MATHEMATICAL AND PHYSICAL SCIENCES $1,253,000,000

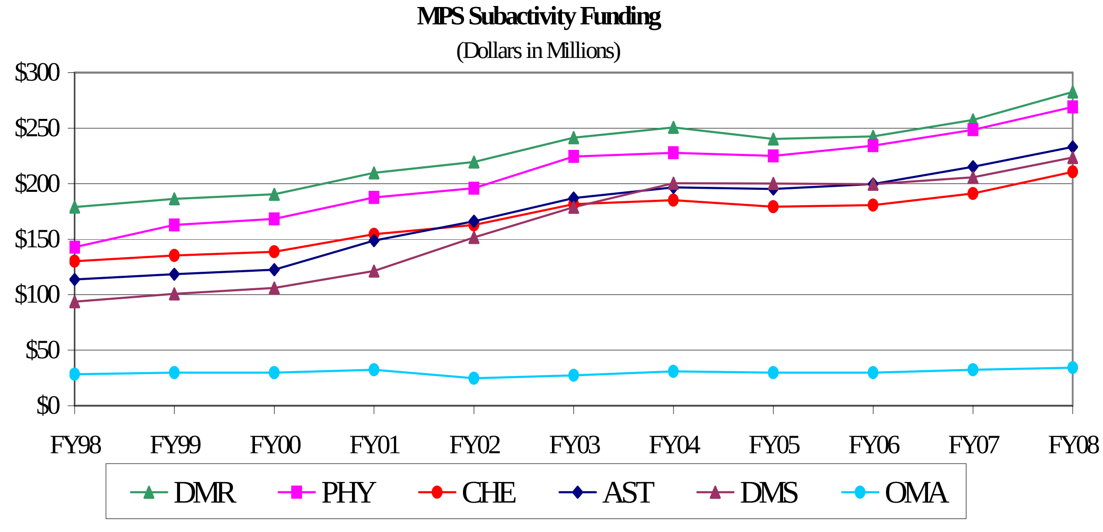
The FY 2008 Budget Request for the Mathematical and Physical Sciences (MPS) Directorate is $1.25 billion, an increase of $102.70 million, or 8.9 percent, over the FY 2007 Request of $1.15 billion.

Mathematical and Physical Sciences Funding
(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Percent
Astronomical Sciences	$199.75	$215.11	$232.97	$17.86	8.3%
Chemistry	180.70	191.10	210.54	19.44	10.2%
Materials Research	242.59	257.45	282.59	25.14	9.8%
Mathematical Sciences	199.52	205.74	223.47	17.73	8.6%
Physics	234.15	248.50	269.06	20.56	8.3%
Multidisciplinary Activities	29.9	32.40	34.37	1.97	6.1%
Total, MPS	$1,086.61	$1,150.30	$1,253.00	$102.70	8.9%

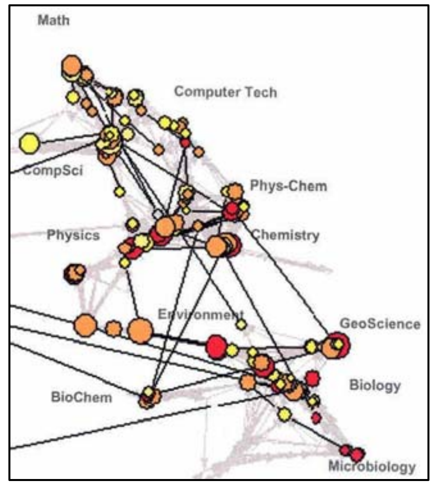
Totals may not add due to rounding.

The Mathematical and Physical Sciences Directorate advances innovation and competitiveness through its portfolio of investments in support of fundamental research, facilities and instruments that enable discovery and development, and integrated education and research activities that contribute to enhancing the breadth and depth 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 NSF priorities and the American Competitiveness Initiative (ACI).



RELEVANCE

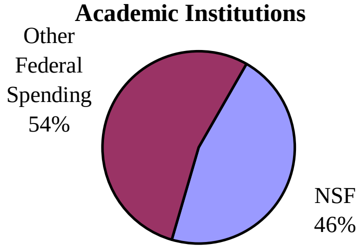
MPS-supported research advances the frontiers of knowledge, drives technological innovation, and stirs the imagination. It involves cutting-edge basic research in areas ranging from the behavior and control of molecules at the nanoscale to the complexity of their chemical interactions in materials and life processes; from the structure and evolution of the universe to the fundamental particles and processes of matter; from developing new mathematical structures and theories to transforming them into models of natural and human-made systems that connect to computation, experimentation, and observation. MPS research spans the full range of spatial and temporal scales accessible to human investigation, and it brings the perspective and methodologies of the physical sciences to exploring complex biological systems, human and social dynamics, sustainable energy, and the environment. Increasingly, it draws on sophisticated and mathematically precise computer models, application-specific software to implement the models, and capabilities for manipulating and extracting information from large, complex data sets.



Detail from a “map” of topics in the 820,000 most-referenced journal articles of 2003 reveals converging interests and connections. *Credit: Kevin W. Boyak, Sandia National Laboratories., Richard Klavans, SciTech Strategies, Inc.*

MPS-supported research in the physical and mathematical sciences plays a major role in innovation and competitiveness. While advancing the scientific frontiers in MPS disciplines, MPS investments also provide the knowledge base for advances in other technical, engineering, and health-related disciplines, as well as for industrial and technological innovation and national security. Exploration of the fundamental properties of matter, the complex laws governing chemical reactivity, the behavior and control of molecules at the nanoscale, the structure and evolution of the universe, and the mathematical ideas underlying our ability to formulate and solve problems have played a fundamental role in the technological leadership of the United States and in maintaining its health, economy, defense, and homeland security. This research sparks innovation that is crucial to maintaining U. S. competitiveness and generating new industries. In addition, by linking research with education and training, MPS promotes development of the future U.S. science, engineering, and technological workforce, with particular emphasis on broadening participation to engage the Nation’s entire talent pool. Consistent with ACI goals and objectives, MPS is increasingly engaged in enabling international partnerships to foster cooperation, build global research capacity, and advance the frontiers of the mathematical and physical sciences.

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

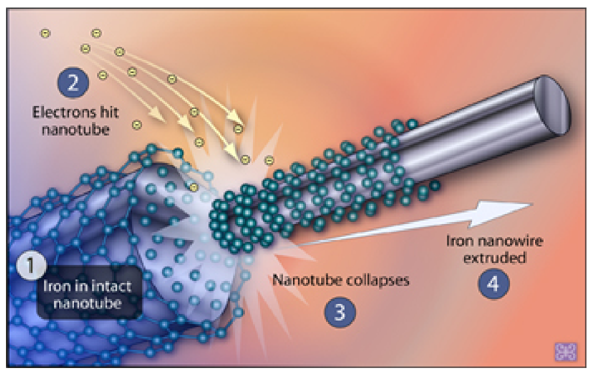


MPS provides about 46 percent of federal funding for basic research at academic institutions in the mathematical and physical sciences and serves as the federal steward for ground-based astronomy and gravitational physics. MPS provides about 43 percent of the federal support for academic astronomy; in chemistry, about 40 percent; in physics, approximately 36 percent; in materials research, approximately 55 percent; and in mathematics, more than 66 percent. MPS collaborates with other disciplines within NSF and partners with other agencies, the private sector, and other nations in exploring areas, such as nanoscale science and engineering, the physics of the universe, molecular processes in the life and environmental sciences, mathematical modeling across scales of time and space, and the evolving scientific capabilities provided by emerging cyberinfrastructure.

The MPS investment portfolio is designed to enable strong, flexible disciplines that generate discoveries across the MPS frontiers, reach out to other disciplines, accept high-risk undertakings that promise transformative advances on fundamental questions, and drive innovation. The portfolio provides broad support across all MPS fields and catalytic support that promotes advances in areas of opportunity, including investments in the infrastructure supporting the conduct of MPS research and education and enabling broad access to that infrastructure. MPS infrastructure investments range from portable instruments to international facilities with hundreds of users and include the development of next-generation instrumentation.

MPS integrates these 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. MPS-supported activities link both formal and informal education programs to forefront research activities in the U.S. and other countries.

ACI places high priority on enhancing the strength of the U.S. technical and instructional workforce. To ensure a diverse, internationally competitive, and globally-engaged workforce of scientists, engineers, and well-prepared citizens, MPS will make selected investments in all phases of education – from K-12 through undergraduate, graduate, postgraduate, and continuing education, as well as outreach activities. MPS is emphasizing activities connecting undergraduate education with research, with a new focus on first and second-year college students, taking advantage of the larger numbers and greater diversity in this pool and aiming toward increasing the science and engineering workforce. The MPS divisions work through partnerships of all types in order to achieve high priority NSF objectives. In all these activities, the MPS strategy relies on using the excitement of research on the frontiers to attract the next generation of scientists and engineers.



Electrons hitting an iron carbide-filled carbon nanotube cause it to contract and extrude material.

According to an international team of scientists, bombarding a carbon nanotube with electrons causes it to collapse with such incredible force that it can squeeze out even the hardest of materials. Pressures within the tubes reach one-tenth the crushing force in the Earth's core. The researchers suggest that carbon nanotubes can act as minuscule metalworking tools, offering the ability to process materials as in a nanoscale jig or extruder. *Credit: Zina Deretsky, NSF*

NSF is the principal source of federal support for strengthening Science, Technology, Engineering, and Mathematics (STEM) education across all levels and is uniquely positioned to provide leadership for the Nation due to its focus on STEM education research. These programs are responsive to MPS's mission and goals, increase American competitiveness in the global economy, and support NSF's underlying strategy of integration of research and education.

