools to handle large data sets; Gemini Observatory operations and instrumentation and continuing ramp-up of operations for the Atacama Large Millimeter Array (ALMA); and strategic public-private partnerships, including design for the Giant Segmented Mirror Telescope.

Chemistry Division (CHE) +$50.45

Increased funding for establishing Centers for Chemical Innovation to address fundamental research grand challenges in chemistry and ACI and ACA goals; create an ACI fellows program to bridge career transitions on the way to becoming science faculty and to promote innovation and diversity in chemistry; support the NSF-wide activity Science and Engineering Beyond Moore's Law[1] as well as Quantum Information processes for future computational paradigms and technology; promote discovery at the interface with the life sciences with special emphasis on "intelligent" adaptive self-assembly and designed emergent properties and functionality; investment in next generation cyber-enabled chemical imaging tools and new collaborations that will lead to transformative approaches to theoretically model complex molecular structures.

Division of Materials Research (DMR) +$64.37

Increased funding for fundamental research addressing nanoscience and engineering and the NSF-wide activity Science and Engineering Beyond Moore's Law that encompasses novel materials and phenomena required for the future development of entirely new computational and communications technologies; quantum information science; the interface between the physical and life sciences including biomaterials and adaptive systems technology. Also, increased support for the materials aspects of computational discovery and innovation; broadening participation in materials research through research and education partnerships; expanded support for Materials Research Science and Engineering Centers; the creation of transformative research groups; support for ACI Fellows; maintaining support for world-class user facilities while enabling the development of future instrumentation; and continuing strong support for international collaborations and partnerships in materials research.

[1] Moore's Law: In 1965 the co-founder of Intel, Gordon E. Moore, predicted that computing power, based on semiconductor integrated circuits, would double every 18 to 24 months, a prediction that has had staying power for over 40 years.

Division of Mathematical Sciences (DMS) +$33.91

In addition to strengthening research in the core disciplines, increased funding for mathematical and statistical sciences supports activities that (1) strengthen the development of underlying concepts and enable effective partnering with other science and engineering disciplines; (2) promote cyber-enabled discovery and innovation through modeling, analysis, algorithms, and simulation that provide new ways of obtaining insight into the nature of complex phenomena; (3) confront the challenges of science and engineering beyond Moore's Law; (4) advance our understanding of algorithms for quantum information science; (5) explore the interface between the mathematical and biological sciences; (6) investigate the mathematical structure of adaptive systems technology; (7) create ACI fellows to provide more undergraduates with interdisciplinary, discovery-based research experiences; and (8) support more early career researchers in the mathematical sciences.

Physics (PHY) +$47.18

Increased funding to advance the frontiers of physics, with emphasis on atomic, molecular, and optical physics, especially science beyond Moore's Law; physics at the information frontier, especially quantum information science, cyberinfrastructure and cyber-enabled discovery; the physics of living systems; and the interagency Physics of the Universe activities with the Division of Astronomical Sciences, Department of Energy, and NASA; expanded resources for the design and development of next-generation instrumentation and facilities, especially the Deep Underground Science and Engineering Laboratory (DUSEL); and education and outreach activities, including broadening participation in the research community and a mid-career ACI Fellows program. Support for operations for IceCube and the National Superconducting Cyclotron Lab (NSCL) will be enhanced, while funding for the Cornell Electron Storage Ring (CESR) will be reduced as part of the phase-out plan.

Office of Multidisciplinary Activities (OMA) +$ 7.30

Increased funding for collaborative activities aimed at initiating innovative cross-disciplinary research and connecting fundamental ideas to innovative technologies, as well as broadening participation in and informing the public about MPS disciplines.

Subtotal, Changes +$235.36

FY 2009 Request, MPS…….…….$1,402.67

Summary of Major Changes in Directorate-wide Investments ***(Dollars in Millions)***

FY 2008 Estimate, MPS.....…….....…….…….....$1,167.31

Discovery +$185.68

Cyber-enabled Discovery and Innovation (CDI) (+$8.65 million).

Modeling, algorithms, software, and simulation are essential research components in all MPS disciplines, as are virtual computing networks accessing common databases and analytic tools. Examples include the synthesis and characterization of new molecular systems; the prediction and discovery of new materials and new states of matter; the creation, manipulation, and control of quantum mechanical states in solid and condensed states of matter; the development of mathematical structures to describe complex, multi-scale networks as typified by electrical power grids and the internet; and the creation of visualization and "mining" techniques for both

sparse and dense data. MPS will continue its collaborations with other directorates in NSF's high priority activities in CDI, creating synergy with related activities in Cyberinfrastructure and enhancing the government-wide Networking and Information Technology Research and Development effort.

Science and Engineering Beyond Moore's Law (+7.0 million)

MPS will lead the Foundation in Science and Engineering Beyond Moore's Law (SEBML), a multidisciplinary research investment with strong ties to economic competitiveness and potential for transformation. Tied to both nanotechnology and cyberinfrastructure, it builds on past NSF investments in these areas and energizes them with new directions and challenges. Activities in this area include research into new materials, devices, and processes that exploit the capability to create and manipulate specific quantum states and new algorithms that exploit hardware and architecture characteristics to deliver maximal total computing power, including those that exploit quantum interactions. MPS will work with the other Directorates in areas such as developing new connection architectures with new control principles, massive parallelism, and designed asynchronicity and indeterminacy and creating new software that allows the effective use of new devices.

Adaptive Systems Technology (+$3.49 million).

MPS will join partners across NSF in support of exploration of questions in Adaptive Systems Technology, such as how a signal from the external world can be represented in the brain, and mechanistic models to describe processes that involve signaling at every level from individual molecules to cells to circuits to systems. Activities will include building models and improving their analyses to enable the prediction of experiments and improve their theoretical underpinnings; understanding the behavior of physical and biological systems, often far from equilibrium, across a wide range of length and time scales; developing new instrumentation that enables new types of exploration; and creating synthetic biological systems that can mimic nature. Emphasis will be placed on information dynamics and networks; multi-scale phenomena and nonequilibrium systems; design of functional systems and devices inspired by brain sciences; and new instrumentation development for study of the brain. Activities in this area show great promise for innovation in an information and knowledge-based society. The research in this area will support the Administration's emphasis on Understanding Complex Biological Systems.

Disciplinary and Interdisciplinary Research (+$140.46 million).

MPS assigns high priority to providing strong support of individual investigators and small groups pursuing fundamental research across all MPS disciplines. Support for the core discovery mission (apart from the special investments immediately above) is paramount to meeting science opportunities in MPS disciplines, to maintaining a competitive workforce in these areas, and to enabling a vital interdisciplinary effort. Extraordinary research opportunities exist in all of the MPS sciences, as well as opportunities to connect with ACI, Administration, and NSF priorities. Within the context of disciplinary and interdisciplinary research, MPS emphasis areas interact with each other, with NSF and Administration priorities, and with the overall portfolio in synergistic fashion, reflecting commonalities in the underlying complex physical systems. In FY 2009, MPS will continue its research in areas such as Science and Engineering Beyond Moore's Law, Physical Sciences at the Nanoscale, Physics of the Universe, Mathematical Sciences, Complex Biological Systems, and Sustainability. Specific emphases for FY 2009 include:

- *MPS Life Science Interface (+$6.0 million).* Lessons from the biological world inform new directions for fundamental physical sciences discovery, solutions for important technological problems facing society, and synergistic advances in the life sciences. MPS has already made a strong investment in research that is at this interface of the mathematical and physical sciences and biology. For FY 2009 MPS will strongly support the Administration's focus on Understanding Complex Biological Systems by increasing funding for this research, developing a cohesive program across MPS and with the Directorate for Biological Sciences. The potential for meeting ACI objectives is extremely high as well, as the MPS emphasis on materials, processes, and devices creates the opportunity for fundamental research that translates quickly into marketable technology in areas such as pharmaceuticals, medical imaging, and various types of implants.

- *Quantum Information Sciences (QIS) (+$5.0 million).* The country that first achieves a viable technology in quantum information sciences will have both a considerable competitive and a strong national security advantage. If another nation should achieve such technology earlier than the U.S., potential exists for significant disruption to our national security. It is therefore important to draw the focus of the academic community into these critical areas. Specifically, MPS will concentrate on quantum computing and quantum communication using entangled states, novel theoretical and experimental research in the condensed matter sciences, and advanced understanding and implementation of algorithms for quantum information sciences.

- *ACI Fellows Program (+$4.0 million).* ACI and ACA call for increased training opportunities and support for young investigators. In FY 2009, MPS will include a concentrated effort to meet this goal, following on the small FY 2008 pilot program in this area. Our ACI Fellows program gives each Division the flexibility to emphasize a different part of this goal. Some of the programs will grant Fellowships intended to link undergraduate and graduate education, postdoctoral research, and early faculty experience in areas of particular relevance to national competitiveness. Others will emphasize broadening participation or increasing industrial experience at all academic levels. A crucial element of all Fellowships will be the connection between fundamental research and innovation. The program will also serve to encourage best practices in departmental culture.

- *Human and Social Dynamics (-$500,000).* The Human and Social Dynamics priority area ends in FY 2008 with activities absorbed into other ongoing programs.

CAREER (+$5.70 million).

The CAREER program remains the primary mechanism for jump-starting junior faculty toward independent careers in research and education, a key element of ACI. The increased funding in FY 2009 will fund at least ten to twelve additional CAREER grants.

Centers (+$20.38 million).

MPS will continue to put emphasis on its Centers program. Centers allow researchers to pursue the goals of the ACI through collaboration towards innovation in the MPS sciences.

- *Centers for Chemical Innovation (+$12.5 million).* The CCI Program was initiated as a pilot in 2004 (under the name *Chemical Bonding Centers*) with several ambitious goals: to support high risk, transformative science; to energize the chemistry research community to tackle grand challenges; and to creatively engage the public. The name change to *Centers for*

Chemical Innovation reflects the addition of innovation as a key feature of the scientific outcomes expected from these centers. The CCI Program awards funds in two phases: Phase I is a three-year grant to explore potentially transformative ideas and initiate partnerships, and Phase II is a five-year grant awarded to extremely promising Centers following competition at the end of their Phase I award. The increase in FY 2009 will allow MPS to start three new Phase I Centers in FY 2009 as well as initiate and expand funding for Centers successful in the FY 2008 Phase II competition.

- *Materials Research Science and Engineering Centers (+$8.0 million).* MRSECs address fundamental problems in materials and condensed matter science of scope and complexity requiring the advantages of scale and interdisciplinary interactions. These centers focus on interdisciplinary research at the interface between materials and biology, computational materials, quantum information science, and nanoscale materials. As underscored by a recent study of MRSECs by the National Academy of Sciences (NAS), the MRSECs support cutting edge, transformative science and engineering of the highest quality, emphasize workforce development through the integration of research, education, and diversity, and stimulate economic activity through active collaborations with industry, national laboratories, and international partners. Based on recommendations by the NAS study, plans are to increase the average center award size, to enhance the support for infrastructure, and to enhance the effectiveness of the national network of MRSECs. The increased funding will allow the full support of 2 - 3 new centers that were initiated with partial start up support as a result of the 2008 MRSEC competition. Emphasis for the new centers will be to continue the MRSEC trademark of high risk, transformative research. In addition, these funds will allow continued support for the newly established MRSEC based instrumentation and facility network. The network will allow cyber-enabled connections and service to non-MRSECs, including smaller institutions.

- *Nanoscale Science and Engineering Centers (+1.0 million).* NSECs support synergistic science and engineering research and education in emerging areas of nanoscale science and technology. This cross-Foundation program addresses a broad spectrum of research topics. NSF currently supports 17 NSECs. DMR co-funds 12 NSECs and has lead responsibility for three. Increased funding will allow additional co-funding for the new NSEC on the Environmental Implications of Nanotechnology (CEIN) and supplementary support for other NSECs at the interface between the physical and biological sciences.

- *Center for Research at the Interface of the Mathematical and Biological Sciences (+$200,000).* In collaboration with the Directorate for Biological Sciences, which will provide the majority of support at $1.80 million in FY 2009, MPS will contribute to this center to stimulate research and education at the interface of the mathematical and biological sciences.

- *Science and Technology Centers (-$1.32 million).* In FY 2009, MPS will phase out funding for its sunsetting STCs. This reduction will affect both the Center for Adaptive Optics in the Division of Astronomical Sciences and the Center for Environmentally Benign Processing in the Division of Chemistry.

Learning +$4.39

Creating a strong environment for learning is a centerpiece of the ACI investment. MPS will continue its focus on existing programs that reach different career levels, from undergraduates through early faculty positions. Discovery-based experiences for undergraduates will continue to be a major priority for MPS. Emphases include broadening participation through increased funding for awards that promote inclusion of women and underrepresented minorities either as principal investigators, students, or postdocs. Specific emphases for FY 2009 include:

- *Research Experience for Undergraduates (REU) (+$1.41 million).* Expansion of REU programs will focus on international research experiences to help develop a workforce that is both globally aware and competitive. A portion of the additional funding requested in FY 2009 will go directly for international REU sites in chemistry.

- *Mathematical Science Post-Doctoral Research Fellowships (MSPRF) (+$1.0 million).* The MSPRF program supports future leaders in the mathematical sciences by providing them with flexibility in the choice of and enabling them to participate in research environments that will have a maximal impact on their future scientific development. The increase in FY 2009 will be primarily used to raise the stipends for these postdoctoral fellowships to a more competitive level.

- *Undergraduate Research Collaboratives (+$840,000).* Underrepresented minorities often leave science before being impacted by the traditional undergraduate research opportunities (including REU programs) that tend to focus on students who have already committed to STEM majors. Undergraduate research at the earliest stages encourages expanded participation by these minorities. Additional models of support are needed that will engage large numbers of first and second year students at both two and four year colleges and that will eventually reach down to middle and high school teachers and students. This program is being piloted by the Division of Chemistry (CHE). Increases in FY 2009 will provide ongoing support for FY 2008 awards as well as new awards in FY 2009.

- *Other (+$1.14 million).* Increases totaling $1.14 million support the Research Experiences for Teachers program, Chemistry's Discovery Corps Fellowships, the Astronomy and Astrophysics Postdoctoral Fellowships, and Integrative Graduate Education and Research Traineeship (IGERT). MPS will provide a total of $8.88 million in FY 2009 for IGERT.

Research Infrastructure +$41.01

Investment in 'tools of science' – facilities and instruments that enable discovery and development – supports not only the science of the MPS disciplines, but also the explicit goals of ACI. MPS will increase support for new and emerging facilities and for instrumentation development, including design and development of future facilities, cyberinfrastructure, and mid-scale projects while downscaling facilities deemed to be of lower priority.

Division of Astronomical Sciences (+$13.25 million).

The increase in the research infrastructure investment for the Division of Astronomical Sciences (AST) is in line with the recommendations of the AST Senior Review.

- *Gemini (+2.0 million).* Increased funding will allow further development of next generation instrumentation, including construction of the Gemini Planet Imager, a camera designed to directly detect planets around nearby stars, and design studies for a wide field optical spectrometer that will collect data from thousands of objects simultaneously.

- *National Astronomy and Ionosphere Center (NAIC) (-$850,000).* Following the recommendation of the Senior Review, funding decreases to achieve a lower base operational level by FY 2010, by emphasizing survey work, modifying the operating mode, and limiting the observing time for astronomical observations.

- *National Optical Astronomy Observatory (NOAO) and National Solar Observatory (NSO) (+$3.28 million).* This increase, keeping pace with inflation, will support the second year of the facilities' response to Senior Review recommendations, which included modest reinvestment in infrastructure and reductions in lower priority programs. Emphasis continues at NOAO on public-private partnerships and development of the national system of astronomical resources through support of the Telescope System Instrumentation Program and other community programs.

- *National Radio Astronomy Observatory (NRAO) and the Atacama Large Millimeter Array (ALMA) (+$8.82 million).* Funding for the Atacama Large Millimeter Array continues to ramp up to enable operations and maintenance of a growing array of antennas and preparation for early science support.

Division of Materials Research (+$12.0 million).

- *National High Magnetic Field Laboratory (NHMFL) (+$5.0 million).* Increased funding will strengthen user support programs and in-house research, education, and training at all levels, including broadening participation, and to meet increased electricity costs.

- *Other MPS Facilities (+7.0 million).* The requested funds will support the technical research and development necessary for the next generation of light source facilities.

Division of Physics (-$3.56 million).

- *Cornell Electron Storage Ring (CESR) (-$5.21 million).* The reduction is targeted toward the close-out of the particle physics program based upon the CESR accelerator. Physicists at Cornell, building upon their technical and analytical expertise, are ramping up their participation in the research programs at the CERN Large Hadron Collider (LHC).

- *IceCube (+$650,000).* MPS shares maintenance and operations for IceCube with the Office of Polar Programs. Operations funding is ramping up toward the steady state as initial research activities are underway.

- *Laser Interferometer Gravitational Wave Observatory (LIGO) (-$1.0 million).* LIGO concluded its mission-defining scientific run (S5), in which a year's data was taken with all three interferometers operating in coincidence, in October 2007. LIGO's operations and maintenance projections and requests for FYs 2008 through 2012 are smaller than the spending for FY 2007, since some employees and resources will be diverted to the Advanced LIGO MREFC project, appropriated as a new start in the FY 2008 omnibus legislation. LIGO operations will, however, continue to analyze data taken during the current and earlier runs and will plan for and conduct future runs until the scheduled shutdown of the detectors

in FYs 2010-2011. Science runs planned to begin in 2009 will test technologies that will become part of Advanced LIGO; the detector sensitivity will be at least twice that during the current S5 run.

- *National Superconducting Cyclotron Laboratory (NSCL, MSU Cyclotron) (+$2.0 million).* FY 2009 support will enable near-optimal operations and research at this unique radioactive ion beam facility; this funding level is consistent with recommendations from an external 2006 science and operations review committee.

Division of Mathematical Sciences (-$670,000).

- *National Center for Atmospheric Research (NCAR) (-$670,000)*. This decrease is due to the expiration of earlier commitments to this Federal Funded Research and Development Center.

MPS-wide (+$19.99 million)

- *Research Resources* (+$19.99 million). MPS will make a focused investment across the directorate in FY 2009 for Research Resources, especially for mid-scale instrumentation ($7.35 million). Included in the increase for Research Resources is a one-time special allocation of $2.0 million to the Division of Astronomical Sciences for their implementation of Senior Review's recommendations, such as reinvestment in optical and infrared instrumentation for NOAO, and $2.3 million for a general boost to the core AST instrumentation program. An additional $2.34 million is requested for CHE for new investments in cyber-enabled chemistry, multi-user facilities, and instrument development for chemical imaging. DMR will use $4.0 million to support Instrumentation for Materials Research and an additional $500,000 will be used to conduct research underpinning the development of future user facilities.