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

FY 2007 Request, MPS........…………………………………………………………………......$1,150.30

Astronomical Sciences Division (AST) +$17.86

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" and those of the interagency Physics of the Universe (POU) activity undertaken in partnership with the Physics Division, DOE and NASA; 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 early operations for Atacama Large Millimeter Array (ALMA); and strategic public-private partnerships, including design for the Giant Segmented Mirror Telescope.

Chemistry Division (CHE) +$19.44

Increased funding for a strong, flexible grants program that advances the frontiers of chemical sciences, emphasizing areas such as complex nanoscale systems and the molecular basis of life processes, design and synthesis of single-molecule electronic devices aimed at the challenge of Moore's Law[1], and sustainability in energy and environment; expansion of the Chemical Bonding Centers program which incorporate ACI-related priorities; cyber-enabled discovery and innovation in chemistry; instrumentation development; and broadening participation in the workforce through investments in new faculty and undergraduate participation in research.

Division of Materials Research (DMR) +$25.14

Increased funding for materials research programs that generate new ideas and novel materials and undergird innovative technologies, with emphasis on materials and phenomena at the nanoscale, complex systems (including biomaterials), materials aspects of computational discovery and innovation, and fundamental research addressing Science Beyond Moore's Law that encompasses novel materials and phenomena required for the future development of entirely new computational and communications technologies; broadening participation in materials research through research and education partnerships; expanded support for Materials Research Science and Engineering Centers; 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.

Division of Mathematical Sciences (DMS) +$17.73

Increased funding for fundamental mathematical and statistical sciences including activities that strengthen the development of underlying concepts and ideas as well as those that enable effective partnering with other science and engineering disciplines; cyber-enabled discovery and innovation that incorporate modeling, algorithms, and simulation to provide new ways of obtaining insight into the nature of complex phenomena, as well as exploring the challenges of "Moore's Law;" enhancing the portfolio of collaborations involving institutes and networks; and enhancing the strength of the workforce through discovery-based experiences for undergraduates.

[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.

Physics (PHY) +$20.56

Increased funding to advance the frontiers of physics, with emphasis on elementary particle physics, biological physics, and the interagency Physics of the Universe activities with the Division of Astronomical Sciences, DOE, and NASA; cyberinfrastructure and cyber-enabled discovery; expanded resources for the design and development of next-generation instrumentation and facilities; and education and outreach activities, including broadening participation in the research community. Early operations for IceCube will begin; enhanced support for operations at NSCL will take advantage of the recent upgrade; reduced support for operations and advanced detector R&D at LIGO reflect initiation of AdvLIGO as an MREFC project.

Office of Multidisciplinary Activities (OMA) +1.97

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 discipline

Subtotal, Changes +$102.70

FY 2008 Request, MPS........…………………………………………………………………..$1,253.00

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

FY 2007 Request, MPS........…………………………………………………………………..$1,150.30

<u>Discovery Research for Innovation</u> +$55.95

Disciplinary and Interdisciplinary Research ($45.95 million).

MPS assigns high priority to providing strong support of individual investigators and small groups pursuing fundamental research across all disciplines of MPS. Support of the core discovery mission 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, as well as opportunities to connect with ACI and NSF priorities, exist in all of the MPS sciences. Within the context of disciplinary and interdisciplinary research, MPS emphasis areas interact with one another, with NSF and Administration priorities, and with the overall portfolio in synergistic fashion, reflecting commonalities in the underlying complex physical systems. Some specific emphases include:

- *Physical Sciences at the Nanoscale.* MPS activities as part of the National Nanotechnology Initiative will expand with emphases on investigating how to control nanoscale objects, features, and devices at the atomic level of precision, understanding the impact of quantum phenomena in the nanoscale regime, and connecting quantum and nanoscale phenomena predictively across length and time scales with the macro properties of materials. Nanoscale activities are key components of ACI, critical for the technologies of the future in communications, energy, and other fields.

- *Science beyond "Moore's Law".* Moore's Law is likely to reach physical limits within 10 to 15 years unless major breakthroughs are made in molecular and nanoscale science and engineering. To go *beyond* Moore's Law will require entirely new science and technologies, as well as new algorithms and new conceptual frameworks for computing. MPS will focus on approaches to the science beyond Moore's Law involving quantum control, carbon-based systems, molecular electronics, spintronics, and single electron transistors. Revolutionizing the size, power, and speed of computers and other electronic and photonic devices has the potential for enormous economic impact and is perfectly aligned with ACI goals.

- *Physics of the Universe (POU)* and *Elementary Particle Physics (EPP).* A series of staggering results describing the mysteries of dark matter and dark energy in the universe and linking our understanding of the smallest elementary particles to the cosmos in which they formed has captured the scientific imagination. POU is a set of activities that builds on the National Science and Technology Council report of the same name, and partners with DOE and NASA in an interagency effort to explore the mysteries of dark matter and dark energy; the earliest phases in development of the universe; the fundamental nature of time, matter and space; and the role of gravitation. POU complements the traditional approach to EPP based on accelerator physics per the recent National Research Council report, *EPP2010*.

- *Complex Systems.* All aspects of the physical sciences deal with complex systems that cross multiple scales of space and time. Physical science-based approaches to exploring complex systems, including computational modeling and simulation, provide new tools for other fields, while the frontiers of these fields provide concrete examples to test predictive capabilities in more easily observed situations. This synergy has the promise for creating innovative new technologies across science and engineering that are important to ACI objectives. The MPS portfolio includes expanded activities in life science areas such as the molecular bases of life processes, biomaterials, biological physics, and neuroscience, as well as fields as diverse as the geosciences (e.g., water systems, natural disasters), engineering, and the social sciences.

- *Fundamental Mathematical and Statistical Sciences*. This is a core component as well as a central enabler of the ACI, both strengthening the mathematical and statistical sciences and enabling effective partnering with other disciplines within NSF and with other agencies. Additional support will be provided to the mathematical science institutes that bring together mathematical scientists, often with researchers in other disciplines, to identify exciting new areas of research. These connections also serve as important mechanisms for broadening participation by members of under-represented groups and institutions.

- *Sustainability*. Sustainable use of energy and natural resources requires new approaches to synthesis of chemicals and materials. The urgent need to produce commodity chemicals, not from petroleum but from carbon-neutral sources, such as bio-renewable materials, is recognized world-wide. Understanding environmental processes from a molecular point of view can lead to scalable, cyber-enabled models that permit effective environmental decision-making. These efforts are critical to the future of energy technologies, which is a high priority for ACI.

Cyber-enabled Discovery and Innovation (CDI) ($10.0 million).

Modeling, algorithms, software, and simulation are essential research components in all MPS disciplines as are virtual computing networks accessing common data bases 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 the internet; and the creation of visualization techniques for both sparse and dense data. MPS will join other directorates in achieving the CDI objective of developing a new generation of computation based discovery concepts and tools to deal with complex, data-rich, and interacting systems, creating synergy with related activities in Cyberinfrastructure such as development of the global computing GRID, and enhancing the government-wide Networking and Information Technology Research and Development (NITRD) effort.

Preparing the Workforce of the 21st Century +$10.52

Creating a strong science and engineering workforce for the future is a centerpiece of the ACI investment, and MPS disciplines are key elements of workforce preparation. MPS will focus on strengthening existing programs that reach different career levels, from undergraduates through early faculty positions. Discovery-based experiences for undergraduates will continue to be a priority. Emphases include broadening participation through increased funding to promote inclusion of women and underrepresented minorities as participants. In addition to the activities called out below, MPS embeds preparation of the workforce and broadening participation in all aspects of its activities, with centers and facilities providing particularly rich environments for these activities.

- *CAREER* and *Postdoc Programs ($5.06 million).* ACI calls for more support for young investigators. The CAREER program is the primary mechanism for jump-starting junior faculty in research and education, while postdoctoral programs enable young scientists and engineers to prepare themselves for faculty positions.

- *Undergraduates ($1.0 million).* MPS will increase support for programs designed to enhance the educational and career opportunities for undergraduate students, with an increasing emphasis on students in the first two years so as to broaden participation and increase the number of majors, through Computational Science Training for Undergraduates in the Mathematical Sciences.

- *Research Experiences for Teachers ($130,000)* MPS continues support for the Research Experiences for Teachers program. This program is designed to enhance the professional development of K-12 science educators through research experience focused on emerging frontiers of science as a mechanism for integrating new knowledge into the classroom.

- *Research Partnerships for Diversity ($4.33 million).* Additional support for the Partnerships for Research and Education in Materials (PREM) and similar activities across MPS is expected to enhance educational and career opportunities for graduate and undergraduate underrepresented minorities. Such awards are made to minority institutions to support research, education, and institutional infrastructure through partnering with MPS-supported centers and facilities.

- *ACI Fellows.* MPS will pilot an ACI fellows activity that will link undergraduate and graduate education, postdoctoral research, and early faculty experience in areas of particular relevance to ACI, including development of instrumentation, nanotechnology, cyber discovery, quantum science, energy security, and sensor development. Key elements will be (1) transition across elements of the education and career ladders in science and engineering, and (2) connection between fundamental research and innovation. In the pilot year, MPS will use field-specific formats, aiming to move forward with an MPS-wide activity in FY 2009 and to share experiences across NSF. The pilot will draw on a combination of funds from discovery research and workforce preparation.