Stewardship +$4.28

A number of activities are funded directly from NSF's programs to advance NSF's Stewardship goal. These include Intergovernmental Personnel Act appointments, NSF-wide studies and evaluations, and mission-related information technology investments. As is discussed further in the Stewardship chapter of this Request, in FY 2009 NSF has realigned IT investments to tie mission-related activities more directly to NSF's programs.

Subtotal, Changes +$235.36

FY 2009 Request, MPS…….…….$1,402.67

MPS Centers Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Centers for Analysis and Synthesis	-	-	$0.20	$0.20	N/A
Centers for Chemical Innovation	3.00	7.50	20.00	12.50	166.7%
Materials Centers	55.97	54.73	62.73	8.00	14.6%
Nanoscale Science and Engineering Centers	12.48	12.96	13.96	1.00	7.7%
Science and Technology Centers	20.02	18.60	17.28	-1.32	-7.1%
Total, MPS	**$91.47**	**$93.79**	**$114.17**	**$20.38**	**21.7%**

Totals may not add due to rounding.

MPS Facilities Funding
(Dollars in Millions)

Facilities	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Cornell Electron Storage Ring (CESR)	$14.71	$13.71	$8.50	-$5.21	-38.0%
GEMINI Observatory	20.00	20.00	22.00	2.00	10.0%
IceCube	0.25	1.50	2.15	0.65	43.3%
Large Hadron Collider (LHC)	18.00	18.00	18.00	-	-
Laser Interferometer Gravit. Wave Obs. (LIGO)	33.00	29.50	28.50	-1.00	-3.4%
NSCL (MSU Cyclotron)	18.50	18.50	20.50	2.00	10.8%
Nanofabrication (NNUN/NNIN)	2.86	2.80	2.80	-	-
Nat'l High Magnetic Field Laboratory (NHMFL)	26.55	26.50	31.50	5.00	18.9%
Nat'l Astronomy and Ionosphere Center (NAIC)	10.46	10.45	9.60	-0.85	-8.1%
Nat'l Center for Atmospheric Research (NCAR)	-	1.12	0.45	-0.67	-59.8%
Nat'l Optical Astronomy Observatories (NOAO) [1]	39.28	38.55	41.83	3.28	8.5%
Nat'l Radio Astronomy Observatory (NRAO)	47.04	44.52	49.79	5.27	11.8%
Atacama Large Millimeter Array (ALMA)	3.70	8.22	11.77	3.55	43.2%
Other MPS Facilities	12.57	12.47	19.47	7.00	56.1%
Total, MPS	**$246.92**	**$245.84**	**$266.86**	**$21.02**	**8.6%**

Totals may not add due to rounding.

[1]The NOAO total for FY 2009 includes funding for the Telescope System Instrumentation Program at $5.0 million, level with the FY 2008 Request.

NSF-WIDE INVESTMENTS

In FY 2009, the Directorate for Mathematical and Physical Sciences will support research and education efforts related to broad, Foundation-wide investments in a number of areas including the Administration's interagency R&D priorities.

MPS NSF-wide Investments
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Adaptive Systems Technology	-	-	$3.49	$3.49	N/A
Biocomplexity in the Environment	1.00	-	-	-	N/A
Climate Change Science Program	6.81	5.45	6.00	0.55	10.1%
Cyber-enabled Discovery and Innovation	8.78	10.40	19.05	8.65	83.2%
Cyberinfrastructure	61.21	64.56	71.06	6.50	10.1%
Human and Social Dynamics	0.50	0.50	-	-0.50	-100.0%
Mathematical Sciences	67.56	-	-	-	N/A
National Nanotechnology Initiative	169.48	169.48	178.07	8.59	5.1%
Networking and Information Technology R&D	73.70	70.89	73.72	2.83	4.0%
Science and Engineering Beyond Moore's Law	-	3.00	10.00	7.00	233.3%

Adaptive Systems Technology (AST): MPS emphasis in Adaptive Systems Technology will be placed on information dynamics and networks; multi-scale phenomena and nonequilibrium systems; design of functional systems and devices inspired by brain sciences; and development of new instrumentation for study of the brain. MPS divisions will contribute the general principles of the neural organization and communications pathways and explain how the system computes.

Biocomplexity in the Environment, Human and Social Dynamics, and **Mathematical Sciences:** With the conclusion of these priority areas in FY 2007 or FY 2008 (as noted in the table above), key components of these investments will be retained for core programs.

Climate Change Science Program (CCSP): Within MPS, investment in this area is led by the Division of Chemistry through the U.S. Global Change Research Program. The focus is on sustainability, including green chemistry, water chemistry, and energy. A small increase of $550,000 is planned for FY 2009.

Cyber-enabled Discovery and Innovation (CDI): MPS will increase its focus on CDI research by investing $19.05 million in FY 2009, an increase of $8.65 million over the FY 2008 Estimate. MPS divisions will support research on the synthesis and characterization of new molecular systems; the prediction and discovery of new materials and new states of matter; the creation, manipulation, and control of quantum mechanical states in solid and condensed states of matter; the development of mathematical structures to describe complex, multi-scale networks as typified by electrical power grids and the Internet; and the creation of visualization techniques for both sparse and dense data. MPS will continue its collaborations with other directorates in NSF's high priority activities in the CDI investment as well as increase funding within the MPS divisions.

Cyberinfrastructure (CI): NSF's CI activities are related to NITRD investments. All MPS divisions emphasize ways in which cyberinfrastructure – high-end computing, networking, and data collection and management – can enable the science they conduct. The developing capabilities create new opportunities for collaboration in science. Modeling, simulation, and visualization are increasingly important tools for MPS fields, particularly for work that crosses scales of time and space. A total of $71.06 million, $6.50 million over the FY 2008 Estimate, will support investments such as the NSF program in Petascale Simulations and Analysis (PetaApps) for improving hardware, software, and data management capabilities that enable researchers to ask new kinds of questions, which, in turn, stimulate the need for new, more powerful capabilities in cyberinfrastructure. In addition, MPS divisions contribute to research for the next generation of cyberinfrastructure through the development of software and algorithms and through research on next-generation materials for computation and computing.

National Nanotechnology Initiative (NNI): MPS plays an important role, both within NSF and in the interagency working environment in NNI, investing a total of $178.07 million at FY 2009 Request, an increase of $8.59 million over the FY 2008 Estimate. Key areas include fundamental nanoscale phenomena and processes and nanomaterials, with significant investments in instrumentation research, major research facilities, societal dimensions, and education. MPS will also increase its funding for the Environmental, Health, and Safety sub-component area by $2.72 million in FY 2009, consistent with the NSF and Administration focus on this important research. Many of the activities are carried out through interdisciplinary research teams. The Division of Materials Research is the lead division, with significant participation from the Divisions of Chemistry, Physics, and Mathematical Sciences.

Networking and Information Technology Research and Development (NITRD): All MPS divisions participate in funding for the NITRD program. The investment continues to focus in high-end computing infrastructure and applications, with contributions in high-end computing R&D as well as human-

computer interaction and information management. Computing in high energy physics and the development of a national virtual astronomical observatory are high-profile examples of MPS investments. In FY 2009, MPS will invest $73.72 million, or $2.83 million over the FY 2008 Estimate.

Science and Engineering Beyond Moore's Law (SEBML): MPS is the lead directorate for Science and Engineering Beyond Moore's Law, partnering with CISE and ENG to promote research into next generation computing power. SEBML research will focus on developing new materials, devices, and processes; new connection architectures; new algorithms; and new software. MPS will invest $10.0 million in FY 2009 for SEBML, an increase of $7.0 million over the FY 2008 Estimate.

QUALITY

MPS maximizes the quality of the R&D it supports through the use of a competitive, merit-based review process. The percent of research funds allocated to projects that undergo external merit review was 89 percent in FY 2007, the last year for which complete data exist.

To ensure the highest quality in processing and recommending proposals for awards, MPS convenes Committees of Visitors (COVs), composed of qualified external evaluators, to review each program every three years. These experts assess the integrity and efficiency of the processes for proposal review and provide a retrospective assessment of the quality of results of NSF's investments. MPS will convene COVs in FY 2008 for the Division of Mathematical Sciences, the Division of Astronomy, and the Office of Multidisciplinary Activities; a COV for the Division of Physics is scheduled for FY 2009.

MPS also receives advice from the Mathematical and Physical Sciences Advisory Committee (MPSAC) on such issues as: mission, programs, and goals that can best serve the scientific community; how MPS can promote quality graduate and undergraduate education in the mathematical and physical sciences; and priority investments in MPS-supported research. The MPSAC meets twice a year. Members represent a cross-section of the mathematical and physical sciences with representatives from many different sub-disciplines within the field and include members from institutions and industry. The committee includes a balanced representation of women, underrepresented minority groups, and geographic regions. MPS also participates in three advisory committees that advise multiple agencies: the High Energy Physics Advisory Panel (with DOE), the Nuclear Science Advisory Committee (with DOE), and the Astronomy and Astrophysics Advisory Committee (with DOE and NASA). Standing committees and studies of the National Research Council provide another mechanism for obtaining advice.

PERFORMANCE

The FY 2009 Budget Request is aligned to reflect funding levels associated with the Foundation's four strategic outcome goals stated in the FY 2006-2011 Strategic Plan. These goals provide an overarching framework for progress in fundamental research and education and facilitate budget and performance integration.

Mathematical and Physical Sciences
By Strategic Outcome Goal
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Discovery	$777.46	$799.23	$984.91	$185.68	23.2%
Learning	71.42	63.68	68.07	4.39	6.9%
Research Infrastructure	291.55	293.05	334.06	41.01	14.0%
Stewardship	10.30	11.35	15.63	4.28	37.7%
Total, MPS	$1,150.73	$1,167.31	$1,402.67	$235.36	20.2%

Totals may not add due to rounding.

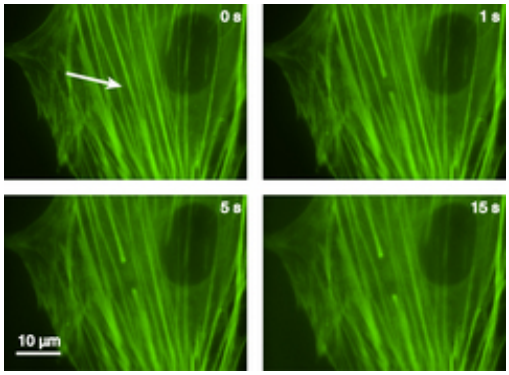
Recent Research Highlights

► **New Tricks with Light**: Researchers at Harvard University have stopped a light pulse in one location and made it reappear in another location a little while later. The researchers stopped a kilometer-long light pulse in a small ball of gas with a diameter about the width of a human hair called a Bose-Einstein condensate. An identical kilometer-long light pulse was subsequently made to appear from a second distinct Bose-Einstein condensate. The information about the shape and color of the light pulse was encoded into the quantum mechanical behavior of the atoms and pushed between the two condensates as a traveling matter wave moving at less than one mile per hour. This achievement demonstrates a possible intermediate step in quantum information processing. (PHY)

In a recent experiment at Harvard, light was absorbed and stored in one gas cloud, transferred to another gas cloud by transmission of a matter wave, and then recreated from the second gas cloud. *Credit: Jay Penni Photography.*

► **A Mathematical Solution for Another Dimension**: Ever since 1887, when Norwegian mathematician Sophus Lie discovered the mathematical group called E8, researchers have been trying to understand the extraordinarily complex object described by a numerical matrix of more than 400,000 rows and columns. Now, with support from NSF and the American Institute of Mathematics, an international team of experts consisting of about 20 researchers from the United States and Europe (including the University of Maryland, Cornell University, University of Michigan, University of Utah, Massachusetts Institute of Technology, University of Poitiers and University of Lyon in France) using powerful computers and programming techniques has mapped E8 – a feat numerically akin to the mapping of the human genome – allowing for breakthroughs in a wide range of problems in geometry, number theory, and the physics of string theory. (DMS)

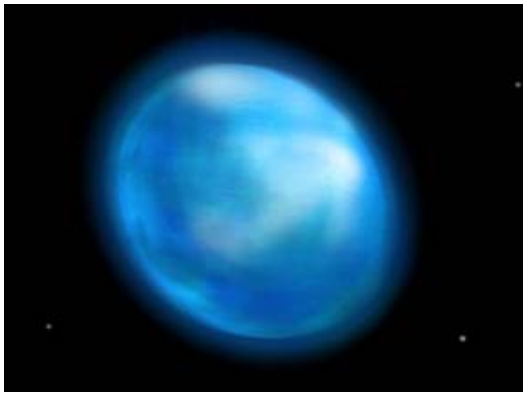
The E8 root system consists of 240 vectors in an 8-dimensional space. *Credit: American Institute of Mathematics.*



Time series of images taken with an optical microscope showing ends of the cut actin filament pulling apart. *Credit: David Weitz.*

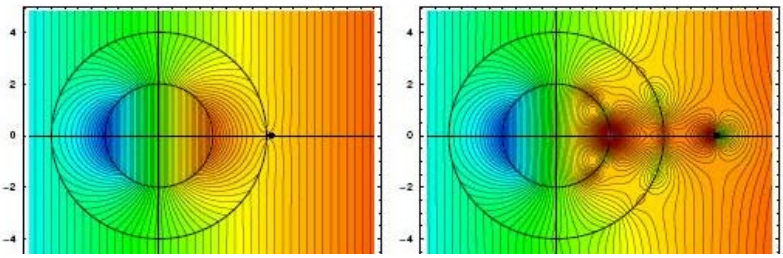
► **Nanosurgery in a Live Cell Using Laser Pulses**: Researchers at the NSF-supported Materials Research Science and Engineering Center at Harvard University performed 'nanosurgery' on a living cell using a pulsed laser to snip a single actin filament. Actin filaments are fibrous strands within a cell that give it structure. When a single filament is cut, it retracts like a broken violin string if the filaments are under tension and being pulled apart. Nanosurgery in a live cell using laser pulses provides critical insight into the behavior of the cytoskeletal network that, in turn, plays a key role in determining the mechanical properties of the cell. (DMR)

► **First Image of a Star Like Our Sun**: Using a suite of four telescopes, an international team of astronomers from St. Andrews University, Cambridge University, Georgia State University, California Institute of Technology, Cornell University, the Laboratoire d'Astrophysique de Grenoble in France, the Michelson Science Center, and the National Science Foundation's National Optical Astronomy Observatory have captured an image of Altair, one of the closest stars to our own and a fixture in the summer sky. This is the first time anyone has seen the surface of a relatively tiny hydrogen-burning star like our own sun. The astronomers captured the image using four of the six telescopes at a facility on Mt. Wilson, California, that is supported in part by NSF. The galaxy is shaped by the effects of relatively rare but powerful, hot, rapidly rotating stars. These stars have more in common with Altair than our own sun; understanding Altair will allow us to better understand how these influential stars scattered throughout the galaxy operate. (AST)



An artist's rendition of Altair, a star that spins so quickly it stretches at its equator. *Credit: Zina Deretsky, NSF.*

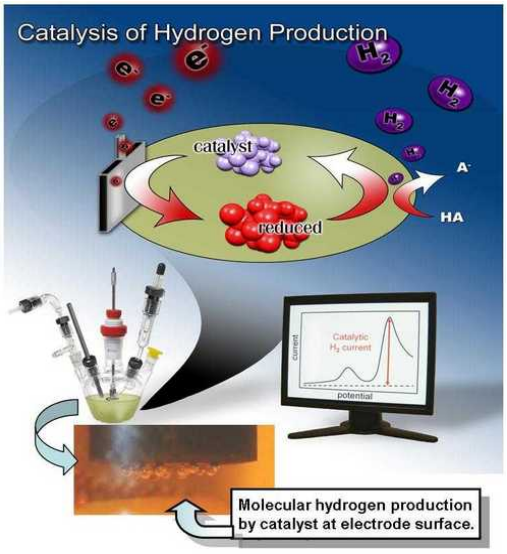
► **The Invisibility Cloak**: Making an object invisible with a cloaking device is commonly regarded as science fiction. Mathematical analysis by NSF-funded researchers at the University of Utah and the University of Technology in Sydney, Australia, however, recently revealed that certain objects are essentially invisible when placed sufficiently close to a superlens. A superlens is a thin transparent film with a negative refractive index that has the ability to resolve scales finer than the wavelength of the incident light. Cloaking occurs when some of the scattered light incident on the object gets trapped at the front surface of the superlens, builds up in intensity via a phenomenon known as anomalous local resonance, and almost exactly cancels the incident light. It's as if the object isn't there. (DMS)



Cloaking action of the cylindrical lens. The figure on the right shows the object in the form of a black dot situated away from the cylindrical lens and significantly disturbing the incident field. The figure on the left shows the object located close to the lens, with the lens and the object essentially invisible to the incident field. *Credit: Professor Graeme Milton.*

► **The Hidden Depths of Pictures**: Steganalysis is the search for hidden messages and is essential because criminals and terrorists may use hidden messages to communicate. Steganography is the process of hiding communications in otherwise innocuous objects, such as digital images. An NSF-supported investigator at the University of Delaware has invented a new method of steganalysis for image-based steganography. The researcher invented a high-performance lossless image compression method that is used to model images and to detect anomalies typical of hidden messages. A test on 1,200 images using two different steganography techniques demonstrated the power of the new method. For the most common technique, steganalysis reached 97 percent accuracy even when only 20 percent of the pixels contained hidden data. For a more concealed embedding, the method was still more than 91 percent correct with 30 percent steganography. (AST)

One of these pictures contains a hidden map of downtown Washington. Can you tell which one? Newly created analysis software does so with ease. *Credit: Charles Boncelet, University of Delaware.*



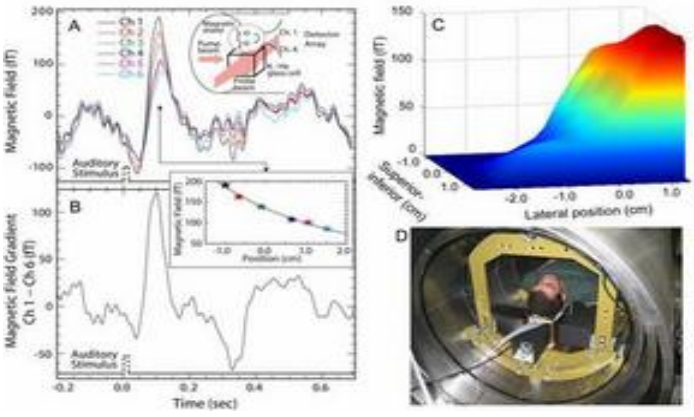
The rate of hydrogen production by these new catalysts is fast. As soon as the acetic acid diffuses to the electrode surface the catalyst converts it to hydrogen and bubbles can be seen at the electrode. *Credit: Suzy Hunter, Greg A.N. Felton, Richard S. Glass, Dennis H. Evans, and Dennis L. Lichtenberger.*