<u>Transformational Facilities and Infrastructure</u> +$23.87

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. Investment in these "tools of science" – facilities and instruments that enable discovery and development – are not only transformative for the science of the MPS disciplines, but also enhance capabilities in other fields, fulfilling the explicit goals of ACI.

- *Current Facilities.* Base operations funding for all AST facilities remains near the FY 2007 level, pending a full implementation plan for the recommendations of the AST Senior Review.[2] See the Facilities chapter for additional details. Funding for the Gemini Observatory increases by $500,000 for second-generation instrumentation. The National High Magnetic Field Laboratory will submit a renewal proposal in 2007 for FY 2008 funds. A $2.5 million increase has been allocated to this facility, contingent on the outcome of the renewal process. Funding for the National Superconducting Cyclotron Laboratory increases by $1.9 million to take advantage of its recent upgrade. Funding for operations of the Laser Interferometer Gravity Wave Observatory (LIGO) will decrease by $4.8 million as staff shift to the construction of Advanced LIGO, the MREFC-funded upgrade to the project. See the "MPS Facilities Funding" table below for additional detail.

- *Design and Development.* Planning and design for a deep underground science and engineering laboratory will begin formally in FY 2008 at a total of $6.0 million, building on activities previously supported under Discovery Research. Funding for design and development related to the Giant Segmented Mirror Telescope will continue at $5.0 million.

- *Facilities under Construction.* Funding requested in FY 2008 from the MREFC account for ALMA reflects the new baseline configuration and cost as approved by the National Science Board. Early operations funding for ALMA increases to $8.2 million within the base budget of the National Radio Astronomy Observatory (NRAO). Two other MPS-related projects are in construction phases with funding requested in FY 2008 from the MREFC account. Funding for operations of IceCube is initiated at the $1.5 million level. Construction on Advanced LIGO begins in FY 2008. See the MREFC chapter for details.

- *Cyberinfrastructure.* The portfolio of world-class facilities maintained by MPS for the science and education communities represents past federal investments of over $1.0 billion.

[2] During FY 2006 the Division of Astronomical Sciences chartered a Senior Review of its facilities and instrumentation portfolio. This high-level committee, with extensive consultation within the astronomical community, evaluated the balance among existing facilities. The committee identified lower priority components of the program for which NSF funding could be reduced – either through increased participation of non-Federal sources or through closure – in order to bolster high priority components and invest in new opportunities.

Remote access to these facilities and analyses of the data they generate are aided by increasingly sophisticated cyberinfrastructure. Close interaction between practicing scientists and information technology developers, iterative approaches to software development and deployment, and mechanisms to share best practices are critical in advancing a cyber-enabled science community.

MPS Facilities Funding
(Dollars in Millions)

Facilities	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Change over FY 2007 Request Percent
Cornell Electron Storage Ring (CESR)	$14.62	$14.71	$14.71	-	-
GEMINI Observatory	18.18	20.00	20.50	0.50	2.5%
IceCube	-	-	1.50	1.50	N/A
Large Hadron Collider (LHC)	13.36	18.00	18.00	-	-
Laser Interferometer Gravit. Wave Obs. (LIGO)	31.68	33.00	28.20	-4.80	-14.5%
NCSL (MSU Cyclotron)	17.34	17.60	19.50	1.90	10.8%
Nanofabrication (NNUN/NNIN)	2.77	2.80	2.80	-	-
Nat'l High Magnetic Field Laboratory (NHMFL)	25.74	26.50	29.00	2.50	9.4%
Rare Symmetry Violating Processes (RSVP)	0.99	-	-	-	N/A
Nat'l Astronomy and Ionosphere Center (NAIC)	10.46	10.46	10.45	-0.01	-0.1%
Nat'l Center for Atmospheric Research (NCAR)	1.03	1.12	1.12	-	-
Nat'l Optical Astronomy Observatories (NOAO) [1]	36.91	40.05	43.18	3.13	7.8%
Nat'l Radio Astronomy Observatory (NRAO)	50.74	50.74	52.74	2.00	3.9%
Other MPS Facilities	12.31	12.47	14.97	2.50	20.0%
Total, MPS	$236.13	$247.45	$256.67	$9.22	3.7%

Totals may not add due to rounding.

[1]The NOAO total includes funding for instrumentation programs that build public-private partnerships. In FY 2008, the Telescope System Instrumentation Program is funded at $5 million. The Adaptive Optics Development Program is funded at $1.5 million, level with FY 2007 request, but moves into the disciplinary instrumentation program and so no longer appears in the NOAO budget in FY 2008. The base NOAO/NSO program funding increases by $3.63 million over the FY 2007 request .

- *Instrumentation.* Technology is a powerful driver for innovation in the support of MPS research and education activities. Through research and development of instruments of varying size and complexity (some carried out through public-private partnerships), MPS ensures a continuing stream of enhanced, cutting edge capabilities that can translate into transformative research. FY 2008 will see continuing emphasis on development of unique instrumentation, including sensors and imaging tools, as well as research and development aimed at the facilities of the future.

Centers Programs +$8.14

The Chemical Bonding Center program establishes centers that address long-term basic chemical research problems that are major themes in the ACI. In FY 2008, both phase I and phase II competitions will take place (+$6.0 million). In Materials Research, up to three new centers will be established using new funds and funds generated by phasing out centers through open competition (+$3.5 million). The centers will undertake research and education in materials and condensed matter that are critical to future American competitiveness in the global marketplace. Two NSF Science and Technology Centers begin ramping down activities, a reduction of $1.36 million according to planned funding profiles. See also the "MPS Centers Funding" table below.

MPS Centers Funding
(Dollars in Millions)

	FY 2006	FY 2007	FY 2008	Change over FY 2007 Request	
	Actual	Request	Request	Amount	Percent
Chemistry Centers	$1.50	$3.00	$9.00	6.00	200.0%
Materials Centers	53.50	55.70	59.20	3.50	6.3%
Nanoscale Science & Engineering Centers	12.89	12.96	12.96	-	-
Science & Technology Centers	15.51	19.60	18.24	-1.36	-6.9%
Total, MPS	$83.40	$91.26	$99.40	8.14	8.9%

Totals may not add due to rounding

<u>Stewardship</u> +$4.22

MPS will enhance its merit review and oversight processes as part of its pursuit of this NSF goal.

Subtotal, Changes +102.70

FY 2008 Request, MPS ……………………………………………………………….................. $1,253.00

NSF-WIDE INVESTMENTS

In FY 2008, MPS will support research and education efforts related to broad, Foundation-wide investments in a number of areas including NSF's multi-disciplinary priority areas and the Administration's interagency R&D priorities.

MPS NSF-wide Investments
(Dollars in Millions)

	FY 2006	FY 2007	FY 2008	Change over FY 2007 Request	
	Actual	Request	Request	Amount	Percent
Biocomplexity in the Environment	$2.63	$1.00	-	-$1.00	-100.0%
Climate Change Science Program	5.45	5.45	5.45	-	-
Cyber-enabled Discovery & Innovation	-	-	10.00	10.00	N/A
Cyberinfrastructure	58.64	63.56	64.56	1.00	1.6%
Human & Social Dynamics	0.50	0.50	0.50	-	-
Mathematical Sciences	70.87	69.26	6.62	-62.64	-90.4%
National Nanotechnology Initiative	158.24	156.42	169.91	13.49	8.6%
Networking and Information Technology R&D	68.93	69.00	76.96	7.96	11.5%

Biocomplexity in the Environment (BE): This priority area is concluding in FY 2007.

Climate Change Science Program (CCSP): MPS investment in CCSP is led by the Division of Chemistry through the U.S. Global Change Research Program. The focus is on studies of atmospheric gases, aerosols, and photochemistry and how these affect climate, as well as sustainability, including green chemistry, water chemistry, and energy.

Cyber-enabled Discovery and Innovation (CDI): MPS will join other directorates in achieving the CDI objective of developing a new generation of computation-based discovery concepts and tools to deal with complex, data-rich, and interacting systems.

Cyberinfrastructure (CI): CI activities at NSF 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. Investments in improving hardware, software, and data management capabilities 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.

Human and Social Dynamics (HSD): MPS funding includes support for areas such as interdisciplinary research modeling of the development and evolution of social and organizational behavior in complex systems. Within MPS, the Division of Mathematical Sciences will support research on dynamic and agent-based models used in studying human and social dynamics.

Mathematical Sciences: With the conclusion of this priority area in FY 2007, the FY 2008 funding reflects spending for continuing awards made in prior years. Other components of this investment will return to core programs for continued support.

National Nanotechnology Initiative (NNI): MPS plays an important role, both within NSF and in the interagency working environment, in NNI, investing a total of $169.91 million in FY 2008, an increase of $13.49 million over FY 2007. Key areas for investment include fundamental nanoscale phenomena and processes and nanomaterials, with significant investments in instrumentation research, major research facilities, societal dimensions, and education. 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 support NITRD. The investment is focused in high-end computing infrastructure and applications, with contributions in high-end computing research and development as well as human-computer interaction and information management. Computing in high energy physics and the development of a national virtual observatory are high-profile examples of MPS investments.

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 86 percent in FY 2006, 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, 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.

The Directorate 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 investment areas 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 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 2008 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.