► **Finding Efficient Catalysts for Generating Hydrogen as an Alternative Fuel**: A major challenge in using hydrogen as an alternative fuel is the development of a cheap, efficient, readily available catalyst for chemically combining two electrons and two protons to form molecular hydrogen. Catalysts are substances that are added to chemical reactions to lower the amount of energy needed to make the reaction start and carry on spontaneously. Catalysts for hydrogen production typically lower this energy barrier more than is actually required for the reaction to occur. This over-potential, as it is called, wastes energy and diminishes the value of the catalysts. An NSF-supported team at the University of Arizona has synthesized a new class of compounds that can catalytically produce hydrogen from acetic acid (a component of vinegar) with very small over-potentials. The research can lead to more efficient hydrogen production and to new technologies needed for sustainable energy supplies. (CHE)

► **Determining the Highest Energies in the Universe**: In western Argentina, on the vast plain known as the Pampa Amarilla, or yellow prairie, a new window on the universe is taking shape. The international Pierre Auger Cosmic Ray Observatory looks at the universe's highest energy particles which shower down on Earth in the form of cosmic rays. While the origin of cosmic rays of low-to-moderate energies is believed to originate in supernova explosions within our galaxy, recent observations made by the Auger Observatory indicate that extremely high-energy cosmic rays may have come from galaxies within a radius of a few hundred million light years from our galaxy. The galaxies from which these high-energy cosmic rays are believed to originate show much higher than normal activity at their centers and, when viewed at radio and x-ray frequencies, exhibit pairs of jets of highly energetic material. By detecting and studying these rare very high energy particles, the Auger Observatory is tackling the enigmas of their origin and existence. (PHY)

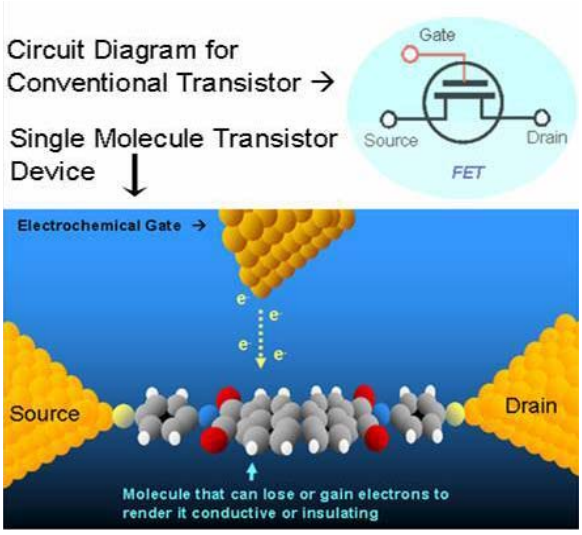
The Los Leones Fluorescence Detector together with its closest Surface Detector tank. *Credit: Pierre Auger Observatory*.

► **Magnetic Brain Imaging**: A modern technique for functional brain imaging, called magnetoencephalography, relies on detecting magnetic fields generated by the brain. Superconducting magnetometers that operate in liquid helium have remained the only detectors with sufficient sensitivity for magnetoencephalography for more than 30 years. A new optical method devised by NSF-funded researchers at Princeton University does not require the complications of cooling with liquid helium and allows the use of much smaller magnetic shields. The technology has the potential to be simpler, less expensive, and more comfortable for the subject. Optical magnetic field mapping also allows much greater flexibility in detector placement compared with cryogenic sensors while using common elements for most components of the system. (PHY)



Magnetic fields recorded with a light detector array (Figure A) and resulting magnetic field gradient (Figure B) due to audible clicks administered with an earphone. The detector shows a response 100 milliseconds after the stimulus, as has been observed with liquid helium cooled sensors. Figure C shows the ability of the new detector to resolve a spatial profile of magnetic fields and Fig. D shows a picture of the apparatus with open magnetic shield door. *Credit: Michael Romalis, Princeton.*

► **Single Molecule Transistors**: By wiring a single molecule to electrodes, researchers at Arizona State directly measure electron transport through the molecule. They can also control the transport by switching the molecule between two forms that are called oxidized and reduced states. These results are among the most compelling in this competitive field and offer an unprecedented opportunity to understand how charges transfer through molecules – a phenomenon that plays vital roles in many chemical and biological processes. It is also a basic requirement toward the goal of building an electronic device using single molecules. (CHE)



Single molecule transistor system under development at Arizona State University. The top of the figure shows the schematic concept. *Credit: Nongjian Tao, Arizona State University.*

Other Performance Indicators

Number of People Involved in MPS Activities

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Senior Researchers	8,212	8,325	9,900
Other Professionals	2,000	2,025	2,400
Postdoctorates	2,171	2,200	2,600
Graduate Students	7,720	7,800	9,300
Undergraduate Students	6,091	6,150	7,300
K-12 Students	615	625	750
K-12 Teachers	478	485	550
Total Number of People	27,287	27,610	32,800

MPS Funding Profile

	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Statistics for Competitive Awards:			
Number	2,361	2,400	2,850
Funding Rate	32%	32	32
Statistics for Research Grants:			0.00
Number of Research Grants	1,848	1,875	2,200
Funding Rate	30%	30	30
Median Annualized Award Size	$105,912	$107,000	$107,000
Average Annualized Award Size	$130,459	$145,000	$145,000
Average Award Duration, in years	3.0	3.1	3.1

ASTRONOMICAL SCIENCES $250,010,000

The FY 2009 Request for the Astronomical Sciences Division (AST) is $250.01 million, an increase of $32.15 million, or 14.8 percent, over the FY 2008 Estimate of $217.86 million.

Astronomical Sciences Funding

(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Astronomical Sciences	**$215.39**	**$217.86**	**$250.01**	**$32.15**	**14.8%**
Major Components:					
Research and Education Grants	90.91	92.80	112.36	19.56	21.1%
Centers Programs	4.00	3.32	2.66	-0.66	-19.9%
Facilities	120.48	121.74	134.99	13.25	10.9%
Gemini Observatory	20.00	20.00	22.00	2.00	10.0%
National Astronomy and Ionosphere Center (NAIC)	10.46	10.45	9.60	-0.85	-8.1%
National Optical Astronomy Observatory (NOAO) [1]	39.28	38.55	41.83	3.28	8.5%
National Radio Astronomy Observatory (NRAO)	47.04	44.52	49.79	5.27	11.8%
Atacama large Milimeter Array (ALMA)	3.70	8.22	11.77	3.55	43.2%

Totals may not add due to rounding.

[1] Includes the National Solar Observatory and the Telescope System Instrumentation Program.

About AST:

AST is the federal steward for ground-based astronomy in the U.S. Research support covers a broad array of observational, theoretical, and laboratory research aimed at understanding the origins and characteristics of planets, the Sun, other stars, our galaxy, extragalactic objects, and the structure and origin of the Universe. Individual investigator awards and fellowship programs for young faculty, postdoctoral researchers, graduate students, and undergraduate students encourage researchers engaged in education and outreach and increase the participation of underrepresented minorities in science. AST provides the U.S. share of funding for the operation of the international Gemini Observatory and supports the operation of the National Astronomy facilities: NAIC; NOAO including the National Solar Observatory (NSO); and NRAO, including the U.S. share of the ALMA project. AST supports the development of advanced technologies and instrumentation and management of the electromagnetic spectrum for scientific use. In its quest to bring more powerful technology and a well-trained workforce to bear on the exploration of the universe, AST makes significant contributions to ACI.

The AST portfolio has two major modes of support: research and education grants and facilities.

- AST research and education grants range from awards to individual investigators to large collaborations carrying out extensive surveys or developing instrumentation.
- AST also supports major world-class facilities that provide access to a wide range of observational resources on a competitive basis.

Approximately 20 percent of the AST portfolio will be available for new research grants in FY 2009. The remainder of the funds will support continuing commitments on research grants from prior years, facilities (54 percent of the total), instrumentation, education and outreach, and centers. In FY 2007, AST received 670 research proposals and made 172 competitive awards for a success rate of 26 percent.

AST Priorities for FY 2009:

Research Grants are AST's highest priority in managing its portfolio. Emphasis will be on addressing scientific priorities articulated in the National Research Council's report "Astronomy and Astrophysics for the New Millennium" and the National Science and Technology Council report for the interagency "Physics of the Universe" activity, supporting work in cyberinfrastructure/ Cyber-Enabled Discovery and Innovation, including a national virtual observatory in partnership with NASA.

Activities related to ACI and ACA focus on using the strong connection to technology and instrumentation in the astronomical sciences to engage students and to promote workforce and career development. FY 2009 will see an increased emphasis in intermediate-scale instrumentation and development of university-based programs in instrumentation for students and faculty in collaboration with industry and national facilities (deferred in FY 2008 for lack of funds).

Public-Private Partnerships are a keystone of the division's strategy. In FY 2009, there will be continued investments in the **Telescope System Instrumentation Program** (TSIP) and **Giant Segmented Mirror Telescope** (GSMT) technology development, examples of such partnerships.

Gemini Observatory and ALMA operations and instrumentation are AST's highest priority in new research infrastructure. Ensuring optimum performance and future instrumentation of our premier and newest facilities enables forefront research by the community and their students in these international partnerships. Reallocation of funds within the facilities portfolio follows recommendations of the AST Senior Review, and optimizes the investment of scarce resources in highest priority capabilities.