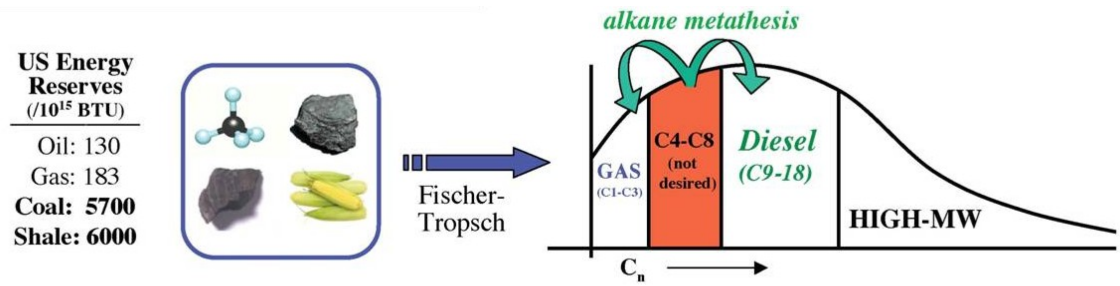
Mathematical and Physical Sciences
By Strategic Outcome Goal
(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Percent
Discovery	$726.81	$787.98	$861.46	$73.48	9.3%
Learning	72.45	63.77	64.90	1.13	1.8%
Research Infrastructure	277.49	291.42	315.29	23.87	8.2%
Stewardship*	9.86	7.13	11.35	4.22	59.2%
Total, MPS	$1,086.61	$1,150.30	$1,253.00	$102.70	8.9%

Totals may not add due to rounding.
*Iincrease in Stewardship over FY 2007 includes a one-time adjustment in estimates for program-related administration.

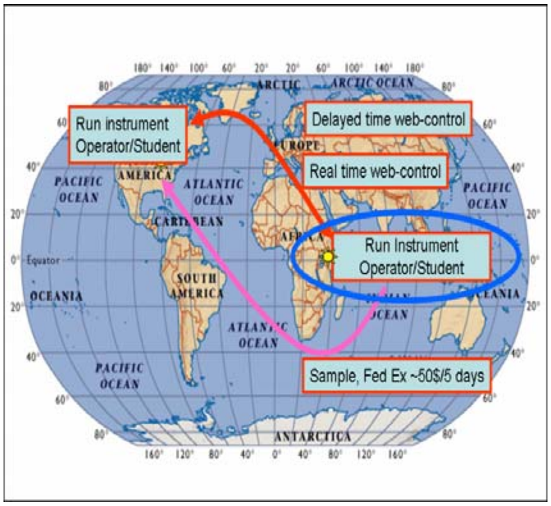
Recent Research Highlights

► **Better Diesel Fuel from Coal:** Coal can be gasified and converted to low molecular weight hydrocarbons through the Fischer-Tropsch process. These small hydrocarbons can then be converted to higher weight hydrocarbons that can be used in diesel fuels. One way of making the desired molecular weight hydrocarbons is to combine the smaller hydrocarbons through a reaction called the olefin



Conversion of coal to diesel by the Fischer-Tropsch process illustrating how alkane metathesis can improve diesel yields. C*redit: Karen Goldberg, University of Washington.*

metathesis reaction. The Chemical Bonding Center for the Activation and Transformation of Strong Bonds has developed an improved catalytic system for the metathesis of alkanes into diesel fuel. This process could improve the economics of the Fischer-Tropsch process and lead to a decreased dependence on foreign oil supplies. It could also enable an increased use of Fischer-Tropsch diesel, which is more environmentally benign than conventional diesel or gasoline. (CHE).



A collaboratory between the University of Dar Es Salaam, Tanzania, Egerton University and Kenya Methodist University of Kenya has been established with Loyola University Chicago. *Credit: Alana Fitch, Loyola University Chicago.*

► **Global Great Lakes Instrumentation Collaboratory:** The Global Great Lakes Instrumentation Collaboratory has established ties between students in East Africa and the Greater Chicago area, allowing them to carry out joint environmental analyses using instruments shared over the Internet. They also share educational resources such as laboratory instructions and curricular material via the Analytical Sciences Digital Library (ASDL) platform.

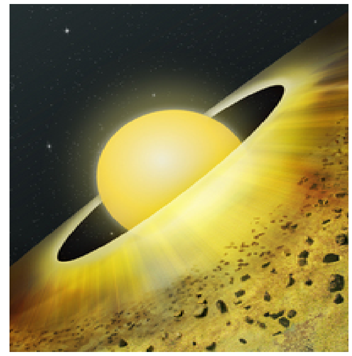
The Collaboratory's participating institutions include Loyola University in Chicago; Egerton University in Njoro, Kenya; Kenya Methodist University; and the University of Dar Es Salaam. The students in Africa prepare water, soil, plant, and fish samples and send them to Loyola University for analysis. They can then access the instruments at Loyola via the Internet, activate them, and monitor progress with a web camera. A database contains the final data which students at the different universities can compare over blogs. Students' learning of instrumentation via remote control is monitored by assessment at strategic points within the entire analytical process. (CHE).

► **Gemini Telescopes Expand Their Capability:** The powerful suite of instruments within each of the Gemini telescopes now follow a queue system, making the structures the most flexibly scheduled ground-based telescopes ever.

Each cluster of imaging and spectroscopic instruments permits Gemini scientists to observe over a remarkably broad spectrum, from the optical through the near-infrared and into the mid-infrared regions of the electromagnetic spectrum. Because of its technique of queue observing, Gemini can use any of these instruments at any point during a night, allowing observers to fine-tune their efforts to the nightly weather and sky conditions. Switching between instruments takes no longer than moving to a new target. This unique and powerful multi-instrument queue brings a new level of efficiency to Gemini operations. (AST).

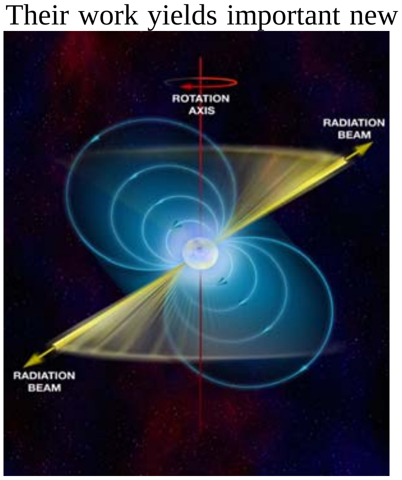
Gemini South telescope at twilight. *Credit: Gemini Observatory.*

► **Astronomers See First Stages of Planet-Building Around Nearby Star:** Future interstellar travelers might want to detour around the star system TW Hydrae to avoid a messy planetary construction site. Researchers at the Harvard-Smithsonian Center for Astrophysics have discovered that the gaseous disk surrounding TW Hydrae holds vast swaths of pebbles extending outward for at least 1 billion miles. These rocky chunks should continue to grow in size as they collide, combine, and eventually coalesce to form planets. The researchers used NSF's Very Large Array to measure radio emissions from TW Hydrae. They detected radiation from a cold, extended dust disk suffused with centimeter-sized pebbles, something no one had seen before. Such pebbles, created as dust collects together into larger and larger clumps, are a prerequisite for planet formation, a process that takes millions of years. (AST).



Artist's conception of a dusty disk around the young star TW Hydrae. *Credit: Bill Saxton, NRAO/AUI/NSF.*

► **Astronomers Discover Fastest-Spinning Pulsar:** Astronomers using the National Science Foundation's Robert C. Byrd Green Bank Telescope (GBT) have discovered the fastest-spinning neutron star ever found, a 20-mile-diameter superdense pulsar whirling faster than the blades of a kitchen blender. Their work yields important new information about the nature of one of the most exotic forms of matter known in the Universe.



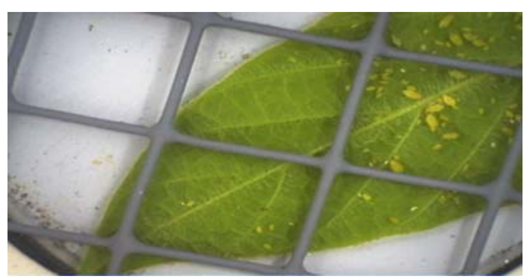
Pulsars are spinning neutron stars that sling "lighthouse beams" of radio waves or light around as they spin. *Credit: Bill Saxton, NRAO/AUI/NSF.*

Pulsars are spinning neutron stars that sling "lighthouse beams" of radio waves or light around as they spin. A neutron star is what is left after a massive star explodes at the end of its "normal" life. With no nuclear fuel left to produce energy to offset the stellar remnant's weight, its material is compressed to extreme densities. The pressure squeezes together most of its protons and electrons to form neutrons; hence, the name "neutron star."

"Neutron stars are incredible laboratories for learning about the physics of the fundamental particles of nature, and this pulsar has given us an important new limit," explained Scott Ransom, an astronomer at the National Radio Astronomy Observatory and one of the collaborators on this work. The great sensitivity of the giant, 100-meter diameter GBT, along with a special signal processor, called the Pulsar Spigot, made possible the discovery of so many millisecond pulsars. "We think there are many more pulsars to be found," Ransom said, "Given that the fast ones are often hidden by eclipses, some of them may be spinning even faster than this new one." (AST).

► **An Eye for Aphids:** A mathematician and his graduate student, both affiliated with the NSF-funded Institute for Mathematics and Its Applications, have developed a new image-analysis technique that can rapidly and accurately count aphids on soybean leaves.

This seemingly low-tech problem turns out to pose a formidable technical challenge, with a potentially large economic impact. Soybeans are a key livestock feed in the United States, as well as being an important human food source in many parts of the world. In the form of biodiesel



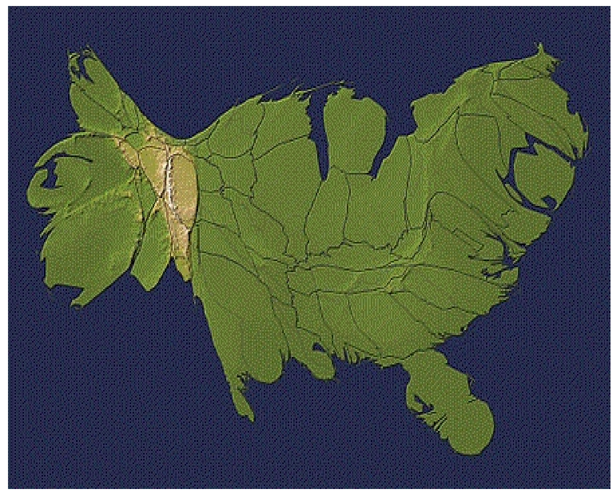
A sample image of aphids on a soybean leaf. Researchers developed an efficient system to distinguish the aphids from the leaf and count them automatically. *Credit: USDA-ARS, Midwest Area Soil and Water Management Unit, St. Paul, MN.*

fuel, moreover, they are a promising source of renewable energy. To maximize yields, however, farmers currently have to plan their crop-dusting schedules based on slow manual counts of the aphids on sample soybean leaves.

Automating this process is a challenge because aphids are very good at hiding. They not only cluster near the veins of the leaf, which have an intricate structure, but they change their colors to blend in as the leaf ages. On young leaves, in fact, the aphids nearly match the leaf veins.

Nonetheless, the mathematician and his student were able to take a previously developed image-analysis algorithm and optimize it for soybean leaf images. Their method is completely automated, and requires no guidance from end users. Within a few weeks of taking up the challenge, the researchers were able to provide highly accurate, efficient aphid counts. (DMS).

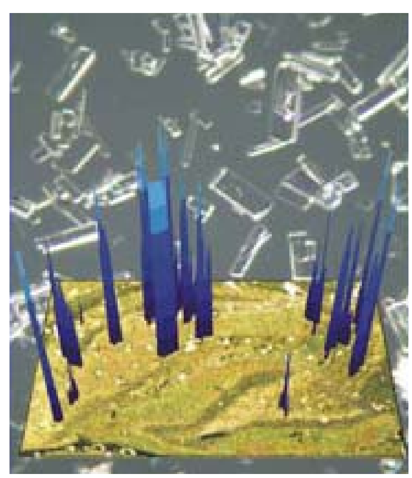
► **Diffusion-based Method for Producing Density-equalizing Maps:** Map makers have long searched for a good way to construct cartograms: maps in which the sizes of geographic regions such as countries or provinces appear in proportion to their population or some other analogous property. Such maps are invaluable for representing census results, disease incidence, and other kinds of human data.
The challenge is to scale the regions and still have them fit together. This typically means distorting the regions' shapes, which often results in maps that are difficult to read. Many methods for making cartograms have been proposed, some of them extremely complex, but all suffer either from this lack of readability, or from other pathologies such as overlapping regions.



The population of the United States shown as a cartogram. *Credit: M. Gastner and M. Newman, Proc. Natl. Acad. Sci. USA 101, 7499-7504 (2004), Copyright 2004 National Academy of Sciences, U.S.A.*

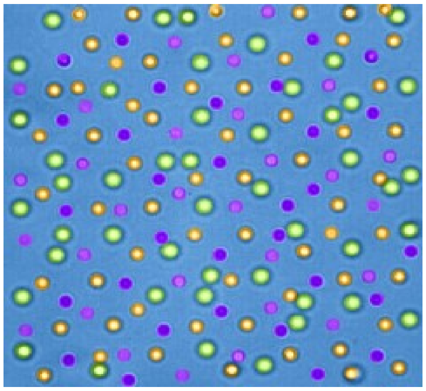
Now, however, NSF-funded mathematicians have developed a technique, based on ideas borrowed from elementary physics, that suffers none of these drawbacks. The method is conceptually simple and produces useful, elegant, and easily readable maps. (DMS).

► **Illuminating Alzheimer's. Research Sheds First-Ever Light on Creatine's Presence in Alzheimer's-Affected Brain Tissues:** For the first time, researchers have found elevated levels of creatine, a newly discovered agent of Alzheimer's, in brain tissue. Indeed, the team of Canadian and American scientists is the first to detect creatine directly in any tissue. Instead of following the usual method – grinding up a large amount of tissue and extracting creatine in bulk – the researchers were able to make a direct detection by using the intense light generated by the University of Wisconsin's Synchrotron Radiation Center, a traditionally physics-centric research tool. (DMR).



The image shows a hippocampus with the location of the creatine microcrystals shown by the blue peaks. The intensity of a blue peak corresponds to the intensity of the Infrared signal. *Credit: Kathleen Gough, University of Manitoba.*

► **Weaving and Bedazzling on a Microscopic Scale with "*Holographic Hands*"** Want to do handicrafts with beads smaller than the wavelength of light? Now you can, using a "holographic trapping" technique to capture microscopic beads floating in a liquid medium and to move and arrange them in patterns of your choice. The technique, perfected by Professor David Grier and his research group at the New York University, makes use of beams of laser light focused in ring-like patterns. These rings of light capture small particles floating in water. The rings can be used like tweezers to manipulate the particles and form the desired three-dimensional patterns. It is the next best thing to having full use of your hands at a microscopic scale. One can arrange micro-beads in three dimensions to construct crystals that mimic what atoms do at much smaller length scales, and to study them. The technique provides researchers a way to fabricate and study wires and structures of polymers, colloidal particles, carbon nanotubes, and membranes. Applications of this *holographic trapping* technique range from surgery within living cells to rapidly sorting fluid-borne objects. This award-winning technology has been commercialized and is being adopted for a wide range of industrial applications, including manufacturing of (photonic) devices that manipulate light much like semiconductors manipulate electrons in electronic circuits. (DMR).



A 'quasicrystal' with 5-fold symmetry assembled from nearly 200 colloidal spheres, a prototype for novel photonic (optical) devices. The spheres are colored by depth, and the five-fold domains should pop out of the picture if you stare at it. *Credit: David Grier, New York University.*

► **Using "Squishy Materials" to Teach Physics:** Is peanut butter a liquid or a solid? At times it seems like a solid: a glob of peanut butter will hold its shape over a period of time. Over time, however, it will flow like a liquid. Materials that behave in this manner are called complex fluids. Some of them change from solid-like to liquid-like, and vice versa, in response to changes in pressure. Many household items are examples, such as creams, shampoo, toothpaste, and ketchup. At Emory University, researchers study the physics of complex fluids to better understand their behavior. The group is interested in how a material's microscopic structure relates to its macroscopic behavior, such as determining how easy is it for a material to spread, flow, or compress – especially in confined spaces.

Postdoctoral fellow Dr. Denis Semwogerere shows a microscopic view of a squishy material. *Credit: Dr. Eric Weeks, Emory University.*

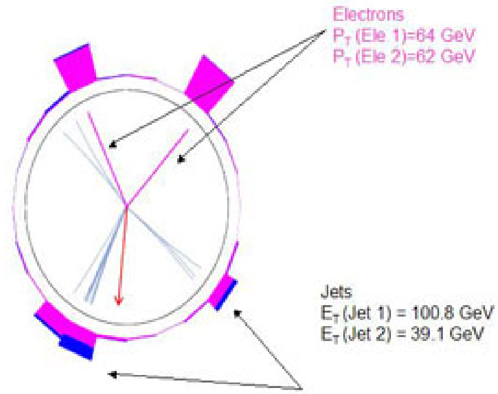
The Emory researchers have used activities involving "squishy materials" to interest schoolchildren in science. The laboratory has hosted groups from kindergarten through 8th grade, and children have the opportunity to study properties of these materials through age-appropriate hands-on activities. The excitement of doing physics research is conveyed to the children during these visits. The laboratory also has a popular website that contains extensive information on using complex fluids to teach freshman students (no matter which major they are pursuing) about current physics research while providing researchers particle tracking software and associated tutorials. (DMR).

Marisol Salgado of Roosevelt High School in Los Angeles works on microfluidic techniques for biological assays in the CSULA-CalTech Partnership for Research and Education in Materials. *Credit: CSULA. Prof. Frank Gomez.*

► **Partnerships Led by Minority-Serving Institutions:** Partnerships for Research and Education in Materials (PREM) enhance diversity in materials research and education by stimulating the development of long-term, collaborative research and education partnerships between minority-serving colleges and universities and NSF-supported centers and facilities in materials and condensed-matter research. PREMs engage the efforts and abilities of individuals from underrepresented groups in science and engineering who can have a significant impact on this critically important interdisciplinary field. Ten NSF PREM awards have been made to date; they constitute a developing national network of innovative partnerships with potential for major impact on materials research and education in the U.S. (DMR).

► **Open Science Grid Aids Search for Elementary Particles:** Theories in elementary particle physics explain a lot, but they all only make sense if fundamental particles have no mass, which is definitely not the case. So in order to account for the masses of particles, theorists add a special contribution to their equations. If this fix-up is correct, then a special, extremely heavy particle called a Higgs boson (after Peter Higgs, who suggested it) must exist. To find it, physicists have built larger and larger accelerators to go to higher and higher energy to produce this particle in collisions.