Changes from FY 2008:

Research and education grants increase by $19.56 million to $112.36 million total. AST will continue to support a wide range of astrophysical investigations from the search for extra-solar planets to the origin of the universe. Development of tools for handling large data sets and implementation of the Virtual Astronomical Observatory in partnership with NASA are emphases in AST's approach to cyberinfrastructure/cyberscience. Education and outreach activities will receive continued emphasis. AST will continue support for technology development for the **Large-Aperture Synoptic Survey Telescope** (LSST).

Support for the **Science and Technology Center for Adaptive Optics** totals $2.66 million, a decrease of $660,000 over the FY 2008 Estimate. This lower funding level is planned as the STC sunsets.

Facilities increase by $13.25 million to $134.99 million total. Base operations funding for all facilities continue implementation of the recommendations of the AST Senior Review. See the Facilities chapter for details. Changes include:

- An increase of $2.0 million for **Gemini Observatory** will enable enhanced operational and visitor support and the funding of a new generation of advanced instrumentation.
- A decrease of $850,000 for **NAIC** reflects the recommendation of the Senior Review.
- An increase of $2.28 million for **NOAO/NSO** will enable infrastructure improvements, deferred in FY 2008, while design funding for the **Advanced Technology Solar Telescope** moves to the MREFC account. TSIP, administered through NOAO, increases by $1.0 million to $5.0 million, an increase originally planned for FY 2008. NRAO/ALMA funding totals $61.56 million, an increase of $8.82 million over FY 2008 Estimate, continuing the ramp up of ALMA operations.

CHEMISTRY $244,670,000

The FY 2009 Request for the Division of Chemistry (CHE) is $244.67 million, an increase of $50.45 million, or 26.0 percent, over the FY 2008 Estimate of $194.22 million.

Chemistry Funding
(Dollars in Millions)

				Change over FY 2008 Estimate	
	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Amount	Percent
Chemistry	**$191.22**	**$194.22**	**$244.67**	**$50.45**	**26.0%**
Major Components:					
Research and Education Grants	167.51	165.61	201.88	36.27	21.9%
Centers Programs	9.60	13.42	25.26	11.84	88.2%
Instrumentation/Facilities	14.11	15.19	17.53	2.34	15.4%

Totals may not add due to rounding.

About CHE:

Chemistry is a bold and creative science that finds efficient ways to prepare Nature's compounds and to make new ones that have never existed before. Investment in basic molecular sciences is a major contributor to the $637 billion U.S. chemical industry. Approximately one third of the industrial output of the U.S. derives from the chemical industry, which in turn requires more than 2,000 PhD graduates per year to operate efficiently. The Chemistry Division plays a crucial role in the vitality of the basic research enterprise, especially in academic laboratories, and needs increased resources to sustain, expand and improve the community's ability to perform transformative and translational research in chemistry.

Approximately 50 percent of the CHE portfolio will be available for new research grants in FY 2009. The remainder will fund previous continuing commitments on grants, as well as grants for instrumentation and education. In FY 2007, CHE received 1,248 research proposals and made 341 competitive awards for a success rate of 27 percent.

CHE priorities for FY 2009:

The Centers for Chemical Innovation (CCI) program represents a new mode of support for transformative basic chemical research on "grand challenges." The CCI Program was initiated as a pilot in 2004 (as *Chemical Bonding Centers*) with several ambitious goals: to support high risk, transformative science; to energize the chemistry research community to tackle grand challenges; and to creatively engage the public. The change to *Centers for Chemical Innovation* reflects the addition of innovation as a key feature expected from these centers. Major themes from the ACI are targeted, such as sustainable technologies, nanotechnology, and molecular electronics.

ACI Fellows (ACI-F) in chemistry will provide consistent bridges across career transitions to the top ranked young talent in chemistry. ACI-F would launch young scientists into the professoriate – from their postdoctoral fellowship to their starting years as junior faculty. Goals include broadening participation and encouraging best practices in departmental culture. ACI-F will increase research capacity in targeted ACI areas such as nanotechnology and energy security.

Science and Engineering Beyond Moore's Law: One way to move beyond Moore's Law will use molecules or small assemblies of these as components of electronic devices. Ultimately, the goal is to develop a new generation of computer chips in which single molecules or small groups of them self-

assemble into pre-designed structures to store information and function as devices. Intensive synthetic effort guided by rigorous theoretical studies is vital to accomplish the effort.

Quantum Information Science: Quantum computing using NMR spectroscopy and entangled states is an area of interest. Quantum effects in nanoparticles are being discovered and modeled effectively, which could find uses in information science and technology. If new paradigms of computing emerge as competitive technologies, the discoveries enabled by funding molecular electronics research will be crucial for successful implementation of these ideas.

Adaptive Systems Technology in CHE will use the chemical circuitry in cells as dynamic building blocks that are combined in precise ways to function, for example, as small chemical factories. The research would involve identifying chemical networks and their necessary vehicles and then inserting them biocompatibly in other cells or artificial structures. Recent advances have increased the capability to mimic and expand upon nature.

Transformational Facilities and Infrastructure: The Chemical Research Instrumentation and Facilities (CRIF) program has four tracks through which CHE addresses its priorities in Shared Instrumentation, Instrumentation Development, Facilities, and Cyberinfrastructure. A concerted effort to develop the next generation of *chemical imaging tools* will have a significant impact on our ability to understand complex biological processes, molecular electronics, chemical processes on catalytic surfaces, and environmental processes, as well as sensors for national security.

Cyber-enabled Discovery and Innovation: The goal of CDI-Chemistry is to stimulate new collaborations that will lead to transformative methods to model complex molecular structures, including excited electronic states. Systems of interest cross many scales of time, energy, and space and involve, for example, weak intermolecular interactions functioning in an environment composed of many thousands of solvent molecules. Development of multi-scale simulation methods for large numbers of interacting elements is at the forefront of simulation science.

Changes from FY 2008:

- CCI increases by $12.5 million to $20.0 million, reflecting the establishment of three additional Phase II centers and six new Phase I centers. Strong support is needed especially because of the budget reduction (one Phase II Center) in FY 2008.
- Other research and education grants increase by $36.27 million to a total of $201.99 million. $29.22 million is dedicated to subdisciplinary programs to fund curiosity-driven fundamental chemistry research. CHE will support: molecular electronics and Science and Engineering Beyond Moore's Law with an investment of $1.75 million; Quantum Information Sciences with $2.0 million; Adaptive Systems Technology with $1.0 million; Cyber-enabled Discovery and Innovation with an increase of $800,000; and ACI-Fellows with an increase of $1.50 million. The Science and Technology Center is phasing out, decreasing by $660,000.
- Funding for learning increases by $1.85 million to $11.93 million in a mix of individual and group activities ranging from undergraduates through professors. Discovery Corps Fellowship support will increase by $500,000 (postponed in FY 2008 due to budget constraints). Its focus will change to integration of research and service aimed at communicating chemistry's value to the public. Undergraduate Research Collaboratives will increase by $840,000 (program was postponed in FY 2008 due to budget); REU support will increase by $510,000.
- Instrumentation/Facilities increase by $2.34 million to a total of $17.53 million, including new investments in cyber-enabled chemistry, multi-user facilities, and instrument development for chemical imaging.

MATERIALS RESEARCH $324,590,000

The FY 2009 Request for the Materials Research Division (DMR) is $324.59 million, an increase of $64.37 million, or 24.7 percent, over the FY 2008 Estimate of $260.22 million.

Materials Research Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Materials Research	**$257.27**	**$260.22**	**$324.59**	**$64.37**	**24.7%**
Major Components:					
Research and Education Grants	146.96	149.51	192.88	43.37	29.0%
Centers Programs	70.19	70.69	79.69	9.00	12.7%
Facilities	40.12	40.02	52.02	12.00	30.0%
National High Magnetic Field Laboratory (NHMFL)	25.00	25.00	30.00	5.00	20.0%
National Nanofabrication Infrastructure Network (NNIN)	2.55	2.55	2.55	-	-
Other MPS Facilities	12.57	12.47	19.47	7.00	56.1%

Totals may not add due to rounding.

About DMR:

The Division of Materials Research advances the intellectual frontiers of materials research. The activities supported are a critical ACI component. DMR awards enable the science and engineering community to make new discoveries about the fundamental behavior of matter and materials; to create new materials and new knowledge about materials phenomena; to address questions about materials that often transcend traditional scientific and engineering disciplines and 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 and condensed-matter science with the public at large.

- The division maintains a balanced portfolio of research topics through individual investigator grants, small groups, centers, and awards for instrumentation and user facilities, with considerable emphasis on interagency and international partnerships to advance materials research and education. DMR also supports six International Materials Institutes (IMI) based at U.S. universities to enhance international cooperation in materials, and a program to support the acquisition and development of instrumentation for materials research. Ten awards for Partnerships for Research and Education in Materials (PREM) are aimed at broadening participation in the materials research field. Both PREM and IMI competitions are planned for FY 2009.

- DMR Centers address major interdisciplinary problems in materials and condensed-matter science. DMR plans to support up to 29 Materials Research Science and Engineering Centers (MRSECs) in FY 2009; three MRSECs were phased out in FY 2007 based on results of the FY 2005 MRSEC competition. The division also supports three Nanoscale Science and Engineering Centers, provides partial support for a further seven NSECs, and supports two Science and Technology Centers.