But measurements do not just require machinery and ingenuity; today it also helps to have the computing power of the grid. Why? The bulk of what is seen in a particle detector is unwanted signal, either from background or from other known signals. So, in order to see anything, theoretical physicists predict how the Higgs particle might be created and how it might decay, and experimental physicists model what those events would look like when viewed through a detector. Data collected from the detector is then compared with simulated data to see if any real events match what theory predicts a Higgs boson would cause, as well as to separate out the unwanted signals.



Simulation of Elementary Particle Collision. *Credit: Ashutosh Kotwal, Duke University.*

For two years, the Collider Detector at Fermilab (CDF) has been using a network of computers worldwide to simulate the hundreds of millions of events per year that are required to make discoveries and measurements. And for the last six months, they have been using the grid to help simplify job submission and management. The grid is ideal for simulations because there is not a lot of data transfer. What is needed is a lot of CPU. Through the Open Science Grid, simulations are being run on three CDF sites in North America, with three more to be added within the next few months. CDF simulations on the grid will also be extended to European sites. The grid will also be used for simulations on the detectors from the Large Hadron Collider when it begins operations. (PHY).

► **International Physics Young Ambassador Symposium:** More than 100 "physics young ambassadors" between the ages of 10 and 16, from 21 countries on five continents, winners of the International Physics Talent Search, met in Taipei, Taiwan to share the physics experience. The International Physics Talent Search was part of the World Year of Physics 2005 (WYP2005), proclaimed to celebrate the centennial year of three of Einstein's major discoveries. Held over New Year's Day 2006, the Symposium was the final event of WYP2005. The Talent Search implemented its goal of promoting physics awareness by allowing girls and boys to earn points through physics – drawing posters to illustrate the laws of physics, discovering that household items can demonstrate physical principles, teaching classmates about physics, or performing laboratory experiments. At the Symposium, the young ambassadors listened to and met with distinguished physicists, presented posters and talks on their work, and exchanged experiences with participants from other countries.

The impact of the event on the participants was beyond measure, as attested to by the comments from parents who participated in the Symposium. Travel to Taipei for U.S. participants and for those from several undeveloped countries was supported by the Office of Multidisciplinary Activities and the Divisions of Physics and Materials Research in MPS (which also supported the US Physics Talent Search) and by the Office of International Science and Engineering. (OMA, PHY, DMR; OISE).

U.S. symposium participants. *Credit: Beverly Hartline.*

Other Performance Indicators

Number of People Involved in MPS Activities

	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate
Senior Researchers	7,318	7,000	7,500
Other Professionals	2,373	2,400	2,450
Postdoctorates	2,214	2,250	2,300
Graduate Students	7,367	7,500	7,800
Undergraduate Students	6,242	6,300	6,500
K-12 Students	250	320	350
K-12 Teachers	480	500	550
Total Number of People	26,244	26,270	27,450

MPS Funding Profile

	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate
Statistics for Competitive Awards:			
Number	2,227	2,250	2,300
Funding Rate	30%	30%	30%
Statistics for Research Grants:			
Number of Research Grants	1,735	1,750	1,800
Funding Rate	28%	28%	29%
Median Annualized Award Size	$100,000	$103,000	$107,000
Average Annualized Award Size	$119,634	$132,000	$145,000
Average Award Duration, in years	3.1	3.1	3.1

ASTRONOMICAL SCIENCES $232,970,000

The FY 2008 Request for the Astronomical Sciences Division (AST) is $232.97 million, an increase of $17.86 million, or 8.3 percent, over the FY 2007 Request of $215.11 million.

Astronomical Sciences Funding

(Dollars in Millions)

	FY 2006	FY 2007	FY 2008	Change over FY 2007 Request	
	Actual	Request	Request	Amount	Percent
Astronomical Sciences	**$199.75**	**$215.11**	**$232.97**	**17.86**	**8.3%**
Major Components:					
Research and Education Grants	79.46	89.86	102.78	12.92	14.4%
Centers Programs	4.00	4.00	3.32	-0.68	-17.0%
Facilities	116.29	121.25	126.87	5.62	4.6%
Gemini Observatory	18.18	20.00	20.50	0.50	2.5%
National Astronomy and Ionosphere Center (NAIC)	10.46	10.46	10.45	-0.01	-0.1%
National Optical Astronomy Observatory (NOAO) [1]	36.91	40.05	43.18	3.13	7.8%
National Radio Astronomy Observatory (NRAO)	50.74	50.74	52.74	2.00	3.9%

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., working in partnership with private institutions to enhance overall observing capacity and capability. 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, special grants, 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 four National Astronomy facilities: the National Astronomy and Ionosphere Center (NAIC), the National Optical Astronomy Observatory (NOAO), including the National Solar Observatory (NSO), and the National Radio Astronomy Observatory (NRAO). AST supports the development of advanced technologies and instrumentation, planning and design for future observational facilities and collaborative projects in astronomy, and management of the electromagnetic spectrum for scientific use. In its quest to bring ever 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 2008. The remainder of the funds will support continuing commitments on research grants from prior years, facilities (55 percent of the total), instrumentation, education and outreach, and centers. In FY 2006, AST received 663 research proposals and made 158 competitive awards for a success rate of 24 percent.

AST Priorities for FY 2008:

Research Grants Programs are AST's highest priority in stewardship of the portfolio. Emphasis will be given to addressing scientific priorities articulated in the National Research Council's "Astronomy and Astrophysics for the New Millennium," supporting activities in the area of cyberinfrastructure/ cyberscience including a national virtual observatory in partnership with NASA, and ensuring a healthy and balanced program of research and education grants to the community.

Physics of the Universe (POU), the highest scientific priority, addresses the compelling questions that have arisen at the interface of physics and astronomy and were posed by the National Research Council report, "Connecting Quarks with the Cosmos." A subsequent National Science and Technology Council report, "The Physics of the Universe: A 21st Century Frontier for Discovery," outlines a national investment plan involving NSF, DOE, and NASA. Within NSF, POU is coordinated and supported by the AST and PHY Divisions. Activities include funding within the grants program, instrumentation development, and new facilities.

Public-Private Partnerships are a keystone of the division's strategy. In FY 2008, there will be renewed investments in the **Telescope System Instrumentation Program** (TSIP) and **Giant Segmented Mirror Telescope** (GSMT) technology development.

Gemini Observatory and ALMA operations and instrumentation are AST's highest priority in facility stewardship. Ensuring optimum performance and future instrumentation of our premier and newest facilities enables forefront research by the scientific community and their students in these international partnerships.

Changes from FY 2007:

Research and education grants increase by $12.92 million to $102.78 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. Support for technology development for the **Large-Aperture Synoptic Survey Telescope** (LSST) continues and that for GSMT will be maintained at $5.0 million.

Funding for the **Science and Technology Center for Adaptive Optics** is $3.32 million, beginning the scheduled decrease as this STC sunsets.

Facilities increase by $5.62 million to $126.87 million total. Base operations funding for all facilities remains near the FY 2007 level, pending a full implementation plan for the recommendations of the Senior Review of AST facilities. See the Facilities chapter for details. Changes include:

- The increase of $500,000 for the **Gemini Observatory** will enable enhanced operational and visitor support and continue the funding of a new generation of advanced instrumentation.
- The **NOAO/NSO** total includes design and development for the **Advanced Technology Solar Telescope**. TSIP, administered through NOAO, increases by $1.0 million to $5.0 million.
- **NRAO** is supported at the level of $52.74 million, an increase of $2.0 million over the FY 2007 Request. The total includes $8.2 million for ALMA early operations.

CHEMISTRY $210,540,000

The FY 2008 Request for the Chemistry Division (CHE) is $210.54 million, an increase of $19.44 million, or 10.2 percent, over the FY 2007 Request of $191.10 million.

Chemistry Funding
(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Percent
Materials Research	**$180.78**	**$191.10**	**$210.54**	**$19.44**	**10.2%**
Major Components:					
Research and Education Grants	157.60	167.39	180.27	12.88	7.7%
Centers Programs	8.08	9.60	14.92	5.32	55.4%
Instrumentation/Facilities	15.10	14.11	15.35	1.24	8.8%

Totals may not add due to rounding.

About CHE:

Extraordinary research opportunities exist today in molecular science that build on our increasing understanding of matter, from its quantum properties to the formation of complex molecular assemblies. Chemistry is inherently interdisciplinary; important practical challenges provide the motivation for considerable academic creativity. The chemical enterprise that results from basic research investments is a major contributor to the U.S. economy.

Approximately 45 percent of the funding requested will be available for competitive research grants in FY 2008, with the remainder supporting continuing commitments on research grants from prior years and the other aspects of the portfolio. The CHE portfolio in FY 2006 consists of 79 percent individual and small group awards, 13 percent shared instrumentation, 4 percent educational projects, and 4 percent centers. The funding rate for proposals in CHE was 26 percent in FY 2006.

CHE priorities for FY 2008:

The Chemical Bonding Centers Program addresses major themes in the ACI such as sustainable technologies, nanotechnology, and molecular electronics. These centers foster interdisciplinary and transformational basic research with very high impact potential. The program philosophy encourages highly creative ideas at the cutting edge to develop new concepts that can lead to fundamental changes and new technologies.