- DMR supports world-class facilities for high magnetic fields, synchrotron radiation, and neutron scattering, and provides partial support for the National Nanofabrication Infrastructure Network. Researchers use these facilities to address challenging problems across a very broad range of disciplines

including materials and condensed-matter science, physics, chemistry, biology, geosciences, and many areas of engineering.

Budget constraints in FY 2008 impacted primarily the following activities: The planned increase for the National High Magnetic Field Laboratory (NHMFL) and the planned support of new MRSECs for the FY 2008 competition could not be made. The requested FY 2009 budget will allow significant investments in these activities.

Approximately 15 percent of the funds requested for DMR in FY 2009 will be available for new competitive research grants; 4 percent will be available for new facility and instrumentation awards and 1 percent will support the planned increase in the funding for NHMFL. In addition, about 2.5 percent of the funds will be available for fully funding awards made in the FY 2009 MRSEC competition. An additional 2 percent of funds will support new transformative group awards that complement current DMR group and center awards. Remaining funds will support continuing commitments from prior years, facilities, instrumentation, and education and outreach. In FY 2007, DMR received 1,352 research proposals and made 301 research grants for a success rate of 22 percent for research grants.

DMR Priorities for FY 2009:

Support for materials research programs that explore new phenomena, develop novel materials, and undergird technological innovation. These programs include awards to individual investigators, interdisciplinary teams, and centers. Emphasis will be given to research on materials and phenomena at the nanoscale and the FY 2009 MPS and NSF-wide investments. Increased emphasis on international activities will lead to additional support for IMIs and enhanced support for research connections in the Pacific Rim.

Broadening participation in materials research. DMR will provide strong support for the participation of undergraduates, pre-college students, and pre-college teachers in research, and for increasing the support for partnerships that strengthen the links between institutions serving under-represented groups and DMR-supported research teams, centers, and facilities.

Maintaining support for world-class user facilities, while enabling the development of future user facilities and major instrumentation for synchrotron radiation, neutron scattering, and high magnetic fields.

Changes from FY 2008:

DMR will increase support for **research and education grants** by $43.37 million to a total of $192.88 million. Additional support will allow creation of the first set of transformative materials research groups that effectively bridge the gap between small groups of individual investigators and centers. There will be increased support for ACI Fellows.

DMR will increase support for **centers** by $9.0 million to a total of $79.69 million. This will provide full support for awards made as a result of the FY 2008 MRSEC competition and supplementary support for the Center for Environmental Issues in Nanotechnology expected to be awarded in FY 2008.

DMR will increase funding for facilities by $12.33 million to a total of $52.40 million. This will allow support of the NHMFL at the planned level. It will enable continued operational support for X-ray, neutron, and nanofabrication user facilities, and support for research and development necessary for the next generation of light source facilities.

MATHEMATICAL SCIENCES $245,700,000

The FY 2009 Request for the Mathematical Sciences Division (DMS) is $245.70 million, an increase of $33.91 million or 16 percent above the FY 2008 Estimate of $211.79 million.

Mathematical Sciences Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Mathematical Sciences	**$205.74**	**$211.79**	**$245.70**	**$33.91**	**16.0%**
Major Components:					
Research and Education Grants	205.74	211.79	245.60	33.81	16.0%
Centers Programs	-	-	0.10	0.10	N/A

Totals may not add due to rounding.

About DMS:

The Division of Mathematical Sciences (DMS) advances the intellectual frontiers of the mathematical sciences and enables the advance of knowledge in other scientific and engineering fields. It plays a key role in training the Nation's science and engineering workforce. Driven in part by increasingly sophisticated and readily available computing environments, advances in science and engineering require ever more sophisticated mathematical and statistical tools.

NSF plays a crucial role in support of basic academic research in the mathematical sciences, as it provides almost 60 percent of all federal university-based support. In the core mathematical areas this percentage is even higher, with NSF supporting a broader range of infrastructure and fundamental and multidisciplinary research topics than other federal agencies. DMS plays a dominant role in developing the next generation of mathematical scientists.

DMS supports areas such as algebra, analysis, applied mathematics, combinatorics, computational mathematics, foundations, geometry, mathematical biology, number theory, probability, statistics, and topology. In addition, DMS supports national mathematical science research institutes; infrastructure, including workshops, conferences, and equipment; and postdoctoral, graduate, and undergraduate training opportunities. The DMS portfolio includes a variety of support modes and mechanisms. These include:

- research grants ranging in scope from individual-investigator awards to awards for multidisciplinary groups of researchers to attack problems of mathematical and scientific importance.
- major support for education and training, particularly through Enhancing the Mathematical Sciences Workforce for the 21st Century, which focuses on research training in the mathematical sciences and mentoring activities aimed at increasing the number of U.S. students choosing careers in the mathematical sciences.
- core support for five mathematical sciences research institutes as well as major support for three other institutes, all funded on a competitive basis to serve as incubators for new ideas and directions in the mathematical sciences and to address the growing interface with other disciplines.

In FY 2009, approximately 61 percent of funds requested for DMS will be available for new research awards, with the remainder going to continuing commitments from earlier years. In FY 2007, DMS received 2,222 research proposals and made 769 awards, for a success rate of 35 percent.

DMS Priorities for FY 2009:

Fundamental mathematical and statistical science, including activities that strengthen the core of the discipline and enable effective partnering with other science and engineering disciplines. This is a central enabler of the ACI.

Interdisciplinary research and education, including key components of ACI where the mathematical sciences play a critical role in discovery for competitiveness and innovation:

- **Cyber-enabled Discovery and Innovation** uses the mathematical sciences to provide new ways of obtaining insight into the nature of complex phenomena in science and engineering.
- **Science and Engineering Beyond Moore's Law** continues the algorithmic "Moore's Law", – the exponential increase in speed of basic computations due to innovative new algorithms, in parallel with Moore's Law for hardware – and develops new mathematical frameworks for computation.
- **Quantum Information Sciences** involves research on quantum computing and communications including the understanding and implementation of algorithms in QIS.
- **MPS-Life Sciences Interface** provides mathematical language, methods, and tools to describe complex, multiscale, and emergent phenomena in the life sciences. This activity promotes the emergence of biology as a quantitative science and encourages bio-technological innovation.
- **Adaptive Systems Technologies** involves a multidisciplinary approach to using the architecture and operation of biological systems to achieve function and complex behavior in man-made adaptive systems. Discovery in this area would lead to innovation in such areas as robotics, sensor systems, specialized materials, and assistive devices.
- **ACI Fellows** improves the freshman and sophomore experience in mathematics through involvement in interdisciplinary, discovery-based activities. It is designed to strengthen the Nation's scientific workforce by increasing numbers of successful undergraduate majors in mathematics, science, and engineering.

Mathematical Sciences Research Institutes and Networks, the Workforce program, and **broadening participation at all levels in the mathematical sciences** remain high priorities for DMS.

Changes from FY 2008:

- **Support for the core** increases by $20.81 million, a significant portion of which will be used to further the aims of the ACI in part through interactions with other science and engineering disciplines and to restore cuts to division programs made in FY 2008. Award size and duration will be increased by providing adequate support for the most compelling projects and, to the extent possible, doing so without unduly reducing the success rate for unsolicited proposals.
- **Cyber-enabled Discovery and Innovation** increases by $3.85 million.
- **Science and Engineering Beyond Moore's Law** will be supported at $1.75 million.
- **Quantum Information Sciences** will be supported at the level of $2.0 million.
- **MPS-Life Sciences Interface** will be supported at the level of $1.0 million.
- **Adaptive Systems Technologies w**ill be supported at the level of $500,000.
- **ACI Fellows** will be supported at the level of $2.0 million.
- **Support for early career investigators** will increase by $2.0 million to a total of $8.16 million in order to increase the number of CAREER awards and to raise stipends for postdoctoral fellowships to a more competitive level.
- Support for the **Center for Research at the Interface of the Mathematical and Biological Sciences** will be $100,000. This will be matched by the MPS Office of Multidisciplinary Activities. This center is predominantly supported by the Directorate for Biological Sciences.

PHYSICS $ 297,700,000

The FY 2009 Request for the Physics Division (PHY) is $297.70 million, an increase of $47.18 million, or 18.8 percent, over the FY 2008 Estimate of $250.52 million.

Physics Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Change over FY 2008 Estimate Percent
Physics	**$248.47**	**$250.52**	**$297.70**	**47.18**	**18.8%**
Major Components:					
Research and Education Grants	156.33	162.95	213.69	50.74	31.1%
Centers	7.68	6.36	6.36	-	-
Facilities	84.46	81.21	77.65	-3.56	-4.4%
Laser Interferometer Gravitational Wave Observatory	33.00	29.50	28.50	-1.00	-3.4%
Large Hadron Collider	18.00	18.00	18.00	-	-
IceCube Neutrino Observatory	0.25	1.50	2.15	0.65	43.3%
National Superconducting Cyclotron Laboratory	18.50	18.50	20.50	2.00	10.8%
Cornell Electron Storage Ring	14.71	13.71	8.50	-5.21	-38.0%

Totals may not add due to rounding.

About PHY:

PHY advances the intellectual frontiers of physics; contributes to advances in other scientific and engineering fields and to the ultimate benefit of the economy, health, and defense of the country; works toward early inspiration of the young, training the next generation of scientists and the high-tech workforce, and sharing the stimulation and understanding provided by science to the general public through the integration of research and education; and stewards the physics community to ensure it remains world-class as it evolves. PHY supports research over a broad range of physics subfields, including atomic, molecular, optical, and plasma physics; elementary particle physics; gravitational physics; nuclear physics; astrophysics; biological physics; physics at the information frontier; and theoretical physics and instrument development across all these subfields. The division maintains a balanced portfolio of research topics using appropriate modes of support and partnering across agency and national boundaries.