Nanoscience, Complexity and Molecular Basis of Life Processes (MBLP): The co-evolution of nanoscience and personalized medicine and biotechnology requires synthesis of sophisticated molecular systems and understanding the interactions of molecules with these systems. To date studies have focused primarily on pairs of molecules; not much is known about more complex assemblies and the consequent phenomena resulting at larger scales. The goal is to program information at the molecular level through synthetic chemistry in order to induce self-assembly and cooperativity and eventually lead to the desired emergent properties. An ultimate goal would be to prepare carefully designed compounds and allow them to self-assemble into self-replicating systems. Self-assembly could lead to the formation of complex materials or devices with unique properties and provide clues to biological processes.

Science Beyond Moore's Law: An important and potentially transformative frontier in molecular science involves the design and synthesis of single-molecule electronic devices. Single-molecule transistors and diodes have already been synthesized and characterized and shown to act as regular devices. These systems work reproducibly and efficiently once they are constructed, but their assembly, connectivity and external addressability remain as major challenges. Other innovative structures need to be designed and synthetic and self-assembling schemes are necessary to produce more efficient and reproducible molecular devices. The potential to revolutionize the size and power of computers and other electronic devices based on molecular electronics is enormous, in perfect alignment with ACI goals.

Sustainability: Chemistry is an essential underpinning of major innovations in green technologies required for society to achieve a sustainable environment. This effort aligns with ACI, which calls for capabilities and technology platforms that will ensure innovation in key areas. There is global recognition that there is an urgent need to produce commodity chemicals not from petroleum but from carbon-neutral sources, such as biorenewable materials. Entirely new approaches need to be developed for the synthesis of chemicals and materials and for the utilization of energy and our natural resources. Study of the unique reactivity of environmental interfaces – for example between water and solids – is critical to understanding both natural biogeochemical cycles and those that have been altered by human activity. Scalable, cyber-enabled models can take molecular observations to regional and global outcomes. This mission is well-suited to NSF, with its emphasis on fundamental transformative research.

Cyber-enabled Discovery and Innovation: While computational modeling and simulation have always been part of chemical inquiry, the quality of science that has emerged from this approach has improved dramatically so that modeling, algorithms, software and simulation now are essential components to gain insights into chemistry. Particularly helpful are simulations of unrealizable systems such as ultrashort-lived key intermediate species that defy detection or of chemical species too dangerous to work with in the laboratory. Networking of remote instruments and facilities couples the people and instruments needed to synthesize and characterize new molecular systems.

Preparing the Workforce of the 21st Century: ACI calls for increased support for young investigators. CHE will increase support for CAREER and Discovery Corps Fellows, as well as continuing partnerships with EHR with the goal of preparing a diverse chemical workforce. CHE will participate in the MPS ACI Fellows pilot through activities requiring industrial collaboration, serving to increase research capacity in targeted ACI areas such as nanotechnology, cyber discovery, quantum science, energy security, and sensors. CHE funding for workforce activities increases by $3.80 million to $31.73 million in a mix of individual and group activities ranging from undergraduate students through junior professors.

Transformational Facilities and Infrastructure: The Chemical Research Instrumentation and Facilities (CRIF) program has four distinct tracks through which CHE addresses its priorities in Shared Instrumentation, Instrumentation Development, Facilities and Cyberinfrastructure. The broad range of chemistry's computational techniques and data types and its large number of independent data producers pose unique challenges. 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, chemical processes at catalytic surfaces and environmental processes, as well as sensors for national security.

Changes from FY 2007:

- Chemistry Centers increase by $6.0 million to $9.0 million total, reflecting establishment of one additional Phase II CBCs and three new Phase I centers. The STC will phase down by $0.68 million.
- Research and education grants increase by $12.88 million to $180.27 million total. Funding for Cyber-enabled Discovery and Innovation will increase by $1.2 million. CHE will support molecular electronics and Science Beyond Moore's Law with an investment of $3.0 million.
- Instrumentation/Facilities increase by $1.24 million to $15.35 million total, including new investments in cyber-enabled chemistry, multi-user facilities and instrument development.

MATERIALS RESEARCH $282,590,000

The FY 2008 Request for the Materials Research Division (DMR) is $282.59 million, an increase of $25.14 million, or 9.8 percent, over the FY 2007 Request of $257.45 million.

Materials Research Funding
(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Percent
Materials Research	**$242.59**	**$257.45**	**$282.59**	**$25.14**	**9.8%**
Major Components:					
Research and Education Grants	138.48	146.13	162.77	16.64	11.4%
Centers Programs	65.03	71.30	74.80	3.50	4.9%
Facilities	39.08	40.02	45.02	5.00	12.5%
National High Magnetic Field Laboratory (NHMFL)	24.25	25.00	27.50	2.50	10.0%
National Nanofabrication Infrastructure Network (NNIN)	2.52	2.55	2.55	-	-
Other MPS Facilities	12.31	12.47	14.97	2.50	20.0%

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 component of the ACI. 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. DMR supports experimental and theoretical research over a broad range of subfields, including condensed matter and materials physics; solid state chemistry; polymers; biomaterials; ceramics; metals; and electronic, magnetic and photonic materials. The division maintains a balanced portfolio of research topics through individual investigator grants, focused research groups, centers, and awards for instrumentation and user facilities. DMR programs support a variety of interagency and international partnerships to advance materials research and education.

The DMR portfolio has three major components: research and education awards, centers, and user facilities. Support for international collaboration and for broadening participation in materials research and education is integrated throughout the portfolio.

- DMR research and education awards comprise grants to individual investigators and small groups, and to teams of several investigators addressing complex problems in materials and condensed-matter research. DMR also supports six International Materials Institutes 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.

- 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 2008; three MRSECs are being phased out in FY 2007. The division also supports three Nanoscale

Science and Engineering Centers (NSECs), provides partial support for a further seven NSECs, and supports two Science and Technology Centers (STCs).

- 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.

Approximately 20 percent of the funds requested for DMR in FY 2008 will be available for new competitive research grants; in addition about 10 percent of the funds will be available for the FY 2008 MRSEC competition. The remaining funds will support continuing commitments from prior years, facilities, instrumentation, and education and outreach. In FY 2006, DMR received 1466 research proposals and made 297 research grants for a success rate of 20 percent for research grants.

DMR Priorities for FY 2008:

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; on complex systems including biomaterials; on computational discovery and innovation; and on the regime in materials and condensed matter where the quantum nature of matter increasingly comes into play. Such programs have significant potential for economic impact and for enhancing U.S. competitiveness.

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 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. (For more details about the National High Magnetic Field Lab, please see the Facilities Chapter.)

Changes from FY 2007:

DMR will increase support for **research and education grants** by $16.64 million to a total of $162.77 million. This will enhance support for research on nanoscale materials and phenomena; on complex systems including biomaterials; on materials aspects of computational discovery and innovation; and for fundamental research addressing “Science Beyond Moore’s Law”, encompassing novel materials and phenomena required for the future development of new computational and communications technologies.

DMR will increase support for the **centers programs** by $3.50 million to a total of $74.80 million. The increase will partially support two to three new materials centers to be established through open competition; further funds will be derived by phasing out support for re-competing centers as needed.

DMR will increase support for **facilities** by $5.0 million to a total of $44.02 million. This will enable continued operational support for X-ray, neutron and nanofabrication user facilities, and includes enhanced support for the conceptual design of future X-ray facilities and for operation of the National High Magnetic Field Laboratory.

MATHEMATICAL SCIENCES $223,470,000

The FY 2008 Request for the Mathematical Sciences Division (DMS) is $223.47 million, an increase of $17.73 million or 8.6 percent above the FY 2007 Request of $205.74 million.

Mathematical Sciences Funding
(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Percent
Mathematical Sciences	**$199.52**	**$205.74**	**$223.47**	**$17.73**	**8.6%**
Major Components:					
Research and Education Grants	199.52	205.74	223.47	17.73	8.6%

Totals may not add due to rounding.

About DMS:

The Mathematical Sciences Division 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 80 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 analysis, geometry, topology, foundations, algebra, number theory, combinatorics, applied mathematics, statistics, probability, mathematical biology, and computational mathematics. Awards in these areas fund a variety of research projects, as well as workshops, computing equipment, and other research and education needs. In addition, DMS supports infrastructure, including national research institutes and postdoctoral, graduate, and undergraduate training opportunities. The DMS portfolio includes a variety of support modes and mechanisms. These include:

- DMS research grants range in scope from individual-investigator awards to awards for multidisciplinary groups of researchers to attack problems of mathematical and scientific importance.
- DMS provides major support for education and training, particularly through Enhancing the Mathematical Sciences Workforce for the 21st Century (EMSW21), which focuses on research training activities in the mathematical sciences and mentoring activities aimed at increasing the number of U.S. students choosing careers in the mathematical sciences.
- DMS provides 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 an incubator for new ideas and directions in the mathematical sciences and to address the growing interface with other disciplines.

In FY 2008, approximately 60 percent of the funds requested for DMS will be available for new research awards, with the remainder going to continuing commitments from earlier years. In FY 2006, DMS received 2,272 research proposals and made 685 awards, for a success rate of 30 percent.

DMS Priorities for FY 2008:

Fundamental mathematical and statistical science includes activities that strengthen the core of the disciplines and enable effective partnering with other science and engineering disciplines. Single investigator and small group research grants form the core of the DMS portfolio and play a central role in advancing the frontiers of knowledge. This is a central enabler of the ACI.