The PHY portfolio has two major modes of support: research and education grants and facilities.

- PHY research and education grants range in scope from individual-investigator awards to awards to major user groups, including groups with responsibility for experiments at national or international user facilities, and awards for frontier research efforts involving centers, institutes, and other multi-investigator collaborations.
- PHY also supports major world-class facilities needed by certain subfields to answer the highest priority science questions.

In FY 2009, approximately 35 percent of the funds requested will be available for new research grants, with the remainder going to continuing commitments from previous years and to facilities (approximately

30 percent of the portfolio), instrumentation, and education and outreach. In FY 2007, PHY made a total of 263 competitive research grants, for a funding rate of 39 percent for competitive actions.

PHY Priorities for FY 2009:

A strong, flexible program of research and education grants to create new ideas and technology and attract and train students is the highest priority in the PHY portfolio. Investments in FY 2009 will focus heavily on new directions grown out of earlier discoveries that show special promise to introduce revolutionary new technologies, especially those that derive from quantum control; to capitalize on modern grid technology and computational capabilities to develop new cyberinfrastructure to enable new discoveries and address increasingly complex scientific problems; and to more rapidly enhance support for emerging physics research on living systems. Support is provided through internal physics programs as well as joint participation with other parts of NSF, other agencies, and international partners.

Physics of the Universe (POU) continues to be a high priority within the Division. Research at this frontier addresses compelling questions at the interface of physics and astronomy in line with the joint investment plan between NSF, Department of Energy, and NASA put forth in the National Science and Technology Council report "The Physics of the Universe: A 21st Century Frontier for Discovery". Within NSF, POU is coordinated and supported by the AST and PHY Divisions. Activities include funding within grants programs, instrumentation development, and technical design for new facilities.

Changes from FY 2008:
Research and education grants increase by $50.74 million to a total of $220.05 million. PHY will enhance its support for ACI-related research in atomic, molecular, and optical physics, especially science beyond Moore's law ($1.75 million), physics at the information frontier, especially quantum information science ($3.0 million), cyberinfrastructure and cyber-enabled discovery ($1.20 million), and the physics of living systems ($2.0 million), with connections to Adaptive Systems Technology and the physical-life sciences interface. A mid-career ACI Fellows program ($1.0 million) will enhance the continuing emphasis on education and outreach activities and expanding diversity within the research community.

Facilities decrease by $3.56 million to a total of $77.65 million. For detail, see the Facilities chapter. This includes:

- Continued support for operations of the Laser Interferometer Gravitational Wave Observatory (LIGO) and for advanced detector R&D during startup of AdvLIGO construction at $28.50 million, a decrease of $1.0 million.
- Increased support for operations of the National Superconducting Cyclotron Laboratory (NSCL) radioactive ion beam facility to a total of $20.5 million, an increase of $2.0 million, back on plan after an unplanned $1.0 million reduction in FY 2008.
- Increased support for operations of IceCube to a total of $2.15 million from PHY, an increase of $650,000.
- Decreased support for the Cornell Electron Storage Ring (CESR) by $5.21 million to a total of $8.50 million as the continuation of the phase-out of operations as a high-energy research facility.
- Funding for instrumentation development and acquisition requiring investment at levels beyond the maximum limit of the agency-wide Major Research Infrastructure program or the resources of disciplinary programs will be increased by $3.35 million to a total of $8.50 million.

Support for technical design for the proposed Deep Underground Science and Engineering Laboratory (DUSEL) and R&D for detectors relevant to the proposed DUSEL will be increased by $6.0 million to a total of $10.0 million.

MULTIDISCIPLINARY ACTIVITIES $40,000,000

The FY 2009 Request for the Office of Multidisciplinary Activities (OMA) is $40.0 million, an increase of $7.30 million, or 22.3 percent, over the FY 2008 Estimate of $32.70 million.

Multidisciplinary Activities Funding
(Dollars in Millions)

	FY 2007 Actual	FY 2008 Estimate	FY 2009 Request	Change over FY 2008 Estimate Amount	Percent
Multidisciplinary Activities	**$32.64**	**$32.70**	**$40.00**	**7.30**	**22.3%**
Major Component:					
Research and Education Grants	32.64	32.70	39.90	7.20	22.0%
Centers Programs	-	-	0.10	0.10	N/A

About OMA:

OMA enables and facilitates MPS support of particularly novel, challenging, or complex projects of varying scale in both research and education that are not readily accommodated by traditional organizational structures and procedures. This is done primarily in partnership with the five MPS disciplinary divisions to encourage multidisciplinary proposals from all segments of the MPS community and especially to encourage activities by multi-investigator, multidisciplinary teams pursuing problems on a scale that exceeds the capacity of individual investigators. Most often, these cooperative undertakings involve two or more partners – within MPS or beyond – that join with OMA to foster new directions of scientific understanding and that broaden and enrich education and research training activities in the MPS disciplines. Such partnerships are critically important to the pursuit of the strategic goals of NSF and of the MPS community and contribute significantly to the preparation of a diverse workforce for the new century that is broadly trained, flexible, and globally competitive. Facilitation by OMA of both disciplinary partnerships and organizational partnerships is vital to the accelerated discovery of new ideas, the development of new tools, and the broadened training necessary to enable the Nation's workforce to meet new and rapidly evolving demands.

The portfolio of OMA is expanded this year to include some resources to address strategic planning for future facilities, again, in partnership with MPS divisions. This recognizes a long-standing need, as the costs for development of large projects are substantial and distort divisional budgets. This role is consistent with OMA primary function of enabling and facilitating complex projects with transformational scientific reach.

Because OMA plays a catalytic role in initiating new multidisciplinary activities and enabling broadening participation, the portfolio includes relatively few commitments from prior years. Approximately 37 percent of requested funds will be available for new research awards. Additional funds will be available for education grants and cooperative agreements supporting projects such as large centers and facilities. Most awards are managed in MPS divisions with co-funding from OMA.

OMA Priorities for FY 2009:

Enabling the creativity of and long-term impact of the MPS community by facilitating partnership-enabled multidisciplinary and high-risk research that extends the intellectual frontiers of the MPS disciplines. Such activities include fundamental multidisciplinary research at the interface between MPS

and the life sciences that provides insights into the molecular basis of life processes, bio-inspired and biomimetic materials, and biological physics; research addressing the fundamental science that will be critical to move future computing and communications technologies beyond Moore's Law; cyber-enabled discovery and innovation; and team efforts by scientists, mathematicians, and engineers aiming to develop next-generation instrumentation, particularly at the mid-scale level, that enables fundamental advances across a wide spectrum of disciplines.

Catalyzing the development of a diverse, well-prepared, internationally competent, and globally engaged Science, Technology, Engineering, and Mathematics (STEM) workforce includes MPS participation in NSF-wide programs and in other activities that leverage the directorate's research investment. These activities enrich education and training at all levels and facilitate the formation of research-based partnerships that not only increase diversity and broaden participation in the STEM enterprise directly, but also build the physical and intellectual capacity of educational institutions, particularly minority serving institutions (MSIs), to produce larger, more diverse cohorts of graduates who are well prepared to both support and to lead the Nation's STEM enterprise in the 21st Century.

Changes from FY 2008:

- Funding for **broadening participation in the MPS disciplines**, including diversity-targeted partnerships involving minority-serving institutions and MPS-supported groups, centers and facilities, and diversity-building partnerships with MPS professional societies, increases by $1.50 million to a total of $5.0 million. These co-investments with the five disciplinary MPS divisions enable research-based collaborative activities primarily between MPS-supported research groups, centers and facilities, and MSIs. These collaborative interactions build research capacity of the MSI faculty; strengthen the research infrastructure of the MSIs; and engage, stimulate, retain, and develop an increasingly diverse cadre of students in the MPS disciplines at the undergraduate and graduate levels.
- Support for **collaborative public education and outreach** activities at MPS-supported research centers and facilities will be maintained at the FY 2008 level of $3.0 million. This investment supports activities that enable effective leveraging of the MPS research investment for public science education, and clear public articulation of crosscutting science themes with significant MPS involvement, such as cyber-enabled discovery and innovation and science and engineering beyond Moore's Law.
- The OMA investment in the **Research Experiences for Teachers** activity (RET) will be sustained at the FY 2008 level of $2.50 million, to provide more than 250 pre-service and in-service K-12 teachers with discovery-based learning experiences in the MPS disciplines. Support for the **NSF Graduate Teaching Fellows in K-12 Education** program will be maintained at the FY 2008 level of $3.0 million.
- Investment in cooperative **international research and training** will be increased by $200,000 to a total of $1.60 million to enhance the global competitiveness of U.S. scientists, engineers, and students.
- Investment in support of research addressing environmental health and safety aspects of **nanoscale science and engineering** will be increased by $500,000 to a total of $1.0 million.
- Investment in support of **cooperative activities between academic research groups and industry** will be increased by $750,000 to a total of $1.50 million.
- Support for the new **Center for Research at the Interface of the Mathematical and Biological Sciences** will be $100,000. This will be matched by funding from the MPS Division of Mathematical Sciences. This center is predominantly supported by the Directorate for Biological Sciences.

The above take place primarily in the context of **disciplinary and interdisciplinary research** and are strongly aligned with goals of the ACI and the America COMPETES Act**.** Increases in selected areas will be accomplished through a combination of new funds and the redirection of existing funds.