Cyber-enabled Discovery and Innovation (CDI) in the mathematical sciences incorporates modeling, algorithms, and simulation to provide new ways of obtaining insight into the nature of complex phenomena in science and engineering. Emphasis areas essential to advancing the ACI include algorithm development and computational tools for large-scale problems of scientific importance, modeling of phenomena that occur over a large range of spatial and temporal scales, and finding patterns in the structure of large data sets.

Science Beyond Moore's Law (SBML) challenges the mathematical sciences to continue the algorithmic "Moore's Law" – i.e., the exponential increase in speed of basic computations due to innovative new algorithms, in parallel with Moore's Law for hardware – and to develop new mathematical frameworks for computation. Emphasis areas include algorithm design, analysis, and implementation; scalability in space and time; quantification of errors and uncertainty; and visualization of large data sets. This is a key component of the ACI.

Broadening participation in the mathematical sciences will emphasize the support of interactions and research networks among a diverse population that will include students and researchers at a wide array of institutions. DMS will continue to emphasize the role of institutes in broadening participation.

Education and training activities include research experiences and mentoring activities aimed at increasing the number of U.S. students choosing careers in the mathematical sciences. Support for EMSW21 remain level.

Changes from FY 2007:

- **Support for the core** increases by $7.30 million in order to sustain the success rate for individual investigator proposals. Award size and duration will be maintained to the extent possible by providing adequate support levels for the most compelling projects and without reducing the success rate for unsolicited proposals. In addition, DMS will move to restore the recent gains made in supporting more graduate students and postdoctoral researchers within single investigator grants. Some of the investments in formal interdisciplinary partnerships through the now concluded Mathematical Sciences Priority Area will be continued. The remainder of these investments will be redirected to unsolicited proposals, while retaining their spirit and integrating them fully into the core.
- **Cyber-enabled Discovery and Innovation (CDI)** will be supported at the level of $5.20 million.
- **Science Beyond Moore's Law (SBML)** will be supported at the level of $1.50 million.
- **Discovery-based undergraduate experiences** will increase by $1.0 million and will build on current investments both within the mathematical sciences and on the interface with other disciplines. This activity is designed, in part, to better prepare students to pursue careers in fields that require integrated strengths between the mathematical sciences and other disciplines.
- **Mathematical sciences institutes and networks** will increase by $2.73 million to support the DMS portfolio of collaborations; research and training projects; scientific and public outreach activities; and programs to broaden participation in the mathematical sciences.

PHYSICS $ 269,060,000

The FY 2008 Request for the Physics Division (PHY) is $269.06 million, an increase of $20.56 million, or 8.3 percent, over the FY 2007 Request of $248.50 million.

Physics Funding
(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Change over FY 2007 Request Percent
Physics	**$234.15**	**$248.50**	**$269.06**	**20.56**	**8.3%**
Major Components:					
Research and Education Grants	145.58	165.19	187.15	21.96	13.3%
Facilities	77.00	83.31	81.91	-1.40	-1.7%
Laser Interferometer Gravitational Wave Observatory (LIGO)	31.68	33.00	28.20	-4.80	-14.5%
Large Hadron Collider (LHC)	13.36	18.00	18.00	-	-
IceCube	-	-	1.50	1.50	N/A
National Superconducting Cyclotron Laboratory (NSCL)	17.34	17.60	19.50	1.90	10.8%
Cornell Electron Storage Ring (CESR)	14.62	14.71	14.71	-	-

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 in the future. 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; theoretical physics; biological physics; physics cyber-enabled discovery and cyberinfrastructure; accelerator physics; and complex systems. 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 that are needed by certain subfields to answer the highest priority science questions.

In FY 2008, approximately 20 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 2006, PHY made a total of 277 competitive research grants, for a funding rate of 44 percent for competitive actions.

PHY Priorities for FY 2008:

- **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 overall stewardship of the portfolio. Emphasis will be given to increasing the support for cyberinfrastructure and cyber-enabled discovery, nanoscience, and biological physics. Additional large-scale, multidisciplinary research activities will be added through an open competition.

- **Elementary Particle Physics (EPP) Investment**. The opportunities for discovery in EPP and the challenges to addressing them are greater than at any time in the last half-century. The tools needed for breakthrough discoveries are more diverse and interdisciplinary, and NSF is well positioned to address the broader needs of EPP. By making the strategic, coordinated investment needed to realize the stunning opportunities laid out in numerous studies and plans, NSF will enable university researchers to participate fully in the emerging discovery period in EPP. The investment has three main components: the Energy Frontier, the Neutrino Frontier, and the Cosmic Frontier.

- **Physics of the Universe (POU)**, the highest scientific priority, addresses the compelling questions that have arisen at the interface of physics and astronomy and were posed by the National Research Council report, "Connecting Quarks with the Cosmos." A subsequent National Science and Technology Council report, "The Physics of the Universe: A 21st Century Frontier for Discovery," outlines a national investment plan involving NSF, DOE, and NASA. Within NSF, POU is coordinated and supported by the AST and PHY Divisions. Activities include funding within the grants program, instrumentation development, and new facilities.

Changes from FY 2007:

- Research and education grants increase by $21.96 million to a total of $187.15 million. PHY will continue to increase its investment in EPP and related areas of POU research. PHY will continue to enhance support for cyberinfrastructure, theoretical physics, biological physics, and computational physics. Education and outreach activities, and expanding diversity within the research community, will receive continued emphasis.

- Facilities decrease by $1.40 million to a total of $81.91 million. For detail, see the Facilities chapter. This includes:

  - Decreased support for operations of the Laser Interferometer Gravitational Wave Observatory (LIGO) and for advanced detector R&D during startup of AdvLIGO construction to a total of $28.2 million, a decrease of $4.8 million.
  - Increased support for operations of Michigan State University's National Superconducting Cyclotron Laboratory radioactive ion beam facility at a total of $19.5 million, an increase of $1.9 million.
  - Initiation of operations for IceCube ($1.5 million)

MULTIDISCIPLINARY ACTIVITIES $34,370,000

The FY 2008 Request for the Office of Multidisciplinary Activities (OMA) is $34.37 million, an increase of $1.97 million, or 6.1 percent, over the FY 2007 Request of $32.40 million.

Multidisciplinary Activities Funding
(Dollars in Millions)

	FY 2006 Actual	FY 2007 Request	FY 2008 Request	Change over FY 2007 Request Amount	Percent
Multidisciplinary Activities	**$29.90**	**$32.40**	**$34.37**	**1.97**	**6.1%**
Major Component:					
Research and Education Grants	29.90	32.40	34.37	1.97	6.1%

About OMA:

The Office of Multidisciplinary Activities 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 initiatives 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 push in 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 the Foundation 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.

Because OMA plays a catalytic role in initiating new multidisciplinary activities and enabling broadening participation, the portfolio contains few commitments from prior years. Approximately 80 percent of the funds requested will be available for new research and education grants. Almost all awards are managed in the MPS divisions with co-funding from OMA.

OMA Priorities for FY 2008:

Enabling the creativity 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 the AST and PHY Divisions that enables advances in our understanding of the physics of the universe; at the interface between the MPS disciplines and the biological sciences that provides insights into the molecular basis of life processes, bio-inspired materials, and biological physics; in the multidisciplinary arena wherein the fundamental science beyond Moore's Law will be explored; and by multidisciplinary teams of scientists, mathematicians, and engineers which leads to the development of next-generation instrumentation, particularly instrumentation 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 STEM workforce includes both MPS participation in Foundation-wide programs and MPS-centric activities that leverage the directorate's research investment. These activities enrich the education and training continuum at all levels and facilitate the formation of research-based partnerships that not only increase diversity and broaden participation in the Science, Technology, Engineering, and Mathematics (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 U.S. graduates who are well prepared to both support and to lead the Nation's STEM enterprise in the 21st Century.

Changes from FY 2007:

Funding for **research-enabled broadening participation in the MPS disciplines**, including the MPS-wide **Research Partnerships for Diversity**, diversity-targeted outreach from MPS centers and facilities, and diversity-building partnerships with MPS professional societies, increases by $750,000 to the level of $5.0 million. These co-investments with the five disciplinary MPS divisions enable research-based collaborative activities primarily between MPS-supported 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 2007 level of $3.0 million. This investment includes the MPS Internships in Public Science Education program and related activities that enable effective leveraging of the MPS research investment for public science education, and clear public articulation of MPS science themes such as Physics of the Universe.

The OMA investment in the **Research Experiences for Teachers** activity (RET) will be sustained at the FY 2007 level of $3.0 million, to provide more than 300 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 (GK-12) will be maintained at the FY 2007 level of $3.0 million.

Investment in cooperative **international research and training activities** will be increased by $200,000 to the level of $1.4 million to enhance the global competitiveness of U.S. scientists, engineers, and students. This international portfolio includes investments in the NSF-wide Pan-American Advanced Study Institutes, international research training networks, and opportunities for graduate students to establish and enrich international dimensions of their individual research and education programs.

All the above activities take place in the context of **disciplinary and interdisciplinary research** and are strongly aligned with the goals of the **ACI.** OMA places particular emphasis on fundamental investigations by multidisciplinary teams of scientists and engineers exploring science beyond Moore's Law, to be co-supported at the level of $2.0 million; on cooperative, high-risk research at the AST-PHY interface focused on Physics of the Universe, which will be co-supported at the level of $2.50 million; and on innovative research in multidisciplinary areas that enhance our understanding of the molecular basis of life processes, biological physics, and bio-inspired materials, to be co-supported at the level of $3.0 million.